The Development of Small Hydroelectric Projects in Vermont

A Report to the Vermont General Assembly

PREPARED BY

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EXECUTIVE SUMMARY

In the 2007 legislative session, H.520 (*An act relating to the Vermont energy efficiency and affordability act*) required the Agency of Natural Resources (Agency) to develop a report for the legislature on a number of issues related to the development and permitting of small hydroelectric projects. Although the bill was ultimately vetoed, the Governor nonetheless directed the Agency to develop this report.

Based on research and discussions within the Agency and with the Public Service Board, Department of Public Service and other parties, this report is intended to inform the legislature and public on several topics that relate to small hydroelectric projects, including the state's undeveloped hydropower potential, the state and federal regulatory processes, the impacts of dams on rivers, the principles behind hydroelectric facility design, the importance of streamflow protection, and project economics.

From a policy perspective, the Agency of Natural Resources supports hydroelectric projects that are environmentally and economically sound. Producing electricity through the responsible use of Vermont's renewable natural resources will help support Vermonters' long-term energy needs while protecting the health of Vermont's waters.

The Agency has developed the following conclusions to help achieve the above policy direction.

1. **Additional hydroelectric capacity:** There are opportunities to develop additional in-state hydroelectric capacity at existing but undeveloped dams. The total capacity is likely to be on the order of 25 MW, assuming new development is restricted to existing dams, but additional study is needed to develop an accurate estimate.
2. **Information for prospective hydroelectric developers:** A comprehensive guide to small hydropower development is needed. The target audience would be the developers of prospective projects, with the focus on those projects that do not exceed 100 kW of installed capacity. The guide would provide information to help prospective developers understand the economic and environmental issues associated with small hydropower projects, the regulatory system, and how to make a very preliminary assessment of whether a given site is economically viable. It could be a print publication, website or both.
3. **Low-impact standard:** Agency policy should specify that any new hydroelectric power facilities meet a "low-impact" standard based on the criteria developed by the Low Impact Hydropower Institute. This standard includes utilizing existing intact dams, so no new dams will be built for the purpose of hydroelectric power production. Preference should be given to dams that currently serve another purpose.
4. **Permitting process:** The existing permitting process, with FERC maintaining jurisdiction over hydroelectric projects, should be retained. Both state agencies and FERC are addressing concerns about timeliness and cost for permitting small projects. Federal and state agencies are working to scale the process so that it works better for smaller projects while at the same time providing a level of protection consistent with the importance of these public resources. Shifting the responsibility to the state would place a significant additional burden on the state's resources with little likelihood that the process would change sufficiently to justify the change.
5. **Prefeasibility assessments:** Subject to availability of resources, the Agency should continue its practice of conducting prefeasibility assessments for all public and private projects and resource assessments (i.e., electrofishing) for municipal/public projects. The prefeasibility assessments have been well received and they give potential developers a sense of a project's environmental feasibility early in the process. We will continue to refine this process based on feedback from project proponents.

6. **Definition of small hydro:** A new definition of “small hydro” is not needed. There are existing definitions (mini-hydro, micro-hydro and pico-hydro) that can be used, where necessary, in statute and rule.
7. **Increased production at existing facilities:** The Department of Public Service should work with Vermont utilities to investigate additional opportunities for increasing hydropower production at existing operating sites. Several of the assessments of undeveloped hydropower capacity note that there is untapped potential at existing hydroelectric facilities. This potential could be realized with more efficient turbines, small turbines at the dams that utilize bypass flows, and turbines that can operate efficiently over a wider range of flows. In many cases, an increase in production should be possible without changing the current operating requirements, essentially increasing energy production without additional environmental impacts. Further study is needed to determine the feasibility of this option. Vermont’s utilities indicate that they have made some initial progress toward improving the operation of existing facilities in recent years. There are, however, indications that further cost-effective improvements are available and deserve further study.
8. **Agency flow procedure:** The Agency should retain its existing flow procedure for establishing conservation flows at hydroelectric projects. The flow procedure defines an approach that is commonly used in the Northeast and provides a scientifically valid basis for setting flow requirements. Since the flow procedure is consistent with the USFWS *New England Flow Policy*, conflicting flow recommendations between state and federal agencies are avoided. It has also been recognized as a generally accepted scientific practice compliant with FERC rules and the Vermont water quality standards.
9. **Dam Removal:** The Agency should commit additional resources to removal of dams that are not serving useful purposes and are unlikely candidates for hydropower development. Restoring stream and river connectivity and eliminating existing water quality and habitat impacts will help balance the cumulative impact of new hydroelectric development.

Recommendations – The Agency offers the following recommendations to the legislature to allow full implementation of the above conclusions.

1. **Funding for updated study of potential hydropower sites:** Conclusion 1 points out that a better estimate of the developable hydroelectric capacity in Vermont is needed. The legislature should consider funding for the Agency, Department of Public Service and Public Service Board to collaborate on an update of the 1980 New England River Basins Commission study to identify the most viable sites for small hydropower development at existing dams. This update is essential for identifying the best opportunities statewide, both ecologically and economically, for new hydropower development.
2. **Funding for a hydropower development publication:** Conclusion 2 identifies the need for better guidance for towns and individuals who are interested in developing small hydropower projects. The legislature should consider funding for the development of such a guide by the Agency, Department of Public Service and Public Service Board.

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INTRODUCTION

Energy is very much in the forefront of public policy debate due to the focus on climate change, the expiration of power supply contracts with Hydro-Quebec and Vermont Yankee between 2012 and 2015, and the approval of Vermont's second utility-scale wind generation facility, among other reasons.

In the last several years, global warming has become a major issue of concern at an international, national and state level. Governor Douglas appointed a Commission on Climate Change (which issued its final report on October 26, 2007), and the legislature spent considerable time taking testimony and deliberating on state policy to address this problem in its last session.

These two issues came together on the specific topic of renewable energy. Several pieces of draft legislation were introduced that related to development of renewable energy sources, including small hydroelectric projects. The Agency of Natural Resources (Agency) provided testimony on several occasions. Ultimately, the small hydropower legislation was incorporated into H.520 *An act relating to the Vermont energy efficiency and affordability act*. Sections 23-25 of the bill (Appendix A) pertain to small hydroelectric projects, with Section 24 requiring the Agency to develop a report to the legislature. The bill passed both houses of the legislature, but was vetoed by the Governor in June. Nonetheless, the Governor directed the Agency to develop this report.

In this report, the Agency provides the legislature with extensive background information and its expert analysis of several issues related to small hydropower development. In addition, there are conclusions related to future Agency actions and recommendations for legislative action related to small hydropower. Our hope is that this report will inform debate in this legislative session and provide a foundation for appropriate action on this issue.

BACKGROUND

Rivers and Dams

Any discussion of small hydropower must take place within the context of dams and their benefits and drawbacks. Almost all hydropower facilities involve the construction of a dam or use of an existing dam.

Dam construction in Vermont began in the 18th century while Vermont was still disputed territory between New Hampshire and New York. The earliest dams were built to provide power for mills which often were central to the communities that developed around them. As time passed, the use of these dams may have changed from providing power for a gristmill or sawmill to other types of commercial enterprises.

Dams were developed for other purposes as well. Beginning in the mid-1800s, dams were constructed for recreational purposes (often to provide fish and wildlife habitat) or to provide drinking water supplies and water for industrial processes. During logging's heyday, temporary dams were constructed to store water for log drives between the forests and downriver sawmills. Following the flood of 1927, several dams were constructed primarily for flood control.

Shortly before the turn of the 20th century, hydroelectric power development began, sometimes at former mill dam sites. By the early 20th century, dams on Vermont rivers and streams were a significant source of electrical and mechanical power.[1] Their importance has declined in the last 75 years or so as hydromechanical power has been replaced by electricity and electrical generation has shifted toward larger hydro and non-hydro sources. Some major points in the history of hydroelectric development in Vermont follow (Bowers 1992, DesMeules and Parks 1988, Vermont Department of Public Service 2005).

- 1882 – Vermont's first electric company is chartered.
- 1882-1900 – Electric service is developed in 52 Vermont communities, most of them relying, at least in part, on hydroelectric power.
- 1920s onward – Technological advances allowed the interconnection of existing electrical distribution systems, providing economies of scale at larger generation facilities. Many small facilities cease operation.
- 1927 – Many hydroelectric facilities are damaged in the November flood. Some economically marginal facilities are so badly damaged they are not rebuilt.
- 1935 – Passage of the Rural Electrification Act spurs extension of electrical service into the Vermont countryside, greatly increasing the demand for electrical power.
- 1978 – Passage of the Public Utility Regulatory Policies Act (PURPA) with its economic incentives fosters renewed interest in development of small hydroelectric projects. The Agency receives 70+ proposals for new projects over the next several years. Of those, 51 are authorized and 41 are constructed.
- 1982 – Vermont has 62 operating hydroelectric facilities (all pre-PURPA). An Agency study finds that flow regulation at three-fourths of the projects is having adverse effects on streams and rivers.
- Late 1980s & 1990s – Changing economics and other factors result in a sharp drop in proposals for new hydropower facilities. Six facilities developed in the early 1980s are decommissioned.
- 1980s-2003 – The Agency issues water quality certifications for 25 pre-PURPA hydroelectric projects, ameliorating the impacts of these facilities on water quality, aquatic habitat and other uses and values.

[1] Appendix B provides an in-depth explanation of the principles behind hydroelectric power generation.

While industrial use of Vermont's rivers has changed over time, so have Vermonters' attitudes about their rivers. At one time, rivers were viewed mainly in economic terms: to power mills, provide transportation or receive waste. By the late 1960s, the damage done to many rivers led to renewed public concern about the ecological, recreational and aesthetic value of rivers, and laws to protect and restore rivers were enacted. In particular, passage of the Clean Water Act in 1972 began a period when concerted public efforts were made to restore the ecological integrity of rivers. These efforts continue today.

Vermont's rivers continue to be used for economic purposes, but there is a general recognition (and legal requirement under the Clean Water Act) that rivers, which are public resources "owned" by all citizens, must meet established biological, physical and chemical standards. The restoration of rivers from their former degraded state has benefitted other economic sectors, including tourism; boating, angling and other outdoor recreation services; and equipment retailers.

Because of this shift in thinking about the value of rivers, it is no longer legally or socially acceptable to dewater sections of a river or regulate flows in ways that are harmful to fish and other aquatic life. As a result, there are now constraints on the development of dams and other water diversions that did not exist in the first half of the 20th century, or before.

The Vermont Dam Inventory contains approximately 1,200 records.[2] At one time, each of these dams provided some societal benefit: power, water supply storage, flood control, recreation, wildlife habitat or aesthetics. Several hundred still do and they are valued and properly maintained. Many others have been essentially abandoned and are slowly deteriorating.

All extant dams – whether serving useful purposes or not – cause ecological impacts, as illustrated and described in Figure 1. While all of these impacts are important considerations, two that are especially significant merit further elaboration: flow and water level manipulation and sediment regime alteration.

Flow and Water Level Manipulation

Instream flow, or the flow of water in a stream or river, is an essential component of a riverine ecosystem. Since the 1980s, scientific understanding of the instream flow needs of aquatic organisms has increased dramatically. At the same time, demands on rivers to supply water for drinking water utilities, irrigation, snowmaking and hydroelectric power have increased, and the debate is sometimes characterized as "people vs. fish." That is really an oversimplification, and the question should be how much water is needed at different times of the year to maintain a healthy ecosystem – something that people value.

Early efforts to protect instream flow focused on a minimum low flow. Today there is an understanding that the full range of natural hydrologic conditions shapes a stream and its aquatic community. For example, high flows can be important to channel maintenance and distributing sediments to key habitat features in downstream channels and floodplains. Salmon are behaviorally influenced to move upstream for spawning by flow increases in the fall. Intermediate flows provide optimal conditions for survival and growth of fish and other organisms.[3]

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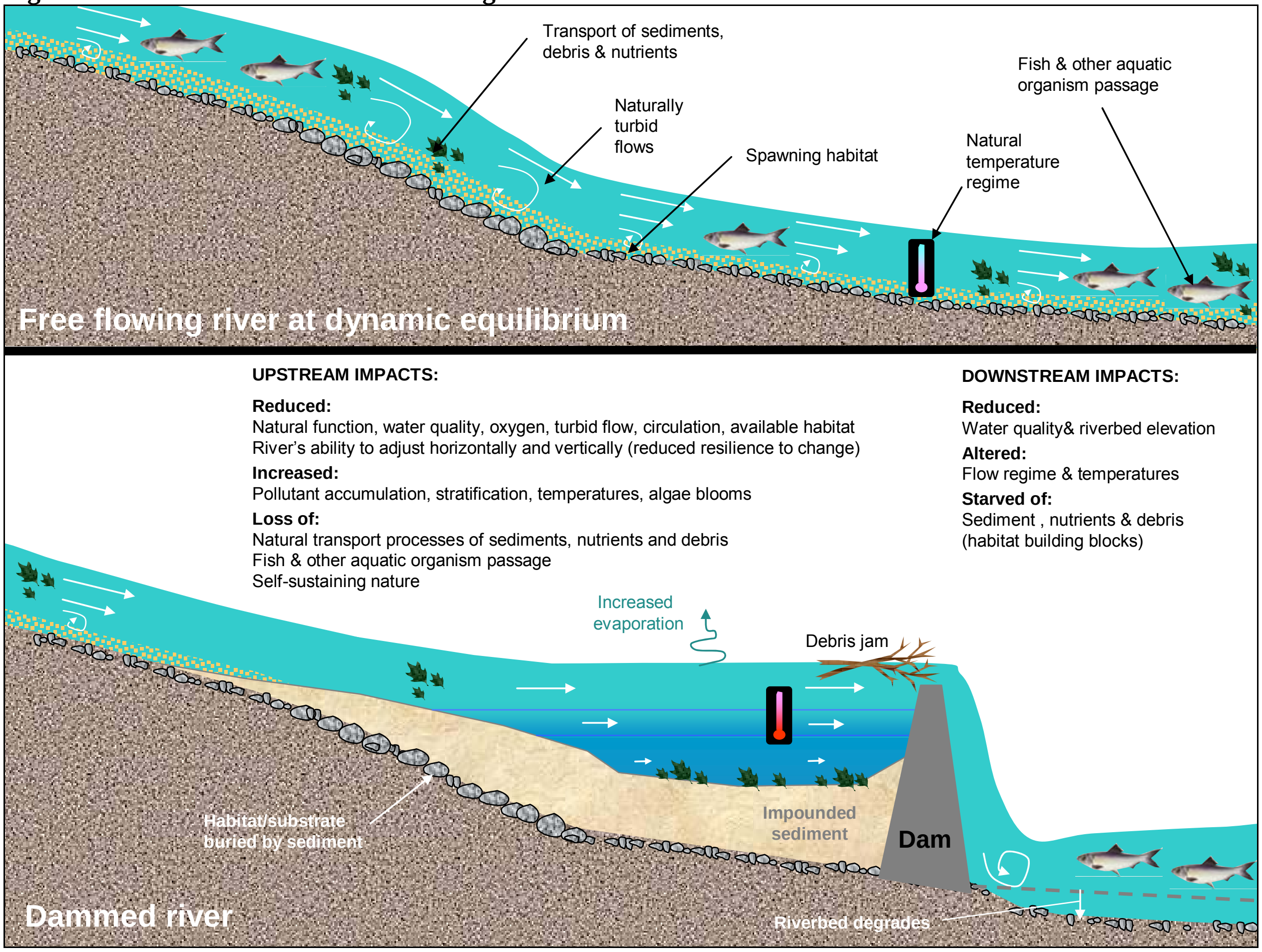
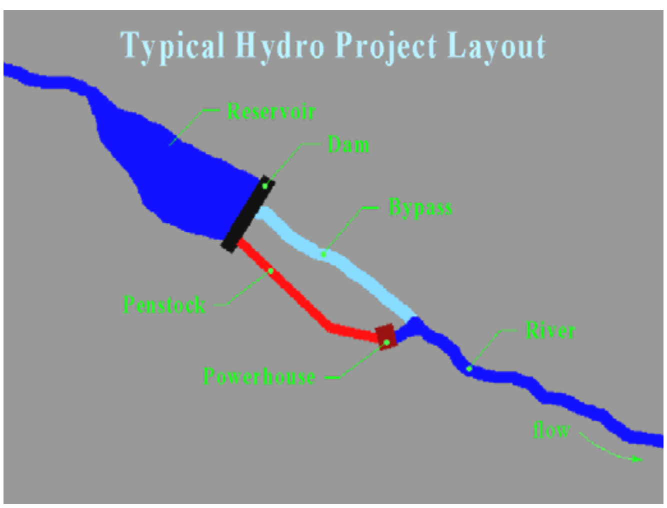
[2] The inventory includes information on dams that has been verified by site visits as well as reported but unverified dams. Some of the listed dams are breached or consist of minor remnants, and a few are the locations of former dams. Based on detailed surveys conducted in a few watersheds, the Agency is confident that there are at least a few hundred small dams in the state that are not listed in the inventory.

[3] Appendix C provides a more thorough discussion of instream flow.

Figure 1. Effects of a dam on a free-flowing river



Graphic courtesy of Laura Wildman, American Rivers



Healthy aquatic systems are important to Vermonters' sense of place and also are significant economically. Fishing alone contributes $65 million annually to the state's economy (U.S Fish and Wildlife Service and U.S. Census Bureau 2003). If we are to have healthy rivers and streams, protecting instream flow is as important as preventing pollution.

Artificial flow manipulation is usually the major environmental issue at hydroelectric projects of all sizes. It has two components: modification of downstream flow, or flow below the tailrace, and the amount of flow that remains in the bypass.[4]

[4] The tailrace is the location at the powerhouse where water reenters the river after passing through the penstock and turbine. The bypass is that portion of the river between the dam and the powerhouse that receives a reduced flow because water is diverted into the penstock and through the turbine. See Appendix B for a more detailed explanation.

With respect to downstream flow, most hydroelectric projects, especially small projects, are operated as "run-of-river." That is, the volume of water released below the dam and powerhouse is equal to the volume of water flowing in the stream or river above the dam on a continuous, real-time basis. Put another way, water is not stored in the impoundment to be released at a later time. For these projects, downstream flow manipulation is not an issue as long as the project is carefully operated

In addition to run-of-river projects, there are projects that operate in "peaking" mode, where water is stored in the impoundment when the demand for electricity is low and released to generate power during high demand periods. These projects regulate downstream flows, potentially resulting in impacts to aquatic organisms and their habitat, dissolved oxygen and water temperature. In addition, the impoundment elevations at peaking projects tend to fluctuate, resulting in upstream impacts to aquatic habitat and wetlands.

The second aspect of flow manipulation is the amount of flow that remains in the bypass. This can often be a significant issue because, while it is central to maintaining the ecological integrity of the bypass, it can have a significant influence on the amount of power that can be generated and, hence, the economics of the project. Larger projects may include a small turbine that generates electricity at the dam using water released into the bypass, but this approach is usually not feasible at small projects, so the bypass flow is not available to produce energy.

Sediment Regime Alteration

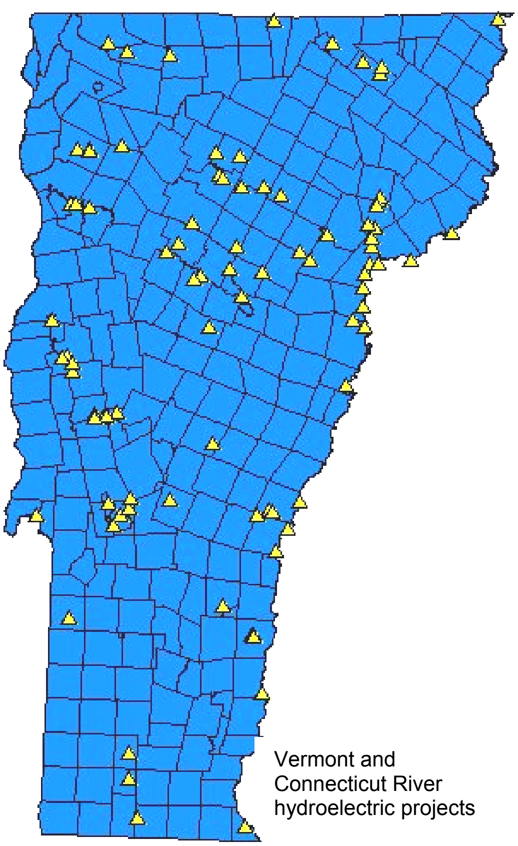
Dams and diversion structures that change the depth and slope of a stream significantly alter the size and quantity of bed sediments and how they are moved, sorted, and distributed along both the cross-section and profile of the channel (MacBroom, 1998). In a natural system, a river's bed sediments (substrate) and eroded riverbank materials are transported downstream during high-flow periods, but there is an equilibrium where the material that is lost from a reach of river is normally replaced, as flows recede, through deposition of material transported from upstream reaches. When the transport of sediments, e.g., gravels and cobbles, is interrupted in an impoundment, the channel may become vertically unstable. The instability takes two forms. The impoundment becomes a sediment "sink" as the sediments from upstream hit the flattened river reach and deposit, resulting in *aggradation*, or raising of the natural riverbed. The downstream instability is essentially the opposite effect. The river channel becomes *incised*, or downcuts, as the materials naturally eroded from the streambed during a flood event below a dam are no longer being replaced by an equivalent amount of sediment from upstream. This mode of sediment regime alteration (i.e., sediment discontinuity) has been observed above and below dams, diversions, and undersized culverts throughout Vermont.

Materials aggraded in the slower and deeper water behind the dam alter habitat structure, typically by finer sediments covering or embedding the larger substrates that provide cover for aquatic organisms. In watersheds with high sediment loads, the aggradation process behind a dam during storm events may lead to significant changes in flood stage, bed and bank erosion, and in some cases an avulsion, or change in course of the stream, as occurred on New Hampshire's Suncook River in 2006. When channel incision occurs due to sediment starvation downstream of a dam, the streambed may drop in elevation until annual flood flows no longer access the floodplain. The erosion/deposition processes and channel evolution that ensue as new floodplains are created often lead to significant habitat and water quality impacts and fluvial erosion hazards over a period of decades.

The Agency has conducted fluvial geomorphic assessments on over 1,000 miles of streams from 2003 to 2007. The data shows that 75 percent of the assessed streams are incised and no longer have the floodplain connection associated with their equilibrium condition. This key finding heightens the concern that new structures may increase sediment discontinuity. Both run-of-river and peaking hydroelectric facilities may alter the sediment regime of a river. Run-of-river projects, although more benign with respect to some environmental issues, typically have the same impact as peaking projects with respect to reducing sediments flows and creating vertical instability on sensitive stream channels. The response of these streams and the potential for new or exacerbated vertical instability in the channel should be factored into the design and permitting of low impact hydroelectric operations. This is especially important when weighing whether new dams should be constructed or old dams preserved for hydroelectric generation.

Hydroelectric Power in Vermont

In-state hydroelectric facilities contribute significantly to Vermont's power mix. Agency records show there are 78 hydroelectric generation facilities operating in the state.[5] The generating capacity of those facilities is 143 megawatts (MW). Electric utilities own 84 MW with the remainder (59 MW) owned by independent power producers (Vermont Department of Public Service 2005). Instate hydroelectric generation in 2006 equaled about 12 percent of the electricity consumed in Vermont (Vermont Department of Public Service 2007), and typically hovers around 10 percent of total consumption (Riley Allen, Vermont Department of Public Service, personal communication). In addition, there are eight facilities on the Connecticut River with a total capacity of 478 MW.



One of the challenges in the current discussion of developing small hydropower in Vermont is accurately estimating how much undeveloped capacity exists and how much of that capacity can be developed in an environmentally benign way. While this question has been studied repeatedly, estimates vary widely depending on the assumptions that are made. Table 1 summarizes the results of several hydroelectric power potential studies. The studies are explained in more detail in Appendix D.

The results of all of these studies should be used with caution. They are broad-brush assessments of the hydropower potential in the state and all suffer from limitations in the available data. Except for the Agency update of the 1980 NERBC study, all include sites where dams do not currently exist. Further, the 1998 and 2006 DOE studies did not include any field work to verify the potential at individual sites. Finally, none of the studies explore economic feasibility in any great depth.

Other recent reports offer their own estimates of Vermont's undeveloped hydroelectric potential. A report prepared for the Vermont Department of Public Service (Barg 2007) concludes that there are 93 MW of undeveloped capacity at existing, unbreached dams. The bulk of that capacity (91 MW) is at 89 sites with a capacity of at least 50 kilowatts (kW), including currently undeveloped capacity at existing hydroelectric facilities. Approximately 2 MW of undeveloped capacity is available at 244 sites, each with a potential capacity of less than 50 kW.

[5] Carver Falls and Dodge Falls are located on border waters, the Poultney River and Connecticut River, respectively.

Table 1. Assessments of Vermont's Undeveloped Hydroelectric Power Potential

Study	Inclusion Criteria and Data Limitations	Total Potential (MW)[6]	Developable Potential	
			Capacity (MW)	Number of Sites
U.S. Department of Energy – 2006[7] (Hall et al. 2006)	*Criteria:* Dammed and undammed sites that would produce at least 10 kW based on GIS analysis; developed sites and sites within protected areas excluded; computer-modeled feasibility and development criteria applied to determine developable potential *Limitations:* Provides theoretical maximum for the state by including all possible sites; no field verification	2,404 MW (1,202 MWa)	434 MW (217 MWa)	1,201
U.S. Department of Energy – 1998 (Conner et al 1998)	*Criteria:* Dammed and undammed sites; computer-modeled "suitability factors" applied to determine developable potential *Limitations:* Estimates are unverified by field reconnaissance; capacity estimate for one 73 MW site is highly suspect , casting doubt on the total estimate	421 MW	174 MW	149
New England River Basins Commission – 1980	*Criteria:* Existing dam sites, including operating hydroelectric dams and dams that were fully or partially breached; head of 5 feet and capacity of 50 kW *Limitations:* Data is nearly 30 years old, so some dams may no longer exist		59 MW	115
New England River Basins Commission – 1980 (reviewed and updated by Agency of Natural Resources, 2007)	*Criteria:* Sites included in NERBC 1980 baseload analysis, but updated to exclude sites developed since 1980, breached dams and former dam sites *Limitations:* Based on field data collected in the 1970s		25 MW	44

The Governor's Commission on Climate Change (2007) developed an estimate of potential hydropower capacity based on the 1998 Department of Energy *Hydropower Resource Assessment*. The Commission filtered 27 sites identified in the DOE assessment to only include sites with a capacity greater than 1 MW, that have an existing impoundment and that do not have major environmental or land use sensitivities that would be likely to preclude development. This resulted in a total capacity of 68 MW at 16 sites including two sites on the Connecticut River. However, the capacity estimate of 68 MW is not a good indicator of future potential. For example, Wyoming Valley (Connecticut River) and East Georgia (Lamoille River) do not have existing impoundments, so they do not meet the listed criteria. Removing these two sites reduces the total capacity to 52 MW.

[6] Potential (total and developable) refers to the installed (nameplate) capacity of the generators.

[7] This study reported the results as "hydropower potential" (see Appendix D), which is approximately one-half the installed capacity. The hydropower potential is reported here in average megawatts (MWa) as well as the estimated installed capacity to allow comparison with other studies.

To add another perspective, and approach, to this characterization of hydropower potential, one can turn to those with experience in hydropower development in Vermont and rely on their best professional judgment. The Vermont Council on Rural Development, in *The Vermont Energy Digest* (Hausauer 2007), cites John Warshow, a Montpelier-based developer of small hydropower facilities. Warshow estimates there is 10 to 15 MW of undeveloped capacity at existing dams once economic and environmental factors are considered, with sizes ranging from 500kW to 2 MW. He goes on to note that there is additional capacity at existing, operating sites. Robert Howland, a consultant with extensive hydropower experience, estimates that there are from 12 to 25 MW of hydropower expansion potential that could be developed in the next 10 years (Howland 2007).

The effect development of additional hydroelectric capacity will have on greenhouse gas emissions is one of the central issues of the public debate. To provide some context, activities in Vermont in 2005 resulted in approximately 9.1 million metric tons of carbon dioxide equivalents ($MMtCO_2e$)[8] (Strait et al. 2007). Vermont contributed about 0.13 percent of the total greenhouse gas (GHG) emissions in the United States. Vermont's electrical supply is predominantly from two sources, Vermont Yankee and Hydro Quebec, both considered low GHG emitters, so the contribution of electricity consumption to the total was relatively small at 0.64 $MMtCO_2e$, or 7 percent of Vermont's GHG emissions.

For 2005, ISO New England (2007) reported a New England marginal emission rate of 1,107 $lbsCO_2$/MWh, or 0.50 $MtCO_2$/MWh.[9] That is to say, every megawatt-hour (MWh) of electricity produced by in-state hydropower will displace a MWh from the projected future marginal sources supplying the New England grid, thus avoiding the production of 0.50 metric tons of CO_2. Assuming an average capacity factor of 0.5, every MW of new hydroelectric installed capacity would avoid production of 2,190 $MtCO_2$ annually.

Economics

The economics of any hydroelectric project – large or small – are difficult to characterize in general terms. We can, however, use some recent pre-feasibility studies to at least provide order-of-magnitude estimates of project costs and revenues.

In 2006, a pre-feasibility study for a Vermont project was funded by a grant from the Vermont Department of Public Service. The study assumed a generator capacity of 400 or 475 kW depending on the final project configuration. The estimated cost of design and construction, including a contingency, was $2.96 to $3.2 million. In addition, the estimated cost of licensing was $250,000 to $500,000, depending on the magnitude of the issues that would have to be addressed during the licensing process. Additional costs associated with bringing the project on-line and operations and maintenance costs were not estimated.

Revenue for the project was calculated using estimates of the annual generation in megawatt-hours for various scenarios and using 20-year market forecasts of wholesale power costs from the *Vermont Electric Plan* (Vermont Department of Public Service 2005). Using the design and construction costs only, the payback periods ranged from 13-15 years to 21-24 years, depending on the scenario chosen. Licensing costs could add from 1 to 3 years to the payback period.

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[8] This figure is gross emissions, which does not account for carbon sinks related to forestry and agricultural activities. It is based on consumption, so it does include the greenhouse gases produced by, for example, out-of-state sources of electricity. These units are CO_2 equivalents, which factors in emissions of methane, nitrous oxide and other greenhouse gases.

[9] This rate accounts for CO_2 emissions only, not CO_2 equivalents, so emissions of other greenhouse gases are not captured.

An independent review of the pre-feasibility study by another consultant with hydroelectric experience basically concurred with the facts and analysis in the pre-feasibility report. Further, the review letter pointed out that hydroelectric developers generally are using a cost[10] of $800 per MWh of average annual generation as a threshold to pursue a project, while the cost of this project exceeds $1,100 to $1,300 per MWh.

Other recent project pre-feasibility studies show similar development costs (Table 2). A recent study of a project in Maine, Coopers Mills on the Sheepscot River, included some information on three projects, including the Vermont project described above (Wamser 2007).

Table 2. Recent hydropower development cost estimates for selected Northeastern sites.

Project Location	Available Head (ft)	Capacity (kW)	Estimated Cost
Massachusetts	15	362	$3,000,000
New York	9	500	$3,900,000
Vermont	21	400	$2,960,000

The Coopers Mills Dam study points out that the dam and an existing fishway are both in poor condition and would require extensive repairs. In addition, installation of an eelway may be necessary. In the case of Coopers Mills, this work would add an estimated $238,000 to the cost of development. While costs will vary depending on the specifics at a particular site, many aging dams require some degree of repair or reconstruction, and that cost must be added to the cost of construction of the hydroelectric facility itself.

Regulation of Hydroelectric Facilities

Hydroelectric facilities are subject to a regulatory framework that has been established to control activities that affect public waters,[11] a resource that is held in trust for all citizens. The principles used in regulation of public resources are fundamentally different from those applied when private resources, e.g., land use, are involved. All activities that take place in rivers, lakes and their tributaries must meet a high standard of resource protection. There is also a legal requirement to protect the rights and interests of downstream riparian users. Even projects that are intended to restore or improve natural resources and ecological integrity, such as dam removal and streambank restoration, must meet the same standards. Because of the potential impact on public waters, hydroelectric power is placed in a different regulatory context than other renewable energy projects, such as wind turbine developments or solar arrays.

Most hydroelectric facilities are under the jurisdiction of the Federal Energy Regulatory Commission (FERC), as mandated by the Federal Power Act.[12] Specifically, FERC has jurisdiction over all non-federal hydroelectric projects that a) are located on navigable waters of the United States; or b) are located on a non-navigable stream, were constructed after August 26, 1935 and affect the interests of interstate or foreign commerce (including providing power to an interstate electric grid). Existing facilities that do not meet these criteria are not regulated by FERC and are subject to state regulation by the Vermont Public Service Board (PSB). In practice, PSB jurisdiction is limited primarily to facilities that were built prior to 1935 and have not been extensively modified since then. Virtually any new hydroelectric project that connects to Vermont's electric grid would be subject to FERC's authority, and state (PSB) jurisdiction would be preempted. Consequently, there would be no 30 V.S.A. § 248 review for projects that are under FERC's jurisdiction.

[10] Engineering, licensing, administrative and capital construction costs.
[11] Vermont statute (10 V.S.A. § 1251) defines "waters" to include "all rivers, streams, creeks, brooks, reservoirs, ponds, lakes, springs and all bodies of surface waters, artificial or natural, which are contained within, flow through or border upon the state or any portion of it."
[12] Appendix E provides a more detailed explanation of state and federal hydropower regulation.

While FERC jurisdiction preempts state statutes, the federal Clean Water Act requires that any project receiving a federal license or permit first receive a state certification that the project meets state water quality standards. In Vermont, that certification is issued by the Agency.

ANALYSIS

In-state hydroelectric power currently makes a significant contribution to Vermont's electrical supply and that contribution is likely to continue. There are certainly benefits associated with this source of electricity. Hydroelectric power is a low-emitter of carbon dioxide and other greenhouse gases relative to fossil-fueled sources. It is renewable. Hydroelectric facilities can contribute to the stability of the electric grid, and in-state hydropower supports Vermont's economy. The question before us now is how and where environmentally sound hydropower development takes place in Vermont.

Discussion of that question must take place with full recognition that every source of energy has some negative impacts. This is certainly true of existing hydroelectric facilities as well as any that are developed in the future. We have described the impacts of dams on free-flowing rivers. Some level of environmental impact occurs at every dam, regardless of size, design or location. Some dams are in place and unlikely to be removed, leaving only the incremental impact of adding the hydroelectric operations. In the case of existing hydroelectric facilities that have been certified by the state in the last 25 years, those impacts have been deemed acceptable given the benefits these facilities provide. Since every facility is unique, decisions regarding the operation of each facility are necessarily made on a case-by-case basis. That approach will continue as new facilities are proposed or existing facilities come up for state certification.

Undeveloped Hydroelectric Capacity

It is tempting to see Vermont's untapped hydroelectric power resource as a significant electric generation source that can be developed with virtually no environmental impact. Our experience and analysis of existing data indicates this is not the case. While some analyses have produced estimates of hundreds of megawatts of undeveloped capacity, those studies lack rigorous field verification of modeled capacity, which invariably reduces the capacity estimate. Further, it would be necessary to build new dams on undammed or formerly dammed rivers and streams to achieve that capacity. This is best illustrated by the 2006 Department of Energy study, which derived a potential capacity estimate by assuming that every possible site is developed, which would entail the construction of hundreds of dams and diversions. Policy-level and project-specific proposals to date call for developing generation at existing dams, and not the development of new dams.

There is undeveloped hydroelectric capacity in Vermont, but it is much more likely to be in the vicinity of 25 MW. This estimate is based on analysis of the 1980 New England River Basins Commission study and the professional judgment of people with Vermont hydropower experience. A targeted effort that updates the 1980 study and identifies those sites most viable economically and environmentally would likely result in more timely and less costly development of additional in-state hydropower capacity.

Additional capacity exists at facilities that are currently in operation. Replacement of aging equipment with more modern and efficient turbines and installation of units that can utilize bypass flow releases would increase energy production at these facilities. Upgrades have taken place or are about to take place at several facilities (Gilman, Essex No. 19 and Vernon) and are being considered elsewhere. Generally, efficiency upgrades that add capacity to an existing licensed facility do not trigger a new licensing process, but instead a simpler license amendment review at FERC.

The driving force that will determine whether a new project is developed or an existing project is upgraded is economics. The most recent economic conditions favoring development of small hydropower facilities reached their zenith in the early 1980s and many small projects were developed. As economic incentives were phased out, interest in small hydro waned, and some projects were decommissioned. The Agency's limited research on this topic indicates that many small projects will not be economic.

Permitting Process for Small Hydroelectric Projects

The legislature has asked the Agency to analyze the existing permitting process for small hydroelectric projects. The process has received harsh criticism and has been characterized as a major impediment to the development of small hydropower in the state.

There are potentially three regulatory paths that an applicant for a new hydroelectric project must negotiate. Two are federal (FERC and U.S. Army Corps of Engineers) and the third is the state process administered by the Vermont Public Service Board. The one that has received the most attention, and the most criticism, is the FERC process.[13]

The FERC process[14] for obtaining a license or exemption is geared toward large hydroelectric projects and completing it can take five or more years for a large, complicated project with many issues and numerous stakeholders. Nonetheless, FERC has tried to respond to increasing interest in small hydroelectric developments to scale the process down so it is shorter and less costly. One aspect that is considered is the generating capacity of the project, which will determine, in part, if the project is eligible for a 5 megawatt exemption. But, the natural resource impacts of the project are major considerations, and the process is likely to be faster, less complicated and cheaper if the resource impacts are small. In other words, the time and cost of completing the regulatory process are largely determined by site-specific factors and are directly proportional to the potential environmental impacts. Those factors include whether or not there is an existing dam, how the project is proposed to be operated (run of river or store and release), the quality of aquatic habitat in the reach affected by the project and the importance of that habitat to target species (e.g., trout, sturgeon), water quality effects of the project (especially on temperature, dissolved oxygen, and sediment regimes), other uses of the affected waters (e.g., swimming and boating), flood and fluvial erosion hazards created by the project, and the presence of historic or archeological resources. The bottom line is that the permitting cost for low impact projects is less than high-impact projects.

A key step that can shorten the timeframe is for the applicant to engage the regulatory agencies early and work collaboratively to define the project's resource issues and resulting information needs. In most cases, some level of field studies will be needed, but the scale and scope of those studies is case-specific. This approach provides the applicant with the opportunity to have all of the information needed by FERC and the state and federal resource agencies in the initial application, avoiding delays while additional information is gathered. For small, simple projects, FERC has shown a willingness and ability to compress the timeframes so that a license or exemption can be issued in less than a year once a complete application is received.

By virtue of the need to obtain a state water quality certification before a license can be issued, there is significant state involvement in the FERC process. In practice, state and federal resource agencies work

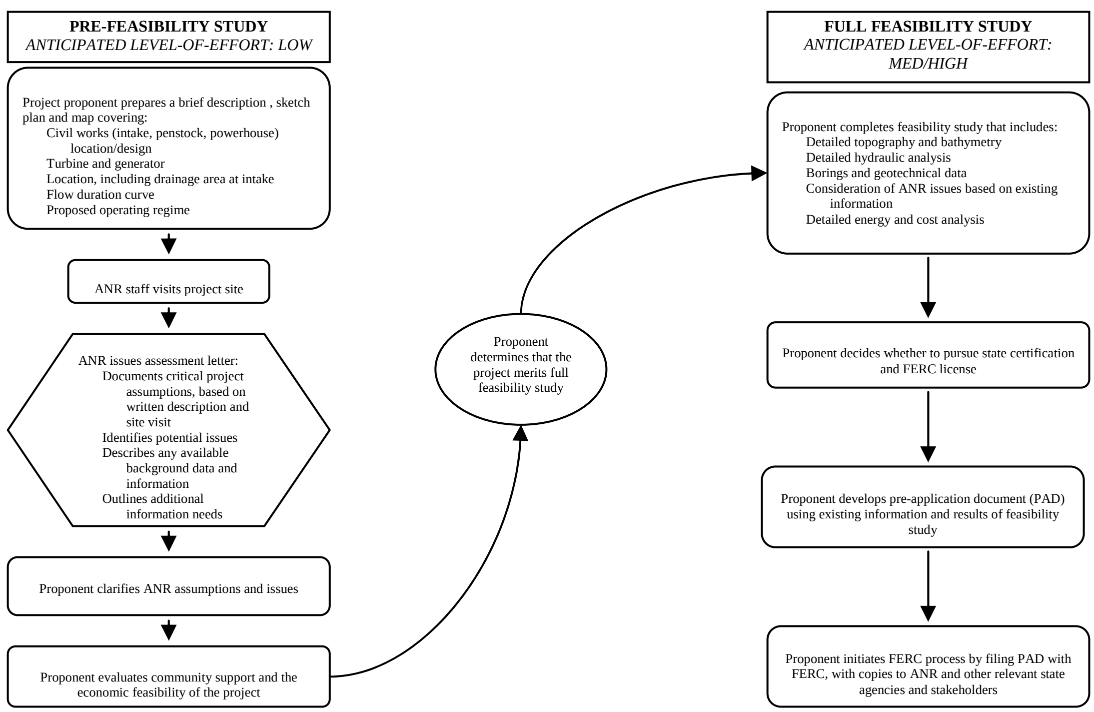
[13] It should be noted that few, if any, new hydroelectric dam proposals have been subject to PSB or Corps jurisdiction. Future projects may go through both a Corps review under Section 404 of the federal Clean Water Act and a FERC review.

[14] FERC issues a license in most cases, but projects meeting certain criteria may qualify for an "exemption from licensing," commonly referred to as an exemption. (Refer to Appendix E for additional details.) There are really three FERC processes that can be used to obtain a license (traditional, alternative and integrated). The three have somewhat different steps and timeframes, but they are similar enough that they are generically referred to as the "FERC process" in this analysis. The integrated licensing process ("ILP") is the newest process and was developed to improve process efficiency. All exemption applications use the traditional process.

closely with the applicant and FERC to identify important issues (scoping) and any studies that are needed to address those issues. Ideally, the processing of the state certification and federal license are concurrent and the information that has to be submitted to the state and federal regulators is very similar, if not identical.

In early 2007, the Agency responded to renewed interest in small hydropower projects by instituting a "pre-feasibility assessment" process. To initiate the process, the proponent of a hydroelectric project contacts the Agency and requests a site visit. Agency technical staff meet with the proponents at the site to become familiar with the location, get a sense of the project proposal (which may simply be a concept at this point) and discuss potential issues and possible design and operational considerations. Following additional discussion within the Agency and possibly further dialogue with the project proponents, the Agency issues a letter that describes the issues and provides a preliminary assessment of any resource issues that may be an obstacle to developing the project. The Agency assessment is but one step in the process of determining if a project is feasible (Figure 2). Appendix F provides a summary of the status of project proposals that have been brought to the Agency's attention.

Figure 2. Project feasibility study process



The purpose of these assessments is to make the process more predictable by giving potential project developers an early indication of the most significant resource issues that will have to be addressed. That said, the letters are advisory only and do not constitute Agency approval or disapproval of the project, which can only occur after there has been an opportunity for public review and comment. Nonetheless, by taking this step early in the process, the Agency hopes that project developers will have better information when they make a decision about investing in more detailed feasibility studies and designs. If the project would have significant impacts on high-quality resources, the Agency may conclude, and tell the proponent, that it is unlikely a viable project exists. In other cases, the Agency may indicate that the resource issues are relatively minor. In either case, it is then up to the proponent to determine the economics of the project and whether to move forward.

There is a perception that the regulatory process in Vermont is not very user-friendly to developers of small hydroelectric projects and an impression that other states in the region have either lower environmental protection standards or a better process, or both. The Agency surveyed the regulatory agencies in five Northeastern states on this issue (Appendix G). The results show that, since small projects will be under FERC jurisdiction, the processes are very similar to Vermont's. The one exception is that Vermont is the only state that conducts pre-feasibility assessments for small projects.

With respect to environmental protection standards, water quality standards do differ among the states, so there will be differences. However, all of the surveyed states use the U.S. Fish and Wildlife Service *New England Flow Policy*[15] to determine flow requirements. The Agency uses its own procedure,[16] which is based on the *New England Flow Policy,* for flow determinations.

There have been calls to remove FERC from the permitting process for small hydroelectric projects to ease the regulatory burden on applicants and the resulting cost. The model most commonly cited was authorized in 2000 by an amendment (P.L. 106-469, §501) to the Federal Power Act. The amendment gives the State of Alaska a mechanism to assume regulatory authority over small (in this case, less than 5 MW) hydroelectric projects. Before this authority can be exercised, the law requires that Alaska develop a regulatory program that provides equivalent protection to the environment and public interest as currently exists with FERC jurisdiction. Compliance with the National Environmental Policy Act, Endangered Species Act and Fish and Wildlife Coordination Act must be addressed in the program. The program must be submitted to FERC for approval before regulatory authority is transferred from FERC to Alaska. Meanwhile, FERC jurisdiction remains in place. Alaska has yet to develop a program for FERC review. The state did develop extensive draft regulations but for reasons related to resource limitations, work priorities and timing, the regulations were never finalized. The Regulatory Commission of Alaska expects to restart this process and have a state program in place by 2009 (Lane 2007).

The Agency has reviewed a draft proposal for federal legislation that would authorize other states to enact similar programs. While some of the details differ from the law that authorized the Alaska program, jurisdiction for projects smaller than a certain size would shift from FERC to the state. This change would amount to a huge unfunded mandate, as state agencies would become responsible for meeting all of the statutory requirements noted above, all of the other processing overhead, follow-up compliance and enforcement once a project began operation, and dam safety.

U.S. Army Corps of Engineers jurisdiction over hydroelectric projects results from its general authority over activities in public waters. This broad authority gives the Corps jurisdiction over structures or work affecting navigable waters of the United States and dredge and fill activities in all waters of the United States. These requirements apply to all activities, such as construction of non-hydroelectric dams, road fills, placement of riprap, construction of boat ramps, etc. In the case of hydroelectric facilities, Corps jurisdiction would apply if there would be any new construction in the stream or river. Some activities that cause minimal environmental impacts are regulated under a general permit, which is a relatively simple and short process. Larger projects with greater impacts receive individual review, since the magnitude of the impacts is greater. Consequently the information requirements are higher and the process takes longer. In the case of an individual permit, the state's water quality certification authority would be triggered. The applicant must coordinate both the FERC and Corps processes to enable the issuance of a single water quality certification for both federal permits.

[15] The U.S. Fish and Wildlife Service *New England Flow Policy* is provided in Appendix H.
[16] The *Agency Procedure for Determining Acceptable Minimum Stream Flows* (July 14, 1993) is provided in Appendix I.

FERC jurisdiction preempts state regulation, so additional authorizations from the Vermont Public Service Board are not necessary once a project has received a FERC license or exemption. Public Service Board review would only be necessary if a project did not trigger FERC jurisdiction. The only such circumstance of which the Agency is aware would be non-capacity upgrades at existing facilities that are already under PSB jurisdiction.

Definition of Small Hydro

One of the specific charges to the Agency in H.520 is to develop criteria for what constitutes a "small hydroelectric facility" in consultation with the Public Service Board. Presumably, this definition would apply if any future legislation or rules are developed to provide incentives for small hydroelectric projects.

Most schemes that classify hydroelectric facilities use installed capacity as the principal criterion. This is a very straightforward approach that relies on the size of the generation equipment. The categories that are typically used are large, small, mini, micro and pico. While there is no industry-wide standard, the definitions used by the European Small Hydropower Association and the European Commission are typical (Taylor et al. 2006). The Europeans define small hydropower as those projects that are 10 MW or smaller. Other definitions set the upper limit at 15, 25 and even 50 MW.

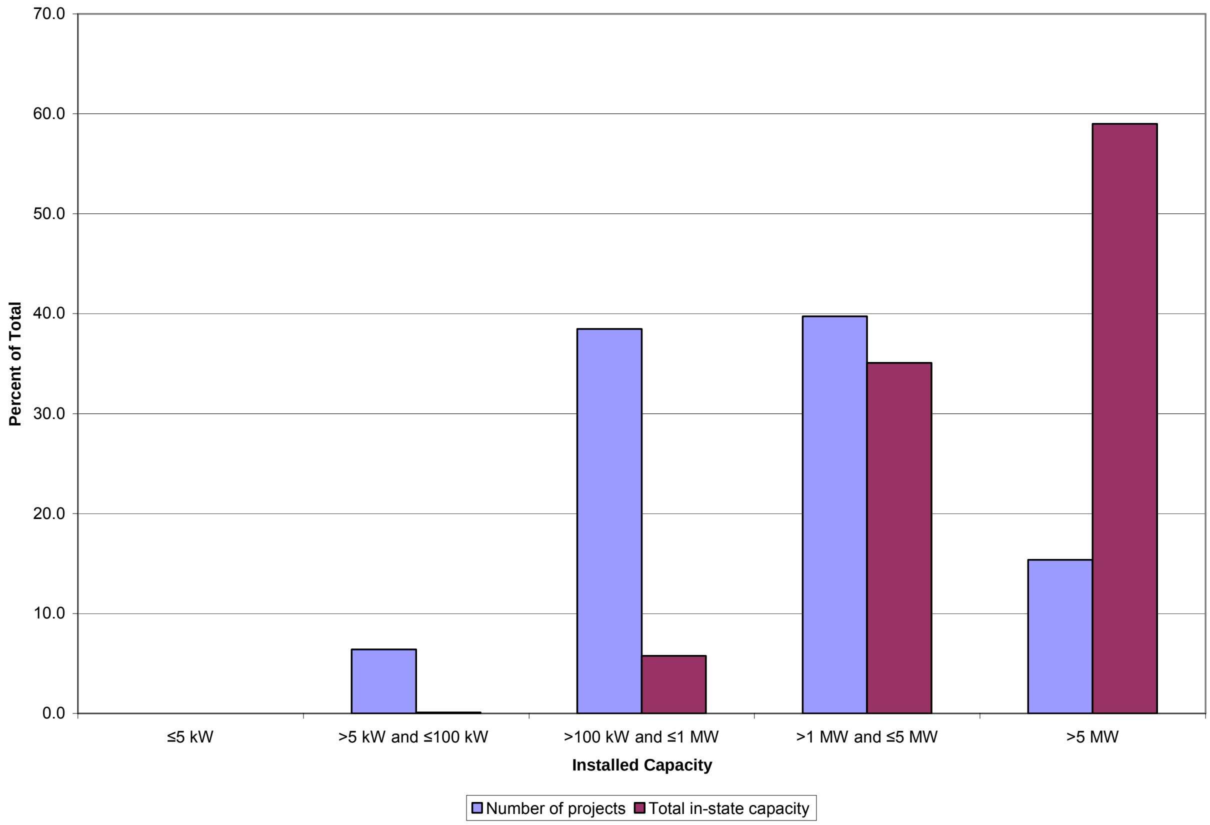
The definitions of the other categories appear to be more generally accepted:

Mini-hydro – 101 kW to 1 MW
Micro-hydro – 6 kW to 100 kW
Pico-hydro – up to 5 kW

Given the size distribution of projects in Vermont (Figure 3), the existing definitions of small hydropower do not work well here – most of the hydroelectric facilities in the state are smaller than 10 MW. Even the FERC definition of 5 MW, which potentially qualifies a project for a FERC exemption, would include 65 of the state's 78 operating generation facilities.

This report does not recommend changes to statute or rule relating to the way that small projects are regulated, so defining "small hydroelectric facility" may not be critical. If it becomes necessary to establish categories for small hydroelectric projects in any statutes or rules, the Agency recommends using the existing definitions of mini, micro and pico. This approach would be scaled to the size of Vermont projects and take advantage of existing definitions to avoid confusion or redundancy with respect to defining projects by size. The Agency has consulted with the Public Service Board and Department of Public Service, and both concur with this approach.

Figure 3. Distribution of in-state hydroelectric projects by installed capacity



Low-Impact Hydro

During discussions and debates of small hydropower, the terms “small” and “low-impact” are sometimes used interchangeably. They are not the same. Small hydroelectric facilities that are added to existing dams and properly operated can certainly provide benefits with limited additional impacts on fish, aquatic habitat, water quality and geomorphic processes. However, this is not true of all facilities, and whether a facility is low-impact must be determined on a case-by-case basis.

There is a program in place to certify “low-impact” hydroelectric facilities. The Low Impact Hydroelectric Institute (LIHI), based in Portland Maine, has developed eight low-impact certification criteria that address the following issues: river flows, water quality, fish passage and protection, watershed protection, threatened and endangered species protection, cultural resources protection, recreation and facilities recommended for removal. The goals and standards for the eight criteria may be found in Appendix J.

LIHI uses a market-based, non-regulatory approach. It is based on recognition that hydroelectric power facilities can have significant adverse environmental impacts. While those impacts are often addressed through the regulatory process (e.g., FERC relicensing), LIHI certification offers an economic incentive to utilities and generating companies by giving them opportunities to realize additional revenue for energy that is produced at certified facilities. One such opportunity is through participation in discretionary qualifying “green pricing” programs, like the CVPS Cow Power™ or GMP’s GreenerGMP program.

Another is by qualifying these facilities for Renewable Energy Credits (RECs),[17] or premium varieties of such RECs in states with a Renewable Portfolio Standard willing to differentiate low-impact hydro from other potentially qualifying renewables. Twenty-three states in the US, including all of Vermont's neighbors, have a Renewable Portfolio Standard. The owners of certified facilities also get public relations benefits for producing "green energy." Twenty-nine facilities have been certified by LIHI, including a Vermont project, Winooski One on the lower Winooski River. Nationwide, applications for eight additional certifications are under review.

In general, the LIHI certification standards rely on resource agency determinations for each of the eight criteria. In one case – river flows – the project must meet the most environmentally protective recommendation if there is a difference among the resource agencies. For small hydroelectric facilities that are new or repowered, the Agency is likely to recommend the following conditions to meet the low-impact standard:

- No new dam or other barrier to aquatic organism movement and sediment transport
- Run-of-river operation
- Bypass flows necessary to protect aquatic habitat, provide for aquatic organism passage and support aesthetics
- Fish passage, where appropriate
- No change in the elevation of an existing impoundment or in water level management
- No degradation of water quality, particularly with respect to dissolved oxygen, temperature and turbidity
- No change in the upstream or downstream flood profile or fluvial erosion hazard sensitivity.

Cumulative Impact

Because of their small size, the cumulative impact of developing multiple facilities in a watershed might not be obvious. Even facilities that meet the low-impact criteria discussed above are not impact free. If they are located at existing dams, the impacts resulting from dams described earlier in the report are present. Bypassed reaches are impacted when water is diverted – the aquatic base flow standard does protect habitat, but the quality of the habitat is degraded relative to natural flow conditions.

Another aspect of small hydropower facilities is that they can be located on smaller streams. In fact, since the majority of economically viable sites on larger streams and rivers have already been developed, the likely trend will be towards small-scale development. While it is hard to generalize, these streams are recovering from the impacts of a statewide deforestation but are less likely to be currently impacted by dams, development of roads and other infrastructure, hydrologic change resulting from development and conversion of forests to other land uses, loss of streamside vegetation, point-source discharges, etc. While the streams may be small, their aggregate contribution to habitat and water quality in the watershed is significant. Consequently, project proposals should not be viewed in isolation but in a watershed context.

Streamflow Protection

As discussed earlier in this report and in detail in Appendix C, providing adequate instream flow at hydroelectric projects is essential to maintaining healthy aquatic ecosystems. For projects that operate as run-of-river, downstream flows (i.e., those below the powerhouse) are not an issue. However, flow

[17] Renewable Energy Credits are tradable certificates that enable load serving entities in states with an Renewable Portfolio Standard to meet the state standards. In New England, the New England Generation Information System administers a program that ties the attributes of generation to actual MWh of generation from the New England generators. These attributes are captured in the form of a Renewable Energy Credit that is eligible for exchange between buyers and sellers. The existence of these credits enables their use in other green pricing programs.

management in the bypassed reach between the dam and powerhouse is a critical, and often contentious, issue. Indeed, H.520 specifically requested that this report address bypass flows at small hydroelectric facilities and seasonal bypass flows at run-of-river facilities.

The Clean Water Act applies to all waters, including bypasses at hydroelectric facilities. Thus, bypasses must meet state water quality standards. Every bypass is unique with respect to the combination of slope, cross-section, and substrate. These and other factors influence the amount and type of aquatic habitat the bypass provides, determining, in turn, which species that will use that habitat and at what points in their life cycles (e.g., spawning). The challenge is in determining the appropriate streamflow needed at different times of the year to provide high-quality habitat.

The Vermont water quality standards and Agency flow procedure provide a framework to make these determinations. They allow developers of hydroelectric projects to use science-based default values that provide adequate habitat protection. These values are not unique to Vermont, but are used regionally. Further, the Agency procedure provides hydroelectric developers with the opportunity to perform habitat studies that will determine the site-specific flow necessary for habitat protection. These studies employ accepted scientific methods that require a considerable amount of data in order to reach a conclusion on appropriate bypass flows. Unfortunately, there is not a quick and cheap site-specific study method that is scientifically valid. That said, there can considerable differences in the scope of studies among individual bypasses. In other words, short bypasses with little habitat value will require much less work (and cost) than long bypasses that provide high-quality habitat.

In summary, it is essential, both ecologically and legally, to maintain bypass flows that provide habitat protection at hydroelectric projects. Further, if the bypass provides spawning habitat, it may be necessary to provide higher flows from fall through spring. Finally, flow determinations can use regional standards or the results of site-specific studies.

Information Needs

There is considerable interest among Vermonters to develop new sources of renewable energy. Many towns are forming energy committees to identify ways to increase efficiency and generate renewable energy. Private dam owners are starting to look at these structures as a possible way to lower their electric bills. An obstacle they often face with respect to a hydropower project is how to get started, or even to decide if a concept is worth pursuing. They are hungry for information. This hunger was demonstrated when the Agency sponsored a one-day small hydropower workshop on April 26, 2007. The workshop was filled to capacity, and people had to be turned away.

Towns and individuals also are limited by not having resources to invest in a potential project that may not be viable. In some cases, they are turning to the Agency to assist them. While we can conduct a prefeasibility assessment and provide public projects with some limited technical assistance, we lack the expertise necessary to offer advice on project economics and the resources to design the project.

The Agency concludes that a comprehensive guide to small hydropower development is needed. The target audience would be the prospective project developers, with the focus on those projects that do not exceed 100 kW of installed capacity. The guide would provide information on the economic and environmental issues associated with small hydropower projects, the regulatory system, and how to make a very preliminary assessment of whether a given site is economically viable. It could be a print publication, website, or both developed by a partnership of the Agency, the Department of Public Service, Public Service Board and NGOs interested in the topic (e.g., Renewable Energy Vermont, Vermont Natural Resources Council, Trout Unlimited). Guides developed by the Agency and the Public Service Board during the 1980s could serve as a foundation.

Dam Removal as an Environmental Benefit

The development of new hydroelectric projects in Vermont will result in unavoidable impacts to Vermont's rivers and streams. Some of the impacts are a consequence of water diversions at hydroelectric projects altering the natural flow regime in bypassed reaches. Further, some projects would likely be located at dams that would otherwise have been removed or have deteriorated and eventually failed due to neglect. Either way, the ongoing impacts of those instream structures would eventually have been eliminated.

Of course, the offsetting environmental benefit is the production of renewable energy. The Agency has a long record of recognizing these tradeoffs, as demonstrated by the number of in-state hydroelectric projects that have been certified and are currently operating. Nonetheless, there is some potential that a large number of small projects will be developed resulting in a significant cumulative impact to environmental resources and recreational use that is significant.

There are many dams in Vermont that are not currently serving a useful purpose and, for both economic and ecological reasons, are unlikely to be developed for hydroelectric power. However, these dams will continue to fragment habitat, degrade water quality and cause other impacts on rivers and streams. With the prospect of a long-term increase in water temperature as a result of climate change, restoring watershed continuity by removing dams and other obstructions will become increasingly important.

For these reasons, the Agency will continue, and expand over time, its efforts to remove dams that no longer serve the public good.

Agency Resource Needs

Agency managers are mindful of the demands a new program places on staff and financial resources. In the case of small hydro, those demands will be based on the activity level. Early indications are that the number of project proposals and the additional work involved will be manageable with current resources. An increase in the number of proposals would result in some strain on the technical staff, especially fisheries biologists and the staff responsible for the water quality certification and hydropower review program. Transferring federal jurisdiction over small hydroelectric projects to the state would result in major additional burdens on the Agency, the Department of Public Service and the Public Service Board.

OTHER ISSUES IDENTIFIED IN H.520

In addition to the topics discussed in the foregoing background and analysis sections, H.520 (Appendix A) identified several additional topics to be addressed in this report. These stand-alone issues are covered in this section.

Dissolved Oxygen Monitoring

From H.520: *Address the need for monitoring of dissolved oxygen at small hydroelectric facilities.*

The dissolved oxygen (D.O.) concentration is important to the health of an aquatic ecosystem. Signature native species, like brook trout, require high D.O. concentrations to thrive. If D.O. levels are reduced beyond a fish's tolerance level, it will die. Low D.O. levels can result from excessive nutrients in the water and lack of aeration.

Typically, characterization of dissolved oxygen is required when a hydroelectric project is permitted or licensed. This characterization is necessary to determine if the dissolved oxygen criterion in the state water quality standards is met during worst-case (summer low-flow) conditions. Monitoring usually includes stations located upstream, within the impoundment, in the bypass reach and below the tailrace.

At existing dams that are the likely sites for small hydro development, water flows over the dam spillway, is released through a gate opening, leaks through the dam, or a combination of all three. Where a significant amount of water flows over the spillway, aeration is likely to result in D.O. levels that are at or near saturation, even if there are low D.O. levels upstream in the impoundment. However, if water is diverted through a penstock and turbine, there is less aeration taking place, raising the possibility that a dissolved oxygen deficit could be created downstream from the tailrace. This situation is unlikely to occur in the small watersheds that are the typical locations of small hydroelectric projects. Further, D.O. problems tend to occur during low-flow periods, when the project is unlikely to be operating and all water would be spilled anyway.

For projects where D.O. is a concern, a carefully planned and executed sampling effort during the permitting process should be able to identify any dissolved oxygen problems that could result from installation of a hydropower facility. The scope of the sampling necessary is developed collaboratively by the applicant and resource agencies, with the objective of collecting the data that is needed, but not gathering more data than necessary. Like most issues related to evaluation of hydroelectric project proposals, the details are determined by site-specific factors, including the existing conditions in the river or stream and the proposed design and operation of the project.

Requirements to monitor dissolved oxygen once the project is operating would be unusual unless there were unresolved questions about the effect of the project on D.O. concentrations, an unlikely scenario at a small project. A typical requirement might be to monitor annually for a period of three years. If D.O. standards are met, the monitoring would be suspended. If not, it would be necessary to devise a change in the design or operation of the project to ensure that standards are consistently met.

Fish and Flow Studies

From H.520: *Address the need for new fish or flow studies for small hydroelectric projects.*

As previously discussed, the developer of a hydroelectric project may opt to conduct a study to determine a site-specific flow for habitat protection rather than use the established regional standards. (For run-of-river projects, this issue applies only to the bypass.) If the site-specific approach is chosen, the data from the study is essential for an informed, scientifically valid decision.

The decision to conduct studies is the developer's, but there are economic trade-offs. The study results may show that a flow lower than the state hydrologic default standard will provide adequate habitat protection, allowing more water to be diverted through the turbine and generating additional electricity. On the other hand, the study increases the cost of developing the project.

Another study-related concern that has been raised is that the results of prior studies may not be accepted by the Agency and the work will have to be repeated. If good data exists that can be used to address flow needs and aquatic habitat protection, the Agency will use it. We see no reason to repeat work that has been done and accepted in the past. That said, past studies will have to be evaluated by the Agency on a case-by-case basis to determine if they provide the necessary information to develop a flow prescription. Because the necessary information is very site-specific, the data would have to have been collected on the reach in question. Unless there had been an earlier proposal for a hydroelectric facility at the same location, such data does not exist.

More generally, the Agency will consider any existing data that may inform the development of a water quality certification for a hydroelectric project. Indeed, one of the first steps in the FERC process is for the applicant to contact resource agencies and compile existing data relevant to the proposed project. If existing data adequately addresses the issue at hand, additional study will be unnecessary.

Use of Flashboards

From H.520: *Address the use of flashboards to increase upstream flooding.*

Flashboards are wooden, steel or, in some cases, inflatable rubber structures attached to the spillway crest of a dam to raise the level of the impoundment and provide additional head or, at peaking projects, both head and storage. Flashboards are normally designed to fail or, in the case of a rubber bladder, be deflated, during high flows to lower the spillway crest and reduce the amount of upstream flooding. Flashboards can increase upstream and downstream flood risk. Wooden flashboards that fail add to downstream floating debris during a flood. If they only partially fail, the capacity of the dam spillway to pass flood flows is reduced. Sudden failure can cause a sudden release of additional flow downstream.

Flashboard failure or manipulation (e.g., replacement) does result in changes in impoundment elevation. These changes can have negative effects on upstream habitats including wetlands, upland habitats immediately adjacent to the impoundment, and shallow-water habitats that are dewatered. Further, flashboard replacement requires downstream flows to be manipulated, a deviation from run-of-river operations, by lowering the impoundment water level to gain spillway access and subsequently to refill the impoundment.

Entrainment/Impingement Mitigation

From H.520: *Address measures to prevent fish from entering turbines and penstocks.*

This problem is easily solved by having intake screens or racks that prevent entrainment (fish being sucked into the intake). A rack with 1-inch spacing between the bars is a standard design. Another issue that must be addressed is impingement, or fish getting trapped against the bars of the rack. This problem is addressed by designing the intake so that the velocity of the water in front of the rack is low enough so fish can swim away. The approach velocity is a value that can be calculated based on the station's hydraulic capacity and the trashrack area to determine if it is below the threshold for the fish species found in the stream in question. Typically, measures to prevent impingement and entrainment are required in the state water quality certification.

Diversion/Penstock Size

From H.520: *Address the size of authorized diversions and penstocks.*

Bill H.70 (2007 session) provided more detail on this specific concern. That legislation, as introduced, included language that limited diversions to one-half of the stream's bankfull width, and penstock diameters to 10 percent of the bankfull width.

The design of diversions is highly site-specific. Any structure that is built in a stream must be evaluated individually to determine its effect on aquatic organism movement, sediment transport and other factors. The final design should be developed in consultation with Agency technical staff to ensure that it addresses these considerations.

Likewise, the sizing of the penstock will be determined by site-specific factors that are considered during the design of the project. In general, the size of the penstock is determined by the capacity of the turbine, and is sized so the energy loss due to friction as the water moves through the pipe is within acceptable limits. From a natural resource protection standpoint, the important thing is that the flow through the turbine can be controlled to ensure that adequate bypass flows are maintained and true run-of-river operation is achieved.

CONCLUSIONS AND RECOMMENDATIONS

In terms of policy, the Agency of Natural Resources supports hydroelectric projects that are environmentally and economically sound. Producing electricity through the responsible use of Vermont's renewable natural resources will help support Vermonters' long-term energy needs while protecting the health of Vermont's waters.

Conclusions - Based on research and discussions within the Agency and with the Public Service Board, Department of Public Service, and other parties, the Agency has developed the following conclusions. Implementing these conclusions will help to achieve the policy direction above.

1. **Additional hydroelectric capacity:** There are opportunities to develop additional in-state hydroelectric capacity at existing but undeveloped dams. The total capacity is likely to be on the order of 25 MW, assuming new development is restricted to existing dams, but additional study is needed to develop an accurate estimate.

2. **Information for prospective hydroelectric developers:** A comprehensive guide to small hydropower development is needed. The target audience would be the developers of prospective projects, with the focus on those projects that do not exceed 100 kW of installed capacity. The guide would provide information to help prospective developers understand the economic and environmental issues associated with small hydropower projects, the regulatory system, and how to make a very preliminary assessment of whether a given site is economically viable. It could be a print publication, website or both.

3. **Low-impact standard:** Agency policy should specify that any new hydroelectric power facilities meet a "low-impact" standard based on the criteria developed by the Low Impact Hydropower Institute. This standard includes utilizing existing intact dams, so no new dams will be built for the purpose of hydroelectric power production. Preference should be given to dams that currently serve another purpose.

4. **Permitting process:** The existing permitting process, with FERC maintaining jurisdiction over hydroelectric projects, should be retained. Both state agencies and FERC are addressing concerns about timeliness and cost for permitting small projects. Federal and state agencies are working to scale the process so that it works better for smaller projects while at the same time providing a level of protection consistent with the importance of these public resources. Shifting the responsibility to the state would place a significant additional burden on the state's resources with little likelihood that the process would change sufficiently to justify the change.

5. **Prefeasibility assessments:** Subject to availability of resources, the Agency should continue its practice of conducting prefeasibility assessments for all public and private projects and resource assessments (i.e., electrofishing) for municipal/public projects. The prefeasibility assessments have been well received and they give potential developers a sense of a project's environmental feasibility early in the process. We will continue to refine this process based on feedback from project proponents.

6. **Definition of small hydro:** A new definition of "small hydro" is not needed. There are existing definitions (mini-hydro, micro-hydro and pico-hydro) that can be used, where necessary, in statute and rule.

7. **Increased production at existing facilities:** The Department of Public Service should work with Vermont utilities to investigate additional opportunities for increasing hydropower production at existing operating sites. Several of the assessments of undeveloped hydropower capacity note that there is untapped potential at existing hydroelectric facilities. This potential could be realized with more efficient turbines, small turbines at the dams that utilize bypass flows,[18] and turbines that can operate efficiently over a wider range of flows. In many cases, an increase in production should be possible without changing the current operating requirements, essentially increasing energy production without additional environmental impacts. Further study is needed to determine the feasibility of this option. Vermont's utilities indicate that they have made some initial progress toward improving the operation of existing facilities in recent years. There are, however, indications that further cost-effective improvements are available and deserve further study.

8. **Agency flow procedure:** The Agency should retain its existing flow procedure for establishing conservation flows at hydroelectric projects. The flow procedure defines an approach that is commonly used in the Northeast and provides a scientifically valid basis for setting flow requirements. Since the flow procedure is consistent with the USFWS *New England Flow Policy*, conflicting flow recommendations between state and federal agencies are avoided. It has also been recognized as a generally accepted scientific practice compliant with FERC rules and the Vermont water quality standards.

9. **Dam Removal:** The Agency should commit additional resources to removal of dams that are not serving useful purposes and are unlikely candidates for hydropower development. Restoring stream and river connectivity and eliminating existing water quality and habitat impacts will help balance the cumulative impact of new hydroelectric development.

Recommendations – The Agency offers the following recommendations to the legislature to allow full implementation of the above conclusions.

1. **Funding for updated study of potential hydropower sites:** Conclusion 1 points out that a better estimate of the developable hydroelectric capacity in Vermont is needed. The legislature should consider funding for the Agency, Department of Public Service and Public Service Board to collaborate on an update of the 1980 New England River Basins Commission study to identify the most viable sites for small hydropower development at existing dams. This update is essential for identifying the best opportunities statewide, both ecologically and economically, for new hydropower development.

2. **Funding for a hydropower development publication:** Conclusion 2 identifies the need for better guidance for towns and individuals who are interested in developing small hydropower projects. The legislature should consider funding for the development of such a guide by the Agency, Department of Public Service and Public Service Board.

[18] A limitation on this is whether flows need to be spilled at the dam to support aesthetics or to maintain D.O. standards.

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Appendix A

Excerpts from H.520
An act relating to the Vermont energy efficiency and affordability act

AN ACT RELATING TO THE VERMONT ENERGY EFFICIENCY AND AFFORDABILITY ACT

Small Hydro Reports

Sec. 23. PUBLIC SERVICE BOARD REPORT ON PERMITTING SMALL HYDROELECTRIC PROJECTS

Prior to December 15, 2007, the public service board shall report to the house committee on fish, wildlife and water resources and the senate committee on natural resources and energy with a recommendation for a simple, predictable, and environmentally sound process, other than the process set forth in subsection 248(j) of Title 30, for issuing a certificate of public good under section 248 of Title 30 for small hydroelectric projects that are not eligible for a net metering permit under public service board rule 5.100. The report shall:

(1) Recommend criteria for determining what constitutes a small hydroelectric facility, including the allowable maximum amount of output capacity at the facility and the type of eligible facilities, natural features, or other sites.

(2) Address permit application requirements, including ownership of the facility, interconnection, and structural safety of the small hydroelectric project.

(3) Address additional uses of the small hydroelectric project such as flood control; fish and wildlife habitat; recreation; water supply; historic resource; and structural grade control for infrastructure, roads, bridges, and houses.

Sec. 24. AGENCY OF NATURAL RESOURCES REPORT ON WATER QUALITY CERTIFICATION FOR SMALL HYDROELECTRIC PROJECTS

Prior to December 15, 2007, the secretary of natural resources shall report to the house committee on fish, wildlife and water resources and the senate committee on natural resources and energy with a recommendation for a simple, predictable, and environmentally sound procedure for completing a water quality certification review, as required by Section 401 of the federal Clean Water Act, of small hydroelectric projects that are not subject to net metering. The report shall:

(1) Recommend, after consultation with the public service board, criteria for determining what constitutes a small hydroelectric facility, including the allowable maximum amount of output capacity at the facility and the type of eligible facilities, natural features, or other sites;

(2) Address bypass flows for small hydroelectric projects.

(3) Address the need for monitoring of dissolved oxygen at small hydroelectric facilities.

(4) Address seasonal flows in bypasses at run-of-river facilities.

(5) Address the need for new fish or flow studies for small hydroelectric projects.

(6) Address the use of flashboards to increase upstream flooding.

(7) Address measures to prevent fish from entering turbines and penstocks.

(8) Address the size of authorized diversions and penstocks.

(9) Include an analysis of the existing permitting process for small hydro projects.

Sec. 25. PILOT PROJECTS FOR SMALL HYDROELECTRIC GENERATORS

In order to promote the timely development of environmentally sound small community hydro projects, and to help inform efforts to develop new permitting processes, the public service department and the agency of natural resources shall work with communities that are seeking to develop small hydro projects, to facilitate those projects through the existing permit processes. These projects shall not have more than 2 MW of name-plate capacity, shall have the support and involvement of the communities in which they are located, and shall not include the construction of a new dam.

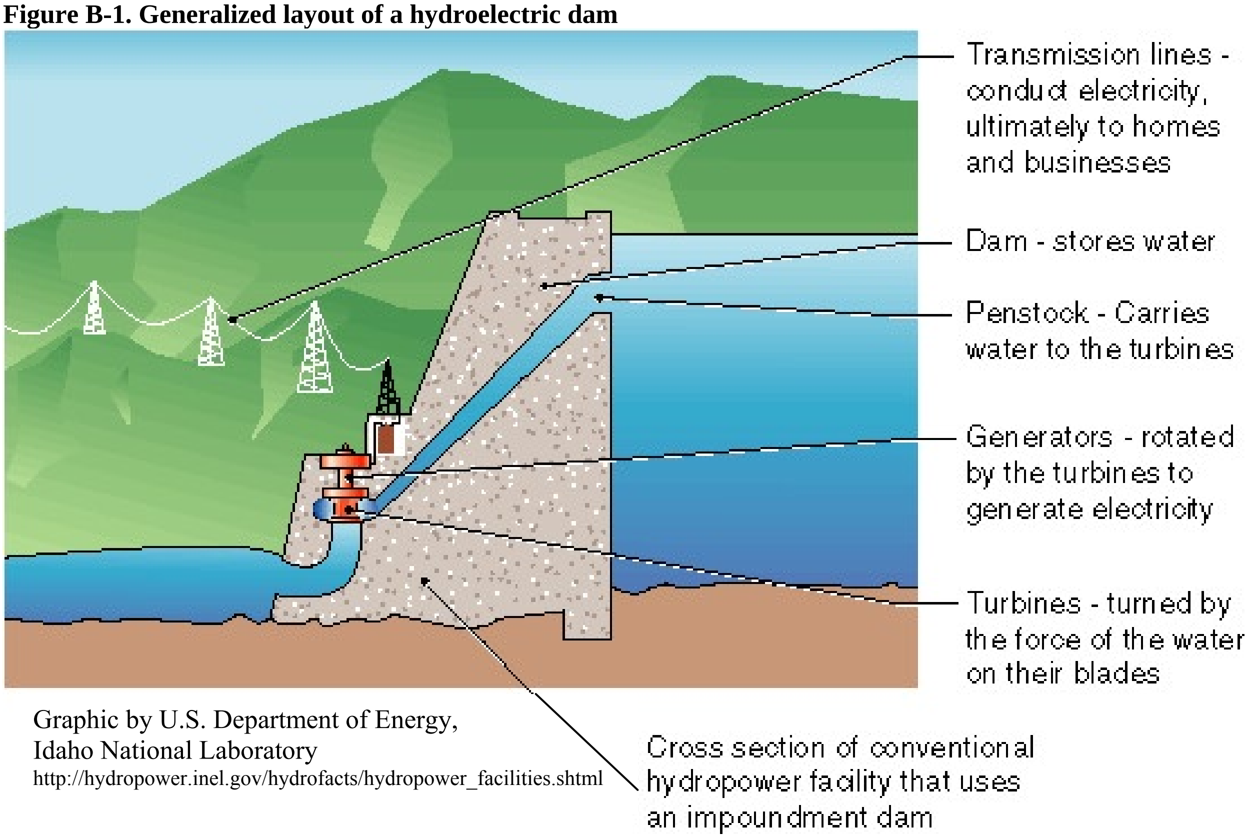
Appendix B

Hydroelectric Facility Design Principles

Fundamentals

Typically, hydroelectric projects consist of a dam, structures to divert water (headworks and penstock) and a powerhouse housing one or more turbines and generators (Figure B-1).

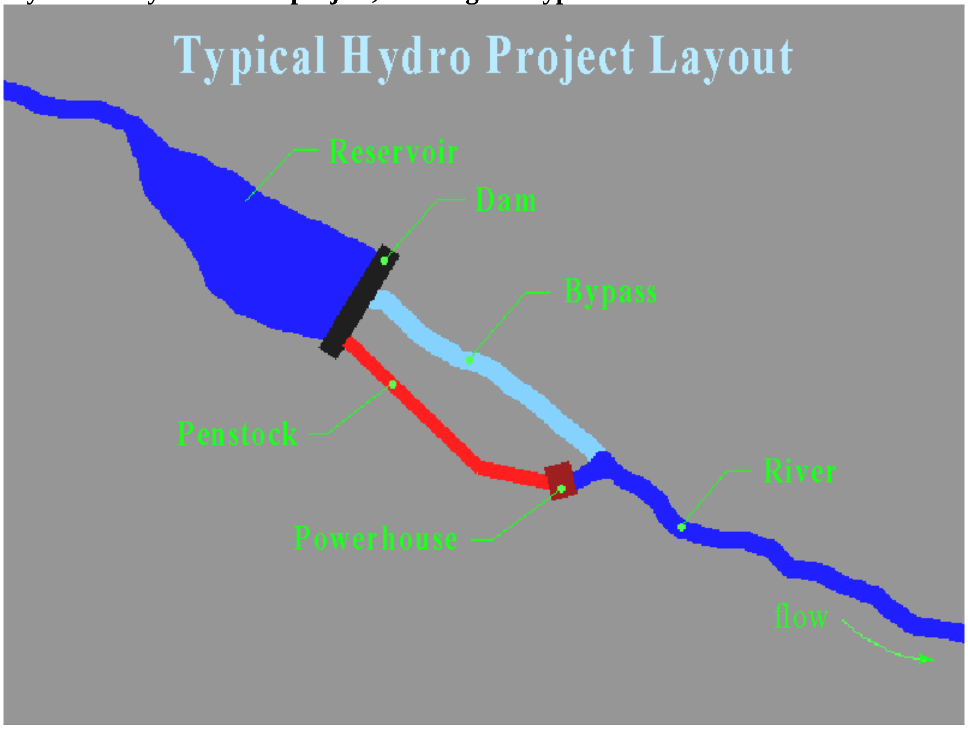
Figure B-1. Generalized layout of a hydroelectric dam



Graphic by U.S. Department of Energy,
Idaho National Laboratory
http://hydropower.inel.gov/hydrofacts/hydropower_facilities.shtml

The dam impounds water, allowing water to be diverted to produce electricity, and in some cases, providing for storage of water flowing into the impoundment to be used at another time for power generation (store-and-release operation, or hydropeaking). The headworks is comprised of a screened intake that allows water to enter while trapping debris and perhaps a headgate or other structure that can be used to shut off the flow of water to the powerhouse when necessary for maintenance or repair activities. The penstock is essentially a pipe that delivers water to the turbine. Turbines can be of several different types but all use the power in the moving water to spin a generator that produces electricity. Water is discharged from the turbine to the tailrace and returned to the river channel. In some cases, the powerhouse and tailrace are immediately adjacent to the dam, as in Figure B-1. In others, a long penstock carries water some distance downhill, increasing the amount of power available (Figure B-2). The "bypass," or stretch of river between the dam and the tailrace, has a lower flow than the rest of the river because a portion of the water is diverted through the penstock.

Figure B-2. Layout of a hydroelectric project, showing the bypass



The Power Equation

The amount of energy that can be produced at a site is directly proportional to the amount of water (flow) and the difference in elevation between the impoundment surface and the turbine (head). A simple calculation using the "power equation" allows one to estimate the amount of energy that can be produced at an assumed design flow:

$$P = \frac{Q \times h \times e}{11.8}$$

Where:

P = power (energy) in kilowatts

Q = design flow in cubic feet per second (cfs)

h = net head (gross head minus energy losses due to friction of water in the intake, penstock and turbine. Typically, net head is about 90 percent of the gross head.)

e = combined efficiency of the turbine and generating equipment. A reasonable efficiency is on the order of 85 percent at the design flow.

11.8 = a constant derived from the density of water (62.4 lbs/cubic foot)

For example, a site utilizing a flow of 250 cfs with a net head of 20 feet would yield:

$$P = 250 \times 20 \times 0.85 \div 11.8$$

$$= 360 \text{ kW}$$

Sizing the Turbine

The relationship of flow, head and power has several important implications to small hydropower projects. Although small hydropower projects often can develop higher heads because they are in steeper watersheds, they normally have less water available than hydrostations on rivers. The small watersheds where small hydroelectric projects are typically located tend to be more “flashy” or exhibit more variable flows in response to storm events than larger watersheds. This phenomenon is due to the fact that flow in a large river integrates the runoff characteristics of a large area while a small watershed is subject to local influences only. A heavy local storm or a large percentage of impervious area (buildings, roads, parking lots), or both, will cause flows in a small stream to rise very rapidly. Likewise, an extended dry period will cause flows to drop to base flows that are sustained only by groundwater. Often these flows are too low to support generation or only generation at a very low efficiency. This variability must be factored into the design of the hydroelectric facility. The size of the turbine must be appropriate so it can operate with reasonable efficiency over a range of flows likely to be experienced at the site. That analysis requires more detailed information than will be provided by the simple power equation calculation provided above, and typically is conducted by an experienced engineer.

Unconventional Systems

In addition to conventional hydro, those with dams, there are at least two other approaches to producing electricity with moving water. The first is the conduit installation. In this case, the turbine is attached to an existing conduit that carries water or wastewater, capturing the energy of the moving water. Examples of conduit installations include municipal water supply feeds and the outlets of wastewater treatment plants. Conduit installations have the advantage of not creating a new withdrawal or diversion and, in some cases at least, avoiding construction in or adjacent to rivers and streams. Their environmental impact can be minimal. Barre City and the Town of Bennington are presently investigating conduit projects.

A second approach is damless hydro. In these installations, a natural feature is used instead of a dam to effect the diversion of water from the stream to the intake. While protection of streamflow remains an issue that must be considered, this approach avoids the creation of a stream barrier and the flooding of upstream habitat. The viability of damless diversions appears to be limited to relatively small installations and sites with the appropriate stream morphology.

Appendix C

Why Rivers Need Water

Vermont has made great strides cleaning up the pollution of its streams and rivers since the Clean Water Act was passed 30 years ago. While our waters are now relatively clean, the need for stream flow, or the quantity of flowing water, has received much less attention. It deserves more. It seems elementary, but rivers need water to exist. River fish need not only clean water, but the right quantity and natural variation in river flow.

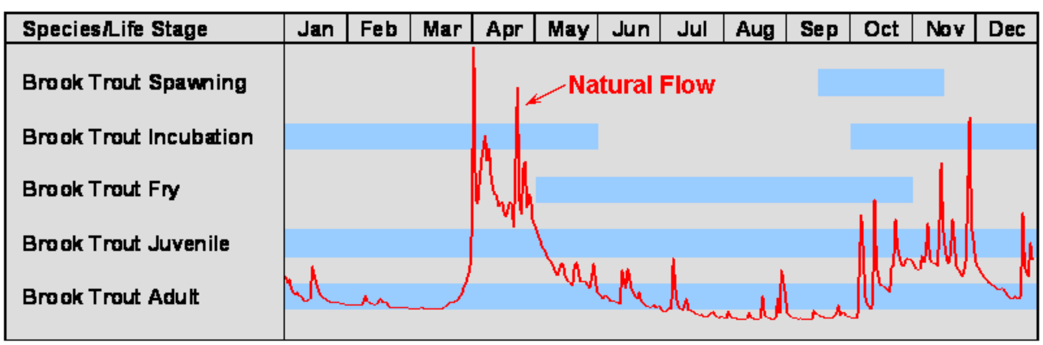
Why is Flow Important to Aquatic Life?

Picture yourself for a moment as a fish, living within the confines of a stream. You are surrounded by water flowing over rocks, gravels and sands. Do you think you would pay much attention to things like water temperature, depth, velocity, and available space? Of course the answer is "yes." And the amount of stream flow has a dominant influence on these features of the aquatic habitat. Consequently stream flow also has a great deal of influence on fish populations, growth and reproduction. The amount and timing of stream flows that fish and other aquatic life require is called the *Instream Flow Need* (IFN).

> ***Instream Flow Needs** (IFNs) are the amount and timing of water necessary to support aquatic ecosystems.*

IFNs are different for different species of fish, and even for different stages of a fish's life. Flow needs change seasonally. For example, newly hatched brook trout fry need quiet, shallow water areas during the summer, whereas adults prefer pools and undercut banks. During the fall, those adults migrate to spawn in areas with ground water upwelling through a gravel stream bottom. Longnose dace, an important forage species often found in Vermont streams, seek out fast-flowing, riffle areas with a rocky bottom substrate. In each instance, the quantity of flow is important to providing the necessary habitat.

To Every Thing there is a Season



The Willoughby River supports a well-known run of rainbow trout that migrate upstream from Lake Memphremagog each spring to spawn. Almost as popular as the fishing is watching these fish as they jump while ascending the falls in Orleans. These fish need the right amount of water to be able to ascend the falls, and they need it at the right time of year.

Stream flow affects depth and velocity directly and many other factors indirectly. For example, flow affects a stream's temperature regime; low summer flow conditions can lead to stressfully high temperatures for trout. Streambank cover will not be available to fish if flows are too low to provide suitable conditions near the edge of the bank. Low flows make fish more vulnerable to predation. There is substantial evidence in the scientific literature that periods of low stream flows have a dominant influence on the number of fish a stream can support.

And there's more. IFNs are not just about the fish, they're about the river itself. River flows, in combination with the size and quantity of available sediments, shape the channel, determine its path, and what vegetation grows along its shores. The slope, depth, and velocity of flow determine the distribution of energy a stream has to move, sort, and distribute the sediment and woody debris that enter along the course of the stream. Flow and sediment regimes define and redefine a river; fish and other aquatic life live in the resulting physical habitat. Fortunately, small hydro projects that do not appreciably affect sediment continuity do not have much effect on the high flows so important to maintaining these processes.

How are Instream Flow Needs (IFNs) Determined?

How much flow is enough? This is the million dollar question. Unfortunately, the issue of IFNs is not as simple as rocket science. And since flows released into the bypass for aquatic life cannot be used to generate electricity, there is considerable controversy over how much is enough.

Flow is About….

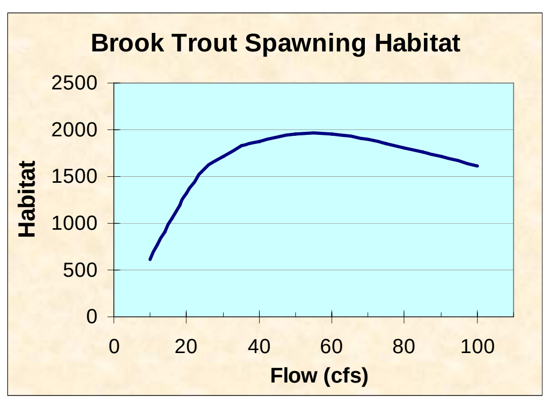
➢ **Magnitude**	***How much?***
➢ **Frequency**	***How often?***
➢ **Duration**	***How long?***
➢ **Timing**	***When?***
➢ **Rate of change**	***How fast?***

Early efforts to protect instream flow focused on a minimum low flow. Today the term "minimum flow" is now seldom used due to recognition that a flat-line flow will result in habitat degradation. There is an understanding that fish and other aquatic life require flow and sediment regimes that mirrors natural patterns, including seasonal and year-to-year variability. For example, high flows can be important to channel maintenance and sediment distribution downstream. Salmon are behaviorally influenced to move upstream for spawning by flow increases in the fall. Intermediate flows provide optimal conditions for fish survival and growth (more on that later). Rapid flow fluctuations can strand fish and aquatic insects, change the species composition, and cause other changes. Scientists describe a flow regime in terms of magnitude, frequency, duration, timing and rate of change. All these elements are important.

The focus of this report is on small hydroelectric projects that operate as run-of-the-river (i.e., river flow is not stored, but used instantaneously). The over-riding flow issue is the bypass flow and the IFNs for aquatic life. ANR generally prescribes a "conservation flow" which is similar to a typical summer flow. Where necessary seasonally to provide for spawning and egg incubation, higher flows are also prescribed.

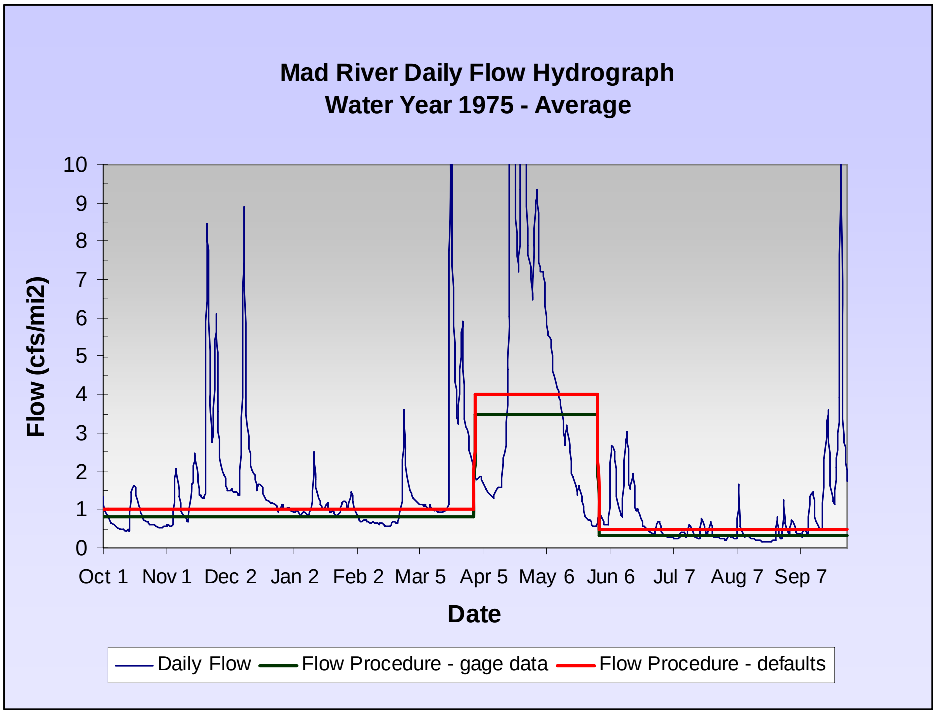
The Agency Procedure for Determining Acceptable Minimum Stream Flows describes how ANR will determine instream flow needs for aquatic life. This can be done using site-specific habitat studies or hydrologic standards. Each has advantages and disadvantages.

Site-Specific Studies: Site-specific habitat studies provide information on how much habitat is available at different flows. The Instream Flow Incremental Methodology (IFIM), developed in the early 1980s, combined hydraulic modeling with information about habitat requirements of fish to define the relationship between habitat and flow, as shown in the example graph. These results are then used to develop a conservation flow prescription, which could be higher or lower than the default hydrologic standards. Site-specific habitat studies are the most scientifically sound way to determine IFNs. The downside is that these studies are expensive – about



$25,000 - $35,000. This method is problematic to apply in streams that are steep and bouldery.

Hydrologic Flow Standards: Hydrologic standards serve as surrogates for aquatic habitat. Flow statistics from historical stream flow gage data are used to develop numerical standards related to the natural, seasonal flow regime. Vermont, the U.S. Fish and Wildlife Service and some other states use the “Aquatic Base Flow” (ABF) method, which recommends the August median flow and, where appropriate, special seasonal releases to protect fish spawning and incubation. During the spring and fall/winter periods, those respective recommendations are the April/May median flow and the February median flow. For rivers lacking adequate gage data, “default” regional average values are used. This graph shows the flow in the Mad River for an average (neither dry nor wet) water year. The green line shows the three seasonal flows described in the Agency Flow Procedure and New England Flow Policy, based on Mad River gage data. The red line shows the three seasonal flows based on the default values that are applied where adequate gage data are lacking.



The ABF method is based on the following assumptions. Aquatic life in New England streams evolved and adapted to the natural flow regime and emulating that regime should provide an adequate level of protection. Low flow conditions during August represent a natural limiting period due to reduced living space, high water temperature and low dissolved oxygen. Because stream organisms have evolved to survive these periodic flow conditions without major, long-term population changes, a base flow equal to the August median flow should perpetuate them. Historical median flows during the spawning and incubation periods will protect reproduction. Note that these are not optimal flows; they are compromises intended to allow for electrical generation without an undue negative impact on aquatic life.

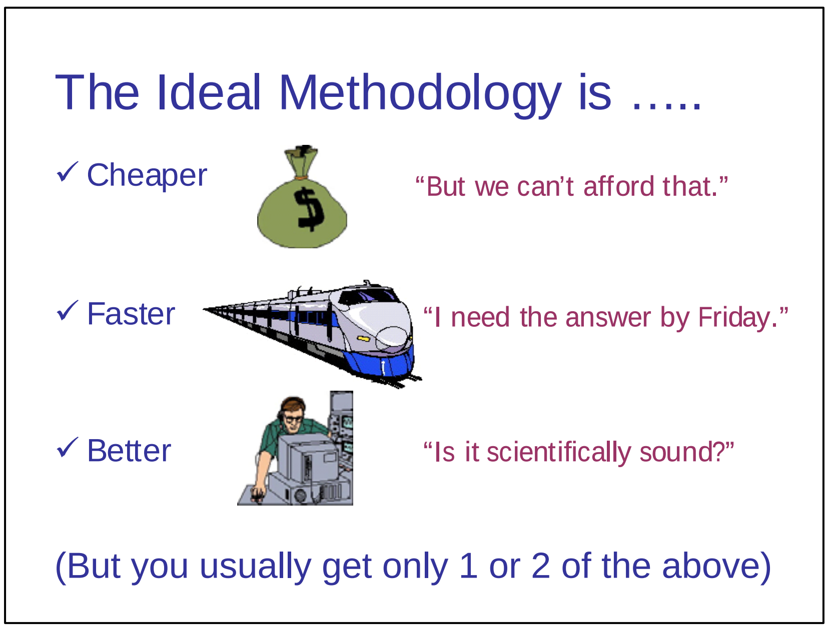
Hydrologic standards fill a need faced by small projects – the IFN is determined quickly and inexpensively. However, the flow recommendation is determined in the absence of any study information. The level of uncertainty is higher where there is no site-specific information, and a more conservative (resource protective) flow prescription must be applied where there is less information. This is a downside from the perspective of the hydro developer because the resulting conservation flows may be higher than those determined by site-specific studies. The downside for aquatic resource protection is that IFNs based on hydrologic standards are approximate. Streams vary in their channel shape and the amount of flow necessary to provide high quality habitat. The use of hydrologic standards results in better habitat conditions at some streams and poorer conditions in others.

Over the years, water users have proposed a myriad of alternative hydrologic standards or different ways to calculate the standards, all of which result in lower instream conservation flows. It is important to keep in mind that hydrologic statistics are only surrogates for habitat conditions, and will be approximate in nature no matter how precisely they measure the hydrology. Available evidence from past site-specific studies suggests that the current ABF default standards are "in the ballpark." Applying lower default values would increase the risk of under-protecting aquatic resources.

Water users sometimes criticize the default flows as overly conservative. Some argue that the stream where their project is located has site-specific characteristics that justify conservation flows lower than the defaults. The problem is that habitat/flow studies to determine site-specific IFNs can be expensive. ANR has been working to find or develop a scientifically valid but inexpensive site-specific field method that could be used at small hydro projects. However, we have been unable to find a method that is both cheap and scientifically sound.

What are the Instream Flow Issues with Small Hydro?

As stated previously, this report focuses on small hydroelectric projects that operate as run-of-the-river. Flow issues can be categorized into three areas: 1) bypass flows for aquatic habitat, 2) flows associated with fish movement, and 3) flow alterations due to operational malfunctions. Each is discussed below.



When the Water Goes To the Powerhouse and Not To the Stream: Hydropower projects run on water, and the water that is sent to the powerhouse is not available to the section of stream between the point of removal and the point at which the powerhouse flow re-joins the stream. We call this section the "bypass" because it is bypassed by the water used for generation. When natural flows are high, a small run-of-river hydro project typically has little effect as there is a substantial amount of excess flow spilled over the dam. However, when natural flow levels are medium to low, the project can remove a significant percentage, if not all, of the flow. To protect instream habitat and other stream values, the hydro project cannot remove a quantity of water that will cause the amount of flow in the bypass to drop below conservation flows prescribed by ANR and the U.S. Fish and Wildlife Service.

Planes, Trains and….When you're a Fish, You Have to Swim: A number of fish species including trout will migrate considerable distances within streams to find the habitat they require. These movements depend on the correct flow conditions. Fish moving downstream have less difficulty with some extra water to help move them along and provide cushioning over rocky areas. Fish that swim upstream to spawn don't want flood levels, but often a very steep section of stream that is impassable at low flows can be ascended at higher levels. Hydro projects whose dams block fish passage may be required to construct and operate fish passage facilities. One example is a fish ladder, which allows fish to move upstream past a dam. Fish moving downstream need a corresponding device so that they don't have to travel through potentially deadly turbines. Fish passage facilities require flow to operate.

It Happens: Hydros are complicated mechanical/electrical projects. They break down, and sometimes these malfunctions drastically reduce stream flows, killing fish and other aquatic life. Unfortunately, recovery can take a long time. This type of hydro impact is "below the radar" in the sense that people presume conservation flow requirements in permits will always protect aquatic life.

Conclusion

Healthy rivers are a part of Vermont's identity. Vermonters use and enjoy rivers, whether for fishing, boating, swimming or simply a peaceful, shoreline walk. Our rivers and streams are an important element of Vermont's tourism attraction. Fishing alone brings in $65 million to Vermont's economy each year.[1] Vermont has invested many millions of dollars cleaning up pollution in our streams and rivers. That progress will be lost if we do not make sure enough water remains in our rivers to maintain healthy aquatic life. State government has a public trust responsibility to conserve fish and wildlife resources for the use and enjoyment of present and future generations. River health means not only clean water, but enough of it as well.

[1] U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2006 National Survey of Fishing, Hunting and Wildlife—Associated Recreation.

Appendix D

Vermont's Undeveloped Hydroelectric Power Potential

New England River Basins Commission Study

This study (New England River Basins Commission 1980), was one of the earliest attempts to estimate the region's hydroelectric power potential. Conducted in the late 1970s, it identified 999 dam sites in Vermont (including 65 hydroelectric dams and 69 dams that were partially or fully breached) using available data and a survey of town clerks. Information on these sites was analyzed to determine potential generating capacity, and 171 dam sites that merited economic analysis[1] were identified. Existing hydroelectric dams were excluded from assessment even if unutilized capacity existed, and 418 sites were not studied due to insufficient information.[2] Prior to conducting the analysis, site visits were conducted at each of the 171 dams. Based on these visits, 19 sites were judged, for a variety of reasons, not to merit further consideration. The study identified 134 MW of peaking capacity at the 152 remaining sites or 59 MW of baseload capacity at a subset of sites that were deemed viable for baseload generation (115 dams out of the 152). These estimates are without consideration of environmental constraints or economics. The baseload capacity was distributed among three dam categories as follows:

Existing intact dams (60)	28.7 MW (172,422 MWh)
Breached dams and former dam sites (47)	13.8 MW (82,653 MWh)
Corps of Engineers constructed dams (8)	16.3 MW (97,941 MWh)

The Agency reviewed the baseload analysis and determined that 24.6 MW of this estimated capacity, or 42 percent, was subsequently developed.[3] This includes several large-scale projects that were estimated at 1 MW or greater capacity: the flood control reservoirs at North Hartland and Wrightsville, the Winooski One Project in Winooski, Bolton Falls on the Winooski River, East Barnet on the Passumpsic River, Deweys Mills on the Ottauquechee River, and Dodge Falls (East Ryegate) on the Connecticut River. Updated to reflect current baseload availability assuming the NERBC parameters, the above tabulation would be:

Existing intact dams (38)	13.1 MW (76,997 MWh)
Breached dams and former dam sites (41)	9.2 MW (55,148 MWh)
Corps of Engineers constructed dams (6)	11.9 MW (71,328 MWh)

U.S. Department of Energy – 1998 Hydropower Resource Assessment

A more recent study by the U.S. Department of Energy identified 149 potential sites with a total capacity of 421 MW (Conner et al. 1998). This study used data from multiple sources, principally FERC's 1988 Hydroelectric Power Resources Assessment. The DOE study classified sites as 1) developed hydropower site generating power but with additional potential; 2) developed site (i.e., impoundment or diversion structure) lacking developed generating capability; and 3) undeveloped site without any impoundment or diversion. The study applied a computer model to determine a "project environmental suitability factor" based on site-specific environmental attributes. Applying the suitability factor reduced the statewide potential to 174 MW. Of that, 32 MW is at hydropower sites that are currently generating electricity,[4] 130 MW at developed sites that are not currently generating,[5] and 12 MW at undeveloped sites.

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[1] The filter used was dams with a generating capacity of at least 50 kW (assumed plant factor of 40 percent for peaking and 70 percent for baseload) and a head of at least 5 feet.
[2] A cursory review of dam sites in this category suggests that they were mostly private ponds with little or no hydroelectric potential.
[3] Barg (2007) has an estimate of 18 MW subsequently developed at 16 sites. The Agency identified 30 sites subsequently developed and still operating.
[4] As indicated previously, there is currently 138 MW of developed in-state capacity.
[5] Of the 130 MW at developed sites, 72.5 MW is attributed to a single site, Williamsville on the West River. There is no developed site on the West River downstream of Townshend Dam, nor is there a dam at the geographic position specified. The most likely explanation is that the report is referring to the former hydroelectric project at

U.S. Department of Energy – 2006 Water Energy Resources Feasibility Assessment

In 2000, the Department of Energy initiated another project to define potential hydropower capacity based on gross power potential of natural streams and not on a review of individual sites (Hall et al. 2006). This study employed digital elevation data and a geographic information system (GIS) analysis to model the hydraulic head and streamflow of every stream reach in a region. GIS tools were used to exclude developed hydropower sites or sites that fall within protected areas where hydropower development is unlikely. Finally, feasibility and development criteria were applied to determine the capacity of "feasible projects." Sites were included if they would produce average generation of 10 kW or greater. Feasible potential projects were classified as either small hydro (1-30 MWa[6]) or low power (<1 MWa). The assumed development model for Vermont streams was to run penstocks up to 2,000 feet in length along streams to develop at least 10 kW at a working flow rate equivalent to half of the stream's estimated mean annual flow. In Vermont's case, the total feasible hydropower potential was estimated at 217 MWa. The feasible capacity is broken down in Table D-1. To achieve DOE's estimated potential, there would be a project density of about one hydroelectric project for every 7.3 square miles of land in the state.

Table D-1. Vermont Hydroelectric Potential

Study/Source	Number of Sites	Capacity	
New England River Basins Commission (1980)	115	**Total baseload capacity:**	**59 MW**
		Developed since 1980:[7]	18 MW
		Undeveloped sites:	41 MW
U.S. Department of Energy (1998)	149	**Total capacity:**	**174 MW**
		Developed hydropower sites:	32 MW
		Dam/diversions w/o generating facilities:	130 MW
		Undeveloped sites:	12 MW
U.S. Department of Energy (2006)	1,201	**Total capacity:**	**217 MWa**
		Large hydro (> 30 MWa):	0 MWa
		Small hydro (≥ 1 MWa & ≤ 30 MWa):	112 MWa
		Low power (< 1 MWa):	
		Conventional turbines:	65 MWa
		Unconventional systems:[8]	6 MWa
		Microhydro (< 100 kWa):	34 MWa
Barg (2007)	333	**Total capacity:**	**93 MW**
	89	Potential site capacity ≥ 50 kW:	91 MW
	244	Potential site capacity < 50 kW:	2 MW
Governor's Commission on Climate Change (2007)	16	**Total capacity:**	**68 MW**
		Developed hydropower sites:	18 MW
		Undeveloped sites	
		Capacity ≤ 0.5 MW:	12 MW
		Capacity > 0.5 MW:	38 MW

West Dummerston, which had a capacity in the 1.4 MW range. In any case, it appears that a significant portion of the reported undeveloped capacity may not actually exist.

[6] MWa refers to "mean annual power" in megawatts. It is the statistical mean of the rate at which energy is produced over the course of one year. Because it is based on actual flow data, it is a more accurate measure of hydroelectric capacity than the "nameplate capacity" used by other studies. Typically, nameplate capacity is double the mean annual power due to the 50 percent capacity factor typically used for hydroelectric plants. Multiplied by the number of hours in a year, the result is an estimate of the megawatt-hours of potential average annual production.

[7] As reported by Barg (2007).

[8] Refers to, among others, ultra-low head systems and kinetic energy turbines.

Appendix E

State and Federal Regulation of Hydropower

Federal Regulation

Pursuant to the Federal Power Act, the Federal Energy Regulatory Commission has jurisdiction over all non-federal hydroelectric projects that a) are located on navigable waters of the United States; or b) are located on a non-navigable stream, were constructed after August 26, 1935 and affect the interests of interstate or foreign commerce (including providing power to an interstate electric grid). In practice, any non-federal hydroelectric project located on navigable waters or their tributaries that has been built or substantially modified since 1935 and is connected to the electric grid is under FERC jurisdiction. State laws are pre-empted by the Federal Power Act.

As a result of amendments to the Federal Power Act passed in 1986, FERC must give equal consideration to both developmental (power generation, irrigation, flood control and water supply) and environmental values. The latter category includes fish and wildlife, visual and cultural resources and recreational opportunities.

Under Section 401 of the Clean Water Act, any project that would result in a discharge to state waters and requires a federal license or permit is required to obtain a water quality certification from the state before the federal license or permit is issued. The certification is a determination that the project meets state water quality standards. Typical concerns are aquatic habitat protection, streamflow, dissolved oxygen and other water quality parameters, recreation and aesthetics. The certification usually contains specific conditions to ensure those standards are met. The final FERC license must incorporate the conditions included in the state certification without modification.

Under FERC regulations, certain hydroelectric projects that would have a capacity of 5 megawatts or less at an existing dam or natural water feature are eligible to receive an "exemption" from licensing.[1] Exempt projects go through a process very similar to "licensed" projects. The biggest difference is that, unlike a license, which is valid for 30 to 50 years, exemptions are valid in perpetuity. An exemptee must comply with any conditions prescribed by federal and state agencies responsible for fish and wildlife (in Vermont, the Agency of Natural Resources). As with projects for which a license is being sought, projects seeking an exemption are subject to a review under the National Environmental Policy Act. After issuance of the exemption, the project is subject to FERC overview, including compliance with the prescriptive environmental conditions and assurance of dam safety.

FERC regulations also provide for "conduit exemptions," which are issued for projects that use the energy in conduits, such as water supply pipelines or wastewater outfalls, for the generation of electricity.

Currently, 70 hydroelectric facilities in Vermont are subject to FERC jurisdiction. Of those, 53 are licensed and 17 have 5 megawatt exemptions. The remaining 27 Vermont facilities do not meet the test for FERC jurisdiction or have not recently been reviewed for jurisdiction and are regulated by the State of Vermont. In addition, 9 FERC-jurisdictional facilities (8 licensed, 1 exempt) are located on the Connecticut River. Some of the 97 Vermont facilities do not generate power, but divert water or provide storage for downstream generating facilities, and a few are not currently operating.

In addition to a FERC license or exemption, any project that involves dredge or fill in a stream requires a permit from the U.S. Army Corps of Engineers. The Corps permitting process is independent of the FERC process, but Section 401 applies to the Corps permit as well, so the state would issue a single water quality certification that would cover issues in both the Corps permit and FERC license or exemption.

[1] The dam must be non-federal and built before 1977. Additionally, any lands involved must be in federal ownership or the applicant must own or have an option to acquire all of the property interests necessary to build and operate the project.

Although FERC jurisdiction preempts most state regulation of hydroelectric projects (including PSB review), the state administers the federal Clean Water Act in Vermont. That authority provides the state with direct jurisdiction to review water quality issues and include mandatory conditions for the license via the water quality certification process.

State Regulation

State regulation of hydropower primarily falls into two arenas: environmental and recreational impacts and effect on the electric grid. Because hydroelectric projects affect public waters, they may come under the jurisdiction of several laws that pertain to protection of aquatic resources and water quality. Jurisdiction under these laws is determined case-by-case, based on the characteristics of the site and the project. Regardless of which statutes apply, the project must comply with the Vermont Water Quality Standards during its construction and operation. As noted above, most Title 10 statutes and 30 V.S.A. § 248 do not apply to activities that are regulated by FERC.

Vermont's water pollution control statute (10 V.S.A. Chapter 47, *Water pollution control*) articulates the state's water quality policy and establishes the authority of the Vermont Natural Resources Board to develop water quality standards and classify the state's waters. It also requires the Agency of Natural Resources to develop watershed management plans for each of Vermont's 17 planning basins on a five-year rotation. In addition to 10 V.S.A. Chapter 47, statutes that may apply to dams and hydroelectric facilities include:

- 10 V.S.A. Chapter 43 *Dams* – This chapter regulates construction, repair and rehabilitation of dams that impound more than 500,000 cubic feet of water or other liquid, including sediment. It requires a dam order (permit) for work on a dam other than routine maintenance. There must be a positive finding that the project is in the public good for a permit to be issued. Several environmental factors are considered during the review. The Public Service Board (PSB) is given jurisdiction over hydroelectric dams, while the Department of Environmental Conservation has jurisdiction over most other dams impounding more than 500,000 cubic feet. (Agricultural dams are the exception.) The PSB has adopted a rule (Rule 4.500) that governs dam safety. FERC jurisdiction over a dam preempts the State's authority under Chapter 43.
- 10 V.S.A. Chapter 41 *Regulation of streamflow* – Several sections of this chapter pertain to hydropower facilities. Section 1003 establishes a process for the Department of Environmental Conservation to confer with the owner of a dam causing artificial streamflow regulation and require the owner to take action to minimize damage to the public interest. Section 1004 designates the Secretary of ANR as the state's agent in FERC proceedings. Sections 1021-1025 define the permit program for stream alterations on streams with drainage areas of at least 10 square miles. The impacts on fish and wildlife and flooding hazards must be considered during the permit review. With respect to state permits, the provisions of Chapter 41 do not apply if a dam is jurisdictional under 10 V.S.A. Chapter 43.
- 10 V.S.A. § 4607 *Obstructing streams* – This section prohibits erecting an obstruction to fish movement in a stream or on the inlet or outlet of a pond on a public stream without the authorization of the Commissioner of Fish and Wildlife.
- 30 V.S.A. § 248 *New gas and electric purchases, investments, and facilities; certificate of public good* – This section requires that a certificate of public good be issued by the Public Service Board before any generation facility is connected to the electric grid. Among the criteria that are considered during the review are the effects of the facility on the stability of the electric grid and most of the environmental criteria defined by Act 250 (10 V.S.A. § 6086(a)). PSB Rule 5.100 establishes regulations pertaining to small net-metered systems.

Appendix F

Small Hydroelectric Project Proposals
December 2006 – January 2008

Project Information	Proposed Capacity	Description	Significant Issues	Status
Municipal and Other Public Projects				
Name: Greensboro *Proponent:* Town of Greensboro *Town:* Greensboro *Stream:* Greensboro Brook	65 kW	A low dam would be constructed in the stream below the outlet of Caspian Lake. There would be a 2,000 foot penstock/bypass.	Bypass flows. The location of the powerhouse will determine whether higher seasonal flows to support trout spawning and incubation are necessary.	The Agency has conducted several site visits and issued a letter providing technical advice on July 17, 2007. There has been additional follow-up, and the Greensboro Energy Committee is evaluating whether to relocate the intake upstream to the outlet of Caspian Lake. The project received a grant from the state Clean Energy Development Fund in August.
Name: Lincoln *Proponent:* Town of Lincoln *Town:* Lincoln *Stream:* New Haven River	not determined	The project is still conceptual, but is proposed to include a diversion (without a dam) discharging about 0.5 mile downstream.	Bypass flows. The Lincoln Energy Committee was advised that flows of 0.5, with 1.0 csm during brook trout spawning and incubation, would apply.	The Agency conducted a site visit on April 4, 2007. Members of the energy committee were advised to contact a competent engineering firm to do a prefeasibility analysis.
Name: Williams Dam *Proponent:* Town of Londonderry *Town:* Londonderry *Stream:* West River	not determined	Williams Dam is a stone/concrete structure that is 20 ft. high and 117 ft. long. The project configuration (turbine size, powerhouse location, etc.) is yet to be determined.	An Agency dam safety inspection in 2007 found the dam to be in poor condition and recommended a detailed engineering assessment. The West River is an important part of the Connecticut River Atlantic salmon restoration program. Salmon fry are currently stocked upstream, so a downstream fishway would be required immediately. An upstream fishway will be required once spawning salmon reach the dam.	The town energy committee is conducting initial research. There have been a few preliminary conversations with Agency staff, but no request for a site visit. The agency will take that step when requested.

Project Information	Proposed Capacity	Description	Significant Issues	Status
Name: Twinfield *Proponent:* Twinfield Union School *Town:* Marshfield *Stream:* Nasmith Brook	82 kW	Water would be diverted from the brook without construction of a dam. Approximately 4,500 feet of stream would be bypassed. The project would discharge into the Winooski River below the Nasmith Brook confluence.	Aquatic habitat. Nasmith Brook supports high quality wild brook and rainbow trout populations and serves as a refuge for fish living in the Winooski mainstem. The project as designed would not provide adequate bypass flows to support aquatic habitat and spawning runs.	Following several meetings, site visits and much correspondence, the Agency issued a prefeasibility assessment letter on June 13, 2007 that indicated the project would not meet VWQS as proposed. In a follow-up letter on November 20, the Agency reiterated that it is unlikely an economically viable and environmentally sound project can be developed at this site.
Name: Batchelder Mill Dam *Proponent:* Town of Plainfield *Town:* Plainfield *Stream:* Winooski River	90 kW	The existing dam is a concrete/stone gravity structure 15 feet high and 75 feet long. The turbine would discharge into the pool at the base of the dam.	Water quality, aquatic habitat and aesthetics. As currently proposed, these issues are adequately addressed.	The Agency conducted a site visit on May 23 and sent a prefeasibility assessment letter on June 13, 2007. The letter indicated that extensive studies are not likely to be needed. No application or other information has been received from the Town since that time.
Name: Bennington Water Supply *Proponent:* Town of Bennington *Town:* Woodford *Stream:* Bolles Brook	17 kW	A turbine would be placed in a municipal drinking water pipeline. The project would likely qualify for a FERC conduit exemption.	Bolles Brook is on the priority waters list to address current conservation flow issues. The intake would have to be appropriately screened to prevent the entrainment and impingement of fish.	The Agency sent a prefeasibility assessment letter on June 13, 2007 indicating there are no major issues. No application or other information has been received from the Town since that time. The project received a grant from the state Clean Energy Development Fund in August.

Project Information	Proposed Capacity	Description	Significant Issues	Status
PRIVATE PROJECTS				
Name: Vermont Tissue *Proponent:* Walloomsac Hydro LLC *Town:* Bennington *Stream:* Walloomsac River	150 kW	The project would use the existing civil works and turbine along with two additional units.	Unknown	Agency staff met the present owner on-site in 2006, before he had acquired the dam and adjacent buildings. Potential dam safety and environmental issues associated with repowering the site were discussed. The Agency received a preliminary proposal on December 20, 2007 and will schedule a prefeasibility assessment.
Name: Hyde Dam *Proponent:* Sam Lincoln *Town:* Bethel *Stream:* Second Br. White River	65 kW	The project is still in the conceptual stage, but it would be constructed at an existing mill dam.	Unknown	Mr. Lincoln has requested an Agency dam safety inspection, which will occur in the late spring or summer when conditions allow. The Agency received a preliminary proposal on January 3, 2008 and will schedule a prefeasibility assessment.
Name: Hannan *Proponent:* Paul Hannan *Town:* Calais *Stream:* Curtis Pond Brook	not determined	This is a preliminary proposal for a micro-hydro project on a small stream near Mr. Hannan's home.	Aquatic habitat. This issue would be addressed by providing a bypass flow of 0.5 csm year-round.	Agency staff visited the site with Mr. Hannan on May 10. Mr. Hannan indicated that he planned to gather additional information from a small-hydro consultant to determine the feasibility.

Project Information	Proposed Capacity	Description	Significant Issues	Status
Name: Chase *Proponent:* Jonathan Chase *Town:* Holland *Stream:* Stearns Brook	not determined	Project is still in the concept stage. Intake would be at a location that would not require construction of a dam. The bypass would be approximately 2,000 feet long.	Bypass flows. The proposed bypass supports wild brook trout, including reproduction.	The Agency conducted a site visit on May 18 and followed-up with a letter in June. The letter described how to estimate streamflow in this ungaged stream so the feasibility of the project could be determined, and there have been further exchanges on hydrology since that time. Agency biologists electrofished the stream to confirm the status of brook trout and shared the results with Mr. Chase in September.
Name: Hand *Proponent:* James Hand *Town:* Manchester *Stream:* W. Br. Batten Kill	20 kW	The Manchester Center Dam is a concrete/stone masonry structure on the Batten Kill. An intake with trashrack was built in the 1980s. The penstock runs through the basement of a building adjacent to the river and discharges less than 100 feet downstream from the dam.	Maintenance of flow over the dam to support aquatic habitat and aesthetics are important at this site. As currently proposed, these issues are adequately addressed.	The Agency conducted a site visit on July 30. Mr. Hand completed a bypass flow study in September in cooperation with the town and provided the results to the Agency. A prefeasibility assessment letter is being prepared.
Name: Lane Shops *Proponent:* Edward Wallbridge *Town:* Montpelier *Stream:* N. Br. Winooski River	66 kW	This site received a FERC exemption and operated for a time in the 1980s. A substantial portion of the civil works remain in place, although a new turbine would be installed.	A state inspection in 2007 found the dam to be in poor condition and recommended a detailed engineering assessment.	The Agency received a proposal on December 20, 2007 and will schedule a prefeasibility assessment.

Project Information	Proposed Capacity	Description	Significant Issues	Status
Name: Frog Hollow *Proponent:* Anders Holm *Town:* Middlebury *Stream:* Otter Creek	400 kW to 475 kW	The proposed project would be located at the Middlebury Upper (Frog Hollow) Dam just below the Main Street bridge in the village. The project would use an abandoned sluiceway which would control the hydraulic capacity of the turbine.	Maintenance of flow over the falls to support water quality, aquatic habitat and aesthetics are important at this site. As currently proposed, these issues are adequately addressed. Development may affect the upstream USGS gage.	The Agency conducted a site visit on April 2 and provided the Mr. Holm with a prefeasibility assessment letter on June 13, 2007. Funding from the state Clean Energy Development Fund was denied in August. The current status of the project is uncertain.
Name: Hotchkin *Proponent:* Charles Hotchkin *Town:* Richford *Stream:* Alder Brook	not determined	This is a preliminary proposal for a micro-hydro project at a former dam site. There would be a low “dam” of some sort and a diversion that would bypass about 400 feet of stream. There is a road culvert between the intake and tailrace.	Aquatic habitat. The Mr. Hotchkin indicated the project would not operate during low-flow periods or when icing is likely to be a problem. This mode of operation would address any aquatic habitat concerns.	Agency staff conducted a site visit with Mr. Hotchkin on August 6, 2007.
Name: Mill Brook *Proponent:* Mill Bk. Housing L.P. *Town:* Windsor *Stream:* Mill Brook	less than 100 kW	Two project configurations with different penstock lengths and powerhouse locations are being considered.	Unknown	The Agency received a draft proposal on January 3, 2008 and will schedule a prefeasibility assessment.

Appendix G

Small Hydroelectric Power Development in Other Northeastern States

To get a sense of how Vermont's process for reviewing small hydroelectric proposals compares to other states, we conducted telephone interviews with state natural resource agency staff in five northeastern states. The purpose of the interviews was to get a sense of the interest level in small hydropower development, understand the process they use once they have received an inquiry from a potential developer, and learn how they determine an appropriate bypass flow at each project. A summary of results is shown in the following table.

State	Level of interest	Process	Bypass flows
Connecticut	Not a lot of new ideas in new places. Projects that they are working on were licensed but not developed. Smallest project is about 400 kW.	All projects are jurisdictional under FERC and are moving through that process.	Require Connecticut ABF or site specific study to determine flows necessary to protect fisheries.
Maine	Low level of interest for many years, and no recent surge.	No prefeasibility site visit or review. Get detailed location information and send proponent any information on affected waters and resources. Send information package explaining the permitting process (state and FERC).	Flows must meet state water quality standards.
Massachusetts	Not much interest now, but expect it to increase as a result of a recent Small Hydropower Initiative funding opportunity by the Mass. Technology Collaborative.	No prefeasibility site visit or review. Explain to proponent FERC and DEP 401 requirements and that it will be necessary to do studies to determine the fish species present and how the habitat will be protected. Provide fish survey data for affected waterbody.	Require ABF or an IFIM study if the bypass has significant habitat value. Now require seasonal flows, not just a minimum flow. If habitat value is not significant, will determine a lower, site-specific bypass flow value.
New Hampshire	Two or three inquiries in the last year, which is an increase over the previous 5 years.	No prefeasibility site visit or review. Proponent comes in to talk to DES staff. Explain permitting process – permit from state wetlands board and 401. Review during 401 process would be the same as larger hydro projects.	Use USFWS flow policy. Usually require ABF flows in bypass or require site specific study to determine flows necessary to protect aquatic life.
New York	Have received maybe 5-6 inquiries. Three were demonstration projects for summer camps that were not interested in power production.	Projects connected to grid go through the FERC exemption process. Projects that are not FERC jurisdictional go through the "bed and bank" permit process. Permit is for construction, not operation., so project is designed so that it can only operate one way and meet operational requirements with respect to flow and fish protection (entrainment).	Bypass flows have to be protective of fish and wildlife resources and are typically based on ABF or Tennant. In at least one case, required aesthetic flow over falls.

Appendix H

U.S. Fish and Wildlife Service
New England Stream Flow Policy

INTERIM
REGIONAL POLICY
FOR NEW ENGLAND STREAM 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.

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

[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.

median August flow for the period of record unless superseded 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 superseded 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.

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.

[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.

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 I

Agency of Natural Resources
Procedure for Determining Minimum Acceptable Stream Flows

AGENCY PROCEDURE FOR DETERMINING ACCEPTABLE MINIMUM STREAM FLOWS

July 14, 1993

Introduction

It is the policy of the State of Vermont to protect and enhance the quality, character and usefulness of its surface waters, prevent the degradation of high quality waters, and prevent, abate or control all activities harmful to water quality. It is further the policy to assure the maintenance of water quality necessary to sustain existing aquatic communities and seek over the long term to upgrade the quality of waters and to reduce existing risks to water quality.

At the same time, it is the policy of the State of Vermont to promote a healthy and prosperous agricultural community, to maintain the purity of drinking water and assure the public health, to decrease Vermont's dependence on non-renewable energy sources, and to allow beneficial and environmentally sound development. (10 V.S.A. §1250 and State of Vermont Executive Order regarding the State Energy Policy)

The procedures described below are applicable to Agency determinations of acceptable minimum stream flow, made pursuant to a) permits issued under 10 V.S.A. Chapter 43 (Dams); b) issuance of water quality certificates pursuant to Section 401 of the Federal Clean Water Act and FERC licensing or relicensing actions; c) stream alteration permits or stream flow regulation under 10 V.S.A. Chapter 41; d) authorization by the Commissioner of Fish and Wildlife to obstruct streams pursuant to 10 V.S.A. Section 4607, and e) positions taken before Act 250 district environmental commissions with respect to projects affecting stream flow.

The foundation of state statutes protecting the natural flow of Vermont's rivers and streams is that the natural flow should be protected and maintained in the public interest. All reasonable alternatives to altering stream flow and water conservation measures should be thoroughly considered before reduction of the natural flow rate is considered. Only when a comprehensive analysis of such measures is completed can a reasoned and rational balance be defined between legitimate but competing users of the stream.

The intent of this procedure is to assure a consistent process is used in determining acceptable minimum stream flows when there are existing or potential competing uses of the water. This does not necessarily mean that a uniform minimum stream flow number will be reached in every case. What it does mean is that the minimum stream flow numbers will be derived using a consistent procedure.

General Procedure

Determination of acceptable conservation flows are made to assure the passage of adequate water to maintain fisheries interests, aesthetic qualities, recreational and potable water supply uses appropriate to the body of water in question. In general, minimum flows adequate to maintain fisheries interests are sufficient to simultaneously maintain acceptable aesthetic qualities and recreational uses. The procedures below therefore focus primarily on determining fisheries related minimum flow requirements. The Agency reserves the right to require, or to recommend to other regulatory bodies, maintenance of minimum low flows in excess of or less than fisheries requirements where specific facts of the proposed project clearly show such higher or lower flows are needed to properly balance the many competing water uses at the site consistent with applicable statutes or rules. Where the Agency needs additional information to make a determination of flow needs for non-fisheries issues the Agency may request that water users perform special studies.

This procedure may be viewed in three (3) simplified steps. First, the Agency will accept the U.S. Fish and Wildlife Service recommended minimum flows of 0.5 csm (cubic feet per second per square mile) (summer), 1.0 csm (fall and winter), and 4.0 csm (spring) as a presumption that stream values and uses are protected with little or no further field examination of the water in question or hydrologic computations.

Secondly, applicants may conduct flow gaging of the subject stream to establish a valid statistical relationship with a long- term stream gage station, which relationship would then be used to compute applicable stream flow statistics as used in the U.S. Fish and Wildlife Service policy.

Finally, where an applicant wishes to seek Agency approval for lower conservation flows, applicant may conduct site specific studies such as the U.S. Fish and Wildlife Service's Instream Flow Incremental Methodology (IFIM) protocols, or other approved habitat assessment methods. Results of valid evaluations, while costly and time consuming, may provide specific habitat information on which to make minimum flow judgments. Where Agency approved evaluations are available, the Agency will use this information to make judgments on acceptable low flows, which judgments may be greater or lesser than the U.S. Fish and Wildlife Service presumptive flow recommendation. It should be noted that some streams are not physically conducive to IFIM analysis, other evaluation methods may be necessary, and that IFIM analysis conducted to date tend to support conservation flows at the February median flow value for the fall/winter period.

Permits and decisions issued pursuant to this procedure shall provide opportunity for the Agency to reopen permits to review and modify conservation flow requirements at anytime after the initial five years when the Agency demonstrates that conflicting uses exist which require a balancing of those uses or that existing environmental problems require a review. Where the conservation flow requirements are contained in permits or approvals issued by other governmental authorities, the Agency will recommend inclusion of similar reopening conditions. In the event Agency rules governing determination of acceptable minimum stream flow change during the term of any permit, the Agency will not reopen the permit for that reason until it has made an affirmative finding that environmental damage or harm is resulting from the permitted minimum flows.

Procedure

A. U.S. Fish and Wildlife Threshold

The Agency will accept minimum stream flows described in the U.S. Fish and Wildlife Service "Interim Regional Policy for New England Stream Flow Recommendations" dated February 13, 1981, subject to the exceptions and modifications described later in this procedure. That policy (attached) calls for year-round release of 0.5 csm unless superseded by spawning and incubation flow requirements, in which case a flow of 1.0 csm for fall/winter spawning and incubation and/or 4.0 csm for spring spawning and incubation shall be required.

The Agency shall assume that fall/winter and spring spawning and incubation requirements exist within a stream unless a site specific determination is made that such requirements do not exist. The Agency may at its own initiative and with available information, or with information provided by the applicant, determine that significant spawning and incubation are not indigenous to the impacted stream segment. The impacted stream segment shall be that reach which extends downstream of the project to a point where 95% of the spawning/incubation flows have been restored by other flows of the drainage basin.

Alternatively, the Agency will use a determination of the median flow for a river or stream segment based upon continuous gage data over a ten year period from a gage located on the same river as the river segment in question and where that gage station and data are acceptable to the Agency. The gage data must be unregulated with defined accuracy and precision, and be from a hydrologically similar watershed region in the river basin as the river segment. The median flow shall be taken as the median of all days of record for that period. The applicable record for hydrological analysis and the periods defining the seasons for the purposes of issuing permits are shown in the following table.

Season	Period	Record for Hydrologic Analysis
Summer	June 1 - Sept. 30	August
Fall/winter	October 1 - March 31	February
Spring	April 1 - May 31	April/May

B. Stream Hydrologic Analysis

When the stream segment is not suited to a habitat assessment or when the applicant elects to conduct stream gaging, a hydrologic evaluation of the stream may be used to determine the appropriate stream flow statistics.

The applicant shall gage the stream for a period of not less than 3 months for the summer or fall/winter spawning and incubation seasons of interest. Applicants shall gage for not less than 2 1/2 months during the spring spawning and incubation period.

The highest 10% of the average daily flows measured at the study stream shall be eliminated and the remaining flows contained in this record shall be regressed against contemporaneous data from a suitable long-term gage to derive an equation that can reliably predict flows at the study site from gaged flows at the long-term gage. The long-term gage must be effectively unregulated, located in a similar basin and acceptable to the Agency.

The analysis shall be considered successful if a correlation coefficient of 0.9 or greater is attained. The equation can then be used to estimate monthly median flows for the study site for the long-term gage statistics. If the gaging period is doubled over a period of at least two years, then the minimum acceptable correlation coefficient shall be 0.8.

Alternatively, the regression equation can be used to estimate monthly median flows for the study site from the long-term gage statistics through the use of confidence intervals. The value used as a flow standard shall be the higher +95% confidence interval value corresponding to the median value for the long-term gage.

The gaging data set shall be furnished to the Agency on 3 1/2 or 5 1/4 inch disc, and the statistical analysis shall be provided.

Acceptable gaging periods are shown in the following table.

Season	Period
Summer	July 1 - Sept. 30
Fall/winter	December 15 - March 15
Spring	March 15 - May 31

C. Instream Flow Incremental Method (IFIM)

The Instream Flow Incremental Methodology (IFIM) is a problem-solving framework and set of comprehensive procedures for making decisions regarding stream flow. The methodology provides a basis for describing the relationship between stream flow and habitat for fish and other aquatic organisms. The method does not generate a single solution, but predicts the impacts of different alternatives. Professional judgment on the part of applicants and the Agency plays a critical role in determining an acceptable stream flow regime.

The Agency will accept use of the IFIM as a basis for establishing conservation flows. Applicants should recognize that IFIM evaluations provide a basis for conservation flow determination which is more site specific that the U.S. Fish and Wildlife Service policy approach, and that the resulting

Agency judgment as to conservation flows may be greater or less than the U.S. Fish and Wildlife Service policy flows or low median monthly flows.

The Agency will accept conservation flows that provide a high level of aquatic habitat protection, except where compelled to reduce standards to properly balance against other competing water uses which apply to the stream segment.

The results of an IFIM evaluation may support a conclusion that acceptable minimum flows are less than the median monthly flow for the time period of interest. Where IFIM results support such a conclusion, the Agency will approve such lower flows provided the approved fall/winter minimum flow is not less than two-thirds of the median monthly flow for the period of interest unless a valid study approved by the Agency demonstrates that ice formation would not be exacerbated. The latter restraint is included to help assure that no undue damage to fisheries will result from exacerbated ice conditions.

The Agency recognizes that there are certain streams which by reason of their size, basin areas, channel shape or other characteristics are not susceptible to IFIM analysis. The stream hydrologic analysis described in B above or another acceptable method as described below may be accepted in such cases in lieu of an IFIM evaluation.

D. Other Methods

The Agency will consider other methods of determining required conservation flows which applicants may wish to propose. In general, the Agency will accept alternative methods of analysis where it concludes the new method is of equal or greater reliability than the methods outlined above. An applicant is encouraged to seek Agency approval of such alternative methods before commencing such investigations.

E. Offstream Uses of Water - Special Policies

Domestic Water Supplies

Many municipalities throughout Vermont draw most or all of their drinking water from surface streams or lakes, and have done so for a number of years, sometimes dating back to the last century. For new water supply systems or for existing water supply systems which are beginning the planning and engineering phase of modifying their systems, it is the policy of the Agency to encourage municipalities to institute water conservation measures and evaluate alternative sources. The Agency will request that all reasonable water conservation measures be evaluated as part of the studies and that all economically reasonable conservation measures be instituted in order to reduce water consumption demands prior to the Agency considering approval of minimum stream flows below those prescribed by the procedure. Possible conservation measures include water metering, system flushing during high stream flow periods, repairing leaks in distribution systems, requiring industrial users to recycle water or take process water from a non-potable source for which minimum flows can be maintained.

Where minimum flows cannot be achieved through conservation, additional water sources and/or storage should be explored. It is recognized that some options such as storage required to provide minimum stream flows may in some cases be extremely expensive. The economic stress to a municipality must be defined and based on engineering studies before reduced instream quality will be considered as part of a balancing process.

It is the purpose of this procedure to recognize that while all legitimate uses of the water body are to be protected to the extent possible, the bias is in favor of public water supply systems only after all water conservation and feasible alternatives have been explored.

Hydroelectric and Hydromechanical

Vermont rivers have served as a source for the production of hydroelectricity for over a century and have provided water to power our mills since the early settlement period. Population increases and the demand for on-peak energy production have resulted in utilities operating some of their projects in a manner which is incompatible with environmental goals with respect to flow maintenance (*Hydropower in Vermont: An Assessment of Environmental Problems and Opportunities*, 1988).

This minimum flow procedure makes a distinction between the river reach downstream of the project tailrace and the bypassed reach between the intake and the tailrace. Flow released at the tailrace of a project can be used to produce energy while water spilled at a dam and passed through a bypass reach may not be usable to produce energy.

Hydropower facilities shall be encouraged to operate in a true run-of-the-river mode to reduce conflicts with other uses and values. For run-of-the-river projects, the General Procedure shall be used to set flows for river management during special conditions after storage depletion (i.e. flashboard replacement, maintenance drawdown, power audits). During extended periods of non-operation, all inflows shall be required to be spilled over the project dam. For projects not operating in a run-of-the-river mode the General Procedure shall be applied to flow setting for the downstream river reach.

Bypasses shall be analyzed case-by-case. Generally, the Agency shall recommend bypass flows of at least 7Q10 in order to protect aquatic habitat and maintain dissolved oxygen concentration in the bypass and below the project. Higher or lower amounts of bypass flows shall be prescribed as a function of the uses and values to be restored or protected in the bypassed reach. In assessing values, consideration shall be given to the length of the bypass; wildlife and fish habitat potential; the aesthetic and recreational values; the relative supply of the bypass resource values in the project area; the public demand for these resources; and any additional impacts of such flows upon citizens of the State of Vermont. Bypass flows shall be at least sufficient to maintain dissolved oxygen standards and wastewater assimilative capacity. Where there are exceptional resource values in need of restoration or protection, the general procedure shall be followed. In most cases, a portion or all of the bypass flows must be spilled over the crest of the dam to reoxygenate water, provide aquatic habitat at the base of the dam and assure aesthetics are maintained.

In order to fulfill Agency responsibilities to strike a balance between competing water uses in the public interest, any deviations from minimum flow requirements as defined by the General Procedure will require an assessment of water and energy conservation alternatives.

Snowmaking

[This section has been removed. Snowmaking water withdrawals are now subject to a separate procedure dated March 4, 1994.]

De Minimis Withdrawals

It is recognized that certain withdrawals are so small in relation to the stream flow even during periods of drought, that the resultant impact on the natural stream values is negligible. In such cases, it is the Agency's policy to permit such withdrawals of water regardless of the natural instantaneous stream flow. For the purposes of this procedure, a withdrawal rate equal to or less than .005 cubic feet per second times the drainage area in square miles at the proposed withdrawal site, or 5% of the 7Q10 stream flow is considered a *de minimis* impact on the stream flow.

Permittees are not entitled to extract *de minimis* withdrawal flows in addition to flows specified in a project specific permit or certificate. In the case where there may be cumulative impacts of *de minimis* withdrawals, the Agency may require a site specific review.

F. Prior Permits/Approvals/Practices

Applicants may seek permits, approvals or Agency positions to modify existing projects for which earlier permits or approvals were granted and where such permits specified acceptable conservation flows less than would be determined by this procedure. Where the conservation flows specified in earlier permits do not correspond with the conservation flows determined under this procedure, or where earlier operating practices resulted in release of substandard low flows, the Agency will generally require that the flows determined under this procedure be restored as of the earliest practical date. The Agency will negotiate a schedule of actions and mitigating measures which will restore acceptable flows at the earliest practical date. The Agency shall consider any public benefits or detriment realized by restoration of acceptable conservation flows compared to any public benefit or detriment realized by the continued release of less than acceptable conservation flows. The Agency may conclude that the greatest public benefits are realized by continued release of less than acceptable conservation flows determined under this interim procedure.

G. Decision Authority

Decision authority for permits issued under V.S.A. Chapter 43 (Dams); water quality certificates issued pursuant to Section 401 of the Federal Clean Water Act; and stream alteration permits issued under 10 V.S.A. Chapter 41 shall rest with the Commissioner of Environmental Conservation or his designee. Decision authority for approvals of fish passage obstructions issued under 10 V.S.A. Section 4607 shall rest with the Commissioner of Fish and Wildlife or his designee. Decision authority for positions taken before Act 250 district commissions or subsequent appeals shall rest with the Secretary of the Agency of Natural Resources or his designee.

Appendix J

Low Impact Hydropower Institute Certification Criteria

LOW IMPACT HYDROPOWER INSTITUTE
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WWW.LOWIMPACTHYDRO.ORG

Low Impact Hydropower Certification Criteria
Summary of Goals and Standards

The Low Impact Hydropower Institute certifies as "Low Impact" those hydropower facilities that meet its eight criteria:

River Flows:

Goal: The facility (dam and powerhouse) should provide river flows that are healthy for fish, wildlife, and water quality, including seasonal flow fluctuations where appropriate.

Standard: For instream flows, a certified facility must comply with recent resource agency recommendations for flows. If there were no qualifying resource agency recommendations, the applicant can meet one of two alternative standards: (1) meet the flow levels required using the Aquatic Base Flow methodology or the "good" habitat flow level under the Montana-Tennant methodology; or (2) present a letter from a resource agency prepared for the application confirming the flows at the facility are adequately protective of fish, wildlife, and water quality.

[Note: "recent resource agency recommendations" are defined as final recommendations made by state, federal, or tribal resource agencies in a proceeding, such as a Federal Energy Regulatory Commission (FERC) licensing proceeding. Qualifying agencies are those whose mission includes protecting fish and wildlife, water quality and/or administering reservations held in the public trust. Agencies such as a state or tribal department of fish and game, or the U.S. Fish and Wildlife Service are considered a "resource agency" but the FERC, with its balancing responsibilities, is not. The agency recommendations must be recent, which means they were issued after 1986 (after enactment of the Electric Consumers Protection Act, which amended the Federal Power Act to increase the profile of recommendations from fish and wildlife agencies in the FERC licensing process). If there are a number of resource agency recommendations, then the most stringent (most environmentally protective) is used. In the case of settlement agreements, the final settlement terms will be considered the agency's "recommendation."]

Water Quality:

Goal: Water quality in the river is protected.

Standard: The water quality criterion has two parts. First, a facility must demonstrate that it is in compliance with state water quality standards, either through producing a recent (after 1986) Clean Water Act Section 401 certification, or demonstrating compliance with state water quality standards (typically by presenting a letter prepared for the application from the state confirming the facility is meeting water quality standards). Second, a facility must demonstrate that it has not contributed to a state finding that the river has impaired water quality under Clean Water Act Section 303(d) (relating to water quality limited streams).

Future Enhancement: In the future, a limited program of regular water quality monitoring and reporting to the public may be required of certified facilities.

Fish Passage and Protection:

Goal: The facility provides effective fish passage for riverine, anadromous and catadromous fish, and also protects fish from entrainment.

Standard: For riverine, anadromous, and catadromous fish, a facility must be in compliance with recent (after 1986) mandatory prescriptions regarding fish passage (such as a Fish and Wildlife Service prescription for a fish ladder) as well as any recent resource agency recommendations regarding fish protection (e.g., a tailrace barrier). If anadromous or catadromous fish historically passed through the facility area but are no longer present, the applicant must show that the fish are not extirpated or extinct in the area because of the facility and that the facility has made a legally binding commitment to provide any future fish passage recommended by a resource agency.

When no recent fish passage prescription exists for anadromous or catadromous fish, and the fish are still present in the area, the facility must demonstrate either that there was a recent decision that fish passage is not necessary for a valid environmental reason, that existing fish passage survival rates at the facility are greater than 95% over 80% of the run, or provide a letter prepared for the application from the U.S. Fish and Wildlife Service or the National Marine Fisheries Service confirming the existing passage is appropriately protective.

Watershed Protection:

Goal: Sufficient action has been taken to protect, mitigate and enhance environmental conditions in the watershed.

Standard: A certified facility must be in compliance with resource agency recommendations and FERC license terms regarding watershed protection, mitigation or enhancement. These may cover issues such as shoreline buffer zones, wildlife habitat protection, wetlands protection, erosion control, etc.

Future Enchantment: The Watershed Protection Criterion was substantially revised in 2004. The revised criterion is designed to reward projects with an extra three years of certification that have: a buffer zone extending 200 feet from the high water mark; or, an approved watershed enhancement fund that could achieve within the project's watershed the ecological and recreational equivalent of land protection in D.1. and has the agreement of appropriate stakeholders and state and federal resource agencies. A Facility can pass this criterion, but not receive extra years of certification, if it is in compliance with both state and federal resource agencies recommendations in a license approved shoreland management plan regarding protection, mitigation or enhancement of shorelands surrounding the project.

Threatened and Endangered Species Protection:

Goal: The facility does not negatively impact state or federal threatened or endangered species.

Standard: For threatened and endangered species present in the facility area, the facility owner/operator must either demonstrate that the facility does not negatively affect the species, or demonstrate compliance with the species recovery plan and any requirements for authority to "take" (damage) the species under federal or state laws.

Cultural Resource Protection:

Goal: The facility does not inappropriately impact cultural resources.

Standard: Cultural resources must be protected either through compliance with FERC license provisions, or, if the project is not FERC regulated, through development of a plan approved by the relevant state, federal, or tribal agency.

Recreation:

Goal: The facility provides free access to the water and accommodates recreational activities on the public's river.

Standard: A certified facility must be in compliance with terms of its FERC license or exemption related to recreational access, accommodation and facilities. If not FERC-regulated, a facility must be in compliance with similar requirements as recommended by resource agencies. A certified facility must also provide the public access to water without fee or charge.

Facilities Recommended for Removal:

Goal: To avoid encouraging the retention of facilities that have been considered for removal due to their environmental impacts.

Standard: If a resource agency has recommended removal of a dam associated with the facility, certification is not allowed.

If a facility meets the requirements under all eight of the criteria, the facility will be certified as a Low Impact Hydropower facility. A facility failing on one or more of the criteria will not be certified.