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METHODS FOR ESTIMATING INSTREAM FLOW REQUIREMENTS FOR PROTECTION OF AQUATIC LIFE

Guidance Document
401 Water Quality Certification Program
Watershed Management Bureau
Department of Environmental Services

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NEW HAMPSHIRE DEPARTMENT OF Environmental Services

METHODS FOR ESTIMATING INSTREAM FLOW REQUIREMENTS FOR PROTECTION OF AQUATIC LIFE

SUMMARY

In order to comply with surface water quality standards, withdrawals or diversions of water from surface waters must be operated so that sufficient water remains to fully support aquatic life. Methods for estimating protected flows for aquatic life in flowing waters range from simple standard setting methods to detailed modeling of fish habitat relative to flow. This document describes methods for estimating instream flow requirements that are used and accepted by the Department of Environmental Services. DES will consider other methods proposed by applicants for Water Quality Certification under RSA 485-A:12, III and IV.

BACKGROUND

Surface water quality regulations require restoration and maintenance of the physical and biological integrity of surface waters. RSA 483:9-c requires DES to establish protected instream flows for designated rivers. Under the Clean Water Act 401-Water Quality Certification program, surface water withdrawals are frequently issued with conditions so that the surface water will continue to support aquatic life and does not violate water quality standards. These conditions for instream flow are determined using one of three methods used by DES. DES uses these methods, listed below from simplest to most complex, for evaluating stream flow protection and water availability:

1) New England Aquatic Baseflow Policy developed by US Fish and Wildlife Service.

2) November 2000 Modified method developed by DES.

3) Instream Flow Incremental Methods whose core components are functionally equivalent to the processes in the Instream Flow Pilot Program as described in Env-Ws 1900.

APPLICABLE LAWS/REGULATIONS

Env-Wq 1702.07 “Biological integrity” means the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

Env-Wq 1702.17 “Designated uses” means those uses specified in water quality standards for each waterbody or segment whether or not such uses are presently occurring.

Env-Wq 1702.23 "Existing uses" means those uses, other than assimilation or waste transport, which actually occurred in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards.

Env-Wq 1703.01 Water Use Classifications.

(b) All surface waters shall be restored to meet the water quality criteria for their designated classification including existing and designated uses, and to maintain the chemical, physical, and biological integrity of surface waters.

(c) All surface waters shall provide, wherever attainable, for the protection and propagation of fish, shellfish and wildlife, and for recreation in and on the surface waters.

(d) Unless the flows are caused by naturally occurring conditions, surface water quantity shall be maintained at levels adequate to protect existing and designated uses.

Env-Ws 1703.19 Biological and Aquatic Community Integrity.

(a) The surface waters shall support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

(b) Differences from naturally occurring conditions shall be limited to non-detrimental differences in community structure and function.

CHAPTER 483 NEW HAMPSHIRE RIVERS MANAGEMENT AND PROTECTION PROGRAM, enacted in 1988, requires the DES to regulate the quantity and quality of instream flow along certain protected rivers. RSA 483:9-c (http://www.gencourt.state.nh.us/rsa/html/L/483/483-9-c.htm) requires DES to adopt rules for protected instream flows on designated rivers.

Chapter 278, Laws of 2002 (HB1449) created a pilot program for developing and implementing instream flow protection specifically on the Lamprey and Souhegan Rivers (http://des.nh.gov/organization/divisions/water/wmb/rivers/instream/documents/ch278.pdf).

Chapter 337, Laws of 2008 (SB158) made New Hampshire statutes consistent with section 401 of the Clean Water Act for activities requiring federal permits or licenses, and extends the review to water use activities requiring registration under RSA 488:3 (http://www.gencourt.state.nh.us/legislation/2008/SB0158.html).

DISCUSSION

In order to issue 401 Water Quality Certifications, streams where a withdrawal is proposed must be evaluated to define protected instream flows or, conversely, water availability that will meet surface water quality standards specific to instream flow. DES will accept any one of three methods to make this evaluation so long as their underlying assumptions are met. These methods range from a simple desktop assessment of hydrology to a more involved desktop assessment of hydrology and finally to a river-specific assessment that includes models of biological and hydrological conditions and assessments of human water use preferences. The desktop assessments are standard setting tools using rules that assume biological flow needs will be met if hydrologic conditions are not allowed to vary beyond given thresholds. The incremental flow model method is a river-specific assessment requiring significant time and effort. This method includes direct measurements of biologically significant parameters to identify limits on flow variation. As with any guidance, DES will consider other methods and work with applicants who desire to use them.

The Natural Flow Paradigm (NFP) (Poff et al., 1997[1]) recognizes that the best environmental flows for aquatic life are flows with the natural variability of unregulated, undiverted streams, but that within this variability there is room for off-stream water use. The NFP points out that it is necessary to use components of magnitude, timing, duration, frequency and rate of change to describe stream flows. Because of the complexity inherent in flow regimes, a single, static value, i.e., minimum, would not adequately describe stream flow. Neither would prescribing a single value as a protected flow be sufficient to describe the range of [1]flow needs for protected entities. A comprehensive description using all the NFP components provides the most detailed representation of flow and of flow needs that allows both water use and support of riverine entities. DES uses the NFP as the framework for describing water availability/stream flow protection. Each of the three assessment methods provides an estimate of natural flow conditions, or allowed deviations from natural. They also use some of the NFP components in describing water availability and stream flow protection.
The New England Aquatic Flow Policy (also know as the New England Aquatic Baseflow Policy, Interim Regional Policy For New England Streams Flow Recommendations or NE ABF) was developed in 1980 by the US Fish and Wildlife Service. DES frequently uses this as a screening tool. This method is usually used only for the simplest cases and as a means of roughly gauging water availability/stream flow protection.

The November 2000 Modified Method uses the flow protection ideas developed for the November 14, 2000 working draft of the Instream Flow Rules, which were not adopted due to legislative action. This draft is available at the Instream Flow Program's website at http://des.nh.gov/organization/divisions/water/wmb/rivers/instream/documents/11142kifr.pdf. Modifications were added to the method later in order to protect high flows and to be consistent with minimum water use availability allotments (representing 5 percent of the 7Q10) described in the current (2003 pilot program) version of the Instream Flow Rules. This is the main method for defining water availability for 401 Water Quality Certifications.

Site-specific incremental instream flow methods are defined as approaches equivalent to the process for the Instream Flow Pilot Program described in Env-Ws 1900 http://des.nh.gov/organization/commissioner/legal/rules/documents/env-ws1900.pdf or subsequent instream flow rule developments. This assessment method results in a final flow determination which then becomes a water quality standard for a particular river reach when approved by DES. These assessment methods are always available as an alternative for water users who wish to refine estimates of protected flows beyond the November 2000 Modified Method. DES will consult in detail with applicants desiring to use one of the available incremental methods.

[1] Poff, N. L. et al. 1997. The Natural Flow Regime**.** *BioScience* Vol. 47, No. 11: pp. 769-784.

GUIDANCE

Criteria for selection of an assessment method

The following are criteria for selecting which of the three assessment methods from the simplest to the most complex is appropriate for use in a given circumstance. The first two assessment methods are standard setting techniques applied as interim assessment methods until a site-specific study is conducted. The last assessment method is a site-specific incremental method that produces reach-specific values for protected flows to be used as water quality standards.

1. New England Aquatic Flow Policy Method – Usually used as a rule of thumb and for preliminary estimating purposes. This is a hydrologic standard setting method requiring low effort and little time. It incorporates only the Natural Flow Paradigm component of magnitude, but timing may be included depending on presence of cold water species or site-specific gaging. As applied by DES, timing on a monthly basis is the minimum application of monthly mean conditions.
Applicable if:

1) The watershed area is greater than 50 square miles.
2) The effects of regulation and existing diversions on stream flow are negligible. For this guidance, rivers with negligible effects of diversions are defined as those rivers whose Annual Water Use Assessments under Env-Wq 1903 show that the river is in compliance with the General Standard and the proposed withdrawal is negligible relative to the remaining capacity. Note that Annual Water Use Assessments are routinely developed only for Designated Rivers. We plan on expanding this method statewide for future "New Hampshire Section 305(B) and 303(D) Surface Water Quality Reports." Negligible effects of regulation (dams) are defined as rivers where all dams are operated as run-of-river or have a reservoir capacity to inflow ratio that does not appreciably retard the flow of water on a monthly time scale. (See "Questions and Answers on the New England Flow Policy" prepared by Vernon Lang, U.S. Fish and Wildlife Service, May 11, 1999. "The phrases "basically free flowing" or "basically unregulated" are intended to reflect stream flow records that may be more than minimally affected by regulation when viewed in its broadest context. Readers are reminded that few, if any, truly unregulated systems exist in the New England landscape due to past and present land and water uses.")
3) The proposed withdrawal does not affect sensitive habitat or species.
4) The proposed withdrawal is not controversial or opposed.

2. November 2000 Modified Method – Applied to most cases requiring a rapid assessment. This is a hydrologic standard setting method requiring low to moderate effort and time. Incorporates Natural Flow Paradigm components of magnitude, and considers timing, frequency and duration.
Applicable if:

1) New England Aquatic Base Flow Policy criteria do not apply because watershed area is smaller than 50 square miles, significant water use or diversions exist, sensitive species or habitat are affected, or the proposed is controversial or opposed.

2) The impacted watershed area is between 3.26 and 689 square miles, however larger watersheds may be assessed using this method with caveats that regulation and watershed size may be affecting the results.
(http://des.nh.gov/organization/commissioner/pip/factsheets/geo/documents/geo-9.pdf).

3. Instream Flow Incremental Methods (IFIM) – Applied to Designated Rivers and other rivers where site-specific flow criteria (related to biology, hydropower, recreation, water supply) are required. This is a river- or river segment-specific incremental modeling method requiring significant effort and time. Site-specific assessments are the final stage of assessment and the results become water quality standards if accepted by DES. Incorporates Natural Flow Paradigm components of magnitude, timing, duration, and frequency--rate of change component is incorporated if a water management plan is developed for implementing protected flows (recommended.)
Applicable if:

1) NE ABF and Nov2K Modified methods cannot be adapted to use.
2) Long-term criteria for a river segment are warranted.
3) Sufficient time and funding are available to complete.

Application of the methods

1. New England Aquatic Flow Policy

Application of the New England Aquatic Flow Policy should be conducted after reference to the documentation in "Questions and Answers on the New England Flow Policy" prepared by Vernon Lang, U.S. Fish and Wildlife Service, Concord, New Hampshire, May 11, 1999, which contains the Interim Regional Policy as its Appendix A. See Attachment 1. In particular, consideration of the assumptions inherent in the policy and of the appropriateness of use of a standard setting technique should be part of the method selection process.

The NE ABF default flow value is the lowest form of this assessment method. The default flow is a generic flow criterion applicable to a stream that does not meet the gaging criteria for applying the NE ABF. The default flows are developed from the flow statistics from 48 stream gages in New England. For rivers where inadequate flow records exist or for rivers regulated by dams or upstream diversions, the recommended minimum flow is 0.5 cubic feet per second per square mile of drainage (cfsm).

This 0.5 cfsm recommendation shall apply to all times of the year, except when superseded by spawning and incubation flow recommendations. If certain species are present, including, but not limited to Eastern Brook Trout, the recommended flow releases are 1.0 cfsm in the fall/winter (October 1 through March 14) and 4.0 cfsm in the spring (March 15 – May 31) for the applicable spawning and incubation periods. As applied by DES, default values are developed for each month or season in order to incorporate the Natural Flow Paradigm component of timing into the flow conditions.

If certain gaging criteria are met, a higher form of this assessment method may be used. The gaging NE ABF criteria include a minimum size drainage area of 50 square miles, a period of record for each stream gaging station of at least 25 years, gaging records of good-to-excellent quality, a basically free flowing or unregulated stream and median monthly flow values calculated by taking the median of monthly average flows for the period of record.

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 NE ABF-recommended flow for all times of the year is the median August flow for the period of record unless superseded by spawning and incubation flow recommendations. The recommended flow releases are the historical median stream flow throughout the applicable spawning and incubations periods. DES applies the median of monthly means as a reasonable extension of this concept.

DES does not consider long-term use of the results of this policy's directives as meeting the conceptual model of variability in the NFP. Use of this method may result in flow conditions that are not protective of high flows. NE ABF is recognized as having the potential to "flatline," or remove the stream variability desired under the NFP. Without this variability a stream's biological integrity is unlikely to be protected, therefore Surface Water Quality Standards are not being met. However, short-term applications may be appropriate in some cases.

2. November 2000 Modified Method

The November 2000 modified method (N2k Modified) is a desktop, standard setting method used by DES to estimate water availability values from historical daily hydrologic data. This method uses criteria that result in more water being available when stream flow is higher. This method was derived from sections of the November 2000 proposed rules.

While this method can identify protected stream flows, more frequently this method is used to answer the converse – What water is available for use? The answer is a function of two parameters: 1) stream flow and 2) existing water use. N2k Modified describes water availability with the remainder of flow retained for instream flow protection. Water availability is derived from formulas based on seasonal stream flow exceedence values. The hydrologic record is evaluated using these criteria to describe the historical water availability on a daily time step. These water availability values are considered as placeholders until more detailed and instream flow studies can be completed using site-specific evaluations to describe flow protections goals.

This entire assessment should be repeated for the downstream watershed to evaluate the existing and proposed water use impacts on the downstream users. The first assessment defines the water available at the proposed site. The second assessment identifies the impacts of the existing and proposed uses on existing water users downstream of proposed site.

Caution must be used in interpreting the results of this method. This method frequently uses historical stream flow data to define future water use availability. The applicability of the frequency distribution of historically available flows as well as their magnitudes to future conditions should be considered. Statistical assessment of the duration and timing of certain volumes of water availability is a separate task that the investigator needs to define and is not addressed here.

Data inputs

A spreadsheet has been created that generates daily water availability values. The inputs for this spreadsheet are:

1. Data from the long-term flow exceedence regression tool (from DES):
    a. Seasonal Q60, Q80, and Q90 values (bias corrected).
    b. Drainage area of the site.
    c. Annual 7Q10 for the site (bias corrected).
2. Data from stream gage record (from USGS). Suitable gage location with a minimum 20 year period of record. Ideal gages are in the same watershed within the range of watershed area

0.5 to 1.5 times the watershed area of the proposed water use site. Transpose the gage stream flow values to the proposed withdrawal location using areal transposition methods to prorate the drainage area:

a. Daily stream flow record
b. Drainage area of the gage

3. Data from the Water Use database (maintained by NH Geological Survey):
   a. Record of water use for upstream users converted to daily values.

Steps of the N2k Modified Method

The N2k modified method uses a spreadsheet (20060418 N2kmod base.xls) to calculate water availability. The steps below describe the process for collecting and processing the data for entry into this spreadsheet.

1. Determine seasonal flow exceedence (Q60, Q80, Q90) values and 7Q10 specific to the assessment locations and insert to the spreadsheet.

   Use the regression tool described below to determine seasonal Q values using regression tool to find seasonal Q60, Q80 and Q90 values and the watershed area for the site.

Seasons definitions:
Winter = Jan - March 15
Spring = March 16 - June
Summer = July - October
Fall = November - December

   Attachment 2 shows an example of the regression analysis results. A fact sheet describing the Automated Streamflow Frequency and Recharge Estimation Tool for Streams and Watersheds in New Hampshire is available through the DES website at http://des.nh.gov/organization/commissioner/pip/factsheets/geo/documents/geo-9.pdf.

2. Determine appropriate daily stream flow record and insert to the spreadsheet.

   Identify an appropriate stream gage with over 20 years of daily flow data.
   Transpose flows at the gage to flows at the study location.

3. Calculate seasonal water availability using the spreadsheet to apply the criteria in the November 2000 rules as modified. Modifications are 1) adding a cap on aggregate water use when stream flow is greater than the seasonal Q60, and 2) increasing water availability to 5% of 7Q10 when stream flow is below the seasonal Q90.

   Insert into the calculations page of the spreadsheet (20060418 N2kmod base.xls) the study location's Q values, 5 percent of 7Q10, site drainage area, and the daily hydrograph dataset as date and stream flow in cfs.

   Copy formulas down to the extent of the daily stream flow dataset.

   The spreadsheet determines applies the appropriate seasonal Q-value criteria based on the date and the daily flow.

The spreadsheet assigns a phase condition to the day and counts the duration of these phases. When flow is below a phase conditions Q-value criteria for more than four days, on the following day that phase's water availability conditions are set for the next 10 days.

If a lower phase condition persists for more than four days, on the following day the lower phase's water availability then are set for the next 10 days.

Phase condition	Criteria	Water availability
Cap	Above seasonal Q60	8% of daily stream flow
Phase I	Below seasonal Q60	4% of seasonal Q60 flow
Phase II	Below seasonal Q80	2% of seasonal Q80 flow
Phase III	Below seasonal Q90	5% of annual 7Q10

If, during a ten-day event period, the estimated average daily flow has been greater than or equal to 1.5 times the applicable phase flow for four consecutive days, the limits are rescinded on the following day.

4. Identify existing aggregate water use in the watershed and apply to the calculated water availability.

Using the Water Use database (NH Geological Survey) identify the existing water use in the watershed.

Determine daily aggregate consumptive use.

Subtract the daily aggregate consumptive use from the daily water availability values to define the residual water availability.

5. Evaluate proposed use demands against the residual water availability.

Conduct an assessment of availability based on probability of occurrence under proposed water use conditions to determine frequency and duration of the desired water availability.

Conduct an assessment of impacts of the existing and proposed water uses by comparing stream flow to stream flow with existing uses by means of The Nature Conservancy's Indicators of Hydrologic Alteration tool.

3. Instream Flow Incremental Method

Application of the Instream Flow Incremental Method (IFIM) method requires discussion with DES to define a project scope suitable to the project and the applicable watershed conditions. This is a site-specific assessment requiring development of scope and detailed work plans. The protected flows developed must be appropriate for acceptance as water quality standards.

IFIM studies will use the comprehensive flow terms of the Natural Flow Paradigm: magnitude, duration, frequency, timing and rate of change. The final assessments are expected to comprise site-specific assessments following the pattern of the Lamprey and Souhegan pilot studies. Review and consider the Scope of Work Guidance for the Lamprey or Souhegan Pilot Instream Flow projects as an outline of the activities needed to complete this assessment method.

Currently the process includes:

- Task 1. Draft List of Protected Entities
- Task 2. Assessment of Well Withdrawal Impacts on Surface Water
- Task 3. On-Stream Survey for Protected Entities
- Task 4. Report Describing Protected Entities and Proposed Protected Instream Flow (PISF) Methods
- Task 5. PISF Assessments and Proposed PISF Report
- Task 6. PISF Public Hearing
- Task 7. PISF Report for the Lamprey River
- Task 8. Assessment of Water Use with Established PISF
- Task 9. Development of Water Management Plans (WMP) Sub-Plans
- Task 10. Proposed WMP
- Task 11. WMP Public Hearing
- Task 12. Final WMP

A thorough evaluation of fish, riparian vegetation and wildlife and human instream uses will be required. This will include incremental methods such as, but not limited to, MesoHABSIM or PHABSIM, as well as other assessment methods.

Attachment 1

Questions and Answers on the New England Flow Policy”
prepared by Vernon Lang,
U.S. Fish and Wildlife Service, Concord, New Hampshire,
May 11, 1999

Questions and Answers on the New England Flow Policy

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

Prepared by: Vernon Lang

U.S. Fish and Wildlife Service

Concord, New Hampshire

May 11, 1999

Introduction

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

QUESTIONS AND ANSWERS ON THE NEW ENGLAND FLOW POLICY

Que. 1 What is the New England Flow Policy?

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

Que. 2 Why was the flow policy developed?

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

Que. 3 When was the flow policy developed?

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

Que. 4 What internal review procedures were utilized during the flow policy development phase?

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

Que. 5 Did the flow policy receive interagency review?

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

Que. 6 What does the term Aquatic Base Flow (ABF) mean?

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

Que. 7 How is the flow policy structured?

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

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

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

Que. 9 What are the ecological underpinnings of ABF?

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

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

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

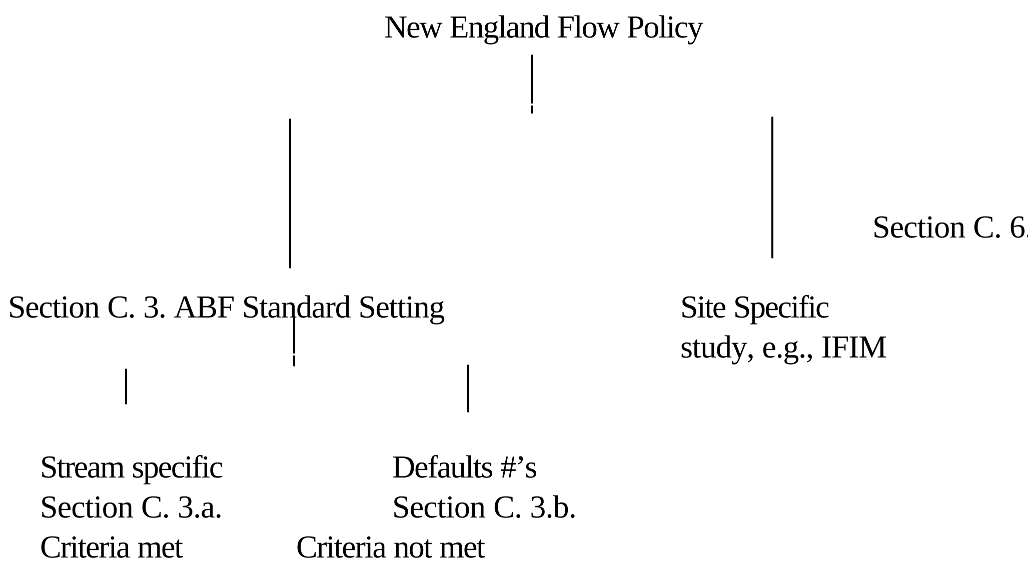


Figure 1

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

Que. 11 Was a risk-based analysis used in the development of the ABF standard setting method?

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

Que. 12 What criteria or sideboards are used in the ABF method?

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

Que. 13 Why were these specific criteria chosen?

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

- The 50-square mile drainage area is intended to insure that a dendritic drainage pattern is included to help smooth out the effects of localized storms, reduce streamflow variability and avoid mass balance issues associated with small drainage systems.
- The 25-year period of record was selected to help insure that the gaging record would include drought and high flow periods and not be unnecessarily skewed by one or the other.
- Stream gaging stations with good to excellent quality records were chosen to insure accuracy in flow measurements. This criterion is occasionally violated at some stations in the winter due to ice conditions.
- The phrases "basically free flowing" or "basically unregulated" are intended to reflect stream flow records that may be more than minimally affected by regulation when viewed in its broadest context. Readers are reminded that few, if any, truly unregulated systems exist in the New England landscape due to past and present land and water uses.
- Median monthly flow values were calculated by taking the median of monthly mean flow. This calculation procedure minimizes the effects of regulation that would be captured, especially during low flow periods, if medians calculated by taking the median of daily average flow were used. These effects of land use, off-stream water use, diversions and storage/release operation by mills and hydroelectric stations tend to skew the median values downward. The longer time step in the monthly average reduces, but does not eliminate, the effect of the regulation. Monthly average (mean) flow was considered as a criterion but this statistic tends to incorporate the effect of high flow events and skews the monthly flow value upwards. The median of monthly average flow reduces but does not eliminate this skew and provides a reasonable measure of central tendency.

Que. 14 Does the flow policy apply only to fish or does it apply more broadly to aquatic life?

Ans. The policy is primarily intended to cover aquatic fauna. However, the policy can be used to address aquatic flora since over time, aquatic plants evolved and adapted to stream conditions in a natural selection process similar to faunal resources.

Que. 15 What is the ABF reference stream and how is it used?

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

Que. 16 How do ABF flow values compare with other standard setting methods such as Tenant?

Ans. The Tenant method uses percentages of average annual flow (AAF) to describe the suitability of seasonal instream flow conditions for aquatic life, e.g., for summer conditions 10% AAF = poor habitat; 30% AAF = fair habitat; and 50% AAF = excellent habitat. The ABF summer default of 0.5 cfsm is slightly less resource conservative than Tenants' 30 percent average annual flow. The 0.5 cfsm default is about 26 percent of the average annual flow of the ABF reference stream.

Que. 17 How does the median August default (0.5 cfsm) compare to optimal flow?

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

Que. 18 Under what conditions should standard setting methods be used?

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

Que.19 When should site-specific studies be undertaken?

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

Que. 20 Does the Service have criteria or sideboards for site-specific studies?

Ans. Yes, Appendix F contains eight specific considerations that should be evaluated when contemplating a site-specific study.

Que. 21 Why was a fall instream flow criterion not included in the ABF method?

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

Que. 22 How does the flow policy fit within the Clean Water Act framework?

Ans. The Service view is that the ABF method provides flow criteria and streamflow recommendations that achieve the interim goal of the Act. However, like other water quality criteria, compliance with the antidegradation policy could be problematic in cases involving high quality waters. It is important to recognize that the flow policy is not structured to provide stream flow recommendations that achieve the full restoration objective of the Act. Appendix G contains a more thorough discussion of these issues.

Que. 23 What do the terms csm/cfsm mean?

Ans. The terms csm and cfsm are simply abbreviations for cubic feet per second per square mile of drainage area. The terms convert discharge in cubic feet per second and drainage area in square miles into a universal expression or unitized value.

Que. 24 What is a default flow?

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

Que. 25 What basic information is needed to develop a flow recommendation from the ABF method?

Ans. This question has two possible answers. If the project is on an ungaged stream or does not meet minimum ABF criteria, then the defaults apply. To use the defaults, you need to know the size of the drainage area above the project (dam, diversion, out take, etc) in square miles. The drainage area is then multiplied by the defaults to obtain the streamflow values in cfs that apply at the project site. If fall spawning fish occur in the stream, or if other critical aquatic needs are identified (winter fish refuge, hibernacula for turtles etc), then both the fall/winter and spring spawning and incubation flow criteria need to be met.

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

Que. 26 What significance attaches to the term Interim above the title on the flow policy?

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

Que. 27 Can the flow policy be used in nonregulatory administrative settings, e.g., in a stand-alone mode?

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

Que. 28 Does ABF provide adequate hydrograph protection?

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

Que. 29 If site-specific study results and ABF standard setting values are both available, which method is used for determining flow recommendations?

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

Que. 30 How do IFIM results compare to ABF values?

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

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

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

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

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

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

Ans. Call Vernon Lang at 603-225-1411, or e-mail Vernon_Lang@fws.gov

Appendix A

INTERIM
REGIONAL POLICY
FOR NEW ENGLAND STREAMS FLOW RECOMMENDATIONS

1. 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.

2. 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.

3. Directive

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

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

2. SFWS 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.

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

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

The USFWS shall recommend flow releases of 1.0 cfsm in the fall/winter and 4.0 cfsm in the spring for the entire applicable spawning and incubation periods.

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

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

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

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

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

4. Exemptions

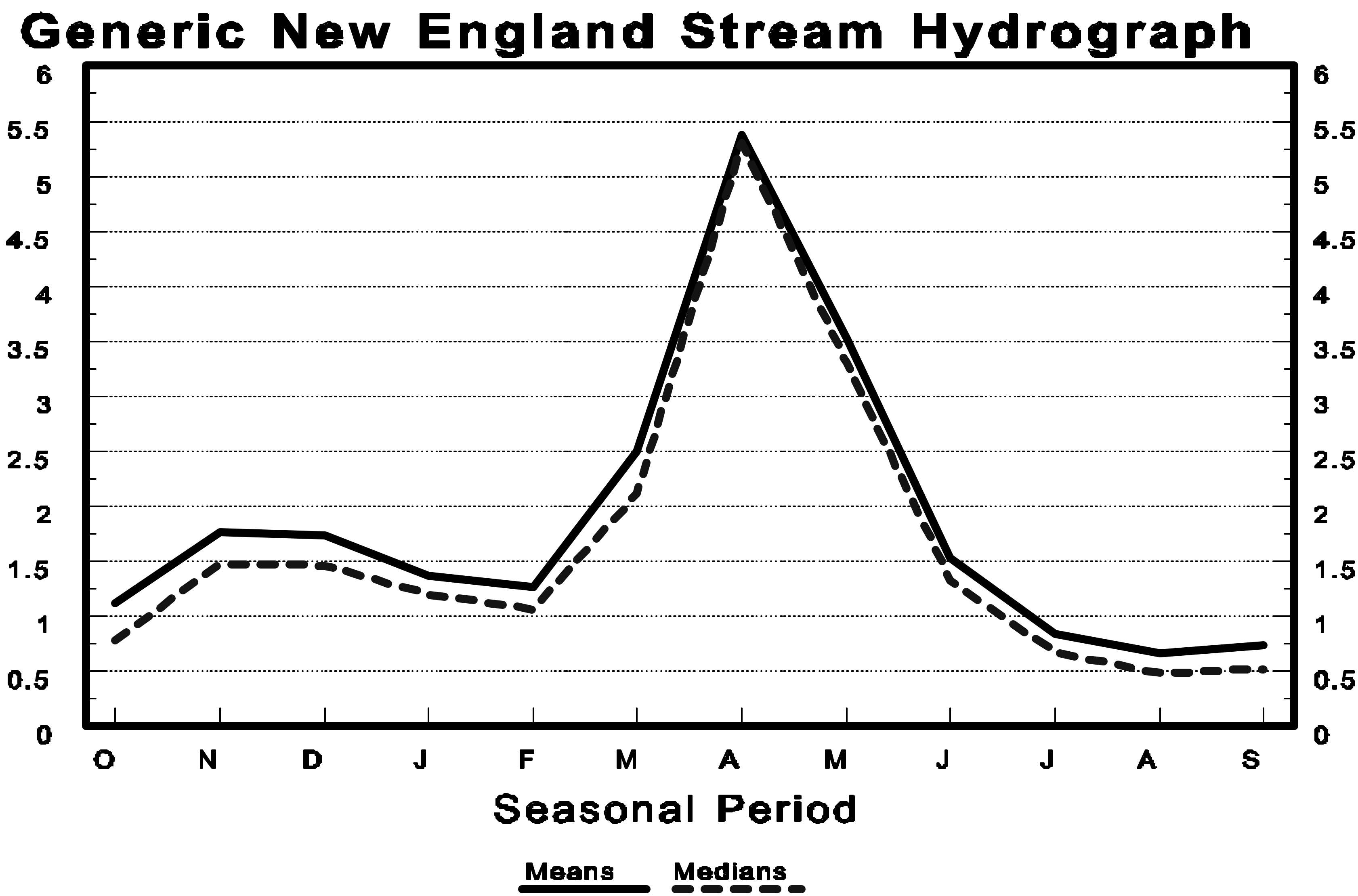
On projects where the USFWS has written agreements citing 0.2 cfsm as a minimum flow, the USFWS shall not recommend greater flows during the lifetime of the current project license. Three hydro-electric projects at Vernon, Bellow Falls and Wilder, Vermont, currently qualify in this regard.

5. 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



Cubic feet/second/square mile of drainage area

New England Stream Flow Patterns

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

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

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

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

Southern and Coastal spring peaks are attenuated by winter precipitation in the form of rain
Interior streams have lower winter lows and higher spring peaks than coastal streams because of snow pack

Stream flow decline in July, August, and September due largely to evapotranspiration
Stream flow increase in October due partly to evapotranspiration decline after killing frost

Appendix D

LIST OF STREAM GAGES USED IN ABF

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

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

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

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

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

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

FROM: Vern Lang

SUBJECT: Considerations for Instream Flow Studies

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

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

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

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

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

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

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

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

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

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

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

When to Apply

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

RELATIONSHIP OF FLOW POLICY TO CLEAN WATER ACT

National Objective -	**Restore and maintain the chemical, physical, and biological integrity of the Nations' waters 33 U.S.C. 1251(a)**
Interim goal -	**Water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water 33 U.S.C. 1251(a)(2)**
Flow policy objective -	**Stream flow conditions that will sustain and perpetuate indigenous aquatic fauna**
Service view - (Interim Goal)	**Flow policy is providing recommendations that achieve the interim goal** **Antidegradation compliance could be problematic where high quality waters are involved 40 CFR 131.12(a)(2) and (3)**
(**National Objective)**	**Restoration objective could be attained by:** (11 prescribing median monthly flows for all months (12 prescribing run-of-river operation (13 prescribing optimum biological flows

Attachment 2

Example regression analysis results.

Duration and low flow estimates for USER PROVIDED POLYGON

Drainage area (sq. mi.)	184.37
Average basin slope (percent)	9.13
Max. basin elevation (ft.)	3127.94
Summer gage precip. (in.)	17.80
Spring gage precip. (in.)	9.25
Winter basin precip. (in.)	8.74
Mean annual temp. (F)	44.69
Mean summer temp. (F)	60.30
Percent coniferous	22.23
Percent coniferous/deciduous	25.97

Seasonal and period of record flow durations

SEASON	% TIME FLOW EXCEED.	FLOW FROM EQN.	Bias CORRECTED FLOW	+SE (%)	-SE (%)	90% Prediction Interval Upper	Lower
WINTER	60	159.19	162.28	23.13	-18.78	225.51	112.38
	70	138.72	141.25	22.53	-18.39	194.89	98.73
	80	114.33	115.96	19.66	-16.43	154.41	84.65
	90	90.40	91.87	20.88	-17.27	124.18	65.81
	95	71.99	73.39	22.63	-18.45	101.31	51.16
	98	54.90	56.69	30.26	-23.23	85.48	35.26
SPRING	60	393.12	395.79	13.04	-11.53	482.66	320.19
	70	314.97	316.85	12.16	-10.84	381.69	259.92
	80	243.96	245.59	13.09	-11.57	299.77	198.54
	90	174.39	175.80	14.55	-12.70	218.96	138.90
	95	130.39	131.61	15.85	-13.68	166.83	101.91
	98	94.40	95.70	19.60	-16.39	127.41	69.95
SUMMER	60	50.62	53.20	42.38	-29.77	91.46	28.01
	70	38.68	41.01	46.50	-31.74	73.30	20.41
	80	30.77	33.09	52.91	-34.60	62.62	15.12
	90	21.04	23.10	61.31	-38.01	46.83	9.45
	95	16.41	18.45	69.92	-41.15	39.85	6.76
	98	12.07	13.76	75.64	-43.07	31.01	4.70
FALL	60	162.11	165.89	25.45	-20.29	236.94	110.92
	70	131.25	135.01	28.55	-22.21	199.81	86.22
	80	102.33	105.69	30.84	-23.57	160.47	65.25
	90	74.19	77.37	35.52	-26.21	123.38	44.61
	95	57.56	61.18	44.01	-30.56	105.98	31.27
	98	43.28	48.04	60.17	-37.57	95.20	19.67
ALL RECORD	60	127.73	129.55	19.37	-16.23	171.78	94.97
	70	87.31	88.88	22.69	-18.49	122.95	61.99
	80	56.95	58.78	31.78	-24.11	90.39	35.88
	90	32.76	34.62	44.05	-30.58	60.35	17.78
	95	22.06	23.77	52.76	-34.54	44.84	10.85
	98	15.48	17.27	66.72	-40.02	36.43	6.58

Seasonal and annual seven-day flow statistics

	R.I.						
WINTER	2	114.27	115.95	18.24	-15.43	151.29	86.32
	10	70.99	72.61	22.89	-18.62	100.24	50.27
SPRING	2	144.43	145.93	15.16	-13.17	182.96	114.02
	10	84.76	85.86	17.28	-14.74	110.70	64.89
SUMMER	2	21.49	24.59	68.35	-40.60	51.39	8.99
	10	11.65	14.82	99.80	-49.95	37.11	3.66
FALL	2	105.71	108.55	25.21	-20.13	154.00	72.57
	10	53.81	57.30	41.21	-29.18	95.87	30.21
ANNUAL	2	20.67	23.66	68.08	-40.51	49.29	8.67
	10	11.03	14.08	102.84	-50.70	36.01	3.38