SUMMARY: FARMINGTON RIVER INSTREAM FLOW STUDY

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I. INTRODUCTION

Purpose

From 1989-1992, a comprehensive instream flow study was conducted of the Farmington's West Branch and main stem. The primary purpose of the study was to provide information on the following questions:

- How do changes in instream flows affect the Farmington's fisheries, recreation, and scenic resources?
- What flows are needed to maintain those resources?
- Is there sufficient water in the Farmington Basin under different rainfall conditions to allow for withdrawals from the West Branch in Connecticut while maintaining those resources?

Answers to these questions are central to the long-term management of the river. Most immediately, they are needed to determine whether any withdrawals could be compatible with protection of the river's resources and, if so, with Wild and Scenic River designation.

When reading the following summary or the final report on the instream flow study itself, there are several important points to keep in mind:

- **The instream flow study report is an information document rather than a decision-making document.** It provides essential new data for determining the compatibility between water supply withdrawals and instream resource protection. That information will be one factor for decision-makers to consider in making future decisions on withdrawals and many other river management issues. Other factors will include legal and statutory requirements, and the standards for river management that are described in the Draft Farmington Wild and Scenic River Study Report.
- **The results of the instream flow study are directly dependent on assumptions related to a number of factors that are of critical importance to water allocation on the Farmington.** Changing any of those assumptions likely would produce different results. The major assumptions are presented in the "Integration" section of this summary, and are analyzed in the "Discussion" section.
- **The instream flow study is not intended to provide detailed, week-by-week or month-by-month operational regimes for how flows should actually be managed.** Instead, it provides information on whether it is possible to satisfy competing resource demands through any of several hypothetical flow scenarios which look at water availability and flow requirements on an annual basis. If a withdrawal is proposed in the future, the applicant would have to satisfy requirements for applicable state and federal permits and resolve other potential constraints. An essential element for permitting would be the development of a plan for reservoir management, including an operational plan and a detailed flow regime.

This summary provides an overview of the major components of the Instream Flow Study, including descriptions of the various methodologies used, the results obtained, and analysis of what the results mean. A complete description can be found in the final instream flow study report.

Project Administration

The instream flow study was made possible through a cooperative effort among the major participants in the ongoing Wild and Scenic River Study, including the Farmington River Study Committee. The study's direct budget of $160,000 was funded jointly by the Hartford Metropolitan District Commission (MDC) ($75,000) and Congressional appropriations through the National Park Service (NPS) ($85,000). In addition, all of the interests involved in the study made substantial in-kind contributions of volunteer and staff time, and other resources.

The Connecticut Department of Environmental Protection (DEP) administered the project, and contracted the Normandeau Associates, Inc. of New Hampshire to conduct the study. A core working group with representatives from the DEP, MDC, NPS, the Farmington River Watershed Association (FRWA), and the Commonwealth of Massachusetts was initially convened to spearhead the resolution of a range of technical concerns (e.g., defining a scope of work; reviewing proposals; selecting a consultant; and addressing unresolved issues that arose during the process). In addition, a broader "technical advisory committee", with approximately 20 representatives from 12 additional agencies and organizations, was formed to assist in scoping the project and finalizing the work plan. Normandeau Associates, Inc. prepared the sections on hydrology, aquatic biology/fisheries, and the final integration into the analysis, and subcontracted with Land & Water Associates for the work on recreation and aesthetics.

General Methodology

Following is an outline of the general methodology and approach used by the consultants:

- Hydrologic modeling was performed to predict total monthly and annual water yields at various points in the watershed under normal, dry and drought conditions.

- For the Massachusetts Wild and Scenic Study Segment, studies of recreation and aesthetics were conducted to determine the relationship between those resources and different flow levels. However, since flows in Massachusetts are largely naturally occurring and are not regularly controlled by dam releases, an instream flow assessment for fisheries was not conducted. Instead, the consultant evaluated the overall health of the aquatic system through analyses of aquatic invertebrate communities and other habitat characteristics.

- For the Connecticut Wild and Scenic Study Segment, the following procedures were performed:

    1) Studies on the relationships between flows and resource quality and related instream flow needs for fisheries, recreation, and aesthetics.
    2) Compilation of flow requirements for other existing uses (these included the 50 cubic feet per second [cfs] minimum release required under state statute; the riparian agreement

with the Farmington River Power Company; waste assimilation needs; and the Colebrook Reservoir fisheries enhancement pool).

3) The integration of annual flow requirements of fisheries and recreation resources with those other existing annual release requirements to establish total annual release volumes.
4) Subtraction of the total release requirements and two potential levels of withdrawal from the annual watershed yields produced through hydrologic modeling to determine whether all of the demands could be met under normal, dry, and drought conditions.
5) As a final step, subtraction of an estimated “flushing flow” volume from the annual watershed yields for normal rainfall years.

The fisheries assessment was conducted for the entire length of the Farmington’s West Branch and main stem in Connecticut down to the confluence with the Connecticut River. However, due to time and budget constraints and the priority of the Wild and Scenic River Study, the recreational and aesthetic evaluations for Connecticut were restricted to the Wild and Scenic Study Segment.

The remainder of this summary presents additional details on how the instream flow study was conducted and how the results were analyzed. Four major topics are addressed: hydrology; aquatic biology; recreation and aesthetics; and integration/synthesis. The summary concludes with a discussion of the study’s implications for future management of the Farmington River and analyses of some of its limitations.

II. HYDROLOGIC MODELING / WATERSHED YIELD

Purposes and Methods

Hydrologic modeling was necessary for the following reasons: 1) the entire study hinges on having the best possible predictions of how much water will be available in the West Branch Reservoirs in normal, dry, or drought years; and 2) in order to estimate accurately the total flows available in the Farmington’s West Branch and main stem downstream of Goodwin Dam, it was first necessary to determine how much flow is contributed by tributaries downstream of the West Branch Reservoirs during normal, dry and drought conditions.

The basic methodology used was as follows:

- The time frame for hydrologic modeling was 1970-1990 – the period since the Colebrook Dam was completed.

- Flow data for that period were obtained from USGS gaging station records on the main stem, the West Branch, and the Still River. [1]

- Those data were extrapolated into mean monthly flows for each site.

- Extrapolations were calculated both for regulated flows (based on actual dam releases from the period of record) and estimated unregulated flows (approximating the natural flows that would have occurred without the dams).

- Statistical analysis was then used to develop monthly regulated and unregulated flow predictions at each gage for normal, dry and drought conditions.

- The monthly unregulated flow predictions for the Riverton gage ultimately were used as the basis for calculating the total amounts of water available under different rainfall conditions at the Goodwin Dam. The unregulated flows were used for that purpose because they reflect natural flow levels and eliminate any effect of storage in the West Branch reservoirs.

- Flow predictions for study sites not near the gaging stations were estimated using data from the nearest gaging station and correcting for differences in drainage area between the study site and the gaging station.

Results

The results of the statistically generated predictions of both regulated and unregulated flows at various points in the watershed are shown, respectively, in Tables 3-1 and 3-2 on pages 30-33 of the final instream flow study report. The total amounts of water available under different rainfall conditions at the Goodwin Dam (shown in Table 4-5 on page 92 of the final report) are as follows:

* 205,083 acre feet in a normal year;

* 137,629 acre feet (67% of the normal year volume) in a dry year (1 in 10 year drought);

* 84,980 acre feet (41% of the normal year volume) in a drought year (1 in 100 year drought).

[1] Gaging records were obtained from stations on the West Branch at Riverton, the Still River at Robertsville, and the main stem at Tariffville and the Rainbow Dam.

III. AQUATIC BIOLOGY STUDY

A. Assessment of Aquatic System Health in Connecticut

Methods

For the Connecticut portion of the river, the relationship between the flow and the health of the aquatic system was evaluated through an assessment of how changing flows affect the amount of fish habitat available. Fish habitat was assessed using the "Instream Flow Incremental Methodology (IFIM)", the most advanced modeling technique for this type of study. This technique is based on the principle that fish populations are directly dependent upon several key habitat characteristics: water depth and velocity; substrate type; and availability of cover. The methodology requires taking field measurements of these characteristics at several sites at a range of flows, and then integrating those measurements into a computer model. The computer model then can be used to predict the availability of habitat for different fish species and lifstages over a range of flows. In IFIM outputs, habitat is measured in terms of "Weighted Usable Area" (WUA), with one unit of WUA being equivalent to one square foot of optimal habitat for the species/life stage in question. The relative quality of habitat is determined based on known preferences of that species/life stage for each of the key habitat characteristics mentioned above.

The fisheries study was conducted for the entire West Branch and main stem in Connecticut – from the Goodwin Dam downstream to the confluence with the Connecticut River. The Wild and Scenic Study Segment was further subdivided into three smaller segments based on where major tributaries enter (the Still River, East Branch, and Nepaug River). Within those three segments, field measurements were taken at a total of 17 specific transect sites which typified the full range of habitat types (rapids, riffles, runs, pools) available in the river. The data were collected across a full range of flows in the spring and summer of 1991 using standard IFIM methods.

The study examined the effects of different flows on the amount of habitat available for several lifestages of the following species: Atlantic salmon, brown trout, brook trout, American shad, smallmouth bass, and longnose dace. The habitat preferences used for each species/life stage were developed from a combination of existing scientific literature, the consultant's professional judgment, and consultation with Connecticut DEP fisheries biologists. These preferences are documented visually in the "Suitability Index curves" which are presented in Appendix A of the final report.

Habitat modeling was performed using standard IFIM procedures, and included use of a model that the U.S. Fish and Wildlife Service's Instream Flow Group recommends for providing the most accurate results over a wide range of flows. The results of the modeling then were used to develop alternative fisheries flow scenarios incorporated later in the water allocation exercise.

Results and Analysis

The results of the IFIM modeling, presented on pages 37-54 of the final report as Weighted Usable Areas curves, show the relationship between flows and habitat for the species and lifestages studied. These results provide the basis for developing alternative flow scenarios to protect fisheries resources. However, before that step could be taken, several significant issues had to be resolved. Those decisions are of importance to both the development of alternative fisheries flow scenarios and to the water allocation modeling exercise. They are described briefly below.

- Species selection – Adult brown trout and juvenile Atlantic salmon were selected to serve as surrogates for the fisheries community as a whole, for which adequate minimum flows should be maintained. They were selected for a variety of reasons, including:

    a) the significance of trout fishery management;
    b) the important of the area to juvenile Atlantic salmon rearing;
    c) the higher flow requirements of the adult stage versus the fry and juvenile stages of brown trout;
    d) the higher flow requirements of the juvenile stage versus the fry stage of Atlantic salmon; and
    e) professional judgment that the projected optimum flows for adult Atlantic salmon and longnose dace did not reflect flow conditions necessary for their sustained health and vitality.

- The segment of the West Branch from the confluence with the Still River downstream to the confluence with the East Branch ("Segment 2") was identified as the most important segment in which optimum or near-optimum conditions for those target species/lifestages should be maintained.

- In recognition of the Still River's significant contribution to flows within Segment 2, the alternative flow scenarios were based on combined projected volumes from Goodwin Dam releases and Still River flows, rather than through sole reliance on reservoir releases. The seasonal and annual variability in Still River flows caused by rainfall was factored into the alternative flow scenarios by adjusting required reservoir releases in response to higher or lower inflow from the Still.

Based on the results of the IFIM analysis and the determinations described above, three alternative flow scenarios to maintain and protect fisheries resources were developed:

1) <u>Optimum habitat scenario:</u> Optimum habitat was defined as the maximum Weighted Usable Area (WUA) for the target species/life stage. For adult trout in Segment 2, maximum WUA is achieved at a flow of 150 cfs. And, although maximum WUA for juvenile Atlantic salmon in Segment 2 is achieved at 100 cfs, the maximum WUA in Segment 3 (the segment immediately downstream of Segment 2) is achieved at 150 cfs. However, to maintain sufficiently low water temperatures necessary for truly optimal conditions in the summer, DEP fisheries staff recommended that at least 130 cfs be provided by reservoir releases, regardless of what inflow from the Still River might be. Therefore, the optimum habitat scenario maintains 150 cfs year-round in Segment 2, with

a minimum of 130 cfs contributed by the Goodwin Dam in June, July, and August. This is referred to as the "150/130 cfs minimum flow scenario".

2) Near-optimum habitat scenario: Near-optimum habitat was defined as within 5% of maximum WUA. For adult trout in Segment 2, this level is provided by a flow of 95 cfs. The near-optimum habitat scenario therefore maintains 95 cfs year-round in Segment 2, with a minimum release of 95 cfs in June, July, and August. This is referred to as the "95 cfs minimum flow scenario".

3) Intermediate scenario: This is a hybrid of the other two scenarios, and maintains habitat levels that are within 5% of those provided by either the historical flow regime or the 150/130 cfs scenario. It compensates for certain monthly deficiencies in the 95 cfs scenario in which habitat levels are significantly below either historical habitat levels or those provided by the 150/130 cfs scenario.

The monthly dam releases needed to maintain these three scenarios, as well as historic flow conditions, are presented in Table 3-3 on page 58 of the final report.

Next, the total WUA provided by each scenario was calculated for the entire coldwater fishery section (from the Goodwin Dam downstream to the confluence with the Pequabuck River). These levels of overall WUA were then compared with the habitat levels provided by the historical flow regime to determine how the alternative flow regimes would affect existing conditions and resources. The data for that comparison are presented in Table 3-4 on page 61 of the final report.

B. Assessment of Aquatic System Health in Massachusetts

Methods

The health of the aquatic system in the Massachusetts Study Segment was evaluated through analyses of aquatic invertebrate communities and other habitat characteristics. The following procedures were used:

- Samples and observations for these indicators were taken at six sites spread throughout the Study Segment.

- Benthic communities were sampled qualitatively using the Environmental Protection Agency's "Rapid Bioassessment Protocol II" (EPA, 1989). This is an accepted methodology designed to determine whether the biological integrity at a site is impaired by water quality or habitat conditions. The technique focuses on several different species of bottom-dwelling organisms, some of which may be highly intolerant of degraded conditions and others of which may thrive in those circumstances.

- General habitat quality was evaluated using accepted EPA procedures which focus on physical and water quality characteristics (such as substrate, cover, channel morphology, bank structure, temperature, dissolved oxygen, etc.) near each sampling station.

Results and Analysis

The assessment at all six sites revealed conditions typical of unpolluted, coldwater environments in southern New England. The samples of benthic organisms were dominated by species which do not survive well in polluted environments, and there was no evidence of significant organic or toxic pollution. The water quality parameters that were sampled indicated very good to excellent conditions throughout the study area.

IV. RECREATION AND AESTHETICS ASSESSMENT

Methods

This portion of the instream flow study evaluated the effects of the different flow levels on the primary recreational uses and scenic values of both the Massachusetts and Connecticut Wild and Scenic Study Segments. The assessment included analyses for the following recreational uses: fishing (both wading and bank fishing); tubing; downriver canoeing; and play boating (kayaking). For each of those activities, as well as for scenic enjoyment, the evaluation identified both the minimum flow needed for an acceptable experience and the optimum range of flows that provides the highest quality experience.

Data for the assessment were collected through three major efforts:

1) More than 3,000 boaters, tubers, and anglers were surveyed on weekends during the spring, summer, and fall of 1991. The surveys were conducted over the full range of normal flows (approximately 10-250 cfs in Massachusetts, and 100-1000 cfs in Connecticut). Respondents were asked whether the flow on that day was about right for their particular activity, or, if not, whether they would have preferred higher or lower flows.

2) An intensive three-day field evaluation was conducted by a team of experts and local volunteers in September, 1991. During that period, dam releases were controlled so that team members could participate in each recreational activity over a full range of flows in close succession.

3) For the scenic assessment, video footage was taken of several strategic sites at each of the different flows that were provided during the three-day field evaluation. Later in the fall and winter, three impartial audiences were asked to view a series of side-by-side videotape images of each location at different flows, and to indicate which flows they considered to be the most scenic.

Preliminary conclusions on the minimum and optimum flow levels for the primary recreation uses were developed by integrating the results from the surveys and the field evaluation. Those findings were presented to representatives of the Farmington’s major user groups, and were revised based on their input. Other local experts were also contacted for their opinions on critical issues such as how different flows affect safety considerations.

Results

The basic results of the recreation and aesthetics assessment are presented in Table 1 which follows:

Table 1: Summary of Minimum and Optimum Recreation and Aesthetics Flows.

Massachusetts Reach

	Minimum	Optimum
Fishing[a]	25 cfs	75-250 cfs
Scenic Enjoyment	n/a	170 cfs
Tubing	unsuitable	unsuitable
Downriver canoeing	250 cfs	250 cfs + 4” [b]
Play boating	250 cfs	250 cfs + 4”-2’ [b]

Connecticut Reach

	Minimum	Optimum
Fishing	100 cfs	150 - 350 cfs
Scenic Enjoyment	n/a	240 - 540 cfs
Tubing	200 cfs	350 - 450 cfs [c]
Downriver canoeing	250 cfs	360 - 980 cfs
Play boating	250 cfs	540 - 980 cfs

[a] While these minimum flows will enhance the physical conditions for fishing techniques, the very low natural stream flows in Massachusetts (often less than 10 cfs) limit fish production, available fish habitat, and pools where fish might be found. Thus, while the recommended flow levels may enhance the conditions for fishing, anglers are unlikely to find many fish except during periods immediately following state fish stocking releases.

[b] Because flows above 256 cfs were not observed, we can only estimate how much water would have to be added to achieve optimum conditions. For downriver canoeing, we estimate 4 inches of water would have to be added to the level in the river stretch above New Boston, and, for play boating, 4 inches to 2 feet would need to be added.

[c] A lifeguard with proper equipment is needed at Satan’s Kingdom, particularly at flows about 350 cfs. Optimum flows for tubing at Satan’s Kingdom start lower (@275 cfs). However, optimum flows on the upper portion of the river (Goodwin Dam to Pleasant Valley) start at 350 cfs.

The next phase of the recreation analysis involved using the minimum and optimum ranges identified to determine how much "recreational opportunity" actually existed historically during normal, dry and drought years. Recreational opportunity was defined as the number of days of both minimum and optimum conditions that existed in a given year for each major recreational use. The historical period of record used for this purpose was 1961-1990, the period since the Goodwin Dam was completed and substantial flow regulation went into effect for the West Branch. Once the historical levels of recreational opportunity were determined, it would be possible to calculate the annual volumes required to provide those levels by multiplying the number of days of minimum and optimum conditions by the daily volume needed for a minimum or optimum experience.

However, before determining the historical levels of recreational opportunity and the annual volumes needed to maintain them, several related issues had to be resolved. A working group, established by the Water Resources Subcommittee, discussed and resolved those issues. Following is a summary of the working group's conclusions[2].

- Recreation seasons – To determine how many days of minimum and optimum conditions existed historically for each major recreational activity, it was first necessary to identify reasonable "recreation seasons" for each activity that encompass the periods of heaviest use. Those seasons were defined as follows:

Fishing:	March 1 – October 31
Tubing:	Weekends only from Memorial Day – July 4th; Daily from July 4th – Labor Day; Weekends only for two weeks after Labor Day
Downriver Canoeing and Play Boating:	April 1 – September 30
Aesthetics:	Daily for the entire calendar year

- Representative rainfall years – Because recreational opportunity was to be evaluated based on actual conditions since the Goodwin Dam was completed, it was necessary to identify the most representative normal, dry and drought years from that period. After considerable analysis, the following years were identified:

Most representative normal year:	1974
Most representative dry year:	1988
Most representative drought year:	1965

[2] The working group, which consisted of staff members from the DEP, NPS, MDC, and FRWA, prepared a detailed memorandum explaining how they reached their conclusions. This memo is contained in Appendix G of the instream flow study report.

While these years are not perfect reflections of a statistically "normal", "dry", or "drought" year (and, in all probability, no actual year ever would be), they are the best available from the period of record and are reasonable to use.

- Selecting specific flows to include in the analysis – To calculate the annual volumes required to maintain historical levels of recreational activity, it was necessary to select specific flows from the minimum and optimum ranges for each activity. The group ultimately recommended using the flow from the low end of both the minimum and optimum ranges for each recreational activity. The rationale for this decision is discussed fully in Appendix G of the instream flow study report.

By comparing the minimum and optimum ranges for each activity with the actual flow records from the representative years, it was possible to determine the numbers of minimum and optimum days that were actually available under historical normal, dry and drought conditions. This information is presented in Table 2 which follows:

Table 2: Historical number of days of minimum and optimum recreational and scenic conditions under different rainfall conditions.

		Drought 1965	Dry 1988	Normal 1974
Fishing (March 1 – October 31)	Minimum	31	22	20
	Optimum	51	171	101
Tubing (Memorial Day – September 15)	Minimum	0	60	9
	Optimum	0	12	43
Scenic (entire year)	Minimum	n/a	n/a	n/a
	Optimum	79	257	243
Play Boating (April 1 – September 30)	Minimum	26	135	111
	Optimum	8	2	18
Downriver Canoeing (April 1 – September 30)	Minimum	19	98	37
	Optimum	15	39	92

The numbers of days with minimum and optimum conditions were then multiplied by the daily volumes (over a 24-hour period) required to maintain the low end flows from each minimum and optimum range. The products are the annual volumes required to provide the historical recreational opportunity for each activity under different rainfall conditions. As was done for fisheries, recreational flows were calculated for the segment downstream of the confluence with the Still River. Therefore, the annual volumes contributed by the Still River were subtracted from overall annual volumes required for recreation producing net annual volumes for reservoir releases required for each recreational use. The results of these calculations are presented in Table 3-6 on page 64 of the final report.

V. INTEGRATION / SYNTHESIS

Methods

To develop viable water allocation scenarios, three fundamental steps were taken:

1) The total annual volumes of water available from the West Branch Reservoirs under normal, dry and drought conditions were calculated based on the results of the hydrologic modeling;

2) The total annual volumes of reservoir releases required to meet the different resource and use demands under varying rainfall conditions were calculated;[3]

3) Those total release requirements were subtracted from the total volumes available to determine if adequate water exists to meet all of the demands in normal, dry and drought years.

The analysis sought to determine the potential for compatible future water supply withdrawals. This was accomplished by conserving reservoir volumes whenever possible, while still meeting basic resource and use requirements. The approach was designed to accommodate all resources and uses, and to determine whether any surplus water would be available.

It was also necessary to make some basic assumptions about a number of additional factors that are of critical importance to water allocation on the Farmington. Those assumptions provide much of the foundation for the results of the entire exercise. Consequently, if any of the assumptions were changed, the results likely would change in response. The principal assumptions are presented below; their implications for river management are addressed in the "Discussion" section at the end of this summary.

Existing legal commitments:

- <u>50cfs minimum flow</u> – This statutory requirement was considered the bottom line for reservoir releases.

[3] Although a full study of the relationship between different flows and scenic values was conducted, an annual volume of water to provide for scenic values was not estimated or incorporated into the final water allocation calculations. These steps were omitted for the following reasons: 1) scenic values are not one of the "outstanding resources" which must be maintained if the river is designated as wild and scenic; and 2) the aesthetics evaluation concluded that there is no minimum flow level to maintain scenic conditions.

- Basic riparian agreement with Farmington River Power Company – The riparian agreement requires the MDC to provide releases totaling 21.7 billion gallons per year; however, the schedule for specific releases varies year-to-year based on the request of the riparian owner within certain seasonal constraints. In order to perform the water allocation modeling, the consultant developed a hypothetical scenario to provide the required releases. The scenario consisted of releases of 300 cfs for 90 consecutive days during the months of July, August, and September, plus an additional 300 cfs for 22 days during mid-winter. This scenario was included in the calculations for normal and dry years only. To conserve reservoir volumes in drought conditions, it was assumed that the full riparian commitment would be bought out in those years by the MDC. (Such financial compensation is allowed under the existing agreement).

- Additional riparian commitments – The calculations did not include the current requirement to release all natural inflow to the West Branch Reservoirs between 50 – 150 cfs and any releases from Otis Reservoir (as required under both the riparian agreement with Farmington River Power Company and another agreement with the Allied Connecticut Towns). That is, the study assumed that all flows above 50 cfs plus Otis Reservoir releases could be stored for future allocation except when necessary to meet the basic riparian demand and/or instream resource requirements.

Reservoir storage capacity:

It was assumed that the West Branch Reservoirs are large enough to capture and store all of the runoff flowing into them during normal, dry, and drought years; that is, the calculations reflect the assumption that all water predicted to be available over the course of a given year could be stored and distributed as desired, and that no water would be lost through spillage, including during seasonal high flows.

Water supply withdrawals:

The MDC was requested to submit two levels of potential water supply withdrawal from the West Branch for inclusion in the water allocation calculations. Those levels were set at constant rates of 10 million gallons per day (MGD) and 20 MGD (or 11,202 acre-feet per year and 22,404 acre-feet per year, respectively).

Fisheries enhancement pools:

In designing its reservoir management program for the Colebrook River Reservoir, the Army Corps of Engineers set aside 5000 acre-feet to enhance anadromous brown trout runs, and an additional 5000 acre feet to enhance American shad runs. The anadromous trout pool is drawn upon frequently; however, water has generally not been provided for shad because that allotment is derived from a small portion of the reservoir's flood control zone. As a result, the water allocation calculations included the brown trout enhancement pool as an annual release requirement under all rainfall conditions, but did not include releases for shad.

Flushing flows / high flow considerations:

There was considerable discussion about what releases, if any, should be provided as "flushing flows", which are generally considered necessary to prevent the unhealthy accumulation of fine grained sediments in the streambed. Lacking an intensive, site-specific study of this issue, a desk-top method was chosen to provide an initial approximation – the 3 day average maximum flow for the period from 1970-1990. This volume was calculated by first averaging the flows from the continuous 3 day period with the highest flows during each year from 1970-1990, and then averaging those 20 yearly 3 day maximums. An assumption was made that extreme high flows are not necessary every year. The analysis therefore incorporated this volume in the water allocation scenarios for normal years, but not for dry or drought years. (See Appendix G of the Instream Flow Study final report for additional discussion of this issue.)

Water quality:

Based on the results of the DEP's waste load allocation studies for the Farmington, the minimum flow of 50 cfs mandated by state statute was assumed to be adequate to meet the standards for Class B water quality classification.

Other issues:

- Use of combined flows from Goodwin Dam and Still River – As described previously, calculations of the flow needs for both fisheries and recreation did not rely exclusively on releases from the West Branch reservoirs, but also included the annual volumes contributed by the Still River under different rainfall conditions.

- Contribution of riparian releases toward fisheries and recreational release requirements – The flows provided to meet the hypothetical schedule of releases for the riparian agreement were assumed to contribute to the flows needed for both fisheries and recreation. (This approach is consistent with the historical reality on the Farmington, where much of the flows that have helped sustain fisheries and provide conditions suitable for recreation – especially in the summer – have been a direct result of riparian releases.)

- Contribution of fisheries flows to recreational release requirements – The base flows provided under the alternative fisheries flow scenarios also were assumed to contribute to the flows needed for recreation.

- Distribution of minimum and optimum days within the recreation seasons – To complete the final calculations of the annual reservoir volumes required to provide historical levels of recreational opportunity, it was necessary for the consultant to distribute the days of minimum and optimum conditions for each use within the recreation season for that use. This was done by scheduling high flow recreation days at times when the greatest flow volume would be provided from the Still River inflow, and riparian releases or fisheries base flows. For instance, all 18 days of optimum conditions for play boating (flows of

540 cfs or higher) in a “normal” year would be provided in April, when Still River inflow is at its peak (estimated 415 cfs).

Results

The final results of the water allocation exercise are shown in Table 3 on the following page. The table shows a series of water allocation scenarios based on the varying amounts of water available in the watershed above Goodwin Dam during normal (“50% exceedence”), dry (“90% exceedence”), and drought (“99% exceedence”) conditions. The allocation scenarios include columns showing the annual volumes required for each of the following:

- the three different flow scenarios for fisheries;
- historical numbers of minimum and optimum days that existed during normal, dry and drought conditions for the different recreational uses;
- two rates of withdrawal for water supply;
- the fisheries enhancement pool;
- the riparian agreement with the Farmington River Power Company; and
- flushing flows (during normal rainfall years only).

In the calculations, the annual volumes for fisheries, recreation, water supply, the fisheries enhancement pool, and the riparian agreement were subtracted from the total watershed yields. The initial results are shown in the “surplus/(deficit) 1” column. The annual volume estimated for flushing flows was then subtracted for normal years only, producing the final results shown in the “surplus/(deficit) 2” column.

Keeping in mind the many assumptions upon which the allocation alternatives rest, the results indicate that during dry, normal and wetter-than-normal years there appears to be sufficient flow to support all resources and uses, although the surplus remaining under certain scenarios is small. Under drought conditions, the MDC has the right to reduce or suspend riparian releases and financially compensate the riparian owner accordingly. However, even with riparian releases eliminated under drought conditions, there is insufficient water available to provide collectively for the “optimum habitat” fisheries scenario, the fisheries enhancement pool, historical levels of recreation, and water supply withdrawals of either 10 MGD or 20 MGD. There does appear to be sufficient water in a drought to provide for a 10 MGD or 20 MGD withdrawal in conjunction with either the near-optimum or intermediate fisheries scenario, although the surpluses with a 20 MGD withdrawal are quite small. It should be noted, however, that near-optimum fisheries flows are substantially higher than historical flows in the 1965 drought. Also, the consultant determined that it is probably unrealistic and unnecessary to maintain higher flows than those in the near-optimum scenario in a drought to protect the long-term integrity of fisheries resources. In considering potential drought situations, it is important to note that during a declared water supply emergency, Connecticut General Statute 22a-378 gives the Commissioner of the Department of Environmental Protection the authority to divert water as needed to ease the emergency conditions. Such diversions could result in reduced or curtailed releases for instream resources.

Table 3: Selected Water Allocation Scenarios for Diverse Uses of the Farmington River. (All quantities are in acre-feet.)

Water Year (% ex-ceedence	Total Watershed Yield	Fishery Flow	Recreation Flow	Water Supply [d]	Fishery Enhance-ment Pool	Riparian Rights	Surplus (Deficit) 1	Flushing Flow	Surplus (Deficit) 2
50%	205,083	30,167[a]	3,431	0	5,000	66,599	99,886	6,425	93,461
“	“	27,945[b]	“	0	“	“	102,108	“	95,683
“	“	27,945[c]	“	0	“	“	102,108	“	95,683
“	“	30,167[a]	“	11,202	“	“	88,684	“	82,259
“	“	27,945[b]	“	11,202	“	“	90,906	“	84,481
“	“	27,945[c]	“	11,202	“	“	90,906	“	84,481
“	“	30,167[a]	“	22,404	“	“	77,482	“	71,057
“	“	27,945[b]	“	22,404	“	“	79,704	“	73,279
”	“	27,945[c]	“	22,404	“	“	79,704	“	73,279
90%	137,629	32,381[a]	2,105	0	“	“	31,544	0	31,544
“	“	27,945[b]	“	0	“	“	35,980	0	35,980
“	“	28,004[c]	“	0	“	“	35,921	0	35,921
“	“	32,381[a]	“	11,202	“	“	20,342	0	20,342
“	“	27,945[b]	“	11,202	“	“	24,778	0	24,778
“	“	28,004[c]	“	11,202	“	“	24,719	0	24,719
“	“	32,381[a]	“	22,404	“	“	9,140	0	9,140
“	“	27,945[b]	“	22,404	“	“	13,576	0	13,576
“	“	28,004[c]	“	22,404	“	“	13,517	0	13,517
99%	84, 980	61,391[a]	9,074	0	“	“	9,515	0	9,515
“	“	44,433[b]	9,337	0	“	“	26,210	0	26,210
“	“	45,504[c]	9,337	0	“	“	25,139	0	25,139
“	“	61,391[a]	9,074	11,202	“	“	(-1,687)	0	(-1,687)
“	“	44,433[b]	9,337	11,202	“	“	15,008	0	15,008
“	“	45,504[c]	9,337	11,202	“	“	13,937	0	13,937
“	“	61,391[a]	9,074	22,404	“	“	(-12,889)	0	(-12,889)
“	“	44,433[b]	9,337	22,404	“	“	3,806	0	3,806
“	“	45,504[c]	9,337	22,404	“	“	2,735	0	2,735

[a] Volume for 150/130 cfs flow scenario.
[b] Volume for 95/95 cfs scenario.
[c] Volume for intermediate flow scenario.
[d] For water supply withdrawals, continuous 10 MGD = 11,202 Ac-ft, 20 MGD = 22,404 Ac-ft.

VI. DISCUSSION

Study Limitations

Throughout this summary, a number of significant assumptions have been identified. Those assumptions have inherent limitations which should be considered in future management decisions. The major limitations include the following:

Existing legal commitments:

- <u>Riparian releases to Farmington River Power Company</u> – The Goodwin Dam releases required under the riparian agreement with the Farmington River Power Company historically have provided a substantial contribution to base flows in the West Branch, thereby providing much if not all of the water for fisheries and recreation. This is particularly true during the drier summer months, when the riparian releases have often produced river flows considerably higher than what might otherwise be available.

In the instream flow study, the hypothetical scenario used to satisfy the riparian commitment represents a near worst-case approach in terms of the reservoir volume required. This conservative approach is reasonable given the variability of releases which the riparian owner is allowed to request. Historically, however, the owner has generally requested riparian releases at lesser rates over a longer period of time than those in the hypothetical scenario. Using a less conservative scenario that more closely reflected historical riparian releases could affect the demand on reservoir volumes required to maintain fisheries and recreation. Stretching the riparian base flow contribution over a longer period could help to reduce the annual reservoir demand needed to provide the relatively low instantaneous flows required for fisheries. Conversely, however, decreasing daily riparian releases during the summer recreation season could necessitate supplemental releases to provide the relatively high flows required for some recreational activities. This could result in an additional demand on reservoir volumes.

- <u>Additional riparian commitments</u> – One of the most significant limitations of the study is the fact that it does not incorporate the current requirement to release all natural inflow to the West Branch Reservoirs between 50-150 cfs plus all Otis Reservoir releases, as mandated under the other existing riparian commitments. The principal implication is that if any of the flow scenarios developed in the study are actually pursued, those commitments would have to be renegotiated. (Note: If the riparian commitments were changed to allow storage of inflow above 50 cfs, adequate releases would still be required to meet downstream management objectives, including satisfying the basic riparian agreement with the Farmington River Power Company and maintaining fisheries and recreational opportunities.)

Reservoir storage capacity:

The results of the study hinge in part on the assumption that the West Branch Reservoirs have adequate capacity to store all the water predicted to be available in any given year (i.e., that no water will be lost to spillage/overflows and thus be unavailable for later distribution). The study concluded that this is probably accurate for most dry and drought years, but it is not clear that the reservoirs can entirely capture and regulate flows during normal rainfall years. Therefore, the actual annual water surpluses for normal years may be somewhat lower than those calculated in the final water allocation table. It should be noted, however, that under these conditions all surplus water will be released. These releases can be used effectively to enhance instream flows.

Based on the historical management constraints for the reservoirs (including the requirements of the existing riparian commitments), these conclusions seem reasonable. However, it is possible that changing the riparian commitments to allow storage of inflow above 50 cfs plus Otis Reservoir releases (as described under the previous issue) could exceed the reservoirs' storage capacity under other rainfall conditions as well.

Flood control management of Colebrook Reservoir:

An additional issue tied to reservoir storage capacity is the Corps of Engineers' management requirements for flood control in Colebrook Reservoir. Those requirements were not considered in the development of the water allocation scenarios. The Corps of Engineers would have to approve any management plan which could infringe on their flood control zone (for instance, by allowing storage of inflow between 50-150 cfs plus Otis Reservoir releases).

Water supply withdrawals:

The withdrawal levels of 10 MGD and 20 MGD are hypothetical rates, used for informational purposes to establish the range of demands that the upper Farmington River watershed can support. As is the norm in water supply planning, the hypothetical withdrawals were established as constant rates (i.e., 10 and 20 million gallons per day over the entire year). However, it is more informative to think of these withdrawals in terms of the annual reservoir volumes they would require (i.e., 11,202 and 22,404 acre feet per year, respectively, as shown in Table 4-5). The withdrawals would likely be made from water collected in the reservoirs during non-recreation season high water periods and storm events.

If withdrawal is pursued, it could be for a lesser or greater amount than those hypothetical rates. Regardless, any specific proposal would need to be evaluated to determine its compatibility with the protection of instream resources.

Flushing flows:

The volume incorporated for flushing flows was only an initial approximation of the river's needs. The precise needs of any given river are difficult to determine. A site-specific empirical study would need to be conducted to determine accurately the Farmington's flushing flow needs.

Reliance on Still River flows:

It is reasonable to focus on the segment below the confluence with the Still River for maintaining fisheries and recreation, and therefore to rely on the combined flow contributions of both the Still and releases from Goodwin Dam. However, the Still River contributions in the instream flow study are based on monthly and annual estimates. Actual daily Still River flows are likely to be highly variable. Such daily variation from the monthly and annual projections will require alterations in dam releases in response to the actual contribution from the Still.

Seasonal distribution of recreational opportunity:

The distribution of days of minimum and optimum recreational conditions within the recreation seasons outlined in the flow management scenario is similar to the seasonal patterns of the representative years. However, this similarity is coincidental rather than intentional. The consultant scheduled days of minimum and optimum recreational conditions to take greatest advantage of flows that would already be in the river for other reasons. For instance, the study targets days of highest recreation flows (i.e., for optimum boating conditions) in April to take advantage of high Still River flows, and targets most days of moderate recreation flows (i.e., for minimum and optimum tubing and minimum boating conditions) in mid-summer, the period when most riparian releases are scheduled. [4] The relatively low flows needed for minimum and optimum fishing conditions are distributed throughout all periods of the recreation season. Certain discrepancies from the historical patterns do exist, largely as a result of how riparian releases are distributed (e.g., diminished boating opportunities in June). To replicate the historical recreational opportunity that existed during those years, the schedule for the minimum and optimum days for each activity may need to be adjusted. Such a schedule may require different annual volumes of releases for recreation than those included in the final water allocation calculations, with potential impacts on the amount of water available for other purposes.

In dry and drought years, the flow management scenario in the instream flow study would provide higher average releases over the recreation season than existed during the representative years. As a result, the total days of recreational opportunity would exceed what existed historically, as shown in Table 4 on the next page. For example, in the representative drought year (1965) there were 51 days of optimum conditions and 31 days of minimum conditions for fishing. Under the flow regime identified in the instream flow study, a total of 114 optimum days and 123 minimum days would be available for fishing.

In normal rainfall years, the instream flow study also would provide more days of recreational opportunity than the representative year (1974), although the flows identified would be lower than historical conditions. This would be achieved by more intensely managing the Goodwin Dam releases to match Still River flows. That is, high Still River flows would be matched by lower Goodwin Dam releases, and vice versa. In this way, West Branch flows would be neither so high nor so low that only limited recreational opportunities would be present.

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[4] In both normal and dry years, the distribution of riparian releases incorporated in the flow management scenario is a significant factor in providing the number of days of recreational opportunity.

Table 4: Comparison of the days of historical recreational opportunity to what would be provided by the flows identified in the instream flow study.

		Drought Year 1965		Dry Year 1988		Normal Year 1974	
		Historic	IFS	Historic	IFS	Historic	IFS
Fishing	Minimum	31	62	22	0	20	0
	Optimum	51	114	171	212	101	184
Tubing	Minimum	0	0	60	72	9	13
	Optimum	0	3	12	9	43	68
Play Boating	Minimum	26	26	135	137	111	165
	Optimum	8	8	2	2	18	18
Downriver Canoeing	Minimum	19	19	98	100	37	91
	Optimum	15	15	39	39	92	92

Note: IFS = Days of recreation using flows as identified in the instream flow study.

Flow needs for minimum and optimum recreational conditions:

Using only the flows from the low end of the minimum and optimum ranges for the various recreational activities does not accurately reflect the actual distribution of flows within the minimum and optimum ranges that was provided during the representative years. Historically, flows spanned the ranges of minimum and optimum recreation conditions. Using the historical flows in calculating the annual reservoir volumes required to support recreation could produce greater total volumes than those produced by using the low end values. This is demonstrated in Table B of Appendix G in the instream flow study report. However, it should be recognized that providing a flow at the low end of the optimum range for some uses will provide conditions well into (or even beyond) the optimum range for other uses. This concept was incorporated into the study. For instance, flows at the low and high ends of the optimum range for tubing were used to fulfill the number of optimum days for that activity while simultaneously meeting some of the flow levels required for lower and higher water demand activities (i.e., fishing and boating, respectively). In addition, the consultant identified a range of flows which provide optimum conditions for each recreational activity, and did not specify that flows at the low or high end were any more desirable.

Opportunities do exist to provide a distribution of flows within the minimum and optimum ranges without placing a substantial additional demand on reservoir volumes. They include:

1) Utilizing surplus water that is available after all resource needs and uses identified in the instream flow have been met. This method is particularly viable for normal rainfall years, in which a large volume of surplus water has been identified.

2) Tying higher recreational flow needs (e.g., for boating) to naturally occurring high flows in the Still River.

These opportunities should be incorporated into any future flow management plan for the West Branch.

Use of representative years in the recreational analysis:

In determining the levels of recreational opportunity present historically, actual flow data from the most representative normal, dry and drought years were used to calculate the number of days of minimum and optimum recreational conditions. Actual flows were used because there is now way to generate daily flow projections for normal, dry and drought conditions statistically. It should be noted, however, that no actual year will precisely mimic the flow pattern for a statistically generated normal, dry or drought year. Finally, the study segment was found eligible for wild and scenic designation based on actual historical levels of recreational opportunity, not a statistically generated level of recreational opportunity.

CONCLUSION

The instream flow study is an unusual example of cooperation among many diverse interests to generate new, objective information on a highly controversial subject. The study would not have been successful without the substantial commitment made by all participants to work cooperatively.

The study provides critical new information for decision-makers both on the flows needed to protect the Farmington’s fisheries, recreation, and scenic values, and on the potential for compatibility between future withdrawals and the protection of those instream resources. That information will be an essential tool for developing a management plan for the river and resolving a range of important issues.

The study also establishes an important precedent which will serve as a model for other wild and scenic river studies with similar issues regarding instream flows and water allocation. This is the first time a study of this type has been used as a tool for decision-making during a wild and scenic river study, prior to a decision on federal designation. It provides all study participants with an indication of whether some level of withdrawal is theoretically possible in conjunction with the strong protection for instream resources required under wild and scenic designation. Looking toward the future, the instream flow study will help in determining if proposed projects would be adverse to the river and, in the case of designation, whether applicable federal permits can be issued.

The reader should keep in mind that the instream flow study is not an evaluation of a specific withdrawal proposal, nor does it define a specific management regime for the West Branch Reservoirs. Rather, it incorporates two hypothetical levels of withdrawal into an intricate resource management and water allocation exercise. As with any scientific analysis, the study is based on a number of important assumptions; these assumptions have related limitations that should be considered in any future management decisions.

If a withdrawal is proposed in the future, the applicant would have to satisfy requirements for applicable state and federal permits and resolve other potential constraints. An essential element for permitting would be the development of a plan for reservoir management, including an operational plan and a detailed flow regime. The plan would identify how the reservoirs and releases would be managed to balance competing uses and protect the river's resources as identified in the instream flow study. Other constraints could include, for example, the need to renegotiate existing flow management agreements.