Downstream releases and flow management on the Swift and South Nashua Rivers

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Background

This paper presents current and historical flow regimes on the Swift and South Nashua Rivers as they are affected by releases from the Quabbin and Wachusett Reservoirs, and explores how changes in release management could be used to better replicate natural flow regimes on these two rivers. The paper does not address the question of whether changes in release management should be conditioned in any way on expansion of the Massachusetts Water Resources Authority (MWRA) system, instead taking the position that questions of release management and system expansion should each be informed by science relevant to the particular question. However, release management and system expansion are linked at least physically in the sense that water released to rivers is not currently available for distribution to municipalities. This paper thus explores the question how meaningful improvements in downstream release management might be achieved while still preserving the "capital" of a clean and abundant water supply for potential expansion needs.

Increasing and naturalizing flow in rivers is an important environmental priority in Massachusetts, particularly in the most developed areas of the state. About 160 rivers in Massachusetts are classified as "flow impaired", despite the region receiving about 44 inches of rain a year. Even as water use efficiency increases, development entails increasing use of ground- and surface-water, while sewering and impervious surface area reduce groundwater recharge and expedite flows, creating unnatural peaks in the hydrograph. Reduced river flow not only reduces habitat space, but also allows pollutants introduced by discharges, atmospheric deposition, and runoff to remain inadequately diluted. Climate change is likely to exacerbate these impacts, as increased temperatures, drought and flooding stress riverine ecosystems to an extent not yet seen.

There are many efforts underway in Massachusetts to address the root causes of flow stress on rivers, including state programs to encourage water conservation and development approaches that promote local recharge of stormwater. In a few instances *where reservoir systems are themselves not stressed*, proactive reservoir management can also help restore more natural flows. In the MWRA system, water conservation efforts and leak repair have reduced system water use to historical lows, and water is being released from the Quabbin and Wachusett Reservoirs at commensurately high levels, suggesting it may be possible to adjust reservoir management to better assure minimum flows in the Swift and Nashua Rivers. Restoration of more natural flow regimes could not only help assure minimum flows, but could also enhance seasonal variability to promote high and low flows, riffles and pools, and changes in temperature and substrate that provide dynamic niches for riparian vegetation, and the correct cues and conditions for spawning and hatching of fish, amphibians, and their invertebrate prey.

Quabbin Reservoir and the Swift River

Current releases and flows on the Swift River

Mandated releases from Quabbin to the Swift River assure the river of steady flows, making it sometimes the only non-stressed river in the state during drought conditions. The minimum release required from the Quabbin Reservoir to the Swift River is 20 mgd (30.9 cfs) as measured at Bondsville, 5 miles downstream of Winsor Dam, but flows are usually greater than this, with measured flows at the USGS gage at West Ware just downstream of the Winsor dam typically above 20 mgd and the intervening watershed area between the West Ware gage and Bondsville accounting for about another 4 mgd.[1] A War Department permit from 1929 requires releases of either 70 cfs (45.2 mgd) or 110 cfs (71.1 mgd) on the Swift from June 1 to November 30th when flow on the Connecticut River falls below certain thresholds (Figure 1; note the two scales in the figure differ by three orders of magnitude).

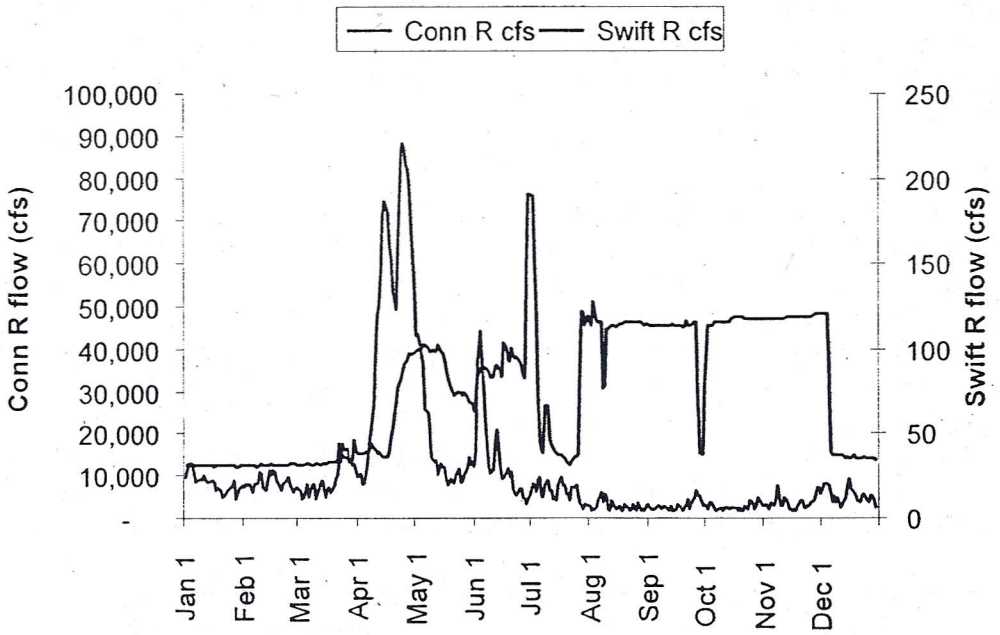

Figure 1. Management of Swift River releases in 2001 to compensate for low flows on the Connecticut River.

The baseflow release and the drought-initiated releases have meant that instead of showing a pattern of reduced flow typical of Massachusetts streams in the summer, the Swift maintains a deep, cold flow, which has contributed to the development of well-known trout fishery.

[1] Water Resources Commission, 2007. Report of the findings, justifications, and decision of the Water Resources Commission relating to the approval of the Town of Reading for an interbasin transfer.

A combination of reduced public water supply use by the MWRA and high precipitation has meant that Quabbin spillage to the Swift has been high in recent years. While the registered volume for the MWRA system is 312 mgd, and the stated safe yield of the system is 300 mgd, water use in the MWRA system has fallen to 220 mgd in 2007 to 206 mgd in 2008 (although low usage in that year was due in part to precipitation levels that were 41% higher than normal, reducing outdoor water use).[2] As a consequence, Swift River flows in the four years of 2005 to 2008 have been historically high, and the river's hydrograph has been showing a large spring speak (Figure 2) closer to that of an undammed system than previously.

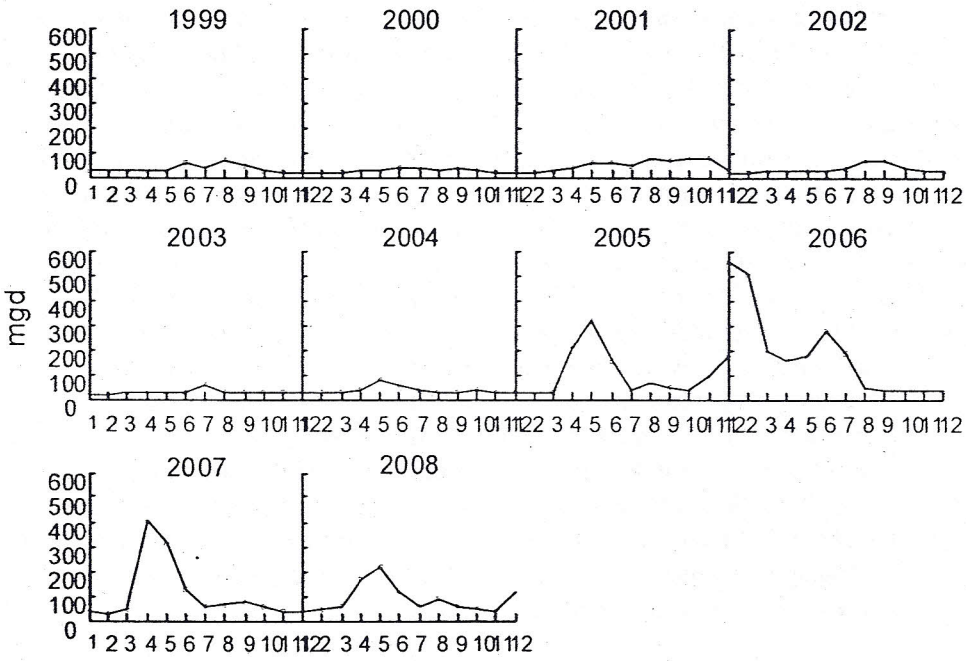

Figure 2. Ten years of monthly average flow on the Swift River (million gallons per day)

Proposals for flow management on the Swift River

Relatively few concrete proposals have been put forward for how flow regimes might be differently managed on the Swift River, although agreement that flow management is a priority has extended to the highest levels, with Secretary of the Environment Robert Golledge stating in a 2007 letter to MWRA that a priority for "surplus" water in the reservoirs should be to ensure the robust health of the riverine systems of the Swift and Nashua rivers. Substantial amounts of water spilling at Quabbin in the last four years have achieved a more natural-looking hydrograph, due both to successful demand management and abundant precipitation, although the latter condition is likely only temporary. One option that has been informally discussed by some environmental groups is abolition of the War Department permit that mandates summer releases in response to

[2] Nvule, Estes-Smargiassi, and Orfeo. Staff summary to the MWRA Board of Directors, January 14, 2009.

low flows on the Connecticut River, which would reduce summer flows on the Swift to levels more typically seen in a river that size. This proposal could potentially impact the river's trout fishery, although maintenance of the minimum flows of 20 mgd (30.9 cfs) at Bondsville (which as stated previously typically experiences flows above this level) would ensure that minimum flow conditions did not decrease below those currently experienced.

Other suggestions for changing flow on the Swift River have been to shift peak spring flows further forward in the spring,[3] and to provide for increased flows in the fall, when Massachusetts rivers typically see an increase. Scouring flow and flows that deposit sandbars provide for a more dynamic riverscape that provides substrate for vegetation and habitat for fish, insects, and other river creatures. One proposal, involving a hydraulic analysis by the United States Fisheries and Wildlife Service, was to add boulders to the Swift River to improve localized geomorphological conditions and habitat for aquatic species, although this project was not ultimately implemented. In recent years uncontrolled spillage has provided spring peak flows on the Swift River, but this pattern will probably not continue indefinitely, so an agreement providing for intentional spring releases above those typically seen prior to 2005 would be a significant cornerstone for sustaining flows. Due to water quality concerns and reduced demand, water is not now often moved from the Ware River to Quabbin, so this represents a source that could potentially be used to support additional downstream releases on the Swift River. However, increased transfers of Ware River water to support downstream releases might introduce water quality and operational concerns for MWRA, and further, might introduce additional flow concerns in the Ware River. Any proposal to increase downstream releases on the Swift will also have to accommodate infrastructure limitations. The Winsor Station release piping is only 48 inches in diameter, and flows are constrained to about 70 MGD; even with retrofit, maximum releases would be at most about 100 MGD. Managing spillage to increase releases is not an option that is favored by reservoir managers, since controls are minimal.

Could changes in reservoir operations improve downstream water quality?

In the past, the MWRA has been receptive toward altering reservoir management to smooth variability in releases, for instance by ramping mandated releases up and down more slowly to mimic disruption to the river. In addition to improving the natural ecology of the river, the argument has been made that additional flow management on the Swift River could also benefit water quality downstream. The Swift River enters the Ware River, which shortly joins the Chicopee River, the largest tributary to the Connecticut River. The Chicopee River has significant water quality impairments,[4] in part due to combined sewer overflows (CSO's). Pollutant concentrations in the Chicopee might be diluted with greater infusions of clean water from the Swift River, although the case is not straightforward. Because the amount of spillage from Quabbin is quite high currently, it is not clear that changes in management would produce much additional effect on the amount of water entering the Chicopee River. Average yearly flows on the Chicopee

[3] Chelsea Gwyther, 2006. Letter from Connecticut River Watershed Council to MWRA.
[4] Massachusetts Executive Office of Environmental Affairs, 2003. Chicopee River: A comprehensive watershed assessment.

River were reduced 24% by the damming of the Swift, decreasing from 1,169 cfs for the 1929 – 1938 period to 890 cfs for the 1940 – 2008 period. However, average yearly flows on the Chicopee River for the 2005 – 2008 period, a period of high spring flows, were 1,251 cfs, higher than historical levels. Even flows during the 15-year 1994 – 2008 period were 1,019 cfs, 87% of pre-Quabbin flows. Water quality impairments from CSO's occur during wet-weather periods when natural streamflow is likely to be highest, and since it is unlikely that Quabbin would be managed to provide even more flow during the spring runoff period when the most spilling is already happening, it is not clear what role additional water from the Swift would play at the present time in reducing pollutant concentrations in the spring. Of course, the spillage of recent history is not guaranteed to continue, so providing for an ongoing peak in spring releases even under drier conditions could potentially support continued water quality improvements on the Chicopee River. Further, there is also currently room for improvement in release management in the autumn, since the Swift River rarely shows the increase in autumn flows typical for river systems in New England. In discussing how flows on the Swift could be further naturalized, it is important to keep in mind that some objectives may conflict with others. For instance, any plan that reduced flows on the Swift River, for instance by eliminating the June 1 – November 30 releases that occur to satisfy the War Department permit, would decrease the amount of fresh water entering the Chicopee and the concomitant dilution of pollutants that currently occurs between June and November.

Wachusett Reservoir and the South Nashua River

Current releases and flows on the South Nashua River

Releases from Wachusett Reservoir to the South Nashua River are mandated under an 1895 act which requires the weekly release of 12 million gallons a week, or 1.71 mgd (2.6 cfs). Approximately another 0.4 mgd is transferred to Lancaster Mills and from there to the river downstream of the dam. Including seepage that occurs under the dam, combined flows at the new USGS gage[5] installed near the Clinton wastewater treatment plant typically range from 4 to over 13 cfs when minimum releases are made. Higher releases from the dam are made according to inflows to the reservoir, and tend to be discharged in 25 million gallon increments, up to about 100 mgd (154.7 cfs). After a request from watershed advocates, releases occurring at the highest levels are now attained gradually, 25 million gallons at a time.

Releases from Wachusett are often made to accommodate large transfers of Quabbin water (Figure 3).

[5] MWRA requested that USGS install this new gage to better understand the role of releases in flows on the Nashua River

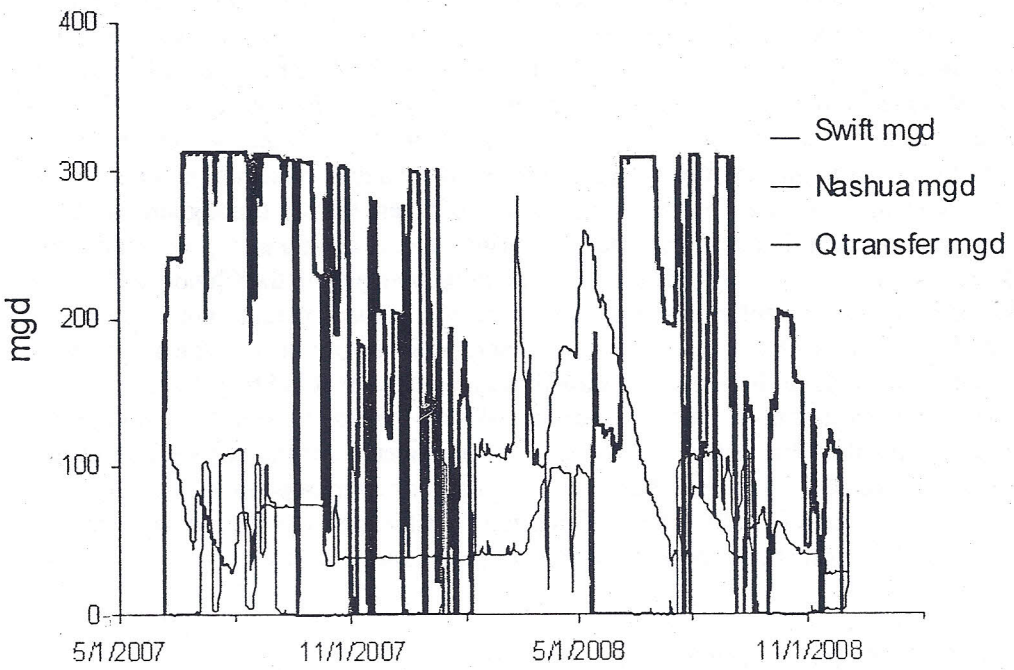

Figure 3. Swift and South Nashua River flows, and transfers from Quabbin to Wachusett from June 2007 to November 2008

Transfer of water from the Quabbin improves overall water quality and reduces treatment costs, reduces the potential for bacterial re-growth within the distribution system, and reduces energy use, allowing hydropower to be generated at the Oakdale station as Quabbin water leaves the aqueduct and enters Wachusett. Transfers are made in such a way as to allow Quabbin water to move through the Wachusett reservoir largely unmixed with Wachusett water. In the past Wachusett levels were allowed to fluctuate to a greater extent prior to initiation of a Quabbin transfer, but in recent years levels are managed more continuously and with greater real-time parity between inflows and outflows.

Expressed relative to the size of the contributing watershed upstream of the Wachusett dam, flows on the South Nashua River are smaller than flows on the Swift relative to its watershed (Figure 4; Nashua River data for the new gage installed in 2007). Releasing water from Wachusett Reservoir in the summer to make room for higher quality Quabbin water leads to atypically high flows in summer relative to what would be seen in a natural hydrograph. However, given that 2007 and 2008 were relatively wet years, the frequency of those releases on the Swift that were tied to low flows on the Connecticut River may have been lower than average, exacerbating the contrast between the hydrographs of the two reservoirs.

Flow patterns on the South Nashua River clearly differ from a typical hydrograph. Comparison with the aquatic base flow standards for New England [6] (at 0.5 cfsm for summer, 1.0 cfsm for fall and winter, and 4.0 cfsm for spring) shows that flows on the South Nashua are relatively low in winter months, and high in summer months. The USGS Streamstats tool estimates August median flows on a hypothetical undammed South Nashua River at 32 cfs, or 0.26 cfsm, considerably lower than the 1.0 – 1.4 cfsm seen in 2007 and 2008.

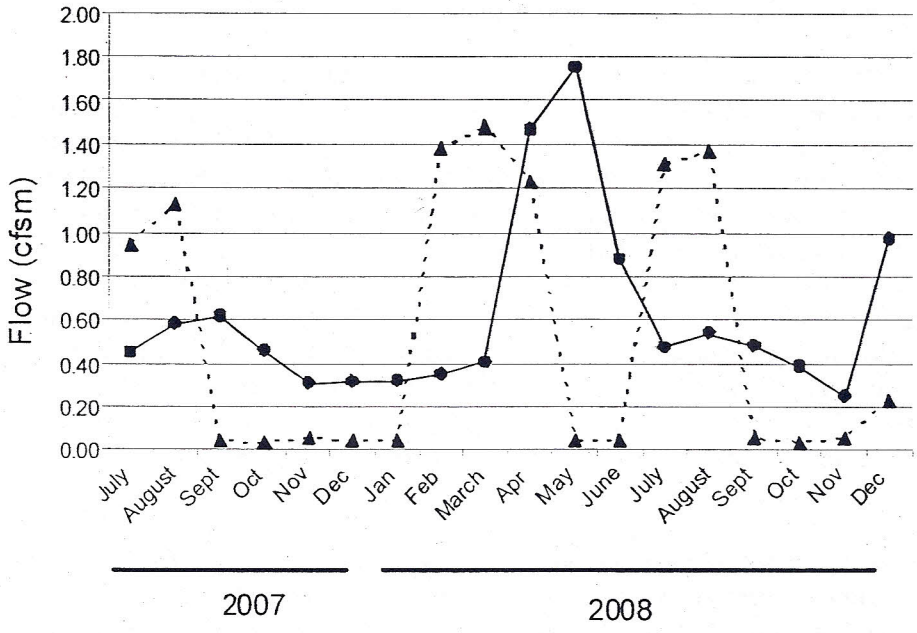

Figure 4. Median monthly flows in the South Nashua River (dotted line, triangles) and Swift River (solid line, circles) in cubic feet per second, divided by watershed area (in square miles).

The 7Q10 flow (i.e. the consecutive seven-day low flow with a ten year return frequency) on an undammed South Nashua would be 8.1 cfs (5.2 mgd), slightly higher than the average flow of 6 cfs (3.9 mgd) measured at the USGS gage when the dam is making the minimum release of 1.7 to 1.8 mgd.

Proposals for flow management on the South Nashua River

Although flows on the South Nashua are clearly low for the size of the basin, few specific proposals for release management have been put forward, in part due to a need for more information. The 2003 Water Quality Assessment Report for the Nashua River

[6] Armstrong, D.S. et al. 2004. Evaluation of streamflow requirement for habitat protection by comparison to streamflow characteristics at index streamflow-gaging stations in Southern New England. USGS Water-Resources Investigations Report 03-4332. Aquatic baseflow standards are simply guidelines; for instance, some rivers in Massachusetts naturally show flows lower than the summer standard.

Watershed recommends optimizing "withdrawal and release practices from the Wachusett Reservoir to maintain a minimum flow and natural flow regime in the Nashua River", due to many pollutant impairments.[7] A task force consisting of representatives of the Nashua River Watershed Association, MA Fish and Wildlife, U.S. Fish and Wildlife, and Trout Unlimited that had been convened to discuss river management scenarios on the South Nashua was ultimately dissolved, pending the acquisition of better flow data with installation of a USGS gage near the Clinton wastewater plant.[8] The new gage was installed in 2007, and relocated slightly upstream in November of 2008 to address some problems that had arisen at low flow conditions. With two year's worth of at least basic flow data now available, the time may be right to reconvene the task force.

It may always be the case that MWRA will need to quickly release large amounts of water from the Wachusett Reservoir to make room for Quabbin inflows, so prospects are limited for restricting large releases at Wachusett Dam to spring and fall. However, there is room for significant improvement in the minimum flows released to the South Nashua, which would benefit downstream habitat and water quality alike. Increasing minimum releases from Wachusett might necessitate greater transfers of water from Quabbin, which could benefit hydropower generation not only at the Oakdale station, but also at Wachusett Dam itself, if a current proposal by MWRA to install a hydropower facility at the dam goes forward. The proposed facility would have a capacity for power generation at flows between 7 and 20 mgd, although the current proposal is to run it at 7 mgd (10.8 cfs) on most days.[9] This would itself represent an increase over the current minimum releases which average around 1.7 mgd, in addition to releases to the Lancaster Mills and seepage.

Increased minimum releases on the South Nashua would have a beneficial effect on downstream pollutant concentrations. The subwatershed located below the Wachusett dam is heavily built up, with a high amount of impervious surface, so that stormwater is likely to carry high pollutant loads. Indeed, the South Nashua River is identified as impaired and requiring a TMDL for pathogens,[10] and was identified as being at "alert" status for phosphorus in 2003.[11] Further downstream, the Clinton wastewater treatment plant discharges on average about 2 mgd into the South Nashua, meaning that treated wastewater inputs are currently about the same magnitude as reservoir water inputs to the river on days when minimum dam releases are made. The Clinton plant has not always met its pollutant discharge limits, and as late as 2008 was occasionally exceeding acute and chronic water quality standards for copper and zinc.[12] Modification of current release regime from the Wachusett Reservoir to increase minimum releases would therefore have definite and quantifiable effects on downstream water quality by diluting pollutant concentrations.

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[7] Mass DEP Division of Watershed Management. Nashua River Watershed 2003 Water Quality Assessment Report. Report number 81-AC-4.
[8] Martha Morgan, pers. comm..
[9] Proposal submitted by MWRA to the Massachusetts Technology Collaborative, 2008.
[10] ENSR International, Mass DEP, and USEPA. Draft pathogen TMDL for the Nashua River Watershed.
[11] Mass DEP Division of Watershed Management. Nashua River Watershed 2003 Water Quality Assessment Report. Report number 81-AC-4.
[12] MWRA Industrial Waste Report #24, October 2008.

How much water is required?

It is probably premature to estimate of the amount of water needed to achieve meaningful ecological restoration on either the Swift or South Nashua rivers, since several factors must be weighed including MWRA's operational capabilities. Given that large releases will continue to be made from Wachusett Reservoir during any season in the foreseeable future, an important question is what the goals should be for restoration on the South Nashua, if true flow naturalization is not possible. Re-convening the stakeholders task force for the South Nashua River is one way this issue could be again brought to the fore. Further, the proposal to install hydropower at the Wachusett dam will likely entail some scrutiny of downstream conditions. Further study of the Swift River would also help to determine how downstream releases should be managed in a changing environment where possibly more water is moved to the Wachusett Reservoir to support releases there. The most balanced outcome will likely result if the MWRA water system is considered as a whole by those interested in increased downstream releases, just as it is by MWRA itself, to avoid the "interests" of one downstream community outweighing those of another.

Finally, with talk of the need for increased downstream releases it is sometimes possible to forget that all water in excess of reservoir capacity is now currently released at both MWRA reservoirs. Thus, discussion of meeting ecosystem goals is mostly a discussion of how current releases can be reallocated. It is a real concern on the part of MWRA that any agreement to changes in release management will limit the Authority's flexibility in the future and prevent resources from being reallocated. Such concerns can stand in the way of achieving an agreement about reservoir and river management. In the past, however, incremental changes in reservoir management have produced real improvements in flow regimes on the rivers, for instance when MWRA agreed to gradual ramping up and down of releases to the South Nashua. The proposal by MWRA to install hydropower at the Wachusett Dam may itself increase minimum flows, so serious and timely consideration should now be given to whether there are additional management changes that can improve the downstream ecosystems on the South Nashua and Swift rivers.

Abbreviations

7Q10	consecutive seven-day low flow with a ten-year return frequency
cfs	cubic feet per second
cfsm	cubic feet (per second) per square mile (of watershed area)
gpd	gallons per day
mgd	million gallons per day