Appendix 1. Methods Used to Develop Input Files for 2030 Model Scenarios

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Appendix 1. Methods Used to Develop Input Files for 2030 Model Scenarios

Estimation of 2030 Monthly Withdrawal Rates for Public Water Supplies

Projected annual water demands for year 2030 for communities using public-supply water sources and projected populations in year 2030 for all communities in the model areas were provided by MAPC (table 1-1). To use the MAPC-demand projections in the computer models, the community-wide projected 2030 demands were apportioned by month among the supply sources. This was accomplished in several steps.

First, average monthly withdrawals were determined from historical records for each community with public-supply sources. Historical records for the model-calibration periods were used—January 1997 through December 2001 for communities in the Assabet River Basin (fig. 1-1A) and January 1989 through December 1998 for communities in the Upper Charles River Basin (fig. 1-1B). A factor representing the percentage by which total monthly demand differed from the annual average demand was calculated by month for each community. Comparison of the monthly factors showed that the same general pattern for each community occurred in each river basin. The monthly factors by community calculated in each basin then were averaged to determine an average monthly factor for both river-basin model areas (fig. 1-1C). Because monthly water-demand patterns in the Assabet River Basin and the Upper Charles River Basin were similar, one set of 12 monthly factors was used as a consistent means to apportion, by month, the year 2030 annual demand for each community in both river basins.

The second step involved apportioning the year 2030 community-specific monthly demand determined in step one by individual source. Historical monthly withdrawal rates by source were used to determine the percentage that each source contributed toward supplying total monthly demand in each community. This percentage then was multiplied by the 2030 monthly demand to determine a 2030 monthly supply rate for each source. This procedure apportioned the 2030 total monthly demand by the historical proportion that each source contributed to meet the total monthly demand. This was done to retain the historical withdrawal patterns that were specific to individual sources in each community.

The third step was to ensure that the newly calculated 2030 supply rate did not exceed the state-permitted limit or the maximum withdrawal limit (MWL) specified for each water source. No maximum withdrawal limit for demand was placed on any community as a whole—the MWL applied to individual sources only. Ground-water wells for public supply in Massachusetts are subject to daily maximum pumping limits established by Massachusetts Department of Environmental Protection (MADEP) that are known as Zone II limits. For each surface-water source, the maximum monthly withdrawal rate during the model calibration periods (1997–2001 in the Assabet River Basin and 1989–1998 in the Upper Charles River Basin) or the highest value among other withdrawal data obtained from the communities was used as the MWL. For sources where the calculated 2030 monthly withdrawal rate did exceed the MWL, the withdrawal rate was set at the MWL. The calculated 2030 demand in excess of the MWL was determined by source as a total for each month. The total excess for each month was then equally distributed in the same month among the other sources where the calculated 2030 withdrawal rate was less than the MWL. Appendix 2 shows the 2030 monthly withdrawal rates for communities in the Assabet and Upper Charles River Basins calculated for each source and either the corresponding Zone II limits for wells or the maximum withdrawal limit used for surface-water sources.

For communities in the model area with some sources outside of the model area (appendix 2), total community-wide 2030 demand was calculated and apportioned among all sources. However, community sources outside the model area were not simulated or included in the volumetric water budgets calculated for this study.

After apportioning the year 2030 demand (table 1-1) among sources in communities with public water supply, some communities in the study area were able to supply projected 2030 demand with their existing sources at rates below the MWLs, whereas other communities had sources projected to pump at or near the MWLs in 2030 (appendix 2). In the Assabet River Basin, three wells in Acton were projected to have withdrawals at or near the MWLs—Lawsbrook Well, Scribner Well, and Assabet Well No.2—whereas withdrawal rates for the remaining wells were below the MWLs. For Concord, two of the seven sources—the Second Division Well and Nagog Pond—were within the model area. None of the apportioned year 2030 withdrawal rates approached the MWLs for sources in Concord. In Hudson, the Chestnut Street Well No. 1 had year 2030 monthly withdrawal rates at the MWL, whereas the other sources had withdrawal rates below the MWLs. Maynard had no wells with year 2030 withdrawal rates at the MWLs. The Andrews Well No. 2 in Westborough had year 2030 withdrawal rates at the MWL, whereas rates at all other sources were below the MWLs. Three sources for Westborough were outside of the model area. Shrewsbury had no active wells in the model area.

In the Upper Charles River Basin, no wells in Bellingham had 2030 withdrawal rates at the MWL. In Franklin, Wells Nos. 3 and 8 had rates at or near the MWL for 12 months and Wells 4 and 6 at the MWL for 5 months. Even though Franklin had two proposed wells, no year 2030

Table 1-1. Percentage of community area, total population, population using public water, and simulated water demand for basecase conditions and year 2030, by subbasin, Assabet and Upper Charles River Basins, eastern Massachusetts

[Mgal/d, million gallons per day; MWRA, Massachusetts Water Resources Authority; --, not determined; Total year 2000 population and projected year 2030 population and water demand from the Metropolitan Area Planning Council (MAPC), written commun., 2006; Data for Boylston, Grafton, and Shrewsbury are from Central Massachusetts Regional Planning Agency through MAPC]

Community	Community area in model area (percent)	Total population		Population using public water (percent)	Water demand for public supply from in-basin sources (Mgal/d)		Remarks
		Year 2000	Projected year 2030		Basecase from documented ground-water models	Projected year 2030 community total	
Assabet River Basin							
Acton	100	20,331	23,139	94	1.928	2.265	
Berlin	100	2,380	2,602	0	--	--	
Bolton	72	4,148	7,219	0	--	--	
Boxborough	66	4,868	5,884	0	--	--	
Boylston	24	4,008	5,000	10	--	--	
Carlisle	29	4,717	5,439	0	--	--	
Clinton	15	13,435	14,337	100	--	--	No sources in the Assabet River Basin.
Concord	36	16,993	19,148	95	.882	.966	Some sources in Assabet River Basin. Total basecase demand is 2.331 Mgal/d and total year 2030 demand is 2.559 Mgal/d.
Grafton	7	14,894	22,500	[1]0	--	--	
Harvard	22	5,981	7,227	[1]0	--	--	
Hudson	94	18,113	21,921	94	2.042	2.259	Most sources in Assabet River Basin. Total basecase demand is 2.567 Mgal/d and total year 2030 demand is 2.842 Mgal/d.
Littleton	42	8,184	12,461	80	--	--	No sources in the Assabet River Basin. Year 2030 demand of 1.499 Mgal/d
Marlborough	43	36,256	40,308	99	1.549	1.791	For 1997–2001: about 32% of demand was supplied by in-model-area sources (1.549 Mgal/d) and 68% by MWRA. Total basecase demand is 4.866 Mgal/d. For 2030: about 32% of demand was supplied by in-model-basin sources (1.791 Mgal/d) and 68% from MWRA. Total year 2030 demand is 5.604 Mgal/d.
Maynard	100	10,433	11,303	100	.959	1.032	
Northborough	94	14,013	15,916	85	.790	.978	For 1997–2000: about 76% of demand was supplied by in-model-area sources (0.790 Mgal/d) and 24% by MWRA. Total basecase demand is 1.047 Mgal/d. For 2030: about 76% of demand was supplied by in-model-area sources (0.978 Mgal/d) and 24% from MWRA. Total year 2030 demand is 1.290 Mgal/d.
Shrewsbury	37	31,640	41,300	97	--	--	No sources in the Assabet River Basin. Total basecase demand is 3.856 Mgal/d and total year 2030 demand is 4.786 Mgal/d.

Table 1-1. Percentage of community area, total population, population using public water, and simulated water demand for basecase conditions and year 2030, by subbasin, Assabet and Upper Charles River Basins, eastern Massachusetts.—Continued

[Mgal/d, million gallons per day; MWRA, Massachusetts Water Resources Authority; --, not determined; Total year 2000 population and projected year 2030 population and water demand from the Metropolitan Area Planning Council (MAPC), written commun., 2006; Data for Boylston, Grafton, and Shrewsbury are from Central Massachusetts Regional Planning Agency through MAPC]

Community	Community area in model area (percent)	Total population		Population using public water (percent)	Water demand for public supply from in-basin sources (Mgal/d)		Remarks
		Year 2000	Projected year 2030		Basecase from documented ground-water models	Projected year 2030 community total	
				Assabet River Basin—Continued			
Stow	100	5,902	6,990	0	--	--	
Sudbury	9	18,716	24,017	[1]100	--	--	No sources in the Assabet River Basin. Projected 2030 demand of 2.602 Mgal/d.
Westborough	41	17,997	20,646	95	1.241	1.424	Most sources in Assabet River Basin. Total basecase demand is 2.461 Mgal/d and total year 2030 demand is 2.843 Mgal/d.
Westford	24	20,754	24,234	75	--	--	No sources in the Assabet River Basin. Projected 2030 demand of 2.035 Mgal/d.
Total demand					**9.391**	**10.715**	
				Upper Charles River Basin			
Ashland	--	14,674	20,565	--	--	--	
Bellingham	52	15,314	16,642	96	0.590	0.602	For 1989–98, 37% of demand supplied by in-model-area sources. Total year 2030 demand is 1.626 Mgal/d.
Franklin	91	29,797	35,867	80	2.772	3.673	
Holliston	100	13,801	16,078	98	1.151	1.347	
Hopedale	--	5,908	6,654	--	--	--	
Hopkinton	--	13,347	15,602	--	--	--	
Medway	100	12,448	14,122	73	.881	1.147	
Mendon	--	5,286	9,300	--	--	--	
Milford	86	26,799	30,301	94	2.985	3.460	
Millis	46	7,902	8,952	85	--	--	No sources in the Upper Charles River Basin. Projected 2030 demand is 0.869 Mgal/d
Norfolk	31	10,461	12,439	58	.393	.689	
Sherborn	--	4,200	4,689	--	--	--	
Wrentham	18	10,554	15,885	80	.734	.980	For 1998–2002, 68% of demand supplied by in-model-area sources. Total year 2030 demand is 1.441 Mgal/d.
Total demand					**9.506**	**11.899**	

[1]Value applies to area of community in basin.

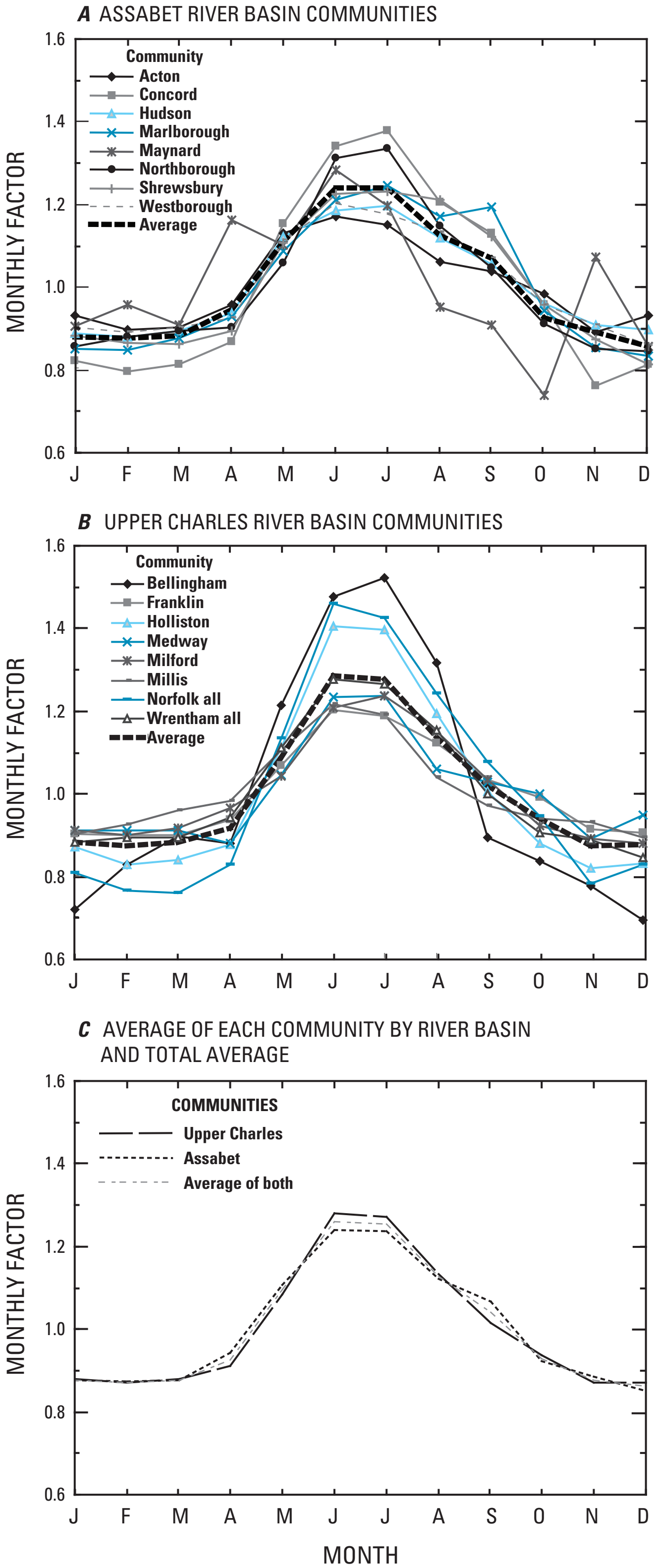

Figure 1-1. Factors representing the percentage difference of total monthly demand from annual average demand for *(A)* January 1997 through December 2001 for communities in the Assabet River Basin, *(B)* January 1989 through December 1998 for communities in the Upper Charles River Basin, and *(C)* the total average demand.

withdrawals had been apportioned to them. Holliston had no wells with withdrawals at the MWLs, and the proposed well had no year 2030 withdrawal rates applied. Medway had one well (Well No. 1) with withdrawal rates at the MWL for 12 months and another well (Well No. 3) at the MWL for 2 months. No year 2030 withdrawals were apportioned to the proposed well in Medway. Wrentham had no wells with monthly year 2030 withdrawal rates at the MWL, and no withdrawals were apportioned to the proposed well. In Milford none of the three well fields (Dilla St. Wells Nos. 1 and 2, Clark Island well field, and Godfrey Brook wells) had withdrawal rates at the MWLs. Withdrawals from the Charles River and Echo Lake were simulated at the rates used for 1989–1998 in the calibrated ground-water model by Eggleston (2004). In Norfolk, the one production well in the model area, Well No.1 Gold Street, had year 2030 withdrawal rates at the MWL for 5 months. The production well outside of the model area, Well No. 2 Spruce Road, had year 2030 withdrawal rates at the MWL for 2 months. The proposed Mill Street well in Norfolk was apportioned 2030 withdrawals for June and July.

Some communities obtained part of their water supply through purchase from outside sources, specifically, the Massachusetts Water Resources Authority (MWRA). The distribution of projected year 2030 withdrawals between in-town and outside sources was the same as for the model-calibration periods. Marlborough purchased water from the MWRA to meet water demand. For the model-calibration period 1997–2001, about 32 percent of Marlborough's water came from sources in the model area and about 68 percent from MWRA. This percent split remained unchanged after simulated withdrawals from Millham Reservoir were increased and the amount of MWRA-supplied water was increased by about 0.5 Mgal/d to meet 2030 demand.

Northborough, in addition to using local wells, purchased water from MWRA to meet demand. In Northborough about 76 percent of the demand was met by sources in the model area, and about 24 percent was imported from MWRA during the period 1997–2000. The period 1997–2000 was used because in 2001 Northborough began to purchase all water from MWRA while a new treatment plant was being built. After completion of the treatment plant, the split in source water was expected to be about the same as the pre-2001 split. After apportioning the year 2030 demand for Northborough among the three wells and the MWRA water purchase, all wells were withdrawing water at less than the MWL. Of the three wells in Northborough, withdrawal rates for the Howard Street well came closest to the MWLs for some months. The split of source water used to meet demand projected for 2030 remained about the same as that for the basecase, including an increase in the amount of MWRA-supplied water of about 0.06 Mgal/d.

Withdrawals from in-basin sources were projected to increase in year 2030 for both the Assabet and Upper Charles River Basins. Basecase withdrawals from in-basin sources were 9.39 and 9.51 Mgal/d for the Assabet and Upper Charles River Basins, respectively. Year 2030 withdrawals from in-basin sources were projected to be about 14 percent greater (10.72 Mgal/d) and about 25 percent greater (11.90 Mgal/d) for the Assabet and Upper Charles River Basins, respectively.

Estimation of 2030 Consumptive Use and Return-Flow Rates

Consumptive use is the component of a water-supply withdrawal that is removed permanently from the ground- or surface-water system through evaporation or other processes. Consumptive-use rates used in this study were calculated as percentages of total water use for the Assabet River Basin (DeSimone, 2004). Because of the similarity of the river basins in this study, the Assabet rates were applied in the Upper Charles River Basin for consistency. After water is withdrawn from the ground-water system for public or private supply, a percentage of that water is used consumptively; the remaining water becomes return flow—the water that is returned to the ground as outflow from septic systems or discharged to surface or ground water at treatment facilities. Because demand for water is predicted to increase by year 2030, both the amount of consumptive use and the associated return flow will increase. Within both model areas, water either returns to the ground by infiltration through septic systems in areas with no public sewer systems or, in areas that have public sewer systems, is transported to WWTFs, then discharged as treated wastewater effluent to the respective main-stem rivers. The WWTF in Acton is the only facility in the model area that discharges treated wastewater to the ground-water system.

Wastewater-return flows were estimated for the year 2030. The monthly water-demand increment from basecase to year 2030 due to the future increase in water demand for each community was reduced by the percentage of water that was used consumptively in that month (DeSimone, 2004). An average yearly residential consumptive use of 13 percent was determined by DeSimone (2004). The remaining water-demand increment was then apportioned by the percentage of the community on public supply and public sewer (DeSimone, 2004; Eggleston, 2004) to determine the amount of water that would become return flow either through septic systems or at a WWTF. The portion of the demand increment that would become return flow at a WWTF was added to the monthly volume that was used in the calibrated ground-water models to determine estimated 2030 flow at each facility.

In the Assabet River Basin (fig. 1-2A), there are five municipal WWTFs for which 2030 flows were estimated and two non-municipal WWTFs that were assigned the return-flow values used in the basecase ground-water simulations. The WWTF in Acton was included in the calibrated model of the Assabet River Basin, but in the simulation was assigned no flow because the facility had not yet begun operation. The Acton WWTF was included in the present study because it began operation in 2002 (fig. 1-2A). The anticipated flow from the Acton WWTF for 2030 was 250,000 gal/d (D. Halley, Director, Town of Acton Health Department, oral commun., 2006). The other municipal WWTFs are in Hudson, Marlborough, Maynard, and Westborough. The Marlborough facility treats and discharges wastewater that includes imported MWRA water from Northborough. The Westborough facility also treats and discharges wastewater from Shrewsbury that originates in the Blackstone River basin.

The Upper Charles River Basin contains two WWTFs that discharge to the Charles River (fig. 1-2B). Wastewater from Milford is treated and discharged at the Milford Treatment Facility (MTF) in Hopedale, and wastewater from Medway, Franklin, Millis, and Bellingham is treated and discharged at the Charles River Pollution Control District facility (CRPCD) in Medway.

In certain communities in the model areas, only a fraction of the currently developed areas are connected to public water supply and sewer systems. In areas of public water supply and private septic systems in these towns, return flow is the water returned to the ground as outflow from septic systems. It was assumed in the 2030 scenarios that sewer systems would not be extended beyond the current basecase extent. Developable areas simulated as developed in the 2030 scenarios were assumed to be served by septic systems if the areas were outside a 400-ft buffer around existing sewer lines. Return flow by private septic systems was simulated for portions of communities in the Assabet River Basin—Acton, Concord, Hudson, Littleton, Marlborough, Maynard, Northborough, Shrewsbury, Sudbury, Westborough, and Westford (fig. 1-3A)—and in the Upper Charles River Basin—Bellingham, Franklin, Holliston, Medway, Milford, Millis, Norfolk, and Wrentham (fig. 1-3B). In communities where more than 90 percent of the population was on public water (DeSimone, 2004), return flow was applied to all areas outside of the extent of public sewer lines. In communities where less than 90 percent of the population was on public water (DeSimone, 2004), return flow was not applied in certain areas outside the extent of public-water-supply lines. Instead, a consumptive-use amount was removed in those areas (figs. 1-4A and 1-4B).

From population projections, MAPC developed water-demand projections as a demand increment from year 2000 to 2030 for residential and commercial water uses for each community in the model areas. Each water-use projection for residential and commercial uses included an additional amount of 15 percent of each demand projection to allow for unaccounted-for demand—water that is pumped but is used at unmetered locations; used for water-system maintenance, such as water-main flushing; lost through leaks from the supply system; or lost or used for other reasons.

Return-flow rates, by community, were based on changes projected from the basecase to year 2030 in residential and commercial water demand and were applied in areas of developable residential and commercial land. Return flow by septic systems in residential areas was calculated as equal to total residential demand minus residential

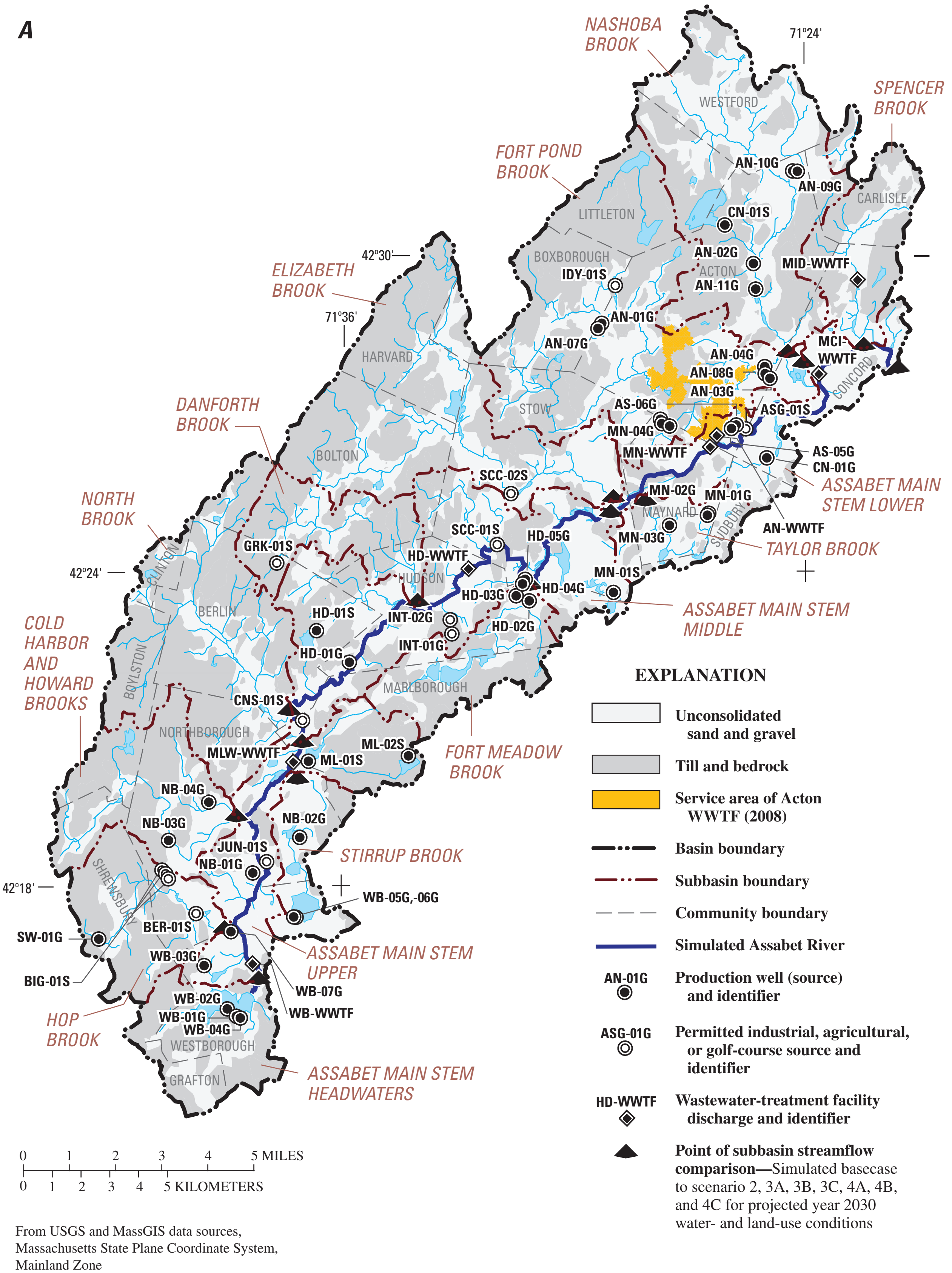

Figure 1-2. Locations of production wells, discharges from municipal and non-municipal wastewater-treatment facilities (WWTF), surficial geology, and Acton sewered area in *(A)* Assabet and *(B)* Upper Charles River basins, eastern Massachusetts.

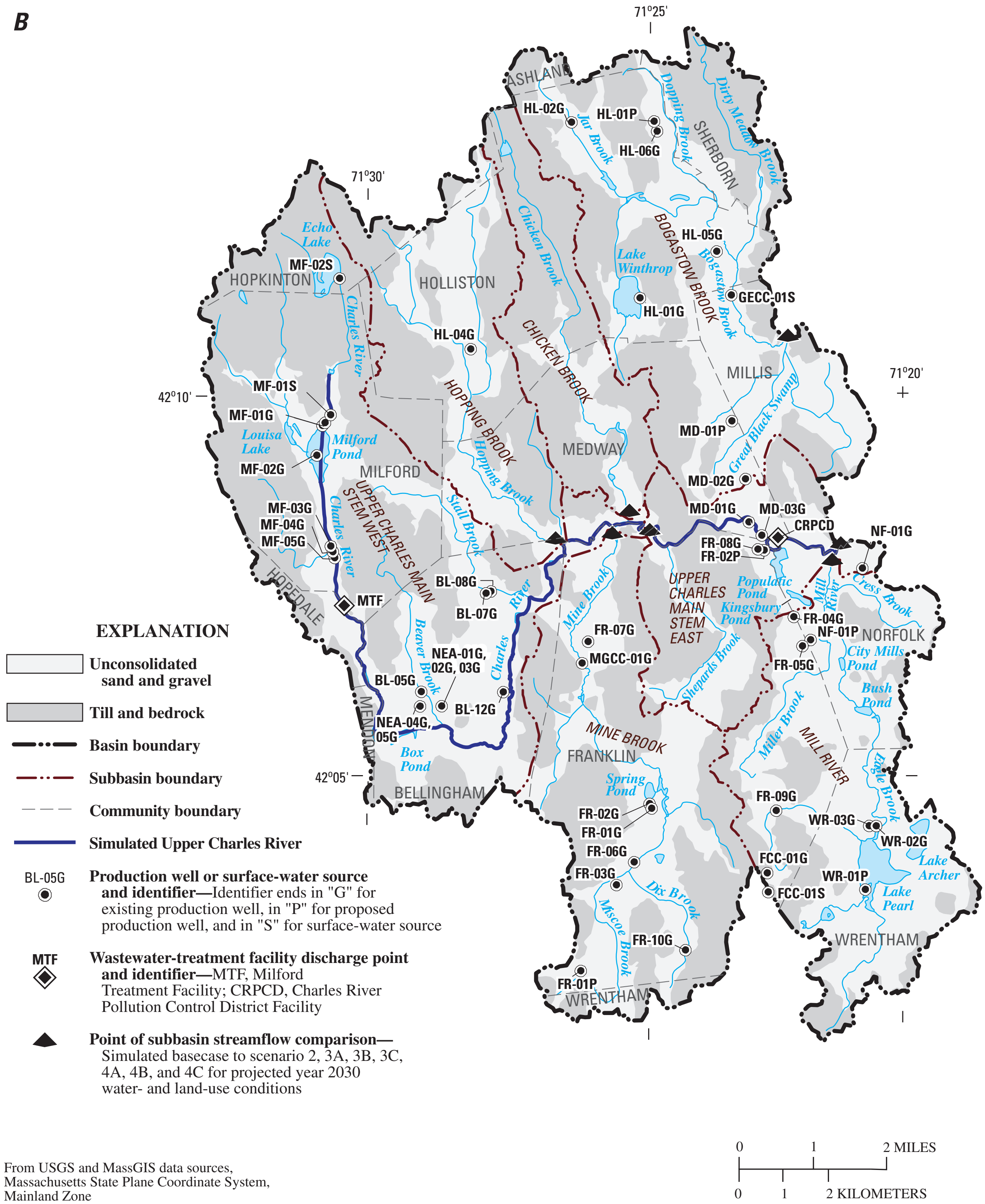

Figure 1-2. Locations of production wells, discharges from municipal and non-municipal wastewater-treatment facilities (WWTF), surficial geology, and Acton sewered area in *(A)* Assabet and *(B)* Upper Charles River Basins, eastern Massachusetts.—Continued

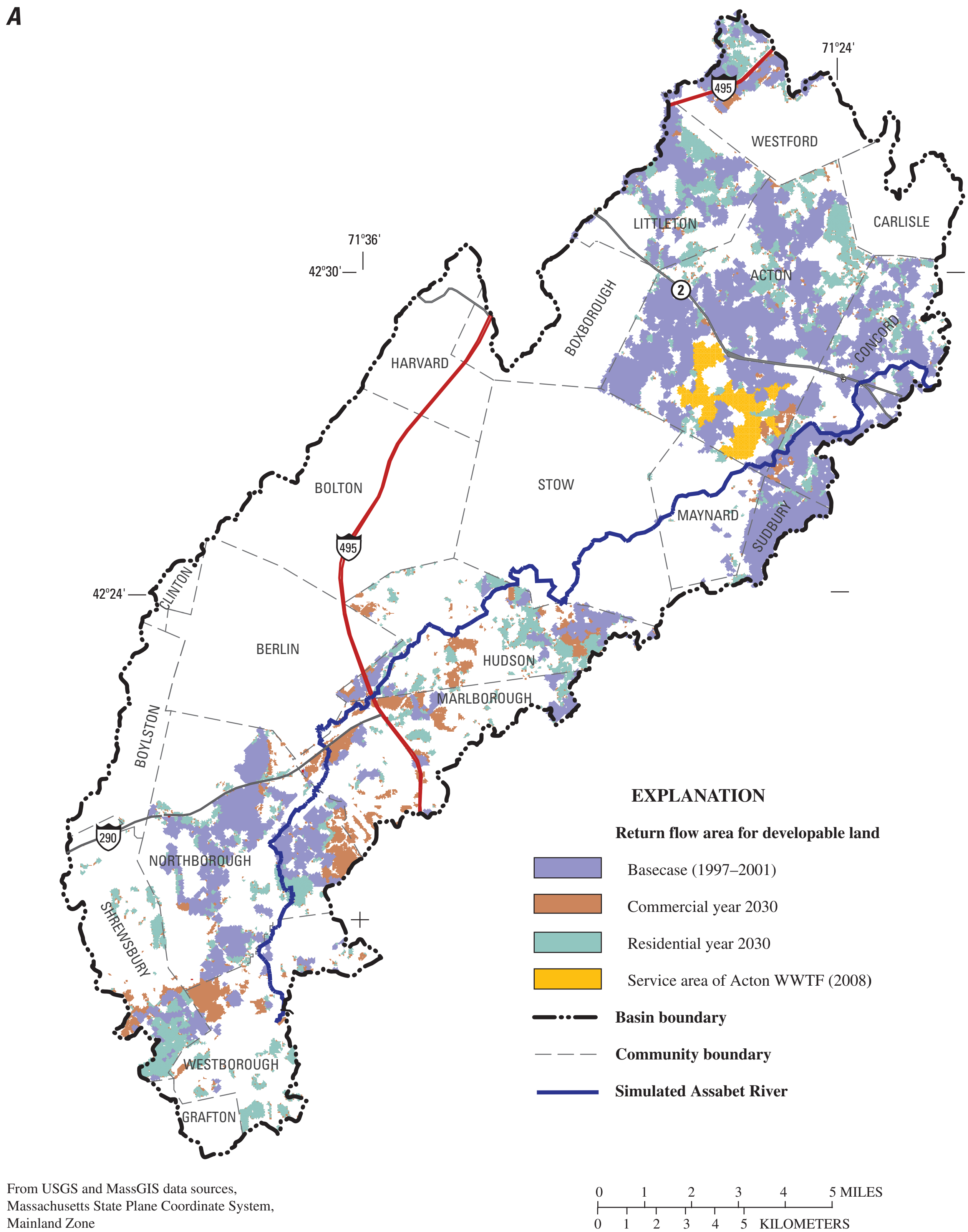

Figure 1-3. Areas of potential return flow (year 2030) from developable land in *(A)* Assabet and *(B)* Upper Charles River Basins, eastern Massachusetts.

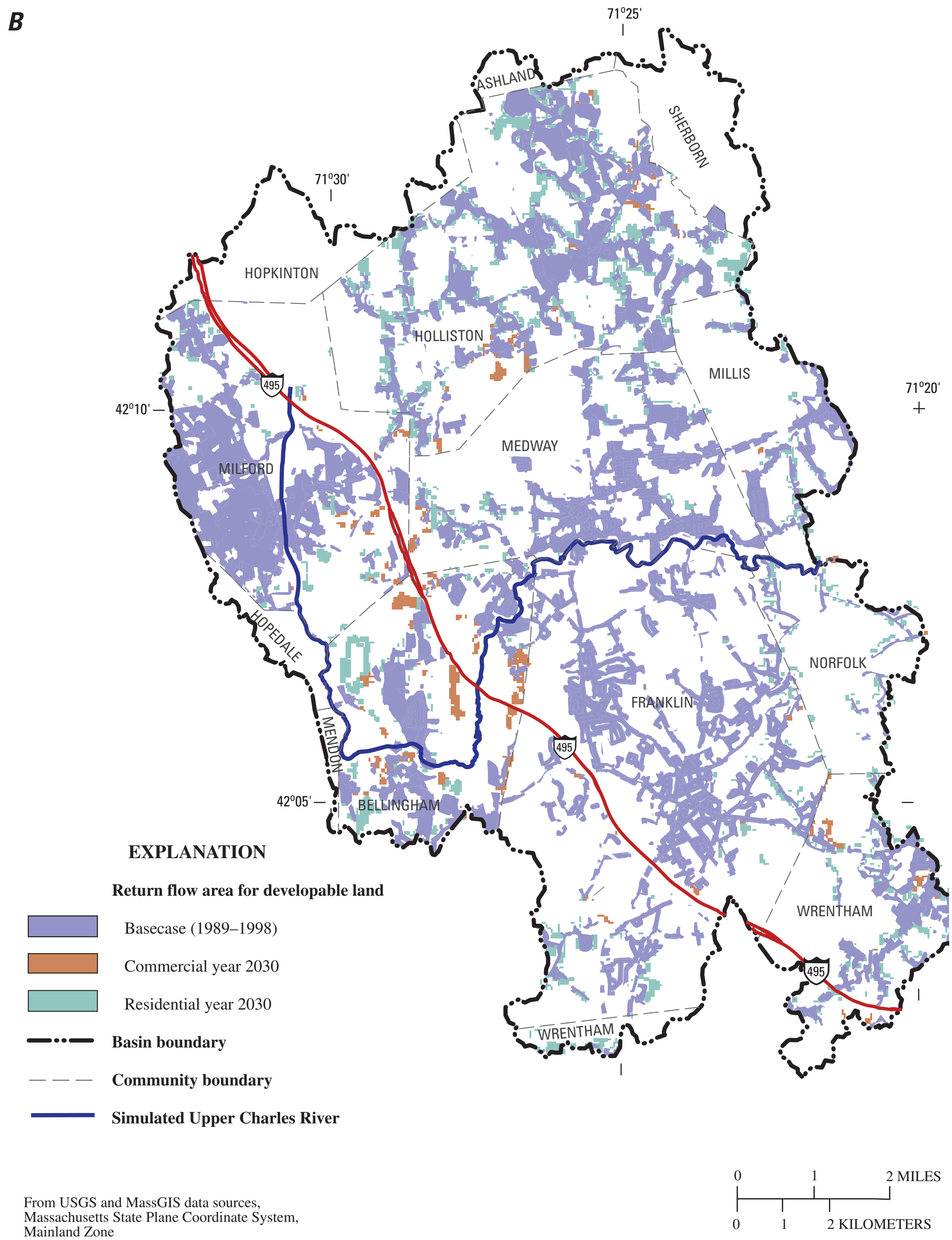

Figure 1-3. Areas of potential return flow (year 2030) from developable land in *(A)* Assabet and *(B)* Upper Charles River Basins, eastern Massachusetts.—Continued

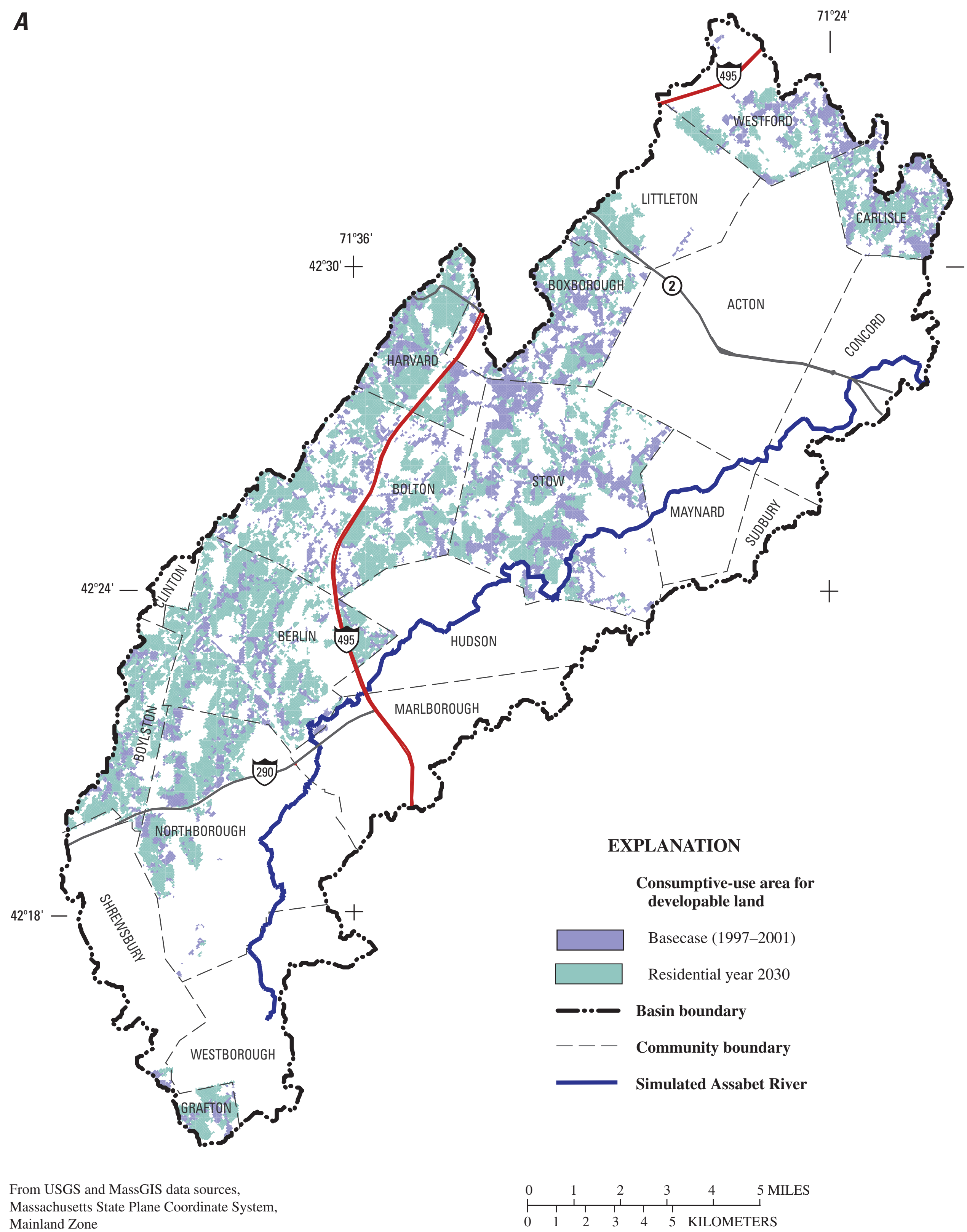

Figure 1-4. Areas of potential consumptive water use (year 2030) in *(A)* Assabet and *(B)* Upper Charles River Basins, eastern Massachusetts.

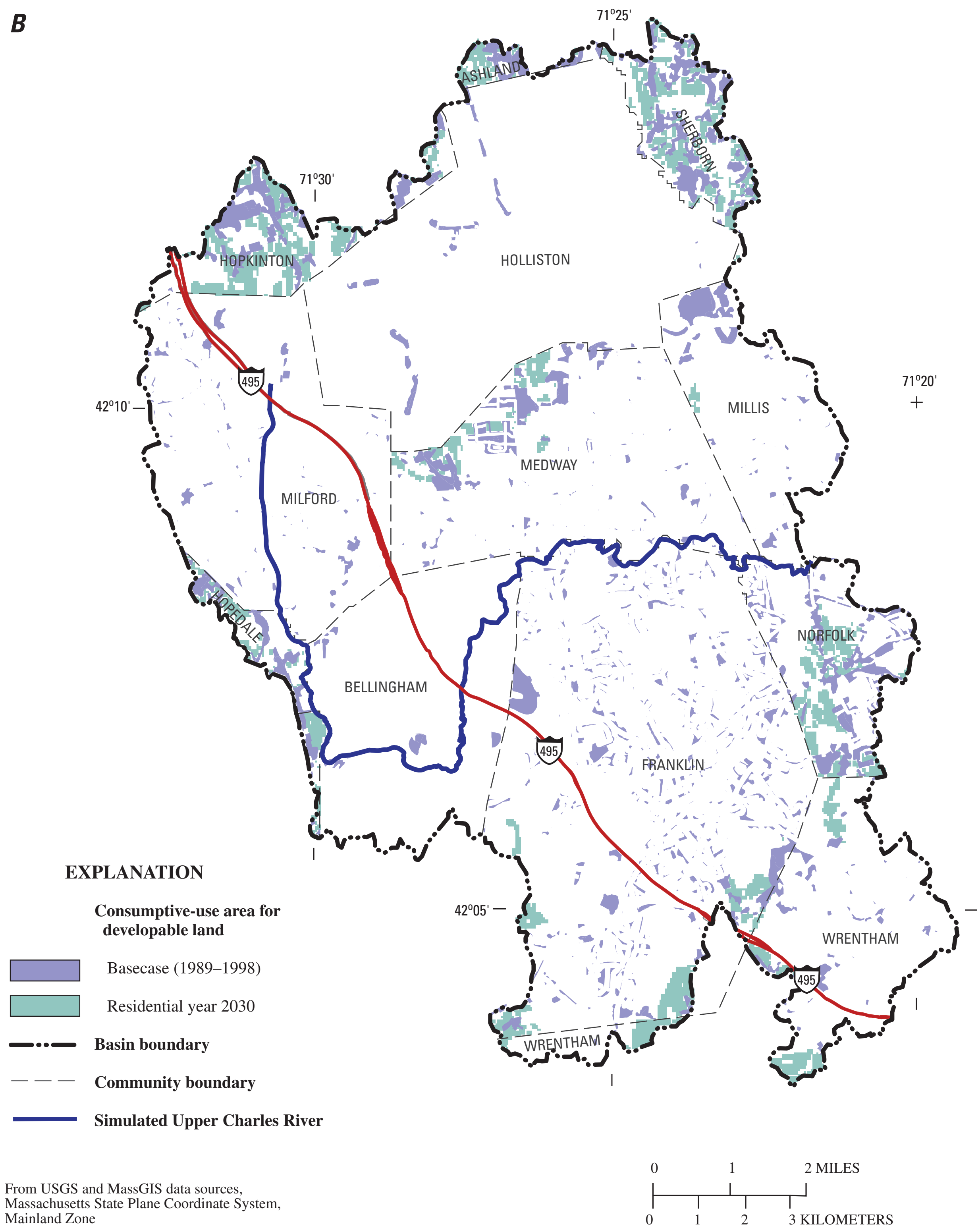

Figure 1-4. Areas of potential consumptive water use (year 2030) in *(A)* Assabet and *(B)* Upper Charles River Basins, eastern Massachusetts.—Continued

consumptive use (13 percent of annual average usage as determined by DeSimone (2004)) minus the volume of demand that ultimately becomes wastewater routed to WWTFs. Consumptive use in commercial areas was not considered in calculating septic-system return flow because data for consumptive use in commercial areas was not available. Return flow by septic systems in commercial areas was equal to total demand minus the volume of demand that ultimately becomes wastewater routed to WWTFs. The volume that was wastewater routed to WWTFs was estimated as the volume of residential and commercial demand multiplied by the percentage of the community on public sewer. Average year 2030 septic-system return-flow volumes for communities in the Assabet River Basin were 0.79 Mgal/d for residential areas (fig. 1-3A) and 0.33 Mgal/d for commercial areas (fig. 1-3B); for the Upper Charles River Basin, return-flow volumes were 0.13 Mgal/d for residential areas and 0.03 Mgal/d for commercial areas. Summed across the communities, the increment of septic-system return flow from basecase to year 2030 was an additional 1.12 Mgal/d for the Assabet River Basin and an additional 0.16 Mgal/d for the Upper Charles River Basin, relative to the basecase. The basecase total of return flow was 4.34 Mgal/d for the Assabet River Basin (DeSimone, 2004) and about 3.1 Mgal/d for the Upper Charles River Basin (DeSimone and others, 2002). The year 2030 return-flow rates for residential and commercial uses then were applied to the areas of developable land, by community, identified by the MAPC as land that could be developed into residential or commercial uses at some point in the future. Return flow was applied in the model as an annual average rate that varied by community. Results of the return-flow estimations increased for year 2030 the community-wide area to which return flow from private septic systems was applied from the basecase ground-water-model simulations.

The average increase in consumptive-use rates from the basecase for year 2030 conditions for each basin was calculated from estimates of consumptive use by community based on (1) the increment of population increase (population increment from the year 2030 new-development data set) from basecase to 2030; (2) a water-use rate of 75 gal/day per person; and (3) the percentage of residential water demand that is used consumptively (13 percent) as estimated by DeSimone (2004). This average basinwide increase in consumptive-use rates then was distributed by month by using the average monthly factor that was used previously to distribute average demand by month (fig. 1-1). Monthly increased volumes of water representing monthly consumptive use for year 2030 were calculated by using these monthly consumptive-use rates and the total area within the study area to be developed by 2030 estimated on the basis of cumulative year 2030 new-development residential acres by community. To determine the monthly rate of consumptive use applied in the numerical model, the monthly volumes of water as calculated above then were distributed basinwide over the area of developable residential acres because it was not known where development would occur within the subset of year 2030 developable acres. As in the basecase model, consumptive use was applied in April through October in areas of private water supply and private septic systems. In the Assabet River Basin, the increases in monthly consumptive use that were added to basecase consumptive use ranged from 0.008 in/yr in April to 0.061 in/yr in July; the average annual rate increase from the basecase was 0.021 in/yr. In the Upper Charles River Basin, the increases in monthly consumptive use that were added to basecase consumptive use ranged from 0.004 in/yr in April to 0.033 in/yr in July; the average annual rate increase from the basecase was 0.012 in/yr. These rates were applied to developable residential acres in areas of privately supplied water to estimate an average annual increase in consumptive use of 0.029 Mgal/d in the Assabet River Basin and 0.003 Mgal/d in the Upper Charles River Basin. In the basecase models, DeSimone (2004) estimated mean annual consumptive use for privately supplied parts of the Assabet River Basin at 0.72 Mgal/d, and Eggleston (2004) estimated consumptive use in the Upper Charles River Basin at 0.05 Mgal/d. Consumptive use was applied in the ground-water model as a basinwide rate that varied by month.

Estimation of 2030 Recharge Rates

Land-use change can affect the amount of water that infiltrates the land surface to recharge ground water as a result of asphalt or concrete paving that replaces a permeable soil, changes in evapotranspiration due to changes in vegetation, and changes in other surficial and hydrologic processes. To evaluate the potential effects of land-use change on recharge for year 2030, several possible scenarios were tested. Alternative scenarios were developed because the effects of land-use change on recharge can differ widely depending on how the land is altered.

Changes in recharge resulting from projected changes in land use in this study were based on the recharge rates assigned to land uses in the calibrated model of the Upper Charles River Basin. Recharge rates in the Upper Charles River Basin study were based, in turn, on the interflow and ground-water components in the Hydrological Simulation Program-FORTRAN (HSPF) model developed for the Ipswich River Basin, which is similar in hydrologic setting to the Assabet and Upper Charles River Basins (Zarriello and Ries, 2000). In that study, hydrologic responses to precipitation and the amount of water flowing into the subsurface differed by land use—forest, open, low-density residential, high-density residential, and commercial—and by the underlying geology—till or sand and gravel. The recharge rates derived from the Ipswich model were used in the Upper Charles model and were modified during calibration of that model (table 1-2).

In the Ipswich model, low-density residential land was defined as land use that represented single-family homes on lots larger than 0.5 acre. High-density residential land was defined as land use that represented multifamily and single-family homes on lots with areas smaller than or equal to 0.5 acre (Zarriello and Ries, 2000). The recharge rates used in the Ipswich HSPF model also accounted for the differing percentages of effective impervious area associated with the low-density residential, high-density residential, and commercial land-use categories. In the present study, the percentages of effective impervious area, by land-use category, in the basecase and seven scenarios of projected 2030 land use were the same as in the Ipswich model.

Recharge rates in the Assabet and Upper Charles River Basin models were applied by using different methods. Recharge rates for the Upper Charles River Basin model used the categories of Zarriello and Ries (2000) that varied by land-use category and surficial geology; recharge rates were increased during the model-calibration process. Recharge rates in the Assabet model differed only by surficial geology, not by land-use categories (DeSimone, 2004). The two methods used in the Assabet and Upper Charles River Basin models to specify recharge rates produced reasonable results, comparable to rates for other basins in New England (Bent, 1995, 1999; Barlow, 1997; Barlow and Dickerman, 2001; DeSimone and others, 2002; DeSimone, 2004; Eggleston, 2004). In this study, a single consistent method for applying a change in recharge caused by projected land- and water-use changes to both the Assabet and Upper Charles River Basin models was needed in order to compare streamflows from different subbasins. To determine a reasonable and consistent method for applying a change in recharge to both calibrated models, the underlying geology, recharge rates, and projected 2030 developable land area and land use were evaluated in order to quantify the proportions of the study area covered by till and sand and gravel, the proportions of the developable land that were forest or open land in 1999, the categories of potential land-use change from 1999 to 2030 depicted in the developable-land map by geology type and the categories of potential land-use change with the greatest percentage of change in recharge rate. Consideration of these factors helped to determine the types of land-use change likely to have the greatest effect on recharge rates.

The data and maps of 1999 land use and developable-land areas provided by MAPC for the study area include a variety of land-use types, such as multifamily residential, urban public, transportation, and industrial (1999 data: MassGIS, 2001; MassGIS, 2006). By using the criteria of Zarriello and Ries (2000) to combine the subcategories of residential land use (multifamily and low, medium, and high density) into low- and high-density residential areas and to combine all other commercial and industrial land-use types into one commercial land-use category, the areas in the developable-land coverage were assigned to three land-use categories: low-density residential, high-density residential, and commercial.

To calculate estimated changes in recharge, the extent of areas where land use may change from its current use to a projected 2030 use were determined. Twelve categories of potential land-use change were determined, as well as the associated change in recharge rate (table 1-3). The change in recharge was calculated for this study from the rates used in the calibrated Upper Charles River Basin model (DeSimone and others, 2002; Eggleston, 2004). The percentage gain or loss for each change-in-recharge combination is shown in table 1-3.

Table 1-2. Simulated recharge rates, by land use and surficial geology, Upper Charles River Basin, eastern Massachusetts.

[in/yr, inches per year]

Land use	Recharge rate (in/yr)	
	Sand and gravel	Till and bedrock
Forest	24.1	20.7
Open	36.5	25.5
Low-density residential	32.9	22.2
High-density residential	29.0	19.5
Commercial	10.7	10.7

To simplify the recharge-change scenarios, the categories of land-use change in the developable areas that accounted for the greatest areal extent within the study area were identified. Table 1-3 shows for the Assabet and Upper Charles River Basins the land-use-change categories by geologic setting identified from the developable-land areas provided by MAPC. Not all of the developable areas will undergo a change in land use by year 2030, but these are locations where a potential change in land use could occur, along with a potential associated change in recharge. The following comparisons are presented in terms of the percentage of developable land that is predicted to change from a current land use—forest or open—to a future land use—commercial or low- or high-density residential—sorted by underlying geology (the values shown will be of the format “ar”/“uc”, where “ar” represents the value for the Assabet River Basin and “uc” represents the value for the Upper Charles River Basin). About 53/43 percent (of the developable land) is currently forest overlying till and is projected to be developed for low-density residential use. About 12/21 percent is currently forest over sand and gravel, and is projected to be developed for low-density residential use and about 8/7 percent of the study area is currently forest over till and is projected to be developed for commercial use. Each of the other combinations of land-use change in areas of forest or open land (and till or sand and gravel) are associated with developable areas that cover less than 10/10 percent of the areas.

In the Assabet and Upper Charles River Basins, the approximate percentages of the developable areas by current land use (regardless of future projected land use)—forest or open—and underlying geology—till or sand and gravel—were

Table 1-3. Change in recharge rates from basecase conditions due to change in land use and magnitude of year 2030 land-use change, by surficial geology, Assabet and Upper Charles River Basins, eastern Massachusetts.

[in/yr, inches per year; <, less than]

Land-use change	Change in recharge rates				Magnitude of year 2030 land-use change of basin area (percent)			
	(in/yr)		(percent)		Assabet		Upper Charles	
	Sand and gravel	Till and bedrock	Sand and gravel	Till and bedrock	Sand and gravel	Till and bedrock	Sand and gravel	Till and bedrock
Forest to low-density residential	8.8	1.5	37	7	12	53	21	43
Open to low-density residential	-3.6	-3.3	-10	-13	7	9	6	7
Forest to high-density residential	4.9	-1.2	20	-6	4	2	<1	<1
Open to high-density residential	-7.5	-6.0	-21	-24	<1	<1	<1	<1
Forest to commercial	-13.4	-10.0	-56	-48	4	8	5	7
Open to commercial	-25.8	-14.8	-71	-58	3	1	2	1

calculated as 79/83 percent forest land and 21/17 percent open land, and 73/62 percent till and 27/38 percent sand and gravel, respectively, of the developable-land alone (regardless of current land use with geology). About 3/less than 1 percent of the developable land is projected to be developed as high-density residential use, 16/17 percent as commercial use, and 81/81 percent as low-density residential use.

Patterns of future development and land-management practices in low-density residential areas are uncertain. For home construction purposes, for example, the number of trees removed per lot can range from removal of trees at the home location and selective removal of other trees to nearly complete tree removal. In preparing a lot for construction, complete tree removal would tend to change the recharge rate from that of forested land to that of developed open land. If selective tree removal is practiced widely, residential areas may undergo a minimal change in recharge rate or a rate between that of forest and open land. If this type of land-management practice were applied to most areas of the developable land projected to become low-density residential, then either no change or a slight change in recharge could be used in the ground-water-model simulation. It is possible that this change could effect an increase or decrease in the rate of recharge, depending on how the land is developed. This is one possible concept of how recharge can change with development, and is not a definitive outcome. Further study of how various amounts of tree removal can affect recharge rates would be useful.

A simplified percent-change-in-recharge approach was used to characterize 2030 recharge rates in this study. This approach takes into consideration land use and underlying geology, the uncertainty regarding the areas of new development, the approach of this study being to quantify water-budget changes on a subbasin scale, and the specification of recharge rates in the basecase ground-water models by surficial geology alone for the Assabet River Basin and by surficial geology and land use for the Upper Charles River Basin. For the residential land-use category, low- and medium-to-high-density residential areas were combined into one category of residential land use because medium- and high-density residential uses are relatively uncommon in the study area, and the 2030 projections from MAPC do not distinguish between low-, medium-, and high-density residential development. Of the developable land in the two study basins, 81/81 percent is predicted to be developed for low-density residential use. About 53/43 percent of the developable forest land overlying till is projected to be developed for low-density residential use. Because the number of acres projected to be developed by 2030 is known but the exact location of those future 2030-developed acres within the developable areas determined by MAPC is unknown, the simplified percent-change-in-recharge rates were applied uniformly to the respective till and sand and gravel areas in each subbasin. This approach was believed to be a reasonable means of implementing potential changes in recharge and land use for this study, given the uncertainties inherent in projecting future demand and population growth on a subbasin scale.

Simplified percent-change-in-recharge rates of plus or minus 10 percent for residential and minus 50 percent for commercial areas were believed to be reasonable values of recharge for this study. To calculate the rates for residential and commercial areas, the percent-change values shown in table 1-3 were used as a guide. The percent-change recharge rates for categories related to a change to high-density residential were not considered because a change to high-density residential use is projected in only 3/less than 1 percent of the river basins. The percent-change recharge rates associated with low-density residential development ranged from a decrease of 13 percent (change of open land to low-density residential in till) to an increase of 37 percent (change of forest to low-density residential in sand and gravel). Although the increase in recharge of 8.8 in/yr (37 percent, table 1-3) associated with the change from forest to low-density residential in sand and gravel is consistent with the findings of Zarriello and Ries (2000), this rate change may not be applicable to the river basins in this study; further study of potential recharge-rate changes from forest to residential land is needed. The recharge rate associated with the change of forest to low-density residential in till increased 7 percent, whereas the recharge rate associated with the conversion of open land to low-density residential in sand and gravel decreased 10 percent (table 1-3). Therefore, a range of minus 10 to plus 10 percent was chosen to represent the recharge change that is likely to occur for the land-use categories and geology types that cover the greatest proportion of the study basins.

Percent-change-in-recharge rates for commercial areas were estimated in a similar manner. The greatest loss in recharge from current land use to a future use is estimated to occur for commercial use (table 1-3). The percent-change-in-recharge rates range from a decrease of 48 percent (forest to commercial in till) to a decrease of 71 percent (open land to commercial in sand and gravel). Forest overlying till is the dominant land type projected for commercial development (covering about 8/7 percent of the river basins). Because a decrease in recharge of 48 percent was associated with the land-use change of forest to commercial overlying till, a simplified percent-change-in-recharge rate of minus 50 percent was believed to be a reasonable value to apply to potential recharge changes associated with future commercial development in this study.

The recharge rates used in the models to simulate scenarios with projected land-use changes in this study were based on 10 and 50 percent of the basecase recharge rates used in the calibrated models of the Assabet and Upper Charles River Basins, the volumes of water represented by the product of the 10 and 50 percent recharge rates and the area of year 2030 new development in each subbasin, and the distribution of those volumes of water over the total developable areas of till and sand and gravel by subbasin. First, 10 and 50 percent of the calibrated recharge rates were calculated for each basin for each type of surficial geology. Second, the volume of water representing the product of each 10 and 50 percent value and the number of year 2030 new-development acres in each subbasin was calculated by till and sand and gravel areas (tables 1-4 and 1-5). The outcome represented the volume of water that would be added to or subtracted from the water budget in each subbasin as a result of a change in recharge applied in the scenarios. Because the location of new 2030 development in each subbasin was uncertain and because streamflow out of each subbasin was the criterion for the comparisons in this study, these volumes were distributed over the total developable till and sand and gravel areas in each subbasin. From these till and sand and gravel areas, the percent-change-in-recharge rates applied to the ground-water models in this study then were calculated (tables 1-4 and 1-5). These values, in inches per year (in/yr), represent the average annual change in recharge from basecase recharge for a decrease in recharge of 50 percent for 2030 commercial areas and a decrease of 10 percent and an increase of 10 percent for 2030 residential areas.

For use in the transient Assabet and Upper Charles River Basin models, the average annual change in recharge rates calculated above were distributed by month by using the proportion by which the calibrated basecase monthly recharge rates differed from the calibrated basecase average annual recharge rates. Monthly recharge rates for the Assabet and Upper Charles River Basins applied to till and sand and gravel areas of projected 2030 new development for a decrease in recharge of 50 percent for 2030 commercial areas and a decrease of 10 percent and an increase of 10 percent for 2030 residential areas are shown in figures 1-5A and 1-5B. Monthly rates used in the basecase simulations are also shown.

Description of 2030 Simulation Model

Simulated changes in streamflow were determined for average annual, March, and September conditions in the Assabet and Upper Charles River Basins. March and September are used to represent the typical wet and dry months of the year (DeSimone, 2004). Changes from the basecase in cumulative downstream flow are shown for the subbasins along the main-stem reaches of the Assabet River in figures 4 and 6 and Upper Charles River in figures 8 and 10 because these subbasins have stream inflows from upstream subbasins. The changes from the basecase in streamflows from individual subbasins are shown for the remaining subbasins in the study area in figure 11. In the Assabet River Basin, streamflows from Cold Harbor and Howard Brook, Stirrup Brook, Hop Brook, and Main Stem Headwater subbasins are tributary to the Main Stem Upper subbasin; streamflows from Danforth Brook, Fort Meadow Brook, North Brook, and Main Stem Upper subbasins are tributary to the Main Stem Middle subbasin; streamflows from Spencer Brook, Fort Pond Brook, Taylor Brook, Elizabeth Brook, and Main Stem Middle subbasins are tributary to the Main Stem Lower subbasin; and streamflow from the Nashoba Brook subbasin is tributary to the Fort Pond Brook subbasin. In the Upper Charles River Basin, streamflows from Hopping Brook, Chicken Brook, and Mine Brook subbasins are tributary to the Main Stem West subbasin, and streamflows from Mill River and Main Stem West subbasins are tributary to the Main Stem East subbasin.

Components of the ground-water budget are the inflows to ground water and outflows from ground water. Changes in the volumes of inflows and outflows can indicate whether any component could contribute to changes in streamflow by subbasin. The inflow components of ground water are recharge, which includes precipitation recharge throughout the study area and return flow applied in areas of public supply and private septic systems; leakage to ground water from streams in losing stream reaches; inflow from other

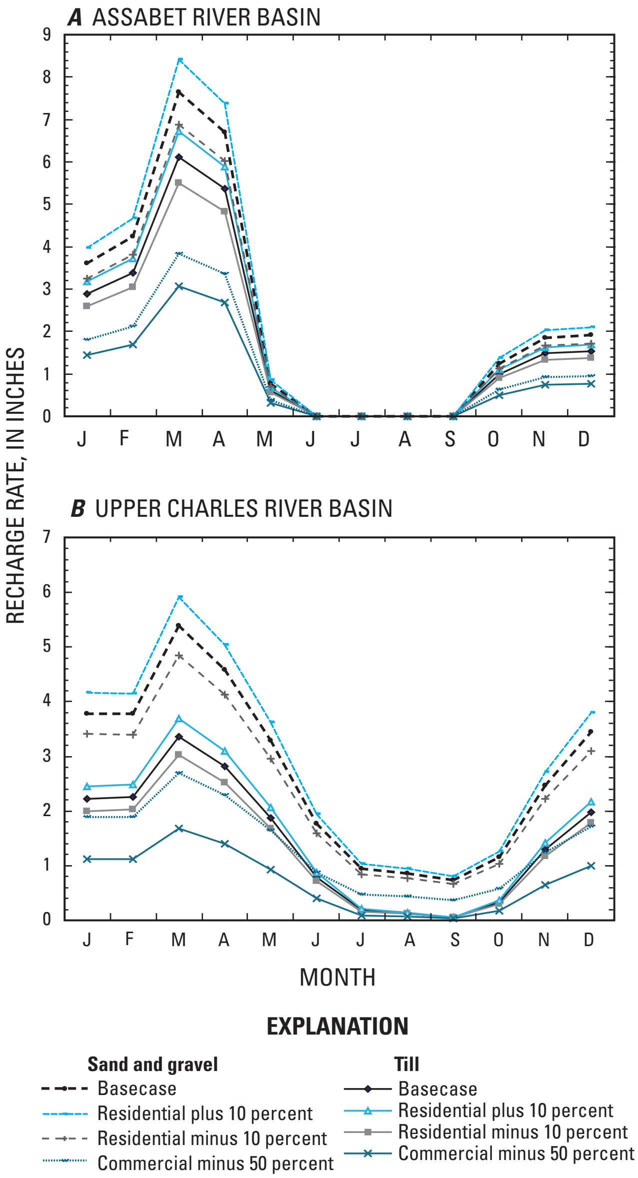

Figure 1-5. Monthly recharge rates used in model simulations for *(A)* Assabet and *(B)* Upper Charles River Basins, eastern Massachusetts.

subbasins; and in the Assabet River Basin, inflow from the Acton Wastewater Treatment Facility. Ground-water-outflow components are evapotranspiration, discharge at pumped wells, consumptive use (applied from April through October in areas of private supply and private septic systems), leakage from ground water to streams in gaining stream reaches, and outflow to other subbasins. The relative magnitudes of flow-component changes in the average annual, March, and September water budgets from basecase values for each scenario differed by subbasin and scenario. Changes in the ground-water-flow components of the scenarios are described in terms of their equivalent volumes in cubic feet per second because these changes to water-budget components can affect streamflow and are not direct changes in streamflow (appendixes 3-6). In the basecase model of the Assabet River Basin, no recharge was applied in the months of June through September. Consequently, for the Assabet River Basin scenarios that include year 2030 land-use changes, there is no change in recharge resulting from land-use change for September. Changes in recharge in previous months can indirectly affect September streamflows. However, scenarios that include year 2030 water use incorporate changes in recharge due to changes in return flow that are applied monthly.

The average annual steady-state water budgets for the ground-water-flow system for each scenario in the Assabet (table 1-6) and Upper Charles River (table 1-7) basins were calculated by simulating steady-state conditions and then comparing the results to the basecase results. Average annual water-budget changes from the basecase are tabulated in appendixes 3 and 5 by scenario and subbasin.

Transient ground-water models were used to simulate variations in hydrologic conditions, particularly during the low-flow period within the annual cycle (late summer months). The effects of water-management practices on hydrologic systems often are a concern during these months because streamflow depletion and water-quality impairments produce their greatest effects during low-flow conditions. Water demands also are typically greatest during the summer. The transient models are similar to the steady-state models for both river basins in that the grid, aquifer geometry, boundary conditions (other than specified flows), and hydraulic properties (with the addition of aquifer storage) are the same. Stresses, however, vary with time. The transient model was used to simulate dynamic equilibrium, or the condition in which there is no net change in storage at the end of the year (Barlow and Dickerman, 2001). Water budgets for March and September, the typical high- and low-flow months of the simulated annual cycle, for the ground-water-flow systems of the Assabet River (table 1-8) and the Upper Charles River (table 1-9) Basins were calculated for each scenario and subbasin by using the transient ground-water model. Changes in water budgets from the basecase for March and September were tabulated in appendix 4 for the Assabet River Basin and in appendix 6 for the Upper Charles River Basin. Average streamflows in September are lower than in March; hence, changes in streamflow during the low-flow months can be more important in terms of minimum streamflow requirements and stream water-quality standards. Because streamflows are lower in September than March, a small change in streamflow in September represents a greater percentage of overall streamflow out of each subbasin than a larger change represents in March.

Table 1-4. Change in recharge rate for acres to be developed by year 2030 for residential and commercial uses, by surficial geology, in subbasins in the Assabet and Upper Charles River Basins, eastern Massachusetts.

[in/yr, inches per year; --, no data]

Subbasin	Projected year 2030 residential areas				Projected year 2030 commercial areas			
	Acres to-be-developed by 2030		Change in simulated recharge (in/yr)		Acres to-be-developed by 2030		Change in recharge (in/yr)	
	Sand and gravel	Till and bedrock	Sand and gravel	Till and bedrock	Sand and gravel	Till and bedrock	Sand and gravel	Till and bedrock
Assabet River Basin								
Assabet Main Stem Headwaters	182	845	0.510	0.655	12	29	-0.169	-0.112
Assabet Main Stem Upper	274	259	.298	.190	90	96	-.493	-.352
Assabet Main Stem Middle	378	522	.184	.224	159	150	-.388	-.323
Assabet Main Stem Lower	310	97	.221	.202	118	3	-.420	-.029
Cold Harbor and Howard Brooks	114	568	.235	.313	0	0	-.003	-.000
Danforth Brook	57	335	.194	.248	5	0	-.080	.000
Elizabeth Brook	234	853	.176	.252	51	17	-.191	-.025
Fort Meadow Brook	183	485	.494	.447	55	40	-.749	-.185
Fort Pond Brook	216	948	.149	.226	57	56	-.196	-.067
Hop Brook	174	438	.433	.281	29	173	-.367	-.556
Nashoba Brook	572	996	.308	.328	77	34	-.207	-.057
North Brook	94	813	.117	.235	22	10	-.138	-.014
Spencer Brook	115	218	.288	.203	--	--	--	--
Stirrup Brook	136	37	.320	.106	44	77	-.520	-1.099
Taylor Brook	76	49	.139	.166	2	0	-.022	-.001
Upper Charles River Basin								
Bogastow Brook	670	783	.429	.219	54	26	-.174	-.037
Chicken Brook	172	555	.751	.266	4	14	-.089	-.035
East Upper Charles	347	542	.533	.315	5	5	-.037	-.016
Hopping Brook	465	601	.606	.253	18	95	-.115	-.200
Mill River	1,241	401	.628	.278	38	22	-.096	-.077
Mine Brook	563	628	.446	.209	68	112	-.270	-.187
West Upper Charles	605	790	.352	.142	137	232	-.398	-.209

Table 1-5. Recharge rates for basecase conditions and rates using 10 and 50 percent of basecase, by surficial geology, Assabet and Upper Charles River Basins, eastern Massachusetts.

[in/yr, inches per year]

Surficial geology	Basecase model recharge rate (in/yr)	10 percent of basecase (in/yr)	50 percent of basecase (in/yr)
Assabet River Basin			
Sand and gravel	28.2	2.8	14.1
Till and bedrock	22.5	2.3	11.3
Upper Charles River Basin			
Sand and gravel	32.3	3.2	16.1
Till and bedrock	17.3	1.7	8.7

Table 1-6. Average annual steady-state water budgets for the ground-water flow system for basecase and seven scenarios, Assabet River Basin, eastern Massachusetts.

[Values are in million gallons per day, Mgal/d; WWTF, wastewater treatment facility; ET, evapotranspiration]

Budget component	Basecase scenario 1	Scenario 2	Scenario 3A	Scenario 3B	Scenario 3C	Scenario 4A	Scenario 4B	Scenario 4C
Inflows								
Acton WWTF discharge to ground water	0.0	0.2	0.0	0.0	0.0	0.2	0.2	0.2
Recharge from precipitation and return flow	180.8	181.8	179.4	177.5	181.3	180.4	178.5	182.3
Stream leakage to aquifer	10.9	11.3	11.0	11.2	11.1	11.3	11.3	11.2
Total inflow	**191.7**	**193.3**	**190.5**	**188.7**	**192.5**	**192.0**	**190.1**	**193.8**
Outflows								
Water-supply withdrawals	9.9	11.2	9.9	9.9	9.9	11.2	11.2	11.2
ET from non-wetland areas	13.0	13.0	12.9	12.8	13.1	12.9	12.8	13.1
ET from wetlands and ponds	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
Ground-water discharge to streams	139.6	140.1	138.5	137.0	140.4	138.9	137.2	140.5
Total outflow	**191.9**	**193.6**	**190.7**	**189.0**	**192.7**	**192.3**	**190.5**	**194.1**
Budget error (inflow minus outflow)	-.2	-.3	-.2	-.3	-.2	-.3	-.3	-.3

Table 1-7. Average annual steady-state water budgets for the ground-water flow system for basecase and seven scenarios, Upper Charles River Basin, eastern Massachusetts.

[Values are in million gallons per day, Mgal/d]

Budget component	Basecase scenario 1	Scenario 2	Scenario 3A	Scenario 3B	Scenario 3C	Scenario 4A	Scenario 4B	Scenario 4C
Inflows								
Recharge from precipitation and return flow	106.1	106.0	105.3	103.8	106.8	105.3	103.8	106.8
Stream leakage to aquifer	5.2	5.5	5.2	5.3	5.1	5.5	5.6	5.4
Total inflow	**111.3**	**111.5**	**110.5**	**109.0**	**111.9**	**110.8**	**109.4**	**112.3**
Outflows								
Water-supply withdrawals	8.2	9.9	8.2	8.2	8.2	9.9	9.9	9.9
Ground-water discharge to streams	103.1	101.6	102.3	100.8	103.8	100.9	99.5	102.4
Total outflow	**111.3**	**111.5**	**110.5**	**109.0**	**111.9**	**110.8**	**109.4**	**112.3**
Budget error (inflow minus outflow)	0	0	0	0	0	0	0	0

Table 1-8. Water budgets for March and September for the ground-water flow system for basecase and seven scenarios, Assabet River Basin, eastern Massachusetts.

[Values are in million gallons per day, Mgal/d; WWTF, wastewater treatment facility; ET, evapotranspiration]

Budget component	Basecase scenario 1	Scenario 2	Scenario 3A	Scenario 3B	Scenario 3C	Scenario 4A	Scenario 4B	Scenario 4C
March								
Inflows								
Storage	0.5	0.7	0.5	0.5	0.5	0.7	0.7	0.7
Acton WWTF discharge to ground water	.0	.2	.0	.0	.0	.2	.2	.2
Recharge from precipitation and return flow	576.0	577.0	571.7	565.6	577.8	572.8	566.7	578.8
Stream leakage to aquifer	11.5	11.8	11.7	11.8	11.6	11.9	12.0	11.8
Total inflow	**588.0**	**589.7**	**583.9**	**578.0**	**589.9**	**585.6**	**579.7**	**591.6**
Outflows								
Storage	260.9	260.9	259.1	256.9	261.3	259.0	256.8	261.2
Water-supply withdrawals	9.3	10.6	9.3	9.3	9.3	10.6	10.6	10.6
ET from wetlands and ponds	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Ground-water discharge to streams	308.5	309.0	306.3	302.6	310.0	306.8	303.1	310.5
Total outflow	**586.4**	**588.1**	**582.4**	**576.5**	**588.3**	**584.1**	**578.2**	**590.1**
Budget error (inflow minus outflow)	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5
September								
Inflows								
Storage	93.8	93.7	93.5	93.0	93.9	93.2	92.8	93.7
Acton WWTF discharge to ground water	.0	.2	.0	.0	.0	.2	.2	.2
Recharge from precipitation and return flow	4.3	5.3	4.3	4.3	4.3	5.3	5.3	5.3
Stream leakage to aquifer	13.4	13.8	13.5	13.6	13.4	13.9	14.0	13.8
Total inflow	**111.5**	**113.1**	**111.2**	**110.9**	**111.6**	**112.6**	**112.4**	**113.1**
Outflows								
Storage	.6	.7	.6	.6	.6	.7	.8	.6
Water-supply withdrawals	10.5	11.7	10.5	10.5	10.5	11.7	11.7	11.7
ET from non-wetland areas	9.7	9.8	9.6	9.5	9.7	9.7	9.6	9.8
Basecase ET from wetlands and ponds, consumptive use, and infiltration to sewers	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2
Ground-water discharge to streams	49.0	49.4	48.9	48.6	49.2	49.1	48.8	49.4
Total outflow	**112.0**	**113.7**	**111.9**	**111.5**	**112.2**	**113.4**	**113.1**	**113.7**
Budget error (inflow minus outflow)	-.5	-.6	-.6	-.6	-.6	-.8	-.7	-.7

Table 1-9. Water budgets for March and September for the ground-water flow system for basecase and seven scenarios, Upper Charles River Basin, eastern Massachusetts.

[Values are in million gallons per day, Mgal/d; ET, evapotranspiration]

Budget component	Basecase scenario 1	Scenario 2	Scenario 3A	Scenario 3B	Scenario 3C	Scenario 4A	Scenario 4B	Scenario 4C
March								
Inflows								
Storage	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Recharge from precipitation and return flow	218.4	218.5	216.9	213.8	220.1	217.0	213.9	220.2
Stream leakage to aquifer	3.0	3.1	3.1	3.1	3.0	3.2	3.3	3.1
Total inflow	**221.5**	**221.7**	**220.1**	**217.0**	**223.2**	**220.2**	**217.2**	**223.3**
Outflows								
Storage	41.7	41.9	41.5	41.0	42.0	41.7	41.2	42.2
Water-supply withdrawals	9.5	10.8	9.5	9.5	9.5	10.8	10.8	10.8
Ground-water discharge to streams	170.3	168.9	169.1	166.5	171.6	167.7	165.1	170.3
Total outflow	**221.5**	**221.6**	**220.1**	**217.0**	**223.2**	**220.2**	**217.2**	**223.3**
Budget error (inflow minus outflow)	.0	.1	.0	.0	.0	.0	.0	.0
September								
Inflows								
Storage	29.9	30.6	29.8	29.4	30.1	30.5	30.3	30.8
Recharge from precipitation and return flow	21.6	21.8	21.5	21.2	21.8	21.7	21.4	22.0
Stream leakage to aquifer	7.1	7.4	7.2	7.2	7.1	7.4	7.5	7.4
Total inflow	**58.6**	**59.8**	**58.5**	**57.9**	**59.0**	**59.6**	**59.1**	**60.2**
Outflows								
Water-supply withdrawals	7.8	9.6	7.8	7.8	7.8	9.6	9.6	9.6
Consumptive use and ET from wetlands	5.6	5.8	5.6	5.6	5.6	5.8	5.8	5.8
Ground-water discharge to streams	45.3	44.5	45.1	44.5	45.6	44.4	43.8	44.9
Total outflow	**58.7**	**59.9**	**58.5**	**57.9**	**59.0**	**59.7**	**59.1**	**60.2**
Budget error (inflow minus outflow)	-.1	-.1	-.0	.0	.0	-.1	.0	.0

Appendix 2. Year 2030 Monthly Ground-Water and Surface-Water Withdrawals, Zone II Limits for Wells or the Maximum Withdrawal Limit Used for Surface Sources, Assabet and Upper Charles River Basins, Eastern Massachusetts

Appendix 2. Year 2030 monthly ground-water and surface-water withdrawals, Zone II limits for wells or the maximum withdrawal limit used for surface sources, Assabet and Upper Charles River Basins, eastern Massachusetts.

[ave, average; ft^3/d, cubic feet per day; gal/min, gallon per minute; Mgal/d, million gallons per day; MWRA, Massachusetts Water Resources Authority; --, no data]

Source	Year 2030 monthly withdrawals (ft^3/d)												ZONE II limit		Comment
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	(gal/min)	(ft^3/d)	
Assabet River Basin															
Acton Whitcomb well	16,024	22,196	22,429	25,210	29,041	19,082	23,675	16,938	18,631	9,334	8,943	12,714	245	47,163	
Acton Conant well	23,194	13,937	8,778	15,167	28,392	31,972	39,632	33,988	25,816	24,248	21,411	15,124	325	62,563	
Acton Lawsbrook well	18,844	16,743	20,213	20,213	20,213	20,213	20,213	20,213	20,213	20,213	20,213	19,353	105	20,213	
Acton Christofferson well	25,006	24,000	23,269	28,331	30,258	38,516	38,492	37,655	32,805	28,611	28,047	25,299	278	53,515	
Acton Scribner well	12,963	13,058	14,328	18,688	19,752	20,213	19,777	17,997	16,443	14,517	11,870	8,951	105	20,213	
Acton Assabet well #1	45,492	47,402	48,416	40,936	49,777	55,083	56,142	53,759	47,727	46,084	39,418	44,332	347	66,798	
Acton Assabet well #2	49,088	48,035	47,318	38,991	63,535	66,363	66,798	66,798	62,124	58,883	58,672	53,651	347	66,798	
Acton Clapp well	7,011	2,846	1,823	4,959	6,860	31,737	26,163	14,756	17,653	11,278	13,006	9,613	245	47,163	
Acton Marshall well	3,898	3,866	3,884	3,290	15,040	7,339	10,955	4,593	752	1,082	987	2,778	208	40,040	
Acton Kennedy well #1–4	54,878	63,931	67,244	67,427	50,657	71,184	60,754	59,105	56,979	52,065	48,131	54,197	375	72,188	
Acton Conant II well #1–5	9,381	7,866	8,134	17,472	17,894	19,507	16,918	15,444	16,297	15,095	15,098	14,969	300	57,750	
Maynard well #1 & 2 Old Marlboro Rd.	39,636	31,886	30,571	29,882	38,288	48,319	35,938	52,886	49,466	45,891	29,772	33,667	405	77,963	
Maynard well #3 Old Marlboro Rd.	16,813	22,097	27,403	20,960	26,671	29,202	10,119	13,887	11,163	12,977	10,226	10,685	202	38,885	
Maynard well #4 Green Meadow School	12,002	9,756	9,970	10,663	19,119	20,744	25,742	35,064	14,026	11,060	10,215	10,028	267	51,398	
Maynard White Pond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	No longer used
Maynard well #2 Rockland Ave.	0	0	0	0	0	0	0	0	0	0	0	0	0		Combined with #5 Rockland
Maynard well #5 Rockland Ave.	52,637	56,484	53,170	66,374	66,917	75,413	101,109	53,634	69,058	58,284	70,883	64,522	785	151,113	Combined with #2 Rockland
Shrewsbury Oak St.	0	0	0	0	0	0	0	0	0	0	0	0	0		Out of model area, well not used
Shrewsbury Lumberts 3-1	80,745	84,431	74,473	75,710	86,919	77,704	73,624	54,533	65,777	61,916	61,267	73,591	520	100,100	Out of model area, well not used
Shrewsbury Lumberts 3-2	1,795	4,838	14,414	21,093	4,637	14,186	11,380	14,508	0	13,813	19,030	0	400	77,000	Out of model area, well not used

Appendix 2. Year 2030 monthly ground-water and surface-water withdrawals, Zone II limits for wells or the maximum withdrawal limit used for surface sources, Assabet and Upper Charles River Basins, eastern Massachusetts.—Continued

[ave, average; ft^3/d, cubic feet per day; gal/min, gallon per minute; Mgal/d, million gallons per day; MWRA, Massachusetts Water Resources Authority; --, no data]

Source	Year 2030 monthly withdrawals (ft^3/d)												ZONE II limit		Comment
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	(gal/min)	(ft^3/d)	
Assabet River Basin—Continued															
Shrewsbury South St.	0	0	0	0	0	0	0	0	0	0	0	0	140	26,950	In model area, but no longer used (April 2006)
Shrewsbury Home Farm 6-1	175,352	31,287	62,202	81,665	132,981	209,389	202,739	207,239	182,929	58,936	157,803	58,803	3,000	577,502	Out of model area, well not used
Shrewsbury Home Farm 6-2	172,657	292,981	276,616	257,825	322,639	351,761	361,979	311,926	295,854	319,493	176,970	279,453	2,100	404,251	Out of model area, well not used
Shrewsbury Sewell St. #4	130,361	144,132	133,081	152,075	152,075	152,075	151,815	132,781	122,070	140,299	146,474	139,695	790	152,075	Out of model area, well not used
Shrewsbury Sewell St. #5	769	0	1,014	2,818	834	330	512	181	0	261	172	0	700	134,750	Out of model area, well not used
Westboro 2328000-02G	27,382	23,921	23,548	23,022	25,932	25,060	27,322	34,875	33,841	31,932	27,108	22,515	278	53,515	Out of model area, well not used
Westboro 2328000-01G	37,479	21,018	9,524	16,764	21,331	43,925	44,138	43,046	56,771	54,055	55,527	49,896	382	73,535	Out of model area, well not used
Westboro 2328000-01S	102,925	123,789	162,502	201,592	183,392	214,660	183,445	137,135	88,634	38,928	25,482	32,874	1,267	243,898	Out of model area, well not used; Maximum monthly withdrawal for calibration period 1997–2001
Westboro Otis well	44,970	32,509	26,028	26,738	43,182	40,855	55,369	55,549	59,025	57,231	46,867	48,321	583	112,228	
Westboro Andrews well #1	27,028	36,992	37,250	38,082	51,645	55,363	55,570	50,125	47,134	46,161	43,075	41,336	460	88,550	
Westboro Andrews well #2	32,378	35,642	33,434	24,223	38,090	36,423	46,200	46,200	46,200	46,200	46,200	46,200	240	46,200	
Westboro Wilkinson well	18,766	20,482	10,657	9,066	15,497	15,010	19,316	16,149	19,796	24,674	25,281	25,599	250	48,125	
Westboro Chauncy I	0	0	1,550	1,640	2,923	613	197	2,283	2,639	2,334	8,087	5,388	420	80,850	
Westboro Chauncy II	42,673	36,866	29,183	11,184	34,005	46,579	44,755	42,547	41,643	50,960	55,394	54,943	550	105,875	
Westboro Indian Meadows	0	0	0	0	0	0	56	417	254	749	603	510	480	92,400	
Hudson Cranberry well	61,672	60,400	66,778	70,220	90,809	106,686	102,528	89,741	86,392	69,723	61,751	68,068	660	127,050	Located in Sudbury basin
Hudson Kane well	11,803	11,861	11,806	8,653	24,197	34,447	39,014	34,389	36,690	28,466	21,414	18,940	350	67,375	
Hudson Chestnut well #1	87,918	93,354	92,091	90,889	99,224	100,100	100,100	95,595	89,209	80,091	74,595	67,711	520	100,100	
Hudson Chestnut well #2	103,104	101,420	96,499	98,978	107,774	116,891	112,268	101,849	96,665	94,410	94,870	94,763	700	134,750	
Hudson Chestnut well #3	58,974	53,741	53,280	72,653	72,987	74,806	68,220	64,163	59,910	61,602	63,972	62,850	700	134,750	

Appendix 2. Year 2030 monthly ground-water and surface-water withdrawals, Zone II limits for wells or the maximum withdrawal limit used for surface sources, Assabet and Upper Charles River Basins, eastern Massachusetts.—Continued

[ave, average; ft^3/d, cubic feet per day; gal/min, gallon per minute; Mgal/d, million gallons per day; MWRA, Massachusetts Water Resources Authority; --, no data]

Source	Year 2030 monthly withdrawals (ft^3/d)												ZONE II limit		Comment
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	(gal/min)	(ft^3/d)	
Assabet River Basin—Continued															
Hudson Gates Pond	10,059	10,372	13,148	10,842	20,916	45,454	54,134	42,499	26,984	18,858	16,951	15,179	694	133,595	Typically 243.06 gal/min (46,789 ft^3/day, 0.35 Mgal/d), but up to 694 gal/min (1 Mgal/d) in summer
Northboro Lyman St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Well not used, inactive
Northboro Brigham St.	55,506	57,721	56,852	46,153	58,874	57,789	53,367	54,437	58,328	60,060	60,060	57,430	312	60,060	
Northboro Crawford St.	49,622	58,115	58,328	54,046	48,523	53,246	50,226	37,085	54,565	55,915	56,940	53,003	303	58,328	
Northboro Howard St.	26,175	23,352	21,562	21,964	25,995	25,043	24,376	18,381	13,946	19,194	20,411	22,265	200	38,500	
MWRA	20,026	11,061	14,620	37,653	55,313	80,975	88,121	84,396	52,766	25,062	13,928	15,900		MWRA	Historical yearly ave 24% MWRA and projected 2030 24% MWRA
Marlboro Millham Reservoir	212,794	271,904	387,334	443,306	418,268	288,470	185,372	154,519	177,508	133,063	81,754	119,514	2,500	481,251	Maximum monthly withdrawal for calibration period 1997–2001
MWRA	444,837	381,033	270,440	251,208	401,788	654,778	753,694	689,848	603,005	563,252	575,922	526,250		MWRA	Historical yearly ave 68% MWRA
Concord Second Division well	91,343	102,846	84,086	110,618	83,754	77,765	75,942	66,799	77,664	86,709	92,538	98,942	587	112,998	
Concord Nagog Reservoir	1,122	0	1,192	1,741	61,127	109,093	103,816	87,092	72,916	36,881	25,216	0	1,400	269,501	
Concord Jennie Dugan well	40,752	41,209	42,466	32,873	45,741	53,304	49,504	37,031	34,041	23,509	18,481	26,290	373	71,803	Out of model area, well not used
Concord Deaconess well	140,140	122,809	140,140	140,140	118,212	98,528	83,442	61,646	78,255	105,327	113,648	127,194	728	140,140	Out of model area, well not used
Concord Hugh Cargill	1,122	0	1,192	1,741	0	0	0	13,571	12,552	11,064	3,408	13,612	350	67,375	Out of model area, well not used
Concord White Pond well	1,122	0	1,192	1,741	38,063	54,940	73,985	75,607	42,419	15,282	0	0	551	106,068	Out of model area, well not used
Concord Robinson	24,694	31,287	30,092	28,284	27,566	37,087	42,119	43,818	38,559	39,187	47,025	28,837	700	134,750	Out of model area, well not used

Appendix 2. Year 2030 monthly ground-water and surface-water withdrawals, Zone II limits for wells or the maximum withdrawal limit used for surface sources, Assabet and Upper Charles River Basins, eastern Massachusetts.—Continued

[ave, average; ft^3/d, cubic feet per day; gal/min, gallon per minute; Mgal/d, million gallons per day; MWRA, Massachusetts Water Resources Authority; --, no data]

Source	Year 2030 monthly withdrawals (ft^3/d)												ZONE II limit		Comment
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	(gal/min)	(ft^3/d)	
Upper Charles River Basin															
Bellingham well #12	301	2,634	930	1,463	2,054	2,447	5,215	4,295	3,995	2,873	2,852	2,813	380	73,150	
Bellingham well #5	30,165	27,477	27,681	29,738	25,005	22,554	23,101	23,942	31,501	30,496	29,438	31,040	200	38,500	
Bellingham well #7	12,895	10,306	11,124	13,852	22,392	20,474	18,080	13,040	11,829	10,415	10,407	7,924	295	56,788	
Bellingham well #8	27,227	29,666	30,868	29,493	38,570	55,768	54,400	49,353	36,451	30,955	27,895	27,536	470	90,475	
Franklin proposed Populatic Pond well	0	0	0	0	0	0	0	0	0	0	0	0	600	115,508	Proposed well
Franklin well #1	10,861	13,271	16,490	10,188	25,174	51,111	47,146	39,360	35,636	28,320	19,196	9,521	325	62,563	
Franklin well #10	35,885	33,490	35,591	38,071	49,024	57,470	60,342	48,945	41,759	41,721	42,476	42,224	350	67,375	
Franklin well #2	10,861	13,271	16,490	10,188	25,174	51,111	47,146	39,360	35,636	28,320	19,196	9,521	500	96,250	
Franklin well #3	43,120	43,075	43,120	43,120	43,120	43,120	43,120	43,120	43,120	43,120	43,120	43,120	224	43,120	
Franklin well #4	109,814	107,193	100,295	119,777	123,200	123,200	123,200	123,200	123,200	108,530	109,996	110,010	640	123,200	
Franklin well #5	30,242	29,119	31,575	27,436	42,498	48,894	49,764	38,975	32,402	26,983	29,038	33,762	345	66,413	
Franklin well #6	66,260	65,363	64,794	71,225	71,225	71,225	71,225	71,225	57,210	50,529	39,521	41,957	370	71,225	
Franklin well #7	50,156	47,796	49,314	57,340	66,552	72,949	71,130	56,352	52,905	43,988	43,859	49,986	400	77,000	
Franklin well #8	35,228	35,228	35,228	35,228	35,228	35,228	35,228	35,228	35,228	35,228	35,228	35,228	183	35,228	
Franklin well #9	38,606	40,153	38,229	42,634	56,298	63,928	67,193	57,660	54,478	49,649	49,432	47,925	350	67,375	In upland area of model grid
Holliston proposed well #7	0	0	0	0	0	0	0	0	0	0	0	0	386	74,304	Proposed well
Holliston well #1 Lake Winthrop	0	0	0	1,929	10,108	16,667	21,337	16,872	13,990	4,602	2,837	0	220	42,350	
Holliston well #2 Maple St.	700	1,189	4,372	3,128	11,894	19,922	25,536	22,457	8,341	2,395	2,115	302	213	41,003	
Holliston well #4 Washington St.	12,626	14,714	15,592	11,919	20,394	34,811	38,394	31,925	28,073	21,456	19,696	15,058	333	64,103	
Holliston well #5 Central St.	72,529	66,052	65,103	75,186	81,314	69,022	68,053	65,994	67,145	69,028	71,883	75,411	490	94,325	
Holliston well #6 Brook St.	72,252	75,022	73,074	74,813	73,447	86,353	72,449	65,753	70,101	69,927	61,587	64,482	600	115,500	

Appendix 2. Year 2030 monthly ground-water and surface-water withdrawals, Zone II limits for wells or the maximum withdrawal limit used for surface sources, Assabet and Upper Charles River Basins, eastern Massachusetts.—Continued

[ave, average; ft^3/d, cubic feet per day; gal/min, gallon per minute; Mgal/d, million gallons per day; MWRA, Massachusetts Water Resources Authority; --, no data]

Source	Year 2030 monthly withdrawals (ft^3/d)												ZONE II limit		Comment
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	(gal/min)	(ft^3/d)	
Upper Charles River Basin—Continued															
Medway proposed well	0	0	0	0	0	0	0	0	0	0	0	0	325	62,567	Proposed well
Medway well #1 Populatic St.	50,435	50,435	50,435	50,435	50,435	50,435	50,435	50,435	50,435	50,435	50,435	50,435	262	50,435	
Medway well #2 Oakland St.	22,490	24,500	23,964	29,751	41,871	61,792	60,936	49,636	40,003	28,249	26,989	21,592	410	78,925	
Medway well #3 Village St.	61,689	58,717	60,244	61,977	75,555	80,850	80,850	72,766	69,328	63,848	57,199	60,157	420	80,850	
Milford Charles River	124,631	229,632	394,823	382,621	93,612	37,438	11,774	0	637	11,372	26,494	40,229	--	--	No change from curent
Milford Clark Island wellfield	87,901	76,312	51,467	55,649	68,447	76,250	99,218	104,967	101,147	95,165	88,093	76,290	556	107,030	
Milford Dilla St. wells #1 and #2	11,279	12,934	11,798	12,184	24,594	28,230	25,641	20,647	19,122	18,240	16,109	14,139	469	90,283	
Milford Godfrey Brook wells, MF-03G, 4G, 5G	66,158	64,538	57,962	56,649	80,167	80,848	78,176	69,295	81,898	75,058	75,653	77,014	549	105,683	
Milford Echo Lake	192,661	192,905	128,012	130,236	239,491	359,604	364,980	326,411	279,092	230,077	199,706	191,028	--	--	No change from curent
Norfolk proposed Mill River well	0	0	0	0	0	1,471	956	0	0	0	0	0	485	93,363	Proposed well
Norfolk #2 Spruce	35,187	32,015	23,148	27,667	43,107	56,788	56,788	53,504	40,867	32,409	23,136	30,282	295	56,788	Not in study area
Norfolk well #1 Gold St.	45,694	48,289	57,750	57,750	57,750	57,750	57,750	50,344	55,127	53,229	57,750	49,139	300	57,750	
Wrentham proposed well	0	0	0	0	0	0	0	0	0	0	0	0	453	87,264	Proposed well
Wrentham well #2	52,959	50,882	55,145	45,002	84,405	69,259	79,530	65,489	40,696	59,509	38,477	35,689	500	96,250	
Wrentham well #3	61,994	63,250	59,833	76,398	58,939	95,619	84,617	82,106	95,737	62,205	76,484	77,190	660	127,050	

Appendix 3. Changes in Average-Annual Water-Budget Inflows and Outflows from Basecase Conditions for the Seven Scenarios by Subbasin, Assabet River Basin, Eastern Massachusetts.

Appendix 3. Changes in average-annual water-budget inflows and outflows from basecase conditions for the seven scenarios by subbasin, Assabet River Basin, eastern Massachusetts.

[ft^3/s, cubic foot per second; WWTF, wastewater treatment facility; scenarios are defined in text]

Scenario	Subbasin	Change in budget flow components (ft^3/s): Inflows					Outflows						Budget error (inflow minus outflow)
		Recharge and return flow	Stream leakage to ground water	Ground-water inflow from other subbasins	Flow to aquifer from Acton WWTF	Total inflows	Consump-tive use in private supply areas	Ground-water discharge to streams	Evapo-transpira-tion	Ground-water outflow to other subbasins	Ground-water with-drawals	Total outflows	
2	Assabet Main Stem Head	0.110	0.033	0.004	0.000	**0.147**	0.000	-0.006	0.002	0.009	0.142	**0.147**	0.000
2	Assabet Main Stem Upper	0.147	0.005	-0.114	0.387	**0.425**	-0.012	0.194	-0.003	-0.044	0.292	**0.427**	-0.002
2	Assabet Main Stem Middle	0.068	0.087	0.023	0.000	**0.178**	-0.002	0.012	-0.005	0.076	0.104	**0.185**	-0.007
2	Assabet Main Stem Lower	0.119	0.099	0.024	0.000	**0.242**	-0.004	-0.105	-0.017	-0.003	0.567	**0.438**	-0.196
2	Cold Harbor and Howard	0.056	0.075	0.004	0.000	**0.135**	-0.003	-0.028	0.001	-0.003	0.167	**0.134**	0.001
2	Danforth	0.001	0.000	0.000	0.000	**0.001**	0.000	0.000	0.000	0.000	0.000	**0.000**	0.001
2	Elizabeth	-0.009	0.001	-0.001	0.000	**-0.009**	0.000	0.016	0.000	0.000	0.000	**0.016**	-0.025
2	Fort Meadow	0.052	0.103	0.075	0.000	**0.230**	-0.002	-0.024	-0.001	0.024	0.233	**0.230**	0.000
2	Fort Pond	-0.144	0.063	-0.050	0.000	**-0.131**	-0.001	-0.160	-0.025	-0.083	0.140	**-0.129**	-0.002
2	Hop	0.138	-0.006	0.003	0.000	**0.135**	-0.003	0.125	0.002	0.011	0.000	**0.135**	0.000
2	Nashoba	0.749	0.056	-0.013	0.000	**0.792**	-0.020	0.461	0.095	0.019	0.219	**0.774**	0.018
2	North	0.016	-0.002	-0.002	0.000	**0.012**	-0.001	0.007	0.002	0.004	0.000	**0.012**	0.000
2	Spencer	0.082	-0.002	0.011	0.000	**0.091**	-0.001	0.083	0.005	0.004	0.000	**0.091**	0.000
2	Stirrup	0.120	0.042	-0.005	0.000	**0.157**	-0.011	0.084	0.008	0.007	0.070	**0.158**	-0.001
2	Taylor	0.022	-0.005	0.007	0.000	**0.024**	-0.003	-0.023	-0.007	-0.007	0.065	**0.025**	-0.001
3A	Assabet Main Stem Head	-0.057	0.002	-0.008	0.000	**-0.063**	0.000	-0.049	-0.006	-0.008	0.000	**-0.063**	0.000
3A	Assabet Main Stem Upper	-0.194	0.006	0.003	0.000	**-0.185**	0.000	-0.155	-0.014	-0.016	0.000	**-0.185**	0.000
3A	Assabet Main Stem Middle	-0.454	0.036	0.009	0.000	**-0.409**	0.000	-0.331	-0.033	-0.039	0.000	**-0.403**	-0.006
3A	Assabet Main Stem Lower	-0.271	0.023	-0.026	0.000	**-0.274**	0.000	-0.228	-0.018	-0.028	0.000	**-0.274**	0.000
3A	Cold Harbor and Howard	-0.001	0.003	-0.020	0.000	**-0.018**	0.000	-0.023	-0.001	0.005	0.000	**-0.019**	0.001
3A	Danforth	-0.008	0.003	-0.008	0.000	**-0.013**	0.000	-0.018	-0.002	0.007	0.000	**-0.013**	0.000
3A	Elizabeth	-0.104	0.002	-0.018	0.000	**-0.120**	0.000	-0.111	-0.008	-0.002	0.000	**-0.121**	0.001
3A	Fort Meadow	-0.142	0.022	-0.014	0.000	**-0.134**	0.000	-0.117	-0.011	-0.005	0.000	**-0.133**	-0.001
3A	Fort Pond	-0.166	0.016	-0.011	0.000	**-0.161**	0.000	-0.138	-0.014	-0.008	0.000	**-0.160**	-0.001
3A	Hop	-0.273	0.018	-0.006	0.000	**-0.261**	0.000	-0.236	-0.002	-0.022	0.000	**-0.260**	-0.001
3A	Nashoba	-0.169	0.004	-0.003	0.000	**-0.168**	0.000	-0.135	-0.025	-0.003	0.000	**-0.163**	-0.005
3A	North	-0.049	0.002	-0.006	0.000	**-0.053**	0.000	-0.053	-0.003	0.004	0.000	**-0.052**	-0.001
3A	Spencer	0.000	0.000	-0.003	0.000	**-0.003**	0.000	-0.004	0.000	0.002	0.000	**-0.002**	-0.001
3A	Stirrup	-0.172	0.029	-0.005	0.000	**-0.148**	0.000	-0.117	-0.017	-0.015	0.000	**-0.149**	0.001
3A	Taylor	-0.004	0.000	-0.006	0.000	**-0.010**	0.000	-0.012	-0.005	0.007	0.000	**-0.010**	0.000

Appendix 3. Changes in average-annual water-budget inflows and outflows from basecase conditions for the seven scenarios by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft^3/s, cubic foot per second; WWTF, wastewater treatment facility; scenarios are defined in text]

Scenario	Subbasin	Change in budget flow components (ft^3/s): Inflows					Outflows						Budget error (inflow minus outflow)
		Recharge and return flow	Stream leakage to ground water	Ground-water inflow from other subbasins	Flow to aquifer from Acton WWTF	Total inflows	Consumptive use in private supply areas	Ground-water discharge to streams	Evapo-transpira-tion	Ground-water outflow to other subbasins	Ground-water with-drawals	Total outflows	
3B	Assabet Main Stem Head	-0.335	0.014	-0.016	0.000	**-0.337**	0.000	-0.251	-0.029	-0.030	0.000	**-0.310**	-0.027
3B	Assabet Main Stem Upper	-0.321	0.008	-0.010	0.000	**-0.323**	0.000	-0.267	-0.025	-0.031	0.000	**-0.323**	0.000
3B	Assabet Main Stem Middle	-0.712	0.068	-0.006	0.000	**-0.650**	0.000	-0.512	-0.051	-0.058	0.000	**-0.621**	-0.029
3B	Assabet Main Stem Lower	-0.427	0.001	-0.055	0.000	**-0.481**	0.000	-0.366	-0.030	-0.049	0.000	**-0.445**	-0.036
3B	Cold Harbor and Howard	-0.185	0.013	-0.034	0.000	**-0.206**	0.000	-0.196	-0.007	-0.002	0.000	**-0.205**	-0.001
3B	Danforth	-0.113	0.010	-0.018	0.000	**-0.121**	0.000	-0.112	-0.006	-0.003	0.000	**-0.121**	0.000
3B	Elizabeth	-0.402	0.004	-0.036	0.000	**-0.434**	0.000	-0.390	-0.026	-0.017	0.000	**-0.433**	-0.001
3B	Fort Meadow	-0.327	0.049	-0.021	0.000	**-0.299**	0.000	-0.258	-0.023	-0.018	0.000	**-0.299**	0.000
3B	Fort Pond	-0.482	0.035	-0.037	0.000	**-0.484**	0.000	-0.424	-0.034	-0.025	0.000	**-0.483**	-0.001
3B	Hop	-0.443	0.032	-0.013	0.000	**-0.424**	0.000	-0.375	-0.003	-0.030	0.000	**-0.408**	-0.016
3B	Nashoba	-0.613	0.081	-0.014	0.000	**-0.546**	0.000	-0.420	-0.081	-0.023	0.000	**-0.524**	-0.022
3B	North	-0.291	0.016	-0.018	0.000	**-0.293**	0.000	-0.273	-0.007	-0.005	0.000	**-0.285**	-0.008
3B	Spencer	-0.094	0.004	-0.011	0.000	**-0.101**	0.000	-0.087	-0.011	-0.003	0.000	**-0.101**	0.000
3B	Stirrup	-0.226	0.042	-0.010	0.000	**-0.194**	0.000	-0.155	-0.022	-0.017	0.000	**-0.194**	0.000
3B	Taylor	-0.042	0.001	-0.010	0.000	**-0.051**	0.000	-0.040	-0.013	0.004	0.000	**-0.049**	-0.002
3C	Assabet Main Stem Head	0.222	-0.014	-0.001	0.000	**0.207**	0.000	0.171	0.024	0.018	0.000	**0.213**	-0.006
3C	Assabet Main Stem Upper	-0.068	0.004	0.016	0.000	**-0.048**	0.000	-0.044	-0.003	-0.002	0.000	**-0.049**	0.001
3C	Assabet Main Stem Middle	-0.196	0.028	0.029	0.000	**-0.139**	0.000	-0.096	-0.008	-0.017	0.000	**-0.121**	-0.018
3C	Assabet Main Stem Lower	-0.116	0.011	0.007	0.000	**-0.098**	0.000	-0.081	-0.007	-0.009	0.000	**-0.097**	-0.001
3C	Cold Harbor and Howard	0.184	-0.008	-0.006	0.000	**0.170**	0.000	0.152	0.005	0.013	0.000	**0.170**	0.000
3C	Danforth	0.098	-0.005	0.002	0.000	**0.095**	0.000	0.076	0.003	0.016	0.000	**0.095**	0.000
3C	Elizabeth	0.193	0.009	0.001	0.000	**0.203**	0.000	0.234	0.024	0.017	0.000	**0.275**	-0.072
3C	Fort Meadow	0.043	-0.004	-0.006	0.000	**0.033**	0.000	0.026	0.000	0.008	0.000	**0.034**	-0.001
3C	Fort Pond	0.151	-0.001	0.014	0.000	**0.164**	0.000	0.151	0.007	0.009	0.000	**0.167**	-0.003
3C	Hop	-0.103	0.005	0.002	0.000	**-0.096**	0.000	-0.081	0.000	-0.014	0.000	**-0.095**	-0.001
3C	Nashoba	0.276	0.250	0.007	0.000	**0.533**	0.000	0.466	0.034	0.017	0.000	**0.517**	0.016
3C	North	0.193	-0.010	0.010	0.000	**0.193**	0.000	0.179	0.002	0.016	0.000	**0.197**	-0.004
3C	Spencer	0.094	-0.003	0.004	0.000	**0.095**	0.000	0.078	0.011	0.007	0.000	**0.096**	-0.001
3C	Stirrup	-0.118	0.017	-0.001	0.000	**-0.102**	0.000	-0.079	-0.011	-0.012	0.000	**-0.102**	0.000
3C	Taylor	0.033	-0.001	-0.002	0.000	**0.030**	0.000	0.017	0.004	0.009	0.000	**0.030**	0.000

Appendix 3. Changes in average-annual water-budget inflows and outflows from basecase conditions for the seven scenarios by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft^3/s, cubic foot per second; WWTF, wastewater treatment facility; scenarios are defined in text]

Scenario	Subbasin	Change in budget flow components (ft^3/s)											Budget error (inflow minus outflow)
		Inflows					Outflows						
		Recharge and return flow	Stream leakage to ground water	Ground-water inflow from other subbasins	Flow to aquifer from Acton WWTF	Total inflows	Consump-tive use in private supply areas	Ground-water discharge to streams	Evapo-transpira-tion	Ground-water outflow to other subbasins	Ground-water with-drawals	Total outflows	
4A	Assabet Main Stem Head	0.054	0.037	-0.005	0.000	**0.086**	0.000	-0.054	-0.004	0.001	0.142	**0.085**	0.001
4A	Assabet Main Stem Upper	-0.048	0.011	-0.111	0.387	**0.239**	-0.012	0.038	-0.017	-0.061	0.292	**0.240**	-0.001
4A	Assabet Main Stem Middle	-0.385	0.122	0.032	0.000	**-0.231**	-0.002	-0.328	-0.038	0.038	0.104	**-0.226**	-0.005
4A	Assabet Main Stem Lower	-0.152	0.021	0.002	0.000	**-0.129**	-0.004	-0.361	-0.042	-0.041	0.567	**0.119**	-0.248
4A	Cold Harbor and Howard	0.054	0.078	-0.016	0.000	**0.116**	-0.003	-0.051	0.001	0.003	0.167	**0.117**	-0.001
4A	Danforth	-0.007	0.002	-0.008	0.000	**-0.013**	0.000	-0.018	-0.002	0.007	0.000	**-0.013**	0.000
4A	Elizabeth	-0.113	0.002	-0.019	0.000	**-0.130**	0.000	-0.120	-0.009	-0.002	0.000	**-0.131**	0.001
4A	Fort Meadow	-0.090	0.128	0.061	0.000	**0.099**	-0.002	-0.139	-0.012	0.019	0.233	**0.099**	0.000
4A	Fort Pond	-0.308	0.080	-0.062	0.000	**-0.290**	-0.001	-0.299	-0.039	-0.090	0.140	**-0.289**	-0.001
4A	Hop	-0.134	0.011	-0.003	0.000	**-0.126**	-0.003	-0.112	-0.001	-0.011	0.000	**-0.127**	0.001
4A	Nashoba	0.580	0.049	-0.016	0.000	**0.613**	-0.020	0.315	0.070	0.016	0.219	**0.600**	0.013
4A	North	-0.032	0.000	-0.007	0.000	**-0.039**	-0.001	-0.045	-0.001	0.009	0.000	**-0.038**	-0.001
4A	Spencer	0.082	-0.002	0.008	0.000	**0.088**	-0.001	0.079	0.004	0.006	0.000	**0.088**	0.000
4A	Stirrup	-0.052	0.072	-0.019	0.000	**0.001**	-0.011	-0.042	-0.009	-0.006	0.070	**0.002**	-0.001
4A	Taylor	0.018	-0.005	0.001	0.000	**0.014**	-0.003	-0.035	-0.012	-0.001	0.065	**0.014**	0.000
4B	Assabet Main Stem Head	-0.225	0.050	-0.013	0.000	**-0.188**	0.000	-0.271	-0.026	-0.023	0.142	**-0.178**	-0.010
4B	Assabet Main Stem Upper	-0.174	0.007	-0.122	0.387	**0.098**	-0.012	-0.078	-0.028	-0.075	0.292	**0.099**	-0.001
4B	Assabet Main Stem Middle	-0.644	0.151	0.015	0.000	**-0.478**	-0.002	-0.563	-0.062	0.015	0.104	**-0.508**	0.030
4B	Assabet Main Stem Lower	-0.308	-0.016	-0.024	0.000	**-0.348**	-0.004	-0.505	-0.063	-0.072	0.567	**-0.077**	-0.271
4B	Cold Harbor and Howard	-0.130	0.089	-0.030	0.000	**-0.071**	-0.003	-0.225	-0.005	-0.005	0.167	**-0.071**	0.000
4B	Danforth	-0.113	0.010	-0.018	0.000	**-0.121**	0.000	-0.112	-0.006	-0.003	0.000	**-0.121**	0.000
4B	Elizabeth	-0.411	0.004	-0.037	0.000	**-0.444**	0.000	-0.401	-0.027	-0.017	0.000	**-0.445**	0.001
4B	Fort Meadow	-0.276	0.157	0.054	0.000	**-0.065**	-0.002	-0.278	-0.024	0.006	0.233	**-0.065**	0.000
4B	Fort Pond	-0.624	0.098	-0.088	0.000	**-0.614**	-0.001	-0.589	-0.059	-0.104	0.140	**-0.613**	-0.001
4B	Hop	-0.304	0.025	-0.011	0.000	**-0.290**	-0.003	-0.266	-0.002	-0.019	0.000	**-0.290**	0.000
4B	Nashoba	0.135	-0.030	-0.025	0.000	**0.080**	-0.020	-0.125	0.009	-0.005	0.219	**0.078**	0.002
4B	North	-0.274	0.017	-0.024	0.000	**-0.281**	-0.001	-0.276	-0.006	0.000	0.000	**-0.283**	0.002
4B	Spencer	-0.012	0.002	0.000	0.000	**-0.010**	-0.001	-0.003	-0.006	0.002	0.000	**-0.008**	-0.002
4B	Stirrup	-0.106	0.084	-0.032	0.000	**-0.054**	-0.011	-0.092	-0.014	-0.006	0.070	**-0.053**	-0.001
4B	Taylor	-0.019	-0.005	-0.003	0.000	**-0.027**	-0.003	-0.065	-0.020	-0.004	0.065	**-0.027**	0.000

Appendix 3. Changes in average-annual water-budget inflows and outflows from basecase conditions for the seven scenarios by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second; WWTF, wastewater treatment facility; scenarios are defined in text]

Scenario	Subbasin	Change in budget flow components (ft³/s)											Budget error (inflow minus outflow)
		Inflows					Outflows						
		Recharge and return flow	Stream leakage to ground water	Ground-water inflow from other subbasins	Flow to aquifer from Acton WWTF	Total inflows	Consump-tive use in private supply areas	Ground-water discharge to streams	Evapo-transpira-tion	Ground-water outflow to other subbasins	Ground-water with-drawals	Total outflows	
4C	Assabet Main Stem Head	0.332	0.019	0.003	0.000	**0.354**	0.000	0.165	0.027	0.027	0.142	**0.361**	-0.007
4C	Assabet Main Stem Upper	0.079	0.009	-0.098	0.387	**0.377**	-0.012	0.149	-0.007	-0.046	0.292	**0.376**	0.001
4C	Assabet Main Stem Middle	-0.127	0.096	0.048	0.000	**0.017**	-0.002	-0.132	-0.019	0.058	0.104	**0.009**	0.008
4C	Assabet Main Stem Lower	0.004	0.059	0.034	0.000	**0.097**	-0.004	-0.219	-0.031	-0.022	0.567	**0.291**	-0.194
4C	Cold Harbor and Howard	0.240	0.066	-0.002	0.000	**0.304**	-0.003	0.123	0.006	0.010	0.167	**0.303**	0.001
4C	Danforth	0.098	-0.005	0.002	0.000	**0.095**	0.000	0.076	0.003	0.016	0.000	**0.095**	0.000
4C	Elizabeth	0.184	0.009	0.000	0.000	**0.193**	0.000	0.177	0.011	0.015	0.000	**0.203**	-0.010
4C	Fort Meadow	0.095	0.100	0.069	0.000	**0.264**	-0.002	0.002	-0.001	0.032	0.233	**0.264**	0.000
4C	Fort Pond	0.008	0.063	-0.036	0.000	**0.035**	-0.001	-0.010	-0.019	-0.073	0.140	**0.037**	-0.002
4C	Hop	0.036	-0.002	0.005	0.000	**0.039**	-0.003	0.043	0.001	-0.003	0.000	**0.038**	0.001
4C	Nashoba	1.023	0.000	-0.006	0.000	**1.017**	-0.020	0.620	0.125	0.036	0.219	**0.980**	0.037
4C	North	0.210	-0.013	0.006	0.000	**0.203**	-0.001	0.178	0.004	0.019	0.000	**0.200**	0.003
4C	Spencer	0.176	-0.005	0.015	0.000	**0.186**	-0.001	0.161	0.016	0.011	0.000	**0.187**	-0.001
4C	Stirrup	0.002	0.059	-0.014	0.000	**0.047**	-0.011	-0.005	-0.003	-0.003	0.070	**0.048**	-0.001
4C	Taylor	0.056	-0.005	0.005	0.000	**0.056**	-0.003	-0.005	-0.003	0.002	0.065	**0.056**	0.000

Appendix 4. Changes in March and September Water-Budget Inflows and Outflows from Basecase for Seven Scenarios, by Subbasin, Assabet River Basin, Eastern Massachusetts

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.

[ft³/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

Month	Scenario	Subbasin	Change in budget flow components (ft³/s)													Budget error (inflow minus outflow)
			Inflows						Outflows							
			Flow into aquifer from Acton WWTF	Net flow from storage	Re-charge and return flow	Stream leakage to ground water	Ground-water inflow from other sub-basins	Total in-flows	Net flow to storage	Ground-water with-drawals	Evapo-trans-piration	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Ground-water outflow to other sub-basins	Total outflows	
Mar.	2	Assabet Main Stem Head	0.000	0.000	0.111	0.013	0.005	**0.129**	-0.023	0.107	0.000	0.000	0.042	0.007	**0.133**	-0.004
Mar.	2	Assabet Main Stem Upper	0.000	0.259	0.124	0.195	0.023	**0.601**	-0.075	0.770	0.000	0.000	-0.185	0.000	**0.510**	0.091
Mar.	2	Assabet Main Stem Middle	0.000	0.000	0.074	0.044	0.011	**0.129**	-0.017	0.066	0.000	0.000	0.019	0.064	**0.132**	-0.003
Mar.	2	Assabet Main Stem Lower	0.387	0.000	0.159	0.016	-0.109	**0.453**	-0.061	0.312	0.000	-0.001	0.225	-0.023	**0.452**	0.001
Mar.	2	Cold Harbor and Howard	0.000	0.000	0.061	0.035	0.006	**0.102**	0.046	0.141	0.000	0.000	-0.083	-0.001	**0.103**	-0.001
Mar.	2	Danforth	0.000	0.000	0.005	0.000	0.000	**0.005**	0.001	0.000	0.000	0.000	0.002	0.001	**0.004**	0.001
Mar.	2	Elizabeth	0.000	0.000	0.000	0.000	-0.001	**-0.001**	0.006	0.000	0.000	0.000	-0.005	0.000	**0.001**	-0.002
Mar.	2	Fort Meadow	0.000	0.000	0.053	0.049	0.063	**0.165**	0.005	0.200	0.000	0.000	-0.058	0.014	**0.161**	0.004
Mar.	2	Fort Pond	0.000	0.000	-0.139	0.005	-0.023	**-0.157**	0.069	0.121	0.000	0.000	-0.251	-0.101	**-0.162**	0.005
Mar.	2	Hop	0.000	0.000	0.141	-0.003	0.003	**0.141**	-0.014	0.000	0.000	-0.001	0.142	0.015	**0.142**	-0.001
Mar.	2	Nashoba	0.000	0.000	0.770	-0.002	-0.010	**0.758**	-0.050	0.146	0.000	-0.002	0.651	0.023	**0.768**	-0.010
Mar.	2	North	0.000	0.000	0.028	0.000	-0.001	**0.027**	0.002	0.000	0.000	0.000	0.024	0.001	**0.027**	0.000
Mar.	2	Spencer	0.000	0.000	0.086	-0.001	0.012	**0.097**	-0.007	0.000	0.000	0.000	0.097	0.006	**0.096**	0.001
Mar.	2	Stirrup	0.000	0.000	0.131	0.050	-0.003	**0.178**	0.042	0.040	0.000	-0.001	0.086	0.008	**0.175**	0.003
Mar.	2	Taylor	0.000	0.000	0.024	-0.002	0.003	**0.025**	0.006	0.035	0.000	0.000	-0.012	-0.005	**0.024**	0.001
Sept.	2	Assabet Main Stem Head	0.000	-0.026	0.111	0.030	-0.003	**0.112**	0.014	0.129	0.011	0.001	-0.055	0.014	**0.114**	-0.002
Sept.	2	Assabet Main Stem Upper	0.000	-0.023	0.119	0.036	0.031	**0.163**	0.000	0.224	-0.015	-0.004	-0.037	-0.006	**0.162**	0.001
Sept.	2	Assabet Main Stem Middle	0.000	-0.133	0.072	0.094	0.013	**0.046**	0.014	0.088	0.003	0.006	0.039	0.064	**0.214**	-0.168
Sept.	2	Assabet Main Stem Lower	0.387	0.031	0.147	-0.015	-0.107	**0.443**	0.010	0.224	-0.003	-0.012	0.249	-0.026	**0.442**	0.001
Sept.	2	Cold Harbor and Howard	0.000	0.042	0.058	0.063	0.005	**0.168**	0.003	0.147	0.001	0.002	0.013	-0.006	**0.160**	0.008
Sept.	2	Danforth	0.000	0.071	0.004	0.064	0.001	**0.140**	0.060	0.000	0.000	0.007	0.035	0.000	**0.102**	0.038
Sept.	2	Elizabeth	0.000	0.013	0.000	-0.002	-0.002	**0.009**	0.000	0.000	-0.001	0.016	0.002	0.000	**0.017**	-0.008
Sept.	2	Fort Meadow	0.000	-0.015	0.052	0.176	0.063	**0.276**	0.019	0.226	-0.001	-0.002	0.018	0.017	**0.277**	-0.001
Sept.	2	Fort Pond	0.000	0.199	-0.138	-0.021	-0.015	**0.025**	-0.010	0.147	-0.021	0.007	-0.178	0.047	**-0.008**	0.033
Sept.	2	Hop	0.000	-0.088	0.139	0.030	-0.003	**0.078**	0.001	0.000	0.002	-0.003	0.103	0.013	**0.116**	-0.038

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

Month	Scenario	Subbasin	Change in budget flow components (ft³/s): Inflows: Flow into aquifer from Acton WWTF	Inflows: Net flow from storage	Inflows: Re-charge and return flow	Inflows: Stream leakage to ground water	Inflows: Ground-water inflow from other sub-basins	Inflows: Total in-flows	Outflows: Net flow to storage	Outflows: Ground-water with-drawals	Outflows: Evapo-trans-piration	Outflows: Con-sumptive use in private supply areas	Outflows: Ground-water dis-charge to streams	Outflows: Ground-water outflow to other sub-basins	Outflows: Total outflows	Budget error (inflow minus outflow)
Sept.	2	Nashoba	0.000	-0.263	0.751	0.109	0.014	**0.611**	0.035	0.219	0.095	-0.016	0.257	0.031	**0.621**	-0.010
Sept.	2	North	0.000	0.000	0.027	-0.002	0.001	**0.026**	0.000	0.000	0.004	0.018	0.003	0.000	**0.025**	0.001
Sept.	2	Spencer	0.000	-0.049	0.084	-0.012	0.002	**0.025**	-0.004	0.000	0.009	0.001	0.014	0.014	**0.034**	-0.009
Sept.	2	Stirrup	0.000	0.044	0.120	0.090	-0.010	**0.244**	0.039	0.063	0.010	-0.012	0.127	0.002	**0.229**	0.015
Sept.	2	Taylor	0.000	0.104	0.022	0.005	0.012	**0.143**	0.007	0.167	-0.004	-0.003	-0.014	-0.006	**0.147**	-0.004
Mar.	3A	Assabet Main Stem Head	0.000	0.000	-0.182	0.008	-0.020	**-0.194**	-0.066	0.000	0.000	0.000	-0.117	-0.010	**-0.193**	-0.001
Mar.	3A	Assabet Main Stem Upper	0.000	0.004	-0.865	0.068	-0.063	**-0.856**	-0.302	0.000	0.000	0.000	-0.483	-0.066	**-0.851**	-0.005
Mar.	3A	Assabet Main Stem Middle	0.000	0.000	-1.449	0.035	0.002	**-1.412**	-0.689	0.000	0.000	0.000	-0.610	-0.102	**-1.401**	-0.011
Mar.	3A	Assabet Main Stem Lower	0.000	0.000	-0.623	0.020	0.013	**-0.590**	-0.374	0.000	0.000	0.000	-0.194	-0.027	**-0.595**	0.005
Mar.	3A	Cold Harbor and Howard	0.000	0.000	-0.002	0.002	-0.058	**-0.058**	-0.021	0.000	0.000	0.000	-0.045	0.008	**-0.058**	0.000
Mar.	3A	Danforth	0.000	0.000	-0.024	0.001	-0.026	**-0.049**	-0.024	0.000	0.000	0.000	-0.037	0.011	**-0.050**	0.001
Mar.	3A	Elizabeth	0.000	0.000	-0.332	0.004	-0.035	**-0.363**	-0.173	0.000	0.000	0.000	-0.191	-0.002	**-0.366**	0.003
Mar.	3A	Fort Meadow	0.000	0.000	-0.455	0.017	-0.041	**-0.479**	-0.240	0.000	0.000	0.000	-0.223	-0.018	**-0.481**	0.002
Mar.	3A	Fort Pond	0.000	0.000	-0.532	0.011	-0.020	**-0.541**	-0.214	0.000	0.000	0.000	-0.306	-0.015	**-0.535**	-0.006
Mar.	3A	Hop	0.000	0.000	-0.872	0.040	-0.013	**-0.845**	-0.144	0.000	0.000	0.000	-0.629	-0.070	**-0.843**	-0.002
Mar.	3A	Nashoba	0.000	0.000	-0.541	-0.003	-0.007	**-0.551**	-0.276	0.000	0.000	0.000	-0.244	-0.009	**-0.529**	-0.022
Mar.	3A	North	0.000	0.000	-0.155	0.006	-0.011	**-0.160**	-0.056	0.000	0.000	0.000	-0.108	0.005	**-0.159**	-0.001
Mar.	3A	Spencer	0.000	0.000	0.000	0.000	-0.007	**-0.007**	-0.005	0.000	0.000	0.000	-0.008	0.006	**-0.007**	0.000
Mar.	3A	Stirrup	0.000	0.000	-0.549	0.056	-0.021	**-0.514**	-0.277	0.000	0.000	0.000	-0.193	-0.043	**-0.513**	-0.001
Mar	3A	Taylor	0.000	0.000	-0.013	0.001	-0.012	**-0.024**	-0.027	0.000	0.000	0.000	-0.013	0.014	**-0.026**	0.002
Sept.	3A	Assabet Main Stem Head	0.000	0.015	0.000	0.007	-0.002	**0.020**	0.022	0.000	-0.006	0.000	0.104	-0.005	**0.115**	-0.095
Sept.	3A	Assabet Main Stem Upper	0.000	-0.079	0.000	0.008	-0.012	**-0.083**	0.008	0.000	-0.012	0.000	-0.060	-0.014	**-0.078**	-0.005
Sept.	3A	Assabet Main Stem Middle	0.000	-0.178	0.000	0.006	0.002	**-0.170**	0.004	0.000	-0.015	0.000	0.022	-0.013	**-0.002**	-0.168
Sept.	3A	Assabet Main Stem Lower	0.000	-0.101	0.000	-0.032	0.001	**-0.132**	0.000	0.000	-0.009	0.000	-0.117	-0.007	**-0.133**	0.001
Sept.	3A	Cold Harbor and Howard	0.000	-0.006	0.000	0.005	-0.001	**-0.002**	0.000	0.000	0.000	0.000	-0.004	0.002	**-0.002**	0.000

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

Month	Scenario	Subbasin	Change in budget flow components (ft³/s) — Inflows: Flow into aquifer from Acton WWTF	Inflows: Net flow from storage	Inflows: Re-charge and return flow	Inflows: Stream leakage to ground water	Inflows: Ground-water inflow from other sub-basins	Inflows: Total in-flows	Outflows: Net flow to storage	Outflows: Ground-water with-drawals	Outflows: Evapo-trans-piration	Outflows: Con-sumptive use in private supply areas	Outflows: Ground-water dis-charge to streams	Outflows: Ground-water outflow to other sub-basins	Outflows: Total outflows	Budget error (inflow minus outflow)
Sept.	3A	Danforth	0.000	0.066	0.000	0.065	-0.001	**0.130**	0.062	0.000	0.000	0.000	0.028	0.001	**0.091**	0.039
Sept.	3A	Elizabeth	0.000	-0.046	0.000	0.004	-0.009	**-0.051**	0.000	0.000	-0.003	0.000	-0.035	0.001	**-0.037**	-0.014
Sept.	3A	Fort Meadow	0.000	-0.077	0.000	0.019	-0.003	**-0.061**	0.001	0.000	-0.010	0.000	-0.050	-0.002	**-0.061**	0.000
Sept.	3A	Fort Pond	0.000	-0.027	0.000	-0.016	-0.004	**-0.047**	-0.017	0.000	-0.008	0.000	-0.061	-0.008	**-0.094**	0.047
Sept.	3A	Hop	0.000	0.063	0.000	0.003	-0.002	**0.064**	-0.004	0.000	-0.004	0.000	0.074	-0.001	**0.065**	-0.001
Sept.	3A	Nashoba	0.000	-0.057	0.000	-0.002	-0.001	**-0.060**	0.004	0.000	-0.018	0.000	-0.032	-0.001	**-0.047**	-0.013
Sept.	3A	North	0.000	-0.016	0.000	0.002	-0.003	**-0.017**	0.000	0.000	-0.002	0.000	-0.015	0.000	**-0.017**	0.000
Sept.	3A	Spencer	0.000	-0.002	0.000	0.001	-0.002	**-0.003**	0.000	0.000	0.000	0.000	-0.003	-0.001	**-0.004**	0.001
Sept.	3A	Stirrup	0.000	-0.034	0.000	0.052	-0.006	**0.012**	0.004	0.000	-0.013	0.000	0.015	-0.005	**0.001**	0.011
Sept.	3A	Taylor	0.000	0.001	0.000	0.009	-0.003	**0.007**	0.000	0.000	-0.001	0.000	0.004	0.005	**0.008**	-0.001
Mar.	3B	Assabet Main Stem Head	0.000	0.000	-1.071	0.044	-0.045	**-1.072**	-0.352	0.000	0.000	0.000	-0.648	-0.069	**-1.069**	-0.003
Mar.	3B	Assabet Main Stem Upper	0.000	0.019	-1.362	0.107	-0.130	**-1.366**	-0.505	0.000	0.000	0.000	-0.762	-0.105	**-1.372**	0.006
Mar.	3B	Assabet Main Stem Middle	0.000	0.000	-2.273	0.052	-0.055	**-2.276**	-1.096	0.000	0.000	0.000	-1.009	-0.152	**-2.257**	-0.019
Mar.	3B	Assabet Main Stem Lower	0.000	0.000	-1.024	0.030	-0.007	**-1.001**	-0.613	0.000	0.000	0.000	-0.341	-0.054	**-1.008**	0.007
Mar.	3B	Cold Harbor and Howard	0.000	0.000	-0.591	0.010	-0.101	**-0.682**	-0.174	0.000	0.000	0.000	-0.486	-0.022	**-0.682**	0.000
Mar.	3B	Danforth	0.000	0.000	-0.361	0.004	-0.059	**-0.416**	-0.083	0.000	0.000	0.000	-0.308	-0.027	**-0.418**	0.002
Mar.	3B	Elizabeth	0.000	0.000	-1.281	0.007	-0.081	**-1.355**	-0.451	0.000	0.000	0.000	-0.836	-0.044	**-1.331**	-0.024
Mar.	3B	Fort Meadow	0.000	0.000	-1.046	0.037	-0.063	**-1.072**	-0.497	0.000	0.000	0.000	-0.521	-0.054	**-1.072**	0.000
Mar.	3B	Fort Pond	0.000	0.000	-1.539	0.020	-0.085	**-1.604**	-0.531	0.000	0.000	0.000	-1.007	-0.061	**-1.599**	-0.005
Mar.	3B	Hop	0.000	0.000	-1.414	0.057	-0.036	**-1.393**	-0.271	0.000	0.000	0.000	-1.017	-0.102	**-1.390**	-0.003
Mar.	3B	Nashoba	0.000	0.000	-1.960	-0.028	-0.039	**-2.027**	-0.911	0.000	0.000	0.000	-1.010	-0.070	**-1.991**	-0.036
Mar.	3B	North	0.000	0.000	-0.927	0.025	-0.058	**-0.960**	-0.174	0.000	0.000	0.000	-0.738	-0.039	**-0.951**	-0.009
Mar.	3B	Spencer	0.000	0.000	-0.300	0.001	-0.029	**-0.328**	-0.133	0.000	0.000	0.000	-0.189	-0.006	**-0.328**	0.000
Mar.	3B	Stirrup	0.000	0.000	-0.720	0.077	-0.034	**-0.677**	-0.381	0.000	0.000	0.000	-0.251	-0.049	**-0.681**	0.004
Mar.	3B	Taylor	0.000	0.000	-0.133	0.002	-0.020	**-0.151**	-0.111	0.000	0.000	0.000	-0.050	0.010	**-0.151**	0.000

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft^3/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

Month	Scenario	Subbasin	Change in budget flow components (ft^3/s)													
			Inflows						Outflows							Budget error (inflow minus outflow)
			Flow into aquifer from Acton WWTF	Net flow from storage	Re-charge and return flow	Stream leakage to ground water	Ground-water inflow from other sub-basins	Total in-flows	Net flow to storage	Ground-water with-drawals	Evapo-trans-piration	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Ground-water outflow to other sub-basins	Total outflows	
Sept.	3B	Assabet Main Stem Head	0.000	0.042	0.000	-0.021	-0.005	**0.016**	0.028	0.000	-0.033	0.000	0.024	-0.014	**0.005**	0.011
Sept.	3B	Assabet Main Stem Upper	0.000	-0.133	0.000	0.010	-0.025	**-0.148**	0.005	0.000	-0.020	0.000	-0.116	-0.023	**-0.154**	0.006
Sept.	3B	Assabet Main Stem Middle	0.000	-0.278	0.000	0.003	-0.001	**-0.276**	0.003	0.000	-0.026	0.000	-0.066	-0.021	**-0.110**	-0.166
Sept.	3B	Assabet Main Stem Lower	0.000	-0.162	0.000	-0.043	-0.005	**-0.210**	0.004	0.000	-0.017	0.000	-0.176	-0.014	**-0.203**	-0.007
Sept.	3B	Cold Harbor and Howard	0.000	-0.042	0.000	0.022	-0.003	**-0.023**	0.001	0.000	-0.002	0.000	-0.032	0.003	**-0.030**	0.007
Sept.	3B	Danforth	0.000	0.074	0.000	0.120	-0.002	**0.192**	0.094	0.000	-0.002	0.000	0.092	0.001	**0.185**	0.007
Sept.	3B	Elizabeth	0.000	-0.117	0.000	0.007	-0.013	**-0.123**	0.000	0.000	-0.011	0.000	-0.103	0.001	**-0.113**	-0.010
Sept.	3B	Fort Meadow	0.000	-0.162	0.000	0.043	-0.005	**-0.124**	0.001	0.000	-0.020	0.000	-0.102	-0.005	**-0.126**	0.002
Sept.	3B	Fort Pond	0.000	-0.104	0.000	0.038	-0.010	**-0.076**	0.004	0.000	-0.017	0.000	-0.061	-0.011	**-0.085**	0.009
Sept.	3B	Hop	0.000	0.023	0.000	0.007	-0.004	**0.026**	-0.004	0.000	-0.005	0.000	0.034	-0.001	**0.024**	0.002
Sept.	3B	Nashoba	0.000	-0.179	0.000	-0.016	-0.003	**-0.198**	0.008	0.000	-0.060	0.000	-0.160	-0.005	**-0.217**	0.019
Sept.	3B	North	0.000	-0.054	0.000	0.001	-0.004	**-0.057**	0.000	0.000	-0.006	0.000	0.021	-0.002	**0.013**	-0.070
Sept.	3B	Spencer	0.000	-0.026	0.000	0.001	-0.005	**-0.030**	0.000	0.000	-0.005	0.000	-0.022	-0.004	**-0.031**	0.001
Sept.	3B	Stirrup	0.000	-0.059	0.000	0.054	-0.008	**-0.013**	-0.019	0.000	-0.017	0.000	0.020	-0.007	**-0.023**	0.010
Sept.	3B	Taylor	0.000	-0.007	0.000	0.008	-0.005	**-0.004**	0.007	0.000	-0.004	0.000	0.004	0.006	**0.013**	-0.017
Mar.	3C	Assabet Main Stem Head	0.000	0.000	0.707	-0.026	0.004	**0.685**	0.232	0.000	0.000	0.000	0.411	0.049	**0.692**	-0.007
Mar.	3C	Assabet Main Stem Upper	0.000	-0.004	-0.367	0.020	0.004	**-0.347**	-0.107	0.000	0.000	0.000	-0.196	-0.027	**-0.330**	-0.017
Mar.	3C	Assabet Main Stem Middle	0.000	0.000	-0.625	0.018	0.058	**-0.549**	-0.282	0.000	0.000	0.000	-0.205	-0.052	**-0.539**	-0.010
Mar.	3C	Assabet Main Stem Lower	0.000	0.000	-0.220	0.006	0.033	**-0.181**	-0.120	0.000	0.000	0.000	-0.044	-0.001	**-0.165**	-0.016
Mar.	3C	Cold Harbor and Howard	0.000	0.000	0.587	-0.006	-0.015	**0.566**	0.134	0.000	0.000	0.000	0.395	0.038	**0.567**	-0.001
Mar.	3C	Danforth	0.000	0.000	0.313	-0.001	0.008	**0.320**	0.044	0.000	0.000	0.000	0.228	0.048	**0.320**	0.000
Mar.	3C	Elizabeth	0.000	0.000	0.618	-0.003	0.012	**0.627**	0.116	0.000	0.000	0.000	0.472	0.041	**0.629**	-0.002
Mar.	3C	Fort Meadow	0.000	0.000	0.138	-0.002	-0.020	**0.116**	0.021	0.000	0.000	0.000	0.073	0.018	**0.112**	0.004
Mar.	3C	Fort Pond	0.000	0.000	0.486	-0.014	0.045	**0.517**	0.108	0.000	0.000	0.000	0.388	0.032	**0.528**	-0.011
Mar.	3C	Hop	0.000	0.000	-0.328	0.009	0.011	**-0.308**	-0.014	0.000	0.000	0.000	-0.250	-0.038	**-0.302**	-0.006

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

			Change in budget flow components (ft^3/s)													
			Inflows						Outflows							
Month	Scenario	Subbasin	Flow into aquifer from Acton WWTF	Net flow from storage	Re-charge and return flow	Stream leakage to ground water	Ground-water inflow from other sub-basins	Total in-flows	Net flow to storage	Ground-water with-drawals	Evapo-trans-piration	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Ground-water outflow to other sub-basins	Total outflows	Budget error (inflow minus outflow)
Mar.	3C	Nashoba	0.000	0.004	0.877	0.017	0.025	**0.923**	0.376	0.000	0.000	0.000	0.497	0.052	**0.925**	-0.002
Mar.	3C	North	0.000	0.000	0.617	-0.014	0.036	**0.639**	0.067	0.000	0.000	0.000	0.523	0.048	**0.638**	0.001
Mar.	3C	Spencer	0.000	0.000	0.301	-0.001	0.015	**0.315**	0.124	0.000	0.000	0.000	0.173	0.018	**0.315**	0.000
Mar.	3C	Stirrup	0.000	0.000	-0.377	0.035	-0.008	**-0.350**	-0.181	0.000	0.000	0.000	-0.133	-0.038	**-0.352**	0.002
Mar.	3C	Taylor	0.000	0.000	0.107	-0.001	-0.004	**0.102**	0.057	0.000	0.000	0.000	0.025	0.017	**0.099**	0.003
Sept.	3C	Assabet Main Stem Head	0.000	0.075	0.000	0.007	0.000	**0.082**	0.014	0.000	0.022	0.000	0.036	0.003	**0.075**	0.007
Sept.	3C	Assabet Main Stem Upper	0.000	-0.029	0.000	0.003	0.001	**-0.025**	0.001	0.000	-0.004	0.000	-0.014	-0.003	**-0.020**	-0.005
Sept.	3C	Assabet Main Stem Middle	0.000	-0.073	0.000	0.002	0.004	**-0.067**	-0.002	0.000	-0.005	0.000	0.112	-0.004	**0.101**	-0.168
Sept.	3C	Assabet Main Stem Lower	0.000	-0.032	0.000	-0.006	0.007	**-0.031**	0.000	0.000	-0.002	0.000	-0.031	0.000	**-0.033**	0.002
Sept.	3C	Cold Harbor and Howard	0.000	0.036	0.000	-0.010	0.000	**0.026**	0.000	0.000	0.002	0.000	0.023	0.001	**0.026**	0.000
Sept.	3C	Danforth	0.000	0.070	0.000	-0.016	0.000	**0.054**	0.018	0.000	0.000	0.000	-0.040	0.001	**-0.021**	0.075
Sept.	3C	Elizabeth	0.000	0.029	0.000	0.002	-0.004	**0.027**	-0.008	0.000	0.004	0.000	0.024	0.001	**0.021**	0.006
Sept.	3C	Fort Meadow	0.000	0.008	0.000	-0.003	-0.001	**0.004**	0.000	0.000	0.000	0.000	0.004	0.002	**0.006**	-0.002
Sept.	3C	Fort Pond	0.000	0.028	0.000	-0.024	0.001	**0.005**	-0.031	0.000	0.003	0.000	-0.015	-0.001	**-0.044**	0.049
Sept.	3C	Hop	0.000	-0.023	0.000	0.000	-0.001	**-0.024**	-0.005	0.000	-0.003	0.000	0.110	0.000	**0.102**	-0.126
Sept.	3C	Nashoba	0.000	0.067	0.000	-0.008	0.001	**0.060**	-0.001	0.000	0.024	0.000	0.044	0.004	**0.071**	-0.011
Sept.	3C	North	0.000	0.024	0.000	0.000	-0.001	**0.023**	0.003	0.000	0.003	0.000	0.016	0.001	**0.023**	0.000
Sept.	3C	Spencer	0.000	0.024	0.000	0.005	0.001	**0.030**	0.002	0.000	0.004	0.000	0.021	0.002	**0.029**	0.001
Sept.	3C	Stirrup	0.000	0.021	0.000	0.064	-0.002	**0.083**	0.043	0.000	-0.009	0.000	0.036	-0.003	**0.067**	0.016
Sept.	3C	Taylor	0.000	0.010	0.000	-0.002	0.000	**0.008**	0.000	0.000	0.002	0.000	0.004	0.003	**0.009**	-0.001
Mar.	4A	Assabet Main Stem Head	0.000	0.000	-0.071	0.020	-0.015	**-0.066**	-0.095	0.107	0.000	0.000	-0.073	-0.004	**-0.065**	-0.001
Mar.	4A	Assabet Main Stem Upper	0.000	0.274	-0.742	0.226	-0.040	**-0.282**	-0.414	0.770	0.000	0.000	-0.574	-0.066	**-0.284**	0.002
Mar.	4A	Assabet Main Stem Middle	0.000	0.000	-1.375	0.075	0.013	**-1.287**	-0.722	0.066	0.000	0.000	-0.582	-0.038	**-1.276**	-0.011
Mar.	4A	Assabet Main Stem Lower	0.387	0.000	-0.464	0.031	-0.097	**-0.143**	-0.423	0.312	0.000	-0.001	0.028	-0.050	**-0.134**	-0.009
Mar.	4A	Cold Harbor and Howard	0.000	0.000	0.059	0.037	-0.052	**0.044**	0.024	0.141	0.000	0.000	-0.127	0.007	**0.045**	-0.001

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

Month	Scenario	Subbasin	Change in budget flow components (ft³/s): Inflows						Outflows							Budget error (inflow minus outflow)
			Flow into aquifer from Acton WWTF	Net flow from storage	Re-charge and return flow	Stream leakage to ground water	Ground-water inflow from other sub-basins	Total in-flows	Net flow to storage	Ground-water with-drawals	Evapo-trans-piration	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Ground-water outflow to other sub-basins	Total outflows	
Mar.	4A	Danforth	0.000	0.000	-0.020	0.001	-0.025	**-0.044**	-0.024	0.000	0.000	0.000	-0.034	0.012	**-0.046**	0.002
Mar.	4A	Elizabeth	0.000	0.000	-0.332	0.004	-0.035	**-0.363**	-0.169	0.000	0.000	0.000	-0.197	-0.002	**-0.368**	0.005
Mar.	4A	Fort Meadow	0.000	0.000	-0.401	0.064	0.022	**-0.315**	-0.232	0.200	0.000	0.000	-0.281	-0.004	**-0.317**	0.002
Mar.	4A	Fort Pond	0.000	0.000	-0.671	0.014	-0.044	**-0.701**	-0.157	0.121	0.000	0.000	-0.561	-0.115	**-0.712**	0.011
Mar.	4A	Hop	0.000	0.000	-0.730	0.036	-0.009	**-0.703**	-0.164	0.000	0.000	-0.001	-0.482	-0.055	**-0.702**	-0.001
Mar.	4A	Nashoba	0.000	0.000	0.229	-0.003	-0.017	**0.209**	-0.311	0.146	0.000	-0.002	0.395	0.013	**0.241**	-0.032
Mar.	4A	North	0.000	0.000	-0.127	0.006	-0.012	**-0.133**	-0.053	0.000	0.000	0.000	-0.083	0.006	**-0.130**	-0.003
Mar.	4A	Spencer	0.000	0.000	0.086	0.000	0.005	**0.091**	-0.013	0.000	0.000	0.000	0.090	0.012	**0.089**	0.002
Mar.	4A	Stirrup	0.000	0.000	-0.418	0.106	-0.024	**-0.336**	-0.235	0.040	0.000	-0.001	-0.104	-0.036	**-0.336**	0.000
Mar.	4A	Taylor	0.000	0.000	0.012	-0.002	-0.009	**0.001**	-0.020	0.035	0.000	0.000	-0.025	0.008	**-0.002**	0.003
Sept.	4A	Assabet Main Stem Head	0.000	-0.010	0.111	0.040	-0.005	**0.136**	0.036	0.129	0.004	0.001	0.053	0.009	**0.232**	-0.096
Sept.	4A	Assabet Main Stem Upper	0.000	-0.109	0.119	0.042	0.020	**0.072**	0.007	0.224	-0.027	-0.004	-0.095	-0.020	**0.085**	-0.013
Sept.	4A	Assabet Main Stem Middle	0.000	-0.307	0.072	0.090	0.015	**-0.130**	0.020	0.088	-0.012	0.006	-0.111	0.051	**0.042**	-0.172
Sept.	4A	Assabet Main Stem Lower	0.387	-0.071	0.147	-0.047	-0.106	**0.310**	0.011	0.224	-0.012	-0.012	0.132	-0.033	**0.310**	0.000
Sept.	4A	Cold Harbor and Howard	0.000	0.035	0.058	0.068	0.004	**0.165**	0.003	0.147	0.001	0.002	0.008	-0.004	**0.157**	0.008
Sept.	4A	Danforth	0.000	0.069	0.004	0.029	-0.001	**0.101**	0.102	0.000	0.001	0.007	0.032	0.001	**0.143**	-0.042
Sept.	4A	Elizabeth	0.000	-0.037	0.000	0.002	-0.009	**-0.044**	0.000	0.000	-0.005	0.016	-0.045	0.001	**-0.033**	-0.011
Sept.	4A	Fort Meadow	0.000	-0.091	0.052	0.195	0.060	**0.216**	0.019	0.226	-0.011	-0.002	-0.031	0.015	**0.216**	0.000
Sept.	4A	Fort Pond	0.000	0.145	-0.138	0.014	-0.019	**0.002**	-0.033	0.147	-0.027	0.007	-0.179	0.042	**-0.043**	0.045
Sept.	4A	Hop	0.000	-0.121	0.139	0.031	-0.005	**0.044**	-0.003	0.000	0.001	-0.003	0.051	0.013	**0.059**	-0.015
Sept.	4A	Nashoba	0.000	-0.316	0.751	0.106	0.013	**0.554**	0.035	0.219	0.077	-0.016	0.219	0.030	**0.564**	-0.010
Sept.	4A	North	0.000	-0.016	0.027	-0.002	-0.002	**0.007**	0.000	0.000	0.002	0.018	0.058	0.000	**0.078**	-0.071
Sept.	4A	Spencer	0.000	-0.051	0.084	-0.012	0.000	**0.021**	-0.004	0.000	0.009	0.001	0.012	0.013	**0.031**	-0.010
Sept.	4A	Stirrup	0.000	-0.043	0.120	0.091	-0.016	**0.152**	-0.026	0.063	-0.003	-0.012	0.119	-0.004	**0.137**	0.015
Sept.	4A	Taylor	0.000	0.107	0.022	0.024	0.010	**0.163**	0.006	0.167	-0.005	-0.003	0.001	-0.001	**0.165**	-0.002

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft^3/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

			Change in budget flow components (ft^3/s)													
			Inflows						Outflows							
Month	Scenario	Subbasin	Flow into aquifer from Acton WWTF	Net flow from storage	Re-charge and return flow	Stream leakage to ground water	Ground-water inflow from other sub-basins	Total in-flows	Net flow to storage	Ground-water with-drawals	Evapo-trans-piration	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Ground-water outflow to other sub-basins	Total outflows	Budget error (inflow minus outflow)
Mar.	4B	Assabet Main Stem Head	0.000	0.000	-0.960	0.056	-0.040	**-0.944**	-0.376	0.107	0.000	0.000	-0.607	-0.063	**-0.939**	-0.005
Mar.	4B	Assabet Main Stem Upper	0.000	0.283	-1.240	0.244	-0.107	**-0.820**	-0.629	0.770	0.000	0.000	-0.852	-0.105	**-0.816**	-0.004
Mar.	4B	Assabet Main Stem Middle	0.000	0.000	-2.199	0.094	-0.044	**-2.149**	-1.122	0.066	0.000	0.000	-0.983	-0.088	**-2.127**	-0.022
Mar.	4B	Assabet Main Stem Lower	0.387	0.000	-0.866	0.039	-0.117	**-0.557**	-0.659	0.312	0.000	-0.001	-0.122	-0.077	**-0.547**	-0.010
Mar.	4B	Cold Harbor and Howard	0.000	0.000	-0.530	0.045	-0.095	**-0.580**	-0.127	0.141	0.000	0.000	-0.569	-0.024	**-0.579**	-0.001
Mar.	4B	Danforth	0.000	0.000	-0.357	0.004	-0.059	**-0.412**	-0.082	0.000	0.000	0.000	-0.304	-0.026	**-0.412**	0.000
Mar.	4B	Elizabeth	0.000	0.000	-1.281	0.007	-0.082	**-1.356**	-0.443	0.000	0.000	0.000	-0.841	-0.044	**-1.328**	-0.028
Mar.	4B	Fort Meadow	0.000	0.000	-0.993	0.084	0.000	**-0.909**	-0.488	0.200	0.000	0.000	-0.578	-0.040	**-0.906**	-0.003
Mar.	4B	Fort Pond	0.000	0.000	-1.678	0.028	-0.108	**-1.758**	-0.464	0.121	0.000	0.000	-1.267	-0.161	**-1.771**	0.013
Mar.	4B	Hop	0.000	0.000	-1.273	0.054	-0.033	**-1.252**	-0.289	0.000	0.000	-0.001	-0.874	-0.087	**-1.251**	-0.001
Mar.	4B	Nashoba	0.000	0.000	-1.190	-0.012	-0.049	**-1.251**	-0.962	0.146	0.000	-0.002	-0.367	-0.048	**-1.233**	-0.018
Mar.	4B	North	0.000	0.000	-0.899	0.024	-0.059	**-0.934**	-0.174	0.000	0.000	0.000	-0.714	-0.037	**-0.925**	-0.009
Mar.	4B	Spencer	0.000	0.000	-0.214	0.001	-0.016	**-0.229**	-0.141	0.000	0.000	0.000	-0.090	0.001	**-0.230**	0.001
Mar.	4B	Stirrup	0.000	0.000	-0.589	0.128	-0.037	**-0.498**	-0.335	0.040	0.000	-0.001	-0.162	-0.041	**-0.499**	0.001
Mar.	4B	Taylor	0.000	0.000	-0.108	-0.002	-0.016	**-0.126**	-0.107	0.035	0.000	0.000	-0.064	0.005	**-0.131**	0.005
Sept.	4B	Assabet Main Stem Head	0.000	0.000	0.111	0.013	-0.007	**0.117**	0.028	0.129	-0.023	0.001	-0.027	0.000	**0.108**	0.009
Sept.	4B	Assabet Main Stem Upper	0.000	-0.155	0.119	0.033	0.006	**0.003**	0.004	0.224	-0.035	-0.004	-0.153	-0.030	**0.006**	-0.003
Sept.	4B	Assabet Main Stem Middle	0.000	-0.406	0.072	0.094	0.012	**-0.228**	0.020	0.088	-0.023	0.006	-0.196	0.043	**-0.062**	-0.166
Sept.	4B	Assabet Main Stem Lower	0.387	-0.131	0.147	-0.058	-0.112	**0.233**	0.015	0.224	-0.020	-0.012	0.072	-0.040	**0.239**	-0.006
Sept.	4B	Cold Harbor and Howard	0.000	-0.007	0.058	0.084	0.002	**0.137**	0.003	0.147	-0.001	0.002	-0.018	-0.003	**0.130**	0.007
Sept.	4B	Danforth	0.000	0.062	0.004	0.086	-0.002	**0.150**	0.121	0.000	0.000	0.007	0.053	0.001	**0.182**	-0.032
Sept.	4B	Elizabeth	0.000	-0.113	0.000	0.005	-0.013	**-0.121**	0.000	0.000	-0.012	0.016	-0.112	0.001	**-0.107**	-0.014
Sept.	4B	Fort Meadow	0.000	-0.177	0.052	0.218	0.058	**0.151**	0.020	0.226	-0.022	-0.002	-0.085	0.012	**0.149**	0.002
Sept.	4B	Fort Pond	0.000	0.061	-0.138	0.113	-0.024	**0.012**	-0.001	0.147	-0.039	0.007	-0.136	0.037	**0.015**	-0.003
Sept.	4B	Hop	0.000	-0.154	0.139	0.022	-0.007	**0.000**	-0.001	0.000	-0.001	-0.003	-0.006	0.011	**0.000**	0.000

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

Month	Scenario	Subbasin	Change in budget flow components (ft³/s): Inflows						Outflows							Budget error (inflow minus outflow)
			Flow into aquifer from Acton WWTF	Net flow from storage	Recharge and return flow	Stream leakage to ground water	Ground-water inflow from other subbasins	Total inflows	Net flow to storage	Ground-water withdrawals	Evapotranspiration	Consumptive use in private supply areas	Ground-water discharge to streams	Ground-water outflow to other subbasins	Total outflows	
Sept.	4B	Nashoba	0.000	-0.461	0.751	0.100	0.011	**0.401**	0.030	0.219	0.035	-0.016	0.106	0.025	**0.399**	0.002
Sept.	4B	North	0.000	-0.054	0.027	-0.002	-0.003	**-0.032**	0.000	0.000	-0.002	0.018	0.026	-0.001	**0.041**	-0.073
Sept.	4B	Spencer	0.000	-0.063	0.084	0.002	-0.003	**0.020**	-0.002	0.000	0.004	0.001	0.005	0.011	**0.019**	0.001
Sept.	4B	Stirrup	0.000	0.075	0.120	0.150	-0.019	**0.326**	0.123	0.063	-0.007	-0.012	0.153	-0.006	**0.314**	0.012
Sept.	4B	Taylor	0.000	0.111	0.022	0.016	0.007	**0.156**	0.021	0.167	-0.008	-0.003	-0.015	0.000	**0.162**	-0.006
Mar.	4C	Assabet Main Stem Head	0.000	0.000	0.819	-0.012	0.009	**0.816**	0.205	0.107	0.000	0.000	0.451	0.055	**0.818**	-0.002
Mar.	4C	Assabet Main Stem Upper	0.000	0.302	-0.244	0.203	0.027	**0.288**	-0.167	0.770	0.000	0.000	-0.281	-0.027	**0.295**	-0.007
Mar.	4C	Assabet Main Stem Middle	0.000	0.000	-0.550	0.060	0.069	**-0.421**	-0.303	0.066	0.000	0.000	-0.183	0.013	**-0.407**	-0.014
Mar.	4C	Assabet Main Stem Lower	0.387	0.000	-0.063	0.022	-0.077	**0.269**	-0.186	0.312	0.000	-0.001	0.178	-0.024	**0.279**	-0.010
Mar.	4C	Cold Harbor and Howard	0.000	0.000	0.649	0.029	-0.008	**0.670**	0.181	0.141	0.000	0.000	0.310	0.037	**0.669**	0.001
Mar.	4C	Danforth	0.000	0.000	0.317	-0.002	0.008	**0.323**	0.043	0.000	0.000	0.000	0.232	0.049	**0.324**	-0.001
Mar.	4C	Elizabeth	0.000	0.000	0.618	-0.003	0.011	**0.626**	0.119	0.000	0.000	0.000	0.466	0.041	**0.626**	0.000
Mar.	4C	Fort Meadow	0.000	0.000	0.191	0.044	0.043	**0.278**	0.027	0.200	0.000	0.000	0.016	0.032	**0.275**	0.003
Mar.	4C	Fort Pond	0.000	0.000	0.347	0.003	0.021	**0.371**	0.173	0.121	0.000	0.000	0.140	-0.069	**0.365**	0.006
Mar.	4C	Hop	0.000	0.000	-0.188	0.006	0.014	**-0.168**	-0.038	0.000	0.000	-0.001	-0.104	-0.023	**-0.166**	-0.002
Mar.	4C	Nashoba	0.000	0.004	1.647	0.005	0.015	**1.671**	0.329	0.146	0.000	-0.002	1.148	0.074	**1.695**	-0.024
Mar.	4C	North	0.000	0.000	0.645	-0.014	0.035	**0.666**	0.068	0.000	0.000	0.000	0.548	0.049	**0.665**	0.001
Mar.	4C	Spencer	0.000	0.000	0.385	-0.001	0.027	**0.411**	0.117	0.000	0.000	0.000	0.270	0.023	**0.410**	0.001
Mar.	4C	Stirrup	0.000	0.000	-0.247	0.085	-0.011	**-0.173**	-0.138	0.040	0.000	-0.001	-0.047	-0.031	**-0.177**	0.004
Mar.	4C	Taylor	0.000	0.000	0.131	-0.002	-0.001	**0.128**	0.066	0.035	0.000	0.000	0.001	0.011	**0.113**	0.015
Sept.	4C	Assabet Main Stem Head	0.000	0.030	0.111	0.038	-0.002	**0.177**	0.014	0.129	0.033	0.001	-0.019	0.017	**0.175**	0.002
Sept.	4C	Assabet Main Stem Upper	0.000	-0.055	0.119	0.046	0.033	**0.143**	0.003	0.224	-0.020	-0.004	-0.044	-0.010	**0.149**	-0.006
Sept.	4C	Assabet Main Stem Middle	0.000	-0.204	0.072	0.100	0.017	**-0.015**	0.017	0.088	-0.002	0.006	-0.012	0.060	**0.157**	-0.172
Sept.	4C	Assabet Main Stem Lower	0.387	-0.005	0.147	-0.021	-0.100	**0.408**	0.010	0.224	-0.005	-0.012	0.218	-0.026	**0.409**	-0.001
Sept.	4C	Cold Harbor and Howard	0.000	0.077	0.058	0.052	0.005	**0.192**	0.011	0.147	0.003	0.002	0.038	-0.005	**0.196**	-0.004

Appendix 4. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Assabet River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second; head, headwaters; WWTF, wastewater treatment facility; scenarios are defined in text]

			Change in budget flow components (ft³/s)													
			Inflows						Outflows							
Month	Scenario	Subbasin	Flow into aquifer from Acton WWTF	Net flow from storage	Recharge and return flow	Stream leakage to ground water	Ground-water inflow from other sub-basins	Total in-flows	Net flow to storage	Ground-water with-drawals	Evapo-trans-piration	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Ground-water outflow to other sub-basins	Total outflows	Budget error (inflow minus outflow)
Sept.	4C	Danforth	0.000	0.057	0.004	-0.014	0.000	**0.047**	0.041	0.000	0.001	0.007	-0.004	0.001	**0.046**	0.001
Sept.	4C	Elizabeth	0.000	0.041	0.000	-0.003	-0.004	**0.034**	0.000	0.000	0.003	0.016	0.011	0.002	**0.032**	0.002
Sept.	4C	Fort Meadow	0.000	-0.005	0.052	0.174	0.062	**0.283**	0.020	0.226	-0.001	-0.002	0.023	0.019	**0.285**	-0.002
Sept.	4C	Fort Pond	0.000	0.216	-0.138	0.001	-0.013	**0.066**	-0.023	0.147	-0.018	0.007	-0.135	0.048	**0.026**	0.040
Sept.	4C	Hop	0.000	-0.093	0.139	0.033	-0.003	**0.076**	0.001	0.000	0.002	-0.003	0.092	0.013	**0.105**	-0.029
Sept.	4C	Nashoba	0.000	-0.218	0.751	0.115	0.015	**0.663**	0.025	0.219	0.119	-0.016	0.322	0.034	**0.703**	-0.040
Sept.	4C	North	0.000	0.021	0.027	-0.002	0.000	**0.046**	0.000	0.000	0.006	0.018	0.021	0.001	**0.046**	0.000
Sept.	4C	Spencer	0.000	-0.028	0.084	-0.009	0.004	**0.051**	-0.004	0.000	0.013	0.001	0.034	0.016	**0.060**	-0.009
Sept.	4C	Stirrup	0.000	-0.012	0.120	0.100	-0.013	**0.195**	0.009	0.063	0.001	-0.012	0.130	-0.001	**0.190**	0.005
Sept.	4C	Taylor	0.000	0.116	0.022	0.004	0.012	**0.154**	0.007	0.167	-0.002	-0.003	-0.010	-0.003	**0.156**	-0.002

Appendix 5. Changes in Average Annual Water Budget Inflows and Outflows from Basecase for Seven Scenarios, by Subbasin, Upper Charles River Basin, Eastern Massachusetts

Appendix 5. Changes in average annual water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Upper Charles River Basin, eastern Massachusetts.

[ft³/s, cubic foot per second]

Scenario	Subbasin	Change in budget flow components (ft^3/s): Inflows				Outflows					Budget error (inflow minus outflow)
		Recharge and return flow	Stream leakage to aquifer	Inflow from other subbasins	Total inflows	Ground-water withdrawals	Consump-tive use in private sup-ply areas	Ground-water discharge to streams	Outflow to other subbasins	Total outflows	
2	Upper Charles River Main Stem West	-0.824	0.260	0.157	**-0.407**	0.183	0.000	-0.534	-0.056	**-0.407**	0.000
2	Upper Charles River Main Stem East	0.368	0.104	0.085	**0.557**	0.390	0.000	-0.074	0.242	**0.558**	-0.001
2	Bogastow Brook	-0.360	0.025	0.296	**-0.039**	0.448	0.000	-0.535	0.047	**-0.040**	0.001
2	Chicken Brook	0.343	0.000	-0.005	**0.338**	0.000	0.000	0.330	0.008	**0.338**	0.000
2	Hopping Brook	0.333	0.010	-0.014	**0.329**	0.035	0.000	0.254	0.040	**0.329**	0.000
2	Mill River	-0.683	0.055	-0.054	**-0.682**	0.829	0.000	-1.558	0.048	**-0.681**	-0.001
2	Mine Brook	0.668	0.023	-0.010	**0.681**	0.777	0.000	-0.221	0.124	**0.680**	0.001
3A	Upper Charles River Main Stem West	-1.333	0.063	0.145	**-1.125**	0.000	0.001	-1.065	-0.062	**-1.126**	0.001
3A	Upper Charles River Main Stem East	0.350	-0.016	0.031	**0.365**	0.000	0.000	0.171	0.194	**0.365**	0.000
3A	Bogastow Brook	-0.548	0.007	0.189	**-0.352**	0.000	0.000	-0.396	0.045	**-0.351**	-0.001
3A	Chicken Brook	0.300	0.001	-0.005	**0.296**	0.000	0.000	0.287	0.009	**0.296**	0.000
3A	Hopping Brook	0.170	-0.007	-0.018	**0.145**	0.000	0.000	0.116	0.029	**0.145**	0.000
3A	Mill River	-0.635	0.005	0.005	**-0.625**	0.000	0.000	-0.625	0.000	**-0.625**	0.000
3A	Mine Brook	0.404	0.009	-0.011	**0.402**	0.000	0.000	0.280	0.121	**0.401**	0.001
3B	Upper Charles River Main Stem West	-1.701	0.094	0.124	**-1.483**	0.000	0.001	-1.423	-0.063	**-1.485**	0.002
3B	Upper Charles River Main Stem East	0.113	0.008	0.024	**0.145**	0.000	0.000	-0.026	0.171	**0.145**	0.000
3B	Bogastow Brook	-0.953	0.008	0.178	**-0.767**	0.000	0.001	-0.809	0.042	**-0.766**	-0.001
3B	Chicken Brook	0.126	0.004	-0.005	**0.125**	0.000	0.000	0.118	0.006	**0.124**	0.001
3B	Hopping Brook	-0.123	-0.015	-0.022	**-0.160**	0.000	0.000	-0.178	0.019	**-0.159**	-0.001
3B	Mill River	-1.176	0.035	-0.007	**-1.148**	0.000	0.001	-1.144	-0.005	**-1.148**	0.000
3B	Mine Brook	0.068	0.022	-0.011	**0.079**	0.000	0.000	-0.031	0.110	**0.079**	0.000
3C	Upper Charles River Main Stem West	-0.964	0.032	0.171	**-0.761**	0.000	0.000	-0.700	-0.060	**-0.760**	-0.001
3C	Upper Charles River Main Stem East	0.587	-0.038	0.040	**0.589**	0.000	0.000	0.369	0.219	**0.588**	0.001
3C	Bogastow Brook	-0.142	-0.009	0.201	**0.050**	0.000	0.000	0.004	0.047	**0.051**	-0.001
3C	Chicken Brook	0.475	-0.003	-0.006	**0.466**	0.000	0.000	0.456	0.011	**0.467**	-0.001
3C	Hopping Brook	0.463	0.003	-0.015	**0.451**	0.000	0.000	0.406	0.044	**0.450**	0.001
3C	Mill River	-0.095	-0.025	0.017	**-0.103**	0.000	0.000	-0.107	0.005	**-0.102**	-0.001
3C	Mine Brook	0.738	-0.004	-0.010	**0.724**	0.000	0.000	0.591	0.132	**0.723**	0.001

Appendix 5. Changes in average annual water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Upper Charles River Basin, eastern Massachusetts.—Continued

[ft³/s, cubic foot per second]

Scenario	Subbasin	Change in budget flow components (ft³/s)									Budget error (inflow minus outflow)
		Inflows				Outflows					
		Recharge and return flow	Stream leakage to aquifer	Inflow from other subbasins	Total inflows	Ground-water withdrawals	Consumptive use in private supply areas	Ground-water discharge to streams	Outflow to other subbasins	Total outflows	
4A	Upper Charles River Main Stem West	-1.291	0.306	0.140	**-0.845**	0.183	0.001	-0.966	-0.061	**-0.843**	-0.002
4A	Upper Charles River Main Stem East	0.354	0.106	0.080	**0.540**	0.390	0.000	-0.090	0.241	**0.541**	-0.001
4A	Bogastow Brook	-0.486	0.035	0.295	**-0.156**	0.448	0.000	-0.651	0.046	**-0.157**	0.001
4A	Chicken Brook	0.321	0.001	-0.005	**0.317**	0.000	0.000	0.308	0.009	**0.317**	0.000
4A	Hopping Brook	0.206	0.004	-0.018	**0.192**	0.035	0.000	0.127	0.029	**0.191**	0.001
4A	Mill River	-0.776	0.060	-0.055	**-0.771**	0.829	0.000	-1.646	0.047	**-0.770**	-0.001
4A	Mine Brook	0.429	0.032	-0.011	**0.450**	0.777	0.000	-0.443	0.116	**0.450**	0.000
4B	Upper Charles River Main Stem West	-1.660	0.343	0.119	**-1.198**	0.183	0.001	-1.317	-0.063	**-1.196**	-0.002
4B	Upper Charles River Main Stem East	0.117	0.131	0.074	**0.322**	0.390	0.000	-0.286	0.219	**0.323**	-0.001
4B	Bogastow Brook	-0.891	0.044	0.284	**-0.563**	0.448	0.001	-1.057	0.044	**-0.564**	0.001
4B	Chicken Brook	0.147	0.004	-0.005	**0.146**	0.000	0.000	0.139	0.006	**0.145**	0.001
4B	Hopping Brook	-0.087	-0.004	-0.022	**-0.113**	0.035	0.000	-0.167	0.019	**-0.113**	0.000
4B	Mill River	-1.315	0.092	-0.065	**-1.288**	0.829	0.001	-2.162	0.045	**-1.287**	-0.001
4B	Mine Brook	0.094	0.046	-0.011	**0.129**	0.777	0.000	-0.754	0.105	**0.128**	0.001
4C	Upper Charles River Main Stem West	-0.921	0.269	0.167	**-0.485**	0.183	0.000	-0.609	-0.060	**-0.486**	0.001
4C	Upper Charles River Main Stem East	0.591	0.083	0.086	**0.760**	0.390	0.000	0.108	0.263	**0.761**	-0.001
4C	Bogastow Brook	-0.081	0.018	0.306	**0.243**	0.448	0.000	-0.254	0.048	**0.242**	0.001
4C	Chicken Brook	0.496	-0.003	-0.006	**0.487**	0.000	0.000	0.476	0.011	**0.487**	0.000
4C	Hopping Brook	0.499	-0.009	-0.015	**0.475**	0.035	0.000	0.395	0.044	**0.474**	0.001
4C	Mill River	-0.234	0.029	-0.045	**-0.250**	0.829	0.000	-1.127	0.050	**-0.248**	-0.002
4C	Mine Brook	0.764	0.019	-0.010	**0.773**	0.777	0.000	-0.132	0.128	**0.773**	0.000

Appendix 6. Changes in March and September Water-Budget Inflows and Outflows from Basecase for Seven Scenarios, by Subbasin, Upper Charles River Basin, Eastern Massachusetts

Appendix 6. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Upper Charles River basin, eastern Massachusetts.

[ft³/s, cubic feet per second]

Month	Scenario	Subbasin	Change in water budget flow components (ft³/s): Inflows					Outflows						Budget error (inflow minus outflow)
			Net flow from storage	Recharge and return flow	Stream leakage to aquifer	Inflow from other subbasins	Total inflows	Net flow to storage	Ground-water with-drawals	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Outflow to other subbasins	Total out-flows	
Mar.	2	Upper Charles River Main Stem West	-0.002	0.043	0.080	-0.012	**0.109**	0.102	-0.355	0.000	0.329	0.000	**0.076**	0.033
Mar.	2	Upper Charles River Main Stem East	0.000	0.004	0.009	0.015	**0.028**	-0.013	0.455	0.000	-0.355	-0.061	**0.026**	0.002
Mar.	2	Bogastow Brook	0.000	0.062	0.020	0.081	**0.163**	0.028	0.483	0.000	-0.355	-0.008	**0.148**	0.015
Mar.	2	Chicken Brook	0.000	0.021	0.000	0.000	**0.021**	0.000	0.000	0.000	0.021	0.000	**0.021**	0.000
Mar.	2	Hopping Brook	0.000	0.036	0.003	0.000	**0.039**	0.021	0.034	0.000	0.006	0.000	**0.061**	-0.022
Mar.	2	Mill River	0.000	0.048	0.030	-0.142	**-0.064**	0.028	0.863	0.000	-0.992	0.023	**-0.078**	0.014
Mar.	2	Mine Brook	0.000	0.026	0.020	0.000	**0.046**	0.144	0.665	0.000	-0.770	-0.012	**0.027**	0.019
Sept.	2	Upper Charles River Main Stem West	0.511	0.043	0.145	-0.002	**0.697**	0.000	0.154	0.001	0.590	0.001	**0.746**	-0.049
Sept.	2	Upper Charles River Main Stem East	0.053	0.004	0.170	0.103	**0.330**	0.000	0.392	0.000	-0.225	0.166	**0.333**	-0.003
Sept.	2	Bogastow Brook	0.158	0.062	-0.042	0.112	**0.290**	-0.015	0.537	0.002	-0.214	-0.017	**0.293**	-0.003
Sept.	2	Chicken Brook	-0.003	0.021	-0.001	0.000	**0.017**	0.000	0.000	0.000	0.016	0.000	**0.016**	0.001
Sept.	2	Hopping Brook	0.005	0.036	0.013	0.000	**0.054**	0.000	0.059	0.001	-0.001	0.001	**0.060**	-0.006
Sept.	2	Mill River	0.048	0.048	0.234	0.054	**0.384**	0.000	1.151	0.002	-0.885	0.120	**0.388**	-0.004
Sept.	2	Mine Brook	0.302	0.026	-0.082	0.000	**0.246**	0.000	0.753	0.001	-0.500	-0.002	**0.252**	-0.006
Mar.	3A	Upper Charles River Main Stem West	0.003	-0.984	0.035	-0.025	**-0.971**	-0.143	0.000	0.000	-0.833	-0.013	**-0.989**	0.018
Mar.	3A	Upper Charles River Main Stem East	0.000	-0.030	0.001	-0.009	**-0.038**	-0.005	0.000	0.000	-0.031	-0.003	**-0.039**	0.001
Mar.	3A	Bogastow Brook	0.000	-0.258	0.006	-0.001	**-0.253**	-0.050	0.000	0.000	-0.199	-0.002	**-0.251**	-0.002
Mar.	3A	Chicken Brook	0.000	-0.048	0.000	-0.001	**-0.049**	-0.003	0.000	0.000	-0.045	0.000	**-0.048**	-0.001
Mar.	3A	Hopping Brook	0.000	-0.282	0.009	-0.011	**-0.284**	-0.042	0.000	0.000	-0.256	-0.006	**-0.304**	0.020
Mar.	3A	Mill River	0.000	-0.189	0.005	-0.002	**-0.186**	-0.046	0.000	0.000	-0.135	-0.003	**-0.184**	-0.002
Mar.	3A	Mine Brook	0.000	-0.506	0.009	-0.001	**-0.498**	-0.067	0.000	0.000	-0.397	-0.024	**-0.488**	-0.010
Sept.	3A	Upper Charles River Main Stem West	-0.038	-0.079	0.025	-0.002	**-0.094**	0.000	0.000	0.000	-0.111	-0.002	**-0.113**	0.019
Sept.	3A	Upper Charles River Main Stem East	0.001	-0.003	0.001	-0.001	**-0.002**	0.000	0.000	0.000	-0.005	-0.001	**-0.006**	0.004
Sept.	3A	Bogastow Brook	-0.028	-0.029	0.004	0.000	**-0.053**	0.005	0.000	0.000	-0.079	-0.001	**-0.075**	0.022
Sept.	3A	Chicken Brook	0.000	-0.003	0.000	0.000	**-0.003**	0.000	0.000	0.000	-0.003	0.000	**-0.003**	0.000
Sept.	3A	Hopping Brook	-0.008	-0.013	-0.002	-0.001	**-0.024**	0.000	0.000	0.000	-0.031	-0.001	**-0.032**	0.008
Sept.	3A	Mill River	-0.023	-0.020	-0.001	0.000	**-0.044**	0.000	0.000	0.000	-0.051	0.000	**-0.051**	0.007
Sept.	3A	Mine Brook	-0.040	-0.040	-0.002	0.000	**-0.082**	0.000	0.000	0.000	-0.085	-0.001	**-0.086**	0.004

Appendix 6. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Upper Charles River basin, eastern Massachusetts.—Continued

[ft^3/s, cubic feet per second]

Month	Scenario	Subbasin	Change in water budget flow components (ft^3/s): Inflows: Net flow from storage	Recharge and return flow	Stream leakage to aquifer	Inflow from other subbasins	Total inflows	Outflows: Net flow to storage	Ground-water with-drawals	Con-sumptive use in private supply areas	Ground-water dis-charge to streams	Outflow to other subbasins	Total out-flows	Budget error (inflow minus outflow)
Mar.	3B	Upper Charles River Main Stem West	0.005	-1.756	0.062	-0.076	**-1.765**	-0.253	0.000	0.000	-1.506	-0.023	**-1.782**	0.017
Mar.	3B	Upper Charles River Main Stem East	0.000	-0.530	0.009	-0.029	**-0.550**	-0.053	0.000	0.000	-0.444	-0.053	**-0.550**	0.000
Mar.	3B	Bogastow Brook	0.000	-1.105	0.027	-0.026	**-1.104**	-0.221	0.000	0.000	-0.880	-0.004	**-1.105**	0.001
Mar.	3B	Chicken Brook	0.000	-0.427	0.002	-0.002	**-0.427**	-0.018	0.000	0.000	-0.401	-0.006	**-0.425**	-0.002
Mar.	3B	Hopping Brook	0.000	-0.896	0.029	-0.021	**-0.888**	-0.094	0.000	0.000	-0.795	-0.018	**-0.907**	0.019
Mar.	3B	Mill River	0.000	-1.278	0.040	-0.022	**-1.260**	-0.308	0.000	0.000	-0.933	-0.014	**-1.255**	-0.005
Mar.	3B	Mine Brook	0.000	-1.203	0.020	-0.001	**-1.184**	-0.170	0.000	0.000	-0.941	-0.058	**-1.169**	-0.015
Sept.	3B	Upper Charles River Main Stem West	-0.105	-0.147	0.048	-0.006	**-0.210**	0.000	0.000	0.000	-0.209	-0.003	**-0.212**	0.002
Sept.	3B	Upper Charles River Main Stem East	-0.025	-0.043	0.008	-0.005	**-0.065**	0.000	0.000	0.000	-0.056	-0.008	**-0.064**	-0.001
Sept.	3B	Bogastow Brook	-0.155	-0.104	-0.006	-0.003	**-0.268**	-0.013	0.000	0.000	-0.258	-0.004	**-0.275**	0.007
Sept.	3B	Chicken Brook	-0.007	-0.025	0.004	0.000	**-0.028**	0.000	0.000	0.000	-0.028	-0.001	**-0.029**	0.001
Sept.	3B	Hopping Brook	-0.061	-0.065	-0.007	-0.003	**-0.136**	0.007	0.000	0.000	-0.147	-0.002	**-0.142**	0.006
Sept.	3B	Mill River	-0.197	-0.151	-0.002	-0.006	**-0.356**	0.000	0.000	0.000	-0.357	0.000	**-0.357**	0.001
Sept.	3B	Mine Brook	-0.099	-0.102	-0.007	0.000	**-0.208**	0.000	0.000	0.000	-0.200	-0.004	**-0.204**	-0.004
Mar.	3C	Upper Charles River Main Stem West	0.000	-0.213	0.008	0.027	**-0.178**	-0.010	0.000	0.000	-0.162	-0.003	**-0.175**	-0.003
Mar.	3C	Upper Charles River Main Stem East	0.000	0.471	-0.006	0.011	**0.476**	0.047	0.000	0.000	0.380	0.049	**0.476**	0.000
Mar.	3C	Bogastow Brook	0.000	0.588	-0.009	0.025	**0.604**	0.140	0.000	0.000	0.466	0.002	**0.608**	-0.004
Mar.	3C	Chicken Brook	0.000	0.331	-0.002	0.000	**0.329**	0.013	0.000	0.000	0.309	0.007	**0.329**	0.000
Mar.	3C	Hopping Brook	0.000	0.332	-0.010	-0.001	**0.321**	0.025	0.000	0.000	0.279	0.006	**0.310**	0.011
Mar.	3C	Mill River	0.000	0.900	-0.026	0.019	**0.893**	0.225	0.000	0.000	0.663	0.009	**0.897**	-0.004
Mar.	3C	Mine Brook	0.000	0.192	-0.003	0.000	**0.189**	0.038	0.000	0.000	0.146	0.010	**0.194**	-0.005
Sept.	3C	Upper Charles River Main Stem West	0.005	-0.011	0.002	0.002	**-0.002**	0.000	0.000	0.000	-0.012	-0.001	**-0.013**	0.011
Sept.	3C	Upper Charles River Main Stem East	0.023	0.037	-0.005	0.002	**0.057**	0.000	0.000	0.000	0.049	0.007	**0.056**	0.001
Sept.	3C	Bogastow Brook	0.088	0.046	0.008	0.002	**0.144**	0.003	0.000	0.000	0.131	0.002	**0.136**	0.008
Sept.	3C	Chicken Brook	0.005	0.019	-0.003	0.000	**0.021**	0.000	0.000	0.000	0.021	0.001	**0.022**	-0.001
Sept.	3C	Hopping Brook	0.017	0.040	0.000	0.000	**0.057**	0.000	0.000	0.000	0.052	0.001	**0.053**	0.004
Sept.	3C	Mill River	0.145	0.111	0.002	0.005	**0.263**	0.000	0.000	0.000	0.258	-0.001	**0.257**	0.006
Sept.	3C	Mine Brook	0.019	0.023	0.001	0.000	**0.043**	0.000	0.000	0.000	0.040	0.001	**0.041**	0.002

Appendix 6. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Upper Charles River basin, eastern Massachusetts.—Continued

[ft³/s, cubic feet per second]

Month	Scenario	Subbasin	Inflows: Net flow from storage	Inflows: Recharge and return flow	Inflows: Stream leakage to aquifer	Inflows: Inflow from other subbasins	Inflows: Total inflows	Outflows: Net flow to storage	Outflows: Ground-water with-drawals	Outflows: Con-sumptive use in private supply areas	Outflows: Ground-water dis-charge to streams	Outflows: Outflow to other subbasins	Outflows: Total out-flows	Budget error (inflow minus outflow)
			Change in water budget flow components (ft³/s)											
Mar.	4A	Upper Charles River Main Stem West	0.001	-0.941	0.117	-0.037	**-0.860**	-0.026	-0.355	0.000	-0.500	-0.013	**-0.894**	0.034
Mar.	4A	Upper Charles River Main Stem East	0.000	-0.025	0.010	0.005	**-0.010**	-0.020	0.455	0.000	-0.384	-0.064	**-0.013**	0.003
Mar.	4A	Bogastow Brook	0.000	-0.196	0.026	0.079	**-0.091**	-0.029	0.483	0.000	-0.549	-0.009	**-0.104**	0.013
Mar.	4A	Chicken Brook	0.000	-0.027	0.000	-0.001	**-0.028**	-0.002	0.000	0.000	-0.026	0.000	**-0.028**	0.000
Mar.	4A	Hopping Brook	0.000	-0.246	0.012	-0.011	**-0.245**	-0.034	0.034	0.000	-0.248	-0.005	**-0.253**	0.008
Mar.	4A	Mill River	0.000	-0.141	0.036	-0.144	**-0.249**	-0.017	0.863	0.000	-1.125	0.020	**-0.259**	0.010
Mar.	4A	Mine Brook	0.000	-0.480	0.027	-0.001	**-0.454**	0.065	0.665	0.000	-1.164	-0.036	**-0.470**	0.016
Sept.	4A	Upper Charles River Main Stem West	0.523	-0.035	0.177	-0.003	**0.662**	0.000	0.154	0.001	0.595	-0.001	**0.749**	-0.087
Sept.	4A	Upper Charles River Main Stem East	0.050	0.002	0.171	0.102	**0.325**	0.000	0.392	0.000	-0.230	0.166	**0.328**	-0.003
Sept.	4A	Bogastow Brook	0.124	0.033	-0.032	0.112	**0.237**	-0.015	0.537	0.002	-0.259	-0.017	**0.248**	-0.011
Sept.	4A	Chicken Brook	-0.004	0.018	-0.001	0.000	**0.013**	0.000	0.000	0.000	0.013	0.000	**0.013**	0.000
Sept.	4A	Hopping Brook	-0.010	0.023	0.013	-0.001	**0.025**	0.000	0.059	0.001	-0.029	0.000	**0.031**	-0.006
Sept.	4A	Mill River	0.015	0.028	0.234	0.054	**0.331**	0.000	1.151	0.002	-0.935	0.120	**0.338**	-0.007
Sept.	4A	Mine Brook	0.252	-0.013	-0.086	0.000	**0.153**	0.000	0.753	0.001	-0.587	-0.003	**0.164**	-0.011
Mar.	4B	Upper Charles River Main Stem West	0.002	-1.713	0.145	-0.089	**-1.655**	-0.126	-0.355	0.000	-1.168	-0.023	**-1.672**	0.017
Mar.	4B	Upper Charles River Main Stem East	0.000	-0.526	0.022	-0.013	**-0.517**	-0.068	0.455	0.000	-0.789	-0.114	**-0.516**	-0.001
Mar.	4B	Bogastow Brook	0.000	-1.043	0.048	0.054	**-0.941**	-0.186	0.483	0.000	-1.227	-0.012	**-0.942**	0.001
Mar.	4B	Chicken Brook	0.000	-0.406	0.002	-0.002	**-0.406**	-0.018	0.000	0.000	-0.380	-0.006	**-0.404**	-0.002
Mar.	4B	Hopping Brook	0.000	-0.860	0.033	-0.021	**-0.848**	-0.101	0.034	0.000	-0.784	-0.018	**-0.869**	0.021
Mar.	4B	Mill River	0.000	-1.230	0.070	-0.163	**-1.323**	-0.271	0.863	0.000	-1.919	0.009	**-1.318**	-0.005
Mar.	4B	Mine Brook	0.000	-1.177	0.037	-0.001	**-1.141**	-0.013	0.665	0.000	-1.708	-0.071	**-1.127**	-0.014
Sept.	4B	Upper Charles River Main Stem West	0.537	-0.103	0.216	-0.007	**0.643**	0.000	0.154	0.001	0.482	-0.002	**0.635**	0.008
Sept.	4B	Upper Charles River Main Stem East	0.031	-0.038	0.180	0.100	**0.273**	0.000	0.392	0.000	-0.280	0.160	**0.272**	0.001
Sept.	4B	Bogastow Brook	0.063	-0.042	-0.058	0.110	**0.073**	-0.010	0.537	0.002	-0.450	-0.020	**0.059**	0.014
Sept.	4B	Chicken Brook	-0.011	-0.004	0.003	0.000	**-0.012**	0.000	0.000	0.000	-0.012	-0.001	**-0.013**	0.001
Sept.	4B	Hopping Brook	-0.044	-0.029	0.007	-0.002	**-0.068**	0.005	0.059	0.001	-0.150	-0.002	**-0.087**	0.019
Sept.	4B	Mill River	-0.146	-0.103	0.238	0.050	**0.039**	0.000	1.151	0.002	-1.240	0.122	**0.035**	0.004
Sept.	4B	Mine Brook	0.203	-0.076	-0.091	0.001	**0.037**	0.000	0.753	0.001	-0.715	-0.006	**0.033**	0.004

Appendix 6. Changes in March and September water-budget inflows and outflows from basecase for seven scenarios, by subbasin, Upper Charles River basin, eastern Massachusetts.—Continued

[ft^3/s, cubic feet per second]

Month	Scenario	Subbasin	Change in water budget flow components (ft^3/s): Inflows: Net flow from storage	Inflows: Recharge and return flow	Inflows: Stream leakage to aquifer	Inflows: Inflow from other subbasins	Inflows: Total inflows	Outflows: Net flow to storage	Outflows: Ground-water with-drawals	Outflows: Con-sumptive use in private supply areas	Outflows: Ground-water dis-charge to streams	Outflows: Outflow to other subbasins	Outflows: Total out-flows	Budget error (inflow minus outflow)
Mar.	4C	Upper Charles River Main Stem West	-0.002	-0.169	0.089	0.014	**-0.068**	0.086	-0.355	0.000	0.177	-0.003	**-0.095**	0.027
Mar.	4C	Upper Charles River Main Stem East	0.000	0.475	-0.002	0.024	**0.497**	0.031	0.455	0.000	0.027	-0.016	**0.497**	0.000
Mar.	4C	Bogastow Brook	0.000	0.650	0.011	0.104	**0.765**	0.159	0.483	0.000	0.129	-0.007	**0.764**	0.001
Mar.	4C	Chicken Brook	0.000	0.352	-0.002	0.000	**0.350**	0.012	0.000	0.000	0.331	0.007	**0.350**	0.000
Mar.	4C	Hopping Brook	0.000	0.368	-0.008	-0.001	**0.359**	0.002	0.034	0.000	0.293	0.007	**0.336**	0.023
Mar.	4C	Mill River	0.000	0.948	0.004	-0.125	**0.827**	0.252	0.863	0.000	-0.323	0.030	**0.822**	0.005
Mar.	4C	Mine Brook	0.000	0.218	0.017	0.000	**0.235**	0.186	0.665	0.000	-0.612	-0.003	**0.236**	-0.001
Sept.	4C	Upper Charles River Main Stem West	0.538	0.032	0.148	0.001	**0.719**	0.000	0.154	0.001	0.576	0.000	**0.731**	-0.012
Sept.	4C	Upper Charles River Main Stem East	0.074	0.041	0.163	0.104	**0.382**	0.000	0.392	0.000	-0.179	0.172	**0.385**	-0.003
Sept.	4C	Bogastow Brook	0.248	0.108	-0.027	0.114	**0.443**	-0.002	0.537	0.002	-0.072	-0.014	**0.451**	-0.008
Sept.	4C	Chicken Brook	0.002	0.040	-0.004	0.000	**0.038**	0.000	0.000	0.000	0.037	0.001	**0.038**	0.000
Sept.	4C	Hopping Brook	0.024	0.076	0.015	0.000	**0.115**	0.000	0.059	0.001	0.053	0.001	**0.114**	0.001
Sept.	4C	Mill River	0.191	0.159	0.230	0.058	**0.638**	0.000	1.151	0.002	-0.635	0.119	**0.637**	0.001
Sept.	4C	Mine Brook	0.322	0.049	-0.081	0.000	**0.290**	0.000	0.753	0.001	-0.462	-0.001	**0.291**	-0.001