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Effects of Jefferson Road Stormwater-Detention Basin on Loads and Concentrations of Selected Chemical Constituents in East Branch of Allen Creek at Pittsford, Monroe County, N.Y.

by Donald A. Sherwood

Water-quality and streamflow data collected from 1990 through 2000 at East Branch Allen Creek in Monroe County, N.Y., indicate that the loads of some nutrients have decreased since the installation of a detention basin at Jefferson Road in August 1995. Mean monthly loads of ammonia + organic nitrogen calculated for 1995-2000 are significantly less than those calculated for 1990-95 while total phosphorus was the only nutrient to show no significant differences in mean monthly load between 1990-95 and 1995-2000.

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Introduction

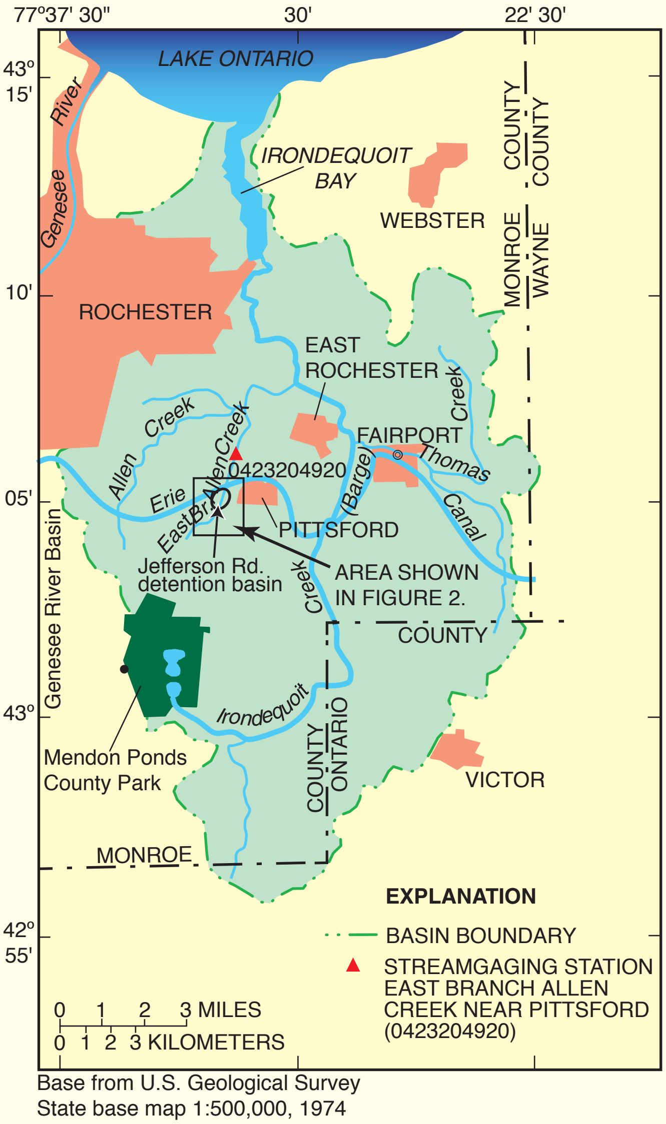

Figure 1. Principal geographic features of Irondequoit Creek basin, Monroe County, N.Y., and location of Jefferson Road stormwater-detention basin in Town of Pittsford.

Analysis of chemical quality data collected from 1990 through 2000 at East Branch Allen Creek indicated that the detention basin at Jefferson Road provides improvement (reduction) in the loads of some constituents.

Stormwater-detention basins are catchments designed to reduce downstream flooding and promote the settling of suspended sediment. They have been widely used in varying forms throughout Monroe County since the 1980's and have been shown to reduce the magnitude of peak flows downstream and to decrease the concentrations of some constituents transported in storm runoff (Zarriello and Sherwood, 1992; Sherwood, 2001). However, the effect these detention basins, particularly a large unvegetated basin such as the Jefferson Road detention basin, have on chemical constituents is still unclear.

The Jefferson Road stormwater-detention basin was constructed on the East Branch of Allen Creek, a tributary to Irondequoit Creek (fig. 1), in the summer of 1995 by the Town of Pittsford, a suburb of Rochester, to alleviate downstream flooding. The detention basin allows water that is impounded during high flows to be released slowly to the creek; it also supplements flow in the creek, as needed, to provide irrigation for downstream country clubs.

Streamflow of East Branch of Allen Creek is continuously monitored by the U.S. Geological Survey in cooperation with the Monroe County Department of Health at a streamflow-gaging station (no. 0423204920) 1.1 miles (mi) downstream (north) of the detention basin and 0.2 mi downstream of State Highway 31 (fig. 1). The Monroe County Environmental Health Laboratory (MCEHL) also collects water samples at this site to assess the chemical quality of the stream. The data collected at this site since its installation in 1990 provide a basis for evaluating the effectiveness of the basin in decreasing the stormwater loads of nutrients and other constituents in the East Branch of Allen Creek.

Description of Detention Basin

The detention basin occupies over 15 acres along the channel of East Branch Allen Creek between Jefferson Road (State Route 252) and the Consolidated Rail Corporation (CONRAIL) railroad tracks (fig. 2). It was placed in full operation during the second week of August 1995. The pond is divided into a smaller "front" pond and a larger "back" pond by an earthen berm with a spillway connecting the two parts (fig. 2). The front pond is designed to dissipate the energy of stormflows to minimize erosion and promote settling of suspended material. The back pond (fig. 3A) is the main storage area. Both portions of the pond are unvegetated during the period of data collection. Water from East Branch Allen Creek flows uncontrolled into the front pond, through the spillway into the back pond, through the outlet control structure, and back into the East Branch Allen Creek channel. Outflow from the pond is controlled at a "weir box" through a system of weirs and valves (fig. 3B). Flow into the weir box is through a 30 in. conduit extending 150 feet (ft) into the pond with the upstream end 2 ft above the pond bottom. When full (466 ft. above NGVD of 1929), the pond contains approximately 7,200,000 cubic feet (ft^3) of water and has a surface area of about 15 acres. The front pond and the back pond are connected by a spillway with the crest at 457 ft. above NGVD of 1929.

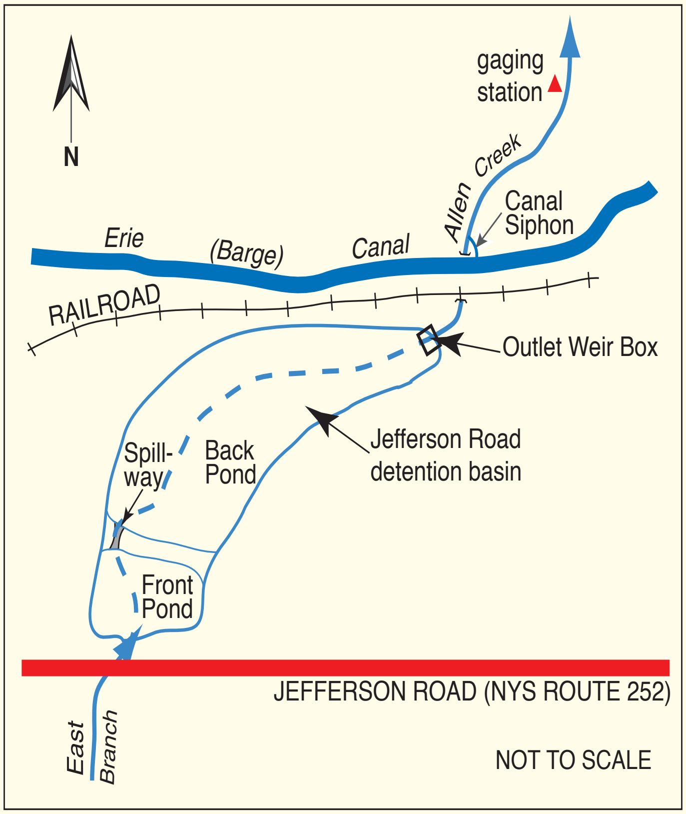

Figure 2. Major features of Jefferson Road detention basin area, Monroe County, N.Y.

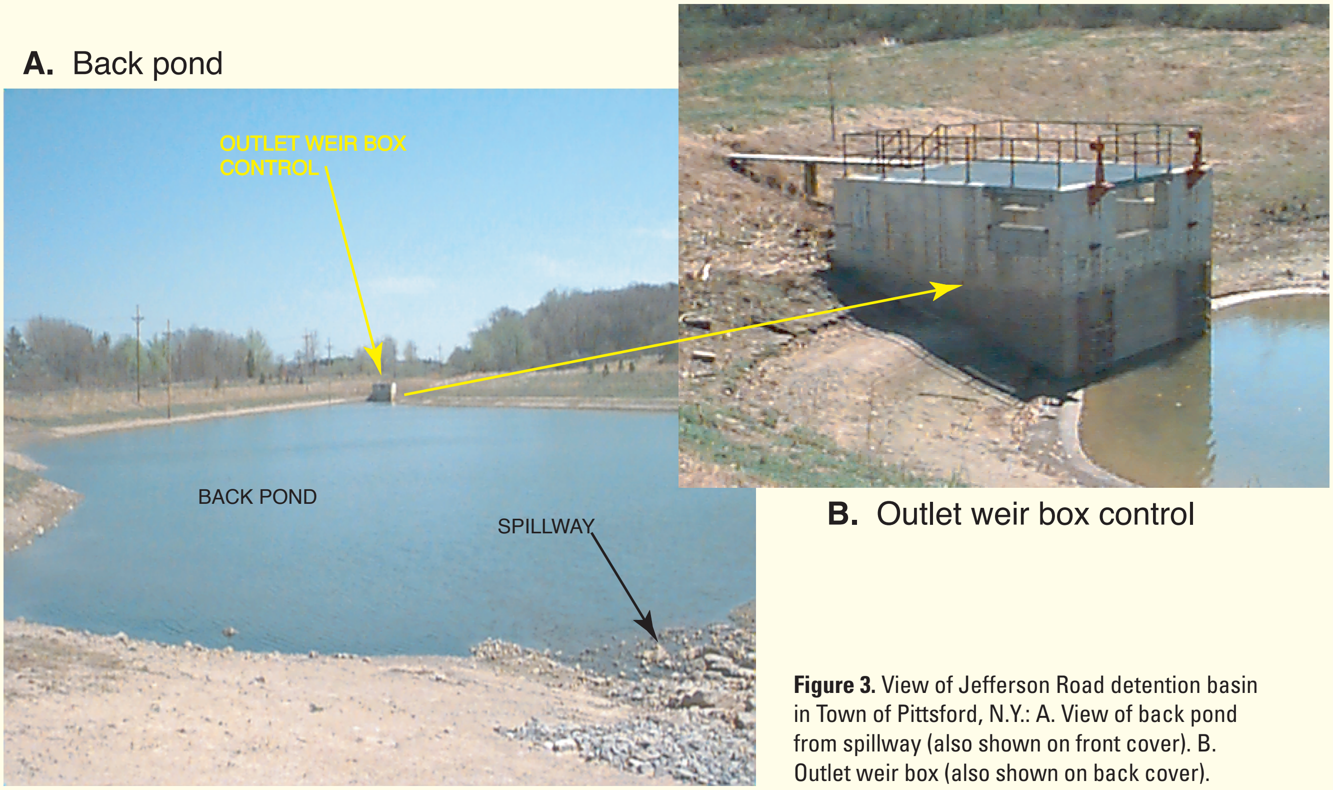

Figure 3. View of Jefferson Road detention basin in Town of Pittsford, N.Y.: A. View of back pond from spillway (also shown on front cover). B. Outlet weir box (also shown on back cover).

Loads and Concentrations of Selected Constituents

Discharge data and water samples have been collected at the East Branch Allen Creek gaging station since May 1990. The 5 years of data collected before installation of the detention basin provide an adequate basis for comparison with data collected since then to assess the efficiency of the basin in chemical load removal.

Loads

A regression equation that relates constituent concentration to flow was used to estimate the monthly mean loads for each month before and after basin installation. The monthly means were grouped by individual month and averaged; for example, the monthly mean loads for each October before basin installation were averaged to produce an average monthly load for October before basin installation, and this load was compared with the average monthly load for October after installation. The monthly loads were then divided by the mean monthly flow to adjust for differences in flow before and after basin installation.

Data Limitations

Calculating the basin's effect on chemical loads from data collected before and after basin construction rather than concurrent data from inflow and outflow sites at the basin is complicated by several factors that could introduce bias: (1) the preconstruction and postconstruction periods differ in frequency and intensity of storms and in their numbers of dry (or wet) years; (2) development within the basin drainage area has increased; this increase, in turn, has altered the drainage patterns and chemical loads carried in storm runoff; (3) during the navigation season inflow from the Erie-Barge canal to the East Branch of Allen Creek between the basin outflow and the gaging station more than 1 mi downstream could affect stream chemistry at the gaging station, and (4) large discharges from the basin could resuspend material that was recently deposited between the basin and the gaging station. Efforts were made during the analyses to minimize the effects of these factors; nevertheless these factors increase the uncertainty of the interpretations.

Statistical Analysis

A statistical analysis (Wilcoxon rank-sum test) of the adjusted mean monthly loads before and after basin installation showed some statistically significant ($\alpha = 0.05$) differences in monthly averages (fig. 4). The values for total suspended solids, ammonia, nitrite + nitrate, and orthophosphate showed statistically significant increases for certain months after basin installation, and significant decreases for other months. Ammonia + organic nitrogen and dissolved sulfate values after basin installation showed months with significantly decreased loads but no months with increased loads, whereas dissolved chloride showed months with significantly increased loads, but no months with decreased loads. Neither total phosphorus nor monthly mean discharge showed changes after basin installation that were statistically significant.

The Wilcoxon rank-sum test was also used to identify significant differences in mean monthly constituent loads for all months before, and all months after, basin installation. The only constituent to show a statistically significant difference was ammonia + organic nitrogen, which showed a smaller median load after basin installation (table 1). The slight increase in mean monthly flows, from 8.71 ft^3/s (cubic feet per second) before basin construction to 9.08 ft^3/s after could result from the peak of record flow in July 1998 and/or an increased amount of inflow from the canal.

Table 1. Mean monthly loads of selected constituents at East Branch of Allen Creek before and after installation of the detention basin at Jefferson Road in the Town of Pittsford, N.Y., August 1995.

[Values are in pounds except as noted. Loads are unadjusted, although statistical test was done on adjusted loads. **Bold** type indicates significant difference at $\alpha = 0.05$. p denotes significance.]

Constituent	Mean monthly load: Before	Mean monthly load: After	p
Flow (cubic feet per second)	8.71	9.08	0.92
Suspended solids (tons)	108	83.6	.08
Ammonia as N, dissolved	55.6	52.6	.09
Ammonia + organic nitrogen as N, total	**1,420**	**1,280**	**<.01**
Nitrite + nitrate as N, total	2,430	2,190	.10
Total phosphorus as P	247	240	.42
Orthophosphate as P, dissolved	38.2	44.5	.36
Chloride, dissolved (tons)	77.0	107	.42
Sulfate, dissolved (tons)	57.8	57.2	.58

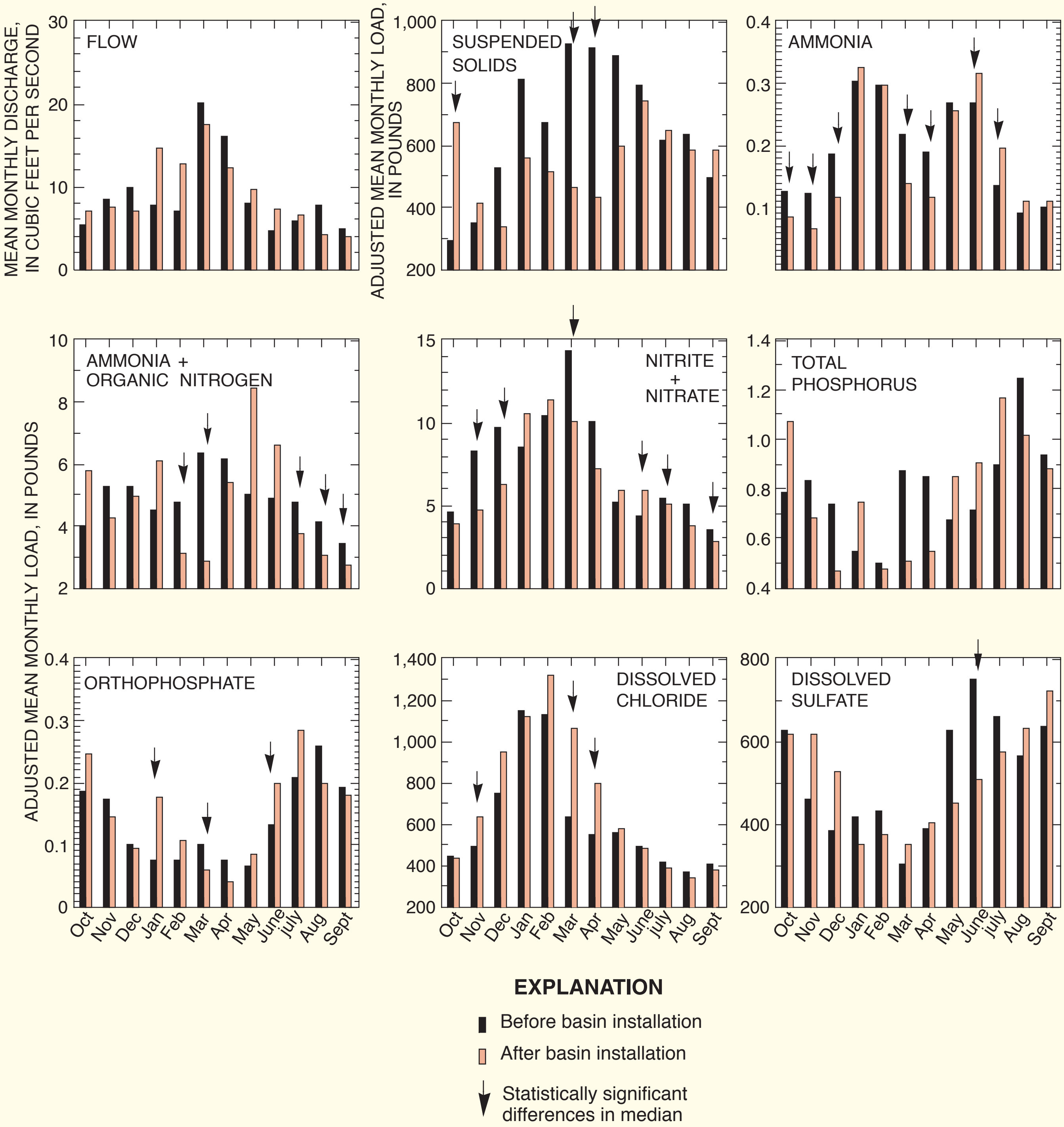

Figure 4. Mean monthly constituent load (in pounds) for each month before and after the 1995 installation of Jefferson Road detention basin Monroe County, N.Y. Loads have been adjusted for before and after differences in flow by dividing the mean monthly load by the mean flow for that month.

Table 2. Median concentrations of selected constituents at East Branch of Allen Creek before and after installation of the detention basin at Jefferson Road in the Town of Pittsford, N.Y., August 1995.

[**Bold** type indicates a significant difference at $\alpha = 0.05$. Values are in milligrams per liter except as noted. p denotes significance.]

Constituent	Median concentration		
	Before	After	p
Suspended solids	119	102	0.18
Suspended solids	119	102	0.18
Ammonia, as N dissolved	.02	.02	.27
Ammonia + organic nitrogen, as N, total	**.78**	**.60**	**<.01**
Nitrite + nitrate, as N, total	**1.5**	**.96**	**<.01**
Total phosphorus, as P	.10	.10	.45
Orthophosphate, as P, dissolved	.02	.02	.14
Chloride, dissolved	**96**	**109**	**.04**
Sulfate, dissolved	86	79	.13

Table 3. Results of seasonal Kendall trend test on concentrations of selected constituents at East Branch of Allen Creek before and after installation of the detention basin at Jefferson Road in the Town of Pittsford, N.Y., August 1995.

[Trend test was considered significant at $\alpha = 0.05$]

Constituent	Trend	
	1990-95	1996-2000
Suspended solids	None	None
Ammonia	None	None
Ammonia + organic nitrogen	None	None
Nitrite + nitrate	None	None
Total phosphorus	None	Downward
Orthophosphate	None	None
Chloride, dissolved	None	None
Sulfate, dissolved	None	None

Concentrations

Concentration of a given constituent may be a more reliable measure of the basin's effectiveness than the load because concentration is measured as mass per unit volume (mg/L), whereas load (mass) is a function of concentration, volume of flow, and some unit of time. It is possible for lower concentrations to produce large loads as a result of high flow and for high concentrations to produce large loads at lower flows; therefore, the better measure of improvement in contamination is reflected in the level of concentration which is independent of flow.

Constituent concentrations before and after the installation of the detention basin were compared through boxplots (fig. 5) and the Wilcoxon rank-sum test; results indicate significant decreases in median concentrations of ammonia + organic nitrogen (from 0.78 mg/L to 0.60 mg/L) and nitrite + nitrate (from 1.5 mg/L to 0.96 mg/L) after basin installation. Both of these nutrients are represented as total values that include the particulate component, which tends to settle out during detention. The concentrations of these nutrients fluctuate seasonally and are related to flow. Concentrations of chloride generally are higher during the winter when road salt application is the greatest and lower at other times. The increased median concentration of dissolved chloride (from 96 mg/L to 109 mg/L) after basin installation (table 2) is probably a result of increased road salt usage.

The seasonal Kendall trend test was used to examine concentration data for the presence of statistically significant ($\alpha = 0.05$) trends before and after basin installation to ensure that there were no already existing upward or downward trends that might obscure the effect of the detention basin. The only constituent for which a trend was indicated was total phosphorus, which showed a downward trend after basin installation (table 3). This trend could be a result of settling within the detention basin, but this cannot be verified.

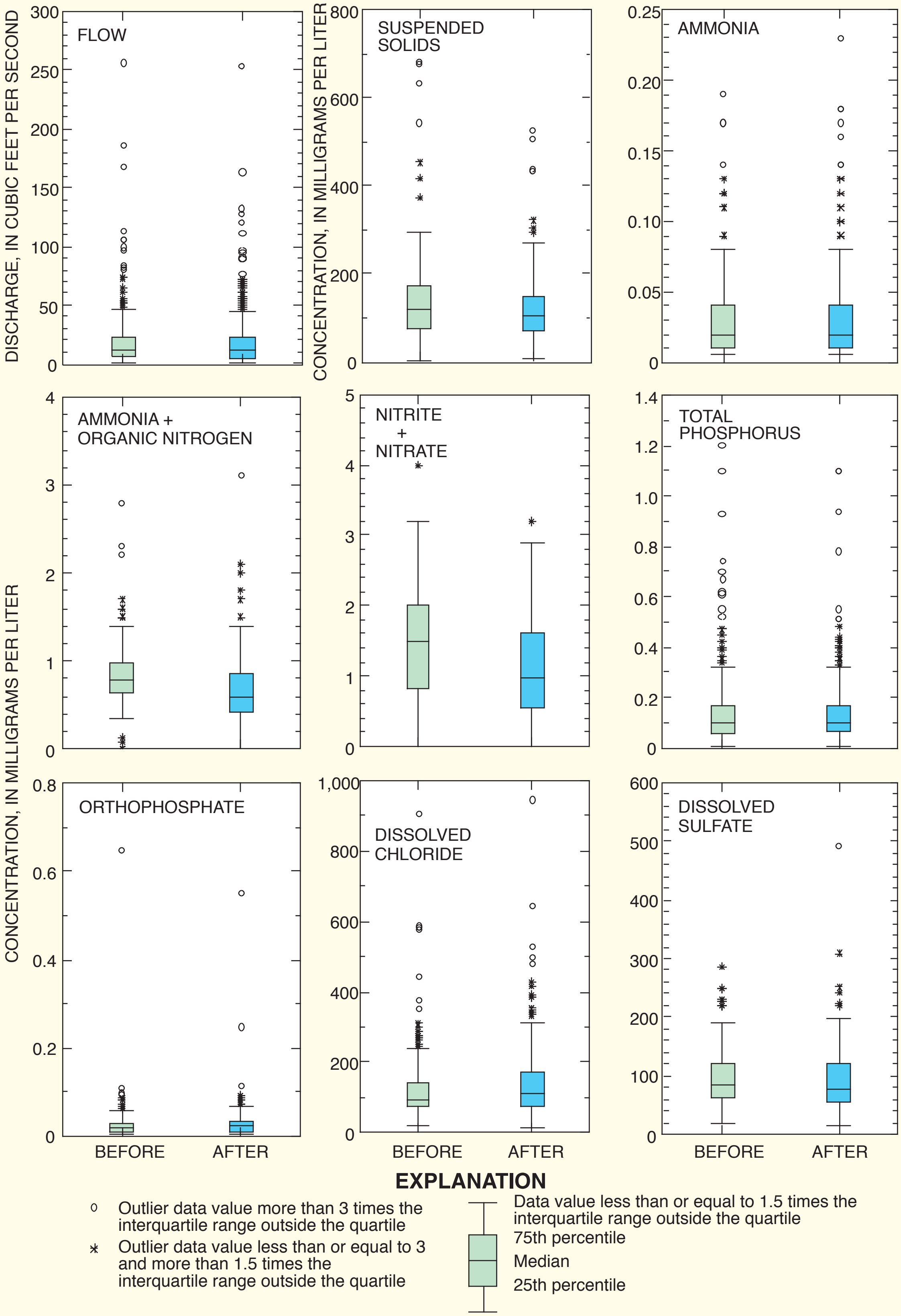

Figure 5. Ranges in concentration of selected constituents in water samples from East Branch Allen Creek before and after 1995 installation of the Jefferson Road detention basin in Town of Pittsford, N.Y.

Conclusions

Discharge and water-quality data collection at East Branch Allen Creek from 1990 through 2000 provide a basis for estimating the effect of the Jefferson Road detention basin on loads and concentrations of chemical constituents downstream from the basin. Mean monthly flow for the 5 years prior to construction of the detention basin (8.71 ft^3/s) was slightly lower than after (9.08 ft^3/s). The slightly higher mean monthly flow after basin construction may have been influenced by the peak flow for the period of record that occurred in July 1998 or variations in flow diverted from the canal. No statistically significant difference in average monthly mean flow before and after basin installation was indicated.

Total phosphorus was the only constituent to show no months with significant differences in load after basin construction. Several constituents showed months with significantly smaller loads after basin construction than before, whereas some constituents showed certain months with smaller and some months with greater loads, after basin construction.

Statistical analysis of the “mean monthly load” for all months before and all months after construction of the detention basin showed only one constituent (ammonia + organic nitrogen) with a significantly lower load after construction and none with higher loads.

Median concentrations of ammonia + organic nitrogen showed a statistically significant decrease (from 0.78 mg/L to 0.60 mg/L) after basin installation, as did nitrite + nitrate (from 1.50 mg/L to 0.96 mg/L); in contrast, the median concentration of dissolved chloride increased from 95.5 mg/L before basin installation to 109 mg/L thereafter. A trend analysis of constituent concentrations before and after installation of the detention basin showed that total phosphorus had a downward trend after installation.

Analysis of the data collected at East Branch Allen Creek indicates that the Jefferson Road detention basin, in some cases, provides an improvement (reduction) in loads of some constituents. These results are uncertain, however, because hydrologic conditions before basin installation differed from those in the 5 years that followed, and because inflow from the Erie-Barge canal may alter the water quality in the 1-mi reach between the basin outflow and the gaging station.

Selected References

Sherwood, D.A., 2001, Effects of a vegetated stormwater-detention basin on chemical quality and temperature of runoff from a small residential development in Monroe County, New York: U.S. Geological Survey Water-Resources Investigations Report 01-4099, 8 p.

Zarriello, P.J., and Sherwood, D.A., 1992, Effects of stormwater detention on the chemical quality of runoff from a small residential development, Monroe County, New York: U.S. Geological Survey Water-Resources Investigations Report 92-4003, 57 p.

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