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ASSESSING THE REPRESENTATIVENESS OF STREAM GEOMORPHOLOGY PARAMETERS IN BASINS

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ABSTRACT: *The BASINS (Better Assessment Science Integrating point and Non-point Sources, Release 2) system, created under the auspice of the U.S. Environmental Protection Agency (EPA), uses ArcView as a framework to integrate several hydrologic/hydraulic and water quality models. The BASINS system also includes a national stream characteristic database that contains reach-scale data on mean stream width, depth and velocity, among other parameters. These data are used to calibrate the non-point source NPSM/HSPF model (Non-point Source Model/Hydrologic Simulation Program-Fortran) in BASINS. The objective of this research was to assess the representativeness of the stream characteristic data provided in BASINS. Geomorphological data collected at nine cross sections on Cazenovia Creek, NY were compared to stream geomorphology parameters provided in the national stream characteristic database in the BASINS system. Cross sections were surveyed and velocity measurements were obtained during low-flow conditions in July 2001. Model runs were performed comparing observed flow in Cazenovia Creek during 1990 with (1) flow results from a calibration using the national stream characteristic database values of mean channel width, depth, and low-flow velocity and (2) flow results from a calibration using our measured values of mean channel width, depth, and low-flow velocity. Despite differences between the stream characteristic database data and our measured values of mean channel width, depth, and low-flow velocity, model results were not different. Future work will investigate the effect measuring higher flow events has on model results.*

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has reviewed various modeling approaches and models that could be used for receiving water analysis (EPA, 1995). One suite of models and databases that came out of that review was the BASINS (Better Assessment Science Integrating point and Non-point Sources, Release 2) system. BASINS uses ArcView as a framework to integrate several hydrologic/hydraulic and water quality models, including the non-point source NPSM/HSPF model (Non-point Source Model/Hydrologic Simulation program-Fortran). BASINS was created under the auspice of the EPA primarily to provide a Total Maximum Daily Load (TMDL) assessment tool. Under the Clean Water Act, states are required to provide TMDL of pollutants from point and non-point sources (EPA, 1998). The BASINS system has become a popular, easy-to-use tool for water quality analysis; however, there are some questions of data quality assurance (Whittemore and Beebe, 2000). While BASINS was subjected to a minimal peer-review in 1998, the national databases and default parameters included in the system were not reviewed (Whittemore and Beebe, 2000).

One national database component included in the BASINS system is a stream characteristic database, which contains reach-scale data on variables such as mean channel width, depth, and velocity for streams nationwide. The EPA compiled these data in 1982 from National Oceanographic and Atmospheric Administration (NOAA) aeronautical charts at a scale of 1:500,000. The stream characteristic data, along with land use characteristics and point sources data, are used to calibrate the NPSM/HSPF model in BASINS. The objective of this research was to provide some quality assurance and assess the representativeness of the stream characteristic data provided in BASINS.

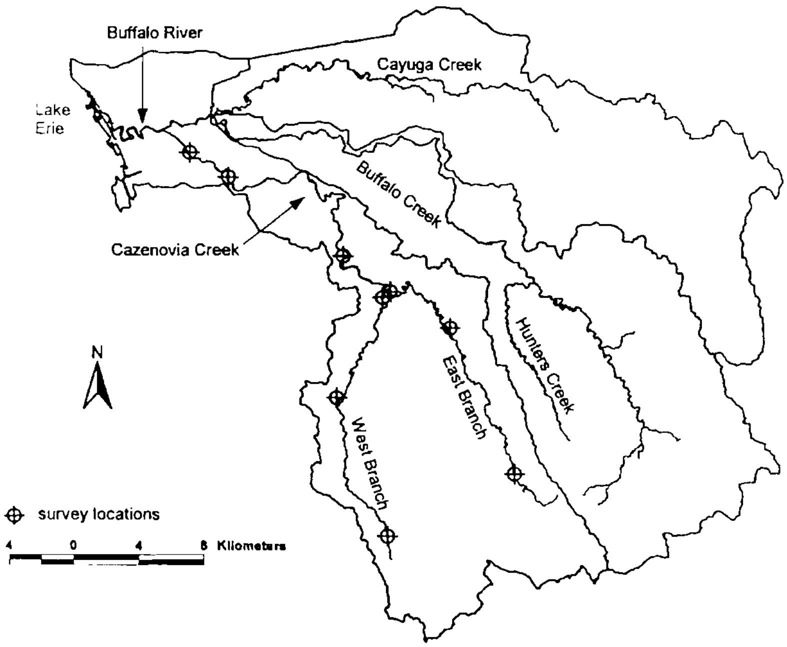


Figure 1. Map of Cazenovia Creek with study site locations identified

METHODOLOGY

Study Area

Cazenovia Creek is one of three tributaries to the Buffalo River, Buffalo, NY (Figure 1). The International Joint Commission (IJC) has designated the Buffalo River as one of 43 Areas of Concern (AOC). The designation was based, in part, on factors like degradation of fish and wildlife habitat and contaminated bed sediment in the river (New York State Department of Environmental Conservation, 1989). Cazenovia Creek is 48 km long and has a drainage area of 350 km^2. Land use in the watershed is varied. Woods and farmland characterize the upper portion of the watershed, but the creek also passes through several small communities and receives industrial, commercial, institutional, residential, and municipal inputs (Irvine and Pettibone, 1996). The creek flows through progressively more suburban landscape before it discharges to the Buffalo River.

Field and Modeling Methods

Geomorphological data were collected on Cazenovia Creek, NY during low-flow conditions in July 2001. This study's two-day sampling campaign took place when the discharge at the USGS gauge station (#04215500) was approximately 6 cfs, which is the discharge BASINS cites as the 7Q10 low-flow discharge (Table 1). The 7Q10 discharge (or velocity) is the lowest flow of a seven-day duration with a 10-year recurrence interval. Channel morphology was surveyed at nine cross sections: three cross sections on the Main Branch, three on the East Branch, and three on the West Branch (Figure 1). Cross sections were surveyed using a surveying tape, rod, and level. Survey locations were spaced every 3.0 m with additional survey locations at edge of water and where there were major changes in topography. The survey data were used to calculate channel width (width of the water surface) and depth at each cross section. Data from each branch of Cazenovia Creek were averaged to yield mean channel width and depth for the three branches. Velocity measurements were obtained using a Marsh-

Table 1 Stream geomorphology data provided in the BASINS national database of stream characteristics

Reach	7Q10 flow (cfs)*	7Q10 velocity (ft/s)	Mean depth (ft)	Mean width (ft)	Mean velocity (ft/s)
East branch	2.11	0.28	0.34	16.38	0.96
West branch	2.39	0.28	0.23	13.86	0.76
Main branch	6.87	0.23	0.42	27.27	0.87

*low-flow discharge that occurs, on average, for seven days with a 10 year recurrence interval

McBirney Model 2000 flow meter. Velocity measurements were taken at 0.6 of the total flow depth at surveyed verticals; this resulted in between three and four velocity measurements per cross section. The cross section velocity data were used to calculate a mean low-flow velocity for each branch of the creek.

The measured geomorphological data were compared qualitatively to the Cazenovia Creek stream geomorphology parameters provided in the BASINS system (Table 1). The NPSM/HSPF model in BASINS was used for two model runs. The first model run compared the U.S. Geological Survey (USGS) observed flow in Cazenovia Creek during 1990, a "typical" flow year, to flow results from a calibration using the national stream characteristic database values of mean channel width, depth, and low-flow velocity. The second model run compared the same 1990 observed flow to flow results from a calibration using our measured values of mean channel width, depth, and low-flow velocity. Nash-Sutcliffe coefficients (R^2) were calculated to evaluate model performance for both model runs:

$$R^2 = 1 - \left[\frac{\sum \left(Q_i - Q_i'\right)^2}{\sum \left(Q_i - Q\right)^2}\right] \qquad [1]$$

where Q_i equals the measured discharge, Q'_i is the computed discharge, and Q is the average measured discharge. The Nash-Sutcliffe coefficient is a measure of the proportion of the initial variance accounted for by the model (Nash and Sutcliffe, 1970). The coefficient varies from $-\infty$ to 1, where one is a perfect fit between observed and computed flows (Laroche et al., 1996).

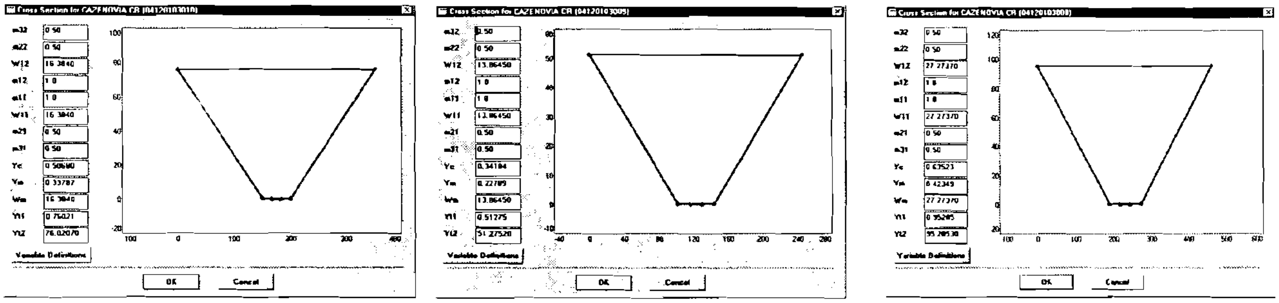
RESULTS

Comparison of Stream Geomorphology Values

Results indicate that there were differences between the national stream characteristic database data and this study's measured values of mean channel width, depth, and low-flow velocity (Tables 2 and 3). Overall, BASINS-provided data underrepresented channel mean width, depth, and the low-flow 7Q10 velocity. Measured mean depth was nearly twice that of the mean depth provided in the stream characteristic database for the Main and East branches of the creek. However, the BASINS-provided and measured mean depths were similar for the West branch (Table 2; Figures 2 and 3). Measured mean width of the East and West branches

Table 2 Stream morphology data from the BASINS stream characteristics database and this study's measured morphology data

Reach	BASINS mean depth (ft)	Measured mean depth (ft)	BASINS mean width (ft)	Measured mean width (ft)
East branch	0.34	0.61	16.38	36.62
West branch	0.23	0.29	13.86	48.59
Main branch	0.42	0.80	27.27	92.27



(a) (b) (c)

Cross Section for CAZENOVIA CR (04120103010)

Cross Section for CAZENOVIA CR (04120103009)

Cross Section for CAZENOVIA CR (04120103008)

	(a)	(b)	(c)
m32	0.50	0.50	0.50
m22	0.50	0.50	0.50
W12	16.3840	13.86450	27.27370
m12	1.0	1.0	1.0
m11	1.0	1.0	1.0
W11	16.3840	13.86450	27.27370
m21	0.50	0.50	0.50
m31	0.50	0.50	0.50
Yc	0.50600	0.34184	0.63523
Ym	0.33787	0.22789	0.42349
Wm	16.3840	13.86450	27.27370
Yt1	0.76021	0.51275	0.95285
Yt2	76.02070	51.27520	95.28530

Figure 2. Cross section profiles from BASINS (a) East branch, (b) West Branch, and (c) Main Branch

was over three times greater than those provided in the stream characteristic database (Table 2; Figures 2 and 3). Measured mean width of the Main branch was greater than twice that of the BASINS-provided mean channel width (Table 2; Figures 2 and 3). The measured mean low-flow velocity in each of the three reaches of Cazenovia Creek was nearly twice that of the low-flow velocity provided in the BASINS stream characteristic database (Table 3).

Model Results

There was no difference between NPSM/HSPF model runs comparing the USGS observed flow with the two calibrations: one using the BASINS stream characteristic database and one using this study's measured values of mean channel width, depth, and low-flow velocity (Figure 4). Nash-Sutcliffe R^2 coefficients for both model runs were 0.34. These results indicate that changing mean channel width, depth, and low-flow velocity did not increase the predictive capabilities of the model because the Nash-Sutcliffe coefficient did not become closer to one. However, changing these parameters result in lower peak discharges and better timed peaks during the late spring and early summer months (Figure 4). Both calibrations overestimated flows in April through June and underestimated flows in September and October (Figure 4).

DISCUSSION AND CONCLUSIONS

The primary objective of this research was to assess the representativeness of the stream characteristic data provided by BASINS. Results show that the BASINS data are not representative of the actual channel characteristics of Cazenovia Creek. Measured values of mean channel width and depth ranged from nearly two to greater than three times the values in the BASINS stream characteristic database. Measured mean low-flow velocity values were nearly twice that of the 7Q10 low-flow velocity provided by BASINS. The measured stream characteristics of Cazenovia Creek reported in this study were taken during low flow conditions. It is expected that measuring the stream channel during high flow will result in greater values of the stream characteristics, moving these values even further away from the BASINS-provided data.

Despite the differences between the BASINS-provided data and this study's measured values of mean channel width, depth, and low-flow

Table 3 Stream velocity data from the BASINS stream characteristics database and this study's measured velocity data

Reach	BASINS 7Q10 velocity (ft/s)	Measured mean low-flow velocity (ft/s)
East branch	0.28	0.46
West branch	0.28	0.53
Main branch	0.23	0.41

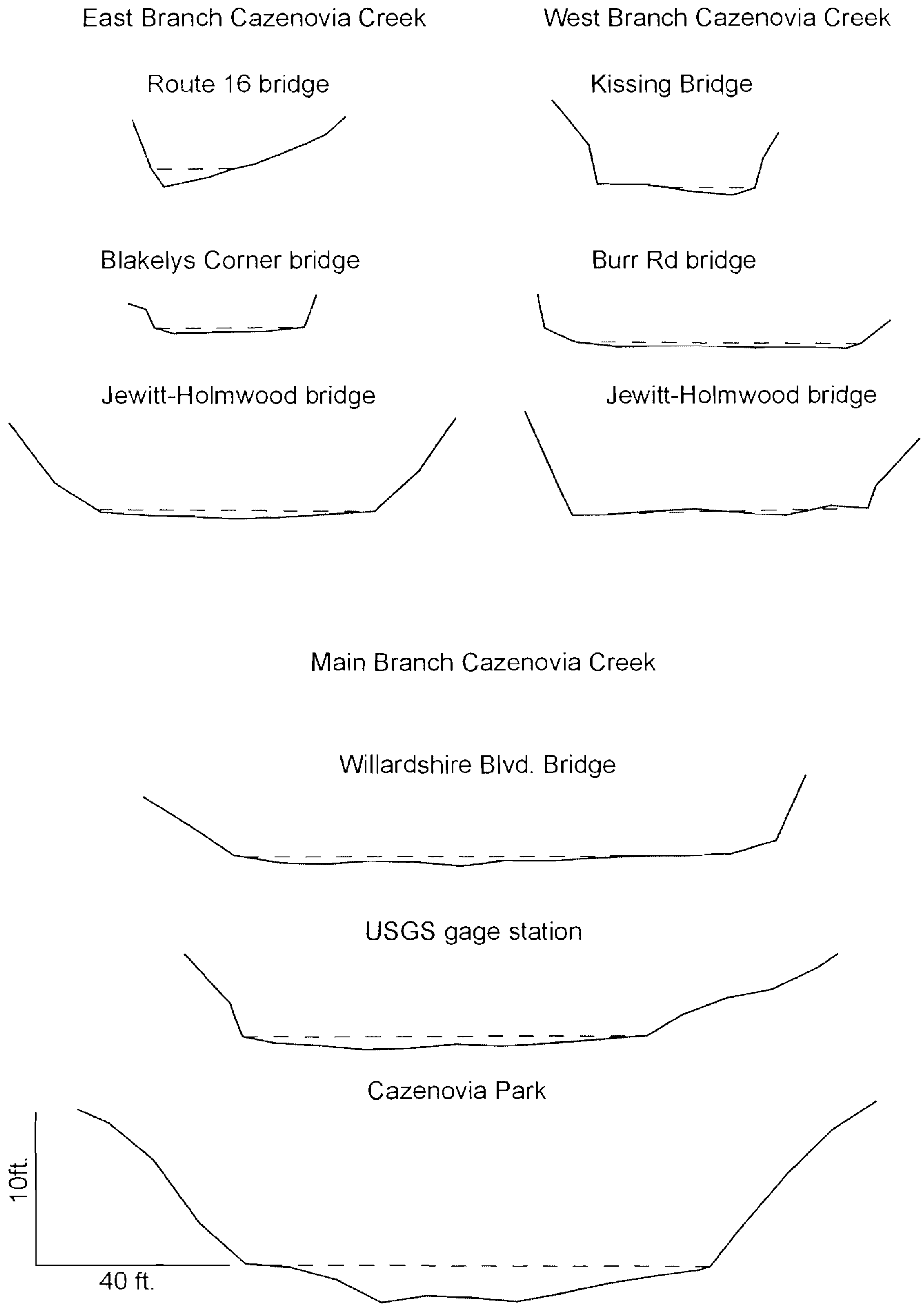


Figure 3. Cazenovia Creek cross section profiles. Dashed line is the water surface.

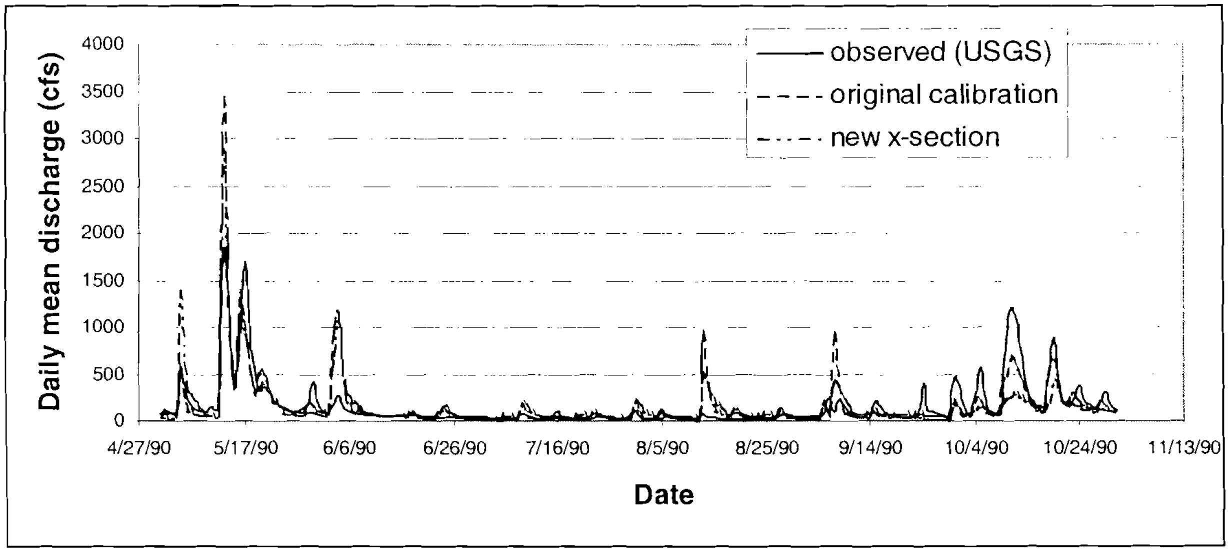


Figure 4. NPSM/HSPF model results

velocity, model results were not affected. The predictive capabilities of the model did not improve when the measured channel characteristics were used. Results from this study, therefore, suggest that overall the model is not sensitive to changes in stream geomorphology. Future work will involve investigating channel geomorphology during high flow events to determine if additional changes in mean width, depth, and velocity would impact model results. Sampling during higher flow events would allow for the determination of an overall mean velocity, another model parameter (see Table 1).

Both model runs accurately predicted baseflow; however, stormflow is not predicted as well as baseflow by either model run (Figure 4). This may be due, at least in part, to stream geomorphology. The discrepancy during storms between observed flow and the two simulated flows may be due to the fact that stream morphology would have a greater impact on flow at higher discharges because a larger portion of the channel would be affected by the flow. If the variance between observed and simulated flow was a result of stream morphology alone, the model run using this study's stream geomorphology values would over estimate flow during stormflow because measured channel width, depth, and velocity were greater than the BASINS-provided data. Interestingly, the model does not consistently over or under estimate flow (e.g., flow was over estimated in the spring and under estimated in the fall). Other model parameters, such as precipitation inputs, may influence model results during both low flows and storm flows. Research has found that BASINS hydrologic modeling is sensitive to changes in parameters such as precipitation inputs and groundwater storage (Perrelli and Irvine, 2001; Brun and Band, 1999). Brun and Band (1999) concluded that differences found between observed and simulated flows during storms was a result of inaccurate precipitation input data. Sensitivity analysis performed by Perrelli and Irvine (2001) indicated that the model was most sensitive to groundwater storage parameters.

In conclusion, states are required to provide TMDL of pollutants from point and non-point sources (EPA, 1998) and BASINS was designed as the primary assessment tool to determine TMDLs; therefore, it will likely continue to be a popular tool for water quality analysis. There is a need for studies like this one to provide information on data quality assurance, particularly because the national databases and default parameters included in the system were not reviewed (Whittemore and Beebe, 2000). Results from studies like these are critical because they can provide a measure of quality assurance for those data contained in the national databases and they can indicate the parameters that most influence model results in individual watersheds.

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