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Post-Audit Verification Of The Model AGNPS In Vermont Agricultural Watersheds

POST-AUDIT VERIFICATION OF THE MODEL AGNPS IN VERMONT AGRICULTURAL WATERSHEDS

FINAL REPORT TO:

ENVIRONMENTAL PROTECTION AGENCY
NONPOINT SOURCE CONTROL BRANCH

SUBMITTED BY:

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ABSTRACT

The purpose of this project was to conduct a verification of the model AGNPS (Agricultural Non-Point Source Pollution Model, Ver. 2.52, 1988). The observed runoff, and concentration and mass export of sediment, nitrogen, and phosphorus from two Vermont agricultural watershed were compared to simulated values for a total of 15 storms in one watershed and 11 storms in another watershed. AGNPS underpredicted discharge except for the largest (1-2 inch) storms. Sediment and nitrogen concentrations and exports were overpredicted by AGNPS. Predicted phosphorus concentrations were of the same order of magnitude as observed. Phosphorus exports were underpredicted. The differences between observed and predicted values obtained in this verification of AGNPS were greater than previously reported. The testing of the model in a completely different climatic region may explain the differences obtained in the accuracy of the model.

ACKNOWLEDGEMENT

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INTRODUCTION

The purpose of this project was to perform a post-audit verification of the model AGNPS (Agricultural Non-Point Source Pollution Model). This model was developed by USDA-Agricultural Research Service in Morris, Minnesota to simulate sediment and nutrient export from agricultural watersheds (Young et al., 1989). The version of the model used for this verification (Ver. 2.52, 1988), was single event-based and thus did not the prediction of periods of no-flow or snowmelt. The model uses measured or estimated parameters as input and does not require calibration or fitting. AGNPS was developed for watershed-scale applications and can be applied to areas of up to 12, 000 ha (Onstad, et al., 1986). One of the unique characteristics of AGNPS, as compared to other nonpoint source models, is that it uses distributed watershed parameters and allows identification of up to 700 cells within a watershed. However, rainfall information is lumped for a watershed. Model outputs include runoff volume and peak rate, and the concentration and mass export of sediment, nitrogen (N), and phosphorus (P) for the event.

AGNPS has received considerable attention nationally as a tool to detect and prioritize nonpoint pollution problems in agricultural watersheds, and to assess the relative effects of alternative conservation practices (Bartholic et al., 1987; Frevert and Crowder, 1987; Lee, 1987; Young et al., 1987). However, comparisons of AGNPS predictions to observed data have been limited. The model authors regressed predicted and observed peak flow for 20 watersheds in the north central United States. The resulting R^2 value was 0.81 (Young et. al., 1989). They also compared observed and simulated sediment yield for two watersheds in Iowa (21 storms) and one in Nebraska (8 storms). The Iowa results indicated that the model overpredicted sediment yield by two percent with a R^2 value of 0.95; the Nebraska comparison resulted in a R^2 value of 0.76 (Bosch, et. al., 1983, Young, et. al., 1986). More recently, the model authors reported observed and predicted concentrations of total N and total P for 20 locations in seven Minnesota watersheds. The observed data were based on small (1-yr, 24-hr) storms. They concluded that AGNPS gave realistic predictions of nutrient concentrations but did not provide statistics on the goodness of fit between observed and predicted values (Young, et. al., 1989).

AGNPS was applied in the Highland Silver Lake watershed in Illinois at three sites (Lee, 1987, Lee and Comacho, 1987). Predicted and observed runoff volume and total suspended solids exports, as a function of rainfall, were presented. They concluded that since model predictions seemed to be an average of observed data, that the model simulations were reasonably close to average field observations (Lee, 1987; Lee and Comacho, 1987). However, these comparisons were not made statistically. They also compared average annual observed exports (over 2.8 years) of sediment, N, and P to simulated annual values. Annualized simulations were obtained from modeling seven storms representing certain precipitation intervals. Modeled results were then multiplied by the frequency of storms per each interval and then summed to yield annual estimates (Lee, 1988, personnel communication). Lee (1987) concluded that the model overpredicted total P load by five times, and total N load by 3.5 times. Sediment loads differed by less than five percent.

D. German (1991, personal communication) compared observed and predicted values for seven storms in 1989 in Loomis Creek, South Dakota. Loomis Creek monitoring is part of the Oakwood Lakes-Poinsett Rural Clean Water Program (RCWP) project. He concluded that AGNPS generally overpredicted discharge volume and peak, and the exports of sediment, N and

P.

There have not been extensive tests of the model AGNPS, although usage of the model is expanding. There has been a lack of verifications applying standard statistical tests as suggested by Thomann (1982) and Reckhow et al. (1990). It is of benefit to the U.S. Environmental Protection Agency (EPA) to assess whether AGNPS is suitable for assessing the effectiveness of agricultural best management practices (BMPs). Both the EPA and the States have multiple needs for such models, including: 1) comparing alternative pollution control plans, 2) developing total maximum daily loads (TMDLs), 3) locating critical areas in watersheds, and 4) estimating the water quality benefits to be gained from implementation of management measures in the coastal zone under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990.

SUMMARY OF AGNPS

AGNPS (Agricultural Nonpoint Source) is an event-based, measured parameter, watershed-scale, distributed model predicting discharge and the concentration and load of N, P, and sediment in runoff (Young et. al., 1987). The model has been described fully in Young et al. (1987) and summarized in Bosch et. al., (1983), Onstad, et. al., (1986), and Young, et. al., (1989).

Flow

AGNPS predicts both runoff volume and peak runoff rate. Runoff volume from each cell is estimated using the Soil Conservation Service (SCS) curve number (CN) technique (USDA-SCS 1972):

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \tag{1}$$

where Q is the runoff volume, P is the precipitation, and S is a retention factor, all in uniform units of length, such as inches or cm. The retention factor (S) is determined from:

$$S = \frac{1000}{CN} - 10 \tag{2}$$

where CN is the curve number for the cell. The curve number is the percentage ratio between stream discharge and precipitation, and varies with land use, hydrologic soil group, and antecedent moisture content (AMC). Curve number are taken from standard tables provided in the model documentation.

Peak runoff rate for each cell is determined from:

$$Q_p = 8.48A^{0.7} * S_c^{0.16} * RO^{(0.824A^{0.0166})} * LW^{-0.19} \tag{3}$$

where Q_p is the peak flow rate (cubic feet per second), A is the drainage area (acres), S_c is the channel slope (ft/ft), RO is the runoff volume (in), and LW is the watershed length-width ratio which is determined from L^2/A where L is the watershed length (ft). Although the units do not cancel in this equation, they do cancel as used in the model (Young et al., 1986). This procedure for estimating peak runoff was developed by Smith and Williams (1980) for the CREAMS model.

Erosion and Sediment

Erosion is determined using the modified universal soil loss equation (USLE):

$$E = (EI)(K)(LS)(C)(P)(SSF) \tag{4}$$

where E is the soil loss (tons/ac), EI is the rainfall energy intensity, K is the soil erodibility factor, LS is the slope length and slope factor, C is the cover and management factor, P is the practice factor, and SSF is the slope shape factor (Wischmeier and Smith, 1978).

Sediment is routed from cell to cell using a mass balance approach, and allowing for deposition (Young et. al., 1989).

Nitrogen and Phosphorus

Both soluble and particulate forms of N and P are predicted using procedures found in the CREAMS model (Frere, et. al., 1982). The concentration of soluble N or P is determined from soil concentrations and extraction coefficients:

$$Nut_{sol} = C_{nut} Nut_{ext} Q \tag{5}$$

where Nut_{sol} is the export (lbs) of soluble N or P in runoff, C_{nut} is the concentration (ppm) of soluble N or P at the soil surface, Nut_{ext} is an extraction coefficient for movement into runoff, and Q is the runoff volume (in). The units cancel as used in the model (Young et al., 1986).

Nutrients transported in the sediment are based on soil nutrient concentrations, an enrichment ratio, and sediment yield from a cell:

$$Nut_{sed} = (Nut_f)Q_sE_R \tag{6}$$

where Nut_{sed} is the N or P transported (lbs) by the sediment in runoff, Nut_f is the N or P content (ppm) of the soil, and E_R is the enrichment ratio determined from:

$$E_R = 7.4Q_s^{-0.2}T_f \tag{7}$$

where Q_s the sediment yield (lbs) and T_f is a correction factor for soil texture.

Model Input

Table 1 summarizes the input requirements for AGNPS (Young et al., 1987). These input parameters, as used in this study, are described in detail in the "Methods" section of this report.

Table 1. AGNPS Input Parameters.

Column No.	Parameter	Source of Input Data
Watershed		
1	watershed identification	User
2	cell area (acres)	User
3	total number of cells	GIS
4	precipitation (inches)	Gage
5	energy - intensity value	Calculated
Cell		
1	cell number	GIS
2	number of cell into which it drains	USGS topographic map
3	SCS curve number	Young et al. (1987)
4	average land slope (%)	USGS topographic map
5	slope shape factor (uniform, convex, concave)	USGS topographic map
6	average field slope length (feet)	VT SCS, 1989
7	average channel slope (%) S_c	USGS topographic map
8	average channel side slope (%)	Young et al. (1987)
9	manning's roughness coefficient (n) for channel	Young et al. (1987)
10	soil erodibility factor (K)	GIS - soil survey
11	cropping factor (C)	Young et al. (1987)
12	practice factor (P)	Young et al. (1987)
13	surface condition constant based on land use	GIS - Young et al. (1987)
14	aspect of drainage from the cell	USGS topographic map
15	soil texture	GIS - Young et al. (1987)
16	fertilization level (zero, low, medium, high)	GIS - land use monitoring
17	incorporation factor (% fertilizer, top 0.5 in. soil)	GIS - Young et al. (1987)
18	point source indicator	none
19	gully source level (estimate of gully erosion)	none
20	chemical oxygen demand factor	not applicable
21	impoundment factor (terrace system)	none
22	channel indicator	GIS

OBJECTIVES

The objectives of this study were to:

1) Perform a post-audit verification of the AGNPS model by comparing simulated runoff and the concentration and mass export of sediment, nitrogen, and phosphorus to observed values from two agricultural watersheds in Vermont to determine the accuracy of AGNPS.

2) Assess methods of extrapolating event-based simulations to long-term findings so that annualized information may be obtained from a series of event simulations.

STUDY AREAS

Two watersheds in northwestern Vermont were used for the study (Figure 1). Both watersheds were used predominantly for dairy agriculture and have been the sites of extensive implementation of land treatment practices and comprehensive monitoring of water quality.

One study area, Subwatershed 3, was located in the LaPlatte River watershed approximately 10 mi. south of Burlington, Vermont. Monitoring in this 400-ac watershed occurred from 1979 to 1990 as part of the USDA Soil Conservation Service's small watershed land treatment program (Public Law 566). The watershed monitoring program and results of monitoring have been described in detail elsewhere (Cassell and Meals, 1981; Meals 1990). Soils in the watershed were largely lacustrine silts and clays. Land uses within the watershed were 77% agricultural, 19% forested, and 4% residential (Figure 2). Climate in the watershed was continental. The normal precipitation was 34 inches and the mean annual temperature was 45°F (NOAA, 1983).

The second study area, the Jewett Brook watershed (Station 21), was located in the St. Albans Bay watershed, Lake Champlain, approximately 35 miles north of Burlington. Monitoring in this 1,384-ha watershed occurred from 1981 to 1991 as part of a Comprehensive Monitoring and Evaluation (CM & E) program associated with the St. Albans Bay Rural Clean Water Program (RCWP) project. The monitoring program and results have been previously described (Cassell et. al., 1983; Clausen, 1985; VT RCWP Coord. Com., 1991). Watershed soils are predominantly lacustrine silts and clays. Land uses in the watershed were 83% agricultural, 15% woodland, and 2% residential (Figure 3). Considering only the agricultural land, 45% of the watershed was hayland, 23% was cornland, and 14% was pasture. Climate

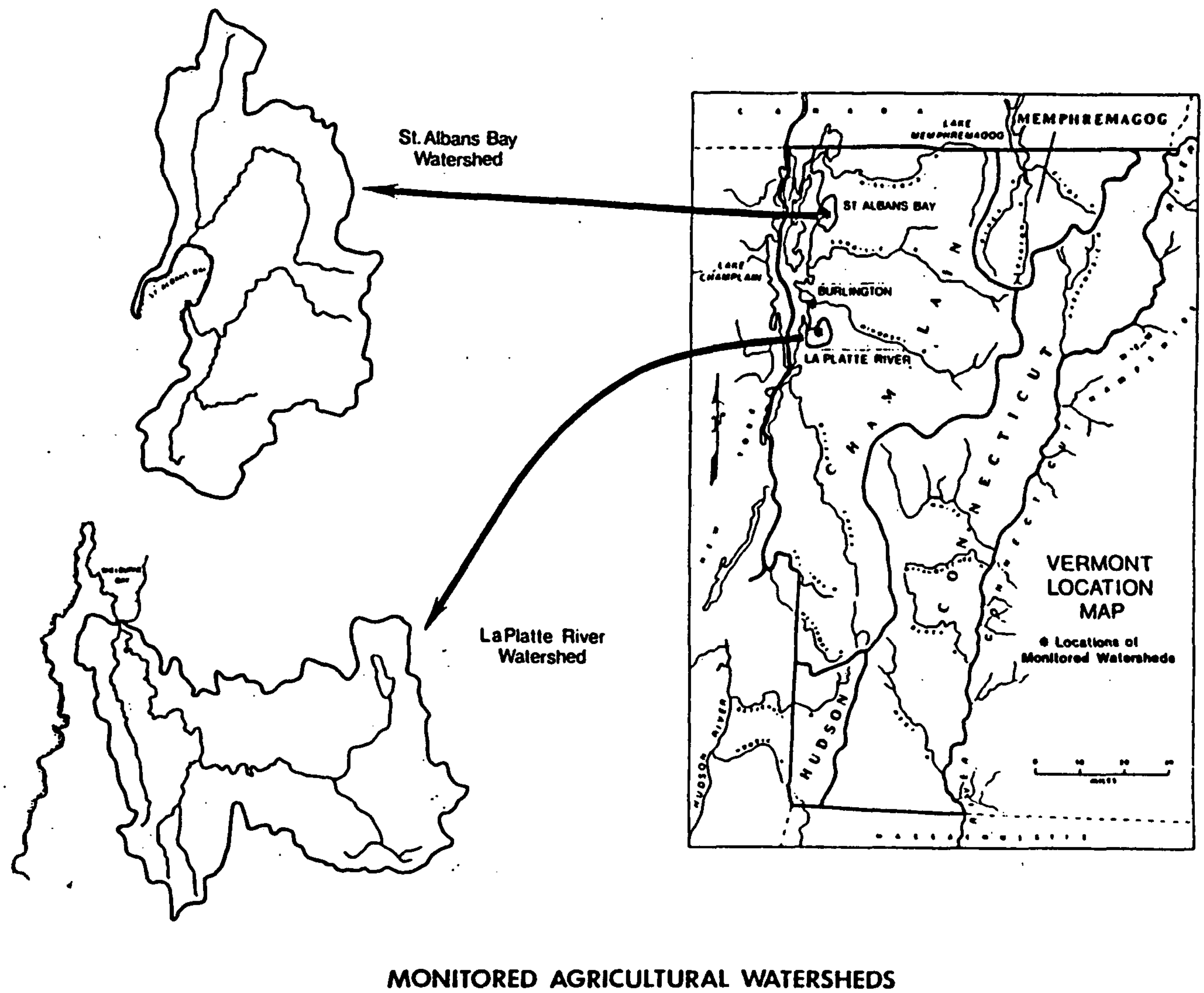

Figure 1. Vermont map showing location of the two study watersheds.

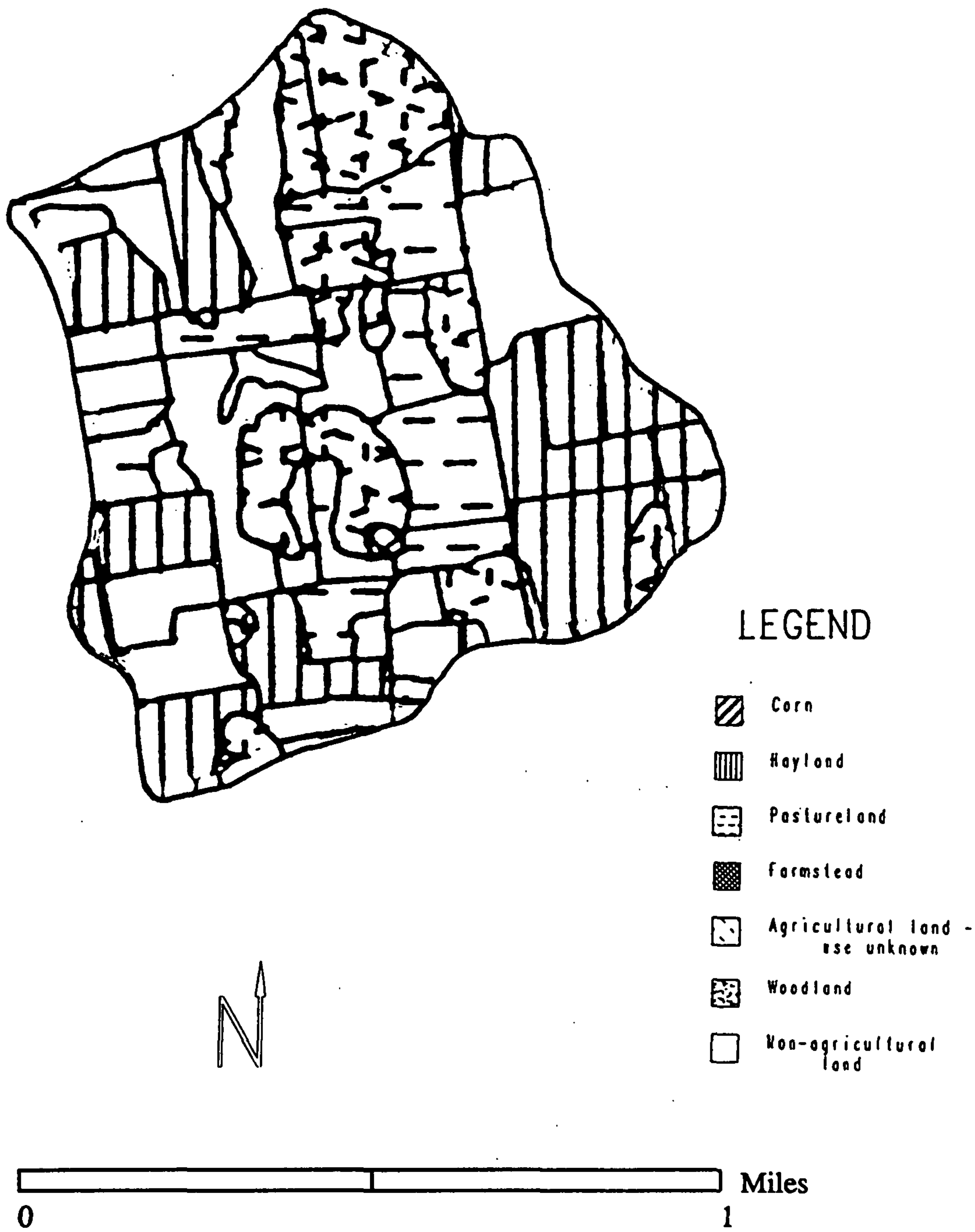

Figure 2. Land use map of Laplatte River Subwatershed 3, 1989.

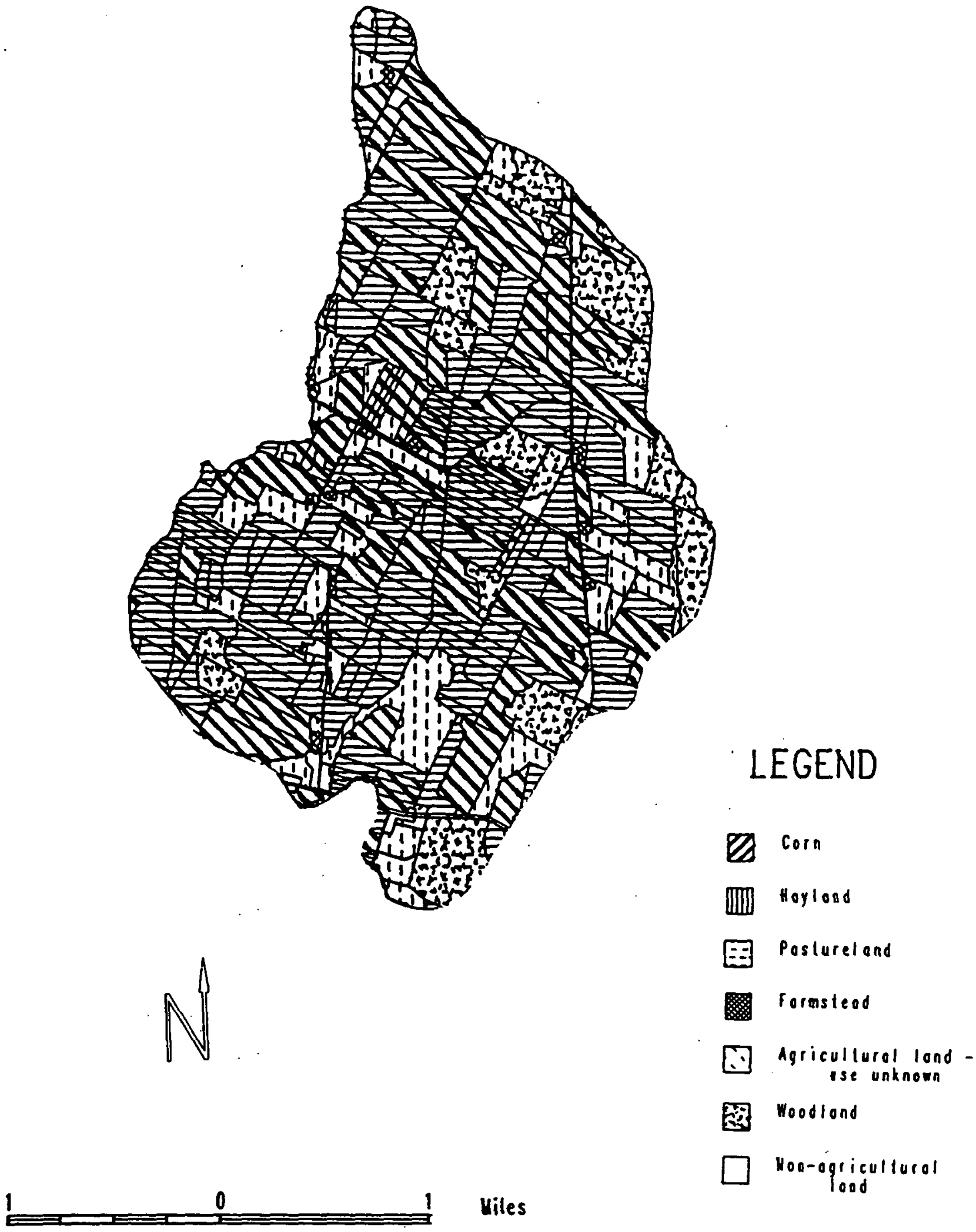

Figure 3. Land use map of the Jewett Brook Watershed, 1988.

for the watershed was cool, humid, and continental. The mean annual temperature was 45° F and the average annual precipitation was 33 inches (Cassell et al., 1983). Thunderstorms occurred an average of 25 times per year.

APPROACH

Model Verification

Model verification refers to the testing of a model with new field data to determine whether the model adequately predicts observed data (Thomann, 1982; Reckhow et al., 1991) This process has also been called model testing, model validation, or model evaluation. This is the final step in a series of stages in model development as outlined by Thomann (1982) (Figure 4). The first step is problem identification. This step is needed to focus the modeling effort. For example, the AGNPS model was originally developed to analyze and prioritize agricultural watersheds in Minnesota in order to correctly direct public funds toward solving pollution problems on a watershed basis. A method to systematically prioritize watersheds was previously lacking. Conceptual modeling refers to a description of the model components, inputs, and outputs as are often described in flow charts. Next, the theoretical equations for the model are written, followed by the setting of appropriate quantities for default parameter values. Model calibration is fitting the model output to observed data. Preferably, calibration is done with a data set different from that used for the original model construction. Sometimes, when several years of observed data are available, a portion of the data set has been used for model construction, and the remaining data was used for model calibration. Model calibration usually includes "tests of reason", including whether the model is predicting "reasonable" values with reasonable input data.

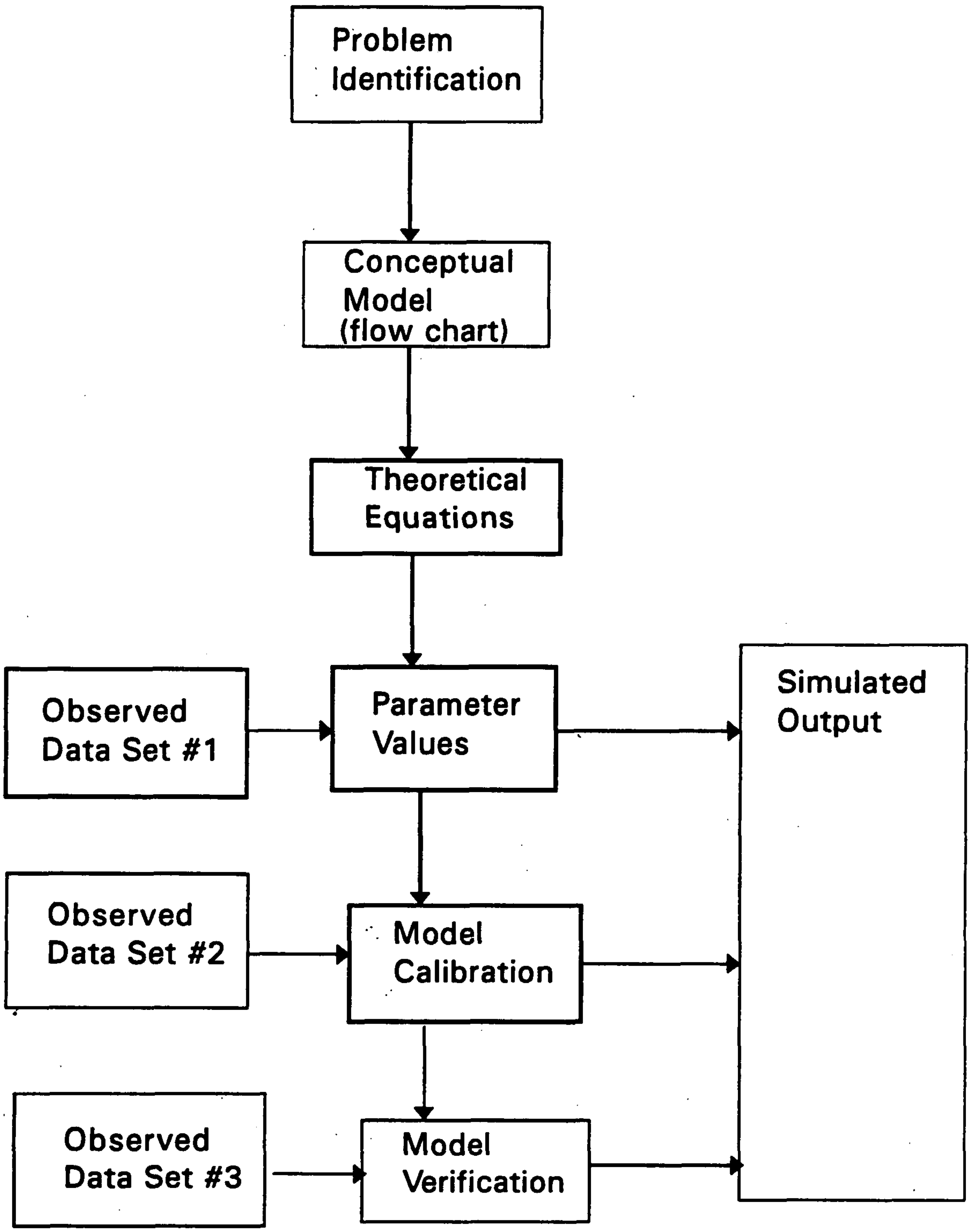

Figure 4. Steps in mathematical model development (after Thomann, 1982).

Verification Methods

There are several measures used for model verification, most of which are statistical. Each of the measures used in this verification are described briefly below. Readers that are unfamiliar with the statistical terms used in this report should consult a statistics textbook.

1. Bivariate plot. A plot of simulated data as a function of observed data can provide a good qualitative evaluation of model performance (Jamieson and Clausen, 1988; Reckhow, et. al., 1990; Thomann, 1982). An example of a bivariate plot is shown in the "Results and Discussion" section of this report (Figure 9).

2. Regression analysis. Simple linear regression can be used to determine if there is a significant relationship between predicted and observed values (Thomann, 1982). The coefficient of determination (r^2) is used to describe the percent of variance accounted for by the regression. Significant r^2 values indicate good correlation but not necessarily accurate predictions. Additional tests of the regression can be made that yield more information about the relationship between observed and predicted values. The students 't' test can be used to test the hypotheses that the intercept is zero and the regression slope is one. Significant t-values for both tests would indicate that the model simulations were accurate. Reckhow et. al. (1990) warn that outlying values and data with little range can adversely influence the meaning derived from hypothesis testing.

3. Mean comparisons. The differences between the predicted and observed means can be evaluated using the 't'-test (Reckhow et. al, 1990; Thomann, 1982). One advantage of the t-test is that there is a wide variety of hypothesis testing that can be performed. For example, one could test whether the difference between predicted and observed values is greater than some acceptable error or threshold value. If the populations are not normally distributed, the Wilcoxon test can be used (Reckhow et. al., 1990).

4. Relative error. The relative error (e) is the percent absolute value difference between observed and predicted mean values (Thomann, 1982):

$$e = \left\{\frac{observed - predicted}{observed}\right\} * 100 \tag{8}$$

The maximum relative error can be 100% in cases where all values are positive. This statistic may be misleading for very low values of observed data, and when the observed data are much larger than the predicted values. James and Burges (1982) suggest a mean relative error of 5% with a standard deviation of 5-10% as criteria for model adequacy. However, the relative error chosen should be a function of model use.

5. Root mean square error. The square root of the sum of the squares of the deviation between observed and predicted values divided by the number of observations (n) is the root mean square error (e_r) (Thomann, 1982). This term has not often been used in model testing. However, it provides a measure of model error, and has been recommended (Thomann, 1982).

$$e_r = \sqrt{\frac{\Sigma(observed - predicted)^2}{n}} \tag{9}$$

6. Differences in distribution. The difference between the observed and predicted cumulative frequency distributions can be assessed using the two-sample Kolmogorov-Smirnov (KS) test (Reckhow et al., 1990). This test determines the maximum difference between all quantiles of the two distributions. The calculated KS value is compared to values found in a table to determine the significance of the difference.

METHODS

Observed Data

For both watersheds, AGNPS predictions were compared to observed values of stormflow depth (in), peak flow during the storm (cfs), and the concentrations (ppm) and mass exports (lbs/acre) of sediment, nitrogen (N) and phosphorus (P). Discharge was obtained from field-determined stage-discharge relationships. Stage was continuously recorded using an ISCO® bubble-type flow meter (Meals, 1990; Vermont RCWP Coordinating Committee, 1991). Water samples in both watersheds were collected by refrigerated ISCO automatic samplers at 8-hr intervals. Samples were analyzed for total suspended solids, total P, and total Kjeldahl N using standard techniques (EPA, 1983). Analysis was conducted according to a QA/QC plan that included standards analysis, duplicates, chemical recovery, and performance testing. Duplicate results ranged from 5 to 12 %; chemical recovery ranged from 98 to 101%. Precipitation was recorded at the Dunsmore station 0.6 miles from the Jewett Brook watershed and at the Hannah gage within 0.6 miles of Subwatershed 3.

The duration of flow was determined by hydrograph separation (Wisler and Brater, 1967). The beginning of stormflow was defined as the rise in stream discharge. The end of stormflow was determined as occurring at the inflection point on the falling limb of the hydrograph. A hydrograph for the September 21, 1983 storm in the LaPlatte Subwatershed 3 is shown in Figure 5. The hydrographs for all storms are given in Appendix A. The accuracy of discharge data was verified by comparison with runoff coefficients from USGS gaging stations located in the Champlain valley. Runoff coefficients have agreed within the 20 percent recommended by Winter (1981) for comparison with regional gages. Generally the error

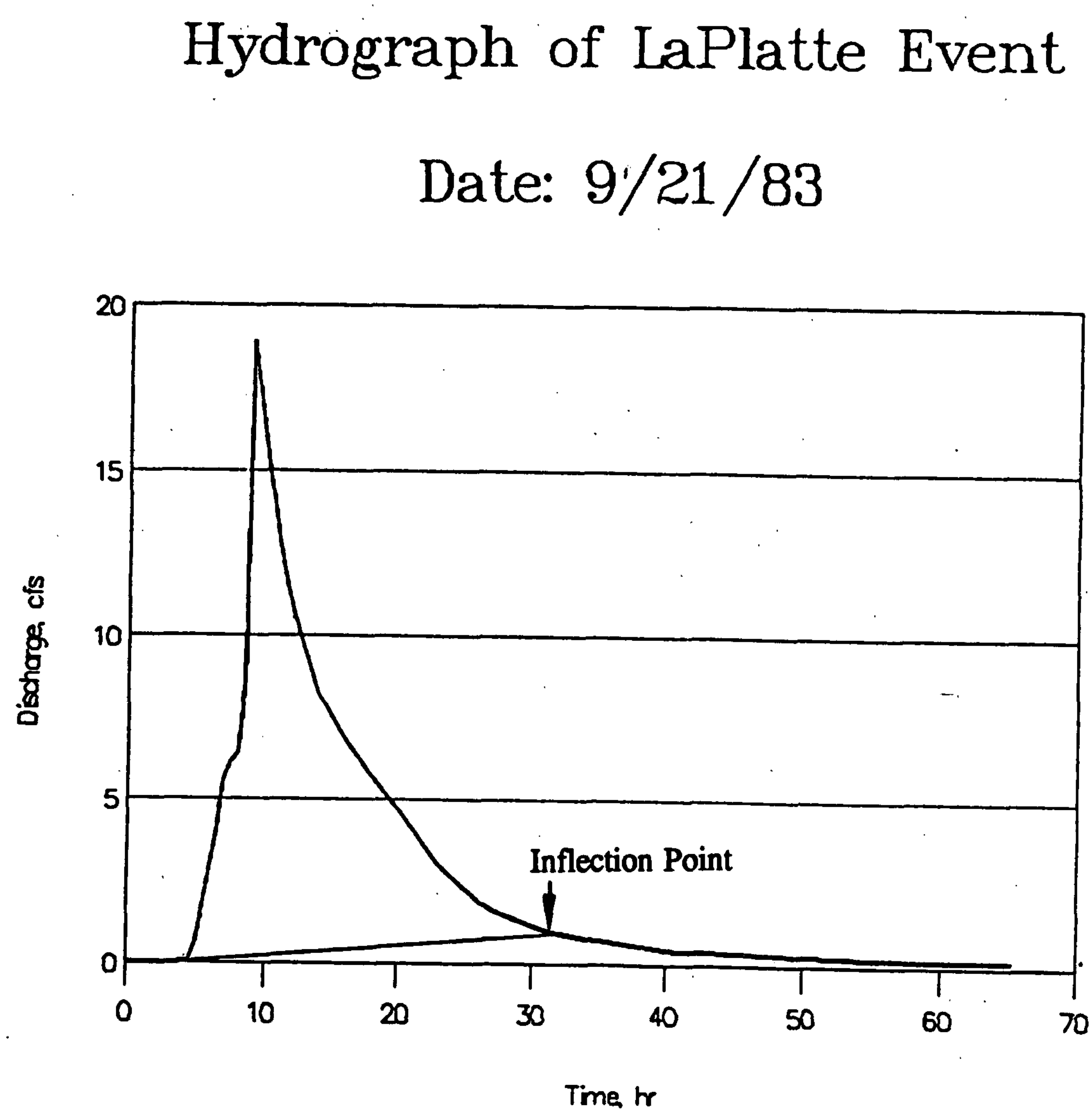

Figure 5. Hydrograph for LaPlatte Watershed 3 for September 21, 1983 storm.

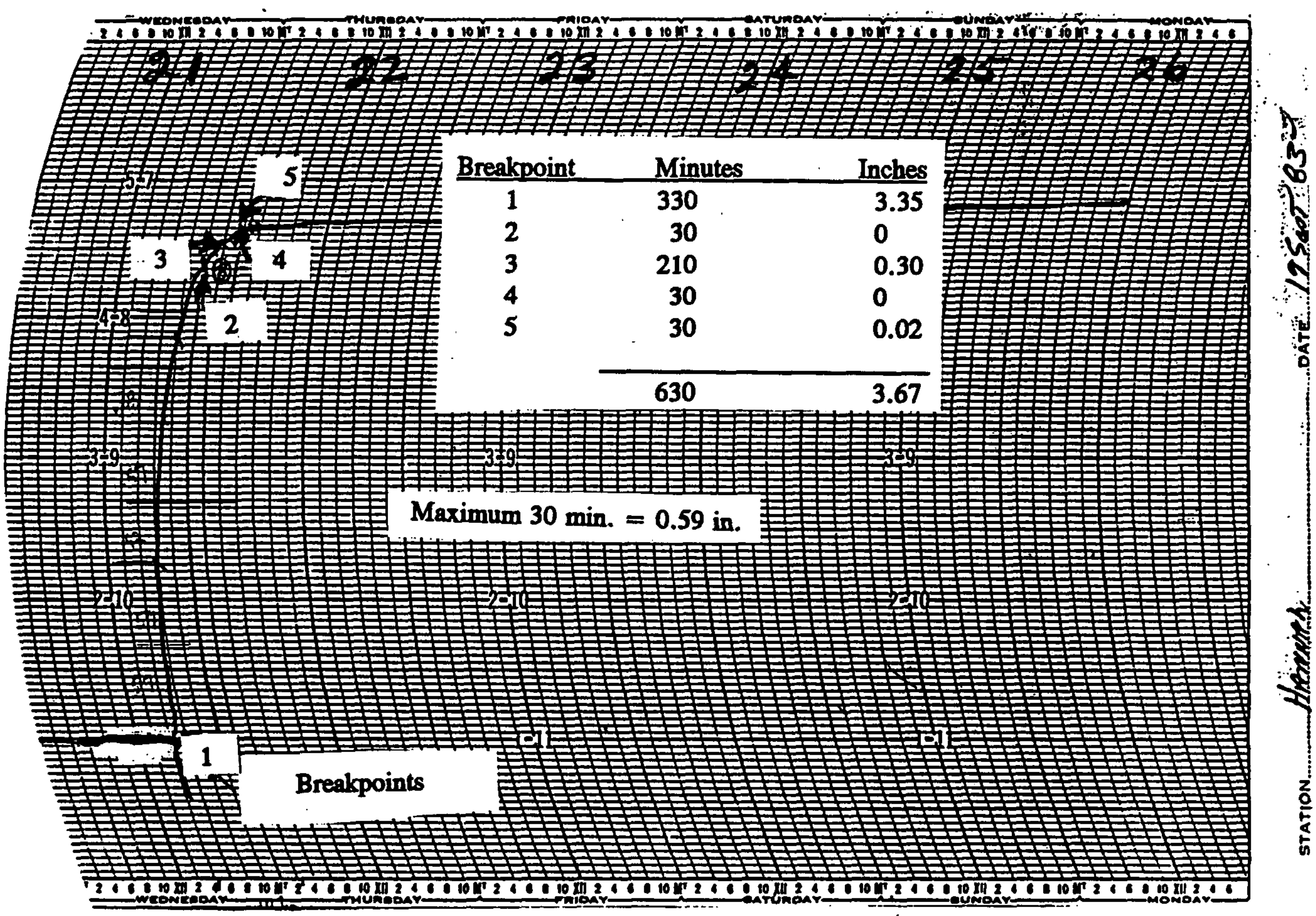

Figure 6. Recording precipitation chart for storm on September 21, 1983, Hannah gage.

associated with discharge measurements are 15 percent (Winter, 1981).

The energy intensity (EI) of the storm (decimal units) was calculated from recording rain gage records using the method described by Wischmeier and Smith (1978). Using this procedure the rainfall intensity (in/hr) was calculated for each break point of the storm trace on the chart. An example precipitation chart is shown in Figure 6; the EI calculation is given in Table 2. The corresponding kinetic energy per inch of rain was determined for each intensity from a table provided by Wischmeier and Smith (1978). The total energy for the storm is the sum of the energy for each breakpoint increment, adjusted for the proportion of total rainfall.

The antecedent moisture condition (AMC) was determined for each selected storm using the five-day cumulative precipitation index (USDA-SCS, 1972). A 5-day growing season total precipitation less than 1.4 inches was assigned to AMC group I (lowest runoff potential), and precipitation of 1.4 to 2.1 inches was assigned to AMC group II (average condition).

Storm Selection

Storms between late March to late November of each year with three or more consecutive 8-hr composite samples were considered. Winter storms were ignored since the version of AGNPS used could not predict snowmelt runoff. The 8-hr composites indicated that the storm was sampled intensively. Groups without precipitation events were dropped. Groups coinciding with snowfall and with temperatures below freezing before, during, and following the event were dropped since AGNPS does not simulate periods of no-flow in the winter. Storms with missing precipitation data were dropped. Hydrographs for the remaining storms were plotted (Appendix A). Hydrographs with complex, multi-peak were dropped because they indicated more than one storm was influencing runoff. Such complex storms could not be easily modeled by AGNPS.

Table 2. Rainfall energy intensity (EI) calculation for September 21, 1983 storm, LaPlatte River Subwatershed 3.

Chart					Energy*	
Time	Depth (in)	Duration (min)	Depth (in)	Intensity (in/hr)	(in^{-1})	Total
16:30	0					
22:00	3.35	330	3.35	0.61	845	2831
22:30	3.35	30	0	0	0	0
02:00	3.65	210	0.30	0.09	570	171
02:30	3.65	30	0	0	0	0
03:00	3.67	30	0.02	0.04	453	9
						3011

* From Wischmeier and Smith (1978)

+ From chart

$$EI = \frac{\text{Total energy} * \text{maximum hourly intensity}^{+}}{100}$$

$$EI = \frac{3011 * 1.18}{100} = 35.53$$

Watershed Data

Land use and soils information were obtained from data stored in a geographic information system (GIS). Using the GIS, the cell area was set by creating a 10-acre grid cell overlay on the watershed boundaries (Figures 7 and 8). This cell size approximates the average field size found in both watersheds. There were 40 cells in the LaPlatte River Subwatershed 3 and 343 cells in the Jewett Brook watershed. A program within the GIS was used to determine land use, soil types, and fertilization levels on a cell-by-cell basis.

Since each cell could contain several soil types and/or land uses, cell averages of attributes were lumped by area weighting. Values for the cropping factor (C), practice factor (P), manning's roughness coefficient (n), and the surface condition constant, which are functions of land use/cover, were determined from tables in Young et al. (1987) based on the predominant (percent of area) land use occurring in the cell. Land uses were determined using the GIS land use data. The soil erodibility factor (K), and soil texture, which are functions of soil type, were determined from county soil surveys for each study area based on an areal, weighted average value for the cell, as suggested by Young et al. (1987). Soil types for each cell were determined from the GIS data files (Table 1). The SCS curve number (CN), which varies with hydrologic soil group, antecedent moisture condition, and land use, was determined from tables in Young et al. (1987) as an areal, weighted- average based on the different soil types and land uses in a cell.

The number of the cell into which another cell drained was determined from the USGS topographic map for the study areas by noting the direction of flow leaving the cell (e.g. Figure 7). This also allowed determining the aspect of the direction of the drainage from the cell.

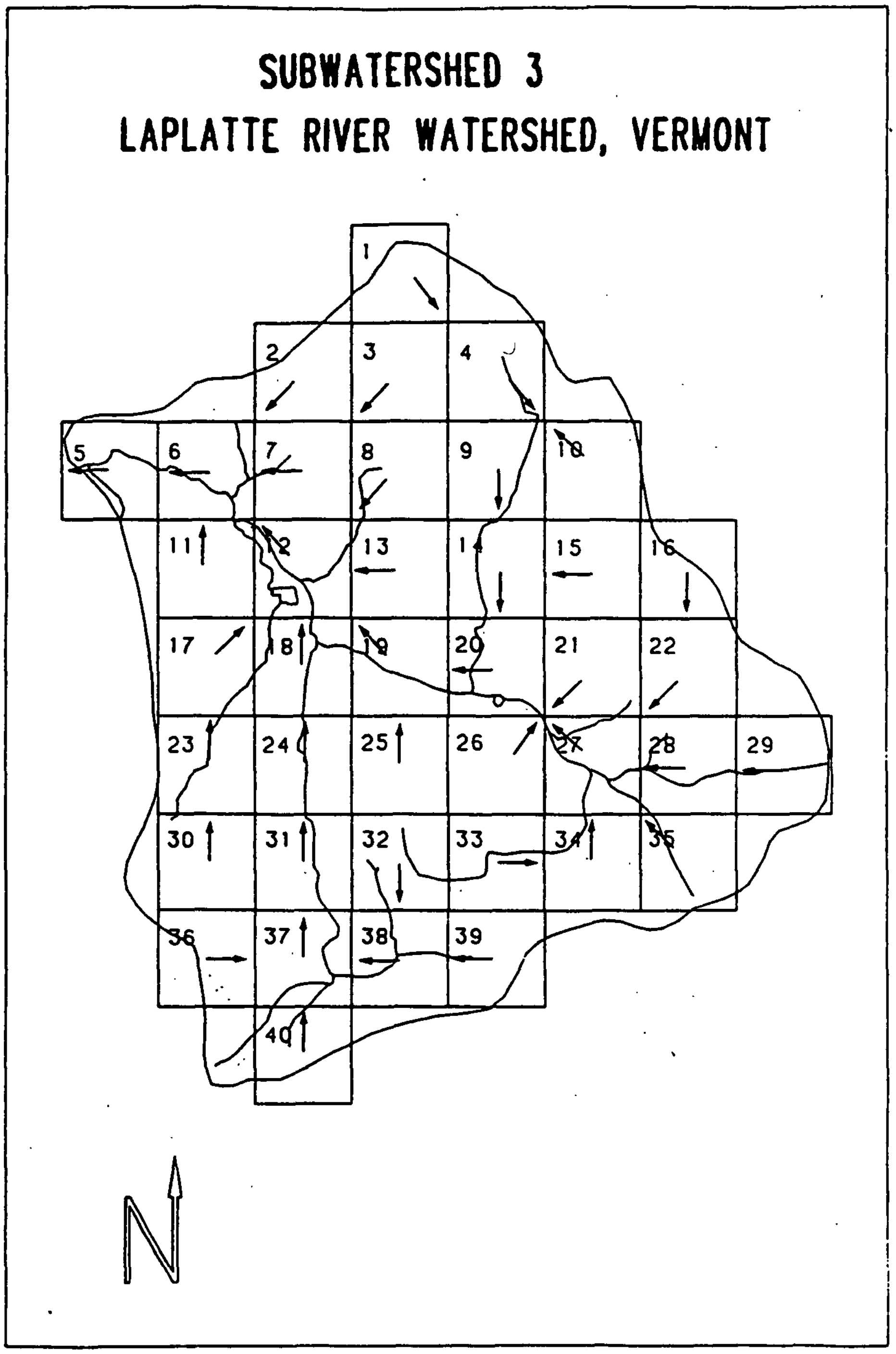

Figure 7. LaPlatte subwatershed 3 with 10-acre grid cells and cell drainage paths.

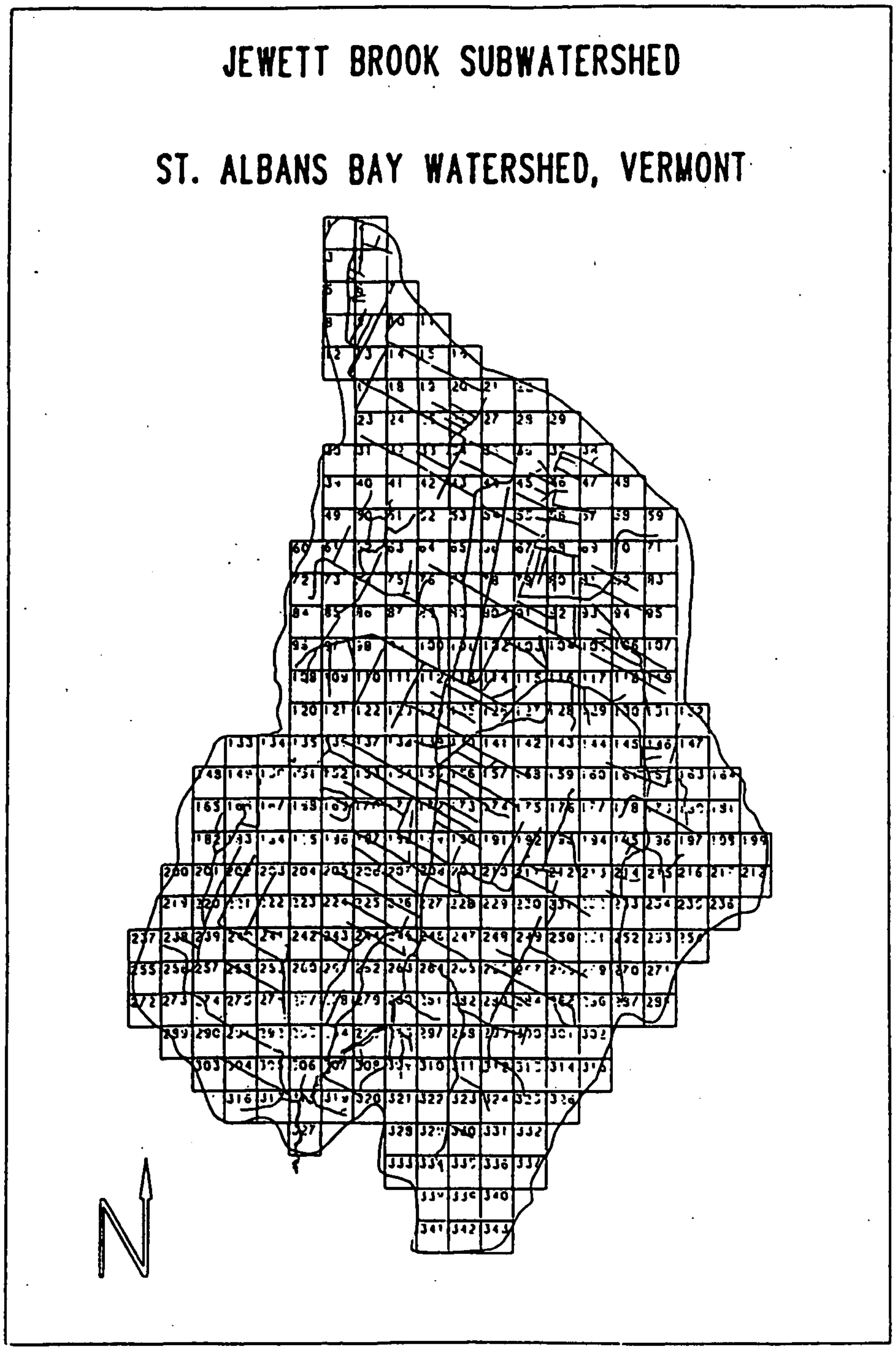

Figure 8. Jewett Brook watershed with 10-acre grid cells and cell drainage paths.

Average land slope and average channel slope also were determined from the USGS topographic maps for each cell as rise over run. The channel side slope was based on recommendations by Young et al. (1987). The slope shape factor of either uniform, convex, or concave was determined for each cell from the USGS topographic maps. Field slope lengths were determined from a table of soil type and average slope length (Vt SCS, 1989). The fertilizer availability (incorporation factor) was based upon GIS data and recommendations of Young et al. (1987). The presence of a channel within a cell (channel indicator) was assessed using GIS data.

Input files were modified for each year since land use and therefore the curve number (CN), C factor, surface condition constant, and roughness coefficient could change each year. Text editors were used to build the input data files rather than the AGNPS preprocessor because it was quicker. AGNPS includes a separate computer program (DBDFL) for forming input data files (Young et al., 1987). Examples of input files for both watersheds are given in Appendix B. These files contain cell-by-cell information on soils, curve numbers, and practices.

Model Adaptation

Although AGNPS does not require calibration, the model was developed assuming Minnesota conditions. Several factors were compared to conditions found in Vermont (Table 3). Although the rainfall concentrations were expected to be different, the impact on precipitation loadings, relative to other loadings, was not considered to be significant. Since these values were not substantially different, the default values were used. One change made to the AGNPS code was to print smaller values of the runoff volume and peak runoff rate. The original code rounded runoff volume to 0.01 in. and peak runoff rate to 0.01 cfs. These values were changed to 0.0001 for runoff volume and 0.001 for peak runoff. This change was made because runoff values simulated by AGNPS were often <0.00 and we wanted to determine if lower values were being calculated but truncated when printed out.

Young et al. (1987) have performed a sensitivity analysis to determine the relative changes in model output associated with changes in model input and model parameters. The most sensitive parameters affecting sediment and nutrient exports were land slope, soil erodibility, cropping factor, practice factor, and curve number. All of these factors vary with local site conditions, and reflect the sensitivity of the curve number technique and the USLE.

Computer Resources

According to Robert et al. (undated), the following equipment is required to run AGNPS:

- IBM-PC or compatible
- Monochrome or color graphics adapter and monitor
- 512K memory
- Floppy disk system or hard disk system
- Dot Matrix printer
- DOS 2.1 or higher

Most AGNPS runs were made on an IBM® PS/2 Model 30, 286 personal computer. Computation time for the 343-cell Jewett Brook watershed took approximately 30 sec. excluding the time required to make input specifications. Additional single cell runs were made on a Zenith® 386-SX personal computer. Average computational time for these runs was a few seconds. The GIS used was ARC-INFO® which was maintained on a VAX® 11/750 computer.

Table 3. AGNPS default values and appropriate Vermont values for model adaption.

Parameter [AGNPS Name] (Units)	AGNPS Value	Vermont Value	Source of Information
Soil Concentrations			
Soluble N [CN] (ppm)	5	2-30	Jokela, 1989
Soluble P [CP] (ppm)	2	1-1.5	"
Sediment N [SOILN] (lb/lb)	0.001	0.001-0.002	"
Sediment P [SOILP] (lb/lb)	0.0005	0.0005-0.001	"
N Fertilizer Application [NPPA]			
Low (lb/ac)	50	50	"
Medium (lb/ac)	100	100	"
High (lb/ac)	200	150	"
P Fertilizer Application [PPPA]			
Low (lb/ac)	20	20	"
Medium (lb/ac)	40	40	"
High (lb/ac)	80	60-80	"
Rain Concentration			
N [RCN] (mg/l)	0.8	1.43	Likens et al., 1977

RESULTS AND DISCUSSION

LaPlatte Subwatershed 3

The precipitation characteristics of the 15 storms that were modeled in Subwatershed 3 are summarized in Table 4. Rainfall amounts ranged from 0.2 to 3.67 inches. These storms represented the full range of observed precipitation events that produced runoff in the LaPlatte watershed, and therefore are appropriate storms to model for a verification of AGNPS. Based on Weather Bureau intensity-duration-frequency maps (Hershfield, 1961), one storm had a 50-yr return period, and one was an 8-yr storm. The remaining storms modeled had a return period of less than one year. The precipitation amounts for all modeled storms were in the upper 50 percent observed in the watershed based on data collected at the Hannah gage in the LaPlatte River watershed.

Prior to full testing of the model, default value assumptions and average state values were checked against monitored results. Calculated EI values using the Wischmeier and Smith (1978) method were substantially lower than the statewide average value of 90 recommended for use for the two study area counties in Vermont (USDA-SCS, 1987). Also, it is recommended in the model documentation that the antecedent moisture condition (AMC) value to use is II, representing average conditions (Young et al., 1987). However, using the 5-day AMC index (USDA-SCS, 1972), 13 out of the 15 storms had AMC values of I which indicates a dryer than average condition. Using calculated, rather than average values for EI and AMC, resulted in lower predictions of discharges, concentrations, and mass export predictions (Table 5). Due to these differences, values of EI and AMC were calculated for each model run to meet the study objectives.

Table 4. Precipitation characteristics of modeled storms, LaPlatte River Subwatershed 3.

Date MM/DD/YY	Precipitation (in.)	EI	AMC	Percent of Storms Less than or equal To observed	Return Period (yr)
3/31/87	0.20	0.15	I	50	<1
8/27/86	0.33	0.80	I	75	<1
4/ 6/85	0.45	0.73	I	84	<1
5/23/84	0.48	1.76	I	84	<1
6/ 5/85	0.74	1.36	I	90	<1
4/17/84	0.78	1.92	II	90	<1
4/10/83	0.90	1.54	I	90	<1
4/17/82	0.92	4.37	I	90	<1
8/11/83	0.99	0.61	I	95	<1
11/11/83	1.00	1.35	II	95	<1
8/ 8/83	1.01	11.71	I	95	<1
9/29/86	1.03	5.82	I	95	<1
6/ 6/83	1.09	9.40	I	95	<1
8/ 3/86	2.45	45.33	I	99	8
9/21/83	3.67	35.53	I	99	50

Table 5. Comparison of predicted discharge, P, and N using default and computed AMC and EI values for two storms for LaPlatte subwatershed 3.

	Date of Storm					
	8/ 03/86			8/27/86		
Variable	Default	Computed	Observed	Default	Computed	Observed
Input						
AMC	II	I		II	I	
EI	90	45.3		90	0.8	
Output						
Runoff Volume (in)	0.68	0.13	0.5	0.0001	0.0	0.23
Runoff Peak (cfs)	196	43	15.83	0.064	0	7.88
P Concentration (mg/l)	0.8	0.1	0.1	0.1	0.1	0.2
P Mass Export (lb/ac)	8.90	3.12	0.01	1.19	0.03	0.01
N Concentration (mg/l)	4.3	1.6	0.74	4.5	4.5	0.88
N Mass Export (lb/ac)	17.57	6.30	0.08	2.39	0.06	0.05

Observed and predicted mean values (15 storms), the relative error, and results from the t-test of means for all modeled variables are summarized in Table 6. The hypothesis for the t-test was that the mean observed and predicted values were not different. A low probability of being greater than the 't' value (Prob >t in Table 6) indicates that the means are significantly different at that probability.

Tests of the goodness of fit of linear regressions between observed and predicted values are summarized in Table 7. These include the Root MSE, the F-statistic for the significance of the regression, and the coefficient of determination (R^2) between observed and predicted values. The significance of the F-statistic is given by the Prob > F. A probability of 0.05 would be significant at the 95 percent level of confidence. A significant R^2 value at a probability of 0.05 would be 0.72.

Discharge. Discharge volume (in.) was underpredicted by AGNPS for all storms less than the 50 year event (Table 8). Mean discharge volumes were significantly different based on the t-test, as indicated by a p value less than 0.01 (Table 6). The relative error in the predicted mean was 87 percent. There was no significant relationship between observed and predicted volumes based on regression (Table 7, Figure 9). For the largest storm monitored, AGNPS predicted discharge depth was of the same order of magnitude as that observed.

Peak discharge also was underpredicted by AGNPS except for storms greater than two inches (Table 8). However, mean observed and predicted values were not different based on the t-test (Table 6), and the relative error was small (9%). There were no significant relationships between predicted and observed discharge based on regression analysis (Table 7, Figure 10). Given the large discrepancy between predicted and observed discharges, the t-test

Table 6. Mean observed values (15 storms) and values predicted by AGNPS with relative errors and t-test between means for LaPlatte Subwatershed 3.

Variable	Means Observed	Means Predicted	Relative Error (%)	t-value	Prob >t
Discharge					
Volume (in)	0.31	0.04	87	4.86**	0.003
Peak (cfs)	15.59	14.2	9	0.13	0.896
Sediment					
Concentration (mg/l)	30.87	1,423,508	4,611,199	-2.29*	0.043
Mass Export (lb/ac)	0.53	124.6	23,409	-1.11	0.290
Phosphorus					
Concentration (mg/l)	0.15	0.11	27	1.31	0.212
Mass Export (lb/ac)	0.01	0.54	5,300	-1.64	0.125
Nitrogen					
Concentration (mg/l)	0.82	3.15	284	-2.32*	0.040
Mass Export (lb/ac)	0.06	1.09	1,717	-1.65	0.128

** $p < 0.01$
* $p < 0.05$

Table 7. Root MSE and significance of regressions between observed and AGNPS predicted values for the LaPlatte Subwatershed 3.

Variable	Root MSE	F	Prob > F	R^2
Discharge				
Volume (in)	0.196	0.335	0.57	0.03
Peak (cfs)	13.670	0.175	0.68	0.01
Sediment				
Concentration (mg/l)	31.087	0.360	0.56	0.03
Mass Export (lb/ac)	0.540	2.472	0.15	0.20
Phosphorus				
Concentration (mg/l)	0.066	0.904	0.36	0.07
Mass Export (lb/ac)	0.008	0.311	0.59	0.03
Nitrogen				
Concentration (mg/l)	0.273	0.407	0.54	0.04
Mass Export (lb/ac)	0.050	1.567	0.24	0.14

Table 8. Discharge observed from LaPlatte River Subwatershed 3 and predicted by AGNPS.

Date MM/DD/YY	Precipitation (in.)	Discharge Depth (in.) Observed	Discharge Depth (in.) Predicted	Discharge Peak (cfs) Observed	Discharge Peak (cfs) Predicted
3/31/87	0.20	0.11	0.00	4.38	0.00
8/27/86	0.33	0.23	0.00	7.88	0.00
4/ 6/85	0.45	0.28	0.00	11.57	0.00
5/23/84	0.48	0.15	0.00	3.94	0.00
6/ 5/85	0.74	0.05	0.00	1.27	0.00
4/17/84	0.78	0.41	0.01	27.24	4.00
4/10/83	0.90	0.43	0.00	17.20	0.00
4/17/82	0.92	0.54	0.00	25.87	0.00
8/11/83	0.99	0.06	0.00	1.61	0.00
11/11/83	1.00	0.47	0.04	36.68	14.00
8/ 8/83	1.01	0.01	0.00	0.29	0.00
9/29/86	1.03	0.45	0.00	18.46	0.00
6/ 6/83	1.09	0.55	0.00	43.53	0.00
8/ 3/86	2.45	0.50	0.13	15.83	43.00
9/21/83	3.67	0.38	0.51	18.93	152.00

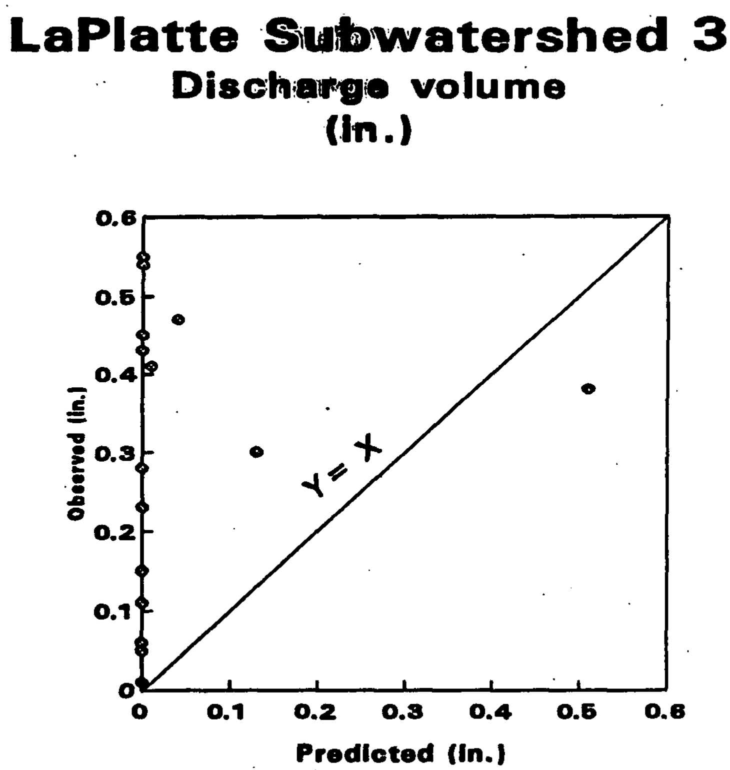

Figure 9. Plot of discharge volume observed in LaPlatte River Subwatershed 3 and predicted by AGNPS.

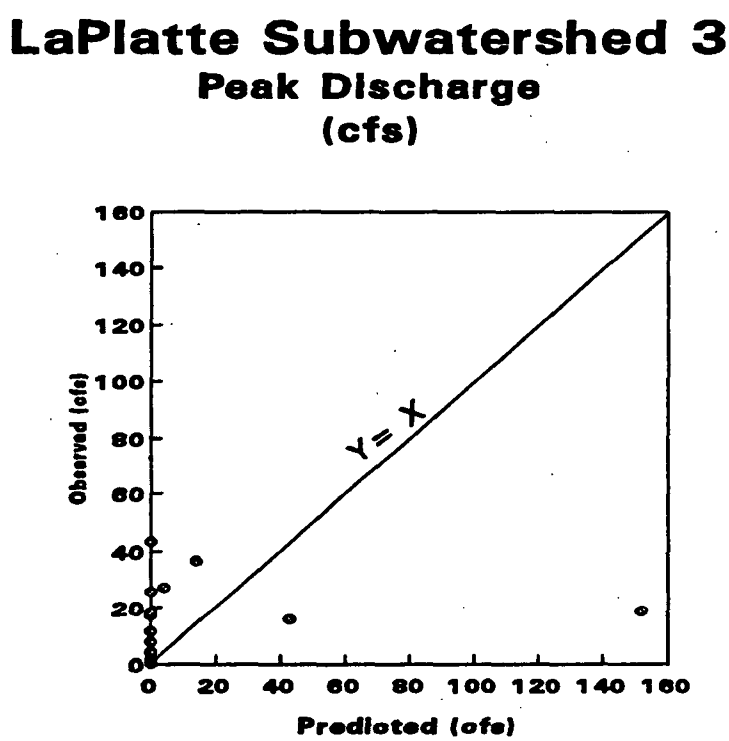

Figure 10. Plot of peak discharge observed in LaPlatte River Subwatershed 3 and predicted by AGNPS.

of means and the relative error of these means appear inappropriate measures for testing model performance in this study.

Sediment. Suspended solids concentrations in runoff from Subwatershed 3 were overpredicted by from two to six orders of magnitude (Table 9). AGNPS predicted values that are unrealistic for streamflow. Mean concentrations were significantly different (Table 6). There was no significant relationship between observed and predicted values (Table 7, Figure 11).

The mass export of sediment also was overpredicted by one or two orders of magnitude (Table 9). Mean export values were not different based on the t-test (Table 6). Inspection of Figure 12 reveals that the points are clustered together. There was no significant relationship between observed and predicted exports (Table 7, Figure 12).

Phosphorus. Predicted phosphorus concentrations were of the same order of magnitude as those observed (Table 10). However, the default concentration of 0.10 mg/l predominated. There was no significant difference between observed and predicted mean concentrations, and their relative error was only 27 percent (Table 6). Also, there was no significant relationship between observed and predicted P concentration values (Table 7, Figure 13). However, it appears that a low default value of 0.10 mg/l was assumed by AGNPS for most cases.

The predicted mass export of phosphorus was of the same order of magnitude as observed for storms less than one inch; larger storms were overpredicted (Table 10). Mean observed and predicted exports were not different, but their relative error was 5,300 (Table 6). This finding again questions the usefulness of the t-test in comparing model predictions to observed values. There was no significant relationship between observed and predicted values

Table 9. Sediment observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS.

Date MM/DD/YY	Precipitation (in.)	Total Suspended Solids: Concentration (mg/l) Observed	Concentration (mg/l) Predicted	Export (tons) Observed	Export (tons) Predicted
3/31/87	0.20	9.2	32,779.	0.05	0.1
8/27/86	0.33	4.1	473,498.	0.04	2.1
4/ 6/85	0.45	89.2	390,446.	1.15	1.7
5/23/84	0.48	24.7	988,888.	0.16	4.4
6/ 5/85	0.74	--	771,295.	--	3.4
4/17/84	0.78	31.3	31,899.	0.59	14.1
4/10/83	0.90	19.9	825,667.	0.39	3.7
4/17/82	0.92	69.0	2,403,695.	1.71	10.7
8/11/83	0.99	2.5	336,046.	0.007	1.5
11/11/83	1.00	17.2	9,579.	0.38	15.5
8/ 8/83	1.01	6.6	6,375,266.	0.003	28.3
9/29/86	1.03	--	3,410,522.	--	14.9
6/ 6/83	1.09	19.9	5,123,946.	0.51	22.7
8/ 3/86	2.45	--	136,222.	--	770.3
9/21/83	3.67	76.8	42,877.	1.34	975.7

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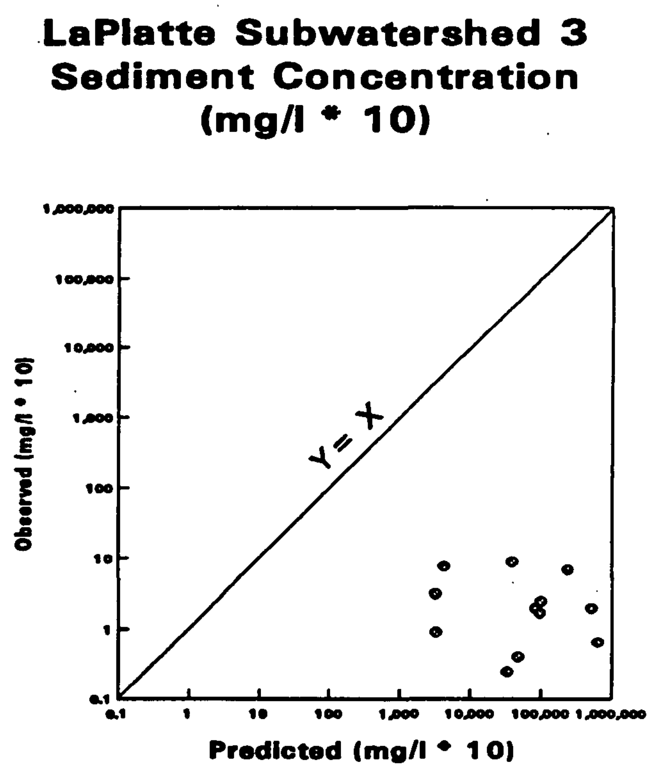

Figure 11. Plot of sediment concentration observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS.

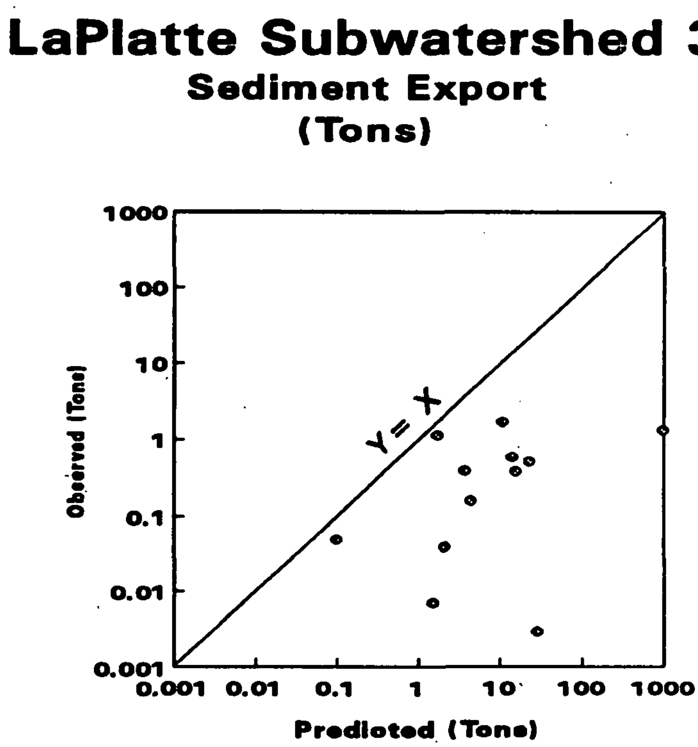

Figure 12. Plot of sediment export observed in runoff from Laplatte River Subwatershed 3 and predicted by AGNPS.

Table 10. Total phosphorus observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS.

Date	Precipitation	Total Phosphorus			
		Concentration (mg/l)		Export (lb/ac)	
MM/DD/YY	(in.)	Observed	Predicted	Observed	Predicted
3/31/87	0.20	0.08	0.00	0.00	0.00
8/27/86	0.33	0.20	0.10	0.01	0.03
4/ 6/85	0.45	0.18	0.10	0.01	0.02
5/23/84	0.48	0.17	0.10	0.01	0.01
6/ 5/85	0.74	0.09	0.10	0.00	0.04
4/17/84	0.78	0.19	0.40	0.02	0.13
4/10/83	0.90	0.14	0.10	0.01	0.04
4/17/82	0.92	0.13	0.10	0.02	0.10
8/11/83	0.99	0.05	0.10	0.00	0.02
11/11/83	1.00	0.14	0.10	0.02	0.14
8/ 8/83	1.01	—	0.10	—	0.22
9/29/86	1.03	0.29	0.10	0.03	0.13
6/ 6/83	1.09	0.08	0.10	0.01	0.19
8/ 3/86	2.45	0.10	0.70	0.01	3.12
9/21/83	3.67	0.22	0.10	0.02	3.78

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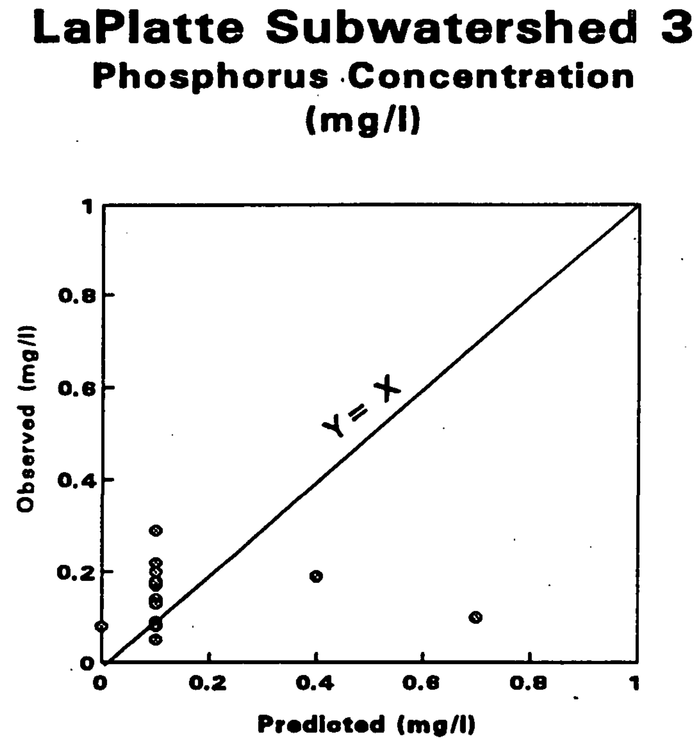

Figure 13. Plot of phosphorus concentrations observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS.

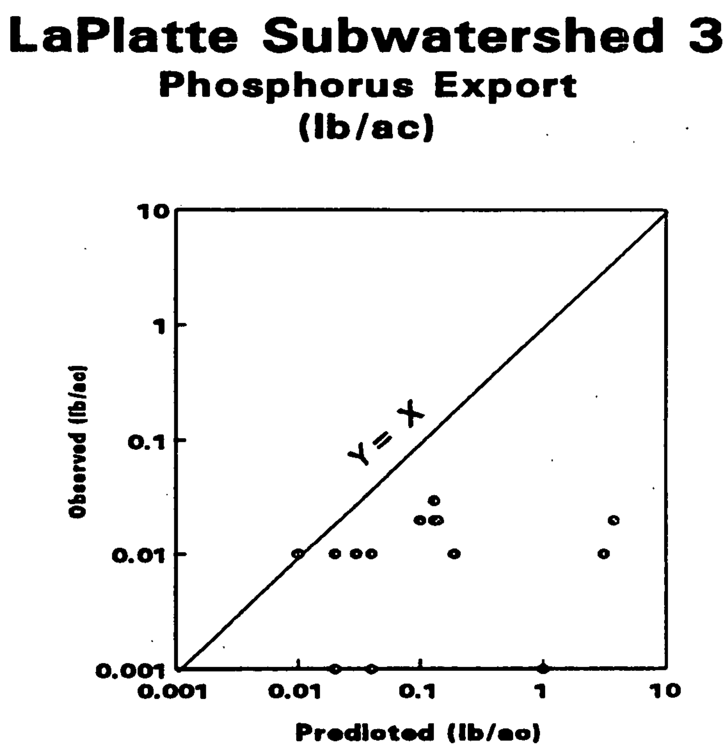

Figure 14. Plot of phosphorus export observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS.

based on analysis of variance of regression (Table 7, Figure 14).

Nitrogen. Predicted nitrogen concentrations were generally two to three times observed values (Table 11). Mean observed and predicted nitrogen concentrations were significantly different based on a t-test (Table 6). There was no significant relationship between observed and predicted nitrogen concentrations (Table 7, Figure 15). If the higher rainfall N concentrations expected in Vermont had been modified in AGNPS, the difference between observed and predicted values would have been greater than given in Table 11.

The mass export of nitrogen generally was overpredicted. The amount of overprediction varied by three to eighty times (Table 11). There was no significant difference between mean export values for nitrogen (Table 6), but the relative error was 1,717. There was no significant relationship between observed and predicted values (Table 7, Figure 16).

Table 11. Nitrogen observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS.

Date	Precipitation	Nitrogen			
		Concentration (mg/l)		Export (lb/ac)	
MM/DD/YY	(in.)	Observed	Predicted	Observed	Predicted
3/31/87	0.20	0.68	15.10	0.02	0.01
8/27/86	0.33	0.88	4.50	0.05	0.06
4/ 6/85	0.45	--	2.80	--	0.05
5/23/84	0.48	0.65	2.80	0.02	0.10
6/ 5/85	0.74	0.70	2.30	0.01	0.08
4/17/84	0.78	0.63	3.50	0.06	0.26
4/10/83	0.90	--	1.90	--	0.09
4/17/82	0.92	1.43	2.10	0.17	0.20
8/11/83	0.99	0.81	1.80	0.01	0.04
11/11/83	1.00	--	1.80	--	0.29
8/ 8/83	1.01	0.64	1.80	<0.01	0.44
9/29/86	1.03	0.60	2.00	0.06	0.27
6/ 6/83	1.09	0.77	1.80	0.10	0.37
8/ 3/86	2.45	0.74	1.60	0.08	6.30
9/21/83	3.67	1.28	1.50	0.11	7.73

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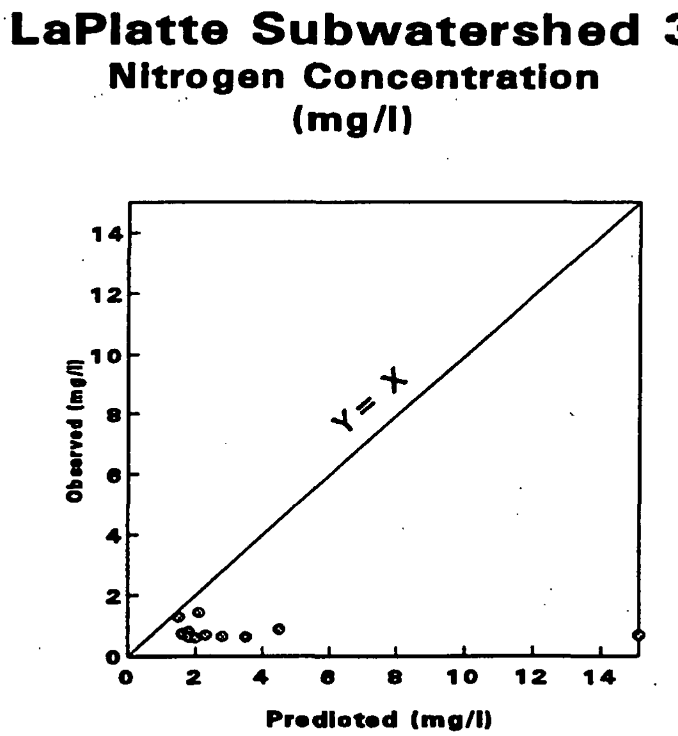

Figure 15. Plot of nitrogen concentrations observed in runoff from LaPlatte River subwatershed 3 and predicted by AGNPS.

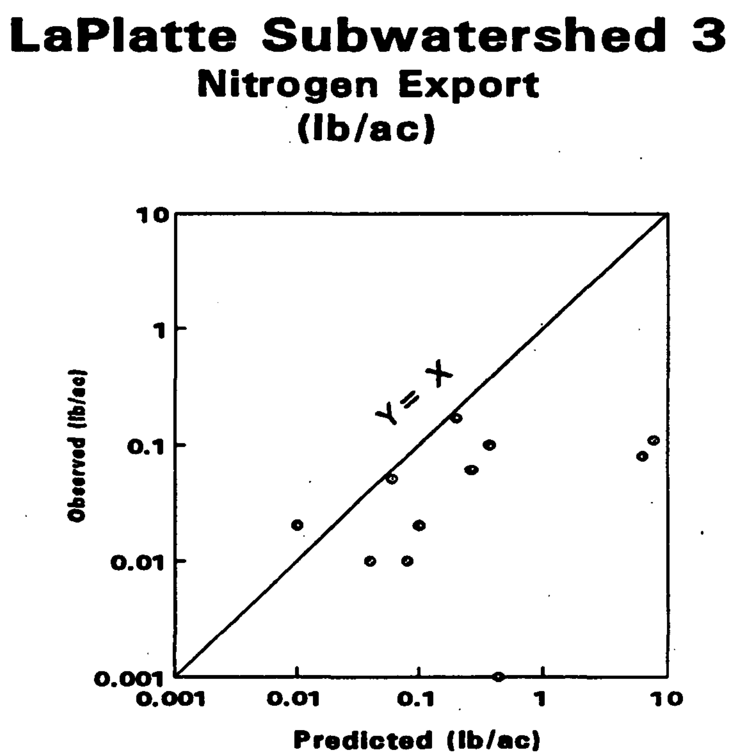

Figure 16. Plot of nitrogen export observed in runoff from LaPlatte River subwatershed 3 and predicted by AGNPS.

Jewett Brook

Eleven storms were modeled in the Jewett Brook watershed (Table 12). These storms ranged in amount from 0.43 to 2.47 inches and occurred during dryer than average conditions (AMC = I). Based on the Weather Bureau precipitation intensity-duration-frequency maps, one storm had an 8-yr return period, and two were 2-year storms. The remaining storms modeled had return periods of less than one year. The storms modeled represented the largest storms monitored during the study; 86 percent of the storms that occurred were smaller than those used for the testing of AGNPS. Comparisons could not be made with nitrogen concentrations or exports due to an insufficient number of samples.

Discharge. As was observed for the LaPlatte Subwatershed 3, discharge volume (in.) was underpredicted for all but the largest storms (Table 15). The mean discharge volumes were significantly different based on the t-test (Table 13), and the relative error in the means was 96%. There was no significant regression relationship between observed and predicted values, and the regression explained only 18% of the variation in values (Table 14, Figure 17).

Peak discharge also was underpredicted except for the three storms greater than 1.3 inches in amount (Table 15). The mean peak discharge predicted by AGNPS was significantly lower than observed (Table 13). There was no significant regression between observed and predicted values (Table 14). For six of the 11 storms modeled, a peak discharge of 0.136 cfs was predicted (Table 15, Figure 18).

Sediment. The concentration of suspended solids was overpredicted by one to two orders of magnitude (Table 16). The mean concentration predicted by AGNPS was significantly greater

Table 12. Precipitation characteristics of modeled storms, Jewett Brook.

Date MM/DD/YY	Precipitation (in.)	EI	AMC	Percent of Storms Less than or equal To observed	Return Period (yr)
4/ 6/85	0.43	1.61	I	86	<1
4/16/85	0.49	0.96	I	88	<1
3/10/83	0.55	1.18	I	92	<1
10/ 5/83	0.69	2.56	I	95	<1
4/17/84	0.77	1.73	I	96	<1
5/29/84	0.94	0.95	I	99	<1
4/18/85	0.94	4.21	I	99	<1
11/26/86	1.03	1.81	I	99	<1
10/28/87	1.32	1.86	I	99	2
5/23/84	1.72	17.17	I	99	2
9/21/83	2.47	9.41	I	99	8

Table 13. Mean observed values (11 storms) and values predicted by AGNPS with relative errors and t-test between mean for Jewett Brook.[+]

Variable	Means Observed	Means Predicted	Relative Error (%)	t-value	Prob > t
Discharge					
Volume (in)	0.47	0.019	96	4.42**	0.001
Peak (cfs)	114.66	17.299	85	2.61*	0.026
Sediment					
Concentration (mg/l)	110.1	7,159	-6,402	-4.06*	0.004
Mass Export (lb/ac)	19.31	3.8	80	2.42*	0.042
Phosphorus					
Concentration (mg/l)	1.65	0.5	70	1.92	0.087
Mass Export (lb/ac)	0.07	0.01	86	4.39**	0.002

[+] insufficient data for nitrogen comparisons.

** $p < 0.01$
* $p < 0.05$

Table 14. Root MSE and significance of regressions between observed and AGNPS predicted values for Jewett Brook.

Variable	Root MSE	F	Prob > F	R^2
<u>Discharge</u>				
Volume (in)	0.229	2.005	0.19	0.18
Peak (cfs)	89.645	2.357	0.16	0.21
<u>Sediment</u>				
Concentration (mg/l)	56.515	3.716	0.09	0.35
Mass Export (lb/ac)	18.227	0.007	0.94	<0.01
<u>Phosphorus</u>				
Concentration (mg/l)	1.829	0.016	0.90	<0.01
Mass Export (lb/ac)	0.047	1.477	0.26	0.16

Table 15. Discharge observed from Jewett Brook and predicted by AGNPS.

Date MM/DD/YY	Precipitation (in.)	Discharge: Volume (in.) Observed	Discharge: Volume (in.) Predicted	Discharge: Peak (cfs) Observed	Discharge: Peak (cfs) Predicted
4/ 6/85	0.43	0.67	0.0001	229.59	0.136
4/16/84	0.49	0.69	0.0001	180.01	0.136
3/10/83	0.55	0.61	0.0001	127.56	0.136
10/ 5/83	0.69	<0.00	0.0001	0.72	0.136
4/17/84	0.77	0.71	0.0001	237.45	0.136
5/29/84	0.94	0.39	0.0001	86.04	0.139
4/18/85	0.94	0.56	0.0001	197.16	0.143
11/26/86	1.03	0.77	0.0002	177.52	0.290
10/28/87	1.32	<0.00	0.0044	1.38	4.809
5/23/84	1.74	0.75	0.0313	17.17	30.736
9/21/83	2.47	0.03	0.1722	6.71	153.490

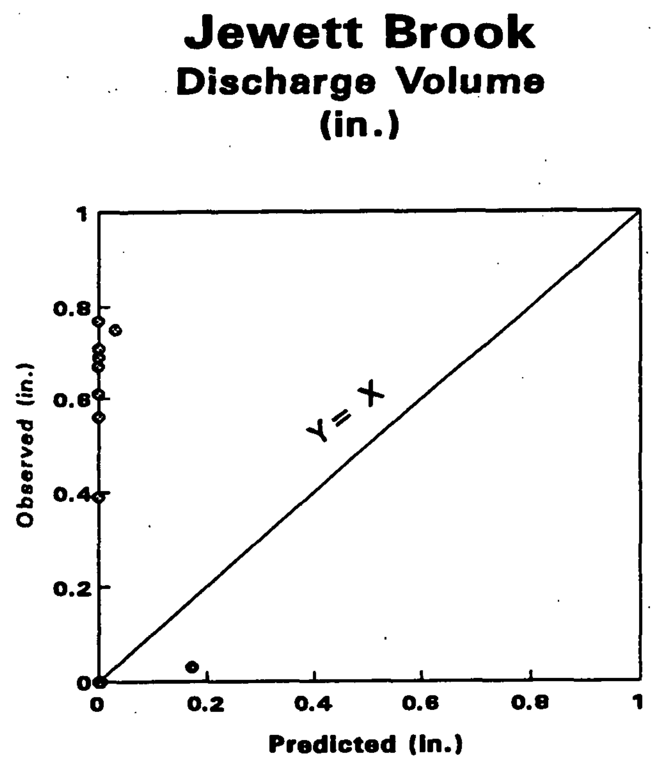

Figure 17. Plot of discharge volume observed in Jewett Brook and predicted by AGNPS.

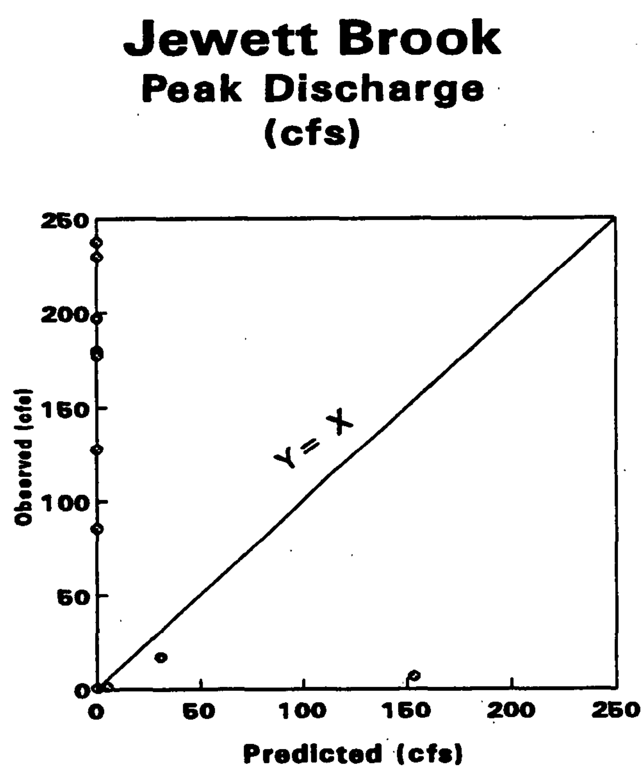

Figure 18. Plot of peak discharge observed in Jewett Brook and predicted by AGNPS.

than the mean concentration of suspended solids observed (Table 13). There was no significant relationship ($p = 0.05$) between observed and predicted sediment values (Table 14, Figure 19).

The mass export of sediment was generally underpredicted by AGNPS, except for the largest storm (Table 16). This result is opposite of the findings for LaPlatte Subwatershed 3 where the export of sediment was overpredicted by AGNPS (Table 9). It is likely that modeling the larger Jewett Brook watershed results in greater settling of sediment than for the smaller Subwatershed 3. The mean predicted export was significantly lower than the mean observed export of sediment (Table 13). There was no significant relationship between observed and predicted sediment exports (Table 14, Figure 20).

Phosphorus. As was observed for simulations in LaPlatte Subwatershed 3, predicted phosphorus concentrations were of the same order of magnitude as those observed (Table 17). There was no significant difference between mean predicted and observed phosphorus concentration values based on the t-test (Table 13). However, the differences were substantial (Figure 19). There was not a significant relationship between observed and predicted phosphorus concentration values (Table 14, Figure 21).

The mass export of phosphorus was underpredicted by AGNPS except for the largest storm modeled (Table 17). This finding is different than observed in Subwatershed 3 where mass export was generally overpredicted (Table 10). Again, the respective sizes of the two watersheds may explain these differences. The mean predicted export of phosphorus was significantly lower than that observed (Table 13). There was no significant relationship between observed and predicted values of the mass export of phosphorus based on regression (Table 14, Figure 22).

Table 16. Sediment observed in runoff from Jewett Brook and predicted by AGNPS.

Date MM/DD/YY	Precipitation (in.)	Sediment Concentration (mg/l) Observed	Sediment Concentration (mg/l) Predicted	Sediment Export (tons) Observed	Sediment Export (tons) Predicted
4/ 6/85	0.43	92.7	9,302.	24.22	0.4
4/16/84	0.49	70.9	5,302.	19.03	0.2
3/10/83	0.55	74.9	5,716.	17.63	0.2
10/ 5/83	0.69	98.9	8,053.	0.01	0.3
4/17/84	0.77	116.2	6,820.	31.96	0.3
5/29/84	0.94	34.7	5,955.	5.28	0.2
4/18/85	0.94	247.5	19,483.	54.03	0.8
11/26/86	1.03	--	6,448.	---	0.5
10/28/87	1.32	181.4	1,355.	0.29	2.3
5/23/84	1.74	73.5	2,449.	21.37	29.2
9/21/83	2.47	--	313.	---	20.5

-- indicates missing data

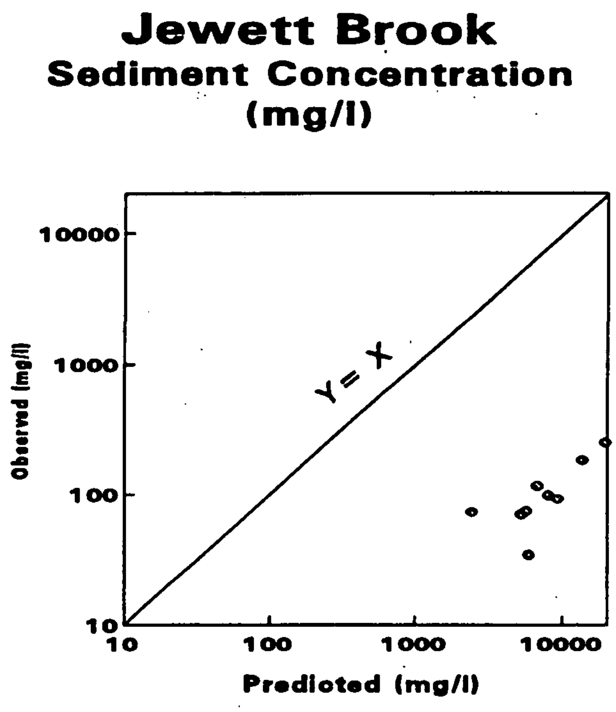

Figure 19. Plot of sediment concentrations observed in Jewett Brook and predicted by AGNPS.

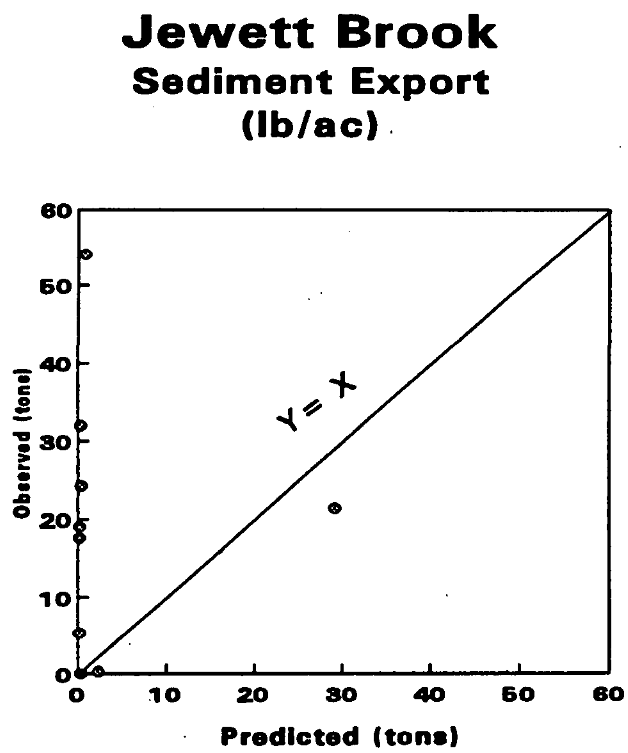

Figure 20. Plot of sediment export by Jewett Brook and predicted by AGNPS.

Table 17. Total phosphorus observed in Jewett Brook and predicted by AGNPS.

Date MM/DD/YY	Precipitation (in.)	Total Phosphorus: Concentration (mg/l)		Export (lb/ac)	
		Observed	Predicted	Observed	Predicted
4/ 6/85	0.43	0.60	1.4	0.09	0.00
4/16/84	0.49	0.45	0.2	0.07	0.00
3/10/83	0.55	0.52	0.8	0.07	0.00
10/ 5/83	0.69	2.95	1.5	<0.01	0.00
4/17/84	0.77	0.63	0.1	0.10	0.00
5/29/84	0.94	0.74	0.2	0.07	0.00
4/18/85	0.94	0.65	0.7	0.08	0.00
11/26/86	1.32	5.51	0.3	0.01	0.00
10/28/87	1.74	1.03	0.1	0.17	0.04
9/21/83	2.47	3.43	0.1	0.02	0.03

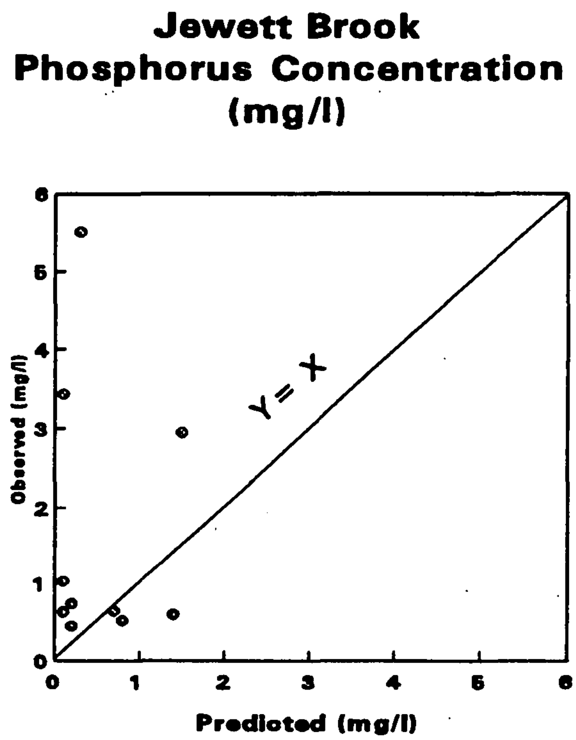

Figure 21. Plot of phosphorus concentrations observed in Jewett Brook and predicted by AGNPS.

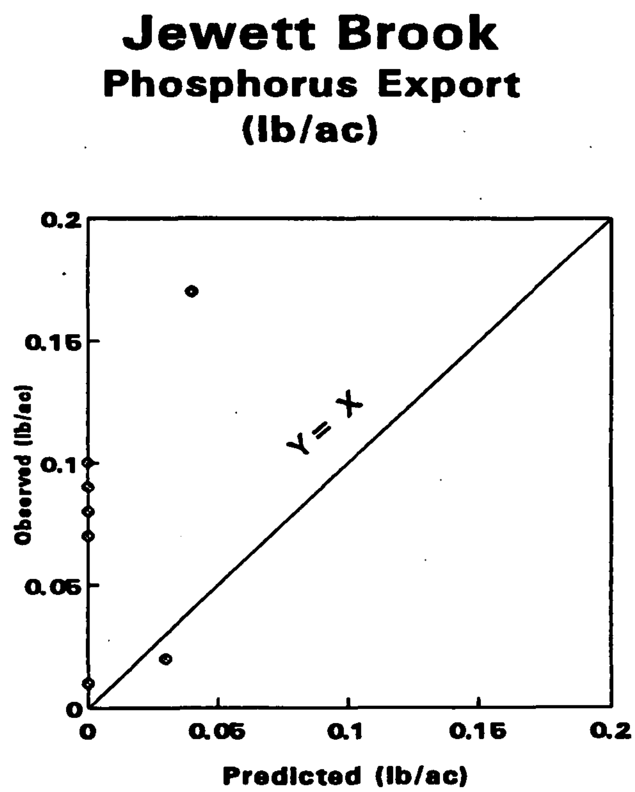

Figure 22. Plot of phosphorus export by Jewett Brook and predicted by AGNPS.

Nitrogen. There was an insufficient number of nitrogen samples analyzed for the modeled storms to perform an adequate evaluation of the ability of AGNPS to predict nitrogen concentrations or mass export in Jewett Brook.

Overall, there was a poor relationship between observed and predicted values for this verification in Vermont. The difference between observed and predicted values was greater than previously reported Bosch et al., 1983; Young et al, 1986, 1989). However, this is the first verification of AGNPS utilizing a full range of statistical testing as recommended by Thomann (1982). The application of the model to a completely different climatic region than where the model was developed may explain the differences obtained in the accuracy of the model. If discharge is not accurately predicted, mass export predictions should be questioned since mass is a function of discharge.

Single cell

For the 15 events observed in the LaPlatte Subwatershed 3, AGNPS simulations were conducted a second time with lumped parameters. Thus, the data from the 40 cells were combined into one cell. These additional simulations were conducted in order to determine if the use of distributed parameters gave better results than lumped parameters. The results of these simulations are presented in Tables 18 - 21 together with the results from the previous simulations. In general, predictions with one-cell parameter values were worse than those using the 40 cells. As compared to the original 40 cell simulations, the one-cell runs usually resulted in higher values (Tables 18 - 21).

Table 18. Comparison of discharge observed from LaPlatte River Subwatershed 3 and predicted by AGNPS using 40 cells versus 1 cell.

Depth (in.)			Peak (cfs)		
	Predicted			Predicted	
Observed	40 - Cell	1 - Cell	Observed	40 - Cell	1 - Cell
0.11	0.00	0.0001	4.38	0.00	0.098
0.23	0.00	0.0001	7.88	0.00	0.098
0.28	0.00	0.0001	11.57	0.00	0.098
0.15	0.00	0.0001	3.94	0.00	0.098
0.05	0.00	0.0001	1.27	0.00	0.098
0.41	0.01	0.0051	27.24	4.00	3.522
0.43	0.00	0.0001	17.20	0.00	0.098
0.54	0.00	0.0001	25.87	0.00	0.098
0.06	0.00	0.0001	1.61	0.00	0.098
0.47	0.04	0.0001	36.68	14.00	0.098
0.01	0.00	0.0001	0.29	0.00	0.098
0.45	0.00	0.0001	18.46	0.00	0.098
0.55	0.00	0.0001	43.53	0.00	0.098
0.50	0.13	0.1529	15.83	43.00	77.424
0.38	0.51	0.4932	18.93	152.00	224.774

Table 19. Comparison of sediment observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS using 40 cells versus 1 cell.

Concentration (mg/l)			Export (tons)		
	Predicted			Predicted	
Observed	40 - Cell	1 - Cell	Observed	40 - Cell	1 - Cell
9.2	32,779.	12,751.	0.05	0.1	0.1
4.1	473,498.	1,667,857.	0.04	2.1	7.6
89.2	390,446.	1,459,488.	1.15	1.7	6.6
24.7	988,888.	3,751,536.	0.16	4.4	17.0
--	771,295.	2,918,064.	--	3.4	13.2
31.3	31,899.	193,791.	0.59	14.1	45.0
19.9	825,667.	3,126,432.	0.39	3.7	14.2
69.0	2,403,695.	9,169,102.	1.71	10.7	41.5
2.5	336,046.	1,125,121.	0.007	1.5	5.7
17.2	9,579.	80,243,010.	0.38	15.5	363.5
6.6	6,375,266.	24,379,960.	0.003	28.3	110.4
--	3,410,522.	605,180.	--	14.9	2.7
19.9	5,123,946.	19,587,500.	0.51	22.7	88.7
--	136,222.	16,328.	--	770.3	113.1
76.8	42,877.	92,167.	1.34	975.7	2,059.4

Table 20. Comparison of total phosphorus observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS using 40 cells versus 1 cell.

Concentration (Mg/l)			Export (Lb/ac)		
	Predicted			Predicted	
Observed	40 - Cell	1 - Cell	Observed	40 - Cell	1 - Cell
0.08	0.00	0.1	0.00	0.00	0.00
0.20	0.10	0.1	0.01	0.03	0.08
0.18	0.10	0.1	0.01	0.02	0.07
0.17	0.10	0.1	0.01	0.01	0.15
0.09	0.10	0.1	0.00	0.04	0.12
0.19	0.40	0.1	0.02	0.13	0.32
0.14	0.10	0.1	0.01	0.04	0.13
0.13	0.10	0.1	0.02	0.10	0.30
0.05	0.10	0.1	0.00	0.02	0.06
0.14	0.10	0.1	0.02	0.14	1.69
---	0.10	0.1	---	0.22	0.65
0.29	0.10	0.1	0.03	0.13	0.03
0.08	0.10	0.1	0.01	0.19	0.55
0.10	0.70	0.1	0.01	3.12	0.66
0.22	0.10	0.1	0.02	3.78	6.76

— indicates missing data

Table 21. Comparison of nitrogen observed in runoff from LaPlatte River Subwatershed 3 and predicted by AGNPS using 40 cells versus 1 cell.

Concentration (mg/l)			Export (Lb/ac)		
	Predicted			Predicted	
Observed	40 - Cell	1 - Cell	Observed	40 - Cell	1 - Cell
0.68	15.10	20.2	0.02	0.01	0.00
0.88	4.50	3.9	0.05	0.06	0.15
--	2.80	2.8	--	0.05	0.14
0.65	2.80	2.4	0.02	0.10	0.29
0.70	2.30	2.0	0.01	0.08	0.24
0.63	3.50	1.9	0.06	0.26	0.63
--	1.90	1.9	--	0.09	0.25
1.43	2.10	1.9	0.17	0.20	0.59
0.81	1.80	1.8	0.01	0.04	0.12
--	1.80	1.8	--	0.29	3.37
0.64	1.80	1.8	<0.01	0.44	1.30
0.60	2.00	1.8	0.06	0.27	0.07
0.77	1.80	1.8	0.10	0.37	1.09
0.74	1.60	1.6	0.08	6.30	1.37
1.28	1.50	1.5	0.11	7.73	13.67

-- indicates missing data

Event extrapolations

The second objective of the project was to assess methods of extrapolating event-based simulations to annualized data. The lack of relationships between observed and predicted values makes any test of a method of extrapolation impossible. However, the following was the method that would have been used for the test.

1. Develop a frequency distribution of precipitation events from local data.

2. Perform simulations for the precipitation amounts that coincide with midpoints of intervals on the cumulative frequency distribution, including the 5, 25, 50, 75, 90, 95, and 99 percentiles.

3. Multiply the simulated mass export results for each frequency times the number of events occurring for each interval and sum the results for a year.

4. Add a base flow component for periods with no storms. However, the version of AGNPS being used in this verification does not predict base flow values.

This overall method assumes that there is a relationship between precipitation and mass export, which may or not be true, depending on local conditions.

CONCLUSIONS

AGNPS underpredicted discharge volume and peak flow except for the larger, rare storms; that is, those storm with greater than an 8-year recurrence interval or 1-2 inches of precipitation. Sediment concentrations were overpredicted by from one to six orders of magnitude. Sediment export was overpredicted in one watershed and underpredicted in the other watershed. Predicted phosphorus concentrations were of the same order of magnitude as observed. Phosphorus exports were underpredicted in one watershed and of the same order of magnitude in another watershed. Nitrogen concentrations and mass exports were overpredicted in the one watershed where sufficient observed nitrogen data was available.

Lumping the parameters into one cell worsened the predictions by AGNPS in the one watershed where the comparison was made with 40 cells for 15 storms.

Based on the results from testing in one watershed, it is recommended that EI and AMC be calculated rather than use "average" values as found in the AGNPS manual.

Some statistics that are often recommended for model verification were not useful in this test of AGNPS, perhaps due to the poor relationship between observed and predicted values. Both the students 't'-test of means and the root MSE were not meaningful and are not recommended for use in applications similar to the one described herein.

RECOMMENDED VERIFICATION METHODS

Based upon the experience obtained in this and other (Jamieson and Clausen, 1988) verifications of water quality models the following steps are recommended as a method for testing nonpoint source models:

1. Locations. Assuming that the model is intended to have application across the U.S., the model should be tested in several locations other than where the model was developed. If models are intended to have broad geographic application, it is especially important to test models in different major climate zones such as those represented by areas where snowmelt or no snowmelt would occur. In some cases, testing in each EPA Region might be appropriate, although the method of testing should be centrally controlled to maintain uniformity in methods of testing.

2. Method. Perform the test by comparing simulated to observed data. A sensitivity analysis, which is determining the effect of varying a parameter value on the output, is not a verification of a model but rather indicates important parameters. The test should display observed and simulated data in a form where they are directly comparable, such as in a table or graph.

3. Fitting. The method of conducting the verification should be consistent with the type of model. For example, a measured parameter model should not be fitted to local data before a test since such a model is intended to be used without fitting. Often, a model will be fitted with one year of data and tested with another year of data. This procedure is appropriate to calibrate a model during development but should not replace a verification using independent data.

4. Statistics. Several statistical tests are recommended for verifications of NPS water quality

models. Enough testing will be needed to achieve statistical significance. Generally, at least 15 pairs of observed and simulated data points are needed for a simple regression.

The following are recommended:

a. Linear regression of predicted and observed values. Analysis of variance of regression should be used to test the significance of the regression equation.

b. The coefficient of determination (r^2) should be determined to describe the percent of variance explained by the regression.

c. Students 't' to test the hypothesis that the intercept of the regression is zero.

d. Students t to test the hypothesis that the slope of the regression is one. A slope of one is a perfect relationship between observed and predicted values.

5. Principal Investigator. The model testing should be conducted by individuals, other than the model authors, who have the observed data in their possession. This independent test prevents bias in the interpretation of the findings. However, it is equally important that a model author or contact person assist in the verification effort. Model authors can notice inappropriate input data quickly, and may understand unusual predictions.

6. Review. Verification results should receive peer review.

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GLOSSARY

Antecedent moisture condition (AMC). An indication of the wetness of the soil, with II being average, I being dryer than average, and III being wetter than average.

Calibration. The process during model development of adjusting parameter values to match observed values. Also, synonymous with fitting in some applications.

Distributed model. A model that defines spatial variations that are broken up into homogeneous area.

Distributed watershed parameters. The variables within a model that change depending upon location within the watershed.

Erodibility factor. A factor used in the Universal Soil Loss Equation that accounts for the ease at which different soils may erode.

Event based. A model that simulates a single runoff event and does not simulate flow between events.

Fitted model. A model that has parameter values obtained by fitting computed results to observed results.

Lumped model. A model that assumes the watershed is homogeneous.

Manning's n. The roughness coefficient used in the Manning's Equation. Greater roughness will result in lower stream velocity. Coefficients are available for various stream conditions.

Mass balance approach. A technique of determining all of the mass inputs, all of the mass outputs, and the storage within a system.

Measured parameters model. A model where all the parameters are from known watershed characteristics by either measurement or estimation.

Model calibration. See calibration above.

Model verification. Testing of a model with new field data to determine whether the model adequately predicts observed data.

Nonpoint. With respect to water resources, nonpoint refers to runoff that would originate in a diffuse manner from the landscape, rather than from a pipe.

Rainfall energy intensity. A factor used in the Universal Soil Loss Equation that represents the energy delivered to the ground to initiate soil detachment. The factor varies with rainfall intensity, season, and location.

Slope shape. A factor used to adjust soil loss depending on whether the slope is uniform, convex, or concave.

Surface condition constant. A value used in AGNPS that adjusts the time for overland flow to become channelized based on the land use condition.

USLE. Represents the Universal Soil Loss Equation used in AGNPS.

Verification. See model verification above.

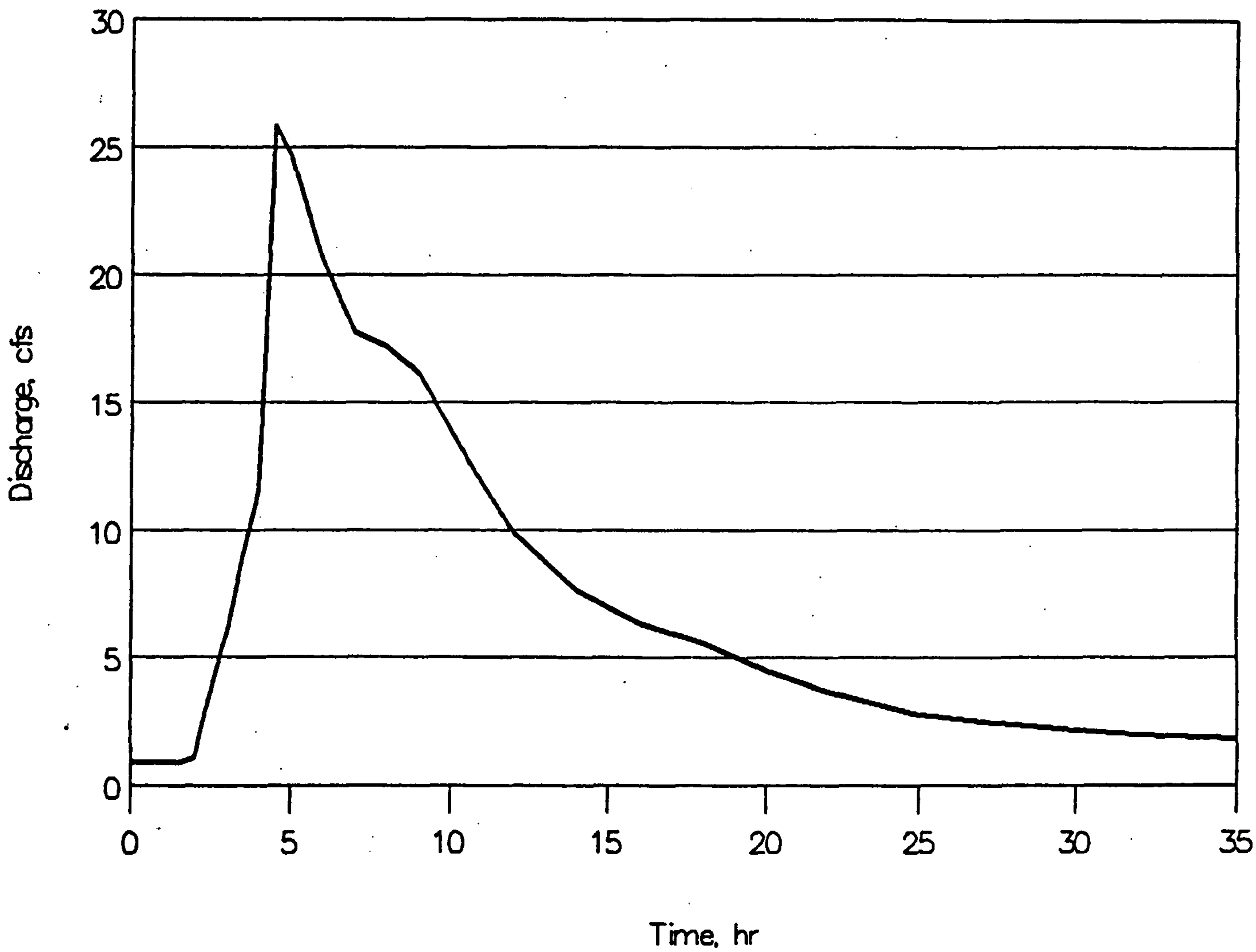
1 yr - 24 hr storm. The amount of a precipitation storm of a 24 hour duration expected to occur, on the average, once a year.

APPENDIX A

Hydrographs

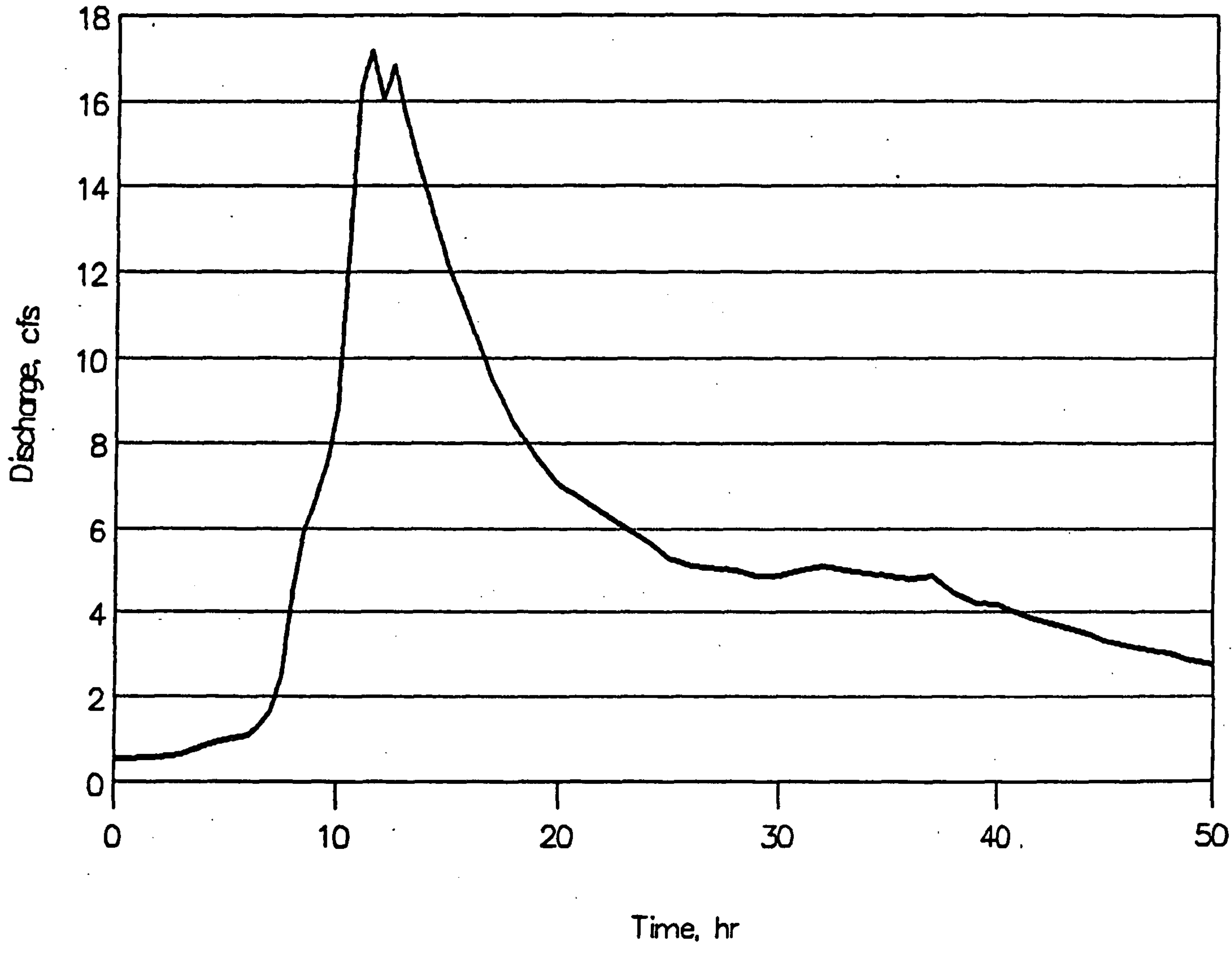
Hydrograph of LaPlatte Event

Date: 4/17/82



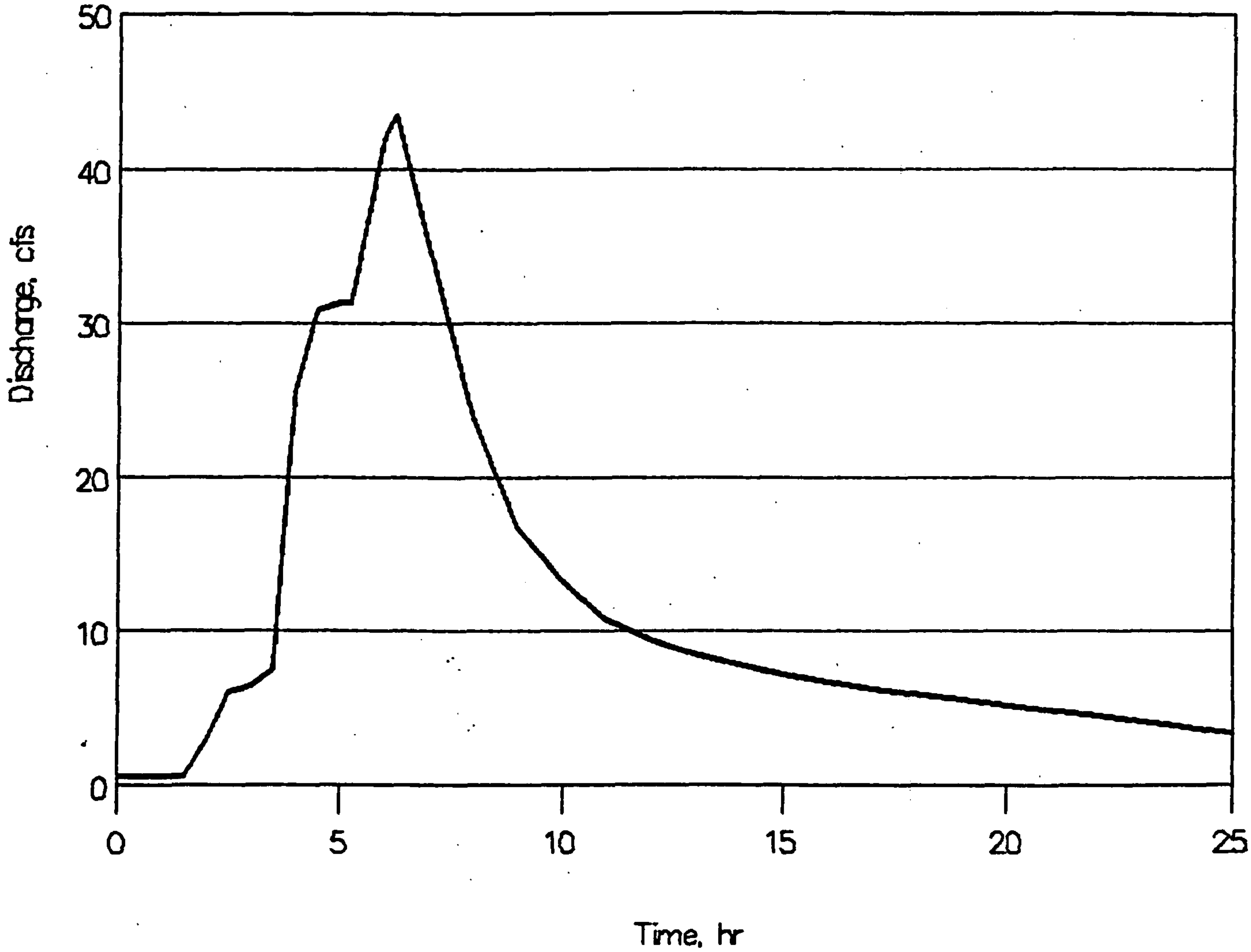
Hydrograph of LaPlatte Event

Date: 4/10/83



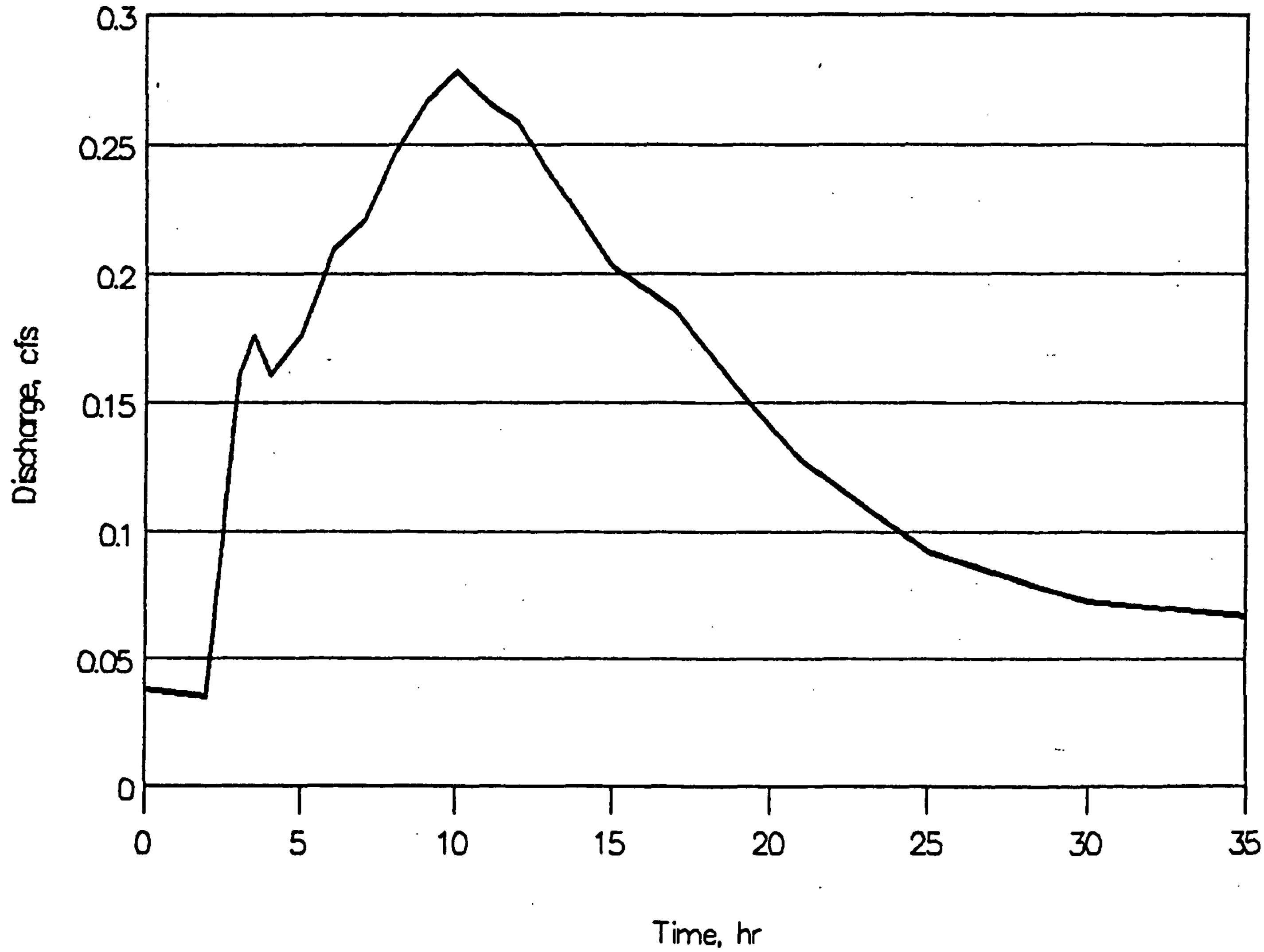
Hydrograph of LaPlatte Event

Date: 6/6/83



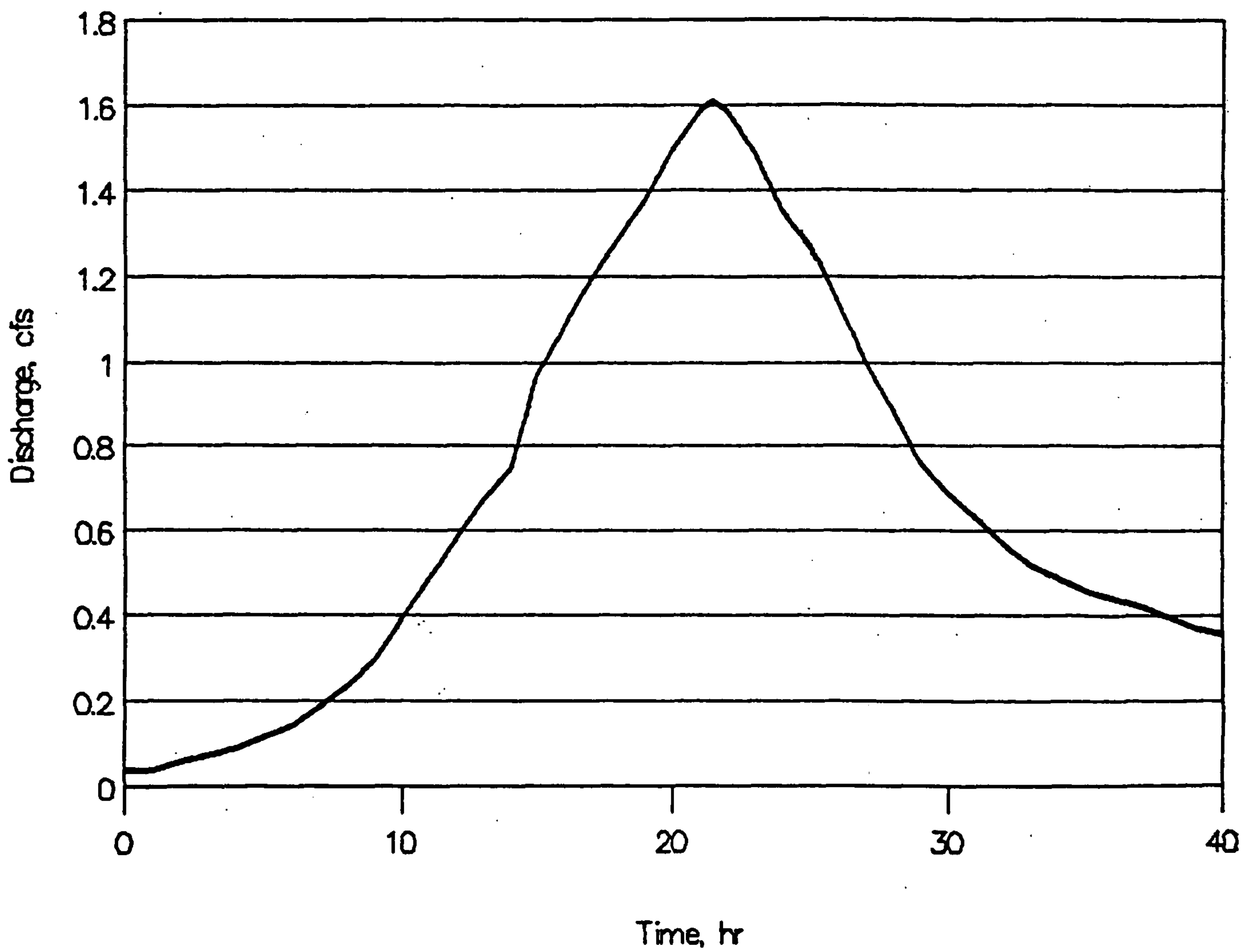
Hydrograph of LaPlatte Event

Date: 8/8/83



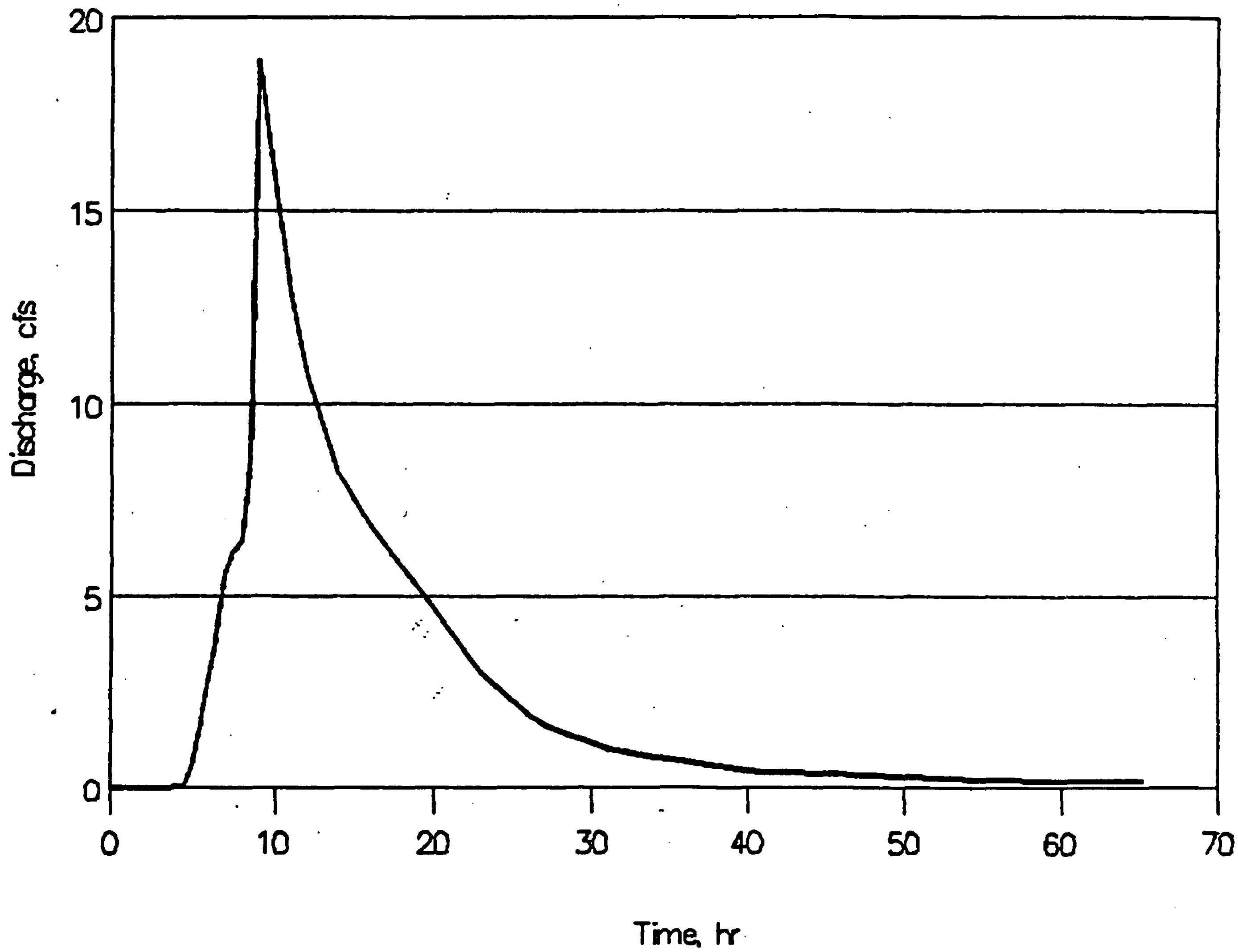
Hydrograph of LaPlatte Event

Date: 8/11/83



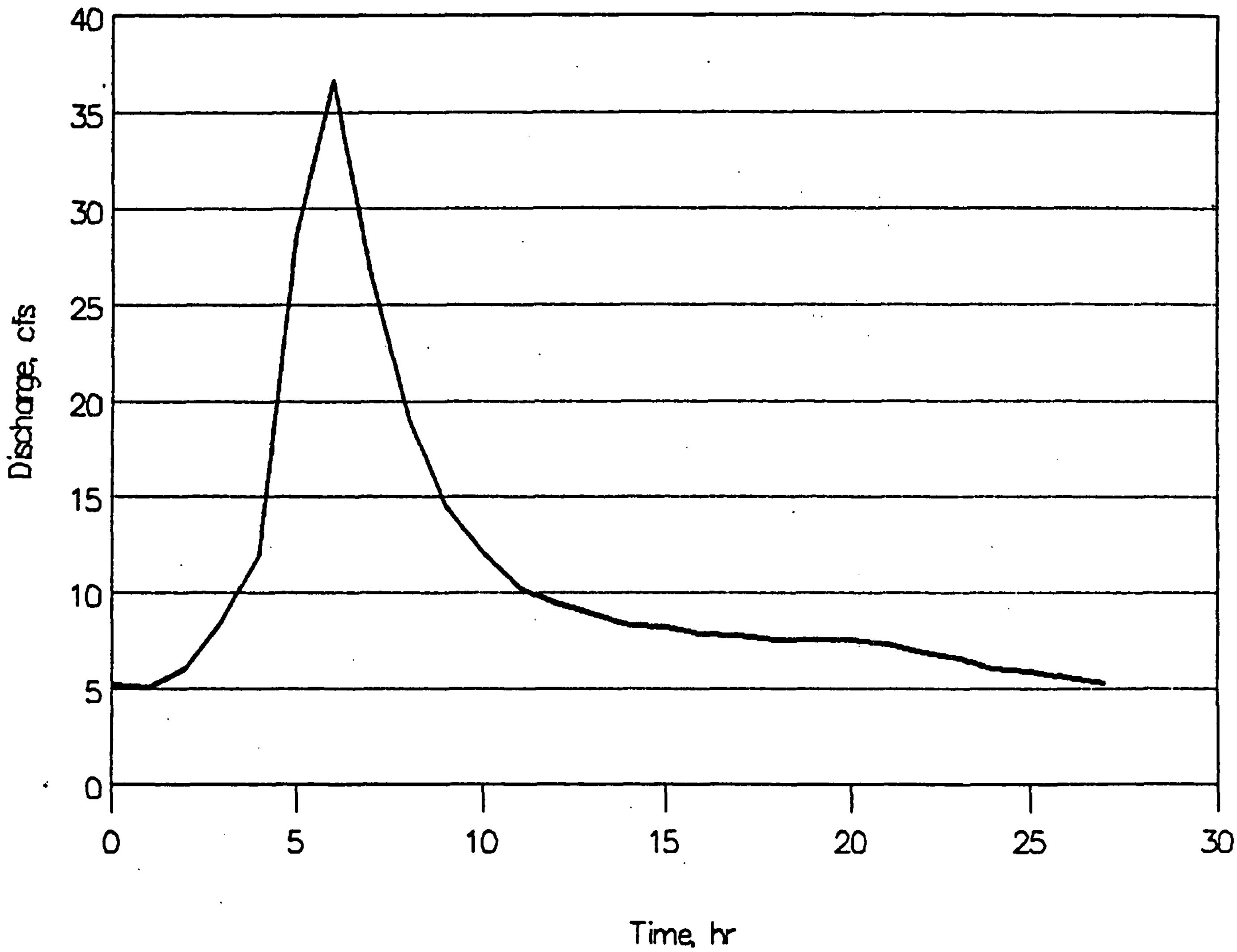
Hydrograph of LaPlatte Event

Date: 9/21/83



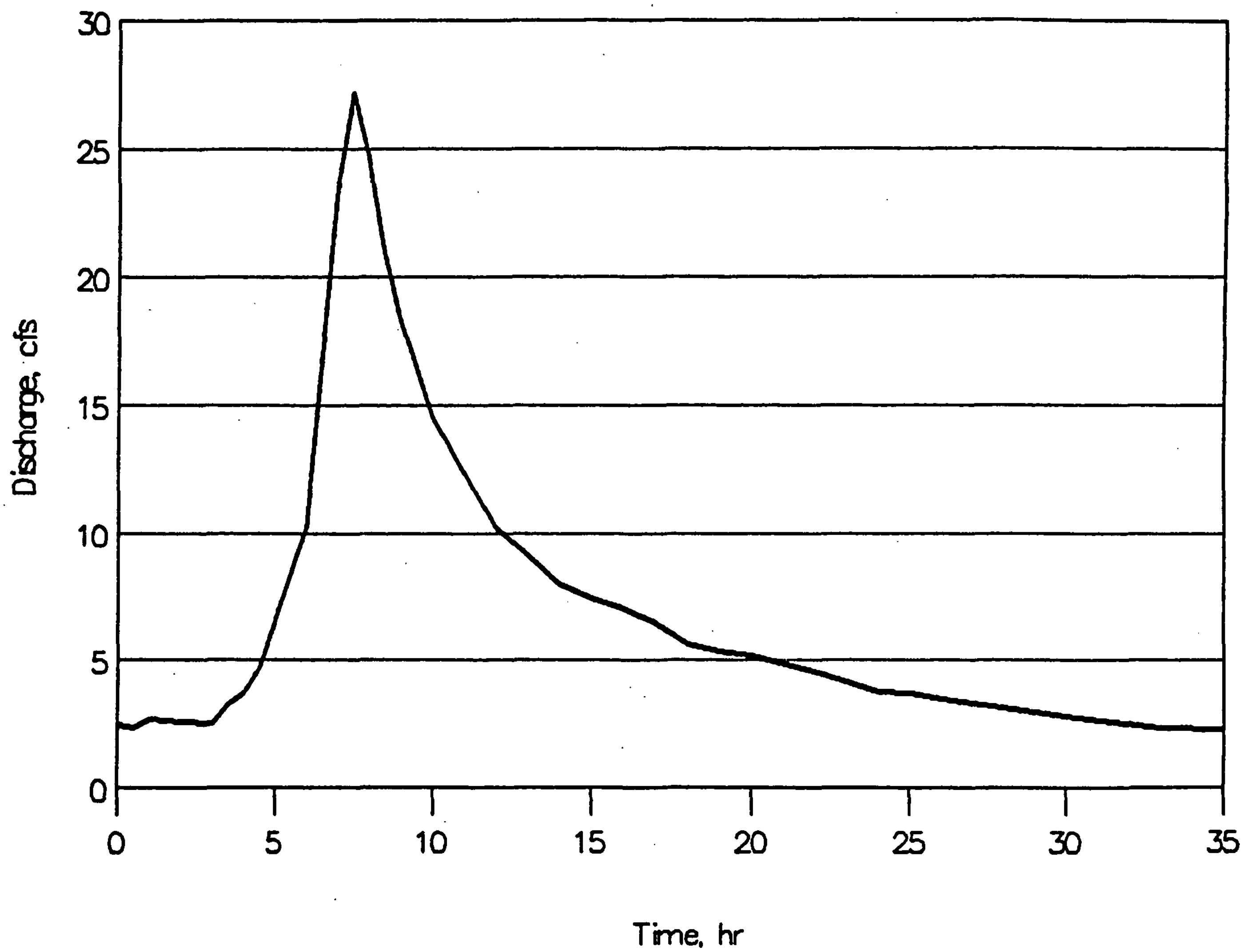
Hydrograph of LaPlatte Event

Date: 11/11/83



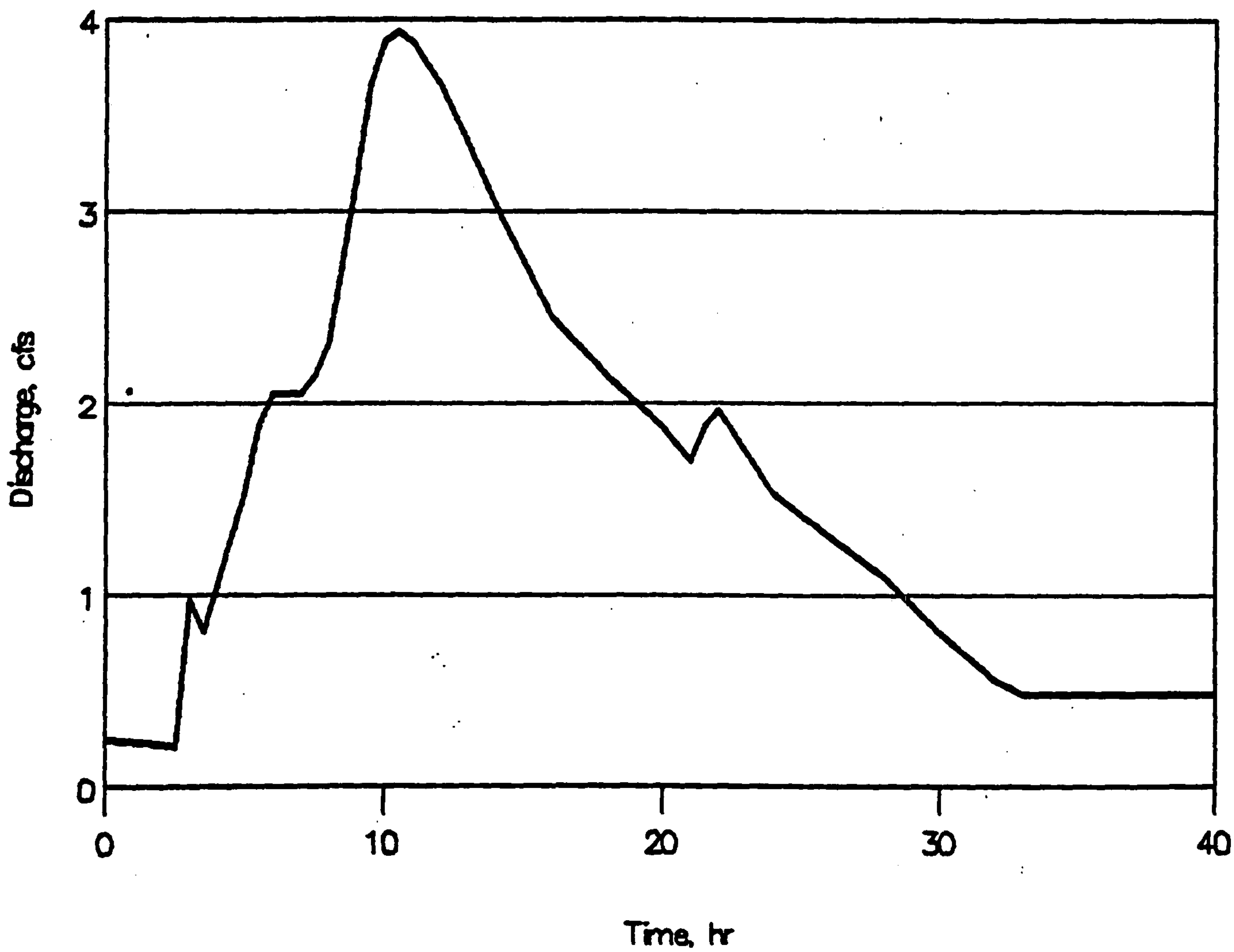
Hydrograph of LaPlatte Event

Date: 4/17/84



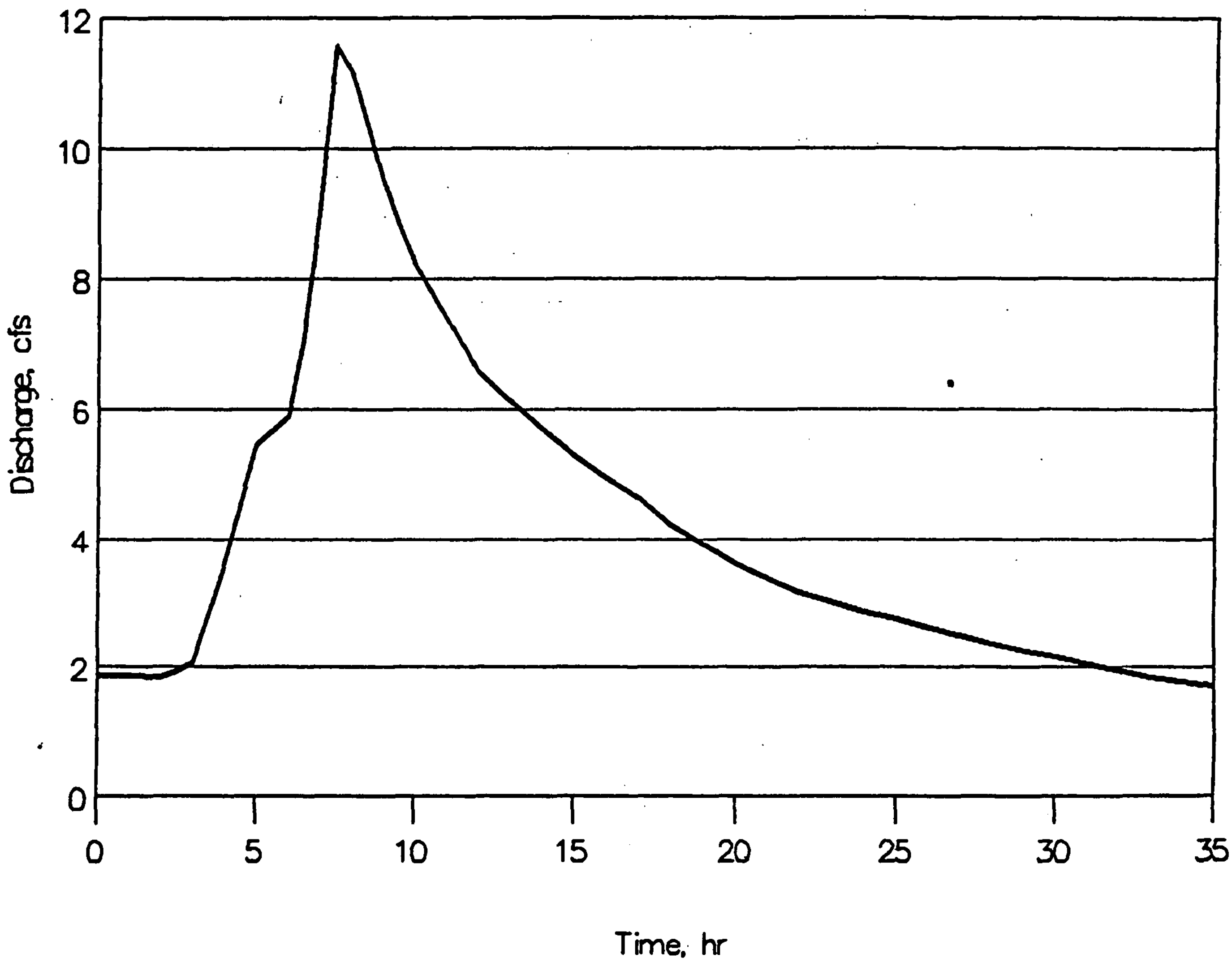
Hydrograph of LaPlatte Event

Date: 5/23/84



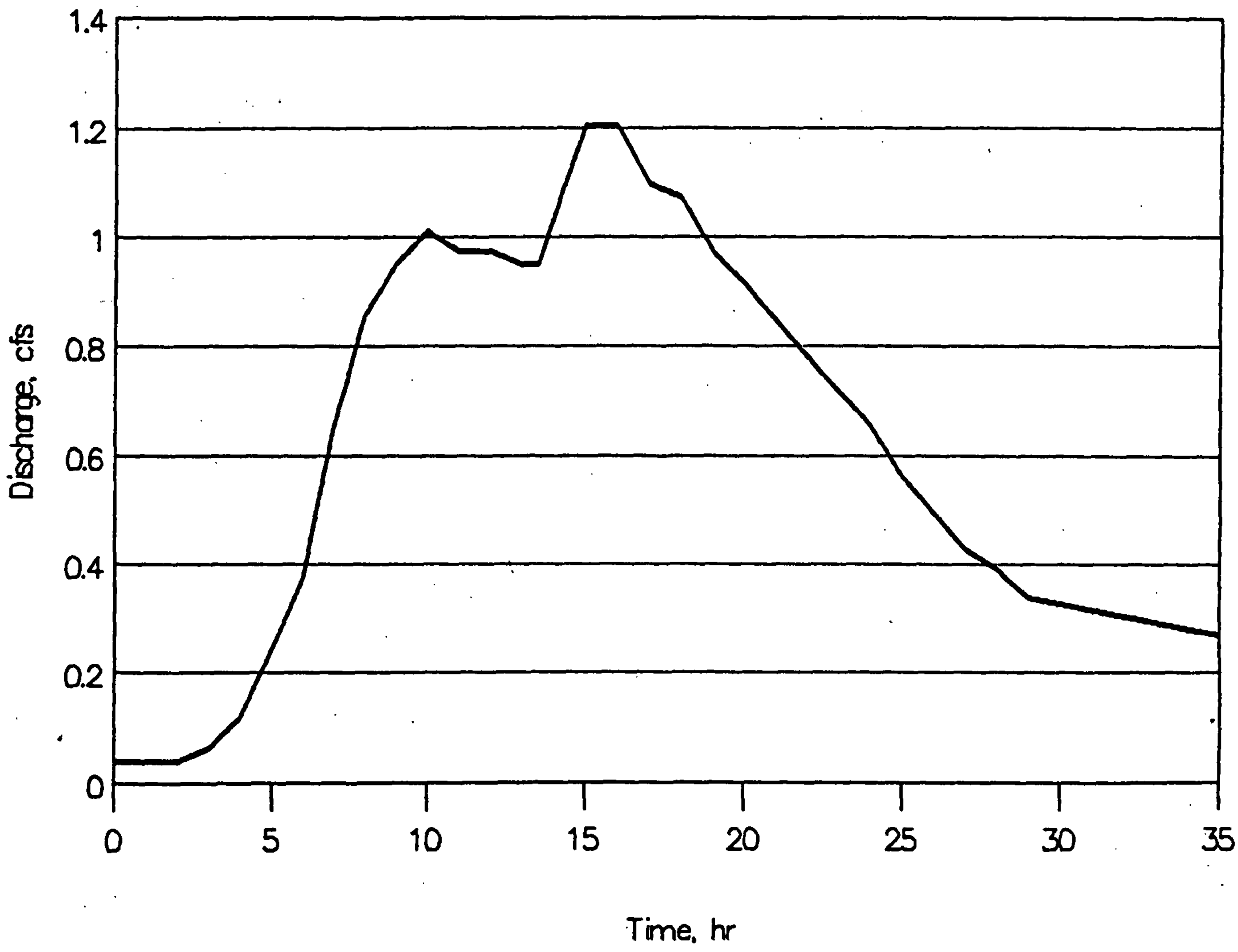
Hydrograph of LaPlatte Event

Date: 4/6/85



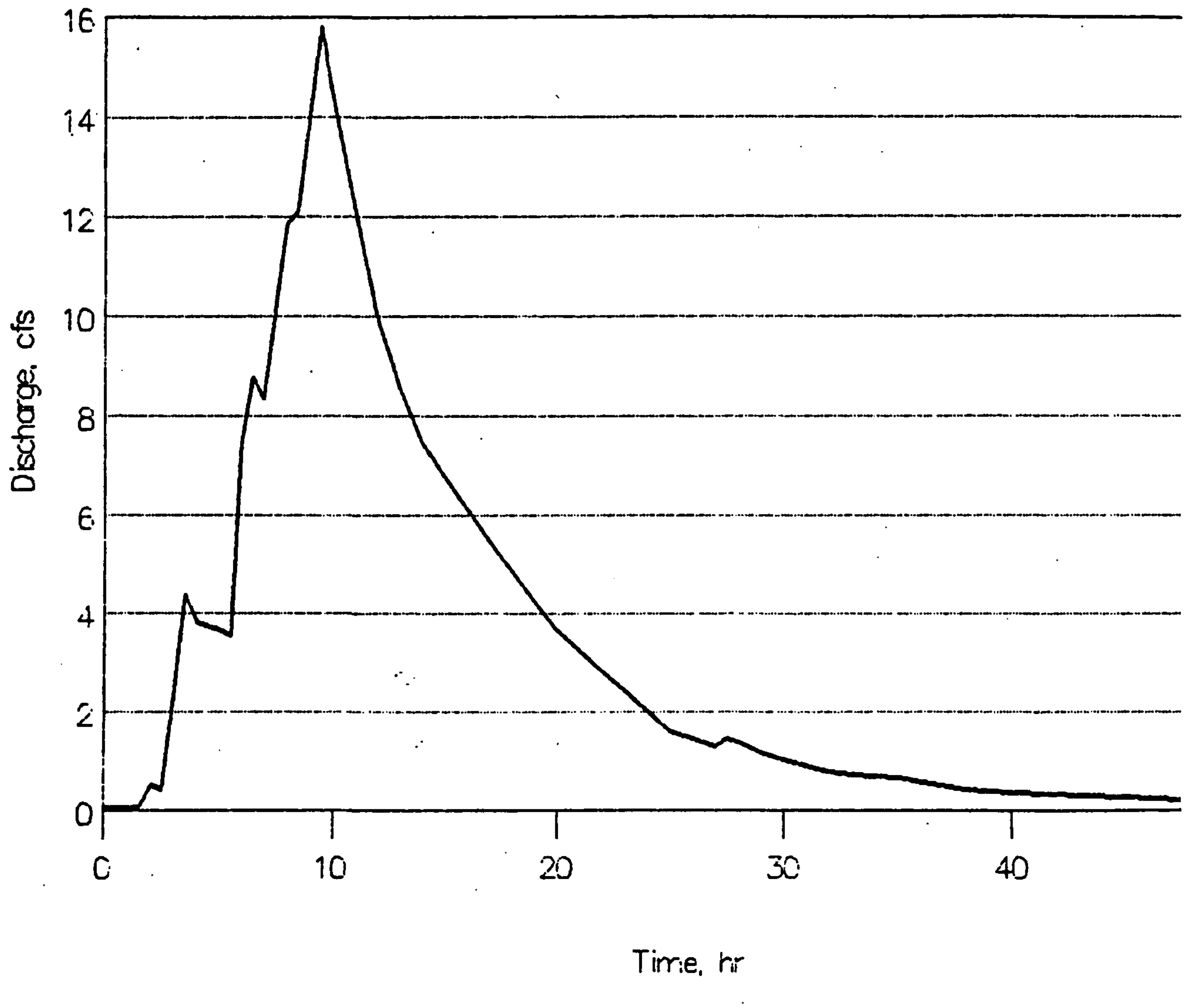
Hydrograph of LaPlatte Event

Date: 6/5/85



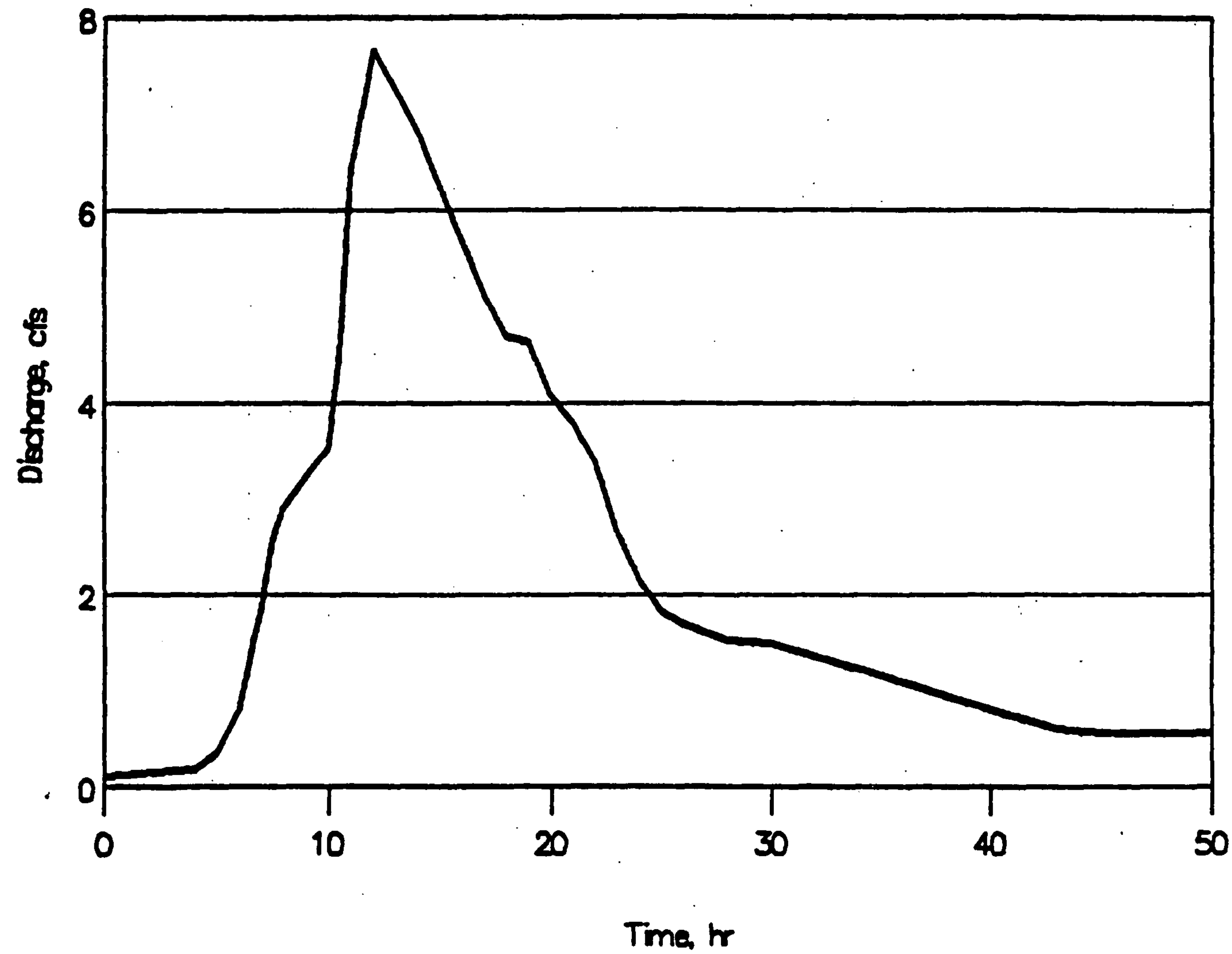
Hydrograph of LaPlatte Event

Date: 8/3/86



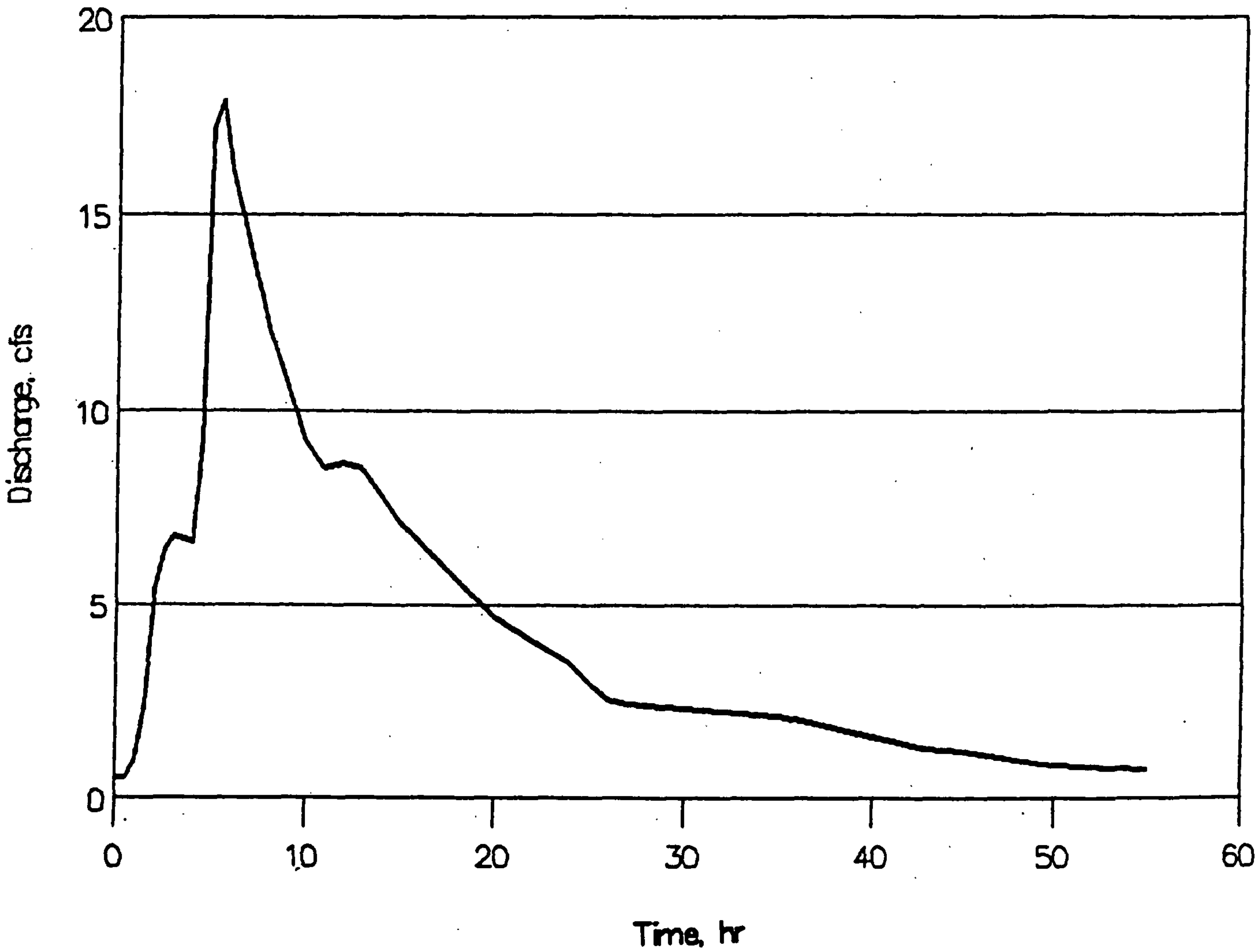
Hydrograph of LaPlatte Event

Date: 8/27/86



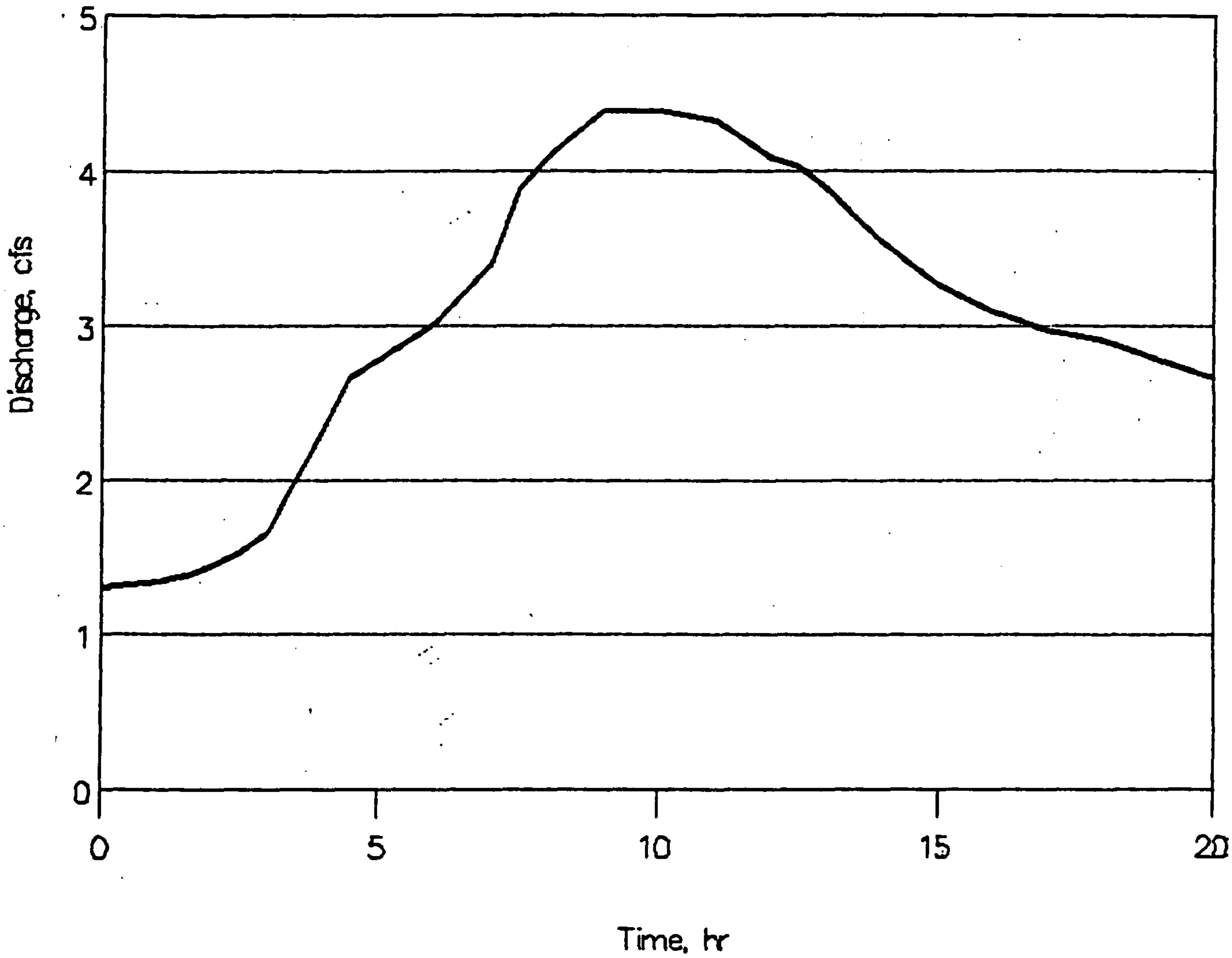
Hydrograph of LaPlatte Event

Date: 9/29/86



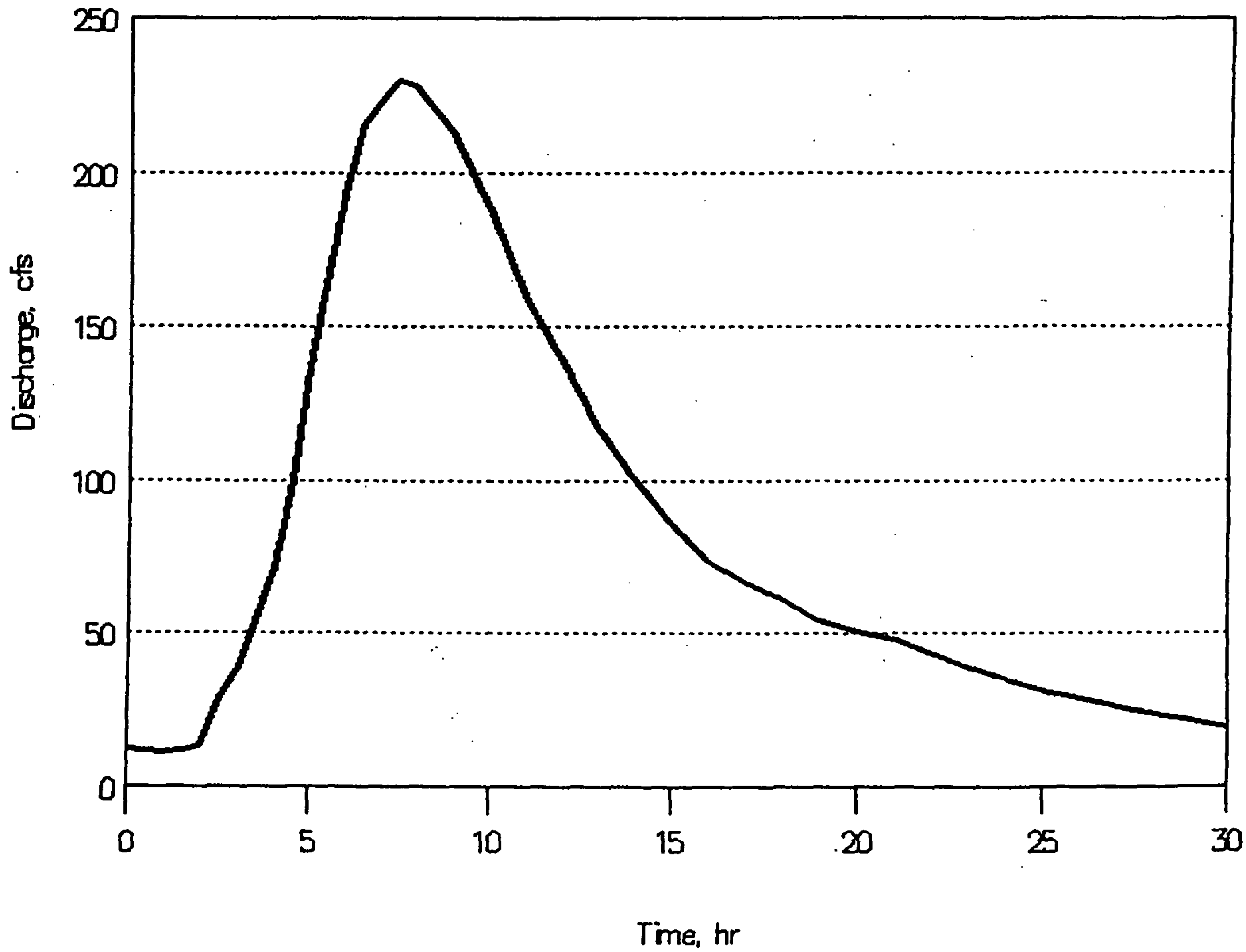
Hydrograph of LaPlatte Event

Date: 3/31/87



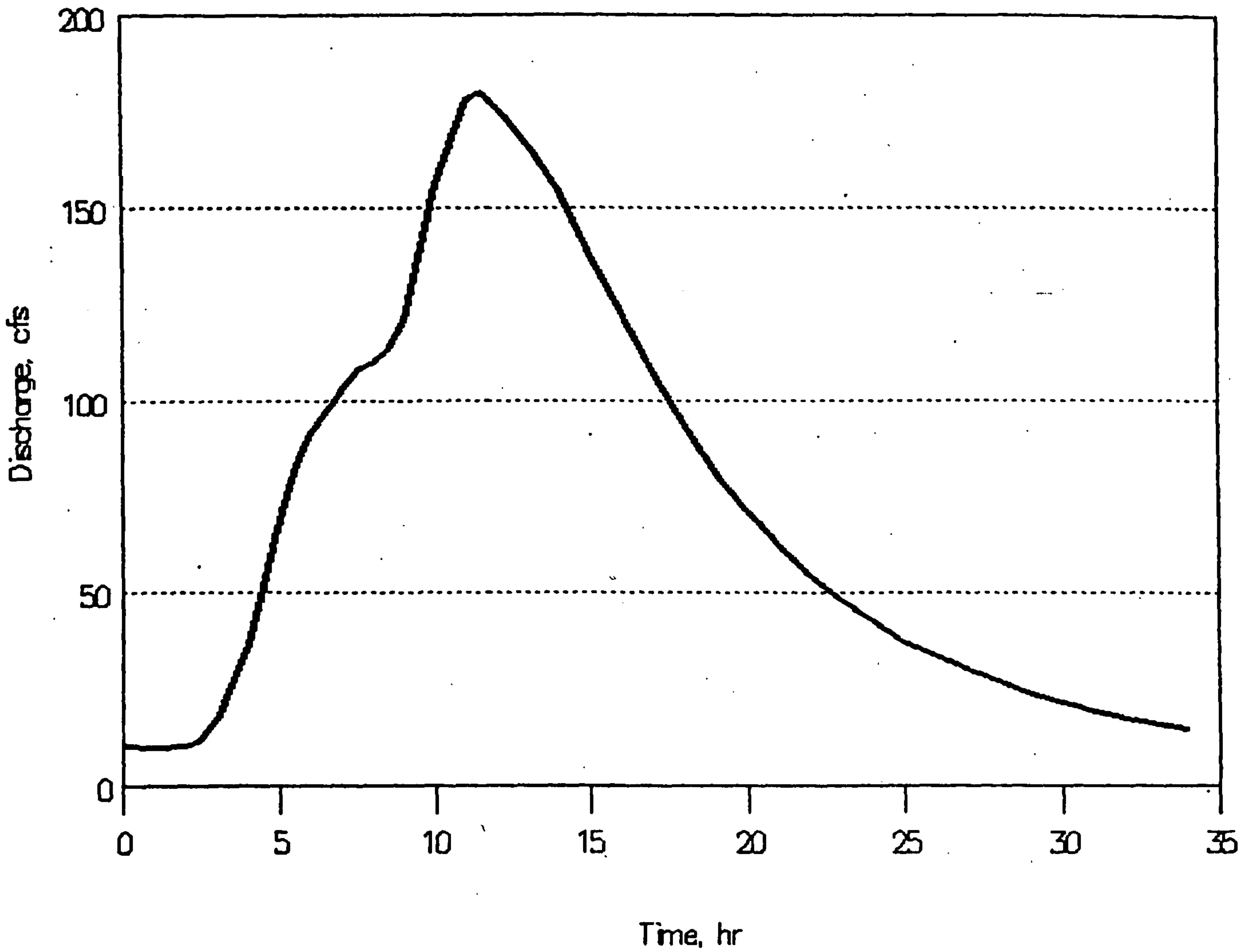
Hydrograph of Jewett Brook Event

Date: 4/6/85



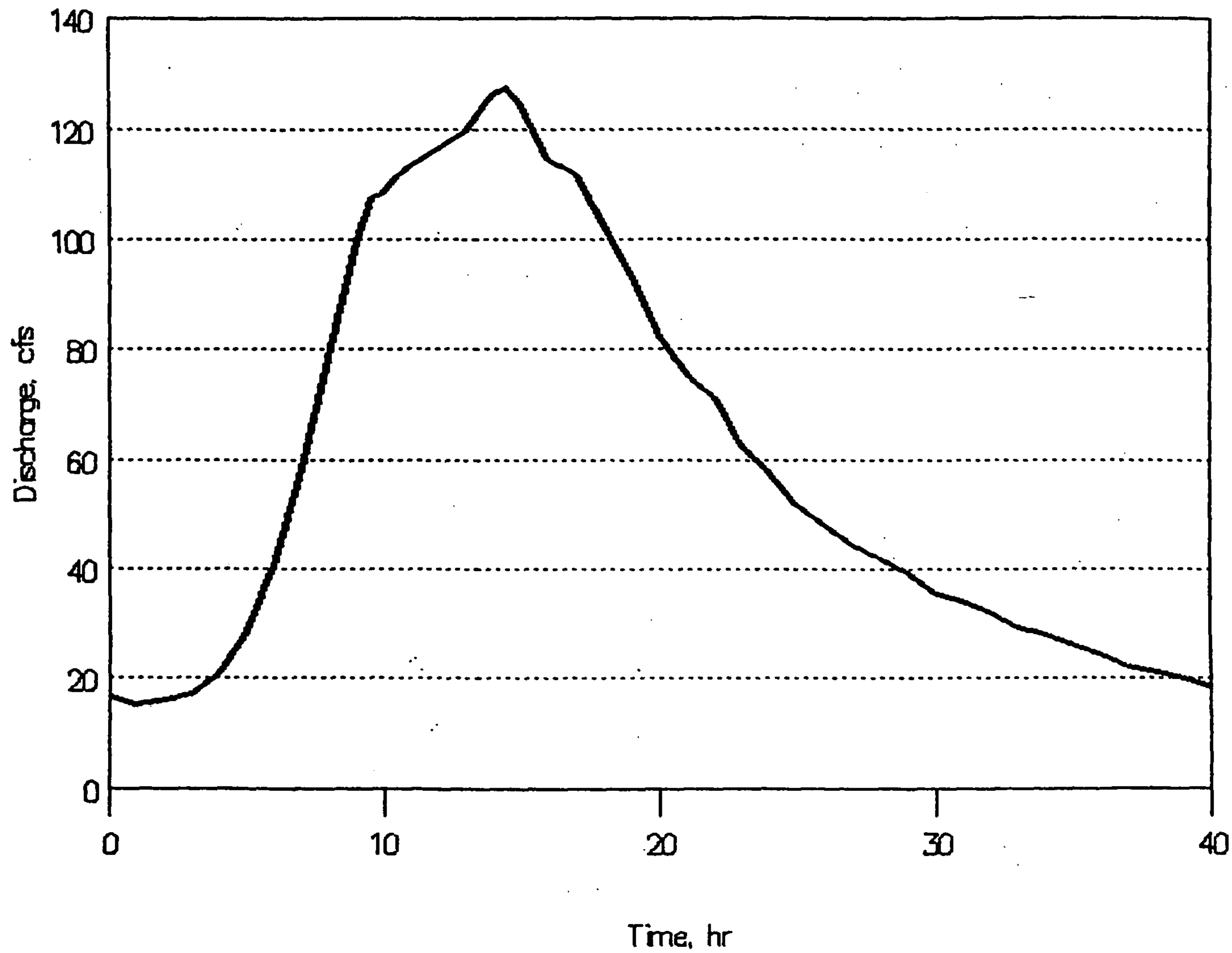
Hydrograph of Jewett Brook Event

Date: 4/16/84



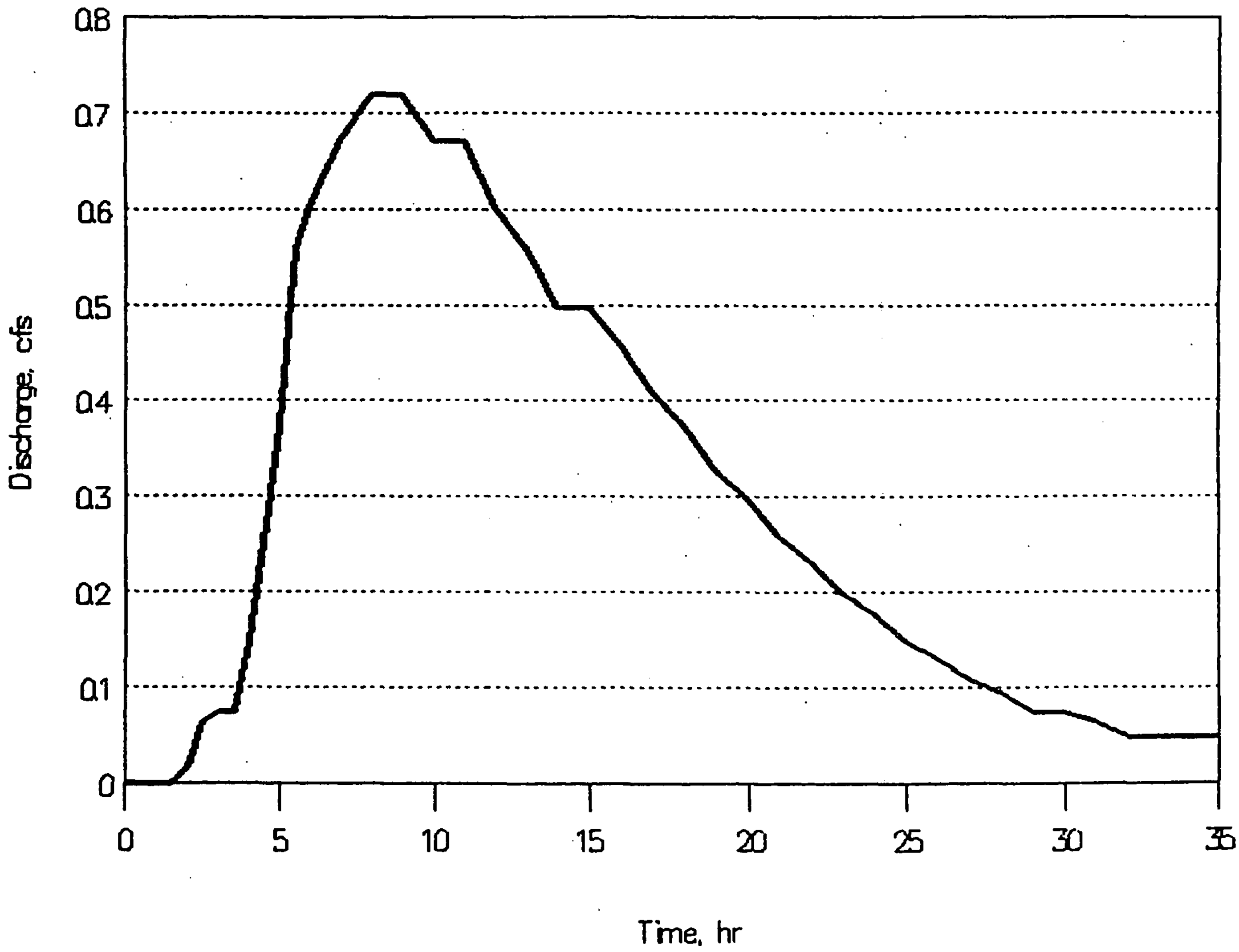
Hydrograph of Jewett Brook Event

Date: 3/10/83



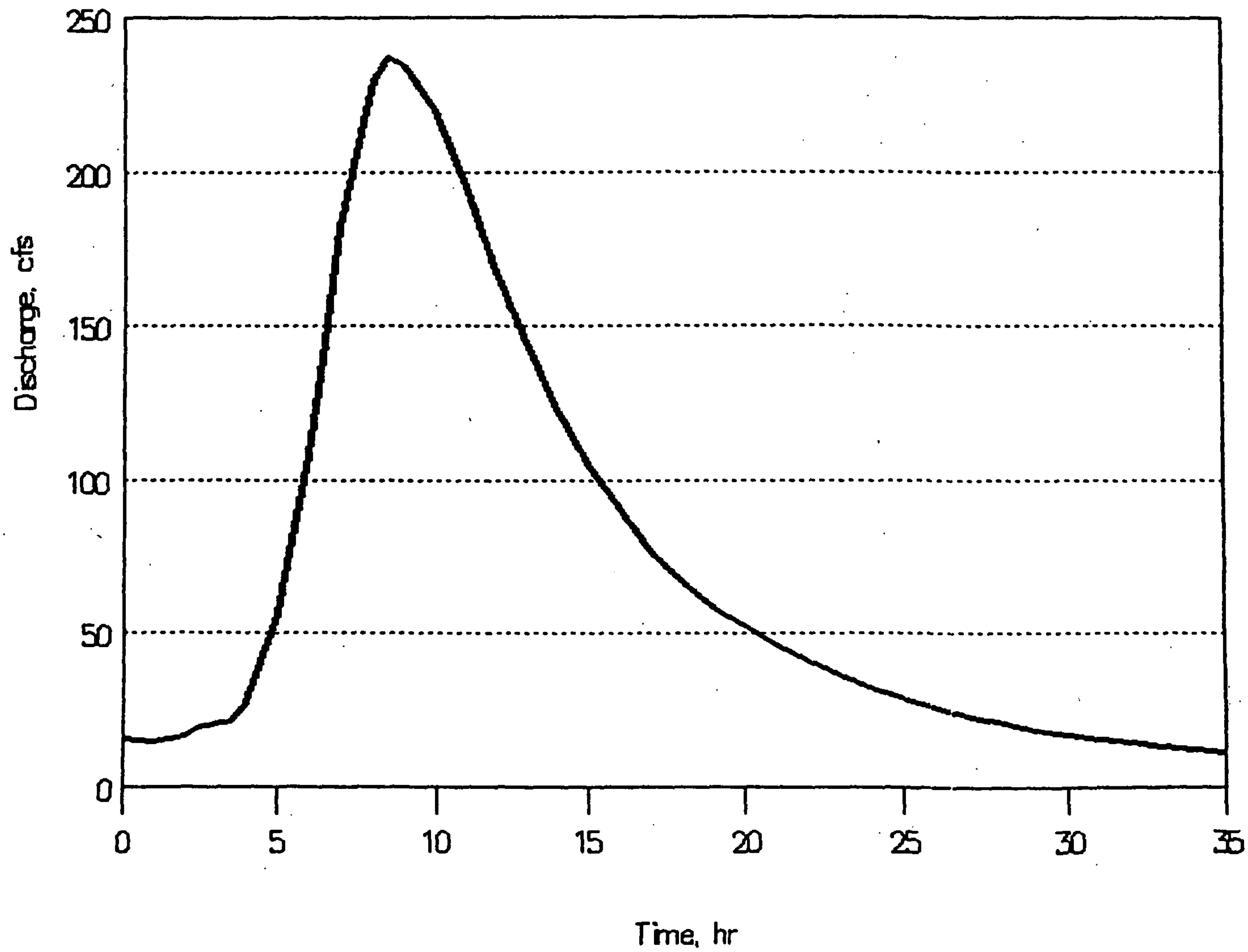
Hydrograph of Jewett Brook Event

Date: 10/5/83



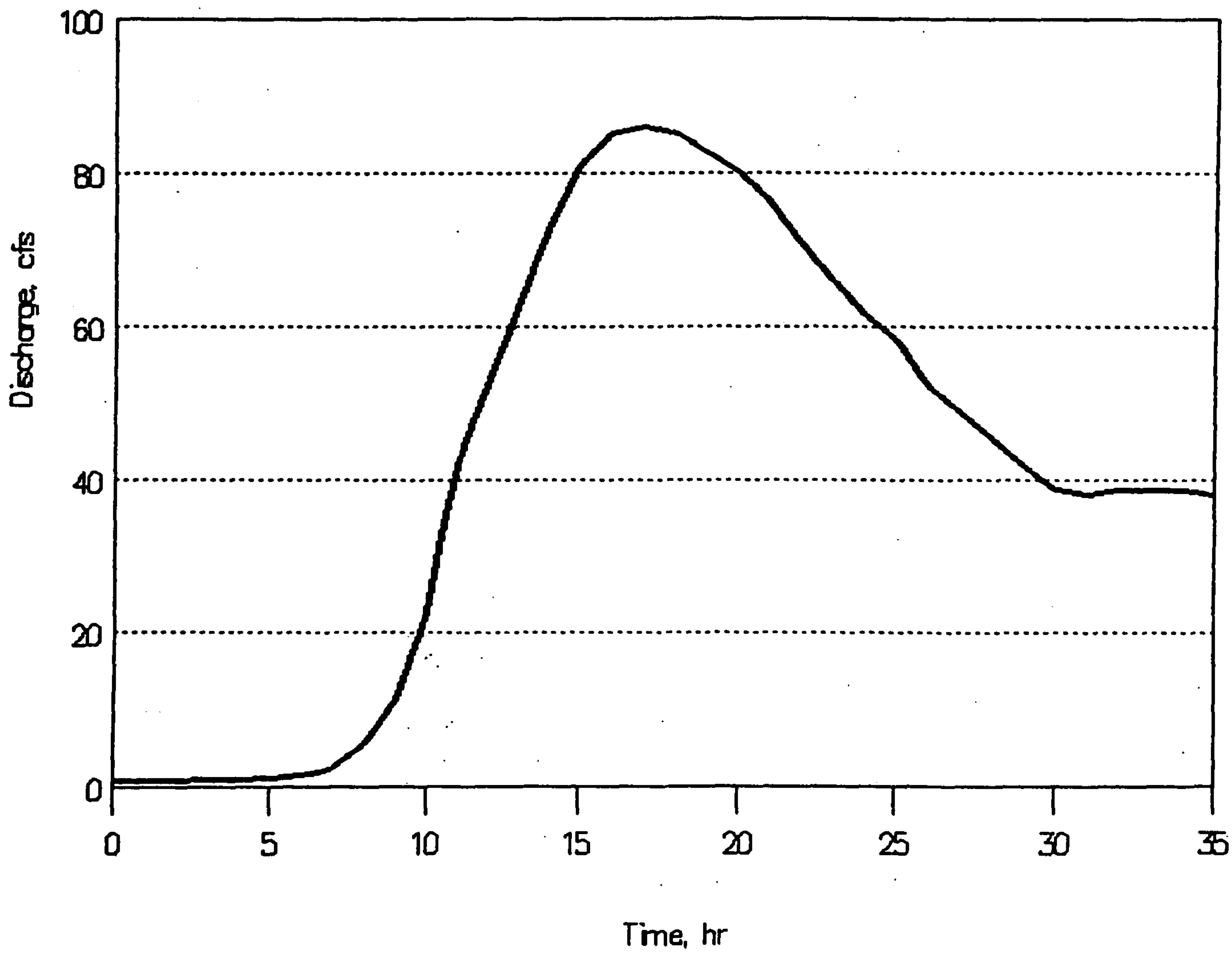
Hydrograph of Jewett Brook Event

Date: 4/17/84



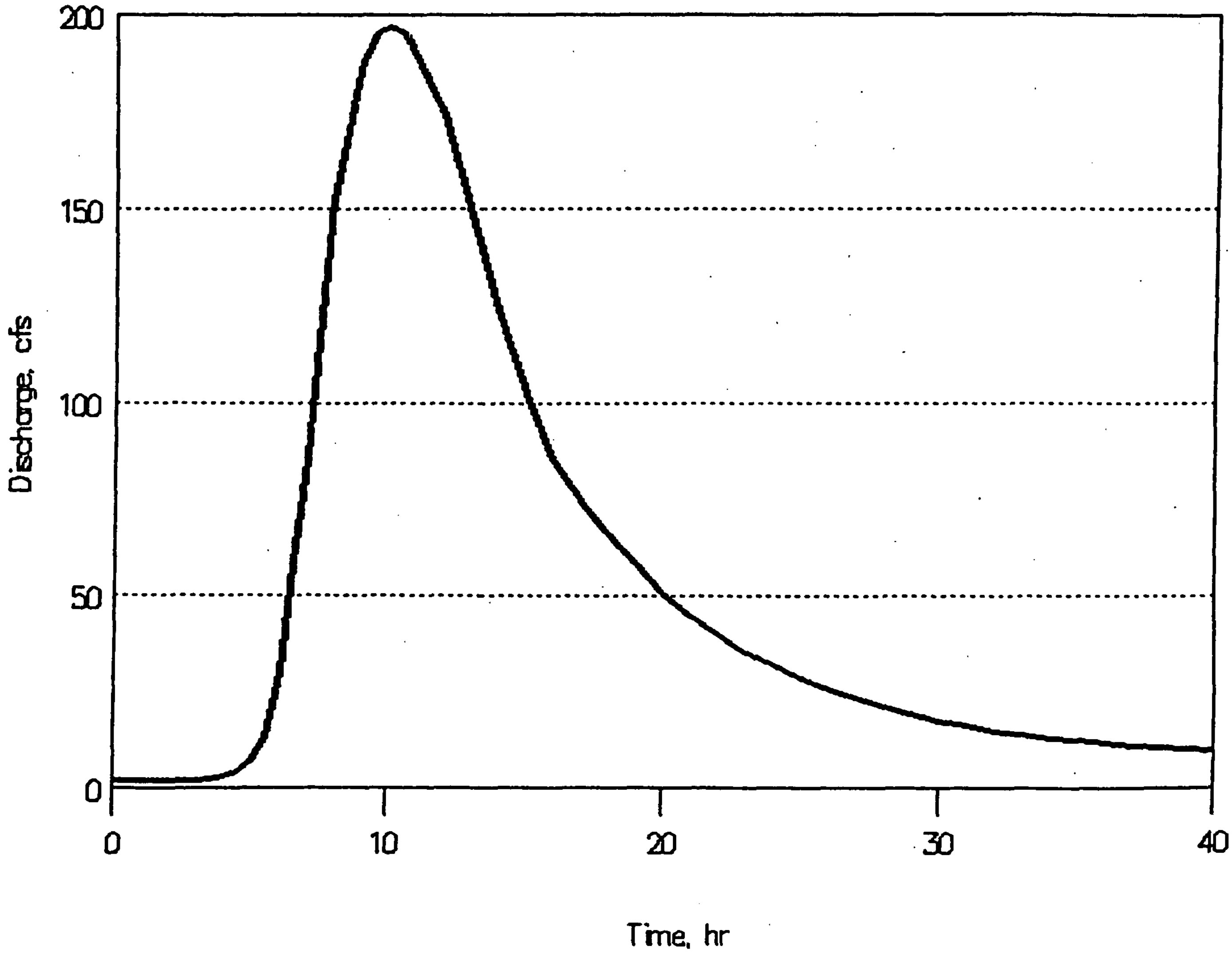
Hydrograph of Jewett Brook Event

Date: 5/29/84



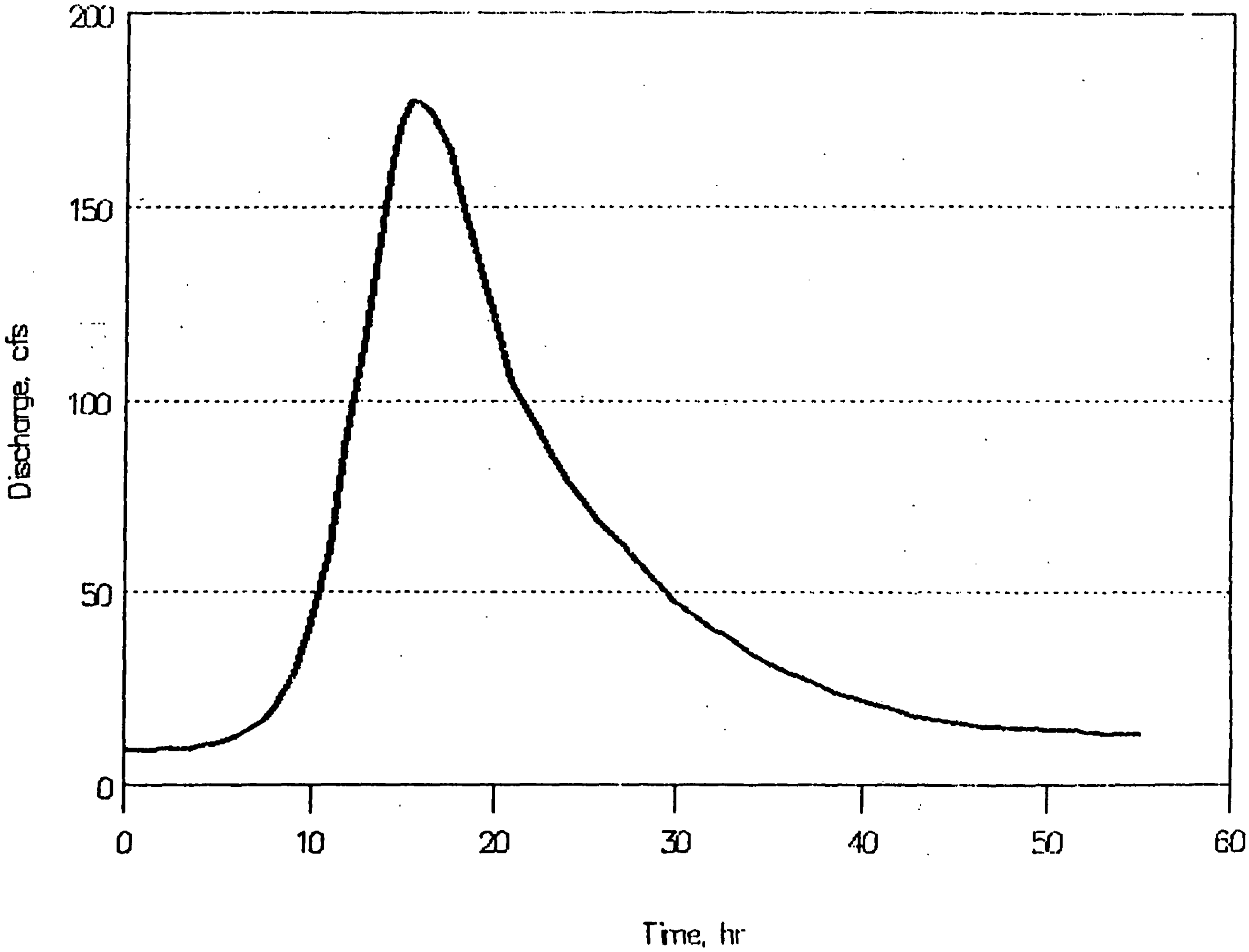
Hydrograph of Jewett Brook Event

Date: 4/18/85



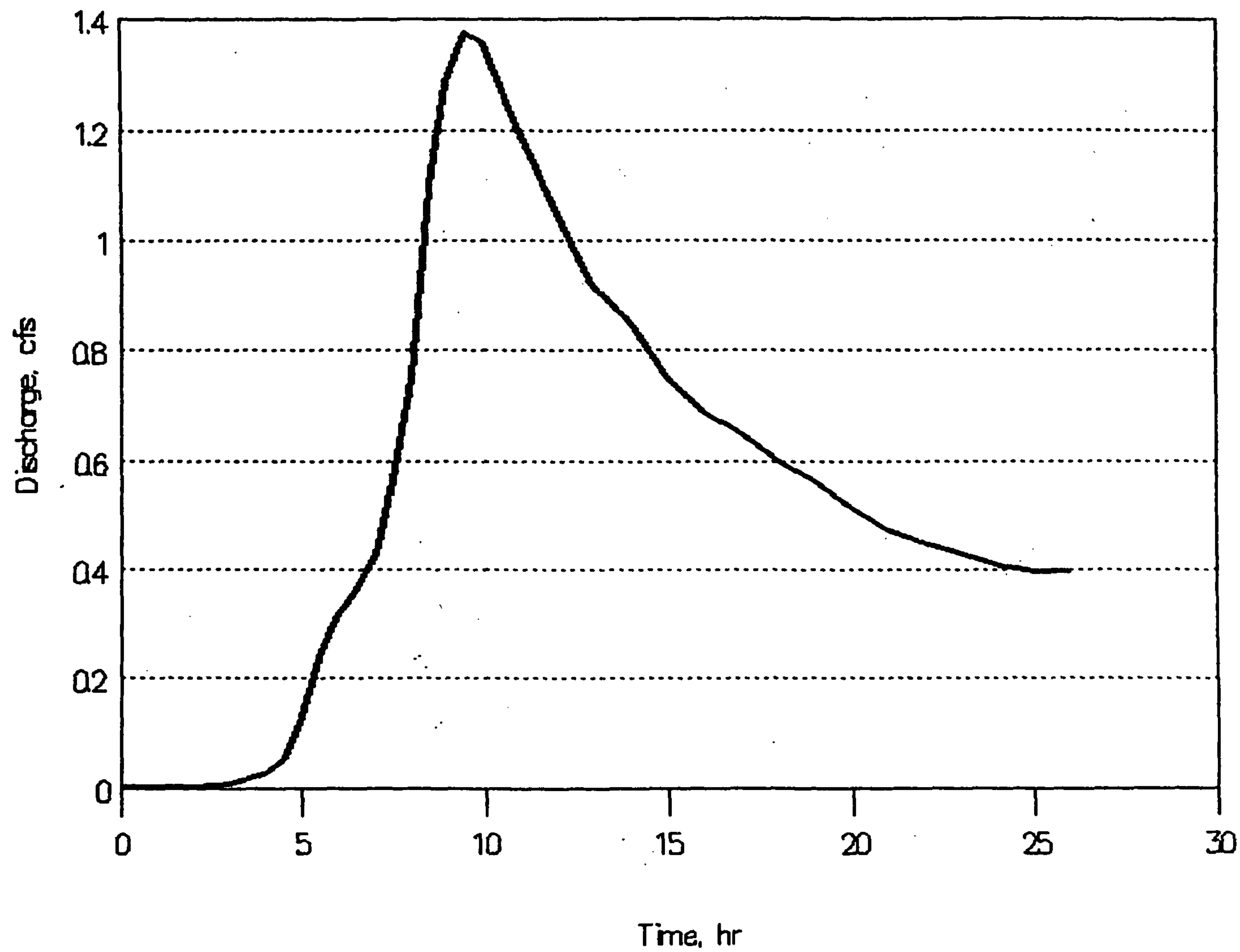
Hydrograph of Jewett Brook Event

Date: 11/26/86



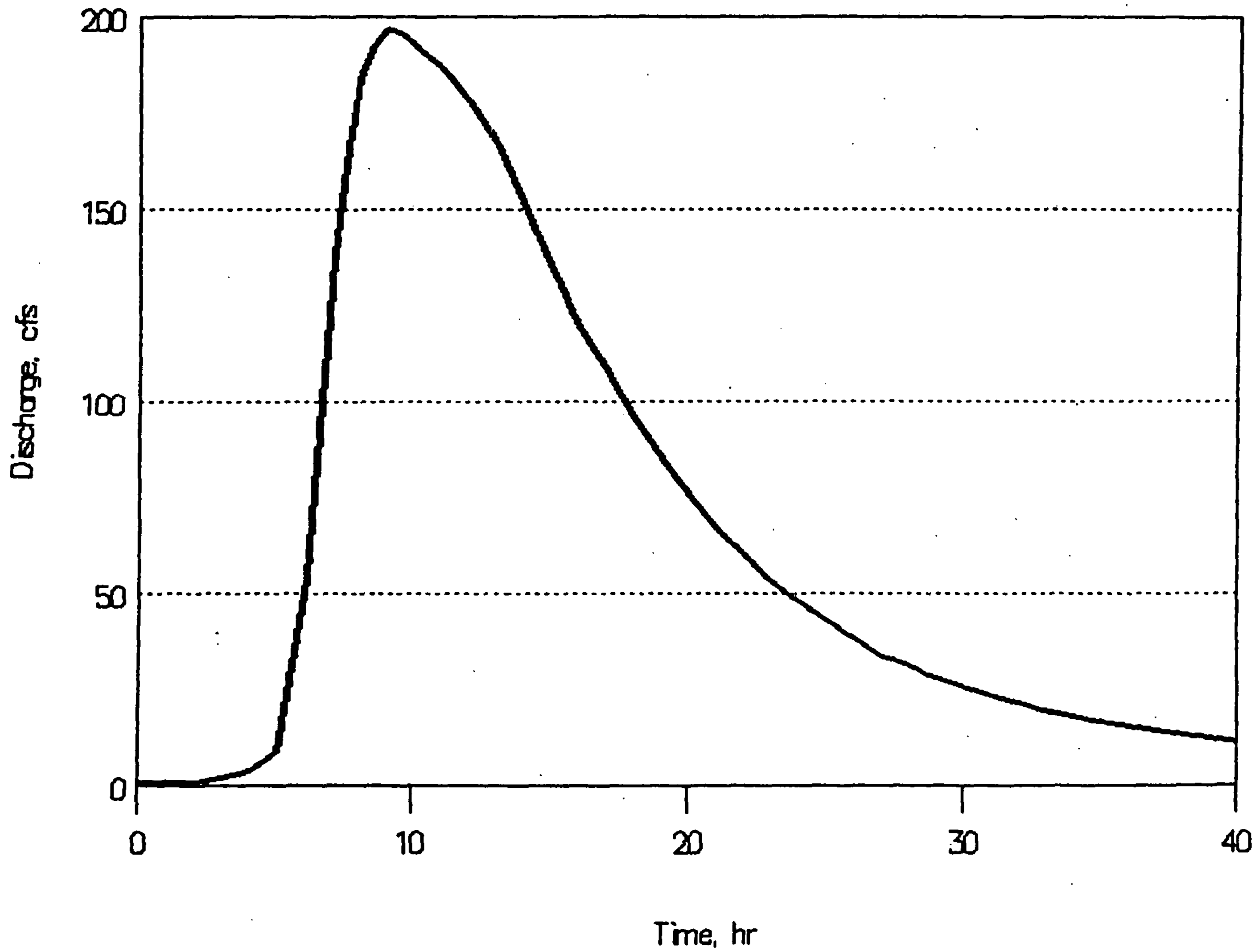
Hydrograph of Jewett Brook Event

Date: 10/28/87



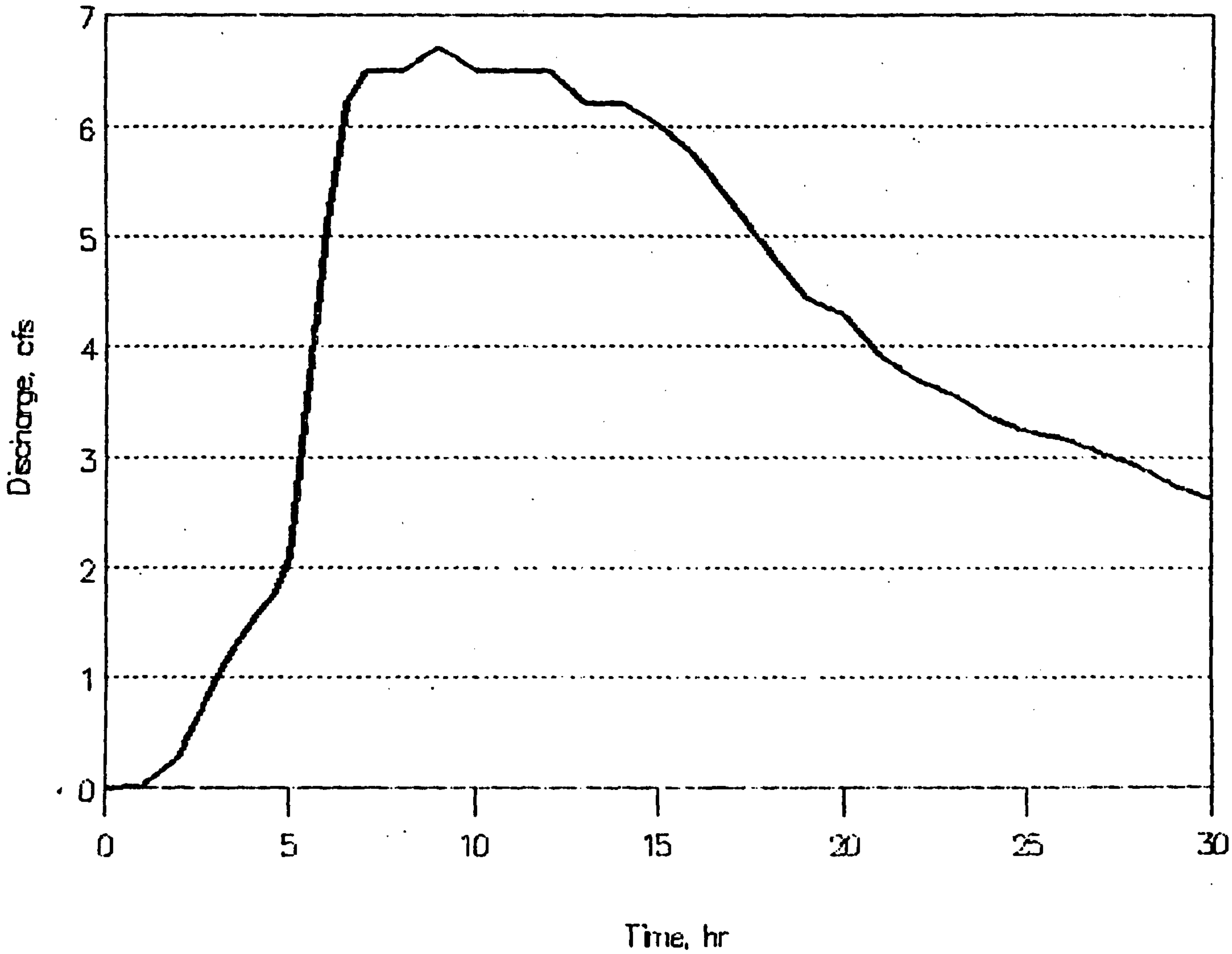
Hydrograph of Jewett Brook Event

Date: 5/23/84



Hydrograph of Jewett Brook Event

Date: 9/21/83



APPENDIX B

EXAMPLE INPUT FILES

LaPlatte River Subwatershed 3

LaP3_4-10-83_1-15-90_R1

9.8 40 .9 1.5

1	4	52	13.7	1	94	6.7	10.0	.100	.35	.01	1.00	.29	4	2	0	100	0	0	65	0	0
2	6	58	13.9	1	125	7.0	10.0	.035	.42	.60	1.00	.22	6	3	0	100	0	0	60	0	0
3	7	53	8.0	2	155	4.0	10.0	.100	.43	.01	1.00	.29	6	3	0	100	0	0	65	0	0
4	9	55	6.8	1	161	5.0	10.0	.100	.44	.01	1.00	.29	5	3	0	100	0	0	65	0	0
5	41	55	24.2	2	128	3.0	10.0	.030	.49	.01	1.00	.15	7	3	0	100	0	0	60	0	0
6	5	59	3.7	1	188	3.0	10.0	.030	.49	.01	1.00	.15	7	3	0	100	0	0	60	0	0
7	6	61	10.4	1	137	4.6	10.0	.080	.40	.40	1.00	.29	7	3	0	100	0	0	60	0	0
8	13	55	8.0	2	134	9.1	10.0	.075	.37	.01	1.00	.29	5	3	0	100	0	0	65	0	0
9	13	55	5.2	1	161	2.0	10.0	.080	.47	.40	1.00	.29	5	2	0	100	0	0	60	0	0
10	9	58	4.5	1	152	2.3	10.0	.080	.37	.40	1.00	.29	7	3	0	100	0	0	60	0	0
11	6	56	3.6	1	200	3.0	10.0	.075	.49	.40	1.00	.05	1	3	0	100	0	0	60	0	0
12	11	63	6.6	2	138	1.3	10.0	.080	.45	.40	1.00	.22	7	3	0	100	0	0	60	0	0
13	12	57	11.3	1	91	8.1	10.0	.035	.37	.60	1.00	.22	7	2	0	100	0	0	65	0	0
14	20	54	15.6	1	97	6.1	10.0	.030	.44	.01	1.00	.15	5	3	0	100	0	0	60	0	0
15	14	57	8.7	2	116	4.4	10.0	.030	.32	.01	1.00	.15	7	2	0	100	0	0	60	0	0
16	22	58	7.5	1	154	3.8	10.0	.030	.43	.01	1.00	.15	5	3	0	100	0	0	60	0	0
17	18	62	4.4	1	191	1.5	10.0	.035	.49	.60	1.00	.22	3	3	0	100	0	0	60	0	0
18	12	63	10.9	2	126	3.0	10.0	.035	.48	.60	1.00	.22	1	3	0	100	0	0	60	0	0
19	18	58	9.9	2	136	1.4	10.0	.035	.45	.60	1.00	.22	7	3	0	100	0	0	60	0	0
20	19	56	6.1	2	166	1.5	10.0	.030	.47	.01	1.00	.15	7	3	0	100	0	0	60	0	0
21	20	58	19.4	2	132	6.1	10.0	.035	.39	.60	1.00	.22	7	2	0	100	0	0	60	0	0
22	27	59	4.0	2	200	2.0	10.0	.035	.49	.60	1.00	.22	6	3	0	100	0	0	60	0	0
23	17	62	7.1	1	164	3.0	10.0	.035	.47	.60	1.00	.22	1	3	0	100	0	0	60	0	0
24	18	59	19.3	2	124	4.6	10.0	.035	.39	.60	1.00	.22	1	2	0	100	0	0	60	0	0
25	19	54	10.3	3	131	5.2	10.0	.100	.40	.01	1.00	.29	1	2	0	100	0	0	65	0	0
26	20	53	9.6	3	132	4.8	10.0	.080	.40	.40	1.00	.29	1	2	0	100	0	0	60	0	0
27	20	61	1.6	1	200	1.1	10.0	.080	.49	.40	1.00	.29	8	3	0	100	0	0	60	0	0
28	27	59	3.6	1	200	3.0	10.0	.035	.49	.60	1.00	.22	7	3	0	100	0	0	60	0	0
29	28	60	3.7	1	177	3.0	10.0	.080	.46	.40	1.00	.29	7	3	0	100	0	0	60	0	0
30	23	62	4.0	1	200	2.0	10.0	.035	.49	.60	1.00	.22	1	3	0	100	0	0	60	0	0
31	24	60	12.8	1	120	1.5	10.0	.035	.43	.60	1.00	.22	1	3	0	100	0	0	60	0	0
32	38	55	8.9	1	159	3.8	10.0	.080	.43	.40	1.00	.29	5	3	0	100	0	0	60	0	0
33	34	55	10.3	1	129	1.5	10.0	.080	.39	.40	1.00	.29	3	2	0	100	0	0	60	0	0
34	27	56	3.7	1	182	2.9	10.0	.100	.47	.01	1.00	.29	1	3	0	100	0	0	60	0	0
35	28	59	1.5	1	197	3.0	10.0	.080	.49	.40	1.00	.29	1	3	0	100	0	0	60	0	0
36	37	56	4.1	1	198	2.1	10.0	.080	.49	.40	1.00	.29	3	3	0	100	0	0	80	0	0
37	31	56	7.5	1	126	1.5	10.0	.080	.46	.40	1.00	.29	1	3	0	100	0	0	80	0	0
38	37	53	5.0	2	163	4.6	10.0	.080	.49	.40	1.00	.29	7	3	0	100	0	0	60	0	0
39	38	53	5.6	1	167	3.0	10.0	.080	.48	.40	1.00	.29	7	3	0	100	0	0	60	0	0
40	37	58	10.4	1	115	3.0	10.0	.075	.40	.40	1.00	.05	1	2	0	100	0	0	60	0	0

Jewett Brook

Jewett Brook Event: 3/10/83

9.8 343 0.6 1.2

1	3	48	2.8	1	314	1.4	10.0	.130	.30	.01	.50	.22	5	2	0	100	0	0	60	0
2	4	42	1.7	1	328	.9	10.0	.200	.31	.02	.60	.59	5	2	0	100	0	0	60	0
3	5	51	1.9	1	351	1.0	10.0	.200	.32	.02	.60	.59	5	2	0	100	0	0	60	0
4	3	46	1.5	1	354	.8	10.0	.200	.30	.02	.60	.59	7	2	0	100	0	0	60	0
5	8	55	1.1	1	398	.6	10.0	.200	.33	.02	.60	.59	5	2	0	100	0	0	60	0
6	9	56	1.4	1	374	.7	10.0	.080	.36	.02	.60	.59	5	2	0	100	0	0	60	0
7	9	58	1.2	1	437	.6	10.0	.200	.47	.02	.60	.59	6	2	0	100	0	0	60	0
8	12	63	1.0	1	423	.5	10.0	.050	.38	.51	.60	.05	5	2	0	100	0	0	115	0
9	13	55	1.2	1	382	.6	10.0	.080	.28	.51	.60	.05	5	2	0	100	0	0	115	0
10	14	36	1.5	1	351	.8	10.0	.200	.28	.02	.60	.59	5	2	0	100	0	0	60	0
11	15	55	1.3	1	404	.7	10.0	.200	.41	.02	.60	.59	5	2	0	100	0	0	60	0
12	17	59	1.0	1	430	.5	10.0	.080	.40	.02	.60	.59	4	2	0	100	0	0	60	0
13	17	54	1.1	1	391	.6	10.0	.080	.28	.02	.60	.59	5	2	2	100	0	0	60	0
14	15	57	1.9	1	320	1.0	10.0	.050	.31	.51	.60	.05	3	2	1	100	0	0	115	0
15	19	56	1.5	1	349	.8	10.0	.080	.29	.02	.60	.59	5	1	0	100	0	0	60	0
16	21	56	1.5	1	348	.8	10.0	.200	.28	.02	.60	.59	4	1	0	100	0	0	60	0
17	18	48	1.6	1	340	.8	10.0	.080	.28	.02	.60	.59	3	2	3	100	0	0	60	0
18	25	54	1.2	1	380	.6	10.0	.080	.30	.02	.60	.59	4	2	3	100	0	0	60	0
19	25	61	1.0	1	400	.5	10.0	.080	.32	.51	.60	.05	5	2	3	100	0	0	115	0
20	26	66	1.4	1	374	.7	10.0	.050	.34	.51	.60	.05	5	2	1	100	0	0	115	0
21	20	50	1.6	1	362	.8	10.0	.130	.29	.01	.60	.22	7	1	0	100	0	0	60	0
22	28	55	1.2	1	400	.1	10.0	.100	.30	.01	.60	.29	5	2	0	100	0	0	65	0
23	24	61	2.0	1	300	1.0	10.0	.050	.25	.51	.60	.05	3	1	0	100	0	0	115	0
24	25	55	1.2	1	381	.6	10.0	.200	.31	.02	.60	.59	3	2	1	10	0	0	60	0
25	26	52	1.0	1	400	.5	10.0	.080	.32	.02	.60	.59	3	2	3	10	0	0	60	0
26	34	60	1.0	1	441	.5	10.0	.080	.46	.02	.60	.59	5	2	3	100	0	0	60	0
27	26	51	1.5	1	373	.8	10.0	.100	.30	.01	.60	.29	7	1	0	100	0	0	65	0
28	36	54	1.2	1	394	.1	10.0	.100	.24	.01	.60	.29	5	2	0	100	0	0	65	0
29	28	61	1.1	1	442	.6	10.0	.100	.47	.01	.60	.29	7	3	0	100	0	0	65	0
30	31	64	1.7	1	352	.9	10.0	.130	.26	.01	.60	.22	3	2	0	100	0	0	60	0
31	32	59	3.8	1	257	1.9	10.0	.050	.31	.51	.50	.05	3	2	0	100	0	0	115	0
32	33	61	1.6	1	371	.8	10.0	.050	.33	.51	.60	.05	3	2	0	100	0	0	115	0
33	34	63	1.0	1	403	.5	10.0	.050	.33	.51	.60	.05	3	2	0	100	0	0	115	0
34	42	66	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	6	2	0	100	0	0	115	0
35	44	64	1.0	1	444	.5	10.0	.050	.48	.51	.60	.05	5	2	0	100	0	0	115	0
36	44	57	1.2	1	417	.1	10.0	.200	.37	.02	.60	.59	6	2	0	100	0	0	60	0
37	46	59	1.2	1	403	.6	10.0	.100	.33	.01	.60	.29	5	2	0	100	0	0	65	0
38	37	58	1.7	1	339	.9	10.0	.050	.24	.51	.60	.05	7	1	0	100	0	0	115	0
39	49	66	1.1	1	396	.6	10.0	.130	.31	.01	.60	.22	5	2	1	100	0	0	60	0
40	50	63	1.7	1	364	.9	10.0	.130	.31	.01	.60	.22	5	2	0	100	0	0	60	0
41	51	64	1.0	1	400	.5	10.0	.130	.35	.01	.60	.22	5	2	0	100	0	0	60	0
42	43	58	1.0	1	413	.5	10.0	.080	.36	.02	.60	.59	3	3	0	100	0	0	60	0
43	53	61	1.0	1	450	.1	10.0	.080	.49	.02	.60	.59	5	3	0	100	0	0	60	0
44	43	63	1.0	1	450	.1	10.0	.080	.49	.02	.60	.59	7	2	0	100	0	0	60	0
45	56	67	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	4	2	0	100	0	0	115	0
46	56	65	1.0	1	450	.5	10.0	.070	.49	.51	.60	.05	5	2	0	100	0	0	115	0
47	46	69	1.0	1	449	.5	10.0	.080	.49	.01	1.00	.01	7	2	0	100	0	0	80	0
48	47	57	1.5	1	381	.8	10.0	.050	.33	.51	.60	.05	7	2	0	100	0	0	115	0
49	61	66	1.1	1	390	.6	10.0	.080	.33	.01	.60	.22	5	2	0	100	0	0	60	0
50	62	64	1.2	1	388	.6	10.0	.130	.28	.01	.60	.22	5	2	0	100	0	0	60	0
51	63	65	1.3	1	384	.7	10.0	.130	.33	.01	.60	.22	5	2	1	100	0	0	60	0
52	53	62	1.0	1	433	.5	10.0	.100	.43	.01	.60	.29	3	3	0	100	0	0	65	0
53	65	64	1.0	1	450	.1	10.0	.080	.49	.01	.60	.29	5	3	0	100	0	0	65	0
54	53	66	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	7	2	0	100	0	0	115	0
55	54	60	1.0	1	450	.5	10.0	.200	.49	.02	.60	.59	7	2	0	100	0	0	60	0
56	67	60	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	6	2	0	100	0	0	60	0
57	56	53	1.4	1	387	.7	10.0	.100	.35	.01	.60	.29	7	2	0	100	0	0	65	0
58	70	45	1.7	1	334	.9	10.0	.070	.17	.01	.60	.29	5	1	0	100	0	0	65	0

59	58	49	1.6	1	339	.8	10.0	.070	.17	.01	.60	.29	7	1	0	100	0	0	65	0
60	61	61	1.8	1	325	.9	10.0	.080	.24	.01	.60	.22	3	2	0	100	0	0	60	0
61	73	69	1.6	1	337	.8	10.0	.080	.43	.51	.60	.05	5	3	0	100	0	0	115	0
62	74	63	1.0	1	398	.5	10.0	.080	.32	.51	.60	.05	5	2	0	100	0	0	115	0
63	64	58	1.0	1	405	.5	10.0	.080	.35	.02	.60	.59	3	2	0	100	0	0	60	0
64	76	62	1.0	1	443	.5	10.0	.080	.49	.01	.60	.29	5	4	0	100	0	0	65	0
65	77	64	1.0	1	450	.1	10.0	.080	.49	.01	.60	.29	5	3	0	100	0	0	65	0
66	78	66	1.0	1	450	.5	10.0	.050	.49	.51	.60	.05	5	2	0	100	0	0	115	0
67	79	60	1.0	1	450	.5	10.0	.070	.49	.02	.60	.22	5	2	0	100	0	0	60	0
68	67	63	1.0	1	450	.5	10.0	.080	.49	.02	.60	.59	7	2	0	100	0	0	60	0
69	68	54	1.5	1	379	.8	10.0	.080	.33	.01	.60	.29	7	2	0	100	0	0	65	0
70	82	42	1.9	1	311	1.0	10.0	.070	.15	.01	.60	.29	5	1	0	100	0	0	65	0
71	70	49	1.6	1	359	.8	10.0	.100	.28	.01	.60	.29	7	1	0	100	0	0	65	0
72	60	55	2.6	1	317	1.3	10.0	.080	.28	.51	.50	.05	1	2	0	100	0	0	115	0
73	74	70	1.4	1	357	.7	10.0	.080	.47	.51	.60	.05	3	3	0	100	0	0	115	0
74	75	57	1.0	1	399	.5	10.0	.080	.37	.02	.60	.59	3	2	0	100	0	0	60	0
75	88	52	1.0	1	400	.5	10.0	.080	.32	.02	.60	.59	4	2	0	100	0	0	60	0
76	77	59	1.0	1	427	.5	10.0	.100	.44	.01	.60	.29	3	3	0	100	0	0	65	0
77	78	64	1.0	1	450	.1	10.0	.080	.49	.01	.60	.29	3	3	0	100	0	0	65	0
78	91	64	1.0	1	450	.5	10.0	.080	.49	.02	.60	.59	4	2	0	100	0	0	60	0
79	91	60	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	5	2	0	100	0	0	60	0
80	79	65	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	7	2	0	100	0	0	60	0
81	80	64	1.5	1	381	.8	10.0	.070	.33	.51	.60	.05	7	2	0	100	0	0	115	0
82	81	59	1.5	1	371	.8	10.0	.070	.31	.51	.60	.05	7	1	0	100	0	0	115	0
83	82	64	1.0	1	448	.5	10.0	.080	.48	.01	.60	.29	7	2	0	100	0	0	65	0
84	85	57	1.1	1	320	.6	10.0	.130	.29	.01	.60	.22	3	3	0	100	0	0	60	0
85	74	59	1.0	1	400	.5	10.0	.080	.41	.02	.60	.59	2	3	0	100	0	0	60	0
86	87	52	1.5	1	377	.8	10.0	.200	.30	.05	.60	.59	3	2	0	100	0	0	60	0
87	88	52	1.0	1	400	.5	10.0	.200	.32	.02	.60	.59	2	2	0	100	0	0	60	0
88	100	56	1.1	1	419	.6	10.0	.080	.42	.02	.60	.59	5	3	0	100	0	0	60	0
89	77	61	1.0	1	450	.1	10.0	.100	.49	.01	.60	.29	1	3	0	100	0	0	65	0
90	102	60	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	5	2	0	100	0	0	60	0
91	90	65	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	7	2	0	100	0	0	60	0
92	104	65	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	5	2	0	100	0	0	115	0
93	81	70	1.0	1	450	.5	10.0	.050	.49	.51	.60	.05	1	2	0	100	0	0	115	0
94	93	67	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	7	2	0	100	0	0	115	0
95	82	66	1.0	1	450	.5	10.0	.080	.49	.01	.60	.29	8	2	0	100	0	0	65	0
96	97	56	1.2	3	360	.6	10.0	.200	.31	.02	.60	.59	3	2	0	100	0	0	60	0
97	98	55	3.0	3	354	1.5	10.0	.080	.33	.01	.50	.22	3	2	0	100	0	0	60	0
98	99	54	1.3	2	383	.7	10.0	.080	.32	.02	.60	.59	3	2	0	100	0	0	60	0
99	100	55	1.0	1	399	.5	10.0	.080	.32	.02	.60	.59	3	2	0	100	0	0	60	0
100	112	54	1.3	1	399	.7	10.0	.080	.40	.02	.60	.59	5	2	0	100	0	0	60	0
101	113	66	1.0	1	450	.1	10.0	.100	.49	.01	.60	.29	5	3	0	100	0	0	65	0
102	114	65	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	5	2	0	100	0	0	60	0
103	115	69	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	4	2	0	100	0	0	115	0
104	116	70	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	5	2	0	100	0	0	115	0
105	117	68	1.0	1	450	.5	10.0	.080	.49	.51	.60	.05	5	2	0	100	0	0	115	0
106	105	68	1.2	1	425	.6	10.0	.080	.45	.51	.60	.05	7	2	0	100	0	0	115	0
107	106	65	1.2	1	413	.6	10.0	.080	.43	.01	.60	.29	7	2	0	100	0	0	65	0
108	96	54	2.0	2	352	1.0	10.0	.200	.27	.02	.60	.59	1	2	0	100	0	0	60	0
109	97	47	4.8	2	298	2.4	10.0	.080	.28	.02	.50	.59	1	2	0	100	0	0	60	0
110	98	50	1.9	3	357	1.0	10.0	.080	.30	.02	.60	.59	1	2	0	100	0	0	60	0
111	99	60	1.0	1	396	.5	10.0	.080	.31	.51	.60	.05	1	2	0	100	0	0	115	0
112	124	65	1.3	1	405	.1	10.0	.070	.41	.51	.60	.05	5	2	0	100	0	0	115	0
113	112	64	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	7	2	0	100	0	0	60	0
114	113	61	1.0	1	450	.5	10.0	.070	.49	.02	.60	.59	7	2	0	100	0	0	60	0
115	127	62	1.0	1	447	.5	10.0	.070	.48	.02	.60	.59	5	2	0	100	0	0	60	0
116	115	66	1.2	1	418	.6	10.0	.070	.43	.01	.60	.22	7	2	0	100	0	0	60	0
117	116	63	1.0	1	419	.5	10.0	.070	.41	.01	.60	.22	7	2	0	100	0	0	60	0
118	117	60	1.0	1	420	.5	10.0	.070	.46	.02	.60	.59	7	2	0	100	0	0	60	0

119	106	65	1.2	1	425	.6	10.0	.080	.45	.02	.60	.59	8	2	0	100	0	0	60	0
120	108	55	2.9	2	300	1.5	10.0	.130	.25	.01	.50	.22	1	2	0	100	0	0	60	0
121	109	51	3.0	1	302	1.5	10.0	.200	.30	.02	.50	.59	1	2	0	100	0	0	60	0
122	111	57	1.1	1	394	.6	10.0	.130	.28	.01	.60	.22	2	2	0	100	0	0	60	0
123	111	59	1.0	1	400	.5	10.0	.080	.29	.51	.60	.05	1	2	0	100	0	0	115	0
124	139	58	1.1	1	430	.1	10.0	.070	.45	.02	.60	.59	5	2	0	100	0	0	60	0
125	124	63	1.0	1	450	.5	10.0	.080	.49	.02	.60	.59	7	2	0	100	0	0	60	0
126	140	62	1.0	1	448	.5	10.0	.070	.48	.02	.60	.59	6	2	0	100	0	0	60	0
127	126	59	1.0	1	411	.5	10.0	.070	.33	.01	.60	.29	7	2	0	100	0	0	65	0
128	116	57	1.5	1	351	.8	10.0	.130	.31	.01	.60	.22	1	2	0	100	0	0	60	0
129	117	59	1.0	3	400	.5	10.0	.080	.30	.01	.60	.22	1	2	0	100	0	0	60	0
130	117	56	1.0	3	400	.5	10.0	.070	.39	.02	.60	.59	8	2	0	100	0	0	60	0
131	130	60	1.0	1	412	.5	10.0	.070	.41	.01	.60	.22	7	2	0	100	0	0	60	0
132	147	54	1.0	1	409	.5	10.0	.070	.23	.02	.60	.59	5	1	0	100	0	0	60	0
133	149	57	1.4	1	376	.7	10.0	.130	.31	.01	.60	.22	5	2	0	100	0	0	60	0
134	149	51	2.4	1	293	1.2	10.0	.130	.24	.01	.50	.22	6	2	0	100	0	0	60	0
135	136	55	2.3	1	319	1.2	10.0	.080	.26	.01	.50	.22	3	2	0	100	0	0	60	0
136	153	49	4.0	1	251	2.0	10.0	.080	.31	.01	.50	.22	4	2	0	100	0	0	60	0
137	154	62	1.0	2	400	.5	10.0	.080	.28	.01	.60	.22	4	2	0	100	0	0	60	0
138	139	64	1.0	1	412	.5	10.0	.080	.33	.01	.60	.22	3	2	0	100	0	0	60	0
139	155	66	1.0	1	450	.1	10.0	.070	.49	.01	.60	.22	5	2	0	100	0	0	60	0
140	155	63	1.0	1	444	.5	10.0	.070	.47	.02	.60	.59	6	2	0	100	0	0	60	0
141	140	57	1.0	1	413	.5	10.0	.080	.37	.01	.60	.29	7	2	0	100	0	0	65	0
142	141	60	1.0	1	400	.5	10.0	.100	.36	.01	.60	.29	7	2	0	100	0	0	65	0
143	127	57	1.0	1	400	.5	10.0	.100	.31	.01	.60	.29	8	2	0	100	0	0	65	0
144	128	60	1.2	1	382	.6	10.0	.080	.29	.01	1.00	.01	8	2	0	100	0	0	80	0
145	130	54	1.0	3	400	.5	10.0	.200	.34	.02	.60	.59	1	2	0	100	0	0	60	0
146	131	61	1.0	1	410	.5	10.0	.070	.47	.01	.60	.22	1	3	0	100	0	0	60	0
147	163	62	1.0	1	449	.5	10.0	.070	.49	.01	.60	.29	5	4	0	100	0	0	65	0
148	149	61	1.0	1	400	.5	10.0	.130	.35	.01	.60	.22	3	2	0	100	0	0	60	0
149	166	54	2.1	3	353	1.1	10.0	.130	.30	.01	.50	.22	5	2	1	100	0	0	60	0
150	166	47	2.0	2	299	1.0	10.0	.130	.24	.01	.60	.22	6	2	0	100	0	0	60	0
151	135	60	1.3	2	365	.7	10.0	.080	.30	.51	.60	.05	1	2	0	100	0	0	115	0
152	170	62	3.1	1	294	1.6	10.0	.080	.31	.51	.50	.05	4	2	0	100	0	0	115	0
153	154	61	1.0	1	402	.5	10.0	.080	.29	.51	.60	.05	3	2	0	100	0	0	115	0
154	155	64	1.0	1	446	.5	10.0	.080	.47	.02	.60	.59	3	2	0	100	0	0	60	0
155	172	65	1.0	1	441	.1	10.0	.070	.46	.01	.60	.22	5	2	0	100	0	0	60	0
156	155	53	1.0	1	402	.5	10.0	.080	.32	.02	.60	.59	7	2	0	100	0	0	60	0
157	140	52	1.0	1	400	.5	10.0	.080	.32	.02	.60	.59	8	2	0	100	0	0	60	0
158	157	54	1.0	1	400	.5	10.0	.080	.30	.02	.60	.59	7	2	0	100	0	0	60	0
159	142	56	1.0	1	400	.5	10.0	.100	.30	.01	.60	.29	8	2	0	100	0	0	65	0
160	144	64	1.1	1	391	.6	10.0	.130	.28	.01	.60	.22	1	2	1	100	0	0	60	0
161	162	65	1.0	3	400	.5	10.0	.080	.37	.01	.60	.22	3	2	0	100	0	0	60	0
162	146	60	1.0	1	400	.5	10.0	.070	.35	.01	.60	.22	1	2	0	100	0	0	60	0
163	162	61	1.7	1	388	.9	10.0	.070	.41	.01	.60	.29	7	3	0	100	0	0	65	0
164	163	61	1.2	1	397	.6	10.0	.100	.10	.01	.60	.29	7	4	0	100	0	0	65	0
165	182	61	1.3	1	375	.6	10.0	.130	.36	.01	.60	.22	5	2	0	100	0	0	60	0
166	182	53	1.9	1	356	1.0	10.0	.080	.29	.01	.60	.22	6	2	1	100	0	0	60	0
167	184	55	1.7	1	338	.9	10.0	.130	.29	.01	.60	.22	5	2	0	100	0	0	60	0
168	169	51	1.9	2	315	1.0	10.0	.130	.28	.01	.60	.22	3	2	0	100	0	0	60	0
169	170	52	2.2	1	332	1.1	10.0	.080	.31	.01	.50	.22	3	2	0	100	0	0	60	0
170	171	65	1.0	1	400	.5	10.0	.080	.28	.51	.60	.05	3	2	0	100	0	0	115	0
171	188	65	1.0	1	444	.5	10.0	.080	.47	.51	.60	.05	5	2	0	100	0	0	115	0
172	189	58	1.1	1	416	.1	10.0	.070	.41	.02	.60	.59	5	2	0	100	0	0	60	0
173	172	59	1.0	1	400	.5	10.0	.080	.29	.02	.60	.59	7	2	0	100	0	0	60	0
174	156	53	1.0	1	400	.5	10.0	.080	.30	.02	.60	.59	8	2	0	100	0	0	60	0
175	157	52	1.0	1	400	.5	10.0	.080	.28	.02	.60	.59	8	2	0	100	0	0	60	0
176	175	56	1.0	1	400	.5	10.0	.080	.28	.01	.60	.22	7	2	1	100	0	0	60	0
177	176	65	1.0	1	400	.5	10.0	.130	.28	.01	.60	.22	7	2	1	100	0	0	60	0
178	179	69	1.0	3	400	.5	10.0	.080	.43	.01	.60	.22	3	3	0	100	0	0	60	0

179	162	70	1.0	1	400	.5	10.0	.080	.49	.01	.60	.22	1	3	0	100	0	0	60	0
180	179	68	1.0	1	399	.5	10.0	.080	.42	.01	.60	.22	7	3	0	100	0	0	60	0
181	164	61	1.0	1	400	.5	10.0	.100	.14	.01	.60	.29	1	3	0	100	0	0	65	0
182	201	63	1.2	1	379	.6	10.0	.080	.41	.01	.60	.22	5	3	0	100	0	0	60	0
183	182	61	1.0	1	400	.5	10.0	.080	.29	.51	.60	.05	7	2	0	100	0	0	115	0
184	203	61	1.3	1	389	.7	10.0	.200	.33	.02	.60	.59	5	2	0	100	0	0	60	0
185	205	46	2.6	2	293	1.3	10.0	.130	.30	.01	.50	.22	4	2	0	100	0	0	60	0
186	206	50	1.5	2	372	.8	10.0	.200	.38	.02	.60	.59	4	3	0	100	0	0	60	0
187	188	62	1.1	3	426	.6	10.0	.080	.42	.02	.60	.59	3	2	0	100	0	0	60	0
188	207	65	1.3	1	394	.7	10.0	.080	.44	.51	.60	.05	5	2	0	100	0	0	115	0
189	208	57	1.2	1	381	.1	10.0	.070	.33	.51	.60	.05	5	2	0	100	0	0	115	0
190	172	66	1.0	1	400	.5	10.0	.080	.30	.51	.60	.05	8	2	0	100	0	0	115	0
191	190	65	1.0	1	399	.5	10.0	.050	.29	.51	.60	.05	7	2	0	100	0	0	115	0
192	175	53	1.0	1	400	.5	10.0	.080	.28	.02	.60	.59	1	2	0	100	0	0	60	0
193	176	53	1.0	1	400	.5	10.0	.080	.28	.02	.60	.59	1	2	0	100	0	0	60	0
194	193	59	1.0	1	404	.5	10.0	.080	.30	.02	.60	.59	7	2	1	100	0	0	60	0
195	196	63	1.4	3	378	.7	10.0	.080	.43	.01	.60	.22	3	2	0	100	0	0	60	0
196	179	68	1.7	1	332	.9	10.0	.080	.49	.01	.60	.22	1	3	0	100	0	0	60	0
197	196	68	1.5	1	348	.8	10.0	.080	.42	.01	.60	.22	7	3	0	100	0	0	60	0
198	181	64	1.2	1	376	.6	10.0	.100	.17	.01	.60	.29	1	3	0	100	0	0	65	0
199	198	62	.9	1	361	.5	10.0	.100	.00	.01	.65	.29	7	4	0	100	0	0	65	0
200	201	60	1.4	1	362	.7	10.0	.130	.33	.01	.60	.22	3	2	0	100	0	0	60	0
201	220	56	1.1	1	393	.6	10.0	.080	.34	.02	.60	.59	5	2	0	100	0	0	60	0
202	220	54	1.0	1	400	.5	10.0	.080	.33	.02	.60	.59	6	2	0	100	0	0	60	0
203	222	51	1.1	1	386	.6	10.0	.200	.29	.02	.60	.59	5	2	0	100	0	0	60	0
204	223	45	1.6	3	338	.8	10.0	.200	.30	.02	.60	.59	5	2	0	100	0	0	60	0
205	206	52	1.1	3	396	.6	10.0	.200	.34	.02	.60	.59	3	2	0	100	0	0	60	0
206	207	50	1.7	1	330	.9	10.0	.080	.39	.02	.60	.59	3	2	0	100	0	0	60	0
207	227	58	1.3	1	375	.7	10.0	.080	.37	.02	.60	.59	4	2	0	100	0	0	60	0
208	227	55	1.6	1	341	.1	10.0	.070	.39	.02	.60	.59	5	2	0	100	0	0	60	0
209	208	60	1.6	1	349	.8	10.0	.080	.38	.02	.60	.59	7	2	0	100	0	0	60	0
210	192	60	1.7	1	367	.9	10.0	.080	.27	.51	.60	.05	2	2	0	100	0	0	115	0
211	192	57	1.0	1	400	.5	10.0	.080	.28	.02	.60	.59	1	2	0	100	0	0	60	0
212	193	53	1.0	1	400	.5	10.0	.080	.28	.02	.60	.59	1	2	0	100	0	0	60	0
213	194	54	1.0	1	407	.5	10.0	.080	.31	.02	.60	.59	1	2	0	100	0	0	60	0
214	195	66	1.3	1	384	.7	10.0	.080	.41	.01	.60	.22	1	2	0	100	0	0	60	0
215	196	57	1.3	1	375	.7	10.0	.130	.33	.01	.60	.22	1	2	0	100	0	0	60	0
216	197	58	1.2	1	378	.6	10.0	.080	.33	.01	.60	.22	1	2	0	100	0	0	60	0
217	198	61	1.0	1	347	.5	10.0	.100	.16	.01	.60	.29	1	3	0	100	0	0	65	0
218	217	62	.7	1	294	.4	10.0	.100	.10	.01	.65	.29	7	4	0	100	0	0	65	0
219	220	56	1.2	1	380	.6	10.0	.080	.33	.01	.60	.22	3	2	0	100	0	0	60	0
220	239	58	1.0	1	400	.5	10.0	.080	.36	.02	.60	.59	5	2	0	100	0	0	60	0
221	240	56	1.6	1	350	.8	10.0	.080	.28	.02	.60	.59	5	2	0	100	0	0	60	0
222	221	56	1.9	1	306	1.0	10.0	.130	.30	.01	.60	.22	7	2	0	100	0	0	60	0
223	224	52	2.0	1	328	1.0	10.0	.130	.33	.01	.60	.22	3	2	0	100	0	0	60	0
224	225	54	2.3	1	334	1.2	10.0	.080	.31	.02	.50	.59	3	2	0	100	0	0	60	0
225	245	58	1.6	1	342	.8	10.0	.080	.43	.02	.60	.59	4	3	0	100	0	0	60	0
226	227	61	1.2	1	382	.6	10.0	.080	.40	.02	.60	.59	3	3	0	100	0	0	60	0
227	246	63	2.0	1	300	.1	10.0	.070	.49	.02	.60	.59	5	3	0	100	0	0	60	0
228	227	58	1.7	1	326	.9	10.0	.200	.45	.02	.60	.59	7	3	0	100	0	0	60	0
229	228	56	1.0	1	396	.5	10.0	.100	.29	.01	.60	.29	7	2	0	100	0	0	65	0
230	249	67	1.2	1	376	.6	10.0	.080	.33	.51	.60	.05	5	2	0	100	0	0	115	0
231	211	61	1.0	1	400	.5	10.0	.080	.28	.51	.60	.05	8	2	0	100	0	0	115	0
232	231	53	1.0	1	400	.5	10.0	.080	.28	.02	.60	.59	7	2	0	100	0	0	60	0
233	214	57	1.0	1	400	.5	10.0	.080	.28	.01	.60	.22	1	2	0	100	0	0	60	0
234	215	58	1.0	1	400	.5	10.0	.130	.28	.01	.60	.22	1	2	0	100	0	0	60	0
235	216	58	1.0	1	400	.5	10.0	.130	.28	.01	.60	.22	1	2	0	100	0	0	60	0
236	217	58	1.0	1	400	.5	10.0	.130	.18	.01	.60	.22	1	3	0	100	0	0	60	0
237	238	58	1.0	1	400	.5	10.0	.200	.42	.02	.60	.59	3	3	0	100	0	0	60	0
238	256	57	1.1	1	393	.6	10.0	.080	.40	.01	.60	.22	5	3	0	100	0	0	60	0

239	238	54	1.0	1	400	.5	10.0	.080	.32	.02	.60	.59	7	2	0	100	0	0	60	0
240	239	57	2.0	1	326	1.0	10.0	.080	.28	.02	.60	.59	7	2	0	100	0	0	60	0
241	259	61	1.8	1	320	.9	10.0	.080	.42	.02	.60	.59	5	2	0	100	0	0	60	0
242	243	50	1.9	1	332	1.0	10.0	.080	.38	.02	.60	.59	3	2	0	100	0	0	60	0
243	261	59	1.8	1	336	.9	10.0	.080	.45	.02	.60	.59	5	3	0	100	0	0	60	0
244	245	58	1.4	1	362	.7	10.0	.080	.41	.02	.60	.59	3	3	0	100	0	0	60	0
245	263	59	1.5	1	352	.8	10.0	.080	.47	.02	.60	.59	5	3	0	100	0	0	60	0
246	263	65	1.9	1	311	1.0	10.0	.070	.47	.51	.60	.05	6	3	0	100	0	0	115	0
247	246	65	1.8	1	316	.9	10.0	.050	.46	.51	.60	.05	7	3	0	100	0	0	115	0
248	247	56	1.3	1	372	.1	10.0	.200	.34	.02	.60	.59	7	2	0	100	0	0	60	0
249	267	64	1.7	1	330	.9	10.0	.080	.43	.51	.60	.05	5	3	0	100	0	0	115	0
250	249	66	1.0	1	400	.5	10.0	.050	.28	.51	.60	.05	7	2	0	100	0	0	115	0
251	250	62	1.0	1	400	.5	10.0	.050	.28	.51	.60	.05	7	2	0	100	0	0	115	0
252	233	57	1.0	1	400	.5	10.0	.080	.28	.01	.60	.22	1	2	0	100	0	0	60	0
253	252	64	1.0	1	398	.5	10.0	.050	.29	.51	.60	.05	7	2	0	100	0	0	115	0
254	271	65	1.6	1	371	.8	10.0	.130	.27	.01	.60	.22	6	2	0	100	0	0	60	0
255	256	62	1.0	1	400	.5	10.0	.100	.49	.01	.60	.29	3	3	0	100	0	0	65	0
256	273	61	1.2	1	383	.6	10.0	.080	.44	.02	.60	.59	5	3	0	100	0	0	60	0
257	256	65	1.2	1	382	.6	10.0	.050	.32	.51	.60	.05	7	2	0	100	0	0	115	0
258	239	63	1.5	1	350	.8	10.0	.080	.43	.51	.60	.05	8	3	0	100	0	0	115	0
259	276	64	1.2	1	377	.6	10.0	.080	.48	.02	.60	.59	5	3	0	100	0	0	60	0
260	278	53	1.3	1	368	.7	10.0	.130	.35	.01	.60	.22	4	2	0	100	0	0	60	0
261	278	60	1.7	1	334	.9	10.0	.080	.44	.01	.60	.22	5	3	0	100	0	0	60	0
262	279	65	1.7	1	327	.9	10.0	.080	.41	.01	.60	.22	5	3	3	100	0	0	60	0
263	280	63	1.6	1	342	.1	10.0	.070	.45	.02	.60	.59	5	3	2	100	0	0	60	0
264	263	59	1.5	1	346	.3	10.0	.080	.37	.02	.60	.59	8	3	0	100	0	0	60	0
265	264	65	2.0	1	300	.3	10.0	.080	.49	.51	.60	.05	7	3	0	100	0	0	115	0
266	247	59	1.7	1	333	.9	10.0	.200	.47	.02	.60	.59	8	3	0	100	0	0	60	0
267	283	66	1.4	1	385	.7	10.0	.080	.48	.51	.60	.05	6	3	0	100	0	0	115	0
268	249	68	1.0	1	430	.5	10.0	.050	.41	.51	.60	.05	8	2	0	100	0	0	115	0
269	268	63	1.0	1	400	.5	10.0	.080	.28	.51	.60	.05	7	2	0	100	0	0	115	0
270	252	64	1.0	1	400	.5	10.0	.080	.37	.01	.60	.22	1	2	0	100	0	0	60	0
271	270	65	1.5	1	375	.8	10.0	.130	.32	.01	.60	.22	7	2	0	100	0	0	60	0
272	273	62	1.0	1	400	.5	10.0	.100	.49	.01	.60	.29	3	3	0	100	0	0	65	0
273	274	57	1.2	1	378	.6	10.0	.080	.32	.01	.60	.29	3	2	0	100	0	0	65	0
274	290	58	1.5	1	350	.8	10.0	.080	.38	.02	.60	.59	5	3	0	100	0	0	60	0
275	291	65	1.4	1	355	.7	10.0	.050	.48	.51	.60	.05	5	3	0	100	0	0	115	0
276	292	63	1.6	1	368	.8	10.0	.080	.46	.51	.60	.05	5	3	0	100	0	0	115	0
277	294	48	3.6	1	289	1.8	10.0	.130	.32	.01	.50	.22	4	2	0	100	0	0	60	0
278	294	50	1.9	1	312	1.0	10.0	.080	.40	.02	.60	.59	5	2	0	100	0	0	60	0
279	278	59	3.2	1	303	1.6	10.0	.080	.30	.01	.50	.22	7	2	3	100	0	0	60	0
280	296	58	1.1	1	394	.1	10.0	.070	.23	.01	.60	.22	5	2	2	100	0	0	60	0
281	264	55	1.0	1	398	.5	10.0	.130	.21	.01	.60	.22	1	2	0	100	0	0	60	0
282	265	69	1.4	1	363	.3	10.0	.080	.46	.51	.60	.05	1	3	0	100	0	0	115	0
283	282	68	1.3	1	367	.7	10.0	.080	.49	.51	.60	.05	7	3	0	100	0	0	115	0
284	283	66	2.3	3	343	1.2	10.0	.080	.36	.01	.50	.22	7	2	0	100	0	0	60	0
285	267	61	4.6	1	331	2.3	10.0	.080	.37	.51	.50	.05	8	2	0	100	0	0	115	0
286	285	65	1.0	1	409	.5	10.0	.050	.32	.51	.60	.05	7	2	0	100	0	0	115	0
287	270	59	1.0	1	400	.5	10.0	.130	.31	.01	.60	.22	1	2	0	100	0	0	60	0
288	271	64	1.0	1	400	.5	10.0	.130	.28	.01	.60	.22	8	2	0	100	0	0	60	0
289	290	64	1.0	1	402	.5	10.0	.080	.42	.01	.60	.29	3	3	0	100	0	0	65	0
290	291	68	1.1	1	391	.6	10.0	.130	.42	.01	.60	.22	3	3	0	100	0	0	60	0
291	292	66	1.3	1	365	.7	10.0	.050	.49	.51	.60	.05	3	3	0	100	0	0	115	0
292	305	57	2.1	1	337	1.1	10.0	.080	.44	.02	.50	.59	5	3	0	100	0	0	60	0
293	307	53	3.0	1	294	1.5	10.0	.130	.34	.01	.50	.22	4	2	0	100	0	0	60	0
294	307	58	3.3	1	258	.4	10.0	.070	.41	.01	.50	.22	5	3	0	100	0	0	60	0
295	294	60	2.8	1	312	.1	10.0	.070	.33	.01	.50	.22	7	2	0	100	0	0	60	0
296	295	57	1.2	1	391	.1	10.0	.070	.27	.01	.60	.22	7	2	0	100	0	0	60	0
297	280	60	1.1	1	389	.6	10.0	.130	.30	.01	.60	.22	8	2	0	100	0	0	60	0
298	282	69	1.3	1	366	.3	10.0	.080	.47	.51	.60	.05	1	3	0	100	0	0	115	0

299	298	65	1.5	1	345	.8	10.0	.080	.49	.02	.60	.59	7	3	0	100	0	0	60	0
300	284	56	1.3	2	388	.7	10.0	.080	.24	.01	.60	.29	1	2	0	100	0	0	65	0
301	285	42	9.8	1	180	4.9	10.0	.100	.23	.01	.50	.29	1	2	0	100	0	0	65	0
302	286	54	1.5	1	376	.8	10.0	.100	.23	.01	.60	.29	1	2	0	100	0	0	65	0
303	304	67	1.0	1	400	.5	10.0	.080	.32	.51	.60	.05	3	2	0	100	0	0	115	0
304	305	70	1.4	1	362	.7	10.0	.080	.49	.01	.60	.22	3	3	0	100	0	0	60	0
305	317	66	2.1	1	318	1.1	10.0	.080	.46	.01	.50	.22	5	3	0	100	0	0	60	0
306	318	59	4.0	1	265	.4	10.0	.070	.37	.01	.50	.22	5	2	0	100	0	0	60	0
307	306	57	4.6	1	244	.4	10.0	.070	.38	.01	.50	.22	7	2	0	100	0	0	60	0
308	295	63	3.2	1	301	1.6	10.0	.080	.33	.01	.50	.22	1	2	0	100	0	0	60	0
309	296	57	1.9	1	351	1.0	10.0	.080	.35	.01	.60	.22	1	2	0	100	0	0	60	0
310	297	59	1.0	1	400	.5	10.0	.130	.36	.01	.60	.22	1	3	0	100	0	0	60	0
311	298	63	1.2	1	387	.7	10.0	.080	.45	.02	.60	.59	1	3	0	100	0	0	60	0
312	299	63	1.7	1	330	.7	10.0	.200	.43	.02	.60	.59	1	3	0	100	0	0	60	0
313	300	48	3.0	2	299	1.5	10.0	.100	.26	.01	.50	.29	1	2	0	100	0	0	65	0
314	301	48	5.7	1	286	2.9	10.0	.100	.22	.01	.50	.29	1	2	0	100	0	0	65	0
315	302	46	3.2	1	289	1.6	10.0	.100	.24	.01	.50	.29	1	2	0	100	0	0	65	0
316	317	68	1.5	1	350	.8	10.0	.080	.49	.51	.60	.05	3	3	0	100	0	0	115	0
317	318	68	2.1	1	318	1.1	10.0	.080	.48	.51	.50	.05	3	3	0	100	0	0	115	0
318	327	49	7.3	1	218	.4	10.0	.070	.27	.01	.50	.22	5	2	0	100	0	0	60	0
319	318	58	2.1	1	303	1.1	10.0	.080	.46	.02	.50	.59	7	3	0	100	0	0	60	0
320	307	61	1.5	1	360	.8	10.0	.080	.38	.02	.60	.59	8	3	0	100	0	0	60	0
321	309	48	4.2	1	267	2.1	10.0	.130	.28	.01	.50	.22	1	2	0	100	0	0	60	0
322	311	51	2.6	1	341	1.3	10.0	.130	.27	.01	.50	.22	2	2	0	100	0	0	60	0
323	311	57	2.9	1	305	.7	10.0	.080	.32	.01	.50	.22	1	2	0	100	0	0	60	0
324	311	63	1.0	1	398	.7	10.0	.080	.26	.01	.60	.22	8	2	0	100	0	0	60	0
325	313	51	2.1	3	344	1.1	10.0	.130	.22	.01	.50	.22	1	2	0	100	0	0	60	0
326	314	49	2.6	3	327	1.3	10.0	.130	.23	.01	.50	.22	1	2	0	100	0	0	60	0
327	344	49	6.0	1	223	.4	10.0	.070	.34	.02	.50	.59	5	2	0	100	0	0	60	0
328	321	46	2.6	1	318	1.3	10.0	.200	.30	.02	.50	.59	1	2	0	100	0	0	60	0
329	322	48	1.8	1	332	.9	10.0	.200	.30	.02	.60	.59	1	2	0	100	0	0	60	0
330	323	60	2.7	1	316	.7	10.0	.080	.30	.01	.50	.22	1	2	0	100	0	0	60	0
331	324	53	2.5	3	327	1.3	10.0	.080	.25	.01	.50	.22	1	2	0	100	0	0	60	0
332	325	46	6.2	3	214	3.1	10.0	.200	.29	.02	.50	.59	1	2	0	100	0	0	60	0
333	328	52	2.3	1	335	1.2	10.0	.200	.29	.02	.50	.59	1	2	0	100	0	0	60	0
334	329	59	1.1	1	386	.6	10.0	.130	.28	.01	.60	.22	1	2	0	100	0	0	60	0
335	330	61	1.3	1	373	.7	10.0	.080	.30	.01	.60	.22	8	2	0	100	0	0	60	0
336	335	44	4.3	3	246	2.2	10.0	.130	.28	.01	.50	.22	7	2	0	100	0	0	60	0
337	336	44	5.5	2	235	2.8	10.0	.200	.27	.02	.50	.59	7	2	0	100	0	0	60	0
338	334	53	1.4	1	379	.7	10.0	.100	.22	.01	.60	.29	1	2	0	100	0	0	65	0
339	334	56	1.0	1	400	.5	10.0	.100	.27	.01	.60	.29	8	2	0	100	0	0	65	0
340	339	48	4.8	2	273	2.4	10.0	.200	.22	.02	.50	.59	7	2	0	100	0	0	60	0
341	338	45	3.6	1	268	1.8	10.0	.100	.25	.01	.50	.29	1	2	0	100	0	0	65	0
342	339	56	1.1	1	395	.6	10.0	.100	.28	.01	.60	.29	1	2	0	100	0	0	65	0
343	342	48	2.6	2	339	1.3	10.0	.100	.22	.01	.50	.29	7	2	0	100	0	0	65	0