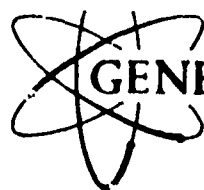


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2



GENERALIZED COMPUTER PROGRAM

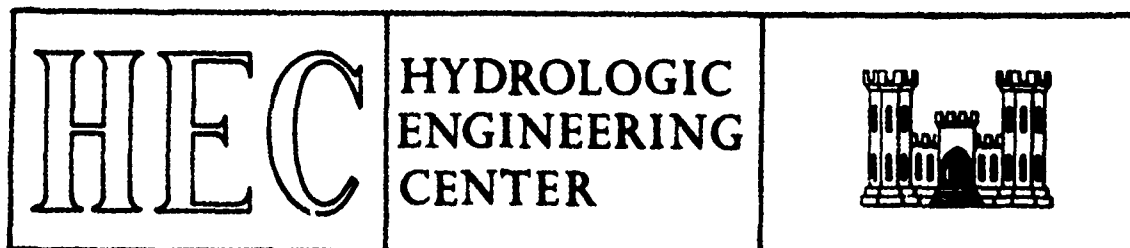
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**STREAMFLOW ROUTING OPTIMIZATION
(OPROUT)**

USERS MANUAL

JANUARY 1982

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Water Resources Support Center

U.S. Army Corps of Engineers

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STREAMFLOW ROUTING OPTIMIZATION
(OPROUT)

January 1982

The Hydrologic Engineering Center
U.S. Army Corps of Engineers
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STREAMFLOW ROUTING OPTIMIZATION
(OPROUT)

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STREAMFLOW ROUTING OPTIMIZATION (OPROUT)

USERS MANUAL

The Hydrologic Engineering Center

INTRODUCTION

1. ORIGIN OF PROGRAM

The computer program "Streamflow Routing Optimization" (OPROUT) was developed at the Hydrologic Engineering Center (HEC) by Vernon R. Bonner. The program consists of optimization routines developed originally by Dr. Anthony Slocum and Ramesh Danekar of Anderson-Nichols & Company, Inc., as a portion of HEC contract, "Evaluation of Streamflow Routing Techniques with Special Emphasis on Determining Nonlinear Routing Criteria," October 1975, (Contract No. DACW05-75-C-0027). These routines were linked with routing and plotting routines from the computer program HEC-5, "Simulation of Flood Control and Conservation Systems," into one program, OPROUT, which this manual describes.

2. PURPOSE OF PROGRAM

This program can be used to determine Modified Puls or Muskingum routing criteria by optimizing parameters for a single reach using observed upstream and downstream hydrographs for one to five events. The main advantage to the program is that the user can develop routing criteria from several events by making one computer program execution.

DESCRIPTION

3. TECHNICAL APPROACH

a. Modified Puls Routing Method. In this routing method, outflow is a unique function of storage. The following relationships apply:

$$\frac{\Delta S}{\Delta t} = I - O \quad (1)$$

where

I = average inflow in the reach during time interval Δt

O = average outflow from the reach during time interval Δt

ΔS = change in storage during time interval Δt

$$O = \frac{O_1 + O_2}{2} \quad (2)$$

where O_1 and O_2 = reach outflow at start and end of time interval, respectively

$$\Delta S = \frac{S_2 - S_1}{2} \quad (3)$$

where S_1 and S_2 = reach storage at start and end of time interval, respectively

substituting (2) and (3) in (1) and rearranging,

$$\frac{S_2}{\Delta t} + \frac{O_2}{2} = \frac{S_1}{\Delta t} - \frac{O_1}{2} + I \quad (4)$$

Let $SI = S + \frac{O}{2}$ = storage indication and $\Delta t = 1$ then,

$$SI_2 = SI_1 + I - O_1 \quad (5)$$

equation (5) can be solved using a storage indication-outflow (SI vs O) relationship and knowing reach inflow.

As can be seen from the described relationships, modified Puls routing requires a storage-outflow relationship for the downstream end of the routing reach. The relation indicates the amount of flow occurring at the downstream end of the reach for a given amount of water stored in the reach between the upstream and downstream ends.

Starting with the given information, an observed hydrograph at the upstream end of the reach and an observed hydrograph at the downstream end of the reach, the problem is associated with defining the proper storage-outflow relationship. The proper relationship when used with modified Puls routing will generate a routed hydrograph (observed upstream hydrograph routed to the downstream end) which is the same as would occur in the real river reach. If there were zero local flows, the routed hydrograph would be equal to the observed downstream hydrograph. In reality there will be local flow entering the reach during at least part of the time period of the observed hydrographs. If this local flow was gaged (all local flow coming from a gaged tributary), the local flow could be subtracted from the downstream observed hydrograph. The result would provide the upstream routed hydrograph. Unfortunately, in the majority of cases, the local flow is ungaged and not known. In this situation, the observed upstream hydrograph can be routed to the downstream end and subtracted from the observed downstream hydrograph to generate the local flow hydrograph. If the routed hydrograph is reasonable, no negative local flows will be generated by this procedure (i.e., for all time periods, the routed hydrograph is always less than or equal to the downstream observed hydrograph). This fact is used to form the objective function for the optimization routine. It is stated:

Objective Function - Minimize the Sum of Negative Local Flow in a given routing reach by proper definition of the storage-outflow relationship and number of routing subreaches using Modified Puls with upstream and downstream observed hydrographs.

One form for the storage-outflow relationship is as follows:

$$S = KO^M \quad (6)$$

where

S = total storage in the routing reach

O = reach outflow

K, M = are constants which cause the function to represent the storage-outflow relationship of the river reach under study

With this function a gradient search approach can be used to achieve the stated objective function. Computationally, a beginning K and M are selected from the observed hydrograph information ($M = 1$ and K equal travel time of peak flow). The number of subreaches is set to one. A modified Puls routing is performed based upon the selected $S = KO^M$ function. The routed hydrograph is subtracted from the observed downstream hydrograph which determines the sum of the negative local flow. Either K or M is changed following a gradient search procedure and a new sum negative local flow is computed which can be compared to the last value. This procedure is continued until the objective function can no longer be improved. The number of routing subreaches is incremented by one and the gradient search procedure is continued. The result provides the optimum K, M and number of subreaches for the given routing reach with the given observed hydrograph. The selected exponent usually is in the

following range:

$$0.6 < M < 0.8$$

and the number of subreaches usually equals 2.

A curve warping routine was written to overcome the computational difficulty and the inflexibility of using only $S = KO^M$ to represent storage-outflow. This routine is very simple and surprisingly effective.

The optimization routine still begins with a macro gradient search $S = KO^M$ to obtain a beginning storage-outflow function which is reasonable. Then the curve warping routine is called. The computed storage-outflow relationship is divided into 17 piece-wise linear segments (this is also used in other HEC programs using modified Puls). This forms a table of storage versus outflow for equally spaced flow segments starting at zero and ending at the peak flow of the observed downstream hydrograph. The number of segments can be input by the user up to a maximum of 18 segments.

The curve warping routine works in the following manner. One cycle consists of testing each point in the storage-outflow table beginning with the lowest point above zero. The flow is held constant and the storage is stepped up, down or not changed depending if the objective function is improved. Storage is never stepped greater than the value for the next higher point in the table or less than the next lower point in the table to keep the function single valued. If an improvement was made during the last cycle, a new cycle is performed. This is continued until no more improvement can be obtained. The step size is reduced and the process is repeated. When no more improvement can be made, the number of subreaches is incremented by one and the curve warp routine is recalled. The final result provides the optimum number of subreaches and the storage-outflow function. The several additional degrees of freedom in this function enable a solution which works well for all magnitudes of flood events within those used to derive the storage-outflow relationship.

The program also employs an optional curve fit routine for smoothing the developed storage-outflow function after the curve warping routine. The program also incorporates several other components of the objective function described previously to improve the reasonableness of the local flow hydrograph and to force the routed hydrograph toward the recession side of the given, observed downstream hydrograph. The total routing objective function is defined as follows;

$$\text{MINIMIZE SUMNL} = \text{SUM} (\text{SUM1} + \text{SUM2} + \text{SUM3}) \quad (7)$$

where the three components are defined as,

- 1) For all time periods,

$$\text{SUM1} = \text{SUM} (\text{negative local flows}) * \text{WT1}$$

- 2) For the recession limb of the routed hydrograph defined as from 85% of the routed hydrograph peak discharge to 15% of the observed downstream hydrograph peak discharge, and where the routed flow is less than 95% of the observed downstream flow (indicating how early this portion of the routed hydrograph is),

$$\text{SUM2} = \text{SUM} (\text{routed hydrograph minus observed downstream hydrograph}) * \text{WT2}$$

- and 3) For all time periods following the peak discharge of the routed hydrograph (indicating how late this portion of the routed hydrograph is),

$$\text{SUM3} = \text{SUM} (\text{negative local flows}) * \text{WT3}$$

Weighting of the individual components of the objective function (WT1, WT2 and WT3) can be input by the user on the RT card as described in Exhibit 2, Input Description. One or both of the second (SUM2) and the third (SUM3) can be eliminated by default values of zero for WT2 and/or WT3 thereby changing the basis of the objective function. The program output lists the value (error)

of each of the three components and the total (SUM1, SUM2, SUM3 and SUMNL) for each iteration as NEG LOCAL, TOO EARLY, TOO LATE and TOTAL, respectively.

b. Muskingum Routing Method. In this method, outflow from a routing reach is a linear function of the sum of prism and wedge storage in the reach. The basic routing equation is:

$$O_n = C_1 I_n + C_2 I_{n-1} + C_3 I_{n-2} \dots \dots \quad (8)$$

where:

O_n = Ordinate of outflow hydrograph at time n

I_n, I_{n-1} , etc. = Ordinates of inflow hydrograph at times n, n-1, etc.

C_1, C_2 , etc. = Routing coefficients, as coefficients of inflow

Equations used to determine the coefficients C_1, C_2 , etc., are as follows:

$$C_1 = (\Delta t - 2XK) / (2K(1-X) + \Delta t) \quad (9)$$

$$CC = ((2K(1-X) + \Delta t) - 2\Delta t) / (2K(1-X) + \Delta t) \quad (10)$$

$$C_2 = C_1 \cdot CC + (\Delta t + 2KX) / (2K(1-X) + \Delta t) \quad (11)$$

$$C_i = C_{i-1} \cdot CC \text{ for } i > 2 \quad (12)$$

where

Δt = Routing time increment

K = Muskingum routing parameter having units of time

X = Muskingum dimensionless routing parameter between 0 and .5

The program has the capability of optimizing Muskingum routing coefficients using the same techniques and search procedures as described for the modified Puls method. The M in equation (6) is equal to 1 for the linear Muskingum method and the same objective function is used to optimize Muskingum routing constants and K and X.

From the above relationships it can be seen that the following relationship between K for each subreach and Δt must be true to avoid negative coefficients.

$$\frac{1}{2(1-X)} \leq \frac{K}{\Delta t} \leq \frac{1}{2X}$$

If a Muskingum routing optimization produces negative coefficients, the user should increase the number of subreaches, thereby reducing K, so that the above limits are met. The method for defining the number of subreaches (RT.3, 3rd field of the RT Card) is described under paragraph 4, Program Capabilities and illustrated in Exhibit 1.

4. PROGRAM CAPABILITIES

The program will provide solutions to the following problems:

a. Determine Muskingum K and X and the number of routing subreaches for a single reach with up to five sets of given upstream and downstream observed hydrographs. Each hydrograph set is given equal weight in the optimization objective function.

b. Determine Modified Puls storage-outflow relationship and number of routing subreaches for a given reach with up to five multiple sets of given upstream and downstream observed hydrographs.

c. Determine routing criteria for a given number of subreaches in either cases a or b above.

d. Determine the storage-outflow curve, as in case b above, with a given coefficient X (Working R&D routing) or an additional lag of the routed hydrograph.

Under any of the above options, a complete trace feature is available to monitor the progress of the optimization computations. This feature is written in the same manner as exists in HEC-5; therefore, a source listing is required to interpret results.

The program can be used to solve the more difficult problem when two or more upstream gages and routing reaches flow to a common downstream gage. This currently cannot be solved automatically by the program; however, the user can develop routing criteria for this situation by multiple executions of the current program. In most cases, one upstream gage will have the dominant flow. The optimization routine can be operated using the dominant upstream gage as the observed upstream hydrograph and the given observed downstream hydrograph. The resulting local flow hydrograph which is computed by the Optimization Routine can be used as the observed downstream hydrograph in conjunction with the next largest upstream gage flow which becomes the observed upstream hydrograph.

This process is repeated until routing criteria is defined for all routing reaches. In most cases, some user smoothing of the local flow hydrographs will be required (while maintaining consistent volume) and a second iteration will be required beginning with the dominant upstream gage. The problem is difficult to solve due to the many additional degrees of freedom. For each additional routing reach, two basic unknowns are added, routing criteria and local flow; whereas, only one known is added, upstream observed hydrograph.

During the performance of the optimization routine, a printer plot can be requested (5th field of J1 card) which will plot the upstream observed hydrograph (values entered on IN cards), downstream observed hydrograph (values entered on IN cards), routed hydrograph (upstream hydrograph routed to downstream location using routing criteria derived by optimization routine) and the computed local flow hydrograph (difference between routed hydrograph and downstream observed hydrograph). This provides a visual check on the results developed by the optimization subroutine.

In addition, upon completion, the optimization routine prints the values for the adopted storage-outflow relationship (table of storage versus flow) and the optimum number of subreaches. The travel time indicator (inverse slope of storage-outflow relationship) is also printed for each incremental linear segment of the storage-outflow table and for the given point to the origin. The upstream hydrograph is printed as read in addition to the routed hydrograph. Incremental local flows are printed twice for each control point. The first is the computed values without adjustment and the second is the adjusted values with all computed negative values set to zero. The negative volume is proportioned to the remaining positive values. Program capabilities are illustrated in Exhibit 1 - Example Input and Output. A detailed description of the program input is presented in Exhibit 2.

EXHIBIT 1

EXAMPLE INPUT AND OUTPUT

EXHIBIT 1

EXAMPLE INPUT AND OUTPUT

Streamflow Routing Optimization (OPROUT)

The input and output for three examples are provided to illustrate the use of selected program capabilities and options and to assist in verifying the correct execution of the program. A brief description of each example is provided below. Printer plots are requested for each of the examples.

a. Example 1 - To determine modified Puls storage-outflow relationship and the number of routing subreaches for a single reach and from a single flood event.

b. Example 2 - To determine modified Puls storage-outflow relationship and the number of routing subreaches using three flood events. (J1.7)

c. Example 3 - To determine Muskingum K and X for one flood event and a user specified number of routing subreaches. (RT.3)

EXAMPLE 1 INPUT

T1EXAMPLE 1 MODIFIED PULS ROUTING OPTIMIZATION

T2 SCIOTO RIVER CHILLICOTHE TO HIGBY OHIO

T3 SINGLE EVENT - JANUARY 1959

J1 100 3 0 0 1 0 0 0 1 1

ID CHILLICOTHE TO HIGBY - JAN 1959

RT 2 3 .5 0 0 0 6 3 3 0

IN 2 JAN59

QO 3160 3093 3025 2940 3020 3207 3800 4660 5650 7203

QO 8395 9653 11400 13300 15200 17075 18600 20150 21700 23575

QO 25800 31250 42800 64650 99900 126000 140000 143000 138000 130500

QO120500 110500 103000 94300 85500 76950 69000 63100 57200 52350

QO 47500 43950 40400 37300 34200 31750 29300 27550 25800 24450

QO 23100 22000 20900 19950 19000 18300 17600 17150 16700 16500

QO 16300 16225 16150 16075 16000 15900 15800 15650 15500 15300

QO 15100 14800 14500 14125 13750 13375 13000 12725 12450 12175

QO 11900 11600 11300 11000 10750 10500 10250 10000 9750 9500

QO 9250 9000 8750 8500 8250 8000 7750 7500 7250 7000

IN 3 JAN59

QO 4580 4449 4317 4277 4420 5850 7635 9595 11800 14500

QO 17750 21450 25200 28125 31550 35000 37900 39580 41450 42975

QO 44700 47050 49400 53300 59400 74850 97350 121000 143000 156500

QO160000 157000 149000 138000 127000 115000 103000 93200 83400 76850

QO 70300 64950 59600 55550 51500 47750 44000 40750 37500 34950

QO 32400 29850 27300 26000 24700 23400 22100 21300 20500 20000

QO 19500 19200 19025 18912 18800 18300 18300 18300 18300 18300

QO 18300 18300 18300 15700 15700 15700 15700 15700 15700 15700

QO 15700 13100 13100 13100 13100 13100 13100 13100 13100 11200

QO 11200 11200 11200 11200 11200 11200 11200 8600 8600 8600

EXAMPLE 1 OUTPUT

ROUTING OPTIMIZATION INPUT DATA

T1EXAMPLE 1 MODIFIED PULS ROUTING OPTIMIZATION
T2 SCIOTO RIVER CHILLICOTHE TO HIGBY OHIO
T3 SINGLE EVENT - JANUARY 1959

J1	NEER	IPER	INPUT	IPRNT	IPLOT	IPUNCH	NFLOOD	NPTSQ	ICURV	IFLOW
	100	3	0	0	1	0	0	0	1	1
ID CHILLICOTHE TO HIGBY - JAN 1959										
RT	RTRF	RTTO	RTMD	RTCOF	XMUSK	LAG	WT1	WT2	WT3	METRIC
IN	2.00	3.00	.50	0.	0.	0.	6.00	3.00	3.00	0.
2 JAN59										
3160.00	3093.00	3025.00	2940.00	3020.00	3207.00	3800.00	4660.00	5650.00	7203.00	
8395.00	9653.00	11400.00	13300.00	15200.00	17075.00	18600.00	20150.00	21700.00	23575.00	
25800.00	31250.00	42800.00	64650.00	99900.00	126000.00	140000.00	143000.00	138000.00	130500.00	
120500.00	110300.00	103000.00	94300.00	85500.00	76950.00	69000.00	63100.00	57200.00	52350.00	
47500.00	43950.00	40400.00	37300.00	34200.00	31750.00	29300.00	27550.00	25800.00	24450.00	
23100.00	22000.00	20900.00	19950.00	19000.00	18300.00	17600.00	17150.00	16700.00	16500.00	
16300.00	16225.00	16150.00	16075.00	16000.00	15900.00	15800.00	15650.00	15500.00	15300.00	
15100.00	14800.00	14500.00	14125.00	13750.00	13375.00	13000.00	12725.00	12450.00	12175.00	
11900.00	11600.00	11300.00	11000.00	10750.00	10500.00	10250.00	10000.00	9750.00	9500.00	
9250.00	9000.00	8750.00	8500.00	8250.00	8000.00	7750.00	7500.00	7250.00	7000.00	
3 JAN59										
4580.00	4449.00	4317.00	4277.00	4420.00	5850.00	7635.00	9595.00	11800.00	14500.00	
17750.00	21450.00	25200.00	28125.00	31550.00	35000.00	37900.00	39580.00	41450.00	42975.00	
44700.00	47050.00	49400.00	53300.00	59400.00	74850.00	97350.00	121000.00	143000.00	156500.00	
160000.00	157000.00	149000.00	138000.00	127000.00	115000.00	103000.00	93200.00	83400.00	76850.00	
70300.00	64950.00	59600.00	55550.00	51500.00	47750.00	44000.00	40750.00	37500.00	34950.00	
32400.00	29850.00	27300.00	26000.00	24700.00	23400.00	22100.00	21300.00	20500.00	20000.00	
19500.00	19200.00	19025.00	18912.00	18800.00	18300.00	18300.00	18300.00	18300.00	18300.00	
18300.00	18300.00	18300.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	
15700.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	11200.00	
11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	8600.00	8600.00	8600.00	

OPTIMIZATION ROUTINE OUTPUT

NEG LOCAL	COMPUTED ERRORS:			TOTAL
	TOO EARLY	TOO LATE		
0.	-33895.69	0.	-33895.69	
0.	-14838.74	0.	-14838.74	
-595.37	0.	-297.69	-893.06	
-68706.87	0.	-34353.43	-103060.30	
-47353.07	0.	-23676.54	-71029.61	
0.	-14405.10	0.	-14405.10	
-68706.87	0.	-34353.43	-103060.30	
0.	-14838.74	0.	-14838.74	
-595.37	0.	-297.69	-893.06	
-4572.76	0.	-2286.38	-6859.13	
-80937.04	0.	-40468.52	-121405.55	
0.	-4046.71	0.	-4046.71	
-7062.22	0.	-3531.11	-10593.33	
0.	-39056.15	0.	-39056.15	
-4572.76	0.	-2286.38	-6859.13	
0.	-44886.79	0.	-44886.79	
-7062.22	0.	-3531.11	-10593.33	
0.	-39056.15	0.	-39056.15	
-1716.79	0.	-858.39	-2575.18	
-3102.68	0.	-1551.34	-4654.02	
-10544.82	0.	-5272.41	-15817.23	
-31181.53	0.	-15590.76	-46772.29	
-20631.11	-14354.03	-10315.55	-45300.68	
-23523.81	0.	-11761.90	-35285.71	
-46611.07	-19877.03	-23305.53	-89793.63	
0.	-1437.73	0.	-1437.73	
-844.79	0.	-422.40	-1267.19	
-304.40	-78335.42	-152.20	-78792.02	
-813.74	0.	-406.87	-1220.61	
-378.71	0.	-189.35	-568.06	
-1417.03	0.	-708.51	-2125.54	
-1019.76	0.	-509.88	-1529.64	
-774.39	-401.72	-387.20	-1563.31	
-7.44	0.	-3.72	-11.16	
-1794.99	0.	-897.49	-2692.48	
0.	0.	0.	0.	
0.	0.	0.	0.	
0.	0.	0.	0.	
0.	0.	0.	0.	

STORAGE-OUTFLOW FUNCTION, UNSMOOTHED

SUM OF COMPUTED ERRORS = 0.

ADOPTED STORAGE-OUTFLOW TABLE TRAVEL TIME INDICATOR(K-STORAGE/DISCHARGE*0.08264)

DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	17584.07	10.6	10.6
40000.00	35659.07	10.9	10.8
60000.00	55609.26	12.1	11.2
80000.00	72313.71	10.1	10.9
100000.00	90796.45	11.2	11.0
120000.00	112771.07	13.3	11.4
140000.00	131972.49	11.6	11.4
160000.00	151229.04	11.7	11.4

STORAGE-OUTFLOW FUNCTION, SMOOTHED

COMPUTED ERRORS:

NEG LOCAL	TOO EARLY	TOO LATE	TOTAL
0.	0.	0.	0.

SMOOTHED BY 4TH ORDER POLYNOMIAL AS FOLLOWS:

$$S = -.2355E+03 Q^{**0} \\ .9422E+00 Q^{**1} \\ -.1643E-05 Q^{**2} \\ .2123E-10 Q^{**3} \\ -.6723E-16 Q^{**4}$$

ADOPTED STORAGE-OUTFLOW TABLE TRAVEL TIME INDICATOR(K-STORAGE/DISCHARGE*0.08264)

DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	18109.60	11.0	11.0
40000.00	36008.59	10.8	10.9
60000.00	54093.49	10.9	10.9
80000.00	72738.12	11.3	11.0
100000.00	92058.15	11.7	11.1
120000.00	111911.10	12.0	11.3
140000.00	131896.37	12.1	11.4
160000.00	151355.19	11.8	11.4

OPTIMUM NUMBER OF SUBREACHES= 1

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

SUM= 2989206.

ROUTED Q FROM MX= 2 TO 3
RTMD= 1.30 RTCOF= 0. K= 0.

COEF= .01568 .08104 .18079 .23416 .20469 .13678 .07689 .03800 .01666 .00651
.00231 .00075

M=	3	3160.	3152.	3130.	3094.	3067.	3078.	3180.
		3433.	3848.	4469.	5271.	6175.	7223.	8458.
		9853.	11366.	12925.	14478.	16031.	17622.	19324.
		21556.	25320.	32232.	44369.	60882.	77811.	92366.
		103236.	110122.	113537.	113973.	112369.	109323.	105010.
		99722.	93638.	87363.	81173.	75013.	69124.	63631.
		58556.	53805.	49451.	45478.	41872.	38617.	35711.
		33135.	30858.	28836.	27039.	25430.	23981.	22683.
		21532.	20520.	19649.	18915.	18309.	17816.	17424.
		17108.	16850.	16633.	16445.	16271.	16104.	15934.
		15757.	15563.	15343.	15095.	14816.	14514.	14195.
		13874.	13564.	13263.	12968.	12674.	12379.	12083.
		11792.	11511.	11238.	10970.	10706.	10446.	10188.
		9932.	9677.	9424.	9171.	8919.	8668.	8417.
		8166.	7915.					

SUM= 2972298.

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UPSTREAM(MX) = 2 DOWNSTREAM(MY) = 3
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Exhibit 1
Example 1
6 of 10

CHILLICOTHE TO HIGBY - JAN 1959

	0.	20000.	40000.	60000.	80000.	100000.	120000.	140000.	160000.	180000.	200000.	220000.
1.	.LR	.	.	.	.	.	.	.	.	.	.	.
2.	.LR	.	.	.	.	.	.	.	.	.	.	.
3.	.LR	.	.	.	.	.	.	.	.	.	.	.
4.	.LR	.	.	.	.	.	.	.	.	.	.	.
5.	.LR	.	.	.	.	.	.	.	.	.	.	.
6.	.LRN	.	.	.	.	.	.	.	.	.	.	.
7.	R N	.	.	.	.	.	.	.	.	.	.	.
8.	RL N	.	.	.	.	.	.	.	.	.	.	.
9.	RIL N	.	.	.	.	.	.	.	.	.	.	.
10.	R IL N	.	.	.	.	.	.	.	.	.	.	.
11.	RI L N.	.	.	.	.	.	.	.	.	.	.	.
12.	R I L .N	.	.	.	.	.	.	.	.	.	.	.
13.	R I L .N	.	.	.	.	.	.	.	.	.	.	.
14.	R I L .N	.	.	.	.	.	.	.	.	.	.	.
15.	R I .L N	.	.	.	.	.	.	.	.	.	.	.
16.	R I .L N.	.	.	.	.	.	.	.	.	.	.	.
17.	R I .L N.	.	.	.	.	.	.	.	.	.	.	.
18.	R I L N	.	.	.	.	.	.	.	.	.	.	.
19.	R .I L .N	.	.	.	.	.	.	.	.	.	.	.
20.	R .IL .N	.	.	.	.	.	.	.	.	.	.	.
21.	R L .N	.	.	.	.	.	.	.	.	.	.	.
22.	.R L I .N	.	.	.	.	.	.	.	.	.	.	.
23.	.LR R .I N	.	.	.	.	.	.	.	.	.	.	.
24.	.L R R .I	.	.	.	I	.	.	.	.	.	.	.
25.	L .R N	.	.	R	N	.	.	.	.	.	.	.
26.	L .R	.	.	.	R	N	.	I	.	.	.	.
27.	L .L	.	.	.	.	N.	.	I	I	.	.	.
28.	.	.	L	.	R	.	N	.	I	.	.	.
29.	.	.	.	.	.	.	.	.	I.N	.	.	.
30.	.	.	L	.	.	.	.	I	.	N	.	.
31.	.	.	.	L	.	.	R	I	.	N	.	.
32.	.	.	.	.	.	.	I.R	.	.	N.	.	.
33.	.	.	L	.	.	.	I R	.	N	.	.	.
34.	.	.	L	.	.	I	R	.	N.	.	.	.
35.	.	.L	.	.	I	.	R	N	.	.	.	.
36.	.	L	.	.	I	R	N	.	.	.	.	.
37.	.	L	.	.	I	R	N	.	.	.	.	.
38.	.	L	.	.	I	R	N	.	.	.	.	.

[illegible]

Exhibit 1
Example 1
8 of 10

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87.	.L	IRN
88.	.L	R N N
89.	.L	R N N
90.	L	RN
91.	.L	RN
92.	.L	RN
93.	.L	IRN
94.	.L	IRN
95.	.L	IRN
96.	.L	R N N
97.	.L	R N N
98.	L	R
99.	L	R
100.	L	R

INC LOCAL FLOWS COMPUTED

COMPUTED LOCAL FLOW

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

SUM= 2989206. --SUM= 0. --MAX= 0.

COMPUTED LOCAL FLOW

M=	3	1420.	1297.	1187.	1183.	1353.	2772.	4455.
		6162.	7952.	10031.	12479.	15275.	17977.	19667.
		21697.	23634.	24975.	25102.	25419.	25353.	25376.
		25494.	24080.	21068.	15031.	13968.	19539.	28634.
		39764.	46378.	46463.	43027.	36631.	28677.	21990.
		15278.	9362.	5837.	2227.	1837.	1176.	1319.
		1044.	1745.	2049.	2272.	2128.	2133.	1789.
		1815.	1542.	1014.	261.	570.	719.	717.
		568.	780.	851.	1085.	1191.	1384.	1601.
		1804.	1950.	1667.	1855.	2029.	2196.	2366.
		2543.	2737.	2957.	605.	884.	1186.	1505.
		1826.	2136.	2437.	2732.	426.	721.	1017.
		1308.	1589.	1862.	2130.	2394.	754.	1012.
		1268.	1523.	1776.	2029.	2281.	2532.	183.
		434.	685.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	3	1420.	1297.	1187.	1183.	1353.	2772.	4455.
		6162.	7952.	10031.	12479.	15275.	17977.	19667.
		21697.	23634.	24975.	25102.	25419.	25353.	25376.
		25494.	24080.	21068.	15031.	13968.	19539.	28634.
		39764.	46378.	46463.	43027.	36631.	28677.	21990.
		15278.	9362.	5837.	2227.	1837.	1176.	1319.
		1044.	1745.	2049.	2272.	2128.	2133.	1789.
		1815.	1542.	1014.	261.	570.	719.	717.
		568.	780.	851.	1085.	1191.	1384.	1601.
		1804.	1950.	1667.	1855.	2029.	2196.	2366.
		2543.	2737.	2957.	605.	884.	1186.	1505.
		1826.	2136.	2437.	2732.	426.	721.	1017.
		1308.	1589.	1862.	2130.	2394.	754.	1012.
		1268.	1523.	1776.	2029.	2281.	2532.	183.
		434.	685.					
SUM=	811142.	-SUM=	0.	-MAX=	0.			

EXAMPLE 2 INPUT

T1EXAMPLE 2 MODIFIED PULS ROUTING OPTIMIZATION
T2 SCIOTO RIVER CHILLICOTHE TO HIGBY OHIO
T3 THREE EVENTS - MAR 1964, FEB 1959, JAN 1959

J1	100	3	0	0	1	0	3	0	1	1
ID	CHILLICOTHE TO HIGBY - 3 EVENTS									
RT	2	3	.5	0	0	0	6	3	3	0
IN	2	MAR64								
QO	333	330	400	500	500	550	750	1250	2250	4000
QO	6500	9000	11500	13000	14000	14500	15000	15500	15750	16000
QO	16500	16750	17000	17000	17000	17000	17000	16800	17000	17000
QO	17000	17000	16700	16250	15500	15000	14000	13250	12000	11200
QO	10500	10200	10500	11700	14200	17000	19500	21500	23700	26500
QO	30000	34000	40000	45500	50000	53000	55200	58300	61500	65000
QO	68500	70750	71600	71500	70600	69000	66000	62500	59000	55500
QO	51750	48000	45200	42000	39500	37000	33750	30750	28500	26000
QO	22600	22100	23000	22500	21500	20750	20000	19500	19000	18750
QO	18500	18000	17500	17000	16500	16250	16000	16000	16000	16000
IN	3	MAR64								
QO	628	633	637	993	1350	3787	6225	8663	11100	15350
QO	19600	22450	25300	27600	29900	31150	32400	31700	31000	30300
QO	29600	28900	28200	27500	26800	26300	25800	25300	24800	24275
QO	23750	23225	22700	21850	21000	20150	19300	18375	17450	16252
QO	15600	15650	15700	22000	28300	35250	42200	47450	52700	59100
QO	65500	72350	79200	91600	104000	115000	126000	125000	125000	124500
QO	124000	121000	118000	115000	112000	109500	107000	102850	98700	93375
QO	88050	82725	77400	72575	67750	62925	58100	54575	51050	47525
QO	44000	41775	39550	37325	35100	34200	33300	32400	31500	31000
QO	30500	30000	29500	28625	27750	26875	26000	25425	24850	24275
IN	2	FEB59								
QO	3310	3310	3310	3310	3310	3310	3310	3310	3310	3360
QO	3480	4580	5680	7670	9660	11630	13600	14600	15600	16750
QO	17900	19675	21450	23225	25000	28400	31800	35200	38600	40700
QO	42800	43100	42600	40575	38550	36525	34500	32300	30100	28350
QO	26600	25350	24100	23200	22300	22125	21950	21775	21600	21500
QO	21400	21300	21200	21175	21150	21125	21100	21300	21500	21700
QO	21900	22000	22100	22000	21900	21650	21400	20850	20300	19600
QO	18900	18200	17500	17013	16525	16037	15550	15063	14575	14087
QO	13600	13275	12950	12625	12300	11850	11400	10620	9840	8860
QO	7880	7215	6550	6283	6015	5747	5500	5300	5100	4900
IN	3	FEB59								
QO	5210	5210	5210	5210	5210	5210	5210	5210	5210	5480
QO	5890	6300	8050	13175	17300	20700	24100	25450	26800	26600
QO	26400	26200	26000	27000	28000	29700	31400	33850	36300	38150
QO	40000	41850	43700	43850	44000	43400	42800	41500	40200	38450
QO	36700	34900	33100	31650	30200	29550	28900	30100	31300	32200
QO	33100	32250	31400	30550	29700	28850	28000	27650	27300	27250
QO	27200	27150	27100	26950	26800	25000	25000	25000	25000	25000
QO	25000	25000	25000	23937	22875	21813	20750	19687	18625	17563
QO	16500	15875	15250	14625	14000	13375	12750	12125	11500	11063
QO	10625	10187	9750	9313	8875	8437	8000	7600	7200	6800

Exhibit 1
Example 2
2 of 25

IN	2	JAN59								
QO	3160	3093	3025	2940	3020	3207	3800	4660	5650	7203
QO	8395	9653	11400	13300	15200	17075	18600	20150	21700	23575
QO	25800	31250	42800	64650	99900	126000	140000	143000	138000	130500
QO	120500	110500	103000	94300	85500	76950	69000	63100	57200	52350
QO	47500	43950	40400	37300	34200	31750	29300	27550	25800	24450
QO	23100	22000	20900	19950	19000	18300	17600	17150	16700	16500
QO	16300	16225	16150	16075	16000	15900	15800	15650	15500	15300
QO	15100	14800	14500	14125	13750	13375	13000	12725	12450	12175
QO	11900	11600	11300	11000	10750	10500	10250	10000	9750	9500
QO	9250	9000	8750	8500	8250	8000	7750	7500	7250	7000
IN	3	JAN59								
QO	4580	4449	4317	4277	4420	5850	7635	9595	11800	14500
QO	17750	21450	25200	28125	31550	35000	37900	39580	41450	42975
QO	44700	47050	49400	53300	59400	74850	97350	121000	143000	156500
QO	160000	157000	149000	138000	127000	115000	103000	93200	83400	76850
QO	70300	64950	59600	55550	51500	47750	44000	40750	37500	34950
QO	32400	29850	27300	26000	24700	23400	22100	21300	20500	20000
QO	19500	19200	19025	18912	18800	18300	18300	18300	18300	18300
QO	18300	18300	18300	15700	15700	15700	15700	15700	15700	15700
QO	15700	13100	13100	13100	13100	13100	13100	13100	13100	11200
QO	11200	11200	11200	11200	11200	11200	11200	8600	8600	8600

EXAMPLE 2 OUTPUT

ROUTING OPTIMIZATION INPUT DATA

TXEXAMPLE 2 MODIFIED PULS ROUTING OPTIMIZATION
T2 SCIOTO RIVER CHILLICOTHE TO HIGBY OHIO
T3 THREE EVENTS - MAR 1964, FEB 1959, JAN 1959

J1 NPER 100 IPER 3 INPUT 0 IPRNT 0 IPLOT 1 IPUNCH 0 NFLOOD 3 NPTSQ 0 ICURV 1 IFLOW 1

ID CHILLICOTHE TO HIGBY - 3 EVENTS

RT 2.00 RTFR 2.00 RTTO 3.00 RTMD .50 RTCOF 0.00 W' 6.00 WT2 3.00 WT3 3.00 METRIC 0.00

IN 2 MAR64

333.00 330.00 400.00 500.00 550.00 750.00 1250.00 2250.00 4000.00
6500.00 9000.00 11500.00 13000.00 14000.00 14500.00 15000.00 15500.00 15750.00 16000.00
16500.00 16750.00 17000.00 17000.00 17000.00 17000.00 17000.00 16800.00 17000.00 17000.00
17000.00 17000.00 16700.00 16250.00 15500.00 15000.00 14000.00 13250.00 12000.00 11200.00
10500.00 10200.00 10500.00 11700.00 14200.00 17000.00 19500.00 21500.00 23700.00 26500.00
30000.00 34000.00 40000.00 45500.00 50000.00 53000.00 55200.00 58300.00 61500.00 65000.00
68500.00 70750.00 71600.00 71500.00 70600.00 69000.00 62500.00 59000.00 55500.00
51750.00 48000.00 45200.00 42000.00 39500.00 37000.00 33750.00 30750.00 28500.00 26000.00
22600.00 22100.00 23000.00 22500.00 21500.00 20750.00 20000.00 19500.00 19000.00 18750.00
18500.00 18000.00 17500.00 17000.00 16500.00 16250.00 16000.00 16000.00 16000.00 16000.00

IN 3 MAR64

628.00 633.00 637.00 993.00 1350.00 3787.00 8663.00 11100.00 15350.00
19600.00 22450.00 25300.00 27600.00 29900.00 31150.00 32400.00 31700.00 31000.00 30300.00
29600.00 28900.00 28200.00 27500.00 25800.00 26300.00 25800.00 25300.00 24800.00 24275.00
23750.00 23225.00 22700.00 21850.00 21000.00 20150.00 19300.00 18375.00 17450.00 16252.00
15600.00 15650.00 15700.00 22000.00 28300.00 35250.00 42200.00 47450.00 52700.00 59100.00
65500.00 72350.00 79200.00 91600.00 104000.00 115000.00 126000.00 125000.00 125000.00 124500.00
124000.00 121000.00 118000.00 115000.00 112000.00 109500.00 107000.00 102850.00 98700.00 93375.00
88050.00 82725.00 77400.00 72575.00 67750.00 62925.00 58100.00 54575.00 51050.00 47525.00
44000.00 41775.00 39550.00 37325.00 35100.00 34200.00 33300.00 32400.00 31500.00 31000.00
30500.00 30000.00 29500.00 28625.00 27750.00 26875.00 26000.00 25425.00 24850.00 24275.00

IN 2 FEB59

3310.00 3310.00 3310.00 3310.00 3310.00 3310.00 3310.00 3310.00 3310.00 3360.00
3480.00 4580.00 5680.00 7670.00 9660.00 11630.00 13600.00 14600.00 15600.00 16750.00
17900.00 19675.00 21450.00 23225.00 25000.00 28400.00 31800.00 35200.00 38600.00 40700.00
42800.00 43100.00 42600.00 40575.00 38550.00 36525.00 34500.00 32300.00 30100.00 28350.00
26600.00 25350.00 24100.00 23200.00 22300.00 22125.00 21950.00 21775.00 21600.00 21500.00
21400.00 21300.00 21200.00 21175.00 21150.00 21125.00 21100.00 21300.00 21500.00 21700.00
21900.00 22000.00 22100.00 22000.00 21900.00 21650.00 21400.00 20850.00 20300.00 19600.00
18900.00 18200.00 17500.00 17013.00 16525.00 16037.00 15550.00 15063.00 14575.00 14087.00
13600.00 13275.00 12950.00 12625.00 12300.00 11850.00 11400.00 10620.00 9840.00 8860.00
7880.00 7215.00 6550.00 6283.00 6015.00 5747.00 5500.00 5300.00 5100.00 4900.00

Exhibit 1
Example 2
4 of 25

IN 3 FEB59											
5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5210.00	5480.00
5890.00	6300.00	8050.00	13175.00	17300.00	20700.00	29700.00	24100.00	25450.00	26800.00	26600.00	26600.00
26400.00	26200.00	26000.00	27000.00	28000.00	29700.00	29700.00	31400.00	33850.00	36300.00	36300.00	38150.00
40000.00	41850.00	43700.00	43850.00	44000.00	43400.00	43400.00	42800.00	41500.00	40200.00	40200.00	38450.00
36700.00	34900.00	33100.00	31650.00	30200.00	29550.00	29550.00	28900.00	30100.00	31300.00	31300.00	32200.00
33100.00	32250.00	31400.00	30550.00	29700.00	28850.00	28850.00	28000.00	27650.00	27300.00	27300.00	27250.00
27200.00	27150.00	27100.00	26950.00	26800.00	25000.00	25000.00	25000.00	25000.00	25000.00	25000.00	25000.00
25000.00	25000.00	25000.00	23937.00	22875.00	21813.00	21813.00	20750.00	19687.00	18625.00	18625.00	17563.00
16500.00	15875.00	15250.00	14625.00	14000.00	13375.00	13375.00	12750.00	12125.00	11500.00	11500.00	11063.00
10625.00	10187.00	9750.00	9313.00	8875.00	8437.00	8437.00	8000.00	7600.00	7200.00	7200.00	6800.00
IN 2 JAN59											
3160.00	3093.00	3025.00	2940.00	3020.00	3207.00	3207.00	3800.00	4660.00	5650.00	5650.00	7203.00
8395.00	9653.00	11400.00	13300.00	15200.00	17075.00	17075.00	18600.00	20150.00	21700.00	21700.00	23575.00
25800.00	31250.00	42800.00	64650.00	99900.00	136000.00	136000.00	140000.00	143000.00	138000.00	138000.00	130500.00
120500.00	10500.00	103000.00	94300.00	85500.00	76950.00	76950.00	69000.00	63100.00	57200.00	57200.00	52350.00
47500.00	43950.00	40400.00	37300.00	34200.00	31750.00	31750.00	29300.00	27550.00	25800.00	25800.00	24450.00
23100.00	22000.00	20900.00	19950.00	19000.00	18300.00	18300.00	17600.00	17150.00	16700.00	16700.00	16500.00
16300.00	16225.00	16150.00	16075.00	16000.00	15900.00	15900.00	15800.00	15650.00	15500.00	15500.00	15300.00
13100.00	14800.00	14500.00	14125.00	13750.00	13375.00	13375.00	13000.00	12725.00	12450.00	12450.00	12175.00
11900.00	11600.00	11300.00	11000.00	10750.00	10500.00	10500.00	10250.00	10000.00	9750.00	9750.00	9500.00
9250.00	9000.00	8750.00	8500.00	8250.00	8000.00	8000.00	7750.00	7500.00	7250.00	7250.00	7000.00
IN 3 JAN59											
4580.00	4449.00	4317.00	4277.00	4420.00	5850.00	5850.00	7635.00	9595.00	11800.00	11800.00	14500.00
17750.00	21450.00	25200.00	28125.00	31550.00	35000.00	35000.00	37900.00	39580.00	41450.00	41450.00	42975.00
44700.00	47050.00	49400.00	53300.00	59400.00	74850.00	74850.00	97350.00	121000.00	143000.00	143000.00	156500.00
160000.00	157000.00	149000.00	138000.00	127000.00	115000.00	115000.00	103000.00	93200.00	83400.00	83400.00	76850.00
70300.00	64950.00	59600.00	55550.00	51500.00	47750.00	47750.00	44000.00	40750.00	37500.00	37500.00	34950.00
32400.00	29850.00	27300.00	26000.00	24700.00	23400.00	23400.00	22100.00	21300.00	20500.00	20500.00	20000.00
19500.00	19200.00	19025.00	18912.00	18800.00	18300.00	18300.00	18300.00	18300.00	18300.00	18300.00	18300.00
18300.00	18300.00	18300.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00
15700.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	11200.00
11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	8600.00	8600.00	8600.00	8600.00

OPTIMIZATION ROUTINE OUTPUT

NEG LOCAL	COMPUTED ERRORS:			TOTAL
	TOO EARLY	TOO LATE		
-849365.76	-2581486.47	-68628.41	-3499480.64	
-819234.68	-2560121.77	-67789.14	-3447145.59	
-785458.14	-2535955.15	-66665.14	-3388078.43	
-747741.89	-2508603.79	-65160.20	-3321505.87	
-705765.27	-2393761.49	-63159.94	-3162686.70	
-664018.08	-2359242.63	0.	-3023260.72	
-616885.35	-2346971.39	0.	-2963856.74	
-565217.43	-2317523.56	0.	-2882740.99	
-508312.16	-2200841.55	0.	-2709153.70	
-445702.86	-2139503.66	0.	-2585206.52	
-377791.89	-2083016.71	0.	-2460808.60	
-306797.41	-2012914.76	0.	-2319712.16	
-233715.53	-1804532.21	0.	-2038247.74	
-158094.69	-1720292.54	0.	-1878387.23	
-89628.87	-1654002.78	0.	-1743631.65	
-43081.67	-1506250.57	0.	-1549332.24	
-7489.41	-1395902.47	0.	-1403391.88	
0.	-1183336.68	0.	-1183336.68	
0.	-1090235.01	0.	-1090235.01	
0.	-990696.19	0.	-990696.19	
0.	-859390.85	0.	-859390.85	
-21646.69	-807705.07	-10823.34	-840175.10	
-165576.24	-713573.95	-82788.12	-961938.32	
-1361447.82	-299571.38	-680723.91	-2341743.12	
-165576.24	-713573.95	-82788.12	-961938.32	
0.	-859390.85	0.	-859390.85	
-21646.69	-807705.07	-10823.34	-840175.10	
-106354.09	-795282.12	-53177.05	-954813.26	
-1804058.03	-303778.83	-902029.02	-3009865.88	
-265306.06	-705002.08	-132653.03	-1102961.17	
-11272.05	-875774.75	-5636.03	-892682.83	
0.	-970422.21	0.	-970422.21	
-1439137.27	-354030.03	-719568.63	-2512735.93	
-106354.09	-795282.12	-53177.05	-954813.26	
0.	-970422.21	0.	-970422.21	
-21797.45	-804259.29	-10898.73	-836955.48	
-4656.47	-755483.82	-2328.24	-762468.53	
-18689.12	-704936.14	-9344.56	-732969.82	
-92123.34	-704936.14	-46061.67	-843121.15	
-5769.89	-719040.88	-2884.94	-727695.72	
-6457.65	-711320.12	-3228.82	-721006.60	
-15443.06	-763747.29	-7721.53	-786911.88	

-42351.17	-718193.01	-21175.59	-781719.77
-62941.55	-675589.33	-31470.78	-770001.66
-29704.89	-766115.68	-14852.45	-810673.02
-32988.86	-722275.17	-16494.43	-771758.47
-3499.33	-756551.31	-1749.67	-761800.31
-40772.56	-704936.14	-20386.28	-766094.98
-4833.06	-729980.56	-2416.53	-737230.14
-8378.95	-729129.11	-4189.47	-741697.53
-11274.88	-711987.76	-5637.44	-728900.08
-17504.97	-715245.47	-8752.49	-741502.93
-7683.38	-727885.32	-3841.69	-739410.38
-12515.39	-717419.30	-6257.69	-736192.38
-5163.13	-748233.11	-2581.56	-755977.81
-8411.34	-704936.14	-4205.67	-717553.16
-8688.69	-724755.31	-4344.34	-737788.34
-10249.36	-703814.24	-5124.68	-719188.28
-11456.35	-720193.71	-5728.17	-737378.23
-8755.88	-710257.95	-4377.94	-723391.76
-12135.24	-704049.89	-6067.62	-722252.75
-6781.60	-705836.91	-3390.80	-716009.31
-7499.38	-705836.91	-3749.69	-717085.99
-6469.06	-705836.91	-3234.53	-715540.50
-153732.84	-718542.37	-76866.42	-949141.63
-154771.06	-718584.02	-77385.53	-950740.61
-181114.45	-701108.55	-90557.23	-972780.23
-161801.65	-664337.35	-80900.82	-907039.82
-217651.59	-771655.81	-108825.79	-1098133.20
-183321.33	-678850.20	-91660.66	-953832.19
-204414.20	-768187.37	-102207.10	-1074808.67
-340020.23	-718542.37	-170010.11	-1228572.71
-76594.71	-721828.48	-38297.35	-836720.54
-153308.16	-717867.30	-76654.08	-947829.54
-156096.26	-719919.43	-78048.13	-954063.82
-135436.39	-702364.76	-67718.19	-905519.34
-173056.85	-734623.49	-86528.42	-994208.76
-150598.35	-714275.36	-75299.17	-940172.88
-159598.66	-757470.92	-79799.33	-996868.92
-209567.90	-718542.37	-104783.95	-1032894.22
-99465.11	-718542.37	-49732.55	-867740.03
-153275.20	-718241.59	-76637.60	-948154.38
-154164.21	-718943.19	-77082.11	-950189.51
-147248.77	-713218.62	-73624.38	-934091.77
-160090.85	-723855.61	-80045.42	-963991.89
-152794.70	-717159.46	-76397.35	-946351.50
-153996.88	-719892.56	-76998.44	-950887.88
-171246.45	-718542.37	-85623.23	-975412.05
-136730.16	-718542.37	-68365.08	-923637.60
-6469.06	-705836.91	-3234.53	-715540.50

STORAGE-OUTFLOW FUNCTION, UNSMOOTHED

SUM OF COMPUTED ERRORS = -715540.5

ADOPTED STORAGE-OUTFLOW TABLE		TRAVEL TIME INDICATOR(K-STORAGE/DISCHARGE*0.08264)	
DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	14548.87	8.8	8.8
40000.00	33657.01	11.6	10.2
60000.00	54972.57	12.9	11.1
80000.00	77082.73	13.4	11.7
100000.00	85120.27	4.9	10.3
120000.00	129715.68	27.0	13.1
140000.00	156314.08	16.1	13.5
160000.00	183725.04	16.6	13.9

STORAGE-OUTFLOW FUNCTION, SMOOTHED

COMPUTED ERRORS:

NEG LOCAL	TOO EARLY	TOO LATE	TOTAL
-68477.12	-832049.77	-34238.56	-934765.45

SMOOTHED BY 4TH ORDER POLYNOMIAL AS FOLLOWS:

S = -.1265E+04 Q**0
.1061E+01 Q**1
-.8053E-05 Q**2
.1023E-09 Q**3
-.3000E-15 Q**4

ADOPTED STORAGE-OUTFLOW TABLE		TRAVEL TIME INDICATOR(K-STORAGE/DISCHARGE*0.08264)	
DISCHARGE CFS	STORAGE ACRE-FEET	INCREMENTAL K HOURS	TOTAL K HOURS
0.	0.		
20000.00	17512.36	10.6	10.6
40000.00	34085.11	10.0	10.3
60000.00	51634.78	10.6	10.4
80000.00	72190.99	12.4	10.9
100000.00	96631.31	14.8	11.7
120000.00	124681.23	17.0	12.6
140000.00	154914.17	18.3	13.4
160000.00	184751.47	18.1	14.0

OPTIMUM NUMBER OF SUBREACHES= 1

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

M=	2	333.	330.	400.	500.	500.	550.	750.
		1250.	2250.	4000.	6500.	9000.	11500.	13000.
		14000.	14500.	15000.	15500.	15750.	16000.	16500.
		16750.	17000.	17000.	17000.	17000.	17000.	16800.
		17000.	17000.	17000.	17000.	16700.	16250.	15500.
		15000.	14000.	13250.	12000.	11200.	10500.	10200.
		10500.	11700.	14200.	17000.	19500.	21500.	23700.
		26500.	30000.	34000.	40000.	45500.	50000.	53000.
		55200.	58300.	61500.	65000.	68500.	70750.	71600.
		71500.	70600.	69000.	66000.	62500.	59000.	55500.
		51750.	48000.	45200.	42000.	39500.	37000.	33750.
		30750.	28500.	26000.	22600.	22100.	23000.	22500.
		21500.	20750.	20000.	19500.	19000.	18750.	18500.
		18000.	17500.	17000.	16500.	16250.	16000.	16000.

SUM= 2541213.

ROUTED Q FROM MX= 2 TO 3
RTMD= 1.30 RTCOF= 0. K= 0.

COEF= .01709 .08728 .19134 .24157 .20394 .13048 .06995 .03292 .01374 .00510

M=	3	333.	333.	341.	368.	401.	431.	486.
		613.	895.	1448.	2391.	3720.	5340.	7054.
		8653.	10041.	11209.	12211.	13058.	13757.	14375.
		14933.	15415.	15808.	16104.	16326.	16493.	16594.
		16670.	16752.	16813.	16860.	16857.	16762.	16542.
		16222.	15795.	15257.	14604.	13859.	13112.	12427.
		11912.	11711.	12018.	12906.	14232.	15787.	17477.
		19367.	21648.	24342.	27637.	31570.	35781.	39872.
		43401.	46706.	49972.	53260.	56600.	59824.	62291.
		64284.	65740.	66614.	66805.	66255.	65070.	63387.
		61285.	58653.	55669.	52681.	49727.	46886.	44036.
		41118.	38184.	35338.	32465.	29833.	27937.	26587.
		25393.	24282.	23265.	22350.	21543.	20849.	20270.
		19756.	19259.	18760.	18262.	17794.	17380.	17038.
		16780.	16587.					

SUM= 2484104.

PLOTTED POINTS (BY PRIORITY) - R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX
UPSTREAM(MX) = 2 DOWNSTREAM(MY) = 3

CHILLICOTHE TO HIGBY - 3 EVENTS

DISCHARGE	0.	20000.	40000.	60000.	80000.	100000.	120000.	140000.	160000.	180000.	200000.	
1.	R	.	.	.	.	.	.	.	.	.	.	.
2.	R	.	.	.	.	.	.	.	.	.	.	.
3.	R	.	.	.	.	.	.	.	.	.	.	.
4.	R	.	.	.	.	.	.	.	.	.	.	.
5.	RN	.	.	.	.	.	.	.	.	.	.	.
6.	RN	.	.	.	.	.	.	.	.	.	.	.
7.	RN	.	.	.	.	.	.	.	.	.	.	.
8.	RI	N	.	.	.	.	.	.	.	.	.	.
9.	RI	LN	.	.	.	.	.	.	.	.	.	.
10.	RI	LN	.	.	.	.	.	.	.	.	.	.
11.	RI	LN	.	.	.	.	.	.	.	.	.	.
12.	RI	LN	.	.	.	.	.	.	.	.	.	.
13.	RI	LN	.	.	.	.	.	.	.	.	.	.
14.	RI	LN	.	.	.	.	.	.	.	.	.	.
15.	RI	LN	.	.	.	.	.	.	.	.	.	.
16.	RI	LN	.	.	.	.	.	.	.	.	.	.
17.	RI	LN	.	.	.	.	.	.	.	.	.	.
18.	RI	LN	.	.	.	.	.	.	.	.	.	.
19.	RI	LN	.	.	.	.	.	.	.	.	.	.
20.	RI	LN	.	.	.	.	.	.	.	.	.	.
21.	RI	LN	.	.	.	.	.	.	.	.	.	.
22.	RI	LN	.	.	.	.	.	.	.	.	.	.
23.	RI	LN	.	.	.	.	.	.	.	.	.	.
24.	RI	LN	.	.	.	.	.	.	.	.	.	.
25.	RI	LN	.	.	.	.	.	.	.	.	.	.
26.	RI	LN	.	.	.	.	.	.	.	.	.	.
27.	RI	LN	.	.	.	.	.	.	.	.	.	.
28.	RI	LN	.	.	.	.	.	.	.	.	.	.
29.	RI	LN	.	.	.	.	.	.	.	.	.	.
30.	RI	LN	.	.	.	.	.	.	.	.	.	.
31.	RI	LN	.	.	.	.	.	.	.	.	.	.
32.	RI	LN	.	.	.	.	.	.	.	.	.	.
33.	RI	LN	.	.	.	.	.	.	.	.	.	.
34.	RI	LN	.	.	.	.	.	.	.	.	.	.
35.	RI	LN	.	.	.	.	.	.	.	.	.	.
36.	RI	LN	.	.	.	.	.	.	.	.	.	.
37.	RI	LN	.	.	.	.	.	.	.	.	.	.
38.	RI	LN	.	.	.	.	.	.	.	.	.	.

Exhibit 1
Example 2
10 of 25

39. .L IR N.
40. .L IRN .
41. .L I RN .
42. .L IRN .
43. .L IRN .
44. .L LR .N
45. .L RIL .N
46. .L R I.L N
47. .L R I L N
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88.	.	L	IR	N	N
89.	.	L	IR	N	N
90.	.	L	IR	N	N
91.	.	L	IR	N	N
92.	.	L	IR	N	N
93.	.	L	IR	N	N
94.	.	L	R.	N	N
95.	.	L	IR.	N	N
96.	.	L	IR.	N	N
97.	.	L	IR.	N	N
98.	.	L	IR.	N	N
99.	.	L	R.	N	N
100.	.	L	R.	N	N

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

N= 2

3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.
3310.	3310.	3360.	3480.	4580.	5680.	5680.	5680.	5680.	5680.
9660.	11630.	13600.	14600.	15600.	16750.	16750.	16750.	16750.	16750.
19675.	21450.	23225.	25000.	28400.	31800.	31800.	31800.	31800.	31800.
38600.	40700.	42800.	43100.	42600.	40575.	38550.	38550.	38550.	38550.
36525.	34500.	32300.	30100.	28350.	26600.	25350.	25350.	25350.	25350.
24100.	23200.	22300.	22125.	21950.	21775.	21600.	21600.	21600.	21600.
21500.	21400.	21300.	21200.	21175.	21150.	21125.	21125.	21125.	21125.
21100.	21300.	21500.	21700.	21900.	22000.	22100.	22100.	22100.	22100.
22000.	21900.	21650.	21400.	20850.	20300.	19600.	19600.	19600.	19600.
18900.	18200.	17500.	17013.	16525.	16037.	15550.	15550.	15550.	15550.
15063.	14575.	14087.	13600.	13275.	12950.	12625.	12625.	12625.	12625.
12300.	11850.	11400.	10620.	9840.	8860.	7880.	7880.	7880.	7880.
7215.	6550.	6283.	6015.	5747.	5500.	5300.	5300.	5300.	5300.
5100.	4900.								

SUM= 1786160.

ROUTED Q FROM MX= 2 TO 3
RTMD= 1.30 RTCOF= 0. K= 0.

COEF= .01709 .08728 .19134 .24157 .20394 .13048 .06995 .03292 .01374 .00510
.00172 .00053

N= 3

3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.
3310.	3310.	3316.	3342.	3513.	3914.	3914.	3914.	3914.	3914.
5607.	6857.	8285.	9727.	11060.	12329.	13568.	13568.	13568.	13568.
14863.	16276.	17780.	19351.	21231.	23540.	26132.	26132.	26132.	26132.
28935.	31723.	34333.	36576.	38209.	39088.	39212.	39212.	39212.	39212.
38776.	37927.	36748.	35304.	33722.	32096.	30503.	30503.	30503.	30503.
28999.	27607.	26343.	25268.	24427.	23760.	23220.	23220.	23220.	23220.
22786.	22438.	22155.	21919.	21729.	21581.	21466.	21466.	21466.	21466.
21374.	21329.	21347.	21413.	21514.	21627.	21737.	21737.	21737.	21737.
21819.	21853.	21833.	21753.	21589.	21325.	20967.	20967.	20967.	20967.
20520.	20008.	19472.	18922.	18388.	17866.	17352.	17352.	17352.	17352.
16844.	16342.	15843.	15347.	14874.	14437.	14028.	14028.	14028.	14028.
13639.	13251.	12848.	12392.	11856.	11234.	10524.	10524.	10524.	10524.
9786.	9066.	8408.	7848.	7360.	6929.	6550.	6550.	6550.	6550.
6215.	5914.								

SUM= 1777471.

PLOTTED POINTS (BY PRIORITY) -R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX

UPSTREAM(MX) = 2 DOWNSTREAM(MY) = 3

CHILLICOTHE TO HIGBY - 3 EVENTS

DISCHARGE	-5000.	0.	5000.	10000.	15000.	20000.	25000.	30000.	35000.	40000.	45000.
1.	.	.	L R N	.	.	.	.	.	.	.	.
2.	.	.	L R N	.	.	.	.	.	.	.	.
3.	.	.	L R N	.	.	.	.	.	.	.	.
4.	.	.	L R N	.	.	.	.	.	.	.	.
5.	.	.	L R N	.	.	.	.	.	.	.	.
6.	.	.	L R N	.	.	.	.	.	.	.	.
7.	.	.	L R N	.	.	.	.	.	.	.	.
8.	.	.	L R N	.	.	.	.	.	.	.	.
9.	.	.	L R N	.	.	.	.	.	.	.	.
10.	.	.	L R N	.	.	.	.	.	.	.	.
11.	.	.	L R N	.	.	.	.	.	.	.	.
12.	.	.	L R N	.	.	.	.	.	.	.	.
13.	.	.	L R N	.	.	.	.	.	.	.	.
14.	.	.	L R N	.	.	.	.	.	.	.	.
15.	.	.	L R N	.	.	.	.	.	.	.	.
16.	.	.	L R N	.	.	.	.	.	.	.	.
17.	.	.	L R N	.	.	.	.	.	.	.	.
18.	.	.	L R N	.	.	.	.	.	.	.	.
19.	.	.	L R N	.	.	.	.	.	.	.	.
20.	.	.	L R N	.	.	.	.	.	.	.	.
21.	.	.	L R N	.	.	.	.	.	.	.	.
22.	.	.	L R N	.	.	.	.	.	.	.	.
23.	.	.	L R N	.	.	.	.	.	.	.	.
24.	.	.	L R N	.	.	.	.	.	.	.	.
25.	.	.	L R N	.	.	.	.	.	.	.	.
26.	.	.	L R N	.	.	.	.	.	.	.	.
27.	.	.	L R N	.	.	.	.	.	.	.	.
28.	.	.	L R N	.	.	.	.	.	.	.	.
29.	.	.	L R N	.	.	.	.	.	.	.	.
30.	.	.	L R N	.	.	.	.	.	.	.	.
31.	.	.	L R N	.	.	.	.	.	.	.	.
32.	.	.	L R N	.	.	.	.	.	.	.	.
33.	.	.	L R N	.	.	.	.	.	.	.	.
34.	.	.	L R N	.	.	.	.	.	.	.	.
35.	.	.	L R N	.	.	.	.	.	.	.	.
36.	.	.	L R N	.	.	.	.	.	.	.	.
37.	.	.	L R N	.	.	.	.	.	.	.	.
38.	.	.	L R N	.	.	.	.	.	.	.	.

Exhibit 1
Example 2
13 of 25

[illegible]

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

2
M=

3160.	3093.	3025.	2940.	3020.	3207.	3800.
4660.	5650.	7203.	8395.	9653.	11400.	13300.
15200.	17075.	18600.	20150.	21700.	23575.	25800.
31250.	42800.	64650.	99900.	126000.	140000.	143000.
113800.	130500.	120500.	110500.	103000.	94300.	85500.
76950.	69000.	63100.	57200.	52350.	47500.	43950.
40400.	37300.	34200.	31750.	29300.	27550.	25800.
24450.	23100.	22000.	20900.	19950.	19000.	18300.
17600.	17150.	16700.	16500.	16300.	16225.	16150.
16075.	16000.	15900.	15800.	15650.	15500.	15300.
15100.	14800.	14500.	14125.	13750.	13375.	13000.
12725.	12450.	12175.	11900.	11600.	11300.	11000.
10750.	10500.	10250.	10000.	9750.	9500.	9250.
9000.	8750.	8500.	8250.	8000.	7750.	7500.
7250.	7000.					

SUM= 2989206.

ROUTED Q FROM MX= 2 TO 3
RTNMD= 1.30 RTCOF= 0. K= 0.

COEF=	.01709	.08728	.19134	.24157	.20394	.13048	.06995	.03292	.01374	.00510
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311

3160.	3152.	3129.	3092.	3065.	3077.	3183.
3442.	3867.	4502.	5320.	6239.	7302.	8554.
9967.	11947.	13070.	14634.	16194.	17792.	19503.
21826.	25782.	30355.	45579.	61964.	77255.	94885.
99882.	104759.	109128.	105925.	109907.	107241.	104424.
100656.	95645.	90194.	84660.	79012.	72751.	66933.
61604.	56211.	51145.	46647.	42656.	39088.	35857.
33064.	30646.	28539.	26694.	25062.	23608.	22318.
21181.	20190.	19371.	18684.	18118.	17657.	17293.
17000.	16761.	16560.	16384.	16221.	16060.	15897.
15724.	15532.	15313.	15065.	14785.	14482.	14161.
13839.	13528.	13227.	12932.	12639.	12344.	12048.
11757.	11476.	11203.	10936.	10673.	10413.	10155.
9900.	9646.	9392.	9140.	8888.	8637.	8386.
8135.	7885.					

SUM= 2972963.

PLOTTED POINTS (BY PRIORITY) -R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX
 UPSTREAM(MX) = 2 DOWNSTREAM(MY) = 3

CHILLICOTHE TO HIGBY - 3 EVENTS

DISCHARGE	-20000.	0.	20000.	40000.	60000.	80000.	100000.	120000.	140000.	160000.	180000.
1.	.	.LR	.	.	.	.	.	.	.	.	.
2.	.	.LR	.	.	.	.	.	.	.	.	.
3.	.	.LR	.	.	.	.	.	.	.	.	.
4.	.	.LR	.	.	.	.	.	.	.	.	.
5.	.	.LR	.	.	.	.	.	.	.	.	.
6.	.	.LRN	.	.	.	.	.	.	.	.	.
7.	.	.RN	.	.	.	.	.	.	.	.	.
8.	.	.RLN	.	.	.	.	.	.	.	.	.
9.	.	.RILN	.	.	.	.	.	.	.	.	.
10.	.	.RILN	.	.	.	.	.	.	.	.	.
11.	.	.RILN	.	.	.	.	.	.	.	.	.
12.	.	.RI L N	.	.	.	.	.	.	.	.	.
13.	.	.RI L N	.	.	.	.	.	.	.	.	.
14.	.	.RI L N	.	.	.	.	.	.	.	.	.
15.	.	.RI L N	.	.	.	.	.	.	.	.	.
16.	.	.RI L N	.	.	.	.	.	.	.	.	.
17.	.	.RI L N	.	.	.	.	.	.	.	.	.
18.	.	.RI L N	.	.	.	.	.	.	.	.	.
19.	.	.RI L N	.	.	.	.	.	.	.	.	.
20.	.	.RI L N	.	.	.	.	.	.	.	.	.
21.	.	.RI L N	.	.	.	.	.	.	.	.	.
22.	.	.RI L N	.	.	.	.	.	.	.	.	.
23.	.	.RI L N	.	.	.	.	.	.	.	.	.
24.	.	.RI L N	.	.	.	.	.	.	.	.	.
25.	.	.RI L N	.	.	.	.	.	.	.	.	.
26.	.	.RI L N	.	.	.	.	.	.	.	.	.
27.	.	.RI L N	.	.	.	.	.	.	.	.	.
28.	.	.RI L N	.	.	.	.	.	.	.	.	.
29.	.	.RI L N	.	.	.	.	.	.	.	.	.
30.	.	.RI L N	.	.	.	.	.	.	.	.	.
31.	.	.RI L N	.	.	.	.	.	.	.	.	.
32.	.	.RI L N	.	.	.	.	.	.	.	.	.
33.	.	.RI L N	.	.	.	.	.	.	.	.	.
34.	.	.RI L N	.	.	.	.	.	.	.	.	.
35.	.	.RI L N	.	.	.	.	.	.	.	.	.
36.	.	.RI L N	.	.	.	.	.	.	.	.	.
37.	.	.RI L N	.	.	.	.	.	.	.	.	.
38.	.	.RI L N	.	.	.	.	.	.	.	.	.

Exhibit 1
 Example 2
 17 of 25

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100.

INC LOCAL FLOWS COMPUTED

COMPUTED LOCAL FLOW

M=	2	333.	330.	400.	500.	500.	550.	750.
		1250.	2250.	4000.	6500.	9000.	11500.	13000.
		14000.	14500.	15000.	15500.	15750.	16000.	16500.
		16750.	17000.	17000.	17000.	17000.	17000.	16800.
		17000.	17000.	17000.	17000.	16700.	16250.	15500.
		15000.	14000.	13250.	12000.	11200.	10500.	10200.
		10500.	11700.	14200.	17000.	19500.	21500.	23700.
		26500.	30000.	34000.	40000.	45500.	50000.	53000.
		55200.	58300.	61500.	65000.	68500.	70750.	71600.
		71500.	70600.	69000.	66000.	62500.	59000.	55500.
		51750.	48000.	45200.	42000.	39500.	37000.	33750.
		30750.	28500.	26000.	22600.	22100.	23000.	22500.
		21500.	20750.	20000.	19500.	19000.	18750.	18500.
		18000.	17500.	17000.	16500.	16250.	16000.	16000.
		16000.	16000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	2	333.	330.	400.	500.	500.	550.	750.
		1250.	2250.	4000.	6500.	9000.	11500.	13000.
		14000.	14500.	15000.	15500.	15750.	16000.	16500.
		16750.	17000.	17000.	17000.	17000.	17000.	16800.
		17000.	17000.	17000.	17000.	16700.	16250.	15500.
		15000.	14000.	13250.	12000.	11200.	10500.	10200.
		10500.	11700.	14200.	17000.	19500.	21500.	23700.
		26500.	30000.	34000.	40000.	45500.	50000.	53000.
		55200.	58300.	61500.	65000.	68500.	70750.	71600.
		71500.	70600.	69000.	66000.	62500.	59000.	55500.
		51750.	48000.	45200.	42000.	39500.	37000.	33750.
		30750.	28500.	26000.	22600.	22100.	23000.	22500.
		21500.	20750.	20000.	19500.	19000.	18750.	18500.
		18000.	17500.	17000.	16500.	16250.	16000.	16000.
		16000.	16000.					
SUM=	2541213.	-SUM=	0.	-MAX=	0.			

COMPUTED LOCAL FLOW

M=	3	295.	300.	296.	625.	949.	3356.	5739.
		8050.	10205.	13902.	17209.	18730.	19960.	20546.
		21247.	21109.	21191.	19489.	17942.	16543.	15225.
		13967.	12785.	11692.	10696.	9974.	9307.	8706.
		8130.	7523.	6937.	6365.	5843.	5088.	4458.
		3928.	3505.	3118.	2846.	2393.	2488.	3223.
		3788.	10289.	16282.	22344.	27968.	31663.	35223.
		39733.	43852.	48008.	51563.	60030.	68219.	75128.
		82599.	78294.	75028.	71240.	67400.	61176.	55709.
		50716.	46260.	42886.	40195.	36595.	33630.	29988.
		26765.	24072.	21731.	19894.	18023.	16039.	14064.
		13457.	12866.	12187.	11535.	11942.	11613.	10738.
		9707.	9918.	10035.	10050.	9957.	10151.	10230.
		10244.	10241.	9865.	9488.	9081.	8620.	8387.
		8070.	7688.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	3	295.	300.	296.	625.	949.	3356.	5739.
		8050.	10205.	13902.	17209.	18730.	19960.	20546.
		21247.	21109.	21191.	19489.	17942.	16543.	15225.
		13967.	12785.	11692.	10696.	9974.	9307.	8706.
		8130.	7523.	6937.	6365.	5843.	5088.	4458.
		3928.	3505.	3118.	2846.	2393.	2488.	3223.
		3788.	10289.	16282.	22344.	27968.	31663.	35223.
		39733.	43852.	48008.	51563.	60030.	68219.	75128.
		82599.	78294.	75028.	71240.	67400.	61176.	55709.
		50716.	46260.	42886.	40195.	36595.	33630.	29988.
		26765.	24072.	21731.	19894.	18023.	16039.	14064.
		13457.	12866.	12187.	11535.	11942.	11613.	10738.
		9707.	9918.	10035.	10050.	9957.	10151.	10230.
		10244.	10241.	9865.	9488.	9081.	8620.	8387.
		8070.	7688.					
SUM=	2078339.	-SUM=	0.	-MAX=	0.			

COMPUTED LOCAL FLOW

M= 2

3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.
3310.	3310.	3360.	3480.	3480.	4580.	5680.	7670.
9660.	11630.	13600.	14600.	15600.	16750.	17900.	
19675.	21450.	23225.	25000.	28400.	31800.	35200.	
38600.	40700.	42800.	43100.	42600.	40575.	38550.	
36525.	34500.	32300.	30100.	28350.	26600.	25350.	
24100.	23200.	22300.	22125.	21950.	21775.	21600.	
21500.	21400.	21300.	21200.	21175.	21150.	21125.	
21100.	21300.	21500.	21700.	21900.	22000.	22100.	
22000.	21900.	21650.	21400.	20850.	20300.	19600.	
18900.	18200.	17500.	17013.	16525.	16037.	15550.	
15063.	14575.	14087.	13600.	13275.	12950.	12625.	
12300.	11850.	11400.	10620.	9840.	8860.	7880.	
7215.	6550.	6283.	6015.	5747.	5500.	5300.	
5100.	4900.						

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M= 2

3310.	3310.	3310.	3310.	3310.	3310.	3310.	3310.
3310.	3310.	3360.	3480.	3480.	4580.	5680.	7670.
9660.	11630.	13600.	14600.	15600.	16750.	17900.	
19675.	21450.	23225.	25000.	28400.	31800.	35200.	
38600.	40700.	42800.	43100.	42600.	40575.	38550.	
36525.	34500.	32300.	30100.	28350.	26600.	25350.	
24100.	23200.	22300.	22125.	21950.	21775.	21600.	
21500.	21400.	21300.	21200.	21175.	21150.	21125.	
21100.	21300.	21500.	21700.	21900.	22000.	22100.	
22000.	21900.	21650.	21400.	20850.	20300.	19600.	
18900.	18200.	17500.	17013.	16525.	16037.	15550.	
15063.	14575.	14087.	13600.	13275.	12950.	12625.	
12300.	11850.	11400.	10620.	9840.	8860.	7880.	
7215.	6550.	6283.	6015.	5747.	5500.	5300.	
5100.	4900.						

SUM= 1786160. -SUM= 0. -MAX= 0.

[illegible][illegible]

Exhibit 1
Example 2
23 of 25

COMPUTED LOCAL FLOW

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10150.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

SUM= 2989206. -SUM= 0. -MAX= 0.

COMPUTED LOCAL FLOW

M= 3

1420.	1297.	1188.	1185.	1355.	2773.	4452.
6153.	7933.	9998.	12430.	15211.	17898.	19571.
21583.	23503.	24830.	24946.	25256.	25183.	25197.
25224.	23618.	20245.	13821.	12886.	20095.	31515.
44118.	51741.	51872.	47675.	40093.	30759.	22576.
14344.	7355.	3006.	-1260.	-2162.	-2451.	-1983.
-2004.	-661.	355.	1103.	1344.	1662.	1643.
1886.	1754.	1311.	606.	938.	1092.	1082.
919.	1110.	1129.	1316.	1382.	1543.	1732.
1912.	2039.	1740.	1916.	2079.	2240.	2403.
2576.	2768.	2987.	635.	915.	1218.	1539.
1861.	2172.	2473.	2768.	461.	756.	1052.
1343.	1624.	1897.	2164.	2427.	787.	1045.
1300.	1554.	1808.	2060.	2312.	2563.	214.
465.	715.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M= 3

1402.	1281.	1173.	1169.	1338.	2738.	4395.
6074.	7831.	9870.	12271.	15017.	17669.	19320.
21306.	23201.	24512.	24626.	24912.	24860.	24874.
24900.	23315.	19986.	13644.	12721.	19837.	31111.
43552.	51078.	51207.	47064.	39579.	30365.	22286.
14160.	7260.	2968.	0.	0.	0.	0.
0.	0.	350.	1089.	1327.	1641.	1622.
1862.	1731.	1294.	598.	926.	1078.	1068.
907.	1095.	1114.	1299.	1365.	1523.	1710.
1887.	2013.	1718.	1892.	2053.	2211.	2373.
2543.	2733.	2949.	627.	903.	1202.	1519.
1837.	2144.	2441.	2733.	455.	746.	1039.
1326.	1603.	1873.	2137.	2396.	777.	1031.
1284.	1534.	1784.	2034.	2282.	2530.	211.
459.	706.					
SUM=	810477.	-SUM=	-10521.	-MAX=	-2451.	

EXAMPLE 3 INPUT

```

TLEXAMPLE 3      MUSKINGUM ROUTING OPTIMIZATION USER SPECIFIED NO. OF SUBREACHES
T2  SCIOTO RIVER  CHILLICOTHE TO HIGBY OHIO
T3  SINGLE EVENT - JANUARY 1959
J1  100          3          0          0          1          0          0          0          1          1
ID CHILLICOTHE TO HIGBY - JAN 1959
RT   2          3          3.6          0          0          0          6          3          3          0
IN   2  JAN59
QO  3160        3093        3025        2940        3020        3207        3800        4660        5650        7203
QO  8395        9653        11400       13300       15200       17075       18600       20150       21700       23575
QO 25800        31250       42800       64650       99900      126000      140000      143000      138000      130500
QO120500      110500      103000      94300       85500       76950       69000       63100       57200       52350
QO 47500        43950       40400       37300       34200       31750       29300       27550       25800       24450
QO 23100        22000       20900       19950       19000       18300       17600       17150       16700       16500
QO 16300        16225       16150       16075       16000       15900       15800       15650       15500       15300
QO 15100        14800       14500       14125       13750       13375       13000       12725       12450       12175
QO 11900        11600       11300       11000       10750       10500       10250       10000       9750        9500
QO 9250         9000       8750       8500       8250       8000       7750       7500       7250       7000
IN   3  JAN59
QO 4580         4449       4317       4277       4420       5850       7635       9595       11800       14500
QO 17750        21450       25200       28125       31550       35000       37900       39580       41450       42975
QO 44700        47050       49400       53300       59400       74850       97350      121000      143000      156500
QO160000      157000      149000      138000      127000      115000      103000      93200       83400       76850
QO 70300        64950       59600       55550       51500       47750       44000       40750       37500       34950
QO 32400        29850       27300       26000       24700       23400       22100       21300       20500       20000
QO 19500        19200       19025       18912       18800       18300       18300       18300       18300       18300
QO 18300        18300       18300       15700       15700       15700       15700       15700       15700       15700
QO 15700        13100       13100       13100       13100       13100       13100       13100       13100       11200
QO 11200        11200       11200       11200       11200       11200       11200       8600       8600       8600

```

EXAMPLE 3 OUTPUT

ROUTING OPTIMIZATION INPUT DATA

EXAMPLE 3 MUSKINGUM ROUTING OPTIMIZATION USER SPECIFIED NO. OF SUBREACHES
T2 SCIOTO RIVER CHILLICOTHE TO HIGBY OHIO
T3 SINGLE EVENT - JANUARY 1959

J1	NPER	IPER	INPUT	IPRNT	IPLOT	IPUNCH	NFLOOD	NPTSQ	ICURV	IFLOW
100	3	0	0	0	1	0	0	0	1	1
ID CHILLICOTHE TO HIGBY - JAN 1959										
RT	RTFR	RTTO	RTMD	RTCOF	XMUSK	LAG	WT1	WT2	WT3	METRIC
2.00	3.00	3.60	0.	0.	0.	0.	6.00	3.00	3.00	0.
JAN59										
3160.0	3093.00	3025.00	2940.00	3020.00	3207.00	3800.00	4660.00	5650.00	5650.00	7203.00
8395.00	9653.00	11400.00	13300.00	15200.00	17075.00	18600.00	20150.00	21700.00	21700.00	23575.00
25800.00	31250.00	42800.00	64650.00	99900.00	126000.00	140000.00	143000.00	138000.00	138000.00	130500.00
120500.00	110500.00	103000.00	94300.00	85500.00	76950.00	69000.00	63100.00	57200.00	57200.00	52350.00
47500.00	43950.00	40400.00	37300.00	34200.00	31750.00	29300.00	27550.00	25800.00	25800.00	24450.00
23100.00	22000.00	20900.00	19950.00	19000.00	18300.00	17600.00	17150.00	16700.00	16700.00	16500.00
16300.00	16225.00	16150.00	16075.00	16000.00	15900.00	15800.00	15650.00	15500.00	15500.00	15300.00
15100.00	14800.00	14500.00	14125.00	13750.00	13375.00	13000.00	12725.00	12450.00	12450.00	12175.00
11900.00	11600.00	11300.00	11000.00	10750.00	10500.00	10250.00	10000.00	9750.00	9750.00	9500.00
9250.00	9000.00	8750.00	8500.00	8250.00	8000.00	7750.00	7500.00	7250.00	7250.00	7000.00
JAN59										
4580.00	4449.00	4317.00	4277.00	4420.00	5850.00	7635.00	9595.00	11800.00	11800.00	14500.00
17750.00	21450.00	25200.00	28125.00	31550.00	35000.00	37900.00	39580.00	41450.00	41450.00	42975.00
44700.00	47050.00	49400.00	53300.00	59400.00	74850.00	97350.00	121000.00	143000.00	143000.00	156500.00
160000.00	157000.00	149000.00	138000.00	127000.00	115000.00	103000.00	93200.00	83400.00	83400.00	76850.00
70300.00	64950.00	59600.00	55550.00	51500.00	47750.00	44900.00	40750.00	37500.00	37500.00	34950.00
32400.00	29850.00	27300.00	26000.00	24700.00	23400.00	22100.00	21300.00	20500.00	20500.00	20000.00
19500.00	19200.00	19025.00	18912.00	18800.00	18300.00	18300.00	18300.00	18300.00	18300.00	18300.00
18300.00	18300.00	18300.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00	15700.00
15700.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	13100.00	11200.00
11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	11200.00	8600.00	8600.00	8600.00	8600.00

OPTIMIZATION ROUTINE OUTPUT

NEG LOCAL	COMPUTED ERRORS:			TOTAL
	TOO EARLY	TOO LATE		
-2397955.45	0.	-1198977.72	-3596933.17	
-2438071.15	0.	-1219035.58	-3657106.73	
-2805310.22	0.	-1402655.11	-4207965.34	
-1958007.04	0.	-979003.52	-2937010.55	
-1484828.73	0.	-742414.36	-2227243.09	
-966220.93	0.	-483110.47	-1449331.40	
-417908.23	0.	-208954.12	-626862.35	
-31046.52	0.	-15523.26	-46559.77	
0.	-57201.35	0.	-57201.35	
-30847.67	0.	-15423.83	-45271.50	
-30174.95	0.	-15087.47	-45262.42	
-29041.42	0.	-14520.71	-43562.13	
-27471.71	0.	-13735.86	-41207.57	
-25501.55	0.	-12750.78	-38252.33	
-23334.28	0.	-11667.14	-35001.42	
-21903.47	0.	-10951.73	-32855.20	
0.	-70563.46	0.	-70563.46	
-43657.20	0.	-21828.60	-65485.79	
-8760.12	0.	-4380.06	-13140.18	
-2983.11	-137.96	-1491.56	-4612.63	
0.	-1990.79	0.	-1990.79	
0.	-6724.15	0.	-6724.15	
0.	-2882.29	0.	-2882.29	
0.	-1134.71	0.	-1134.71	
0.	-455.11	0.	-455.11	
0.	-159.54	0.	-159.54	
0.	0.	0.	0.	

MUSKINGUM OPTIMIZATION COMPLETED

MUSKINGUM K (HOURS PER SUBREACH) = 3.70
MUSKINGUM X = .15
NUMBER OF ROUTING SUBREACHES = 3

Exhibit 1
Example 3
4 of 9

UPSTREAM HYDROGRAPH ROUTED DOWNSTREAM

N= 2

3160.	3093.	3025.	2940.	3020.	3207.	3800.
4660.	5650.	7203.	8395.	9653.	11400.	13300.
15200.	17075.	18600.	20150.	21700.	23575.	25800.
31250.	42800.	64850.	99900.	126000.	140000.	143000.
138000.	130500.	120500.	110500.	103000.	94300.	85500.
76950.	69000.	63120.	57200.	52350.	47500.	43950.
40400.	37300.	34200.	31750.	29300.	27550.	25800.
24450.	23100.	22000.	20900.	19950.	19000.	18300.
17600.	17150.	16700.	16500.	16300.	16225.	16150.
15675.	15000.	15900.	15800.	15650.	15500.	15300.
15100.	14800.	14500.	14125.	13750.	13375.	13000.
12725.	12450.	12175.	11900.	11600.	11300.	11000.
10750.	10500.	10250.	10000.	9750.	9500.	9250.
9000.	8750.	8500.	8250.	8000.	7750.	7500.
7250.	7000.					

SUM= 2989206.

ROUTED Q FROM XX= 2 TO 3

RTMD= 3.20 RTCOF= .15 K= 3.70

COEF= .00842 .06388 .18416 .25859 .20828 .13217 .07354 .03765 .01816 .00820

N= 2

3160.	3159.	3155.	3137.	3103.	3062.	3049.
3117.	3336.	3764.	4427.	5327.	6414.	7625.
8981.	10512.	12190.	13942.	15683.	17366.	19018.
20744.	22855.	26184.	32353.	43514.	60853.	82315.
103143.	119199.	128541.	131387.	125153.	123577.	115307.
108337.	100016.	91582.	83334.	75617.	68623.	62344.
56737.	51767.	47389.	43491.	39981.	36814.	33981.
31479.	29299.	27402.	25749.	24292.	22995.	21825.
20763.	19814.	18977.	18258.	17662.	17187.	16829.
16569.	16387.	16255.	16150.	16055.	15957.	15848.
15721.	15572.	15397.	15189.	14941.	14654.	14331.
13986.	13633.	13290.	12970.	12669.	12378.	12090.
11799.	11508.	11224.	10951.	10688.	10431.	10178.
9926.	9676.	9425.	9175.	8925.	8675.	8425.
8175.	7925.					

SUM= 2973350.

PLOTTED POINTS (BY PRIORITY)-R=INFLOW AT MX ROUTED TO MY, N=OBS OR NAT AT MY, L=LOCAL (INC) AT MY, I=INFLOW AT MX

UPSTREAM(MX)= 2 DOWNSTREAM(MY)= 3

CHILLICOTHE TO HIGHY - JAN 1959

DISCHARGE	0.	20000.	40000.	50000.	80000.	100000.	120000.	140000.	160'00.	180000.	200000.
1. .LR	.	.	.	.	.	.	.	.	.	.	.
2. .LR	.	.	.	.	.	.	.	.	.	.	.
3. .LR	.	.	.	.	.	.	.	.	.	.	.
4. .LR	.	.	.	.	.	.	.	.	.	.	.
5. .LR	.	.	.	.	.	.	.	.	.	.	.
6. .LRN	.	.	.	.	.	.	.	.	.	.	.
7. .RN	.	.	.	.	.	.	.	.	.	.	.
8. .RLN	.	.	.	.	.	.	.	.	.	.	.
9. .RILN	.	.	.	.	.	.	.	.	.	.	.
10. .RILN	.	.	.	.	.	.	.	.	.	.	.
11. .RI LN	.	.	.	.	.	.	.	.	.	.	.
12. .RI LN	.	.	.	.	.	.	.	.	.	.	.
13. .RI LN	.	.	.	.	.	.	.	.	.	.	.
14. .RI LN	.	.	.	.	.	.	.	.	.	.	.
15. .RI LN	.	.	.	.	.	.	.	.	.	.	.
16. .RI LN	.	.	.	.	.	.	.	.	.	.	.
17. .RI LN	.	.	.	.	.	.	.	.	.	.	.
18. .RI LN	.	.	.	.	.	.	.	.	.	.	.
19. .RI LN	.	.	.	.	.	.	.	.	.	.	.
20. .RI LN	.	.	.	.	.	.	.	.	.	.	.
21. .RI LN	.	.	.	.	.	.	.	.	.	.	.
22. .RI LN	.	.	.	.	.	.	.	.	.	.	.
23. .RI LN	.	.	.	.	.	.	.	.	.	.	.
24. .RI LN	.	.	.	.	.	.	.	.	.	.	.
25. .RI LN	.	.	.	.	.	.	.	.	.	.	.
26. .RI LN	.	.	.	.	.	.	.	.	.	.	.
27. .RI LN	.	.	.	.	.	.	.	.	.	.	.
28. .RI LN	.	.	.	.	.	.	.	.	.	.	.
29. .RI LN	.	.	.	.	.	.	.	.	.	.	.
30. .RI LN	.	.	.	.	.	.	.	.	.	.	.
31. .RI LN	.	.	.	.	.	.	.	.	.	.	.
32. .RI LN	.	.	.	.	.	.	.	.	.	.	.
33. .RI LN	.	.	.	.	.	.	.	.	.	.	.
34. .RI LN	.	.	.	.	.	.	.	.	.	.	.
35. .RI LN	.	.	.	.	.	.	.	.	.	.	.
36. .RI LN	.	.	.	.	.	.	.	.	.	.	.
37. .RI LN	.	.	.	.	.	.	.	.	.	.	.
38. .RI LN	.	.	.	.	.	.	.	.	.	.	.

Exhibit 1
Example 3
5 of 9

Exhibit 1
Example 3
6 of 9

39. L . R
40. .L . R
41. .L . RN
42. .L . RN
43. .L . RN
44. .L . RN
45. .L . RN
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72. .L . RN
73. .L . RN
74. L . RN
75. L . RN
76. .L . RN
77. .L . RN
78. .L . RN
79. .L . RN
80. .L . RN
81. .L . RN
82. L . RN
83. L . RN
84. .L . RN
85. .L . RN

[illegible]

INC LOCAL FLOWS COMPUTED

COMPUTED LOCAL FLOW

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

M=	2	3160.	3093.	3025.	2940.	3020.	3207.	3800.
		4660.	5650.	7203.	8395.	9653.	11400.	13300.
		15200.	17075.	18600.	20150.	21700.	23575.	25800.
		31250.	42800.	64650.	99900.	126000.	140000.	143000.
		138000.	130500.	120500.	110500.	103000.	94300.	85500.
		76950.	69000.	63100.	57200.	52350.	47500.	43950.
		40400.	37300.	34200.	31750.	29300.	27550.	25800.
		24450.	23100.	22000.	20900.	19950.	19000.	18300.
		17600.	17150.	16700.	16500.	16300.	16225.	16150.
		16075.	16000.	15900.	15800.	15650.	15500.	15300.
		15100.	14800.	14500.	14125.	13750.	13375.	13000.
		12725.	12450.	12175.	11900.	11600.	11300.	11000.
		10750.	10500.	10250.	10000.	9750.	9500.	9250.
		9000.	8750.	8500.	8250.	8000.	7750.	7500.
		7250.	7000.					

SUM= 2989206. -SUM= 0. -MAX= 0.

COMPUTED LOCAL FLOW

N=	3	1420.	1290.	1162.	1140.	1317.	2788.	4586.
		6478.	8464.	10736.	13323.	16123.	18786.	20500.
		22569.	24488.	25710.	25638.	25767.	25609.	25682.
		26306.	26545.	27116.	27047.	31336.	36497.	38685.
		39857.	37301.	31459.	25613.	19847.	14423.	10693.
		6663.	2984.	1618.	66.	1233.	1677.	2606.
		2863.	3783.	4111.	4259.	4019.	3936.	3519.
		3471.	3101.	2448.	1551.	1708.	1705.	1575.
		1334.	1486.	1523.	1742.	1838.	2013.	2196.
		2343.	2413.	2045.	2150.	2245.	2343.	2452.
		2579.	2728.	2903.	511.	759.	1046.	1369.
		1714.	2067.	2410.	2730.	431.	722.	1010.
		1301.	1592.	1876.	2149.	2412.	769.	1022.
		1274.	1524.	1775.	2025.	2275.	2525.	175.
		425.	675.					

LOCAL FLOW ADJUSTED FOR NEGATIVE VALUES

N=	3	1420.	1290.	1162.	1140.	1317.	2788.	4586.
		6478.	8464.	10736.	13323.	16123.	18786.	20500.
		22569.	24488.	25710.	25638.	25767.	25609.	25682.
		26306.	26545.	27116.	27047.	31336.	36497.	38685.
		39857.	37301.	31459.	25613.	19847.	14423.	10693.
		6663.	2984.	1618.	66.	1233.	1677.	2606.
		2863.	3783.	4111.	4259.	4019.	3936.	3519.
		3471.	3101.	2448.	1551.	1708.	1705.	1575.
		1334.	1486.	1523.	1742.	1838.	2013.	2196.
		2343.	2413.	2045.	2150.	2245.	2343.	2452.
		2579.	2728.	2903.	511.	759.	1046.	1369.
		1714.	2067.	2410.	2730.	431.	722.	1010.
		1301.	1592.	1876.	2149.	2412.	769.	1022.
		1274.	1524.	1775.	2025.	2275.	2525.	175.
		425.	675.					
SUM=	810090.	-SUM=	0.	-MAX=	0.			

EXHIBIT 2

INPUT DESCRIPTION

Streamflow Routing Optimization (OPROUT)

To determine the optimization routing criteria using modified Puls or Muskingum routing methods for a single reach, at least one set of observed hydrographs are required for the upstream and downstream ends of the reach. A maximum of five sets of observed hydrographs can be used to develop the routing criteria. The observed upstream hydrograph must be input ahead of the downstream hydrograph for each event. There is a date variable on the input cards so that the starting date of each flood can be input with the flow data.

If several floods are used to develop the routing criteria, all the flow data must have the same number of periods. This means shorter events must be extended with base flow values up to the number of periods of the longest event. The added data should be included at the end of the actual flood and the upstream values generally should be less than the downstream values.

The following INPUT DESCRIPTION provides a detailed description of data input. Input format is the standard HEC ten fields of 8 columns each with the first two card columns reserved for the card identification. Card ID is not read by the program. Three title cards are used to provide labeling information. The job card defines job options using integers (no decimal points). The identification card provides a label for plots, and the routing card provides the routing optimization information. The remaining cards contain the flow data (upstream then downstream hydrograph).

INPUT DESCRIPTION

Streamflow Routing Optimization Program (OPROUT)

T1, T2, T3 Cards - Title Cards

Job title cards; three cards required. Both alphabetic and numeric information may be placed on these cards. Information on these cards will be printed out as job title on the first page of output.

J1 Card - Job Card - all integers

<u>Field</u>	<u>Variable</u>	<u>Value</u>	<u>Description</u>
1	NPER	+	Number of values on each set of flow data cards (IN). Each set of flow data must have NPER Values (300 maximum).
2	IPER	+	Time interval (Δt) in hours between flow values.
3	INPUT	0	First input card for each flow set will have control point number in field 1 and date in field 2 and no other data. Subsequent cards contain 10 fields of flow data.
		5	Flow data will be in default HEC-5 format. First two fields of first card are for control point and date with flow data on the remaining 8 fields. Subsequent cards contain 10 fields of flow data.

J1 Card - Continued

<u>Field</u>	<u>Variable</u>	<u>Value</u>	<u>Description</u>
4	IPRNT	0	Output will be limited to Input Data, Optimization Errors, and optimization results.
		1	Same as above plus optimization trace.
		15	Same as above plus routing trace.
		20	Same as above plus detailed routing trace.
5	IPL0T	0	No hydrograph plot.
		1	Plot hydrograph for Inflow (Routed Downstream), Observed flow downstream, Computed Local Flow, and Inflow Upstream.
6	IPUNCH	0	No punch cards.
		1	Punch computed local flow data.
7	NFLOOD	0	One flood event will be used to optimize routing criteria.
		+	Number of flood events (5 maximum) requires upstream and downstream flow data for each event.
8	NPTSQ	0	Number of storage-outflow points to be derived from optimization routing is equal to 9.
		+	Number of storage-outflow points to be derived (18 maximum). The more points used, the longer the optimization time.
9	ICURV	0	No adjustments will be made to the storage-outflow curve (UNSMOOTHED CURVE).

J1 Card - Continued

<u>Field</u>	<u>Variable</u>	<u>Value</u>	<u>Description</u>
		+	A fourth order polynomial curve should be fitted to the unsmoothed curve. The smooth curve will then be used for computing local flows.
10	IFLOW	0	Input flow data is average for the period.
		1	Input flow data is end of period data. Flow data will be averaged before routing.

ID Card - Identification Card for Reach

<u>Field</u>	<u>Variable</u>	<u>Value</u>	<u>Description</u>
1- 5	CPT(K)	+	Title (alphanumeric) of routing reach in columns 3-40. Title will be printed on hydrograph plots.
6-10	Not used		

RT Card - Routing Card

<u>Field</u>	<u>Variable</u>	<u>Value</u>	<u>Description</u>
1	RTFR	+	Control point number of upstream end of routing reach.
2	RTTO	+	Control point number of downstream end of routing reach.
3	RTMD	+	Number of subreaches to the left of the decimal and routing method to the right of the decimal (.5 for modified Puls and .6 for Muskingum). If subreaches are not given, the number will be optimized.

RT

RT Card - Continued

<u>Field</u>	<u>Variable</u>	<u>Value</u>	<u>Description</u>
4	RTCOF	0	Muskingum routing coefficient "X" will be optimized if Muskingum optimization is requested (RT.3 = .6).
		+	Coefficient X will not be optimized. The given value will be used for Muskingum or modified Puls.
5	XMUSK	0	Travel time (Muskingum K) in hours will be optimized if Muskingum optimization is requested.
6	LAG	0	No lag in addition to routing.
		+	In addition to routing, lag outflow by the number of periods shown.
7	WT1	0	Weighting of negative local flow equals one (1.0).
		+	Weighting factor for negative local flow. Use any number.
8	WT2	0	Weighting factor (penalty) for recession leg being too early equals zero (0).
		+	Weighting factor for recession leg being too early. (Suggested value near 1.0.)
9	WT3	0	Weighting factor of error on recession leg of hydrograph being too late equals zero (0).
		+	Weighting factor for recession leg being too late. Use in conjunction with WT2. (Suggested value near 4.0.)
10	METRIC	0	English units.
		+	Metric units.

IN Cards - Flow data for upstream and then downstream station.*

<u>Field</u>	<u>Variable</u>	<u>Value</u>	<u>Description</u>
1	MM	+	Control point number for input hydrograph. First hydrograph for the upstream location, and then the downstream location.
2	DATE	+	Starting date of flow data for identification only. Can be alphanumeric data.
3-10	QII	+	Flow data in cfs or m ³ /SEC if INPUT (J1.3) equals 5. Remaining data starts in field 1 of succeeding cards. (NPER values.)
or			
1-10	QII	+	Flow data starts in field 1 of the second card if INPUT (J1.3) equals 0 (NPER values).

*Repeat IN cards for both control points. Two sets of flow data in turn for each flood up to the number of floods prescribed (NFLLOOD on J1.7).

* IN MM DATE QII QII

RT RTFR RTTO RTMD RTCOF XMUSK LAG WT1 WT2 WT3 METRIC

ID Title of routing reach (cols 1-40)

J1 NPER IPER INPUT IPRNT IPLOT IPUNCH NFLOOD NPTSQ ICURV IFLOW

T3

T2

T1 Output title information, three cards required

*Include IN cards for inflow then outflow of reach for each flood event.