

STORM WATER REPORT

FOR

CASSVILLE, MISSOURI



April 10, 2012

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1.0 INTRODUCTION

Olsson was requested to evaluate the sanitary sewer inflow problem that results from the flooding along Town Branch and Hawk Branch. The analysis is focused on the drainage for Town Branch and Hawk Branch upstream of the confluence of Flat Creek. The purpose of the analysis is to analyze sanitary sewer inflows which occur during flood events and develop a solution for these problems.

The Town Branch drainage area extends to the West of the city and drains 3,260 acres. The area upstream of Highway 37 is mostly undeveloped open space while downstream of Highway 37 contains residential and industrial areas near the confluence with Hawk branch. This drainage area has been subdivided into three sections.

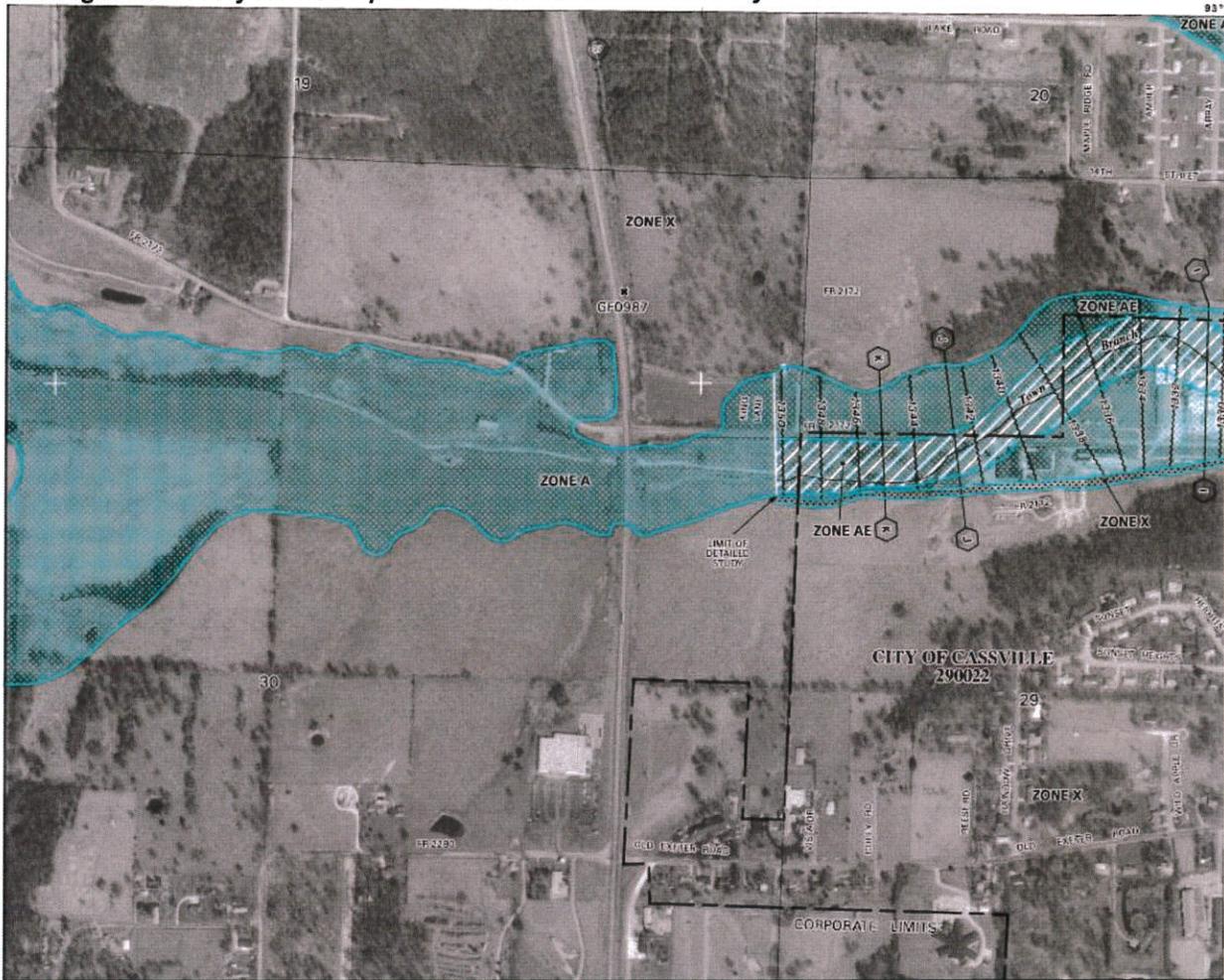
The Hawk Branch drainage area extends to the Northwest of the city. This drainage area is 530 acres and includes 190 acres of residential mostly concentrated in the Southeast corner of the drainage area closest to the city.

2.0 FLOODING HISTORY

In April of 1970, an estimated 7 year frequency storm caused flooding that damaged 40 residences and 5 commercial firms as well as many streets and utilities. Total damages for the 1970 storm exceed \$100,000. Also, recurrent flooding occurs in Cassville's business district from Town Branch flooding, even when Flat Creek is not at flood stage.

Flooding also impacts the sanitary sewer system by causing inflows to the system. The inflows have the potential to cause surcharging of the system and sewage backups into residential and commercial structures. Also, due to the nature of the aquifer, the flooding temporarily causes a rise in the regional water table for potentially weeks after the floodwaters recede. The elevated water table enters the sanitary sewer system through cracked pipes and leaking joints. This increased volume flows to the Waste Water Treatment plant and causes additional treatment costs. A study is currently underway to identify locations of high infiltration and assess methods to improve the water tightness of the system.

Figure 3 - 100-year flood plain on Hawk Branch near Hwy 37 on the west side of Cassville.



3.0 HYDROLOGY

Runoff calculations were performed using the SCS Curve Number Method. Curve Numbers (CN) were developed using an overlay of the Soil Survey in Appendix A and the Zoning Map for the City of Cassville. Existing land use in the county was estimated based on aerial photographs. Within City limits, it was assumed all property was developed to the level current zoning allows. Table 1 provides the Curve Number values used for the soil and land use types present in the watershed.

Table 1 - Runoff Curve Numbers and contributing drainage areas by land use.

Land Use	Type B Soil		Type C Soil	
	Area (Acre)	CN	Area (Acre)	CN
Pasture	896	61	2,069	74
Woods	225	55	438	70
Residential, R-2	151	75	166	83
Residential, R-3	3	85	0	90
Commercial, C-1, C-2	13	91	46	93

Table 2 - Composite drainage areas and curve numbers.

Location	Drainage Area (Acre)	Composite Curve Number
Town Branch above Hwy 37	2,728	70
Town Branch at Confluence with Hawk Branch	3,256	70
Town Branch at confluence with Flat Creek	4,164	71
Hawk Branch at confluence with Town Branch	793	71

Times of concentration for each drainage area were calculating using TR-55. Precipitation depth was taken from *TP-40, Rainfall Frequency Atlas of the United States*. Precipitation was distributed using the Huff 1st quartile distribution, the storm runoff hydrograph was determined using the SCS Unit Hydrograph Method. Hydrographs were routed using the Muskingham-Cunge method for open channels and Kinematic Wave method for enclosed storm sewers. A critical storm duration analysis was performed and the two hour event resulted in the highest peak flows. The critical duration analysis is available in Appendix A.

Table 3 summarizes the flows at road crossings for the Olsson Calculated values and for the estimated FEMA flows. The Flood Insurance Study (FIS) did not specifically state the flows that were used in the analysis. Values for the FEMA flows were estimated from the FIS floodway table. FEMA flows are about twice as large as the Olsson calculated flows. The USGS method for calculating peak flows from ungaged rural watersheds was used for a comparison check. The calculated flow in Town Creek at the confluence with Flat Creek is 3,700 cfs. This value is much closer to the flows calculated by Olsson and hence the Olsson calculated flows were used in the remainder of this study. Although uncommon, perhaps the FEMA calculated flow was for a fully developed watershed assuming no detention was performed.

Table 3 - Town Branch Flow Summary in cubic feet per second (cfs).

Location	Return Frequency			FEMA
	2 Yr.	10 Yr.	100 Yr.	100 Yr.
Town Branch				
Farm Road 2172	660	1,760	3,730	3,300
County Farm Road	690	1,880	4,010	7,100
Townsend Street	860	2,330	5,000	9,300
Main Street	900	2,410	5,160	9,300
East Street	900	2,410	5,160	9,300
Hawk Branch				
Stephens Dr	145	400	860	2490
County Farm Rd	175	460	980	2490
14 th St	175	460	980	2490
Presley Dr	175	460	980	2490
W 11 th St	175	460	980	2490

4.0 HYDRAULIC MODELING

The Effective HEC-RAS model was requested from the FEMA library through an external data request. FEMA was unable to locate the effective model and the vast majority of the supporting documentation. Since the effective model and cross section information was not available, Olsson performed a limited topographic and drainage structure inventory survey. The intent of the new survey and hydraulic modeling is not to develop new FEMA regulatory maps but rather to develop a tool to evaluate the existing level of flooding and evaluate

alternative to lower the flood depths. Tables 4 and 5 summarize the drainage structure inventory and Table 6 summarizes the FEMA 100-year flood elevations compared to the Olsson modeled elevations.

Table 4 - Town Branch Drainage Structure Inventory

Location	Drainage Structure	Size	Slope	Capacity ⁽¹⁾ (cfs)
Hwy 37	Concrete Box Culvert	Triple 15'w x 7'h	0.9%	3,320 ⁽²⁾
Downstream of Hwy 37	Open Channel	24' top width x 12' deep	1.4%	3,320 ⁽²⁾
Farm Road 2172	Steel Bridge	60' clear span	NA	1,200
Downstream of FR 2172	Open Channel	34' top width x 6' deep	0.8%	700
Private Bridge	Steel Truss	34' clear span	NA	700
Upstream of County Farm Road	Open Channel	82' top width x 8' deep	1%	1,400
County Farm Road	Pipe Culverts	Triple 60" diameter CMP	0.5%	400
Upstream of the Confluence with Hawk Branch	Open Channel	39' top width x 4' deep	0.5%	600
Downstream of the Confluence with Hawk Branch	Open Channel	39' top width x 7' deep	0.6%	800
Townsend Road	Box Culvert	10'w x 5.5' h	5%	350
Between Townsend and Main Street	Open Channel	37' top width x 9' deep	1.3%	1,000
Main Street	Box Culvert	10'w x 6' h	1.4%	525
Between Main and East Street	Open Channel	116' top width x 10' deep	1%	1200
East Street	Box Culvert	12.5'w x 6.5'h	2.7%	600
Confluence with Flat Creek	Open Channel	60' top width x 8' deep	0.6%	600

Notes:

- 1) **Capacity assumes no backwater and is just prior to significant out of bank flow or street overtopping.**
- 2) **Capacity exceeds 100 Yr.**

Table 5 - Hawk Branch Drainage Structure Inventory

Location	Drainage Structure	Size	Slope	Capacity ⁽¹⁾ (cfs)
Upstream of Stephens Dr.	Open Channel	30' top width x 4' deep	1.8%	1,000
Stephens Dr	Pipe Culverts	Triple 42" Diameter CMP	0.8%	160
Downstream of Stephens Dr.	Open Channel	33' top width x 4' deep	1.0%	1,100
County Farm Rd	Pipe Culvert	36" Diameter CMP	1.0%	35
Downstream of County Farm Rd.	Open Channel	45' top width x 3' deep	1.0%	550
Oakhill Dr	Pipe Culvert	36" Diameter CMP	0.8%	50
Downstream of Oakhill Dr.	Open Channel	30' top width x 4' deep	2.2%	600
14th St	Pipe Culverts	15" and 24" Diameter CMP	1.7%	25
Downstream of 14th St.	Open Channel	13' top width x 3' deep	1.3%	50
Presley Dr	Pipe Culverts	Triple 40" Diameter CMP	0.8%	210
Downstream of Presley Dr.	Open Channel	50' top width x 6' deep	1.0%	1,800
Downstream of Sapp St.	Open Channel	25' top width x 3. Ft. deep	1.8%	500

Notes:

- 1) *Capacity assumes no backwater and is just prior to significant out of bank flow or street overtopping.*

Table 6 - FEMA 100-year flood elevations versus calculated elevation by Olsson.

Location	100-year Flood Elevations (Ft.)	
	Olsson Calculated	FEMA BFE
Town Branch		
Farm Road 2172	1339.8	1342.0
County Farm Road	1326.7	1327.1
Townsend Street	1314.2	1317.8
Main Street	1311.9	1316.0
East Street	1309.9	1312.8
Hawk Branch		
Stephens Dr	1356.2	NA
County Farm Rd	1344.1	NA
Oak Hill St	1339.4	1334.8
14 th St	1334.1	1333.7
Presley Dr	1329.4	1328.3
W 11 th St	1320.7	1326.0

5.0 PROPOSED ALTERNATIVES

5.1 Conveyance Improvements Only

For Town Branch, 10-year and 100-year conveyance improvements were modeled in HEC-RAS assuming upstream detention is not performed. In general, the 10-year design utilized 60 foot wide bridges and the 100-year design utilized 90 wide bridges. Channel improvements were needed between the proposed bridges. The most difficult area was at 11th Street near the confluence with Hawk. 11th Street parallels the creek and the street sits low in comparison to the creek bottom. The low elevations of the sanitary sewer manholes in the street result in large amount of inflow potential at this location. During surcharge conditions, these manhole lids might blow off causing a hazard for cars. The proposed designs would reduce the flooding depth on 11th street in this area but was not able to completely eliminate them. Under both the 10-year and 100-year options, it appeared very difficult to keep 10th Street open and allow enough room to convey the flow. Potentially, retaining walls along 10th street and 11th street might be required for a short distance to keep both roadways open. Table 7 summarizes the 10-year and 100-year options on Town Branch

5.2 Upstream Development Potential

If the County were to fully develop without requiring detention, there could be a large increase in flows reaching the City. The large increase in flows would exasperate the existing flooding and sanitary sewer inflow problems. It is recommended the City request the County to require detention on all new development for the watersheds that flow into town. Calculations for the proposed system presented in the subsequent sections are based on the County adopting such detention regulations.

Table 7- Town Branch 10-year and 100-year drainage improvements.

Location	Existing	10 Yr. Size	100 Yr. Size
Hwy 37	Triple 15'w x 7'h	use existing	use existing
Downstream of Hwy 37	24' top width x 12' deep	use existing	clean out & shape channel
Farm Road 2172	60' clear span	use existing	90' Bridge
Downstream of FR 2172	34' top width x 6' deep	clean out & shape channel	85' top width x 6' deep
Private Bridge	34' clear span	remove	remove
Upstream of County Farm Road	82' top width x 8' deep	clean out & shape channel	95' top width x 8' deep
County Farm Road	Triple 60" diameter CMP	60' Bridge	90' Bridge
Upstream of the Confluence with Hawk Branch	39' top width x 4' deep	62' top x 4' deep	95' top width x 4' deep
Downstream of the Confluence with Hawk Branch	39' top width x 7' deep	78' top x 7' deep	95' top width x 7' deep
Townsend Road	10'w x 5.5' h RCB	60' Bridge	90' Bridge
Between Townsend and Main Street	37' top width x 9' deep	78' top x 9' deep	115' top x 9' deep
Main Street	10'w x 6' h	60' Bridge	90' Bridge
Between Main and East Street	116' top width x 10' deep	clean out & shape channel	clean out & shape channel
East Street	12.5'w x 6.5'h RCB	60' Bridge	90' Bridge
Confluence with Flat Creek	60' top width x 8' deep	clean out & shape channel	clean out & shape channel

5.3 Detention Option

The proposed detention includes two separate locations. The first location consists of two regional detention ponds on Town Branch upstream of Hwy 37. These two ponds will detain a total of 2,655 acres of the upstream portion of Town Branch. The second detention pond is located on Hawk Branch upstream of Stephens Drive. Please see Figure 7 for Detention Site Location Map. The detention pond on Hawk Branch detains runoff from 508 acres of the upstream portion of Hawk Branch. The total anticipated construction cost of all three detention ponds is \$1.5 million. Detention calculations were performed using Hydraflow Hydrographs Extension for AutoCAD Civil 3D. A critical duration analysis was performed on the pond and

indicated that the third quartile Huff 24 hour storm resulted in the highest reservoir stage. Therefore, the detention pond was designed to contain the 100-year, 24 hour rainfall event. Tables 8 and 9 show the ability of the detention ponds to reduce the peak flow at the location immediately downstream.

Table 8 - Town Branch flow summary at Hwy 37 for existing watershed conditions and the resulting flows if regional detention basins were built.

Return Frequency (Yr.)	Existing Runoff (cfs)	With Regional Detention Basins (cfs)	Percent Reduction in Flows
1	360	140	61%
10	1760	350	80%
100	3730	600	84%

Table 9 - Hawk Branch flow summary at Stephens Drive for existing watershed conditions and the resulting flows if a regional detention basin were built.

Return Frequency (Yr.)	Existing Runoff (cfs)	With Regional Detention Basins (cfs)	Percent Reduction in Flows
1	80	20	75%
10	400	110	73%
100	850	230	73%

Table 10 - Flow summary comparing existing flows versus flows with new regional detention ponds.

Location	10 Yr. Flow Summary		100 Yr. Flow Summary	
	Without Detention	With Detention	Without Detention	With Detention
Town Branch				
Farm Road 2172	1760	350	3730	600
County Farm Road	1880	500	4010	970
Townsend Street	2330	690	5000	1350
Main Street	2410	800	5160	1580
East Street	2410	800	5160	1580

Hawk Branch				
Stephens Dr	400	110	850	230
County Farm Rd	460	160	980	340
Oak Hill St	460	160	980	340
14 th St	460	160	980	340
Presley Dr	460	205	980	425
W 11 th St	460	205	980	425

The peak flows for the 100 year event on Town Branch and Hawk Branch are reduced by 84% and 73% immediately downstream of the respective detention ponds. This reduction translates to a 73% reduction in peak flow at the confluence of Town Branch and Hawk Branch. As discussed previously the existing system is limited to less than 400 cfs before out of bank flooding occurs. Although the proposed regional detention basin would reduce the flooding, some improvements will still be necessary for sufficient capacity. Because the reduced flowrates were much lower, the open channels and conveyance structures were analyzed and resized to sufficiently convey the 25 year flow with upstream detention. See Table 11, Table 12, and Figure 8 for information on the proposed 25 year system.

Table 11 - Town Branch 25-year drainage improvements for detention option.

Location	Existing	25 Yr. Size
Hwy 37	Triple 15'w x 7'h	Use existing
Downstream of Hwy 37	24' top width x 12' deep	Use existing
Farm Road 2172	60' clear span	Use existing
Downstream of FR 2172	34' top width x 6' deep	Use existing
Private Bridge	34' clear span	Use existing
Upstream of County Farm Road	82' top width x 8' deep	clean out & shape channel
County Farm Road	Triple 60" diameter CMP	Two 10' x 5' RCB
Upstream of the Confluence with Hawk Branch	39' top width x 4' deep	60' top width x 4' deep
Downstream of the Confluence with Hawk Branch	39' top width x 7' deep	67' top width x 7' deep
Townsend Road	10'w x 5.5' h RCB	Two 10' x 6' RCB
Between Townsend and Main Street	37' top width x 9' deep	70' top width x 8' deep

Main Street	10'w x 6' h	Two 10' x 6' RCB
Between Main and East Street	116' top width x 10' deep	clean out & shape channel
East Street	12.5'w x 6.5'h RCB	Two 10' x 6' RCB
Confluence with Flat Creek	60' top width x 8' deep	clean out & shape channel

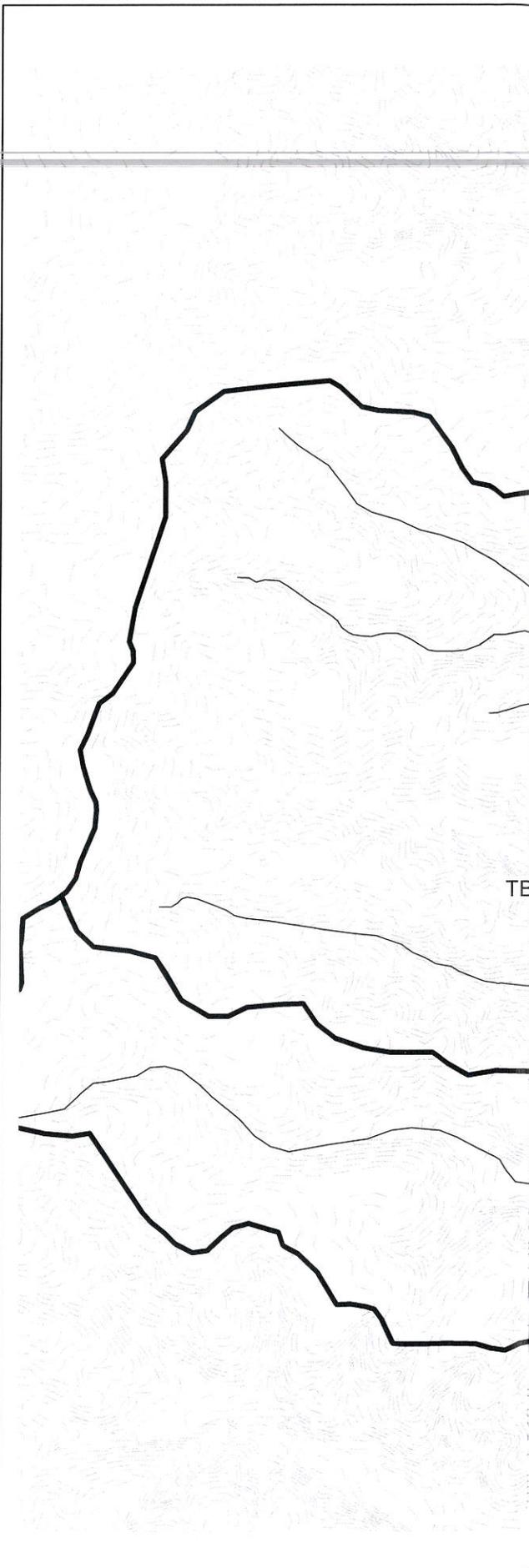
Table 12 - Hawk Branch 25-year drainage improvements for detention option.

Location	Existing	25 Yr. Size
Upstream of Stephens Dr.	30' top width x 4' deep	Use existing
Stephens Dr	Triple 42" Diameter CMP	Use existing
Downstream of Stephens Dr.	33' top width x 4' deep	Use existing
Parallel to County Farm Rd	NA	Double 42" RCP
Upstream of 14 th St	NA	21' top width x 3' deep
14 th St	NA	8' x 4' RCB
Upstream of 11 th St	9' top x 2' deep	23' top width x 4' deep
W 11 th St	Double 4' x 1.4' CMP	10' x 4' RCB



Hydrologic Calculations

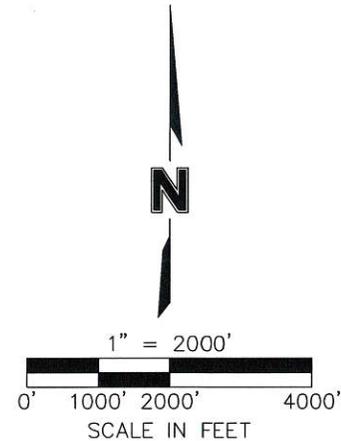
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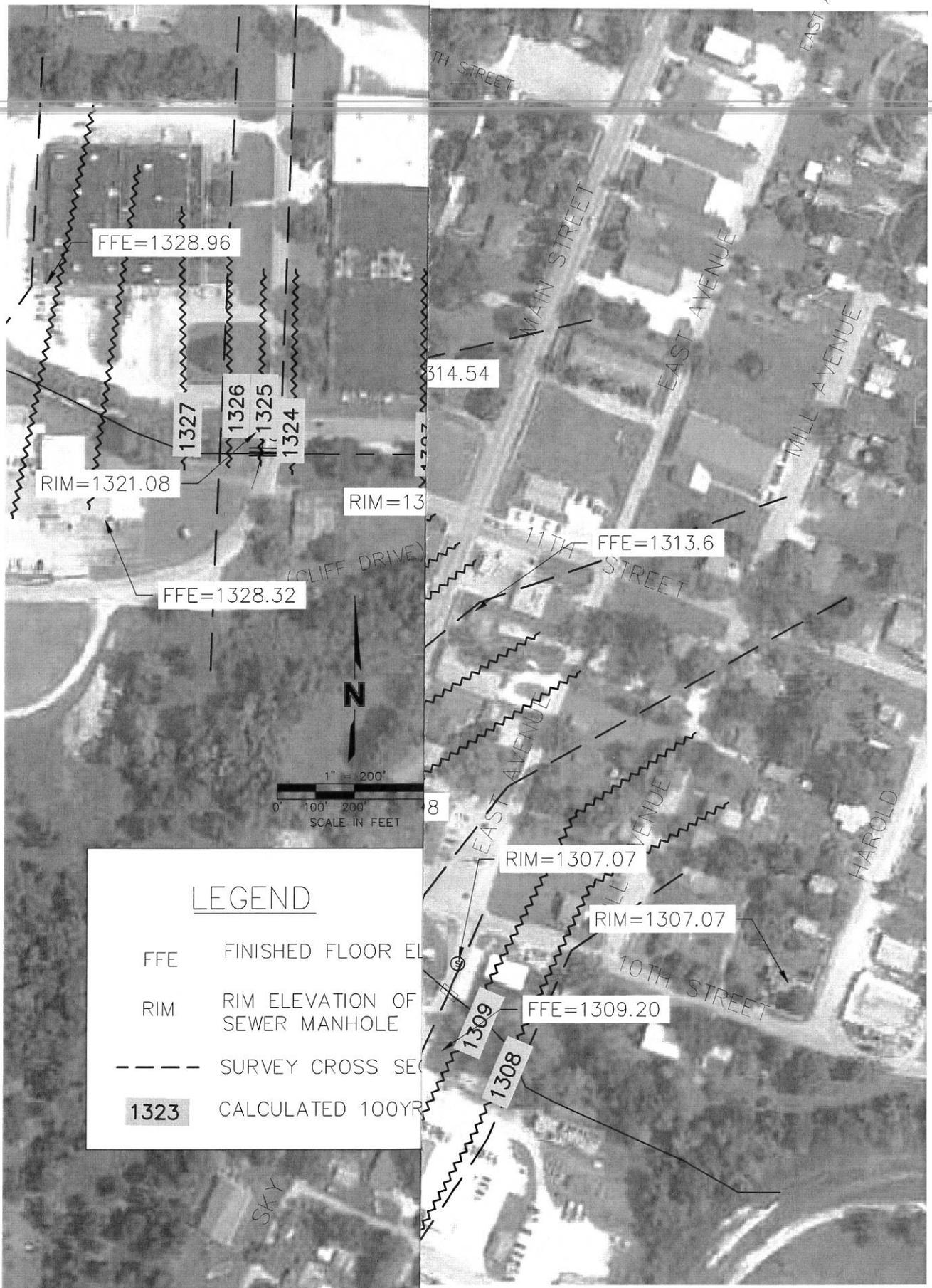


SUMMARY			
REGION	AREA (ac.)	CN	Tc (min.)
TB-1	1733	70	45.0
TB-2	923	70	52.0
TB-3	287	70	33.0
TB-4	316	71	40.0
TB-5	115	84	29.0
HB-1	508	71	45.0
HB-2	162	69	26.0
HB-3	77	78	20.0
HB-4	47	78	20.0

LEGEND

- TB DRAINAGE AREA BOUNDARY
- FLOW PATH
- EXISTING 5' CONTOUR INTERVAL
- IMPACT POINT





PROJECT: 011-0399

DRAWN BY: CRL

DATE: 11.15.2011

CASSVILLE

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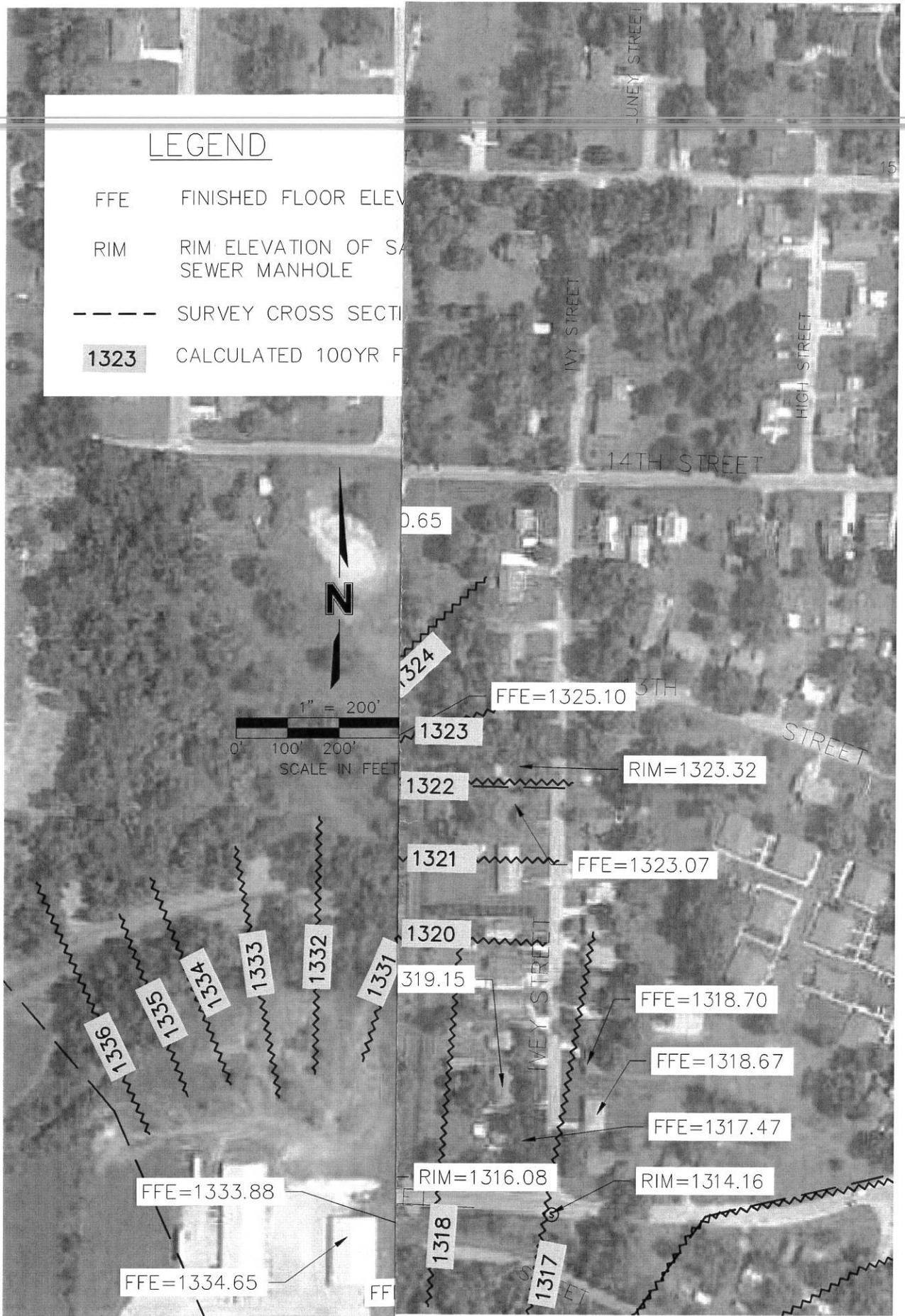


FIGURE

4

LEGEND

- FFE FINISHED FLOOR ELEVATION
- RIM RIM ELEVATION OF SANITARY SEWER MANHOLE
- SURVEY CROSS SECTION
- 1323** CALCULATED 100YR FLOOD ELEVATION



PROJECT: 011-0399

DRAWN BY: CRL

DATE: 11.15.2011

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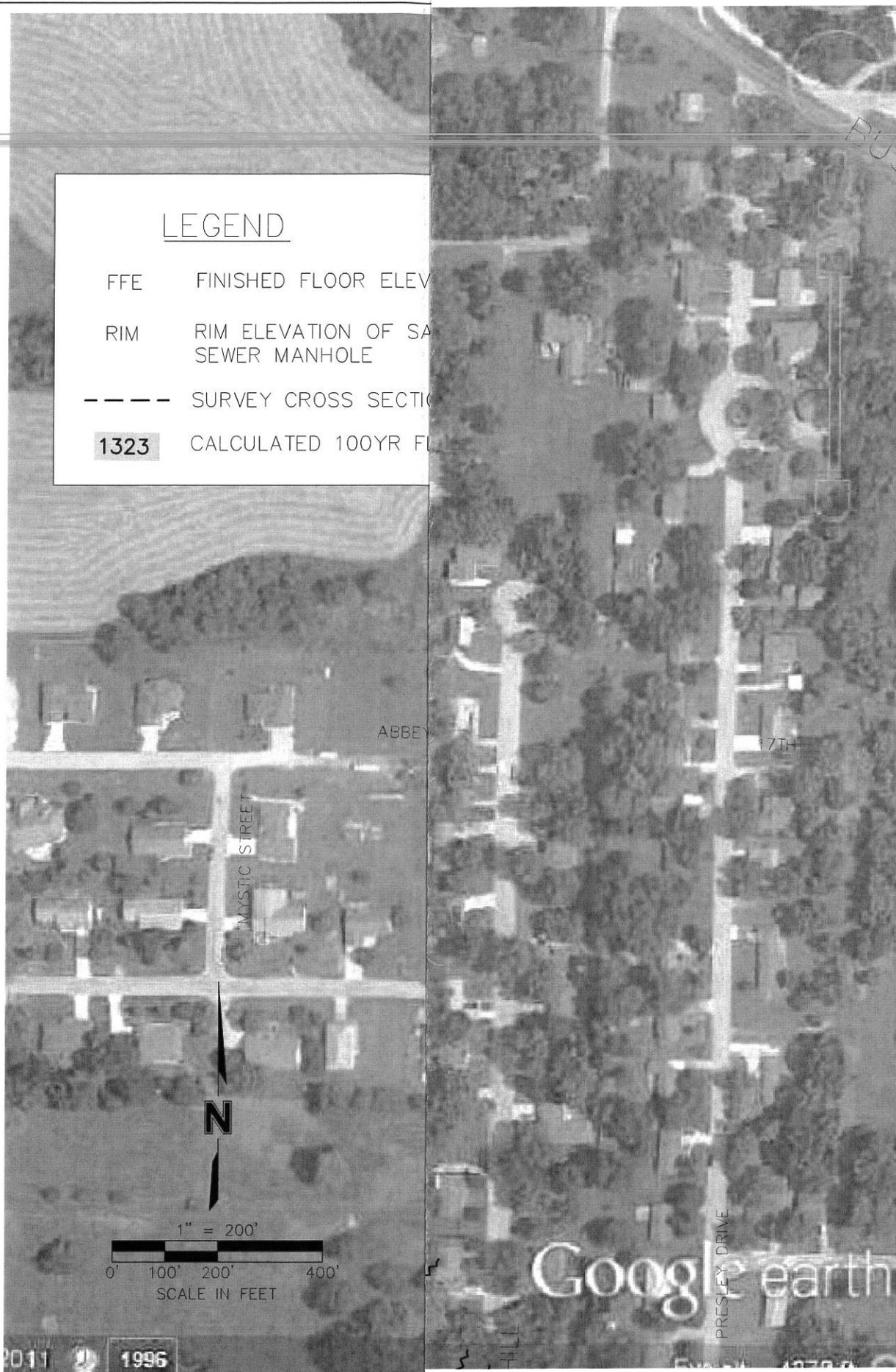


FIGURE

5

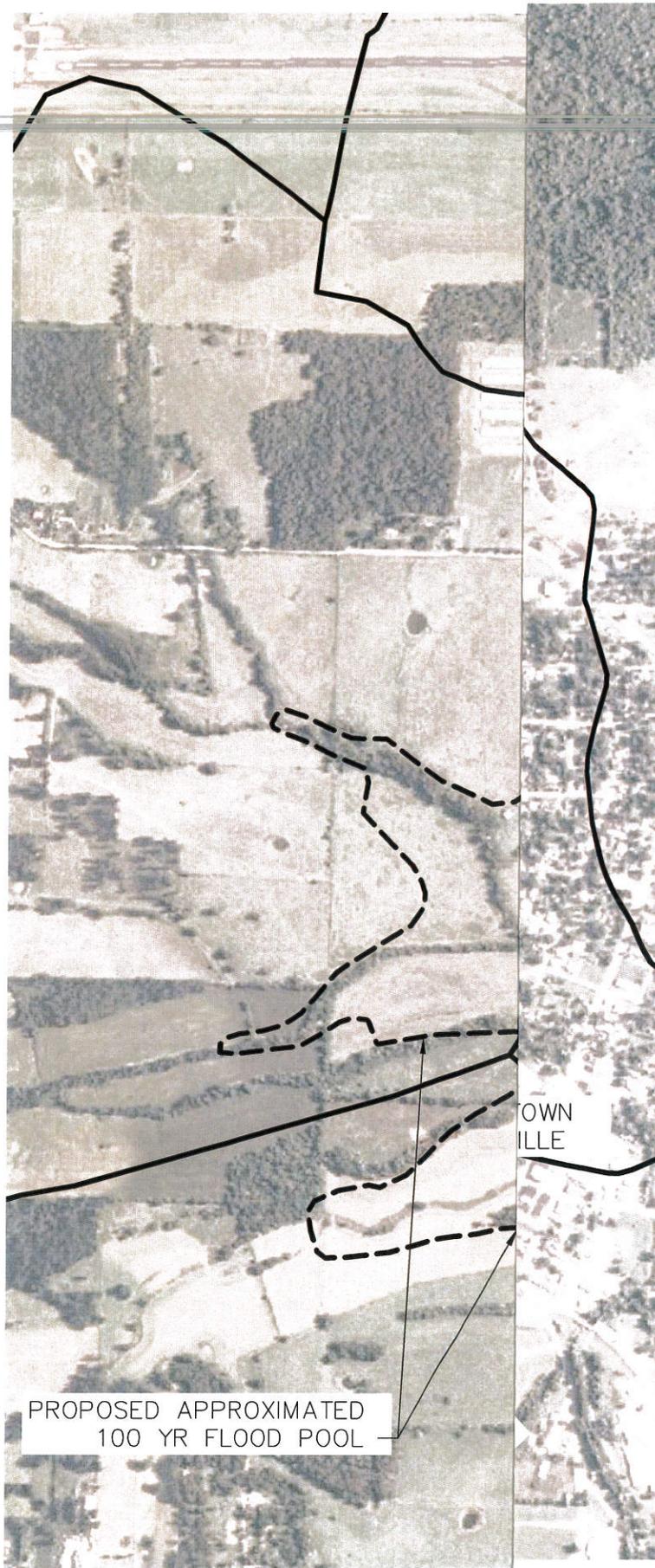
LEGEND

- FFE FINISHED FLOOR ELEVATION
- RIM RIM ELEVATION OF SANITARY SEWER MANHOLE
- SURVEY CROSS SECTION
- 1323** CALCULATED 100YR FLOOD ELEVATION



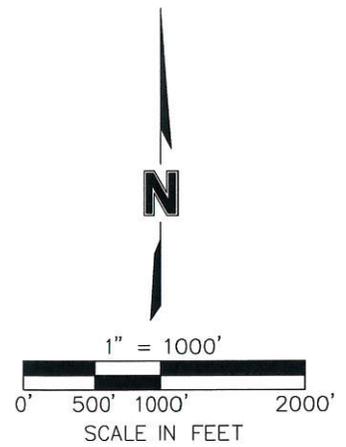
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LEGEND

- 100 YEAR PONDING ELEVATION
- LIMIT OF GRADING
- DRAINAGE AREA BOUNDARY



PROPOSED APPROXIMATED
100 YR FLOOD POOL

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FIGURE
7

APPENDIX A

Calculations

TR-55 Time of Concentration Calculations

IB-1

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	200	4	0.005		26.6

SCF		Time (min)
Length	Velocity (ft/s)	
350	4	1.46

Channel		Time (min)
Length	Velocity (ft/s)	
10682	10	17.8

Total **45.8**

IB-2

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	200	4	0.005		26.6

SCF		Time (min)
Length	Velocity (ft/s)	
300	4	1.25

Channel		Time (min)
Length	Velocity (ft/s)	
14857	10	24.8

Total **52.6**

Reach Length 1990

IB-3

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	175	4	0.005		23.9

SCF		Time (min)
Length	Velocity (ft/s)	
2830	6	7.86

Channel		Time (min)
Length	Velocity (ft/s)	
980	10	1.6

Total **33.4**

Reach Length 5050

IB-4

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	150	4	0.005		21.1

SCF		Time (min)
Length	Velocity (ft/s)	
3760	5	12.53

Channel		Time (min)
Length	Velocity (ft/s)	
3923	10	6.5

Total **40.2**

Reach Length 1325

IB-5

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	100	4	0.005		15.3

SCF		Time (min)
Length	Velocity (ft/s)	
4585	6	12.74

Channel		Time (min)
Length	Velocity (ft/s)	
415	10	0.7

Total **28.7**

HB-1

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	225	4	0.005		29.2

SCF		Time (min)
Length	Velocity (ft/s)	
1785	4	7.4375

Channel		Time (min)
Length	Velocity (ft/s)	
1398	10	2.3

Total **39.0**

Reach Length 5210

HB-2

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	300	4	0.01		27.8

SCF		Time (min)
Length	Velocity (ft/s)	
900	4	3.75

Channel		Time (min)
Length	Velocity (ft/s)	
5810	10	9.7

Total **41.3**

Reach Length 3450

HB-3

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	150	4	0.01		16.0

SCF		Time (min)
Length	Velocity (ft/s)	
250	7	0.5952381

Channel		Time (min)
Length	Velocity (ft/s)	
2400	10	4.0

Total **20.6**

HB-4

Overland					Time (min)
n	L	P ₂	S (ft/ft)		
0.15	150	4	0.01		16.0

SCF		Time (min)
Length	Velocity (ft/s)	
1000	7	2.3809524

Channel		Time (min)
Length	Velocity (ft/s)	
950	10	1.6

Total **20.0**

Critical Duration Analysis

Cassville, Missouri (From TP-40)

Rainfall Depth

		Duration					
		1hr	2hr	3hr	6hr	12hr	24hr
Return	1yr	1.5	1.82	2.05	2.3	2.8	3.3
	10yr	2.62	3.2	3.5	4.25	5.1	5.8
	100yr	3.75	4.5	5	6	7.2	8.4

100 year Peak Discharge

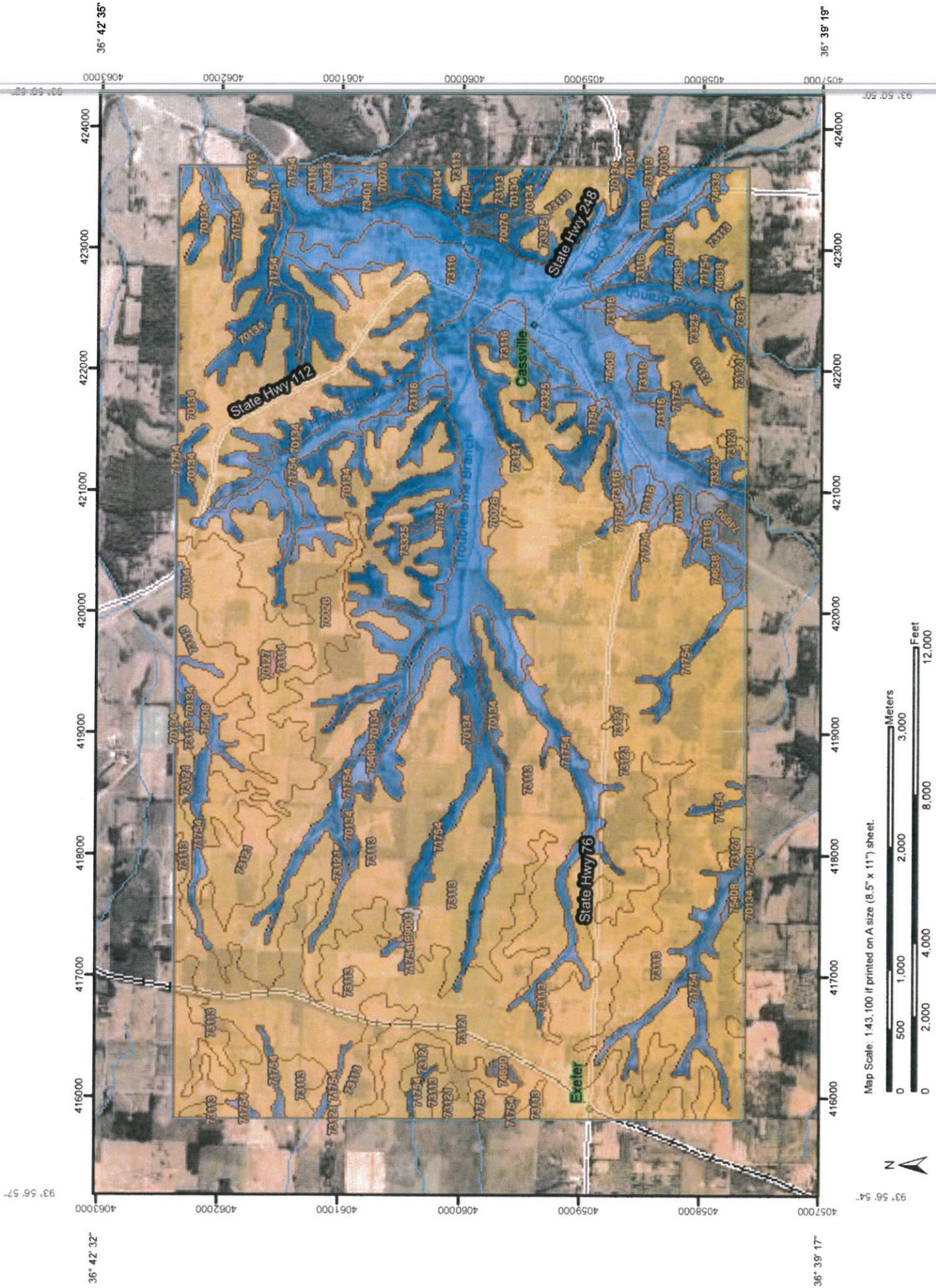
	Detention Drainage			Undetained Town Creek			Hawk Creek at Confluence with Town Branch		
	1yr	10yr	100yr	1yr	10yr	100yr	1yr	10yr	100yr
	1hr	196	1114	2491	49	267	594	57	329
2hr	297	<u>1317</u>	2668	63	<u>297</u>	<u>610</u>	87	<u>381</u>	768
3hr	323	1296	<u>2678</u>	71	287	594	95	375	<u>772</u>
6hr	280	1241	2419	57	258	502	83	362	704
12hr	360	1294	2308	73	262	466	106	379	675
24hr	<u>386</u>	1072	1853	<u>78</u>	215	366	<u>113</u>	314	542

Impact Point 2

	1yr	10yr	100yr
1hr	110	647	1376
2hr	201	747	<u>1451</u>
3hr	224	740	1451
6hr	211	718	1307
12hr	264	<u>768</u>	1291
24hr	<u>297</u>	683	1096

100 year Peak Stage for Detention Site

	1hr	2hr	3hr	6hr	12hr	24hr	48hr
100yr	1384.8	1386.9	1388.27	1390.61	1392.97	<u>1394.7</u>	1393.67



MAP LEGEND

- Area of Interest (AOI)**
 -  Area of Interest (AOI)
- Soils**
 -  Soil Map Units
- Soil Ratings**
 -  A
 -  A/D
 -  B
 -  B/D
 -  C
 -  C/D
 -  D
- Not rated or not available
- Political Features**
 -  Cities
- Water Features**
 -  Streams and Canals
- Transportation**
 -  Rails
 -  Interstate Highways
 -  US Routes
 -  Major Roads

MAP INFORMATION

Map Scale: 1:43,100 if printed on A size (8.5" x 11") sheet.
 The soil surveys that comprise your AOI were mapped at 1:24,000. Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>
 Coordinate System: UTM Zone 15N NAD83

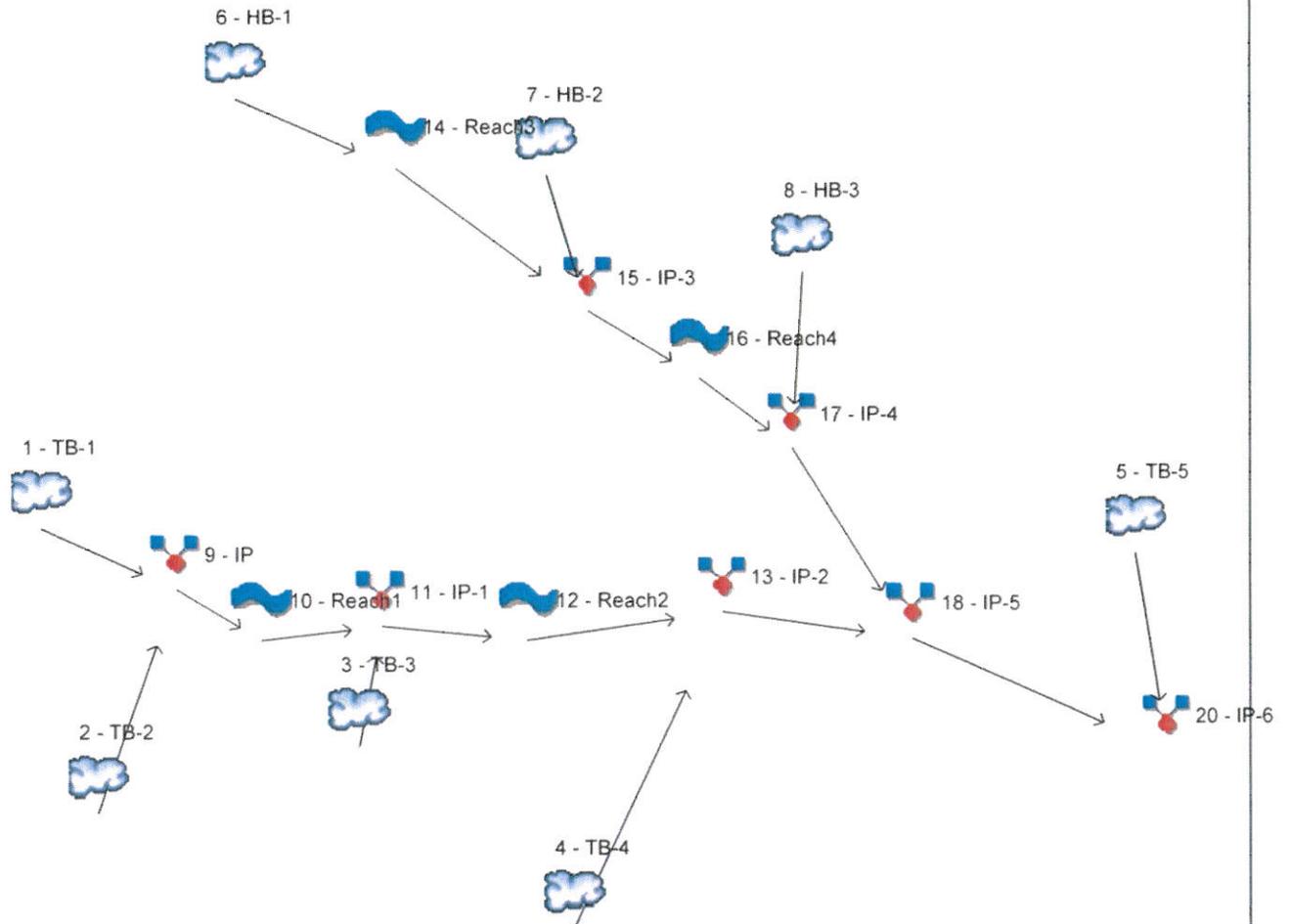
This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Barry County, Missouri
 Survey Area Data: Version 12, Oct 28, 2009
 Date(s) aerial images were photographed: 8/6/2007; 7/7/2007

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2011 by Autodesk, Inc. v8



Legend

Hyd. Origin	Description
1	SCS Runoff TB-1
2	SCS Runoff TB-2
3	SCS Runoff TB-3
4	SCS Runoff TB-4
5	SCS Runoff TB-5
6	SCS Runoff HB-1
7	SCS Runoff HB-2
8	SCS Runoff HB-3
9	Combine IP
10	Reach Reach1
11	Combine IP-1
12	Reach Reach2
13	Combine IP-2
14	Reach Reach3
15	Combine IP-3
16	Reach Reach4
17	Combine IP-4
18	Combine IP-5
20	Combine IP-6

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2011 by Autodesk, Inc. v8

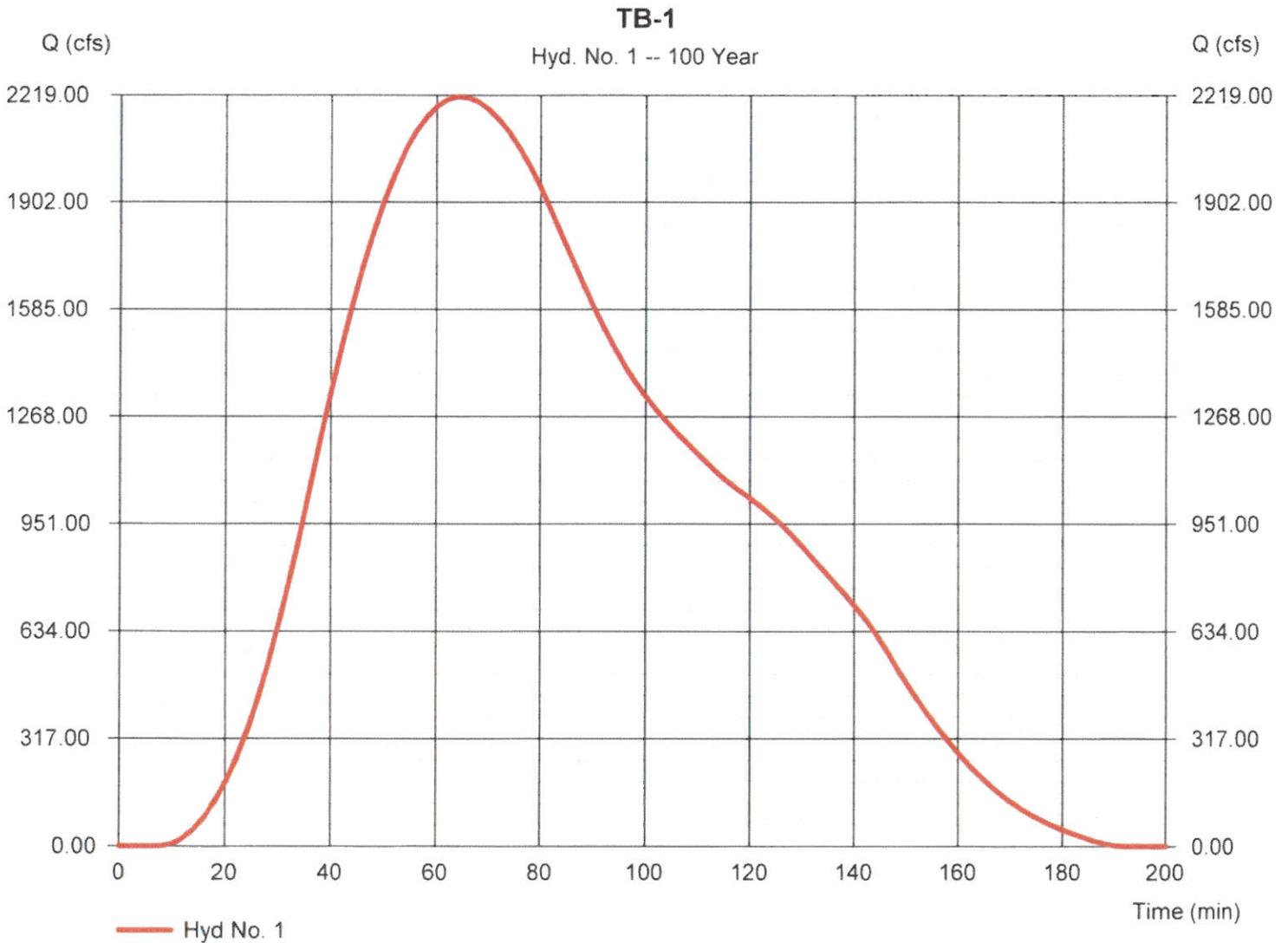
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	2212.66	2	64	10,819,074	-----	-----	-----	TB-1
2	SCS Runoff	1115.41	2	70	5,856,423	-----	-----	-----	TB-2
3	SCS Runoff	310.59	2	54	1,352,127	-----	-----	-----	TB-3
4	SCS Runoff	441.78	2	58	2,033,882	-----	-----	-----	TB-4
5	SCS Runoff	305.19	2	42	1,181,174	-----	-----	-----	TB-5
6	SCS Runoff	376.13	2	58	1,726,256	-----	-----	-----	HB-1
7	SCS Runoff	511.96	2	62	2,461,933	-----	-----	-----	HB-2
8	SCS Runoff	281.75	2	40	1,056,666	-----	-----	-----	HB-3
9	Combine	3315.06	2	66	16,675,498	1, 2,	-----	-----	IP
10	Reach	3303.70	2	70	16,675,496	9	-----	-----	Reach1
11	Combine	3556.63	2	68	18,027,628	3, 10	-----	-----	IP-1
12	Reach	3470.22	2	76	18,027,620	11	-----	-----	Reach2
13	Combine	3835.07	2	74	20,061,498	4, 12	-----	-----	IP-2
14	Reach	350.05	2	70	1,726,250	6	-----	-----	Reach3
15	Combine	856.46	2	66	4,188,182	7, 14	-----	-----	IP-3
16	Reach	839.59	2	72	4,188,179	15	-----	-----	Reach4
17	Combine	984.38	2	68	5,244,846	8, 16	-----	-----	IP-4
18	Combine	4802.47	2	74	25,306,344	13, 17	-----	-----	IP-5
20	Combine	4964.23	2	72	26,487,516	5, 18,	-----	-----	IP-6

Hydrograph Report

Hyd. No. 1

TB-1

Hydrograph type	= SCS Runoff	Peak discharge	= 2212.66 cfs
Storm frequency	= 100 yrs	Time to peak	= 64 min
Time interval	= 2 min	Hyd. volume	= 10,819,074 cuft
Drainage area	= 1733.000 ac	Curve number	= 70.4
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 46.90 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484



Hydrograph Report

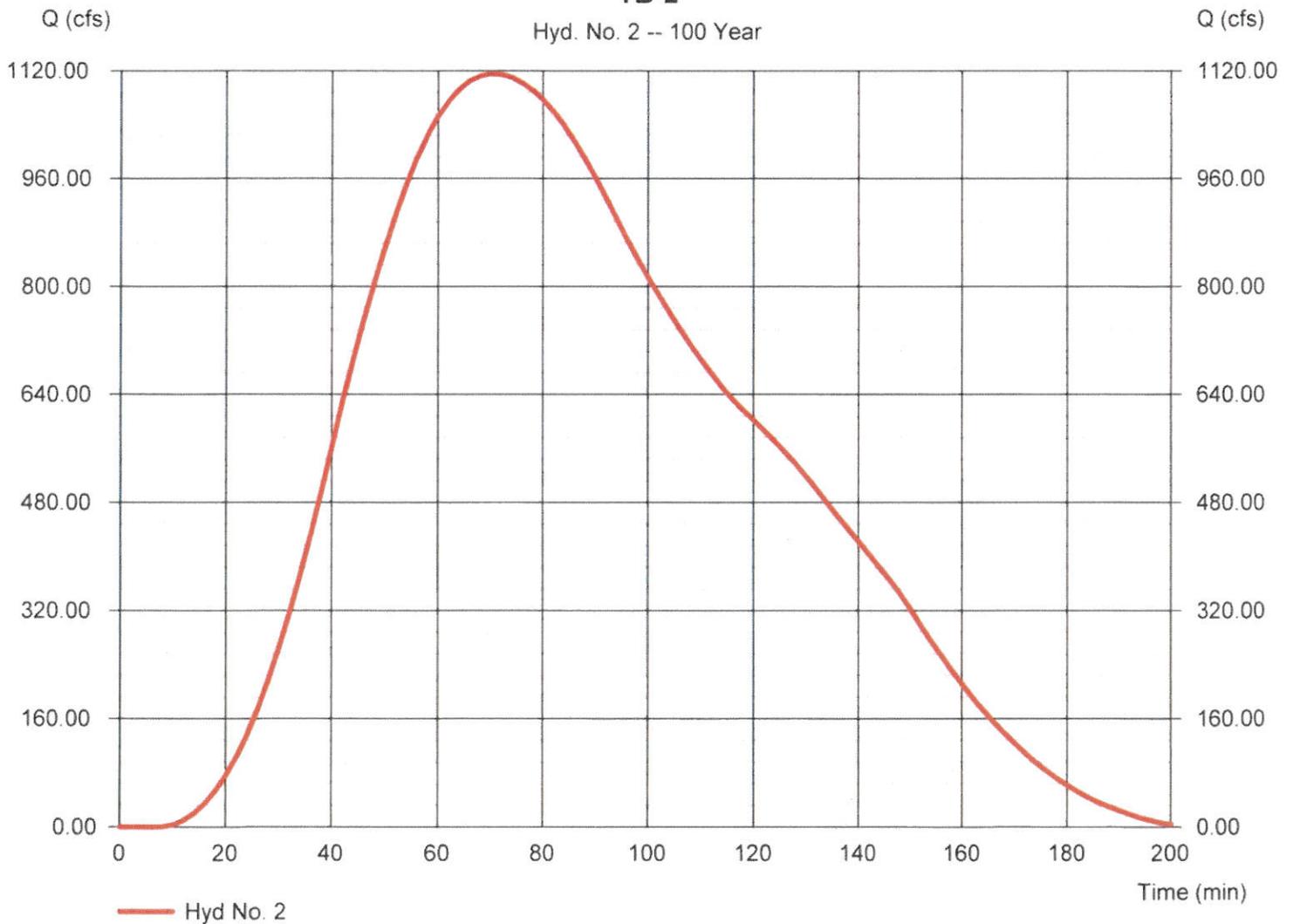
Hyd. No. 2

TB-2

Hydrograph type	= SCS Runoff	Peak discharge	= 1115.41 cfs
Storm frequency	= 100 yrs	Time to peak	= 70 min
Time interval	= 2 min	Hyd. volume	= 5,856,423 cuft
Drainage area	= 922.500 ac	Curve number	= 70.4
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 52.00 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484

TB-2

Hyd. No. 2 -- 100 Year

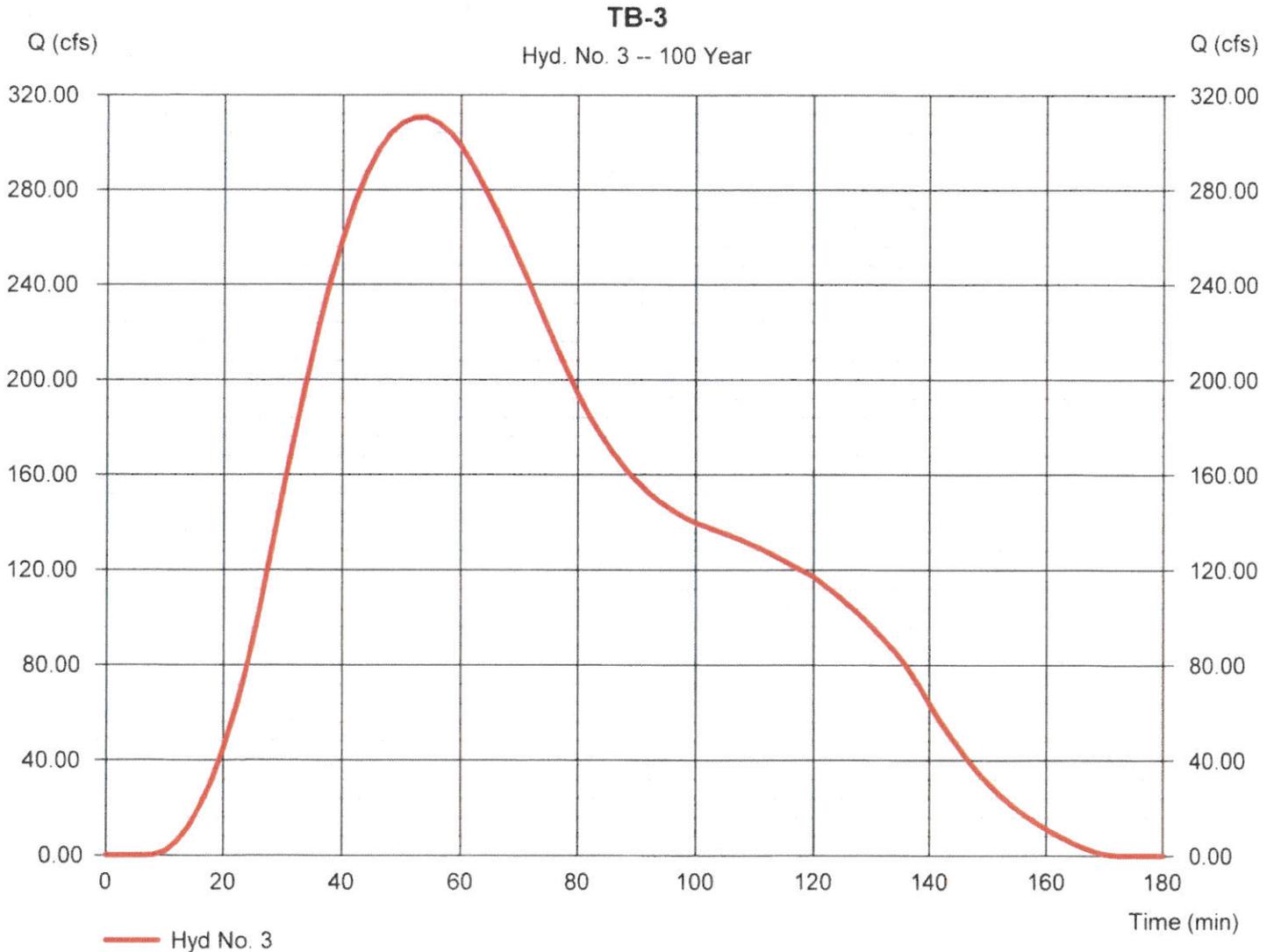


Hydrograph Report

Hyd. No. 3

TB-3

Hydrograph type	= SCS Runoff	Peak discharge	= 310.59 cfs
Storm frequency	= 100 yrs	Time to peak	= 54 min
Time interval	= 2 min	Hyd. volume	= 1,352,127 cuft
Drainage area	= 212.000 ac	Curve number	= 70.4
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 33.40 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484

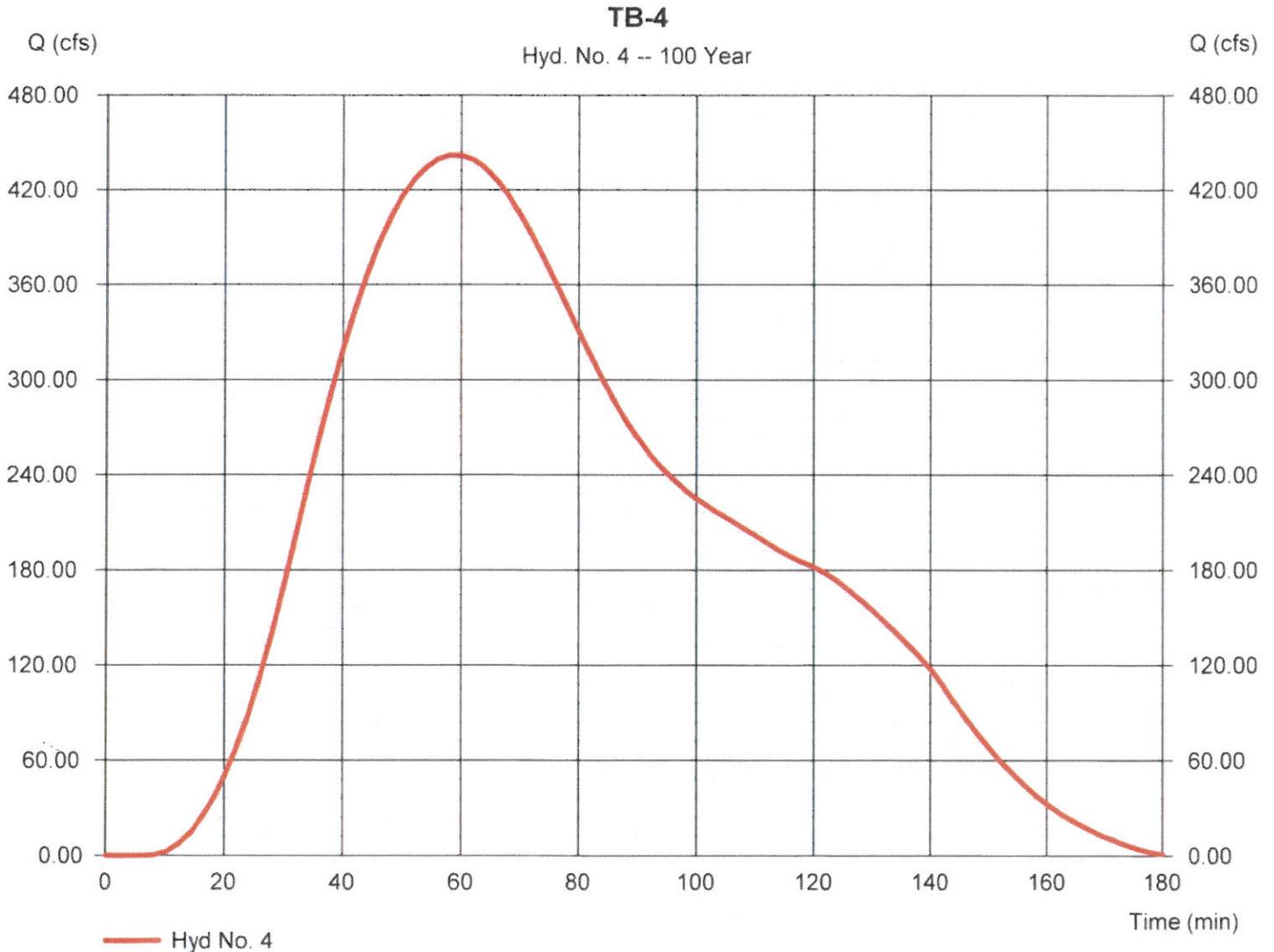


Hydrograph Report

Hyd. No. 4

TB-4

Hydrograph type	= SCS Runoff	Peak discharge	= 441.78 cfs
Storm frequency	= 100 yrs	Time to peak	= 58 min
Time interval	= 2 min	Hyd. volume	= 2,033,882 cuft
Drainage area	= 316.000 ac	Curve number	= 70.9
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 40.20 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484

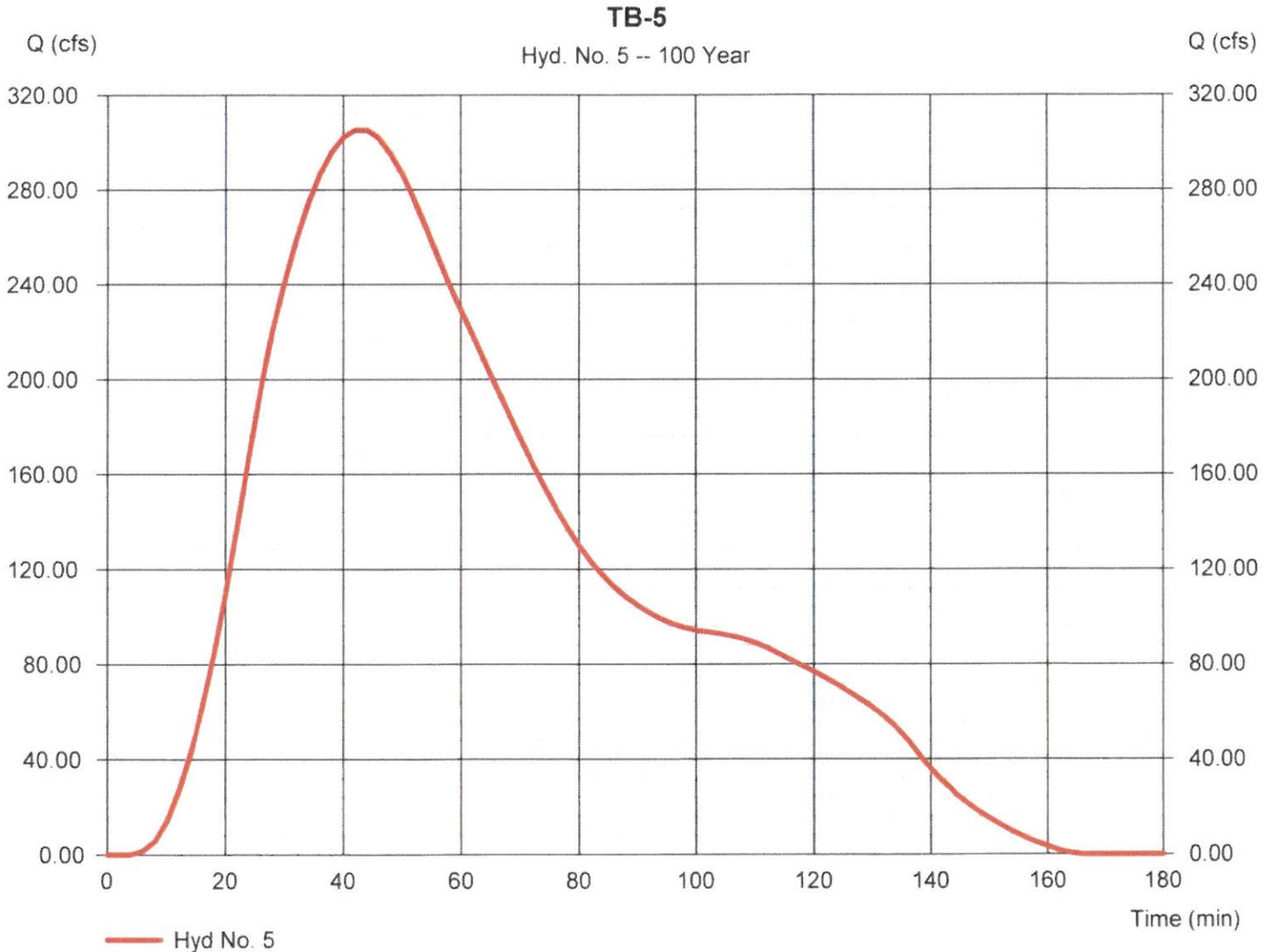


Hydrograph Report

Hyd. No. 5

TB-5

Hydrograph type	= SCS Runoff	Peak discharge	= 305.19 cfs
Storm frequency	= 100 yrs	Time to peak	= 42 min
Time interval	= 2 min	Hyd. volume	= 1,181,174 cuft
Drainage area	= 115.000 ac	Curve number	= 83.7
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 28.70 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484

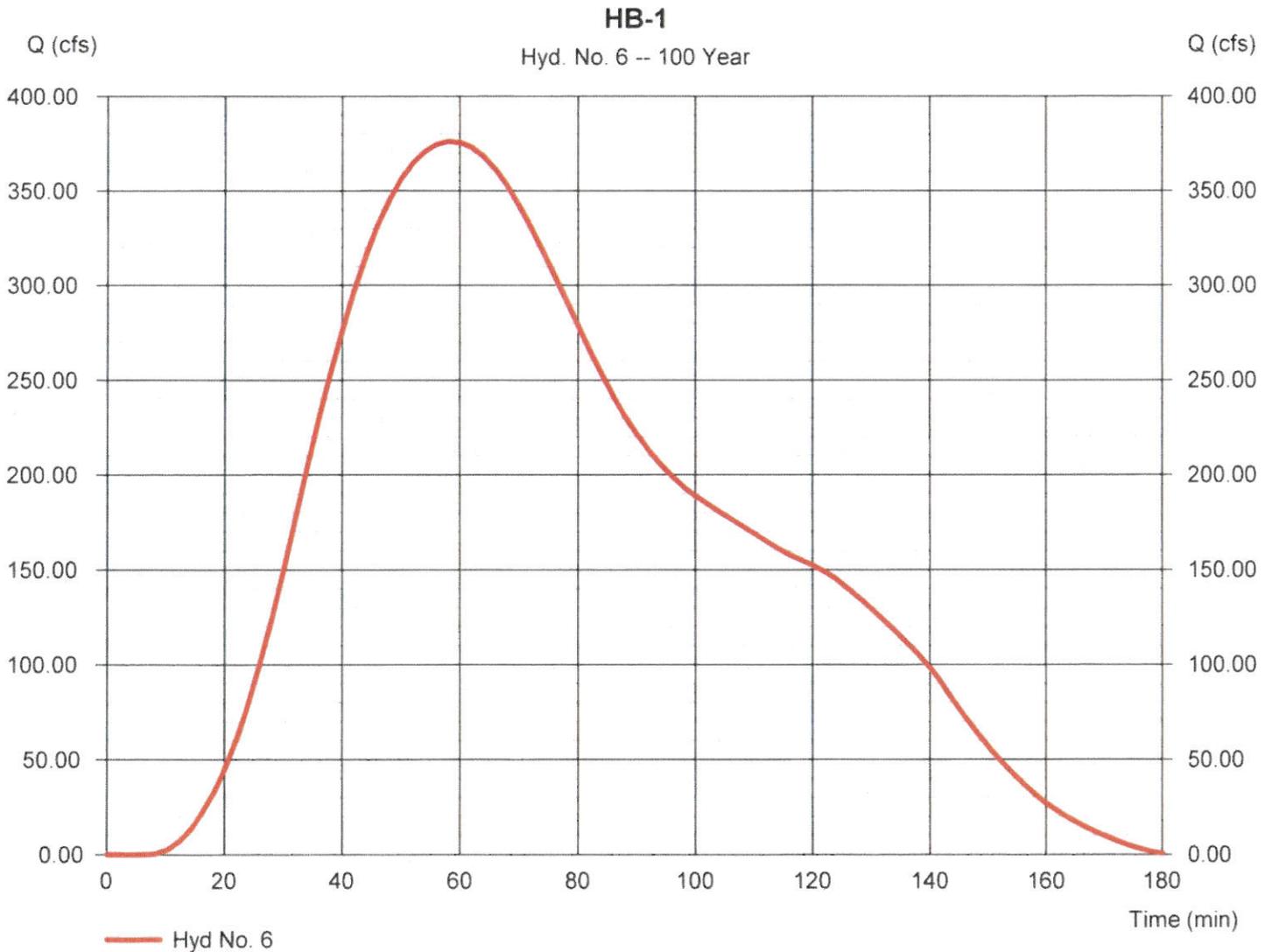


Hydrograph Report

Hyd. No. 6

HB-1

Hydrograph type	= SCS Runoff	Peak discharge	= 376.13 cfs
Storm frequency	= 100 yrs	Time to peak	= 58 min
Time interval	= 2 min	Hyd. volume	= 1,726,256 cuft
Drainage area	= 260.400 ac	Curve number	= 71.6
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 39.00 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484

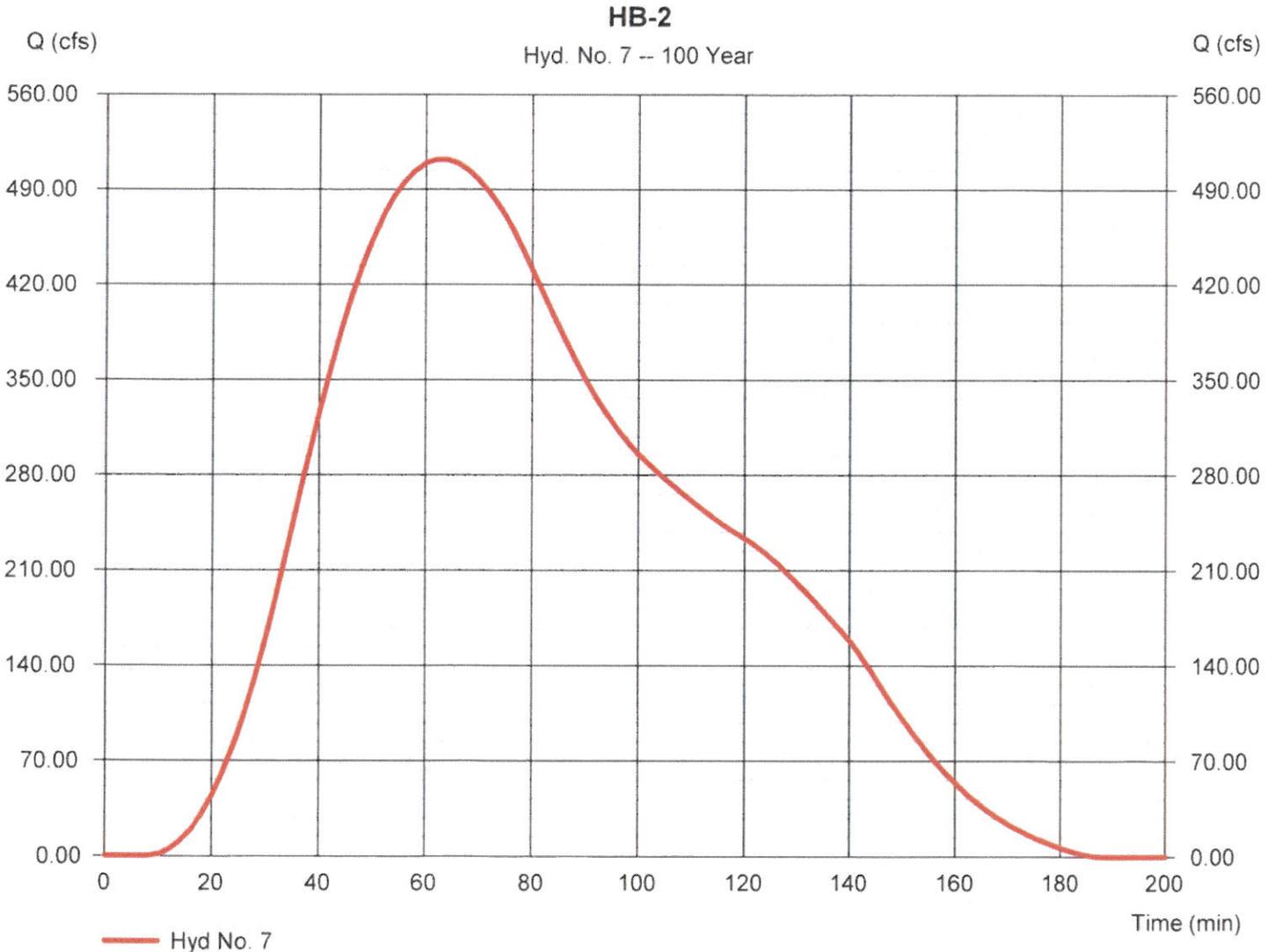


Hydrograph Report

Hyd. No. 7

HB-2

Hydrograph type	= SCS Runoff	Peak discharge	= 511.96 cfs
Storm frequency	= 100 yrs	Time to peak	= 62 min
Time interval	= 2 min	Hyd. volume	= 2,461,933 cuft
Drainage area	= 409.000 ac	Curve number	= 69.1
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 41.30 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484

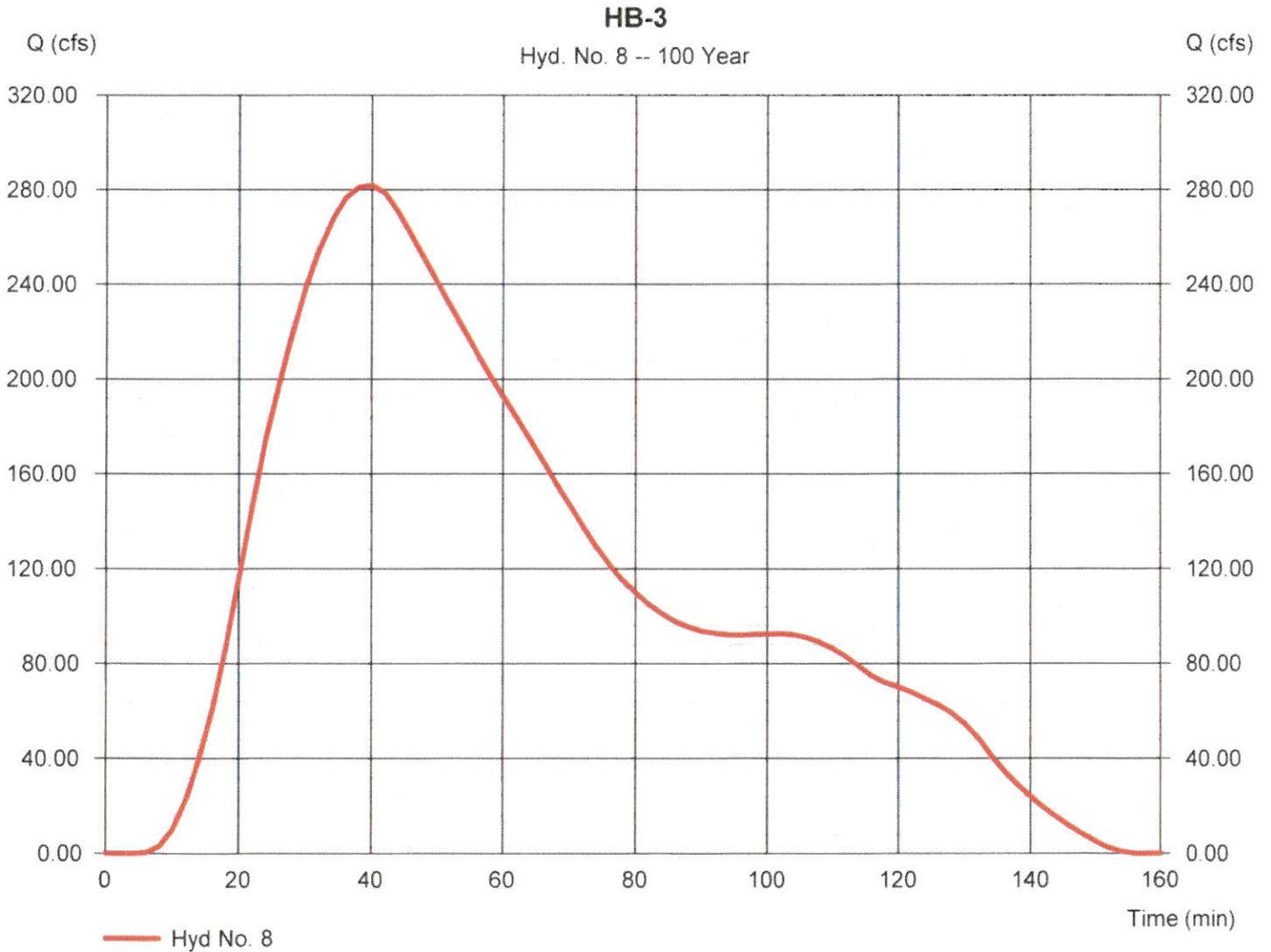


Hydrograph Report

Hyd. No. 8

HB-3

Hydrograph type	= SCS Runoff	Peak discharge	= 281.75 cfs
Storm frequency	= 100 yrs	Time to peak	= 40 min
Time interval	= 2 min	Hyd. volume	= 1,056,666 cuft
Drainage area	= 124.000 ac	Curve number	= 77.7
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 21.50 min
Total precip.	= 4.55 in	Distribution	= Huff-1st
Storm duration	= 2.00 hrs	Shape factor	= 484

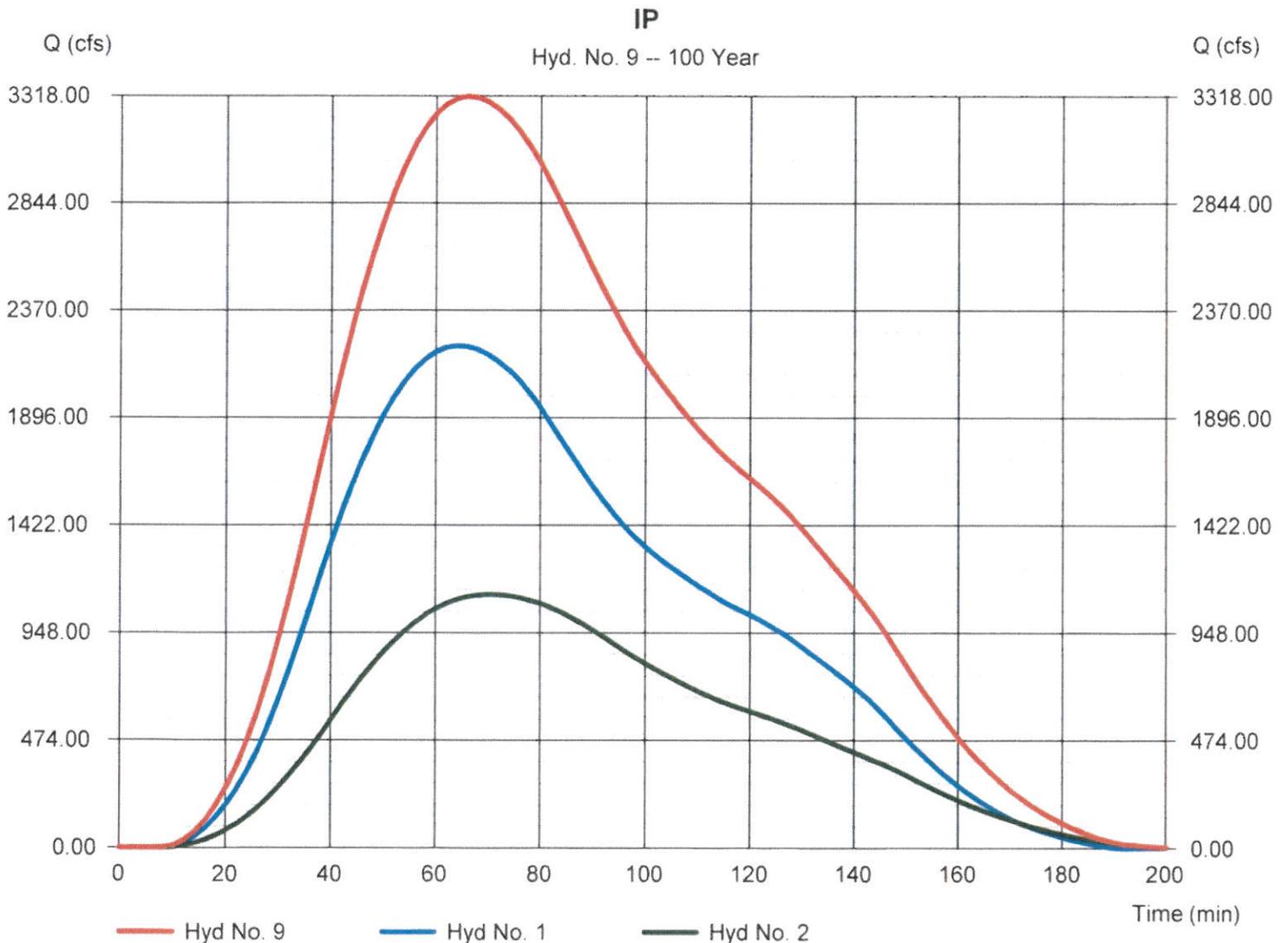


Hydrograph Report

Hyd. No. 9

IP

Hydrograph type	= Combine	Peak discharge	= 3315.06 cfs
Storm frequency	= 100 yrs	Time to peak	= 66 min
Time interval	= 2 min	Hyd. volume	= 16,675,498 cuft
Inflow hyds.	= 1, 2	Contrib. drain. area	= 2655.500 ac



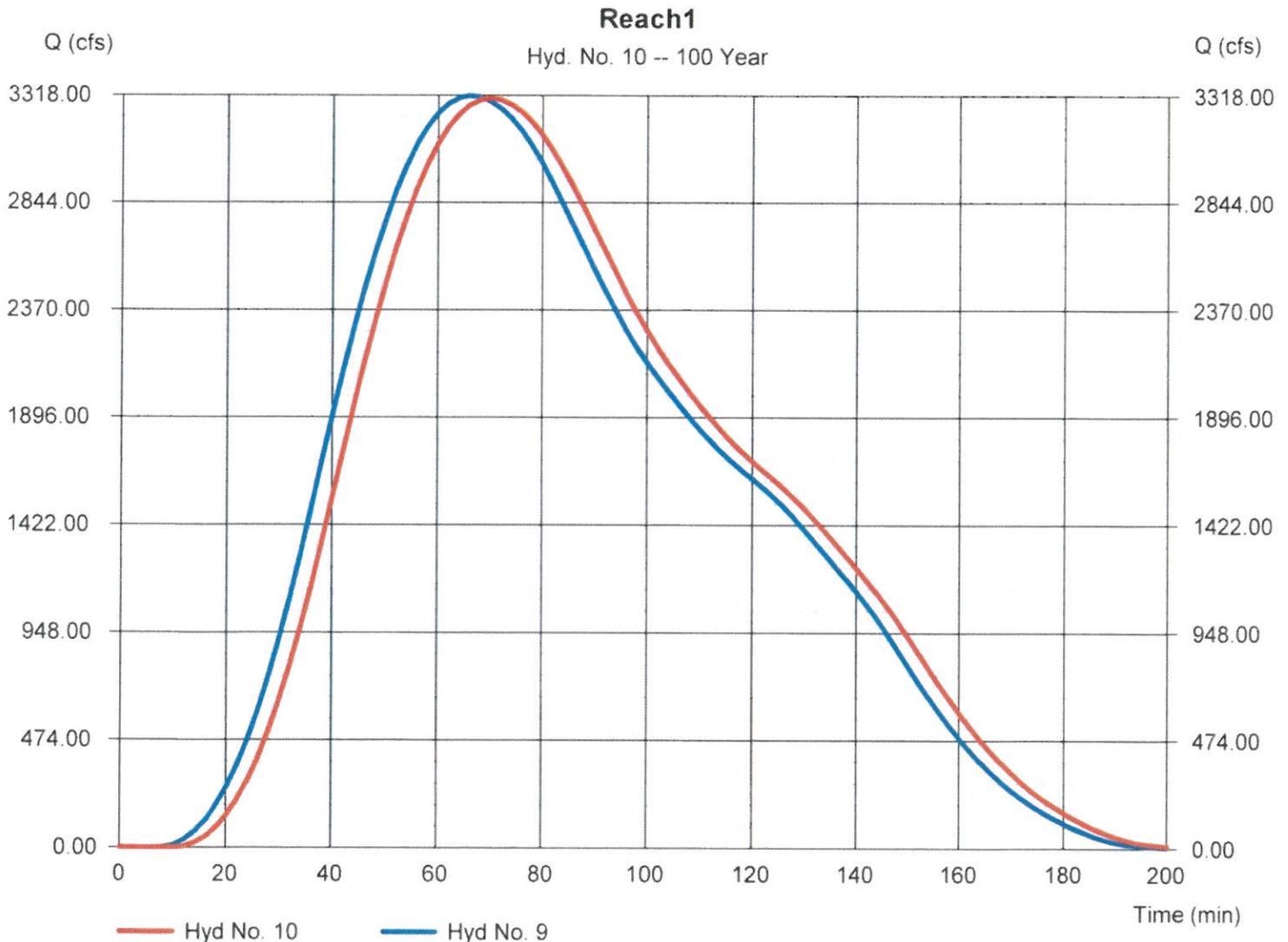
Hydrograph Report

Hyd. No. 10

Reach1

Hydrograph type	= Reach	Peak discharge	= 3303.70 cfs
Storm frequency	= 100 yrs	Time to peak	= 70 min
Time interval	= 2 min	Hyd. volume	= 16,675,496 cuft
Inflow hyd. No.	= 9 - IP	Section type	= Trapezoidal
Reach length	= 1990.0 ft	Channel slope	= 1.0 %
Manning's n	= 0.035	Bottom width	= 6.0 ft
Side slope	= 4.0:1	Max. depth	= 5.0 ft
Rating curve x	= 1.289	Rating curve m	= 1.338
Ave. velocity	= 9.39 ft/s	Routing coeff.	= 0.5495

Modified Att-Kin routing method used.

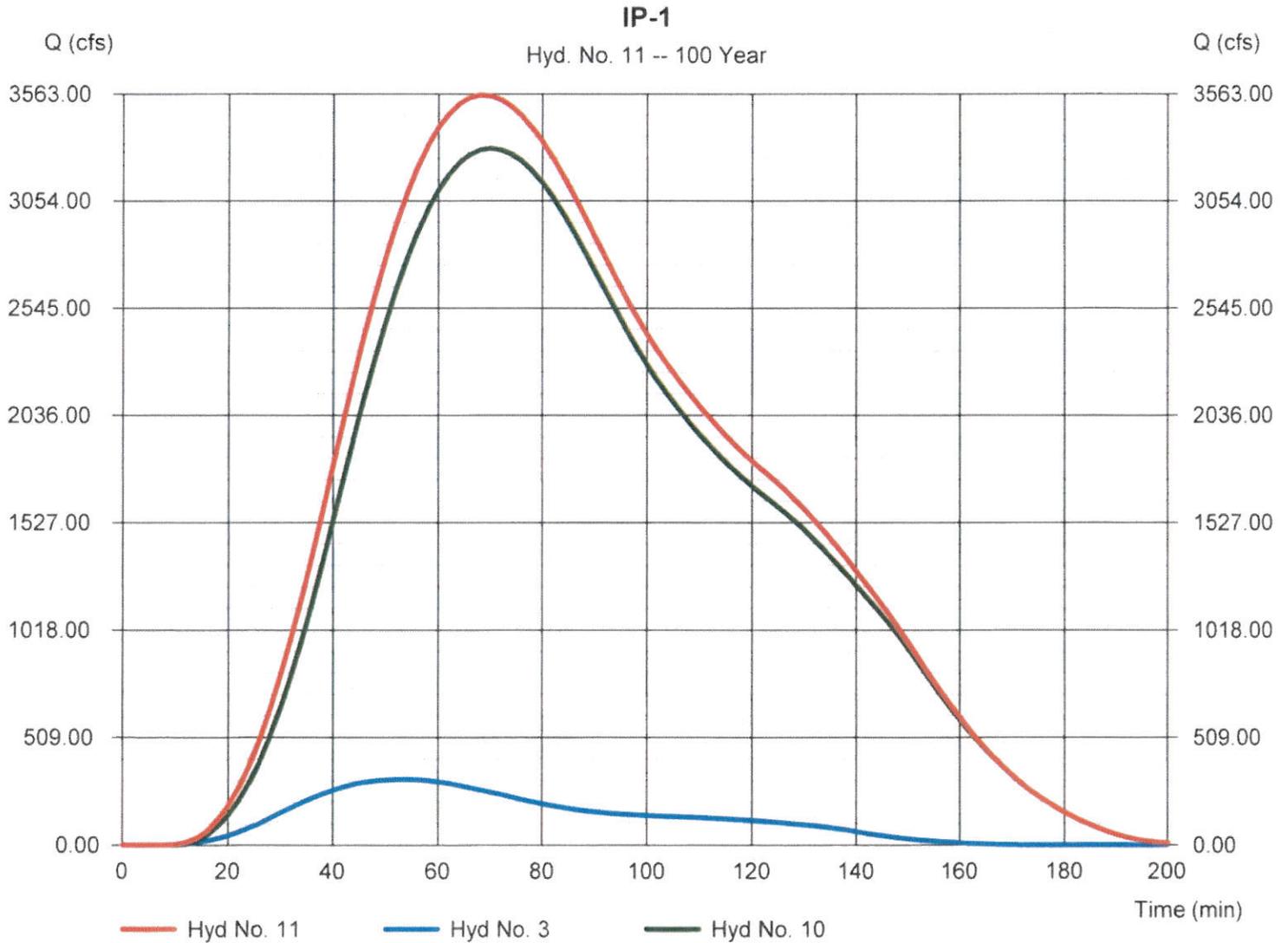


Hydrograph Report

Hyd. No. 11

IP-1

Hydrograph type	= Combine	Peak discharge	= 3556.63 cfs
Storm frequency	= 100 yrs	Time to peak	= 68 min
Time interval	= 2 min	Hyd. volume	= 18,027,628 cuft
Inflow hyds.	= 3, 10	Contrib. drain. area	= 212.000 ac



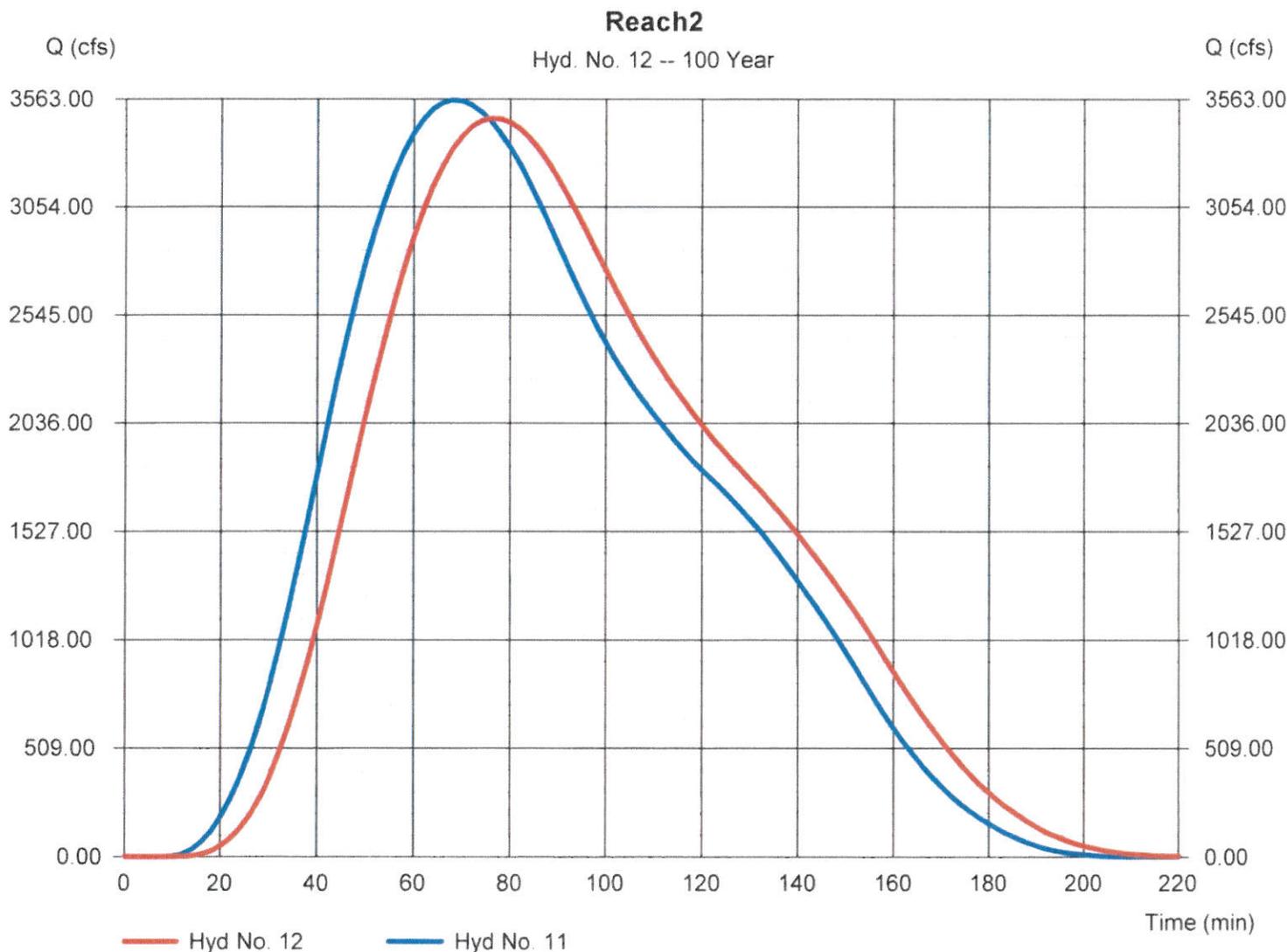
Hydrograph Report

Hyd. No. 12

Reach2

Hydrograph type	= Reach	Peak discharge	= 3470.22 cfs
Storm frequency	= 100 yrs	Time to peak	= 76 min
Time interval	= 2 min	Hyd. volume	= 18,027,620 cuft
Inflow hyd. No.	= 11 - IP-1	Section type	= Trapezoidal
Reach length	= 5050.0 ft	Channel slope	= 1.0 %
Manning's n	= 0.035	Bottom width	= 6.0 ft
Side slope	= 4.0:1	Max. depth	= 5.0 ft
Rating curve x	= 1.289	Rating curve m	= 1.338
Ave. velocity	= 9.56 ft/s	Routing coeff.	= 0.2638

Modified Att-Kin routing method used.

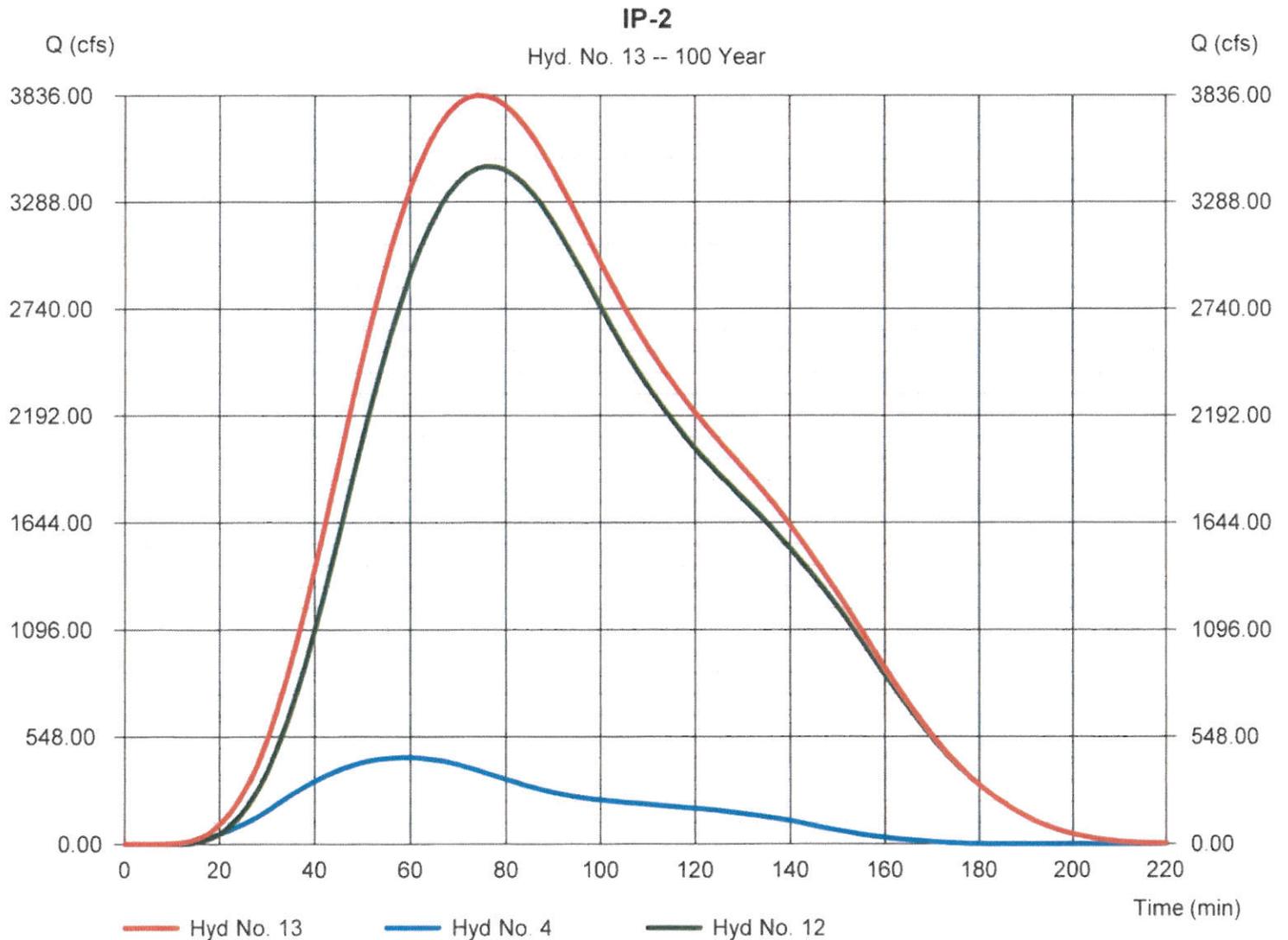


Hydrograph Report

Hyd. No. 13

IP-2

Hydrograph type	= Combine	Peak discharge	= 3835.07 cfs
Storm frequency	= 100 yrs	Time to peak	= 74 min
Time interval	= 2 min	Hyd. volume	= 20,061,498 cuft
Inflow hyds.	= 4, 12	Contrib. drain. area	= 316.000 ac



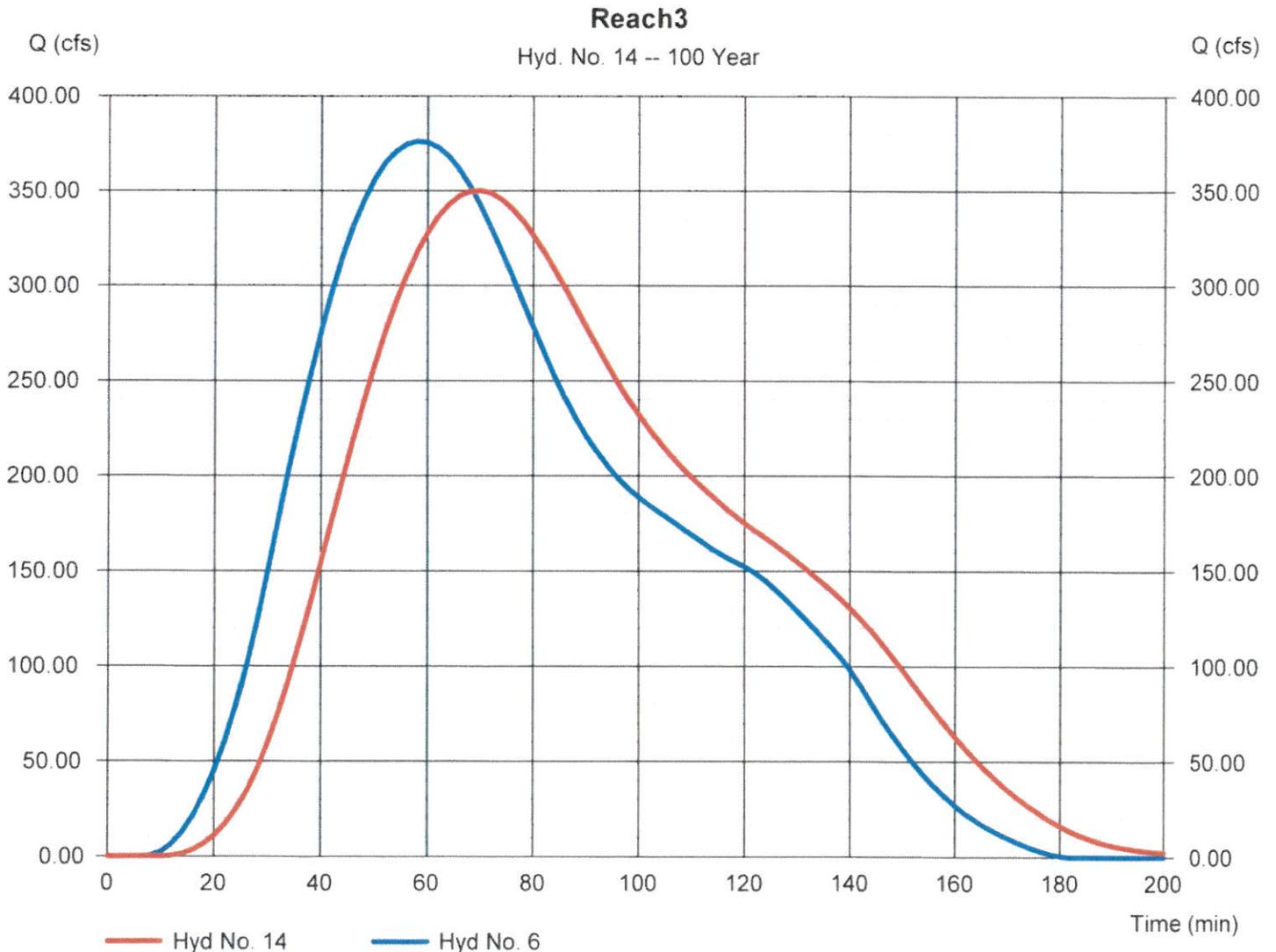
Hydrograph Report

Hyd. No. 14

Reach3

Hydrograph type	= Reach	Peak discharge	= 350.05 cfs
Storm frequency	= 100 yrs	Time to peak	= 70 min
Time interval	= 2 min	Hyd. volume	= 1,726,250 cuft
Inflow hyd. No.	= 6 - HB-1	Section type	= Trapezoidal
Reach length	= 5210.0 ft	Channel slope	= 1.5 %
Manning's n	= 0.035	Bottom width	= 6.0 ft
Side slope	= 4.0:1	Max. depth	= 5.0 ft
Rating curve x	= 1.578	Rating curve m	= 1.338
Ave. velocity	= 6.30 ft/s	Routing coeff.	= 0.1770

Modified Att-Kin routing method used.

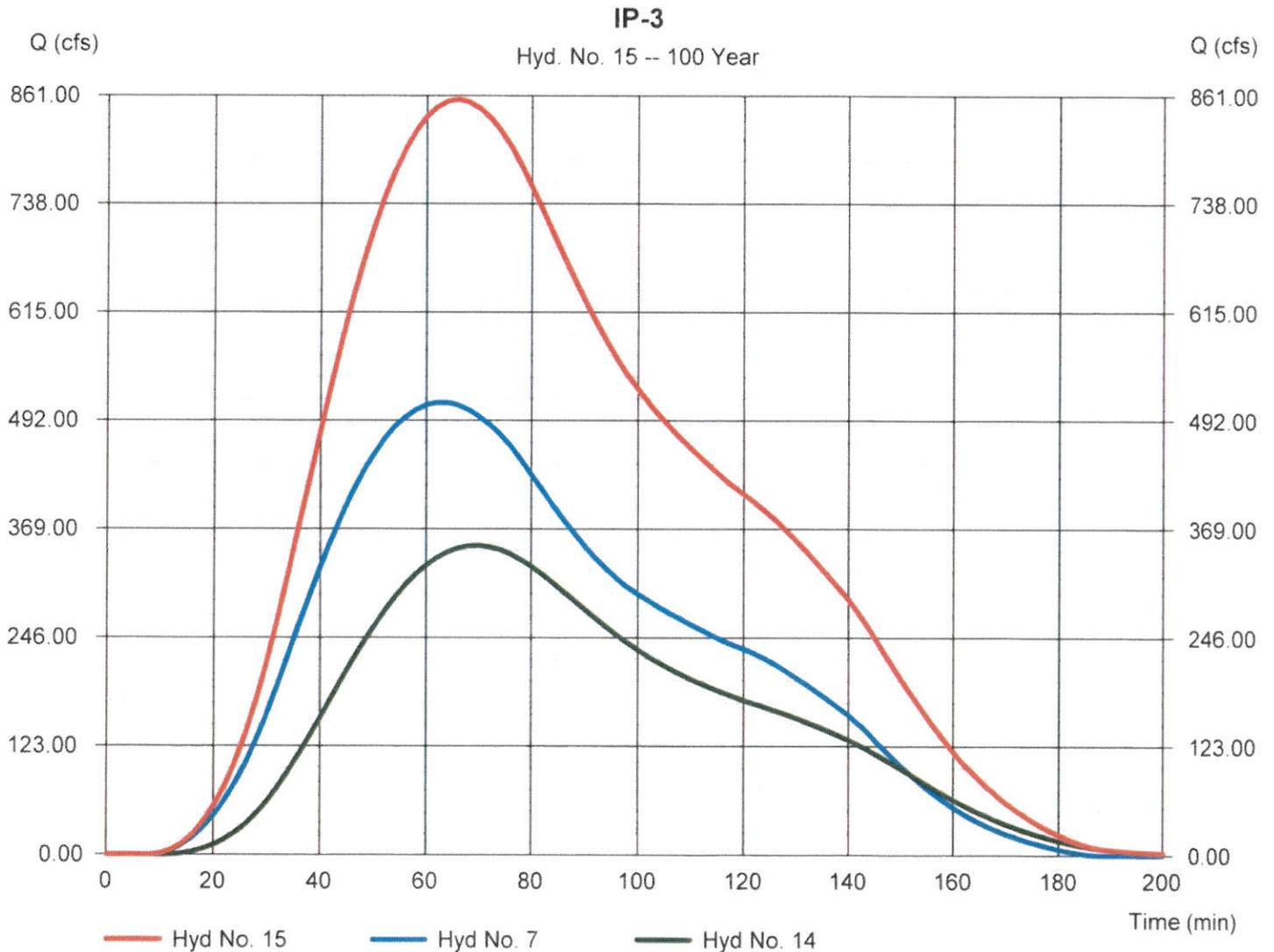


Hydrograph Report

Hyd. No. 15

IP-3

Hydrograph type	= Combine	Peak discharge	= 856.46 cfs
Storm frequency	= 100 yrs	Time to peak	= 66 min
Time interval	= 2 min	Hyd. volume	= 4,188,182 cuft
Inflow hyds.	= 7, 14	Contrib. drain. area	= 409.000 ac



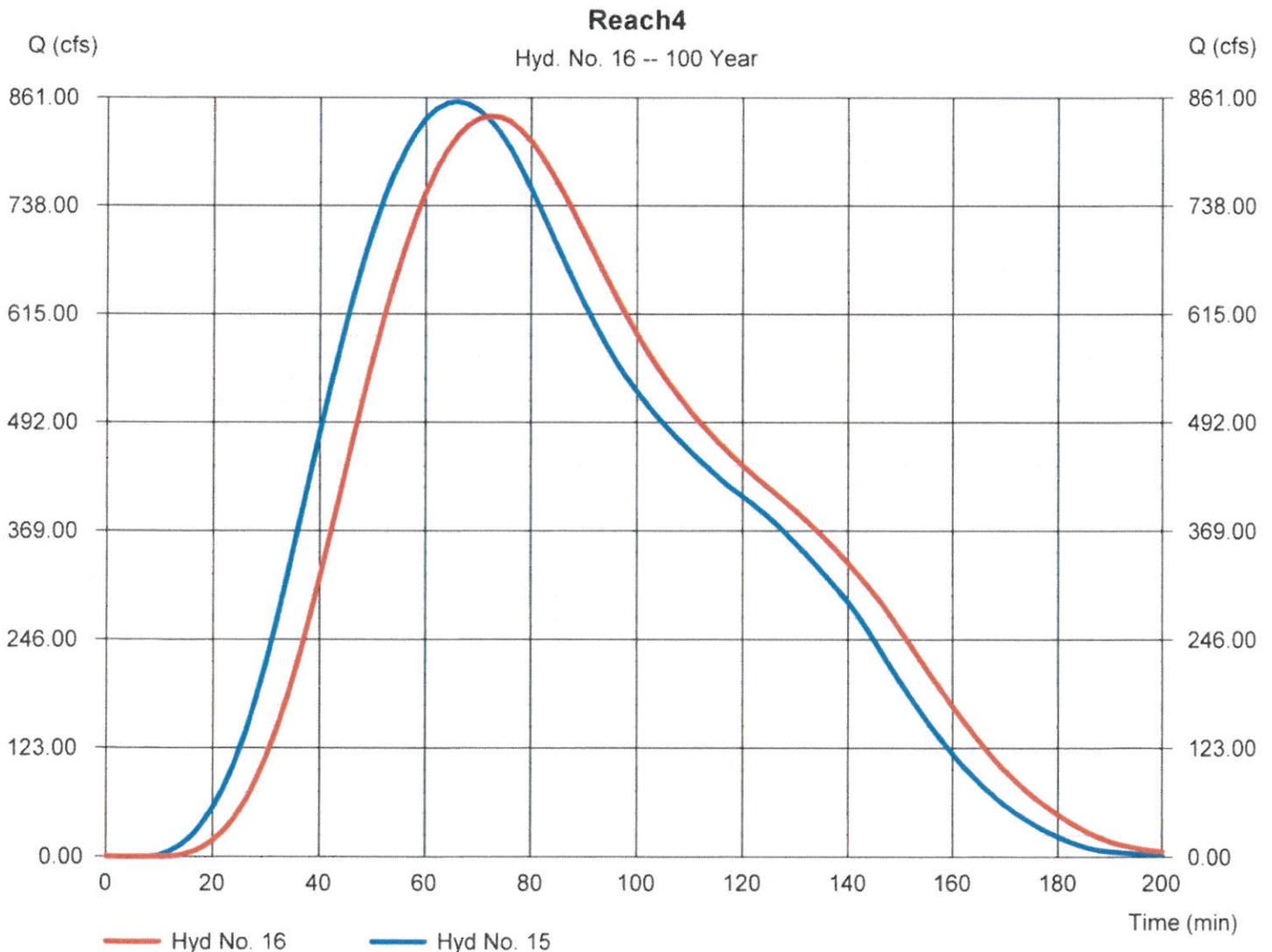
Hydrograph Report

Hyd. No. 16

Reach4

Hydrograph type	= Reach	Peak discharge	= 839.59 cfs
Storm frequency	= 100 yrs	Time to peak	= 72 min
Time interval	= 2 min	Hyd. volume	= 4,188,179 cuft
Inflow hyd. No.	= 15 - IP-3	Section type	= Trapezoidal
Reach length	= 3450.0 ft	Channel slope	= 1.5 %
Manning's n	= 0.035	Bottom width	= 6.0 ft
Side slope	= 4.0:1	Max. depth	= 5.0 ft
Rating curve x	= 1.578	Rating curve m	= 1.338
Ave. velocity	= 7.76 ft/s	Routing coeff.	= 0.3059

Modified Att-Kin routing method used.

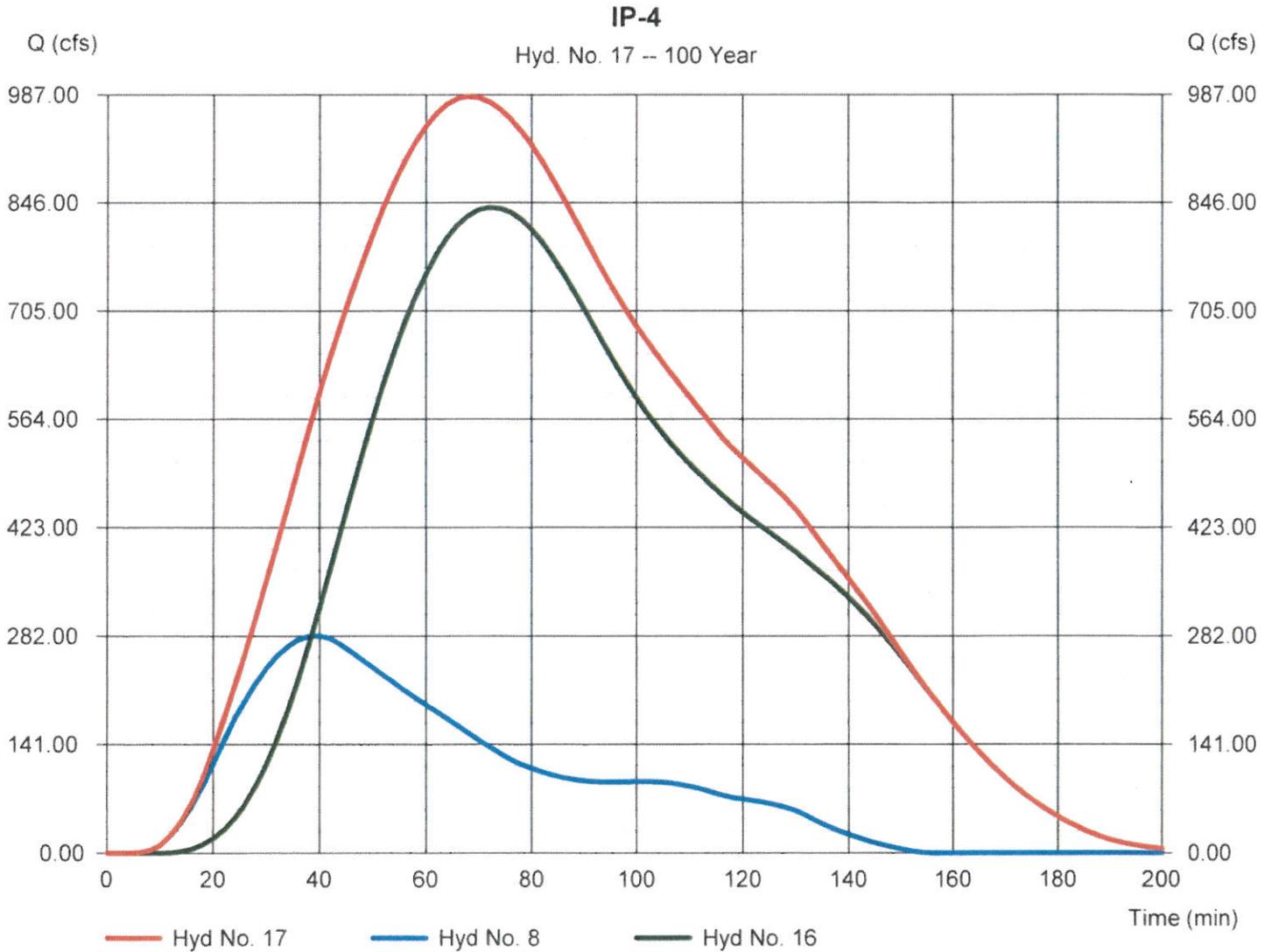


Hydrograph Report

Hyd. No. 17

IP-4

Hydrograph type	= Combine	Peak discharge	= 984.38 cfs
Storm frequency	= 100 yrs	Time to peak	= 68 min
Time interval	= 2 min	Hyd. volume	= 5,244,846 cuft
Inflow hyds.	= 8, 16	Contrib. drain. area	= 124.000 ac

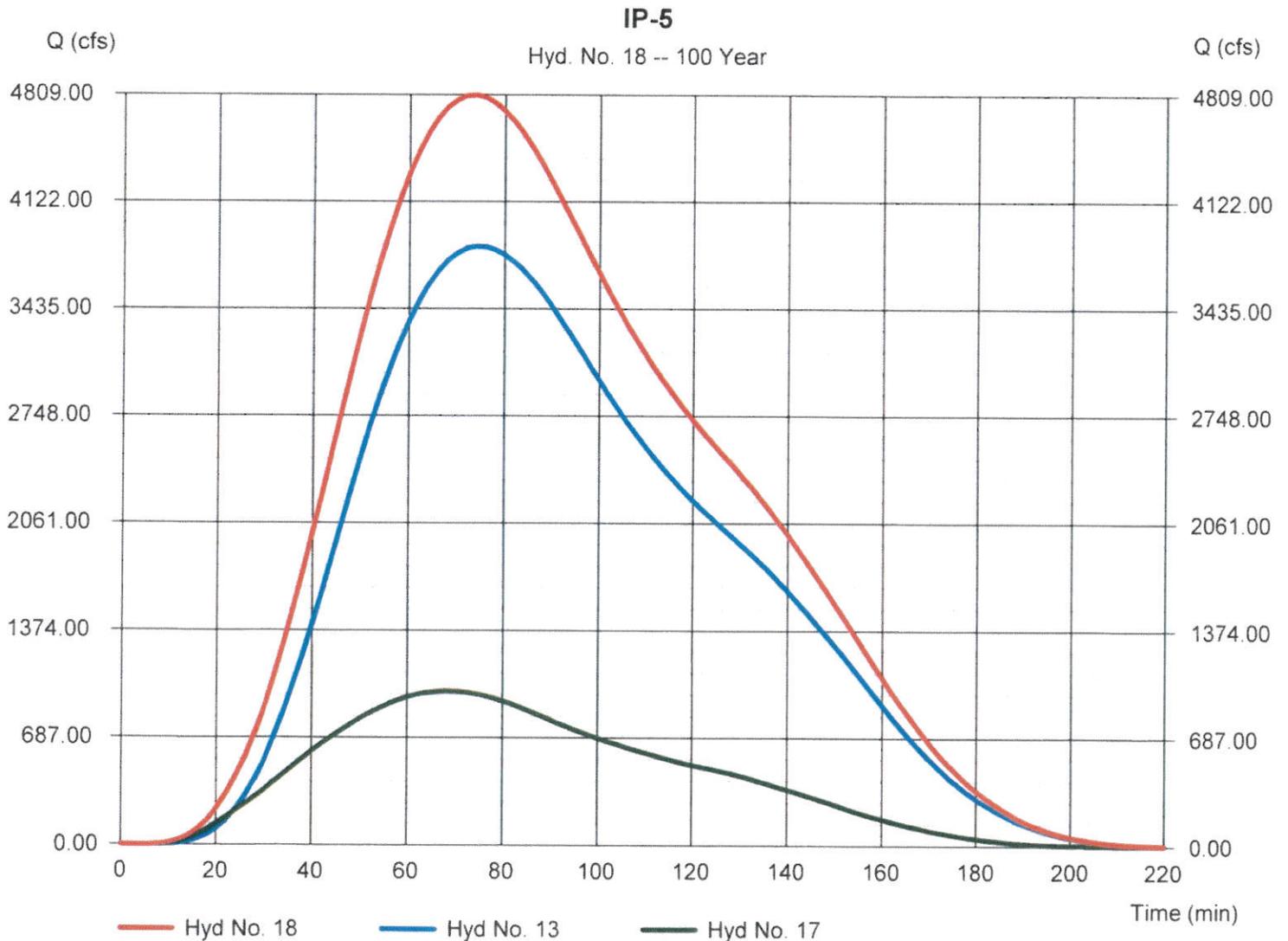


Hydrograph Report

Hyd. No. 18

IP-5

Hydrograph type	= Combine	Peak discharge	= 4802.47 cfs
Storm frequency	= 100 yrs	Time to peak	= 74 min
Time interval	= 2 min	Hyd. volume	= 25,306,344 cuft
Inflow hyds.	= 13, 17	Contrib. drain. area	= 0.000 ac



Hydrograph Report

Hyd. No. 20

IP-6

Hydrograph type	= Combine	Peak discharge	= 4964.23 cfs
Storm frequency	= 100 yrs	Time to peak	= 72 min
Time interval	= 2 min	Hyd. volume	= 26,487,516 cuft
Inflow hyds.	= 5, 18	Contrib. drain. area	= 115.000 ac

