DA-FR-046

DA-FR-046 is located in a meadow and forested areas with steep slopes and contains gravel roads and impervious areas. A stream crosses the drainage area. Total impervious area is less than 1.3% of the overall drainage area. No new impervious area is proposed within DA-FR-046. The total phosphorus load reduction required for DA-FR-046 is –1.20 lb/yr. Multiple points of analysis were evaluated within DA-FR-046 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-046 was sub-divided into six sub-drainage areas (sub-areas A through F).

Sub-area 046A contains both agricultural and non-agricultural areas within the limits of disturbance (LOD). Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction. In non-agricultural areas, land use will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. For SWM quality, agricultural areas within the LOD are considered/included and the total permanent ROW is analyzed via VRRM; agricultural areas are considered “Forest/Open Space” in these calculations.

Stormwater quantity is met via the energy balance method for each of the six sub-areas DA-FR-046A through DA-FR-046F. Agricultural areas within the study area are included in the SWM analysis, but an Improvement Factor (IF) of 1.0 is used when applying the Energy Balance Method. This improvement factor is used to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate a reduction in flows ranging from 0.00 to 2.93 cfs for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-046A	13.13	10.20	-2.93
DA-FR-046B	8.46	7.91	-0.55
DA-FR-046C	10.13	10.13	0.00
DA-FR-046D	9.90	9.31	-0.59
DA-FR-046E	3.25	3.03	-0.22
DA-FR-046F	1.08	0.94	-0.14

Figures and calculations for each of the sub-areas for DA-FR-046 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-046A
6.24 acres
Weighted CN =

DA-FR-046B
4.18 acres
Weighted CN =

DA-FR-046C
5.69 acres
Weighted CN =

DA-FR-046D
5.26 acres
Weighted CN =

DA-FR-046E
1.87 acres
Weighted CN =

DA-FR-046F
0.33 acres
Weighted CN =

DA-FR-046G
0.80 acres
Weighted CN =

S-E31
S-E30
S-E29
S-E28
S-E27
S-E26
S-E25
S-E24
S-E23
S-E22
S-E21

259.2
259.3
259.4
259.5
259.6
259.7
259.8
259.9

1200
1250
1300
1150
1200

Grassy Hill Rd
Green Level Rd

A
B
C

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Gravel
- Impervious
- Meadow
- Waterbody
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:3,000

250 125 0 250 Feet

N
W E
S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-046
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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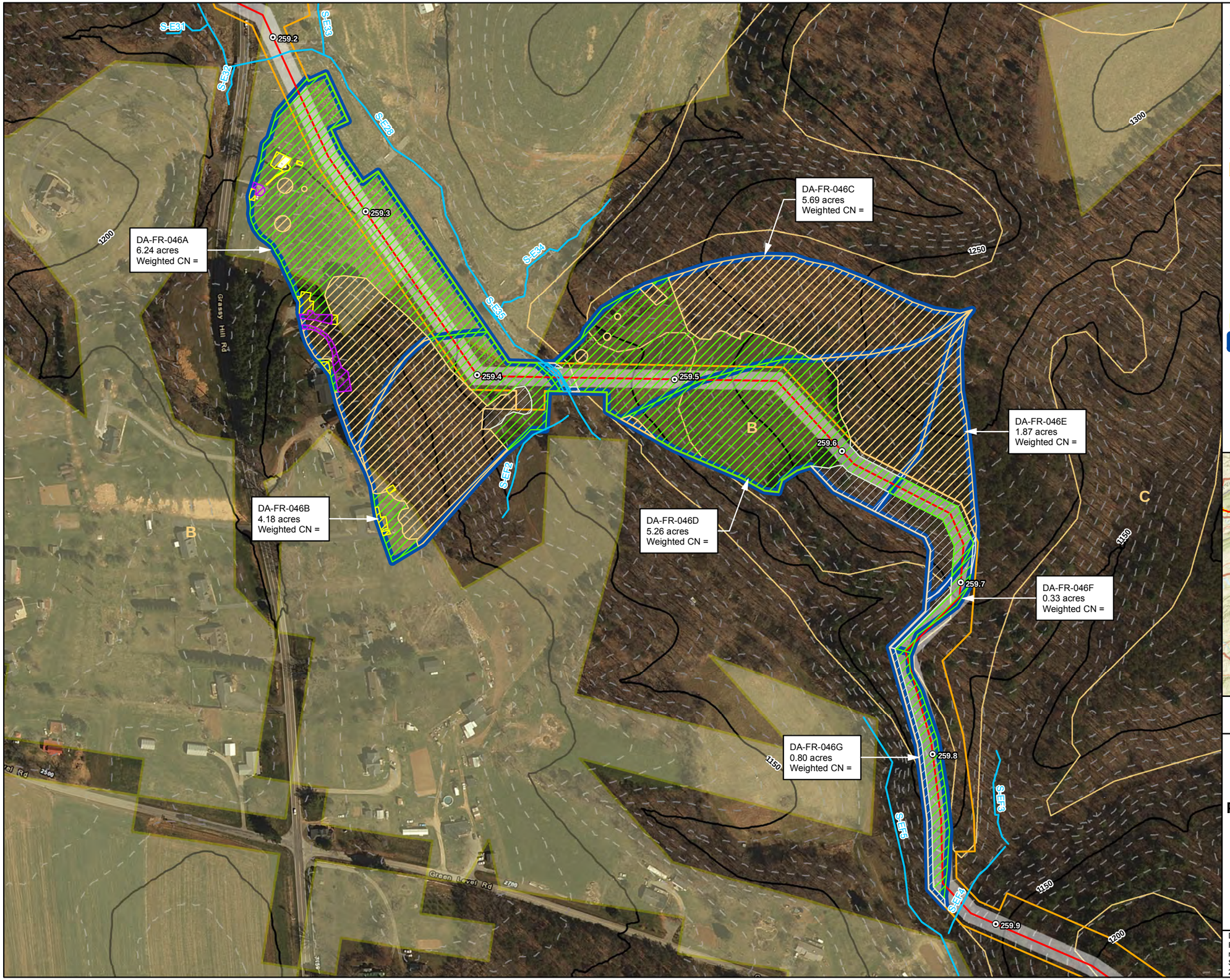

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Brush
- Gravel
- Impervious
- Meadow
- Waterbody
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:3,000

N
W E
S

250 125 0 250 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-046
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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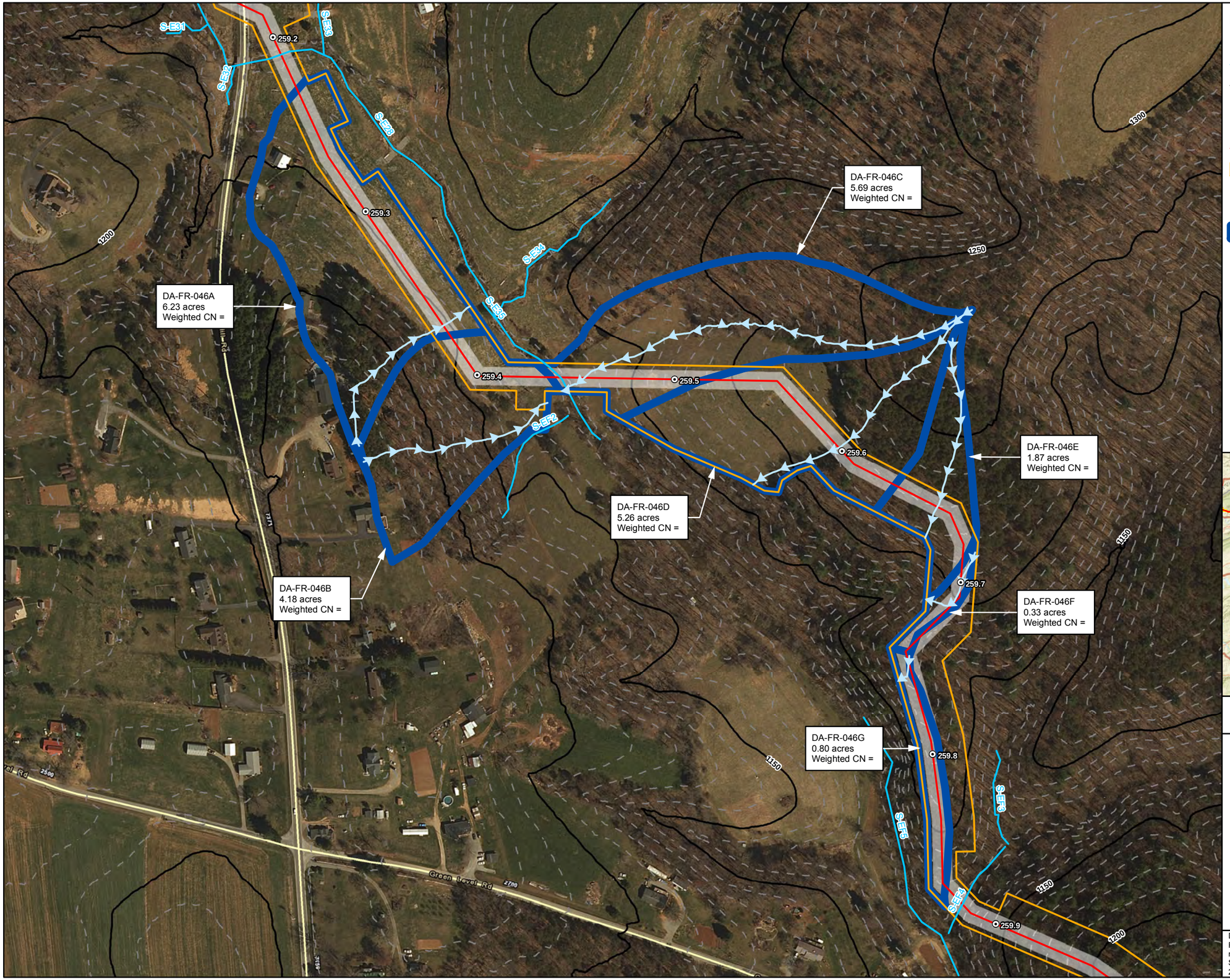


Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:3,000

N
W E
S

250 125 0 250 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration DA-FR-046 Spread 10

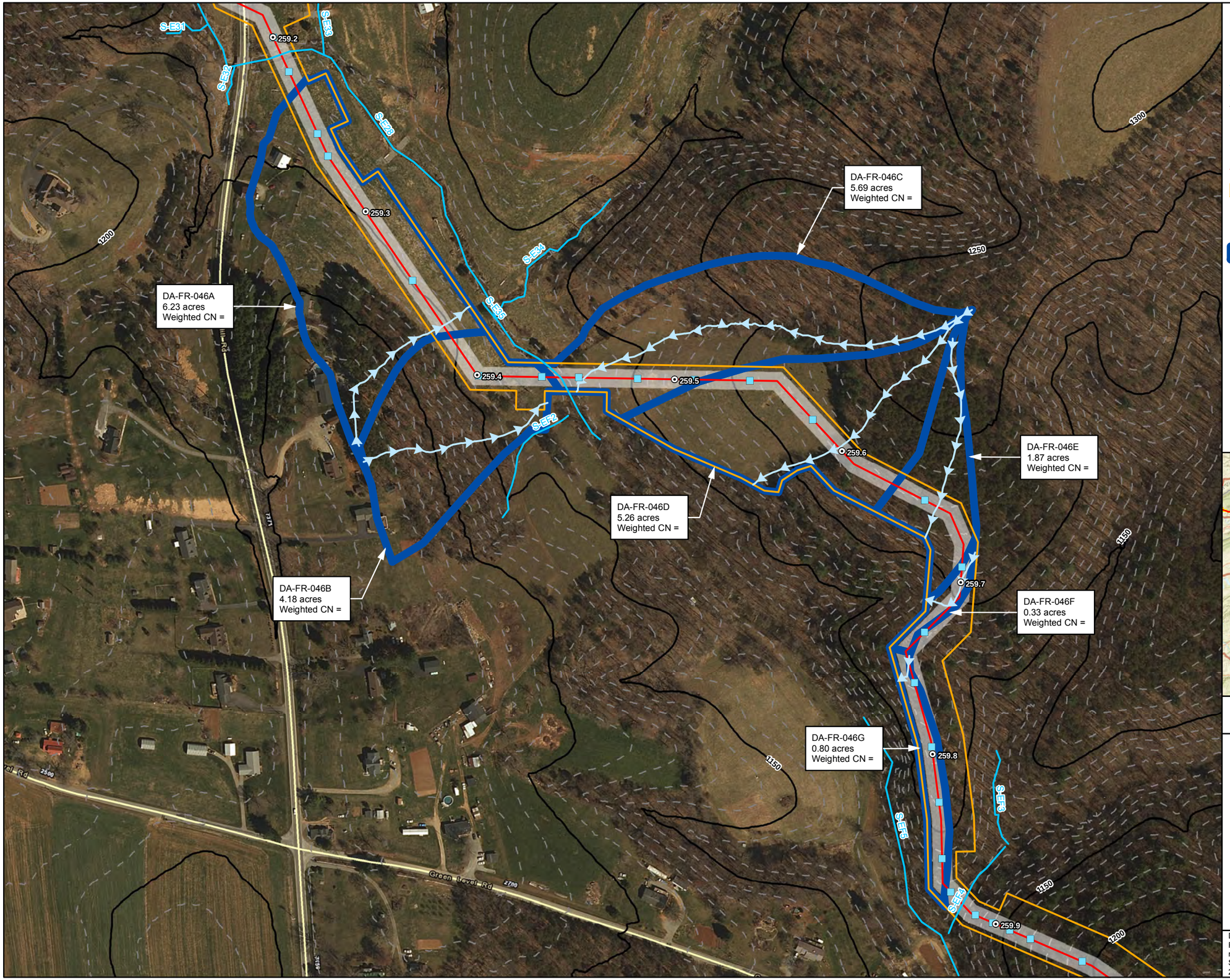
Figure 3

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-046_3.mxd



Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:3,000

N W E S

250 125 0 250 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration DA-FR-046 Spread 10

Figure 4

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-046_4.mxd

Virginia Runoff Reduction Method New Development Worksheet - v2.8 - June 2014

Site Data Summary

Total Rainfall = 45 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	2.56	1.05	0.00	3.61	*100.00*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
					3.61	*100.00*

Site Rv	0.03
Post Development Treatment Volume (ft3)	431
Post Development TP Load (lb/yr)	0.28
Post Development TN Load (lb/yr)	2.03
Total TP Load Reduction Required (lb/yr)	-1.20

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0
Total TN Load Reduction Achieved (lb/yr)	0.00
Adjusted Post Development TP Load (lb/yr)	0.28
Remaining Phosphorous Load Reduction (Lb/yr) Required	0.00

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest (acres)	3.61	0.00	0.00	0.00	0.00	*3.61*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
						3.61

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*
TN Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*

DA-FR-046A

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	2.214	9312
Developed Condition	2.214	9312
Pre-Developed (Forest) Condition	1.027	6357

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 2.214 ≤ 2.214 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 2.214 ≤ 2.214 OK

Check #3: $Q_{developed}$ *shall not* be required to be $\leq (Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 2.214 *shall not* be required to be ≤ 0.701

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-046A DEV
2	SCS Runoff	DA-FR-046A FOR
13	SCS Runoff	DA-FR-046A PRE

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	2.214	3.619	-------	-------	13.13	-------	-------	-------	DA-FR-046A DEV
2	SCS Runoff	------	1.027	2.042	-------	-------	10.20	-------	-------	-------	DA-FR-046A FOR
13	SCS Runoff	------	2.214	3.619	-------	-------	13.13	-------	-------	-------	DA-FR-046A PRE

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.214	1	725	9,312	------	------	------	DA-FR-046A DEV
2	SCS Runoff	1.027	1	726	6,357	------	------	------	DA-FR-046A FOR
13	SCS Runoff	2.214	1	725	9,312	------	------	------	DA-FR-046A PRE

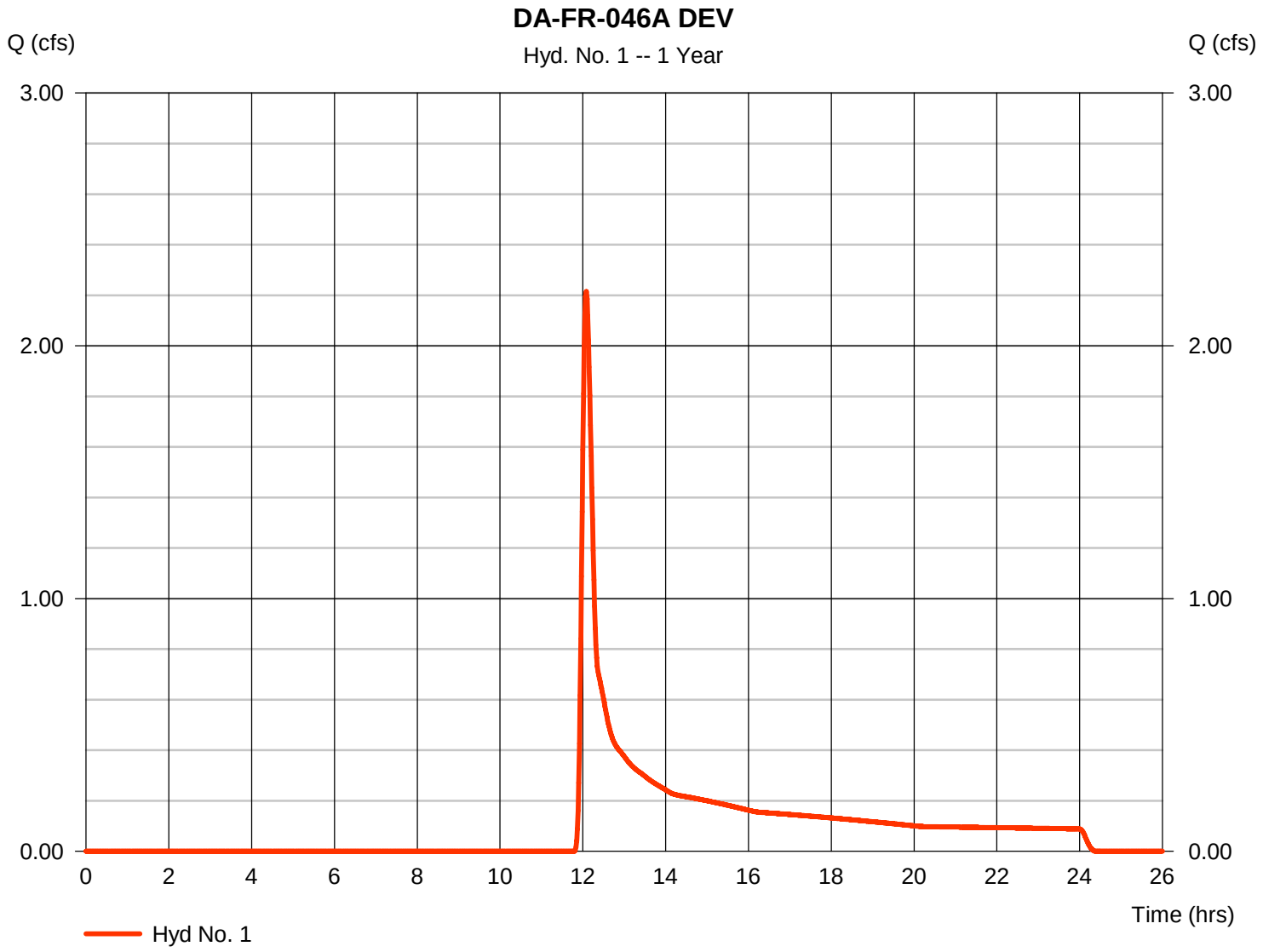
Hydrograph Report

Hyd. No. 1

DA-FR-046A DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.214 cfs
Storm frequency	=	1 yrs	Time to peak	=	12.08 hrs
Time interval	=	1 min	Hyd. volume	=	9,312 cuft
Drainage area	=	6.230 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.145 x 85) + (0.118 x 98) + (4.312 x 58) + (1.654 x 55)] / 6.230



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-046A DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.90		0.00		0.00		
Travel Time (min)	**= 12.96**	**+**	**0.00**	**+**	**0.00**	**=**	**12.96**
Shallow Concentrated Flow							
Flow length (ft)	= 452.58		0.00		0.00		
Watercourse slope (%)	= 23.06		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.75		0.00		0.00		
Travel Time (min)	**= 0.97**	**+**	**0.00**	**+**	**0.00**	**=**	**0.97**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

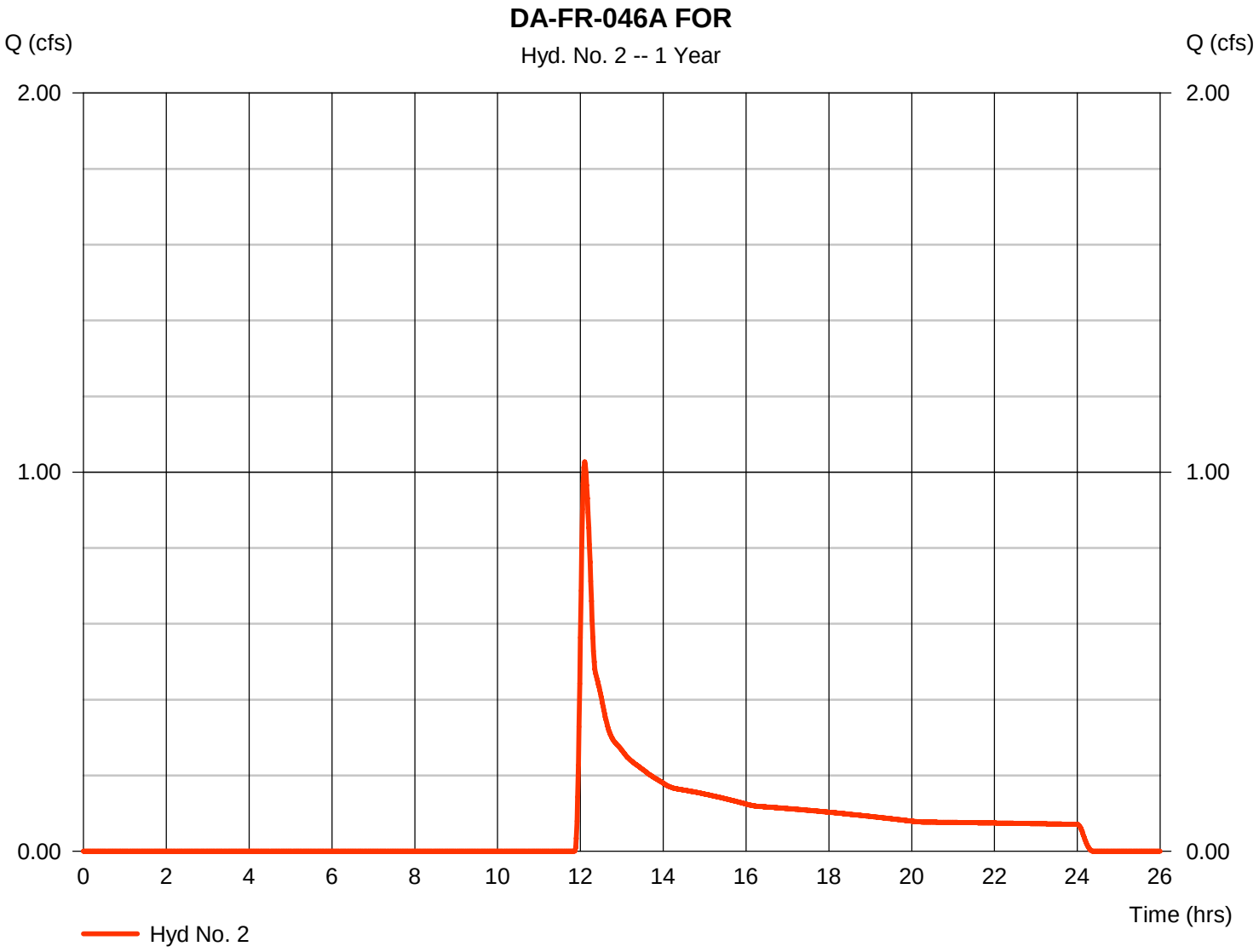
Total Travel Time, Tc ..... 13.90 min

Hydrograph Report

Hyd. No. 2

DA-FR-046A FOR

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.027 cfs
Storm frequency	=	1 yrs	Time to peak	=	12.10 hrs
Time interval	=	1 min	Hyd. volume	=	6,357 cuft
Drainage area	=	6.230 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-046A FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 5.90		0.00		0.00		
Travel Time (min)	**= 12.96**	**+**	**0.00**	**+**	**0.00**	**=**	**12.96**
Shallow Concentrated Flow							
Flow length (ft)	= 452.58		0.00		0.00		
Watercourse slope (%)	= 23.06		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.75		0.00		0.00		
Travel Time (min)	**= 0.97**	**+**	**0.00**	**+**	**0.00**	**=**	**0.97**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 13.90 min

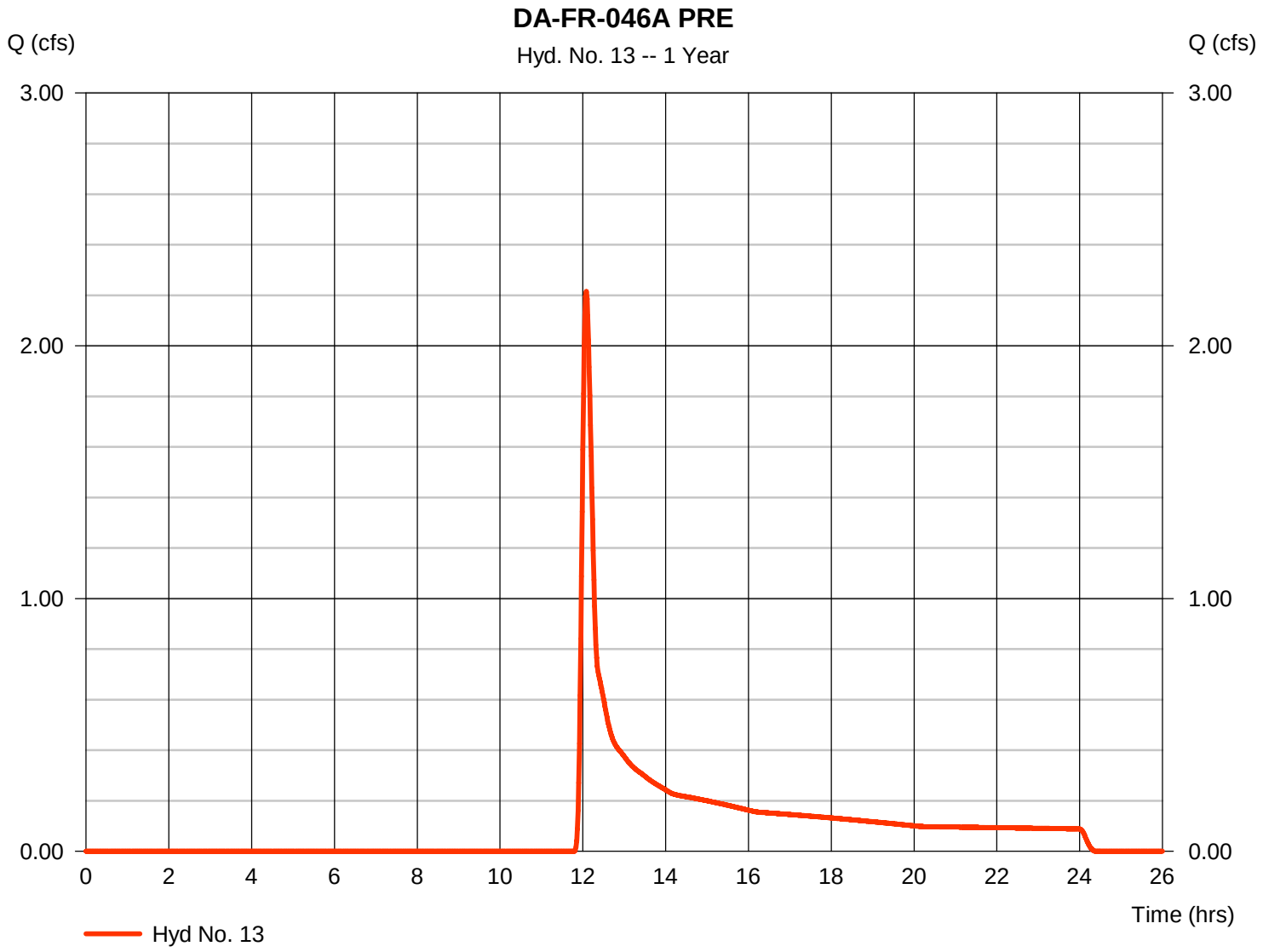
Hydrograph Report

Hyd. No. 13

DA-FR-046A PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.214 cfs
Storm frequency	=	1 yrs	Time to peak	=	12.08 hrs
Time interval	=	1 min	Hyd. volume	=	9,312 cuft
Drainage area	=	6.230 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.145 x 85) + (0.118 x 98) + (4.312 x 58) + (1.654 x 55)] / 6.230



TR55 Tc Worksheet

Hyd. No. 13

DA-FR-046A PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.90		0.00		0.00		
Travel Time (min)	**= 12.96**	**+**	**0.00**	**+**	**0.00**	**=**	**12.96**
Shallow Concentrated Flow							
Flow length (ft)	= 452.58		0.00		0.00		
Watercourse slope (%)	= 23.06		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.75		0.00		0.00		
Travel Time (min)	**= 0.97**	**+**	**0.00**	**+**	**0.00**	**=**	**0.97**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 13.90 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	3.619	1	724	13,035	------	------	------	DA-FR-046A DEV
2	SCS Runoff	2.042	1	725	9,398	------	------	------	DA-FR-046A FOR
13	SCS Runoff	3.619	1	724	13,035	------	------	------	DA-FR-046A PRE

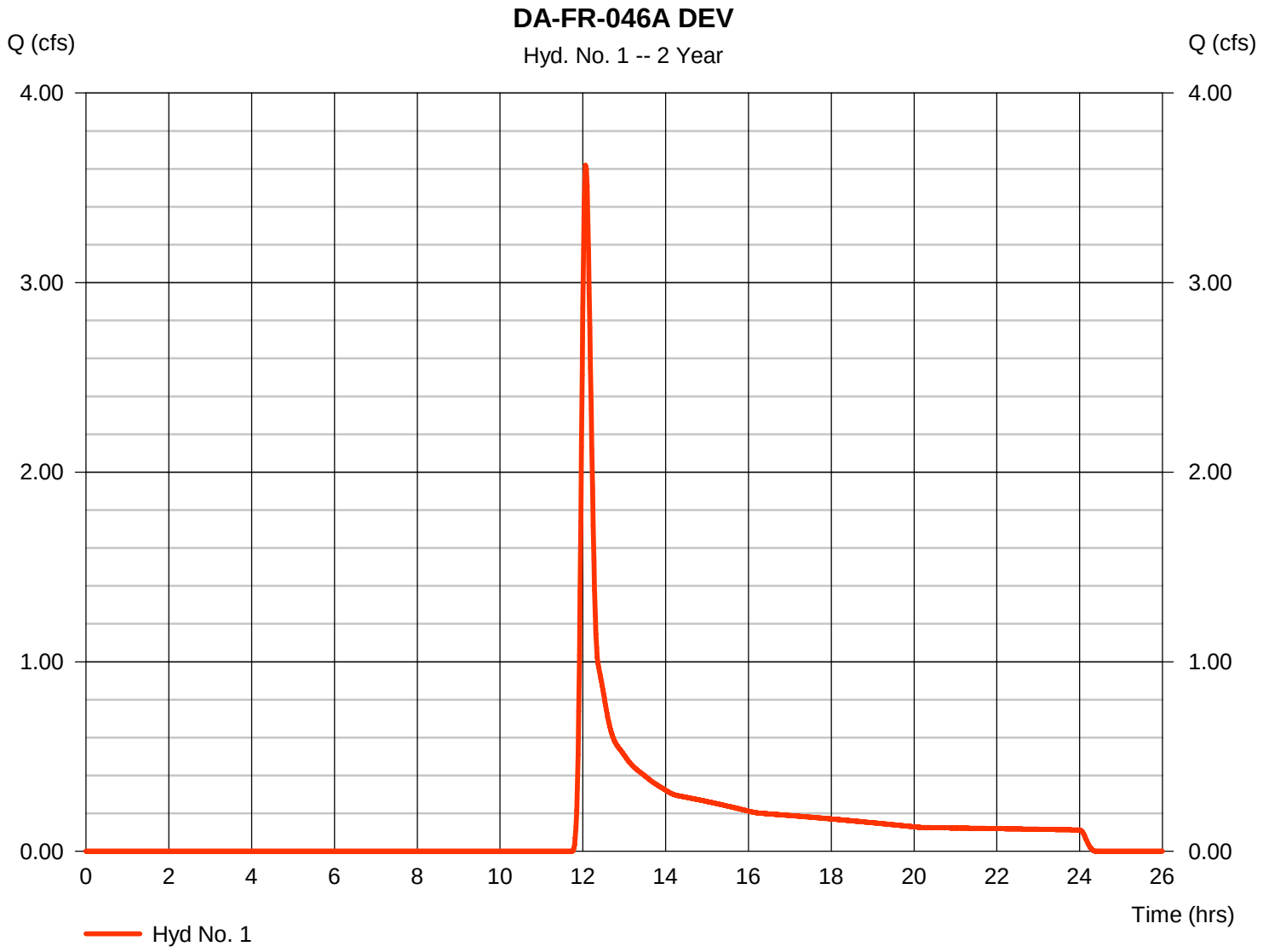
Hydrograph Report

Hyd. No. 1

DA-FR-046A DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.619 cfs
Storm frequency	=	2 yrs	Time to peak	=	12.07 hrs
Time interval	=	1 min	Hyd. volume	=	13,035 cuft
Drainage area	=	6.230 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.145 x 85) + (0.118 x 98) + (4.312 x 58) + (1.654 x 55)] / 6.230

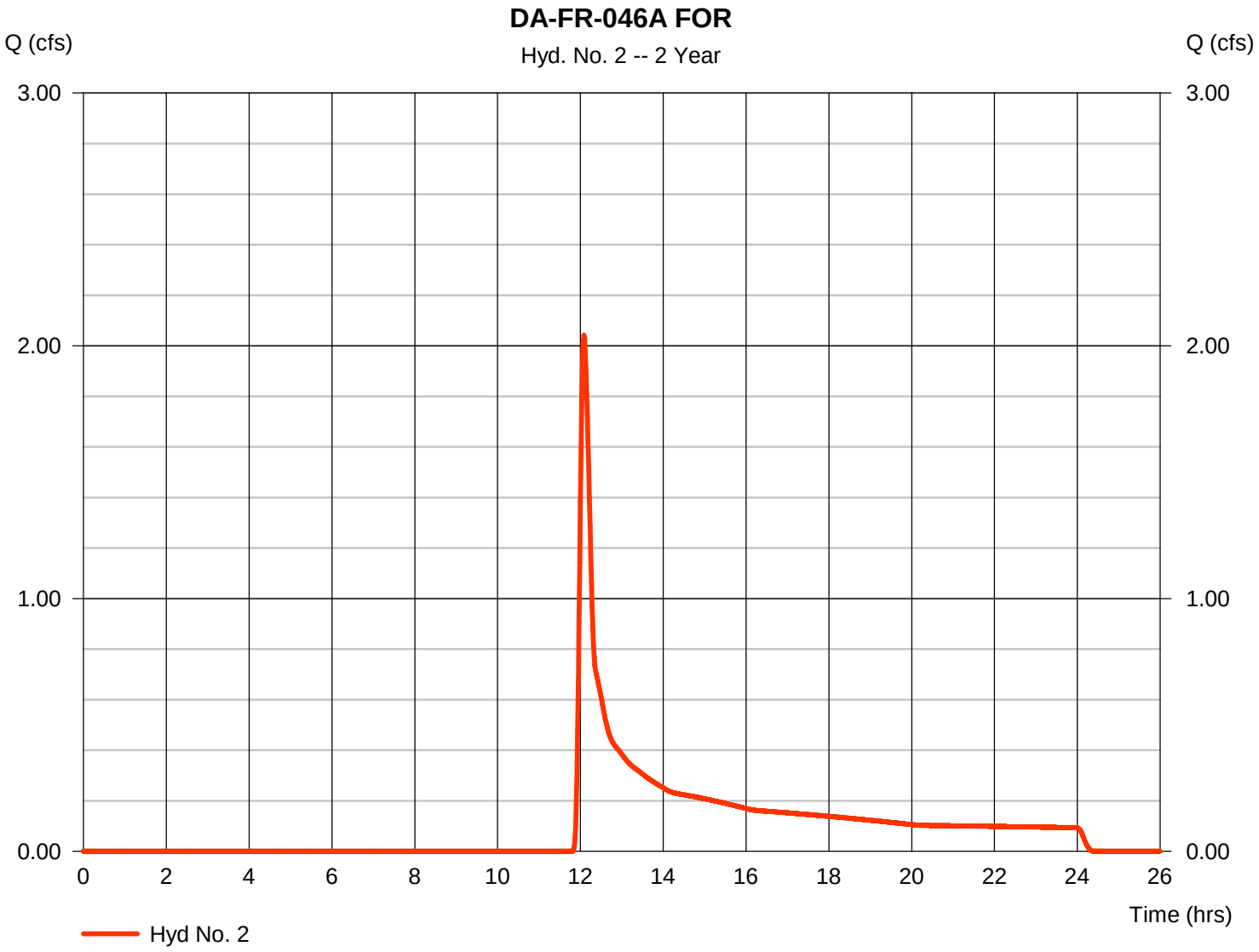


Hydrograph Report

Hyd. No. 2

DA-FR-046A FOR

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.042 cfs
Storm frequency	=	2 yrs	Time to peak	=	12.08 hrs
Time interval	=	1 min	Hyd. volume	=	9,398 cuft
Drainage area	=	6.230 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



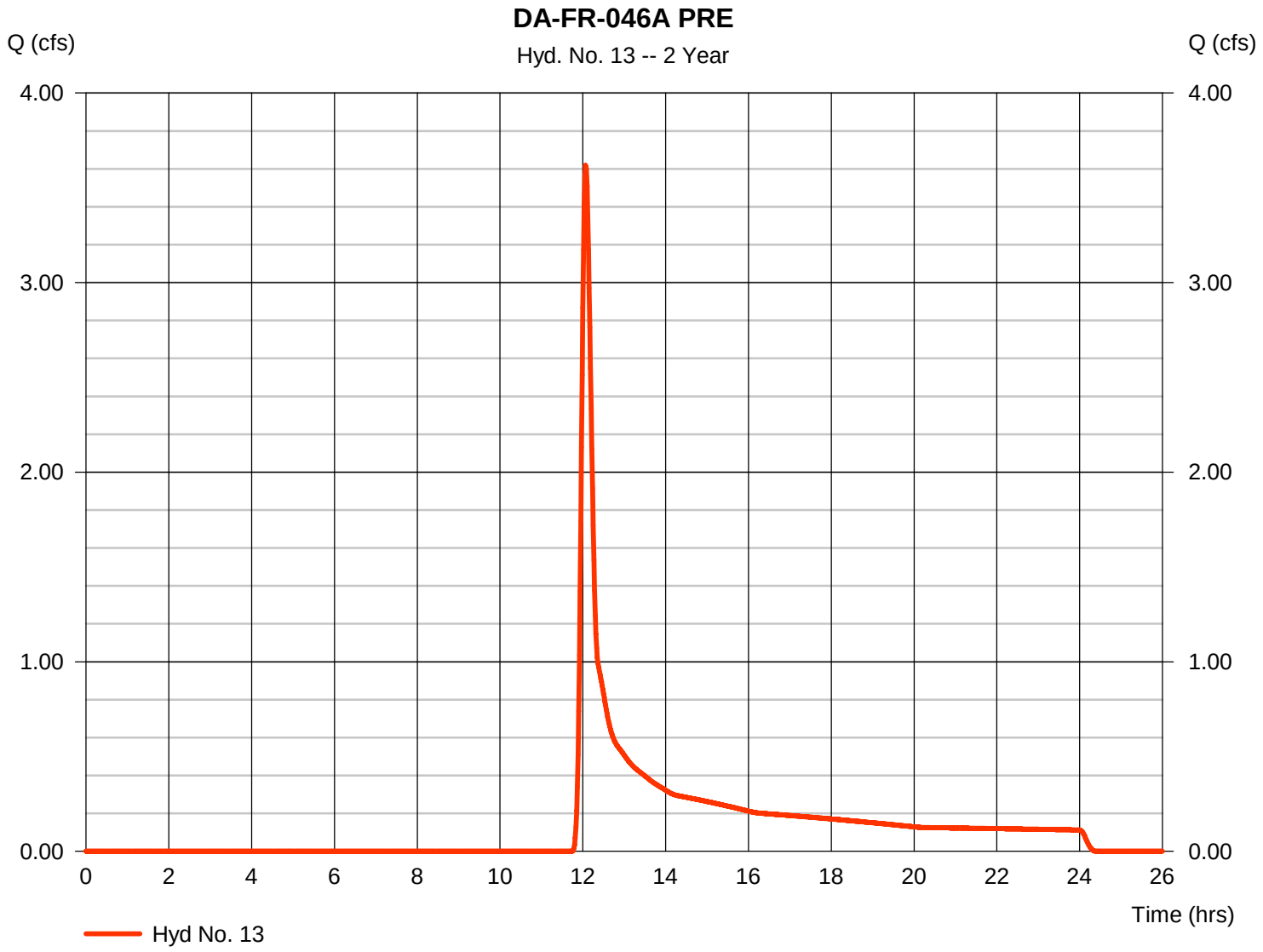
Hydrograph Report

Hyd. No. 13

DA-FR-046A PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.619 cfs
Storm frequency	=	2 yrs	Time to peak	=	12.07 hrs
Time interval	=	1 min	Hyd. volume	=	13,035 cuft
Drainage area	=	6.230 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.145 x 85) + (0.118 x 98) + (4.312 x 58) + (1.654 x 55)] / 6.230



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	13.13	1	723	37,314	------	------	------	DA-FR-046A DEV
2	SCS Runoff	10.20	1	723	30,496	------	------	------	DA-FR-046A FOR
13	SCS Runoff	13.13	1	723	37,314	------	------	------	DA-FR-046A PRE

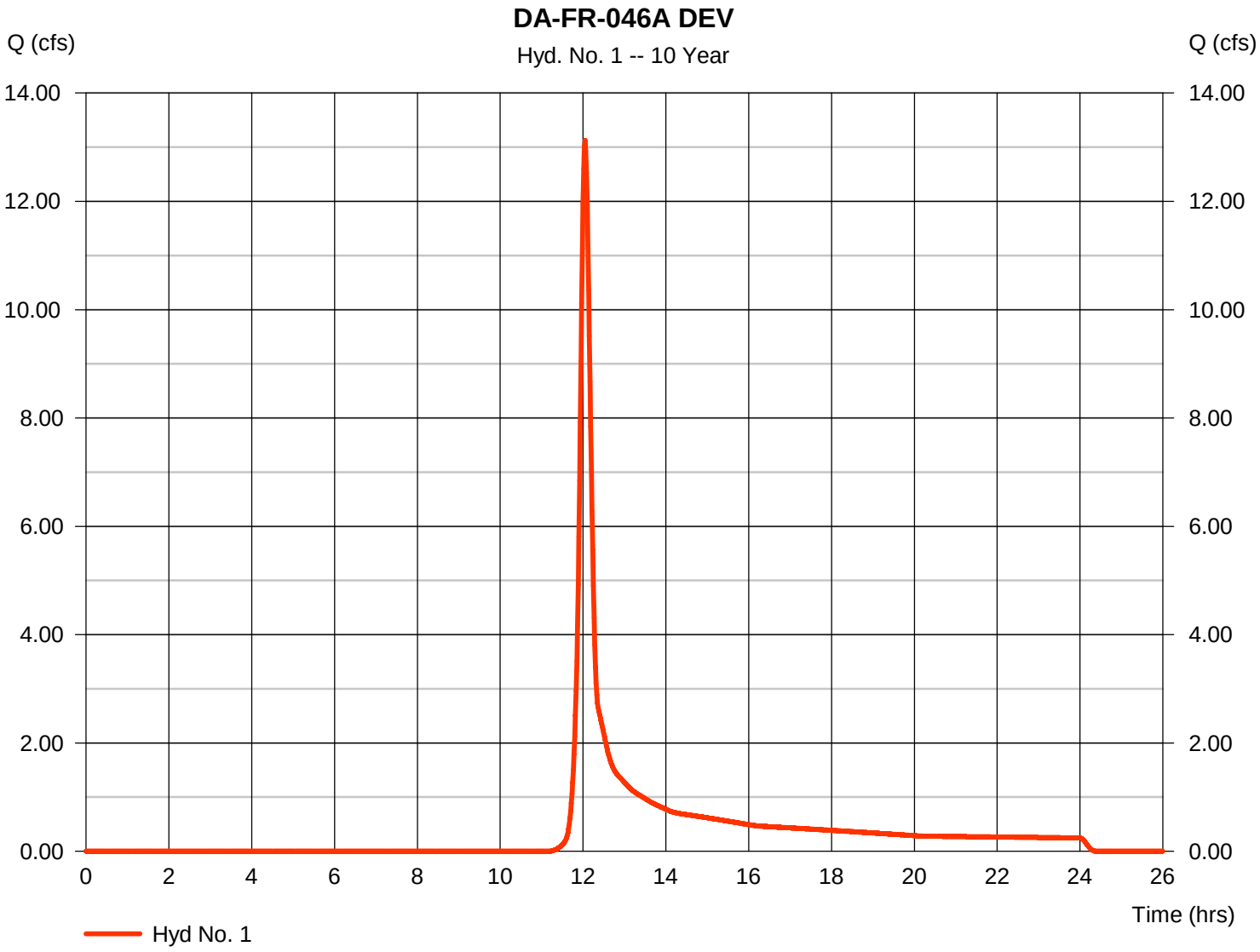
Hydrograph Report

Hyd. No. 1

DA-FR-046A DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	13.13 cfs
Storm frequency	=	10 yrs	Time to peak	=	12.05 hrs
Time interval	=	1 min	Hyd. volume	=	37,314 cuft
Drainage area	=	6.230 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.145 x 85) + (0.118 x 98) + (4.312 x 58) + (1.654 x 55)] / 6.230

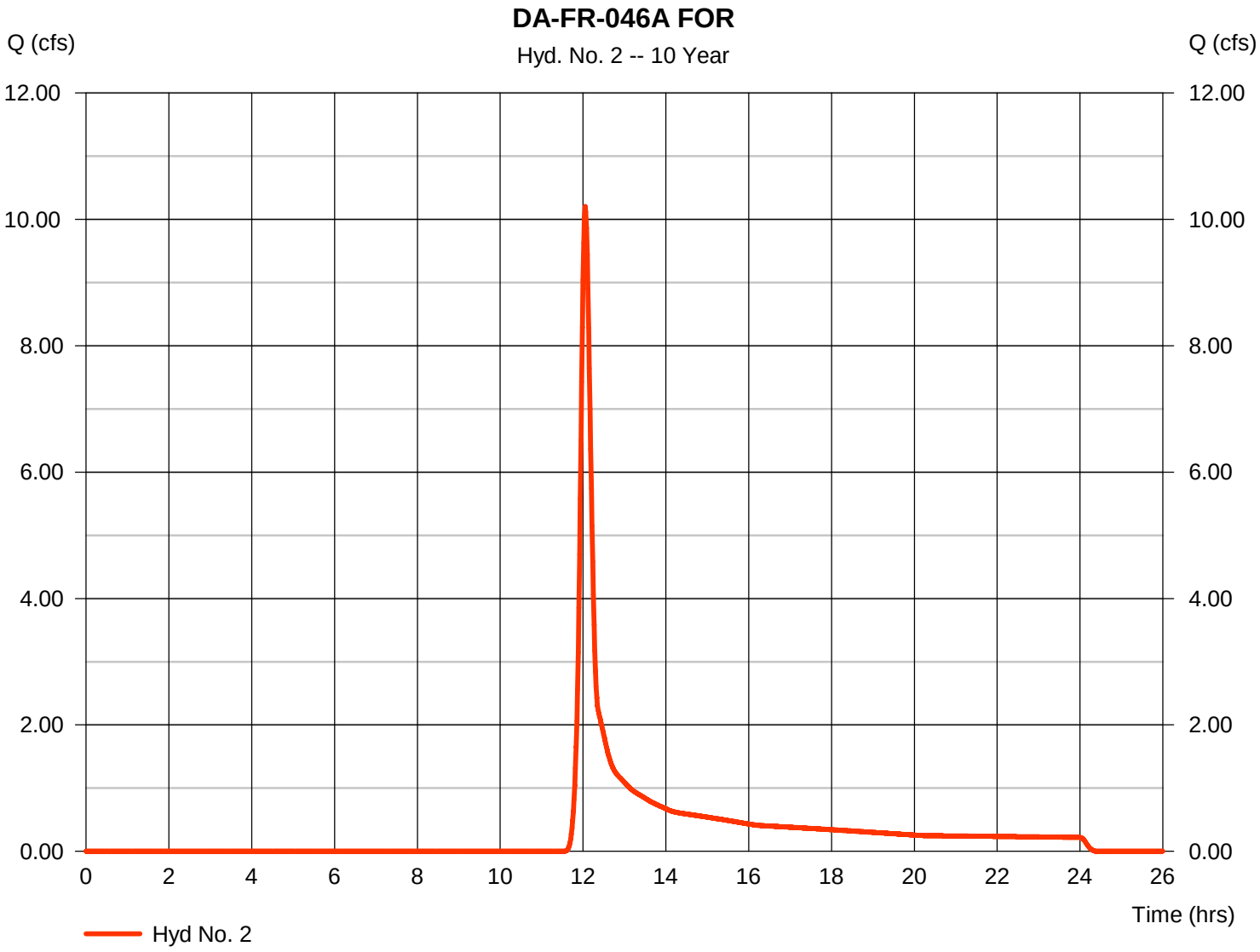


Hydrograph Report

Hyd. No. 2

DA-FR-046A FOR

Hydrograph type	=	SCS Runoff	Peak discharge	=	10.20 cfs
Storm frequency	=	10 yrs	Time to peak	=	12.05 hrs
Time interval	=	1 min	Hyd. volume	=	30,496 cuft
Drainage area	=	6.230 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



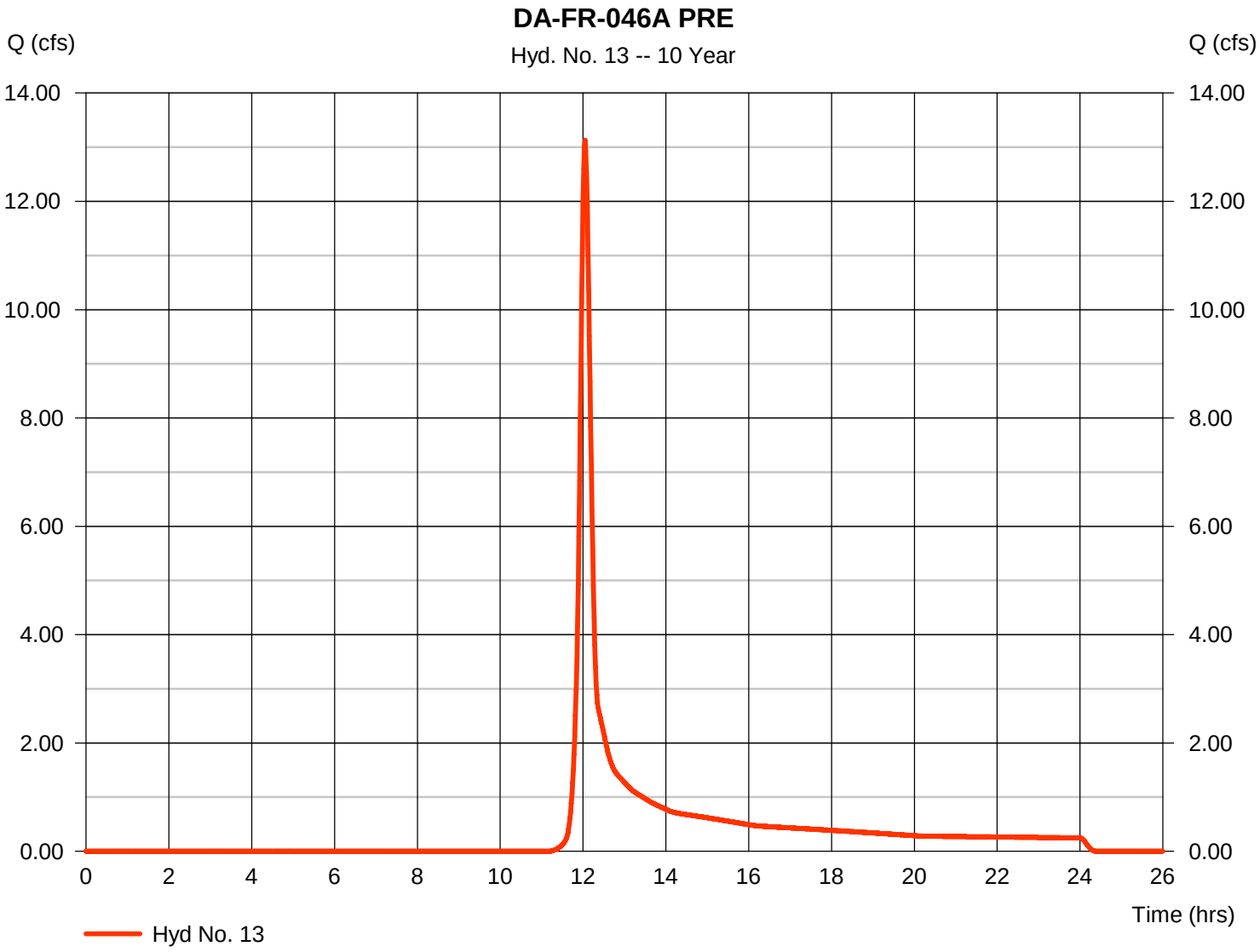
Hydrograph Report

Hyd. No. 13

DA-FR-046A PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	13.13 cfs
Storm frequency	=	10 yrs	Time to peak	=	12.05 hrs
Time interval	=	1 min	Hyd. volume	=	37,314 cuft
Drainage area	=	6.230 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.90 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.145 x 85) + (0.118 x 98) + (4.312 x 58) + (1.654 x 55)] / 6.230



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.p

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-046B

STORAGE VOLUME OF WATERBAR WITH SOIL COMPOST AMENDMENT AREA

Equations Used:

[1] $V_{gravel\ storage} = L*W*D_{gravel}*(40/100)$

[2] $V_{soil\ storage} = L*W*D_{soil}*(20/100)$

[3] $V_{surface\ storage} = [W*S*D^2]+[L*S*D^2]+[W*L*D]+[((2*S*D)^2*D)/3]$

[1] Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that gravel is made up of 40% voids.

[2] Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that soil compost amendment is made up of 20% voids.

[3] Equation #1 under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, but calculation also takes into account surface side slopes.

Inputs:

Depth of Gravel Layer, D_{gravel} (ft) =	0	
Depth of Soil Amendment Area, D_{soil} (ft) =	1	Refer to Table 4.3 in VA DEQ Stormwater Design Specification No. 4; Note that compost amendment may not be necessary for HSG A/B soils
Length of Waterbar Soil Amendment Area, L (ft) =	40	Assume max. length of 50' for waterbar soil amendment areas (i.e., limited to permanent ROW)
Width of Waterbar Soil Amendment Area, W (ft) =	3	
Inside Embankment Side Slopes, S (H:V) =	2	Assume 2H:1V surface side slopes for waterbars
Number of Perm. Waterbars in Drainage Area, n =	4	
Design Infiltration Rate, IR (in/hr) =	0.2	Min. rate of 0.30 in/hr for HSG A soils and 0.15-0.30 in/hr for HSG B soils (see Chap. 4, p. 4-30 in VA Stormwater Management Handbook Volume II (First Edition, 1999)
Surface Ponding Depth, D (ft) =	0.5	Assume 0.5' CFS height at the end of waterbars

Calculations:

Total Storage Depth per BMP (ft) =	1.5
Surface Storage Volume per BMP (cf) =	82
Subsurface Storage Volume per BMP (cf) =	24
Total Storage Volume per BMP (cf) =	106
Total BMP Storage Volume in Drainage Area (cf) =	425
Calculated Infiltration Period per BMP (hr) =	53

Depth-Storage Data

Depth (ft)	Width (ft)	Length (ft)	Storage Volume per BMP (cf)	Storage Volume in Drainage Area (cf)
0	3	40	0	0
0.5	3	40	12	48
1	3	40	24	96
1.5	5	42	106	425
2	7	44	235	941

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.021	4813
Developed Condition	0.756	4388
Pre-Developed (Forest) Condition	0.817	4314

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \le IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.756	≤ OK	0.896
Check #2:	$Q_{developed} \le Q_{pre\text{-}developed}$ ---------->	0.756	≤ OK	1.021
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.756	*shall not* be required to be ≤	0.803

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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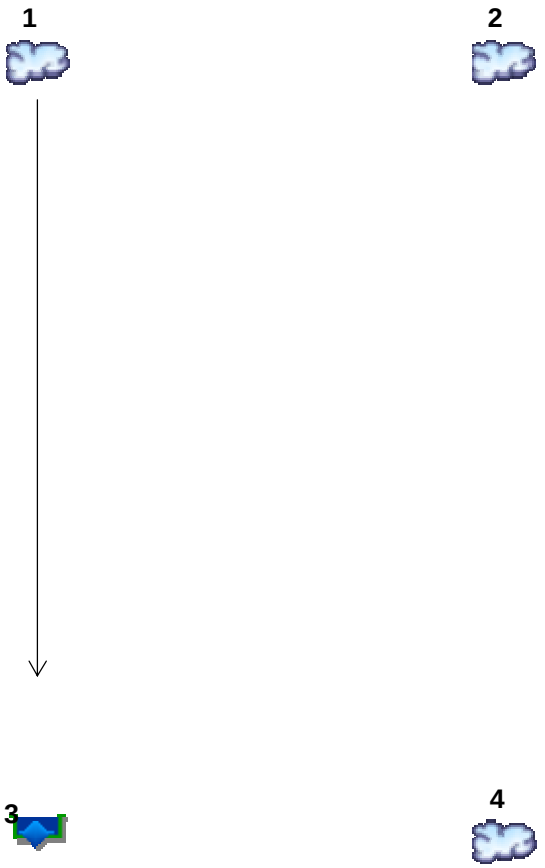
Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-046B DEV
2	SCS Runoff	DA-FR-046B FOR
3	Reservoir	WB SOIL AMENDMENTS
4	SCS Runoff	DA-FR-046B PRE

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.021	1.911	-------	-------	8.460	-------	-------	-------	DA-FR-046B DEV
2	SCS Runoff	------	0.817	1.627	-------	-------	7.914	-------	-------	-------	DA-FR-046B FOR
3	Reservoir	1	0.756	1.805	-------	-------	8.391	-------	-------	-------	WB SOIL AMENDMENTS
4	SCS Runoff	------	1.021	1.911	-------	-------	8.460	-------	-------	-------	DA-FR-046B PRE

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.021	1	723	4,813	------	------	------	DA-FR-046B DEV
2	SCS Runoff	0.817	1	724	4,341	------	------	------	DA-FR-046B FOR
3	Reservoir	0.756	1	729	4,388	1	101.59	520	WB SOIL AMENDMENTS
4	SCS Runoff	1.021	1	723	4,813	------	------	------	DA-FR-046B PRE

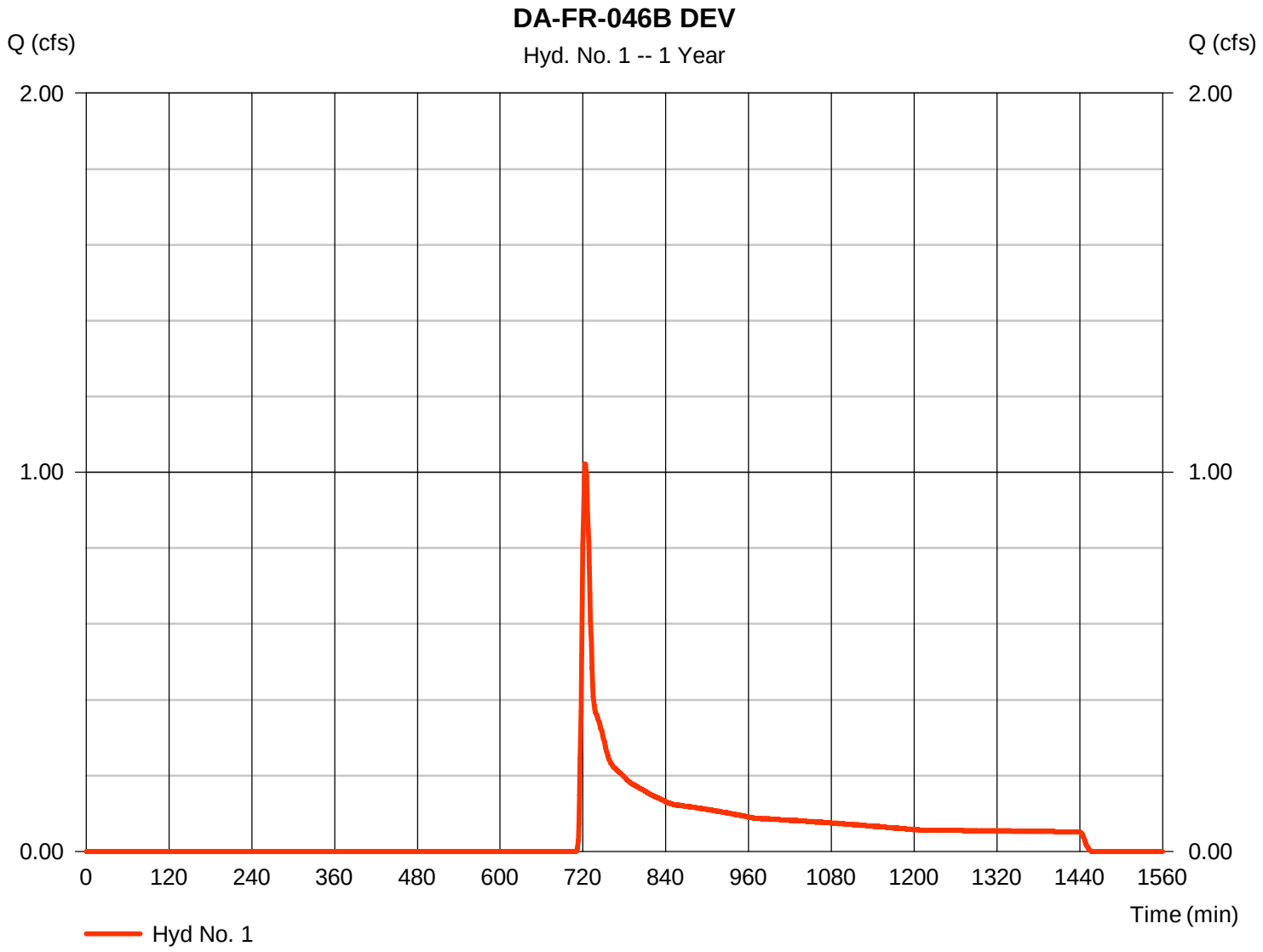
Hydrograph Report

Hyd. No. 1

DA-FR-046B DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.021 cfs
Storm frequency	=	1 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	4,813 cuft
Drainage area	=	4.180 ac	Curve number	=	56*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	10.60 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.134 x 48) + (0.034 x 98) + (1.229 x 58) + (2.784 x 55)] / 4.180



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-046B DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 12.47		0.00		0.00		
Travel Time (min)	**= 9.60**	**+**	**0.00**	**+**	**0.00**	**=**	**9.60**
Shallow Concentrated Flow							
Flow length (ft)	= 455.71		0.00		0.00		
Watercourse slope (%)	= 22.17		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.60		0.00		0.00		
Travel Time (min)	**= 1.00**	**+**	**0.00**	**+**	**0.00**	**=**	**1.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

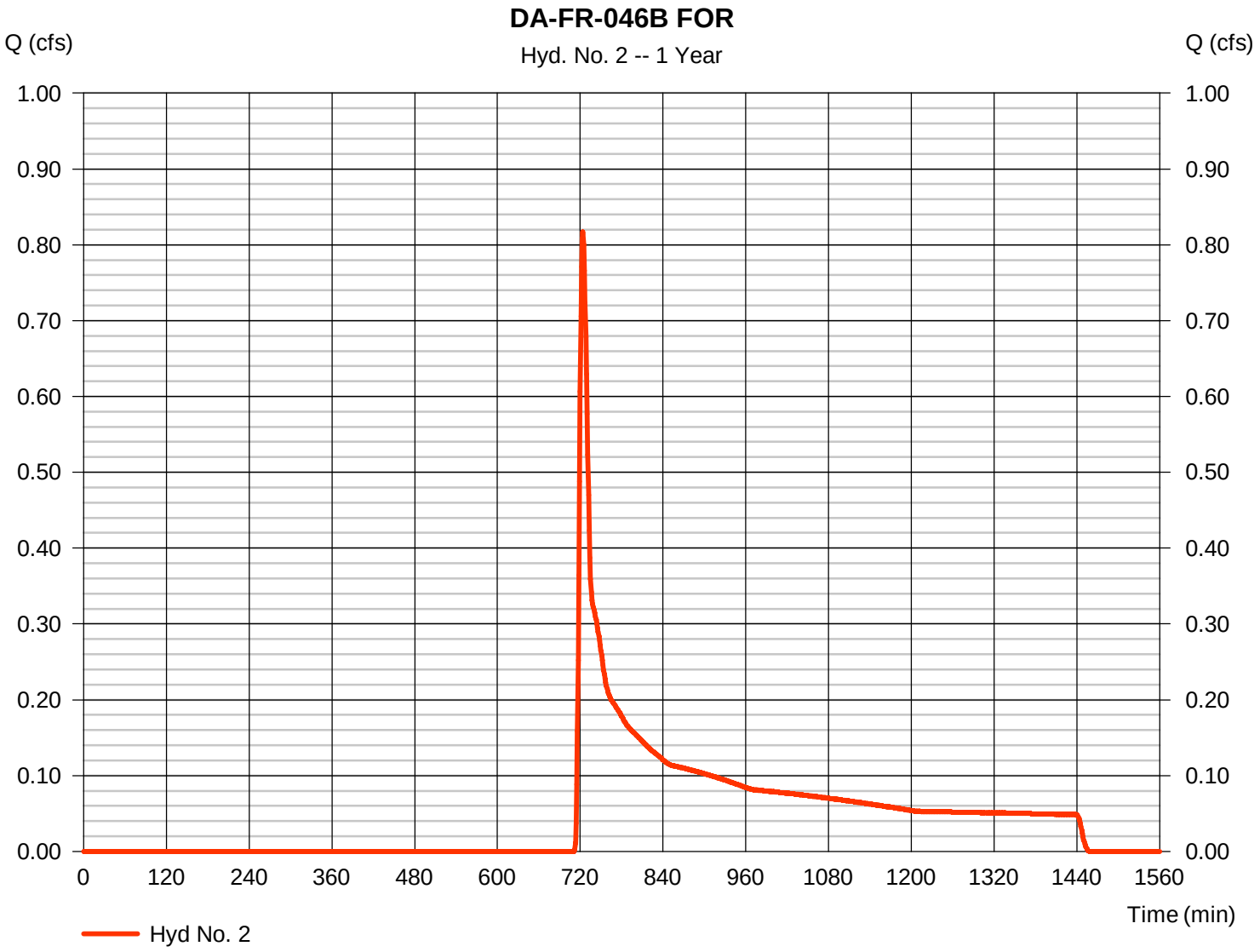
Total Travel Time, Tc ..... 10.60 min

Hydrograph Report

Hyd. No. 2

DA-FR-046B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.817 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 4,341 cuft
Drainage area	= 4.180 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-046B FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 12.47		0.00		0.00		
Travel Time (min)	**= 9.60**	**+**	**0.00**	**+**	**0.00**	**=**	**9.60**
Shallow Concentrated Flow							
Flow length (ft)	= 455.71		0.00		0.00		
Watercourse slope (%)	= 22.17		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.60		0.00		0.00		
Travel Time (min)	**= 1.00**	**+**	**0.00**	**+**	**0.00**	**=**	**1.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 10.60 min

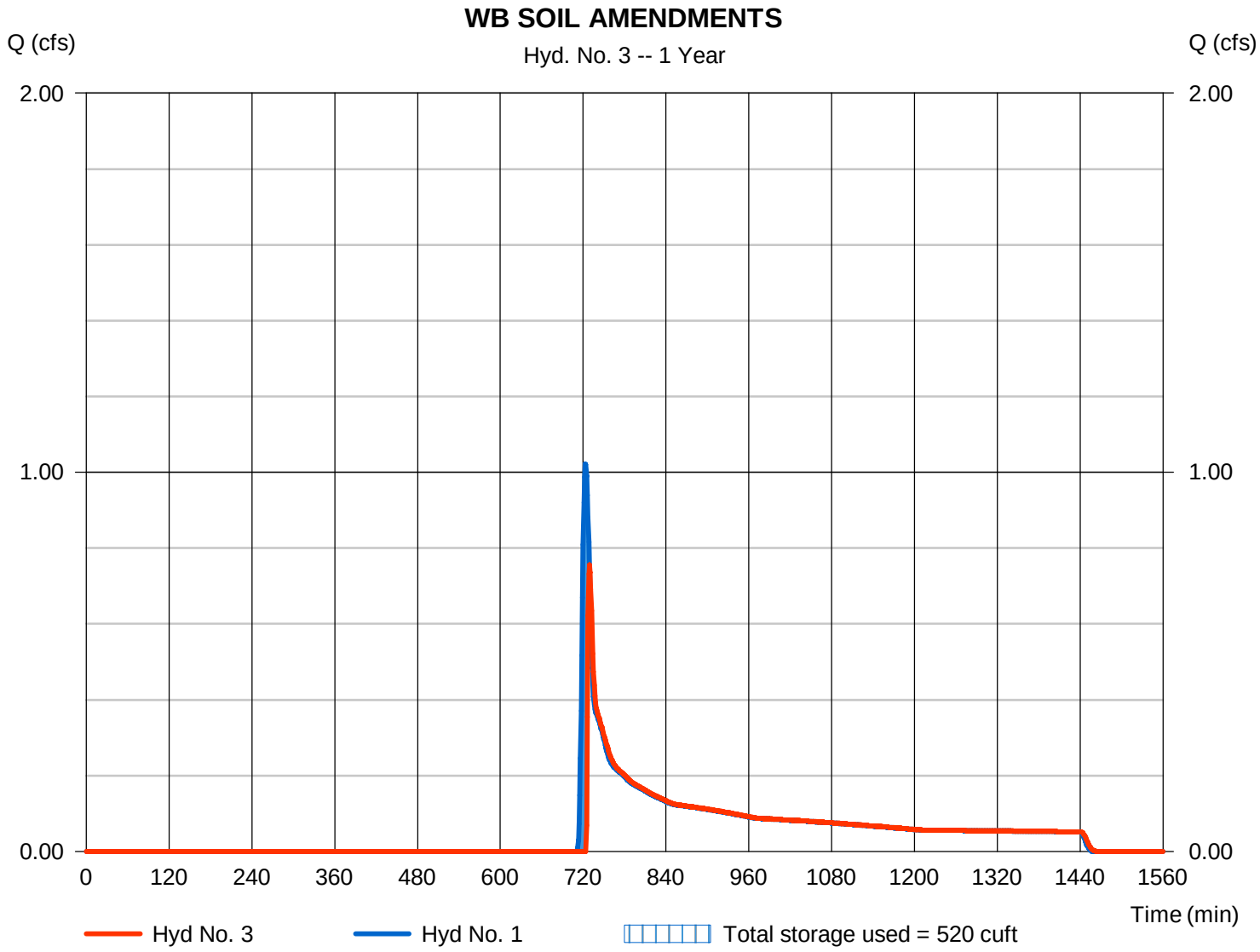
Hydrograph Report

Hyd. No. 3

WB SOIL AMENDMENTS

Hydrograph type	=	Reservoir	Peak discharge	=	0.756 cfs
Storm frequency	=	1 yrs	Time to peak	=	729 min
Time interval	=	1 min	Hyd. volume	=	4,388 cuft
Inflow hyd. No.	=	1 - DA-FR-046B DEV	Max. Elevation	=	101.59 ft
Reservoir name	=	WATERBAR SOIL AMENDMENTS	Max. Storage	=	520 cuft

Storage Indication method used.



Pond No. 1 - WATERBAR SOIL AMENDMENTS

Pond Data

Pond storage is based on user-defined values.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	100.00	n/a	0	0
0.50	100.50	n/a	48	48
1.00	101.00	n/a	48	96
1.50	101.50	n/a	329	425
2.00	102.00	n/a	516	941

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 0.00	0.00	0.00	0.00
Span (in)	= 0.00	0.00	0.00	0.00
No. Barrels	= 0	0	0	0
Invert El. (ft)	= 0.00	0.00	0.00	0.00
Length (ft)	= 0.00	0.00	0.00	0.00
Slope (%)	= 0.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 8.00	0.00	0.00	0.00
Crest El. (ft)	= 101.50	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Rect	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	100.00	---	---	---	---	0.00	---	---	---	---	---	0.000
0.05	5	100.05	---	---	---	---	0.00	---	---	---	---	---	0.000
0.10	10	100.10	---	---	---	---	0.00	---	---	---	---	---	0.000
0.15	14	100.15	---	---	---	---	0.00	---	---	---	---	---	0.000
0.20	19	100.20	---	---	---	---	0.00	---	---	---	---	---	0.000
0.25	24	100.25	---	---	---	---	0.00	---	---	---	---	---	0.000
0.30	29	100.30	---	---	---	---	0.00	---	---	---	---	---	0.000
0.35	34	100.35	---	---	---	---	0.00	---	---	---	---	---	0.000
0.40	38	100.40	---	---	---	---	0.00	---	---	---	---	---	0.000
0.45	43	100.45	---	---	---	---	0.00	---	---	---	---	---	0.000
0.50	48	100.50	---	---	---	---	0.00	---	---	---	---	---	0.000
0.55	53	100.55	---	---	---	---	0.00	---	---	---	---	---	0.000
0.60	58	100.60	---	---	---	---	0.00	---	---	---	---	---	0.000
0.65	62	100.65	---	---	---	---	0.00	---	---	---	---	---	0.000
0.70	67	100.70	---	---	---	---	0.00	---	---	---	---	---	0.000
0.75	72	100.75	---	---	---	---	0.00	---	---	---	---	---	0.000
0.80	77	100.80	---	---	---	---	0.00	---	---	---	---	---	0.000
0.85	82	100.85	---	---	---	---	0.00	---	---	---	---	---	0.000
0.90	86	100.90	---	---	---	---	0.00	---	---	---	---	---	0.000
0.95	91	100.95	---	---	---	---	0.00	---	---	---	---	---	0.000
1.00	96	101.00	---	---	---	---	0.00	---	---	---	---	---	0.000
1.05	129	101.05	---	---	---	---	0.00	---	---	---	---	---	0.000
1.10	162	101.10	---	---	---	---	0.00	---	---	---	---	---	0.000
1.15	195	101.15	---	---	---	---	0.00	---	---	---	---	---	0.000
1.20	228	101.20	---	---	---	---	0.00	---	---	---	---	---	0.000
1.25	260	101.25	---	---	---	---	0.00	---	---	---	---	---	0.000
1.30	293	101.30	---	---	---	---	0.00	---	---	---	---	---	0.000
1.35	326	101.35	---	---	---	---	0.00	---	---	---	---	---	0.000
1.40	359	101.40	---	---	---	---	0.00	---	---	---	---	---	0.000
1.45	392	101.45	---	---	---	---	0.00	---	---	---	---	---	0.000
1.50	425	101.50	---	---	---	---	0.00	---	---	---	---	---	0.000
1.55	477	101.55	---	---	---	---	0.30	---	---	---	---	---	0.298
1.60	528	101.60	---	---	---	---	0.84	---	---	---	---	---	0.843
1.65	580	101.65	---	---	---	---	1.55	---	---	---	---	---	1.548
1.70	631	101.70	---	---	---	---	2.38	---	---	---	---	---	2.383
1.75	683	101.75	---	---	---	---	3.33	---	---	---	---	---	3.330
1.80	735	101.80	---	---	---	---	4.38	---	---	---	---	---	4.378
1.85	786	101.85	---	---	---	---	5.52	---	---	---	---	---	5.517
1.90	838	101.90	---	---	---	---	6.74	---	---	---	---	---	6.740

Continues on next page...

WATERBAR SOIL AMENDMENTS

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
1.95	889	101.95	---	---	---	---	8.04	---	---	---	---	---	8.043
2.00	941	102.00	---	---	---	---	9.42	---	---	---	---	---	9.419

...End

Hydrograph Report

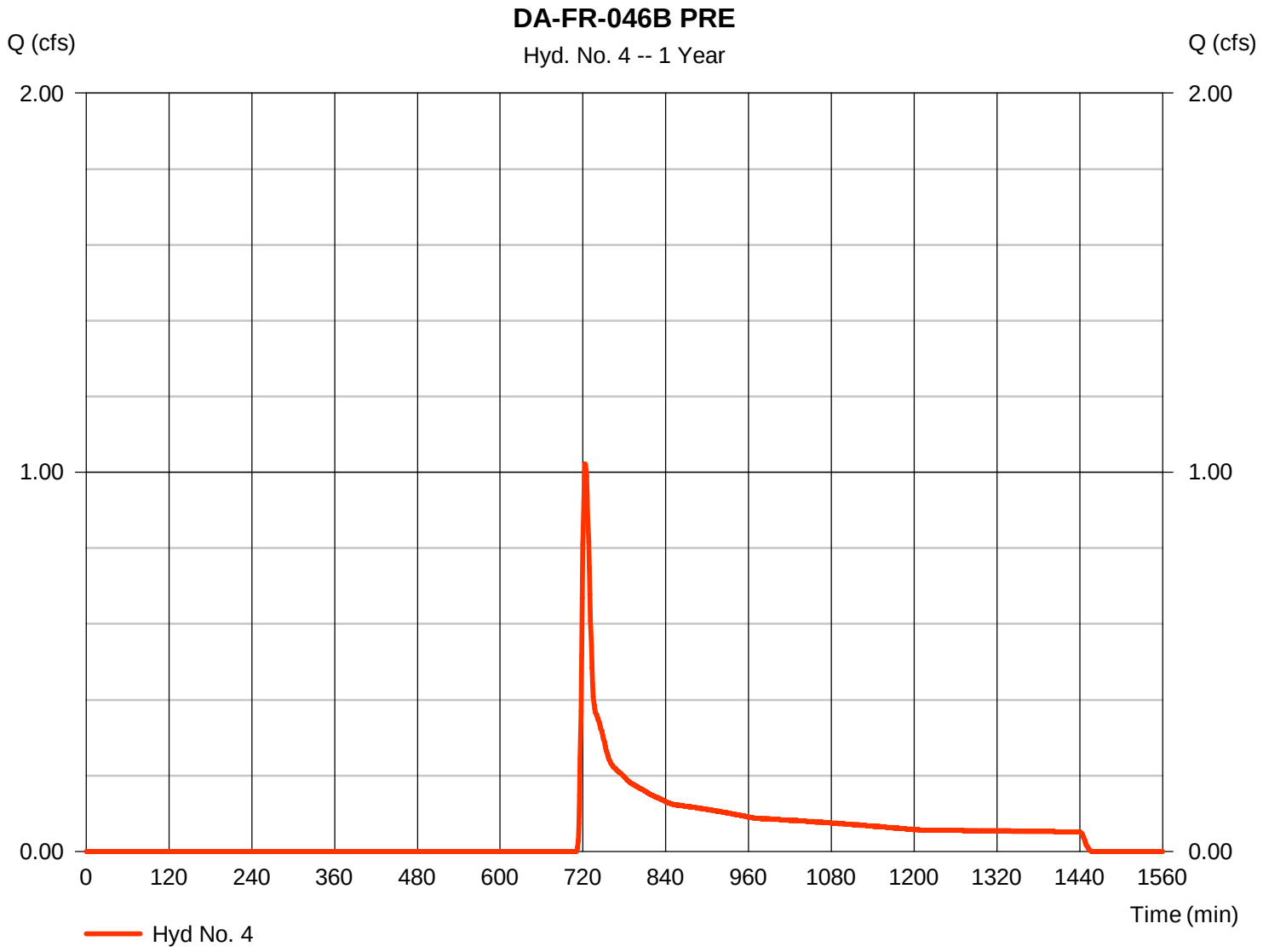
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 4

DA-FR-046B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 1.021 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 4,813 cuft
Drainage area	= 4.180 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.034 x 98) + (1.229 x 58) + (2.917 x 55)] / 4.180



TR55 Tc Worksheet

Hyd. No. 4

DA-FR-046B PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 12.47		0.00		0.00		
Travel Time (min)	**= 9.60**	**+**	**0.00**	**+**	**0.00**	**=**	**9.60**
Shallow Concentrated Flow							
Flow length (ft)	= 455.71		0.00		0.00		
Watercourse slope (%)	= 22.17		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.60		0.00		0.00		
Travel Time (min)	**= 1.00**	**+**	**0.00**	**+**	**0.00**	**=**	**1.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 10.60 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.911	1	723	7,007	------	------	------	DA-FR-046B DEV
2	SCS Runoff	1.627	1	723	6,418	------	------	------	DA-FR-046B FOR
3	Reservoir	1.805	1	725	6,581	1	101.67	596	WB SOIL AMENDMENTS
4	SCS Runoff	1.911	1	723	7,007	------	------	------	DA-FR-046B PRE

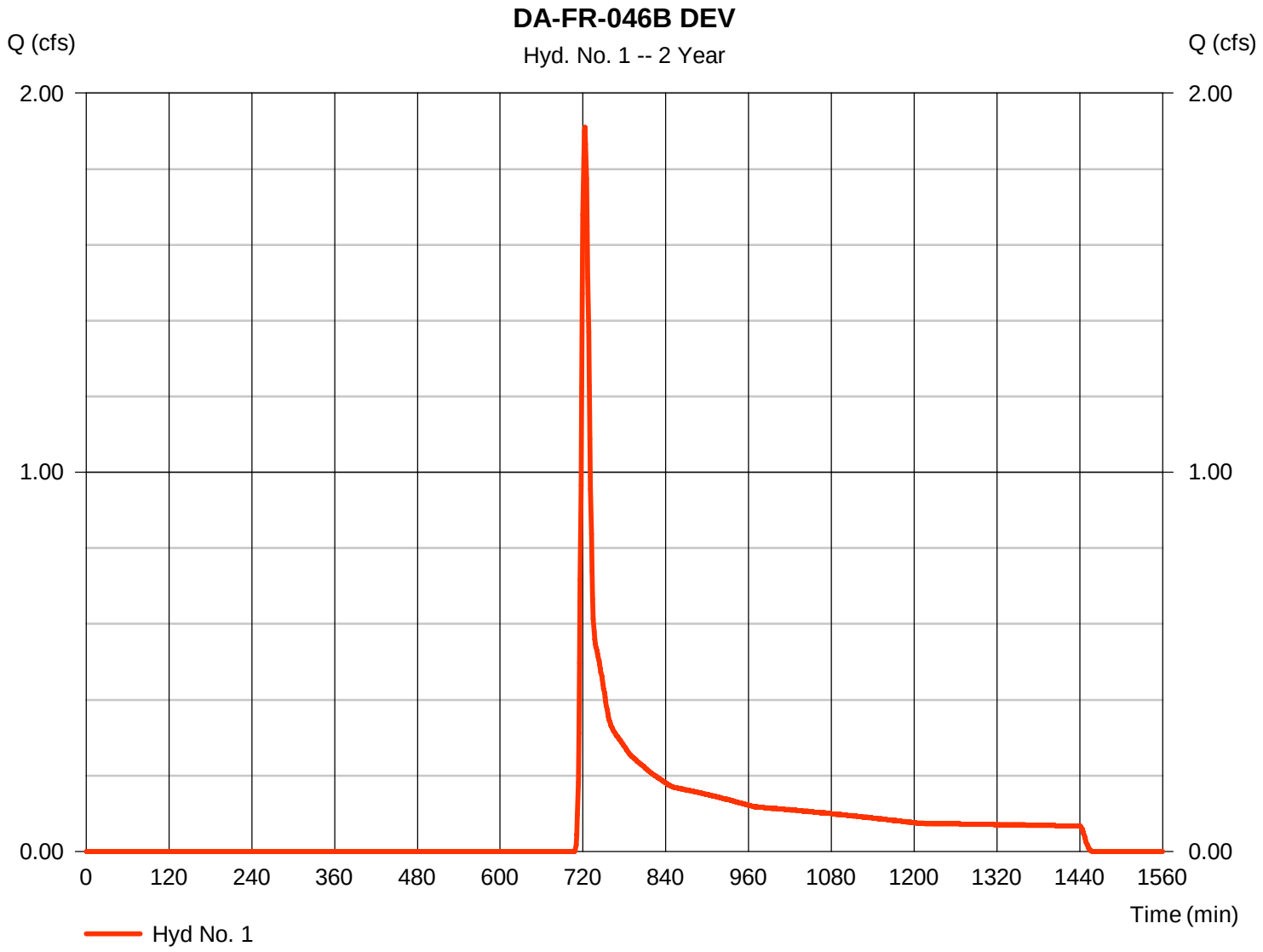
Hydrograph Report

Hyd. No. 1

DA-FR-046B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 1.911 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 7,007 cuft
Drainage area	= 4.180 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.134 x 48) + (0.034 x 98) + (1.229 x 58) + (2.784 x 55)] / 4.180

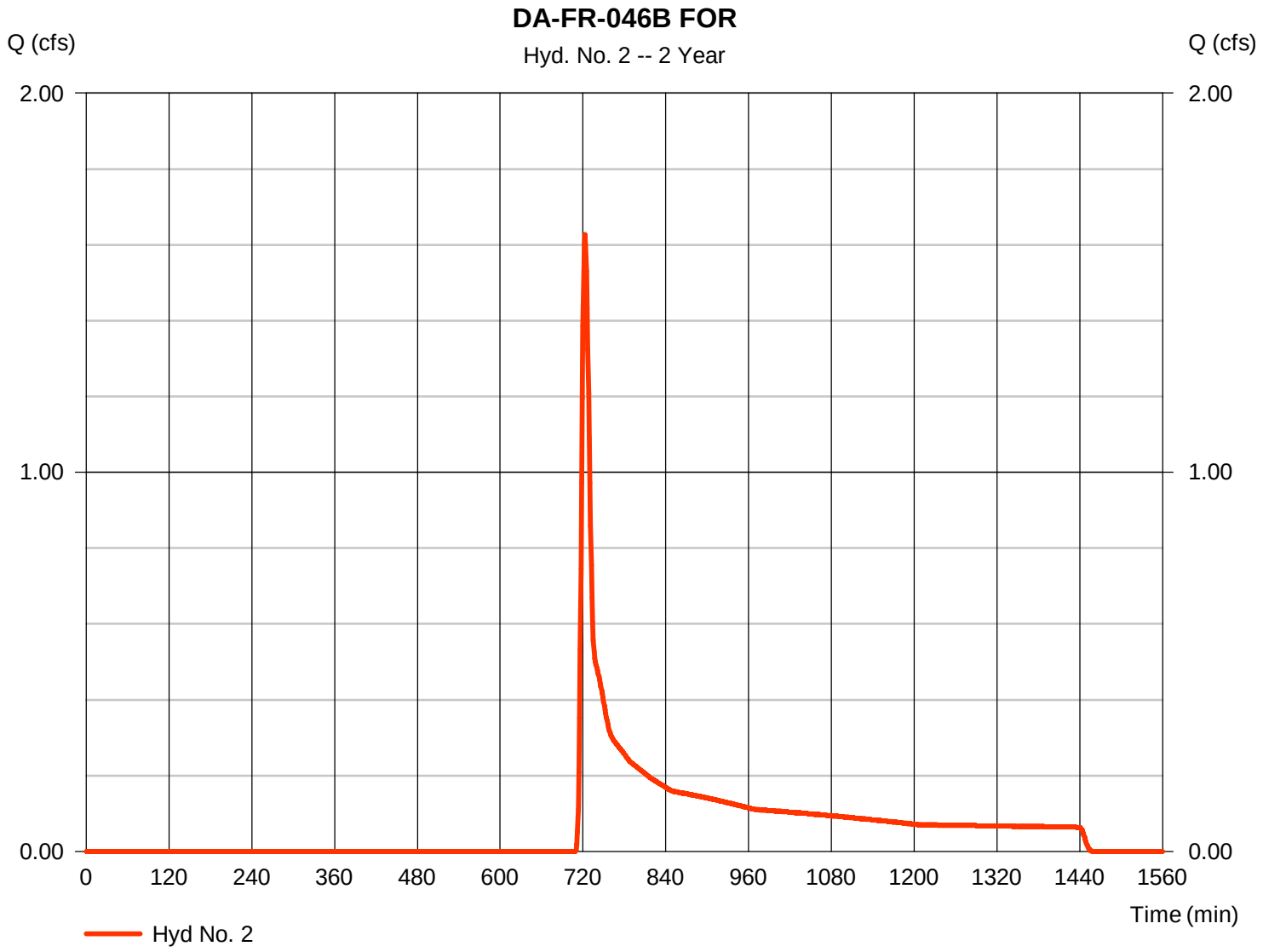


Hydrograph Report

Hyd. No. 2

DA-FR-046B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.627 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 6,418 cuft
Drainage area	= 4.180 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



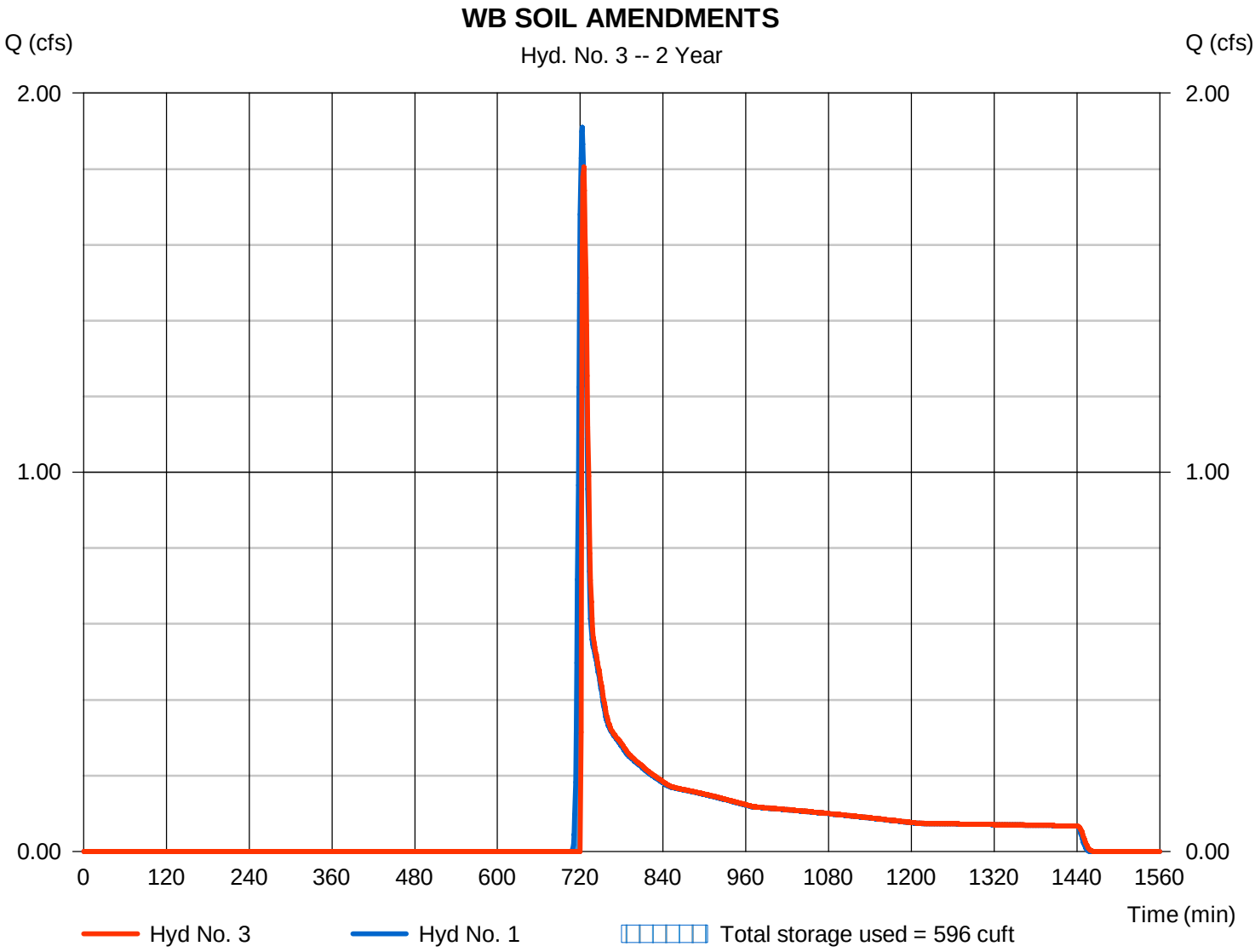
Hydrograph Report

Hyd. No. 3

WB SOIL AMENDMENTS

Hydrograph type	=	Reservoir	Peak discharge	=	1.805 cfs
Storm frequency	=	2 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	6,581 cuft
Inflow hyd. No.	=	1 - DA-FR-046B DEV	Max. Elevation	=	101.67 ft
Reservoir name	=	WATERBAR SOIL AMENDMENTS	Max. Storage	=	596 cuft

Storage Indication method used.



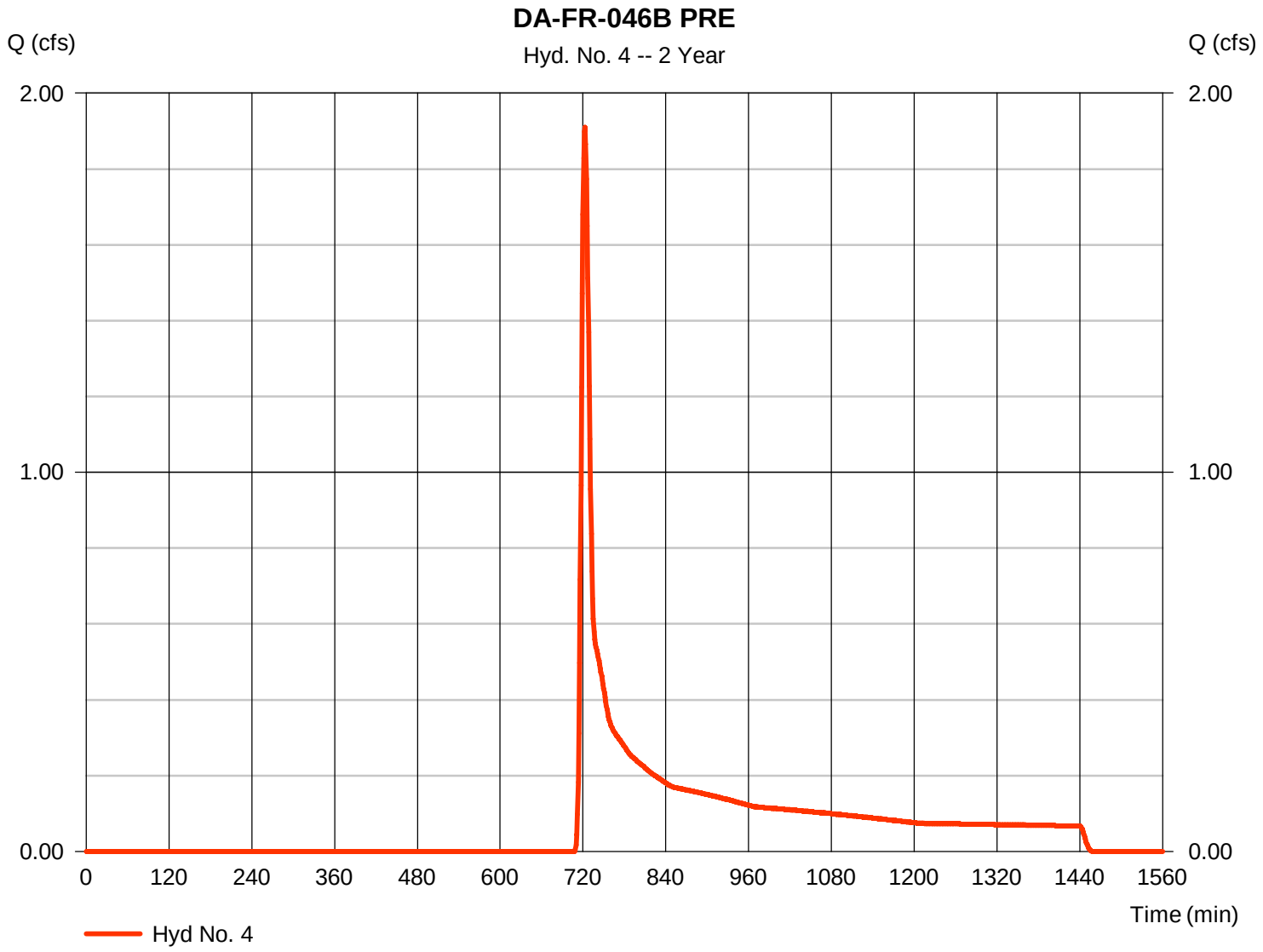
Hydrograph Report

Hyd. No. 4

DA-FR-046B PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.911 cfs
Storm frequency	=	2 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	7,007 cuft
Drainage area	=	4.180 ac	Curve number	=	56*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	10.60 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.034 x 98) + (1.229 x 58) + (2.917 x 55)] / 4.180



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	8.460	1	721	21,964	------	------	------	DA-FR-046B DEV
2	SCS Runoff	7.914	1	721	20,827	------	------	------	DA-FR-046B FOR
3	Reservoir	8.391	1	722	21,539	1	101.96	902	WB SOIL AMENDMENTS
4	SCS Runoff	8.460	1	721	21,964	------	------	------	DA-FR-046B PRE

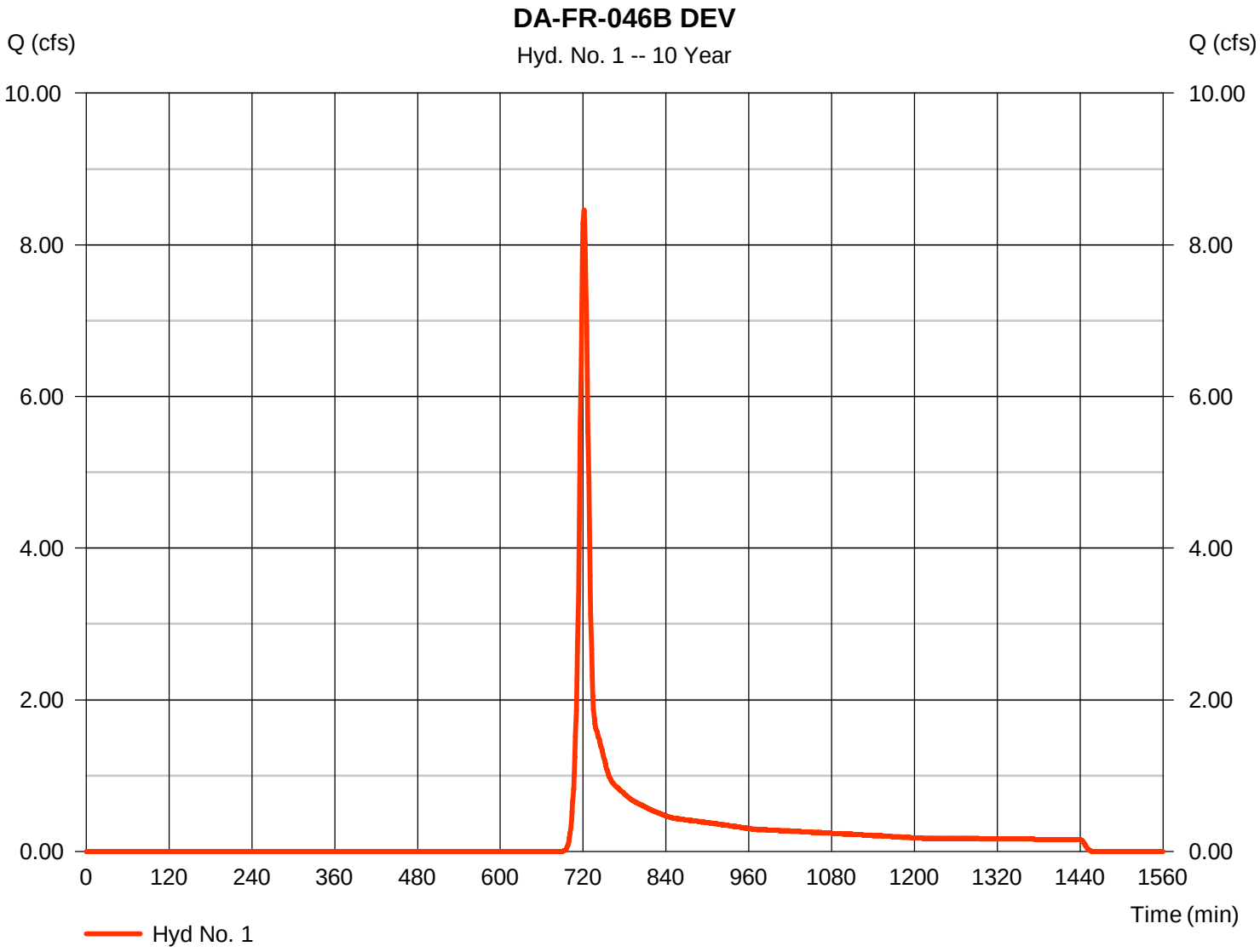
Hydrograph Report

Hyd. No. 1

DA-FR-046B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 8.460 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 21,964 cuft
Drainage area	= 4.180 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.134 x 48) + (0.034 x 98) + (1.229 x 58) + (2.784 x 55)] / 4.180

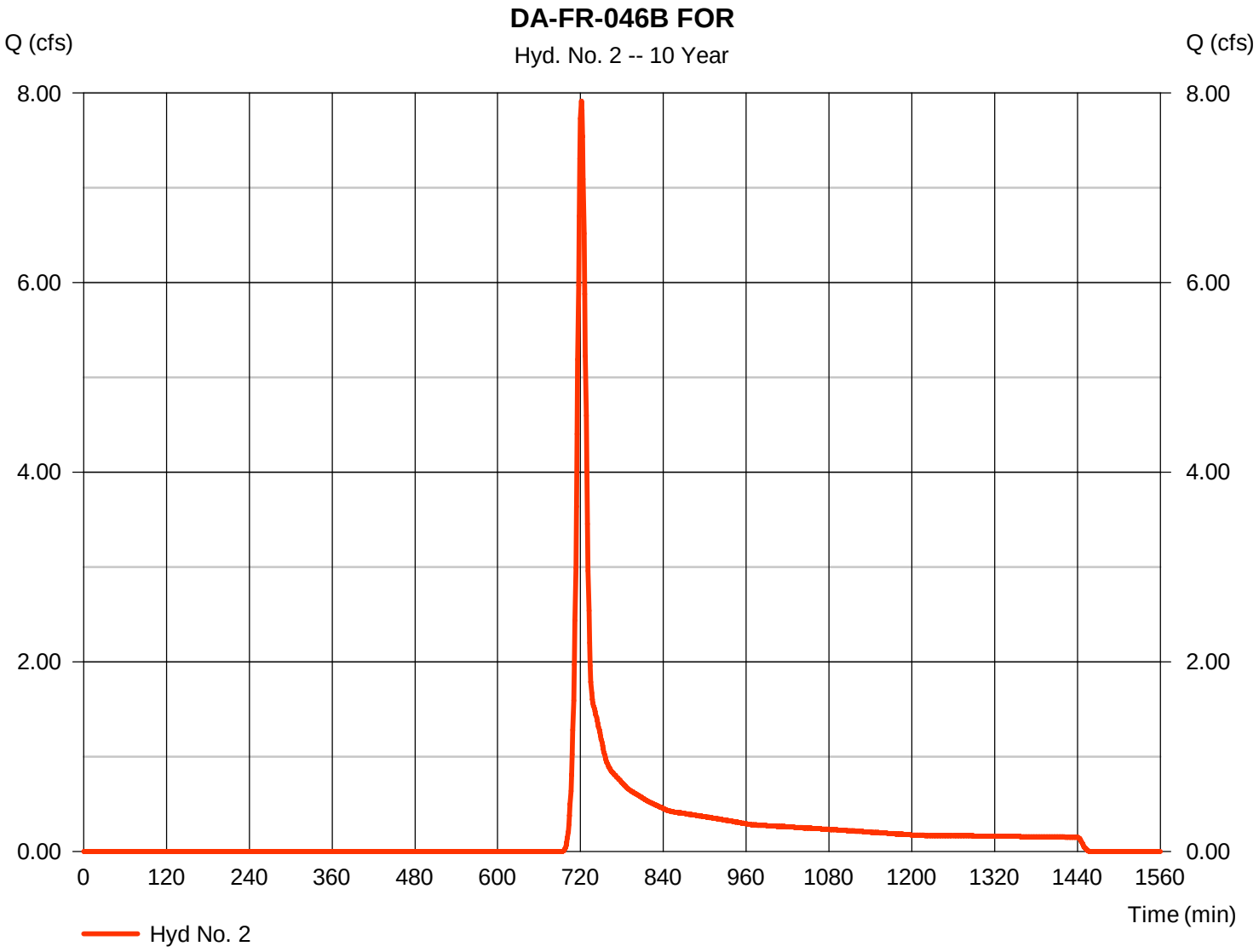


Hydrograph Report

Hyd. No. 2

DA-FR-046B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 7.914 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 20,827 cuft
Drainage area	= 4.180 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



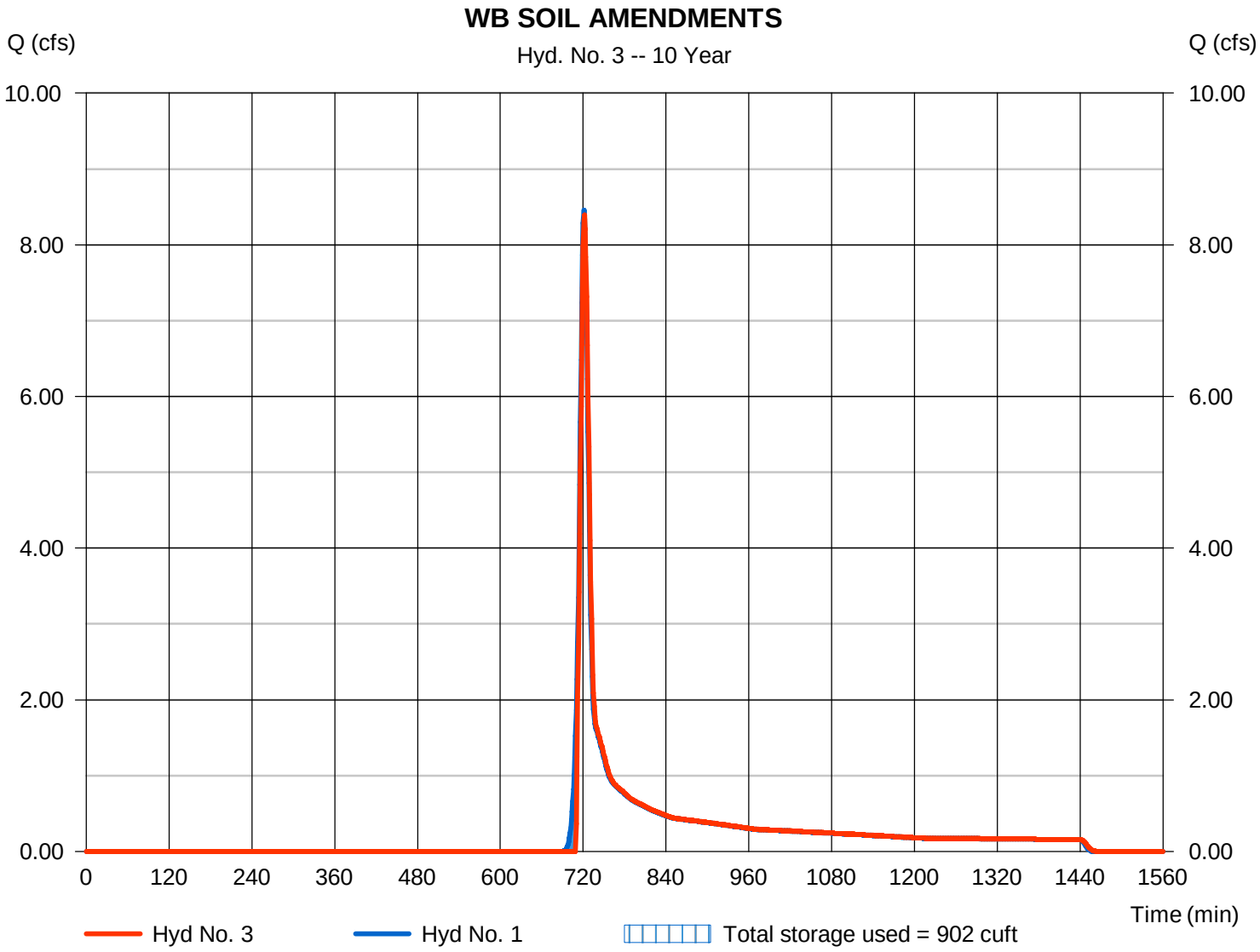
Hydrograph Report

Hyd. No. 3

WB SOIL AMENDMENTS

Hydrograph type	=	Reservoir	Peak discharge	=	8.391 cfs
Storm frequency	=	10 yrs	Time to peak	=	722 min
Time interval	=	1 min	Hyd. volume	=	21,539 cuft
Inflow hyd. No.	=	1 - DA-FR-046B DEV	Max. Elevation	=	101.96 ft
Reservoir name	=	WATERBAR SOIL AMENDMENTS	Max. Storage	=	902 cuft

Storage Indication method used.



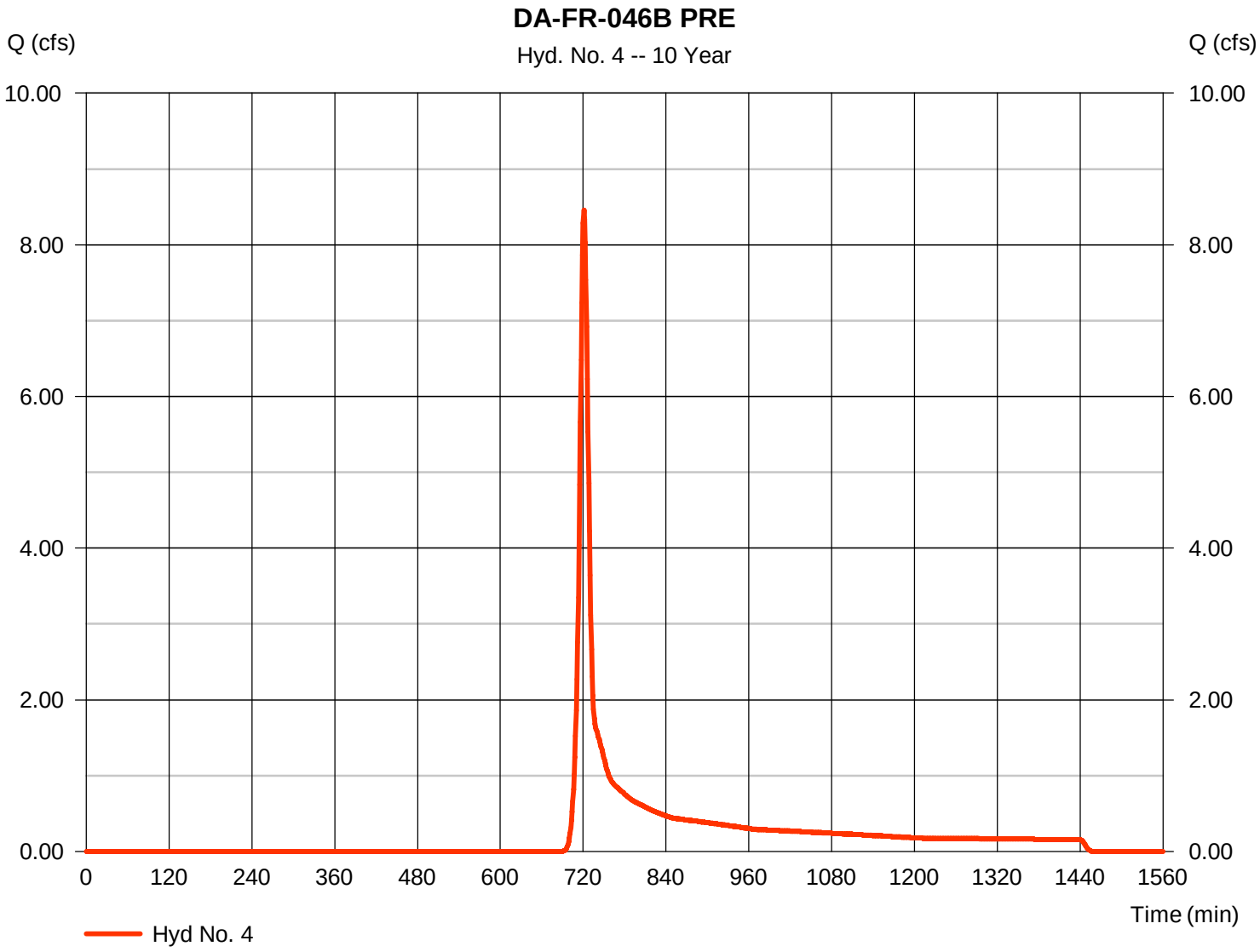
Hydrograph Report

Hyd. No. 4

DA-FR-046B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 8.460 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 21,964 cuft
Drainage area	= 4.180 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.60 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.034 x 98) + (1.229 x 58) + (2.917 x 55)] / 4.180



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-046C

STORAGE VOLUME OF WATERBAR WITH SOIL COMPOST AMENDMENT AREA

Equations Used:

[1]Vgravel storage = L*W*D_{gravel}*(40/100)

[2]Vsoil storage = L*W*D_{soil}*(20/100)

[3]Vsurface storage = [W*S*D^2]+[L*S*D^2]+[W*L*D]+[((2*S*D)^2*D)/3]

[1]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that gravel is made up of 40% voids.

[2]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that soil compost amendment is made up of 20% voids.

[3]Equation #1 under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, but calculation also takes into account surface side slopes.

Inputs:

Depth of Gravel Layer, D_{gravel} (ft) =	0	
Depth of Soil Amendment Area, D_{soil} (ft) =	1	Refer to Table 4.3 in VA DEQ Stormwater Design Specification No. 4; Note that compost amendment may not be necessary for HSG A/B soils
Length of Waterbar Soil Amendment Area, L (ft) =	50	Assume max. length of 50' for waterbar soil amendment areas (i.e., limited to permanent ROW)
Width of Waterbar Soil Amendment Area, W (ft) =	3	
Inside Embankment Side Slopes, S (H:V) =	2	Assume 2H:1V surface side slopes for waterbars
Number of Perm. Waterbars in Drainage Area, n =	7	
Design Infiltration Rate, IR (in/hr) =	0.2	Min. rate of 0.30 in/hr for HSG A soils and 0.15-0.30 in/hr for HSG B soils (see Chap. 4, p. 4-30 in VA Stormwater Management Handbook Volume II (First Edition, 1999)
Surface Ponding Depth, D (ft) =	0.5	Assume 0.5' CFS height at the end of waterbars

Calculations:

Total Storage Depth per BMP (ft) =	1.5
Surface Storage Volume per BMP (cf) =	102
Subsurface Storage Volume per BMP (cf) =	30
Total Storage Volume per BMP (cf) =	132
Total BMP Storage Volume in Drainage Area (cf) =	925
Calculated Infiltration Period per BMP (hr) =	53

Depth-Storage Data

Depth (ft)	Width (ft)	Length (ft)	Storage Volume per BMP (cf)	Storage Volume in Drainage Area (cf)
0	3	50	0	0
0.5	3	50	15	105
1	3	50	30	210
1.5	5	52	132	925
2	7	54	291	2039

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.658	8505
Developed Condition	1.389	7580
Pre-Developed (Forest) Condition	0.775	5806

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	1.389	≤ OK	1.488	
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	1.389	≤ OK	1.658	
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	1.389	*shall not* be required to be ≤	0.594	

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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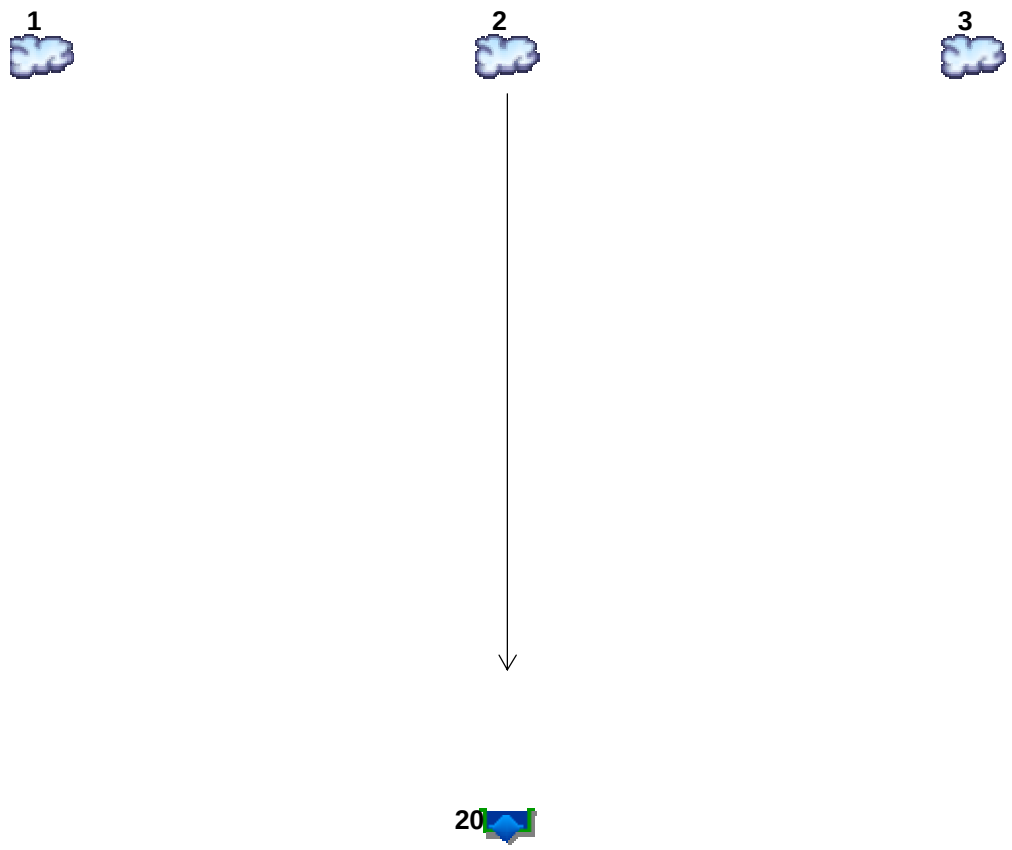
Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-046C PRE
2	SCS Runoff	DA-FRE-046C DEV
3	SCS Runoff	DA-FR-046C FOR
20	Reservoir	WB SOIL AMENDMENTS

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.658	2.719	-------	-------	10.13	-------	-------	-------	DA-FR-046C PRE
2	SCS Runoff	------	1.658	2.719	-------	-------	10.13	-------	-------	-------	DA-FRE-046C DEV
3	SCS Runoff	------	0.775	1.530	-------	-------	7.802	-------	-------	-------	DA-FR-046C FOR
20	Reservoir	2	1.389	2.588	-------	-------	10.07	-------	-------	-------	WB SOIL AMENDMENTS

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.658	1	728	8,505	------	------	------	DA-FR-046C PRE
2	SCS Runoff	1.658	1	728	8,505	------	------	------	DA-FRE-046C DEV
3	SCS Runoff	0.775	1	730	5,806	------	------	------	DA-FR-046C FOR
20	Reservoir	1.389	1	735	7,580	2	101.60	1,138	WB SOIL AMENDMENTS

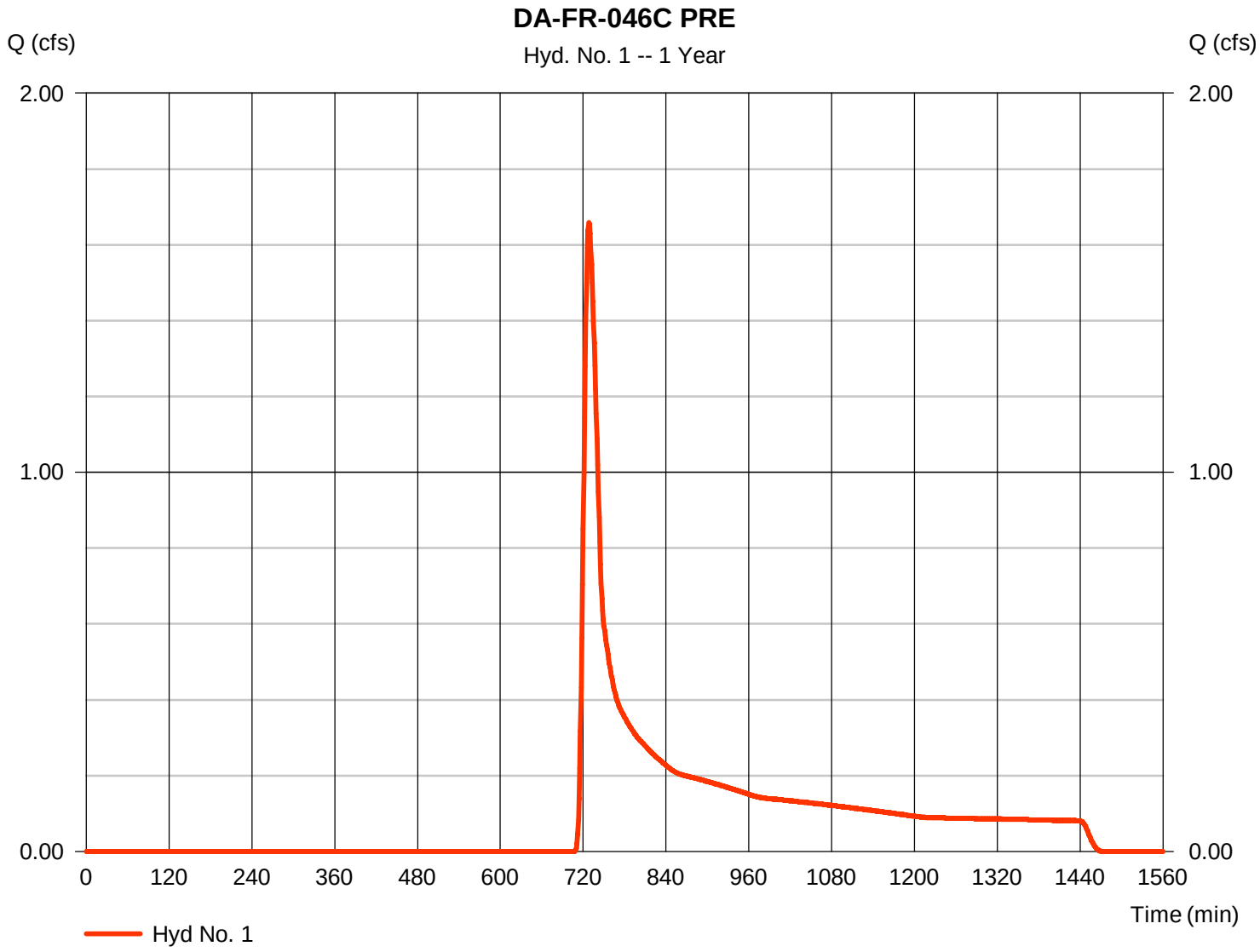
Hydrograph Report

Hyd. No. 1

DA-FR-046C PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.658 cfs
Storm frequency	=	1 yrs	Time to peak	=	728 min
Time interval	=	1 min	Hyd. volume	=	8,505 cuft
Drainage area	=	5.690 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	19.90 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(1.273 x 58) + (1.121 x 71) + (0.035 x 100) + (3.217 x 55) + (0.042 x 70)] / 5.690



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-046C PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 3.11		0.00		0.00		
Travel Time (min)	**= 16.74**	**+**	**0.00**	**+**	**0.00**	**=**	**16.74**
Shallow Concentrated Flow							
Flow length (ft)	= 446.17		0.00		0.00		
Watercourse slope (%)	= 14.08		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.05		0.00		0.00		
Travel Time (min)	**= 1.23**	**+**	**0.00**	**+**	**0.00**	**=**	**1.23**
Channel Flow							
X sectional flow area (sqft)	= 0.99		0.00		0.00		
Wetted perimeter (ft)	= 5.77		0.00		0.00		
Channel slope (%)	= 13.90		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=5.68						
			0.00				
					0.00		
Flow length (ft)	({0})647.8		0.0		0.0		
Travel Time (min)	**= 1.90**	**+**	**0.00**	**+**	**0.00**	**=**	**1.90**

Total Travel Time, Tc ..... 19.90 min

Hydrograph Report

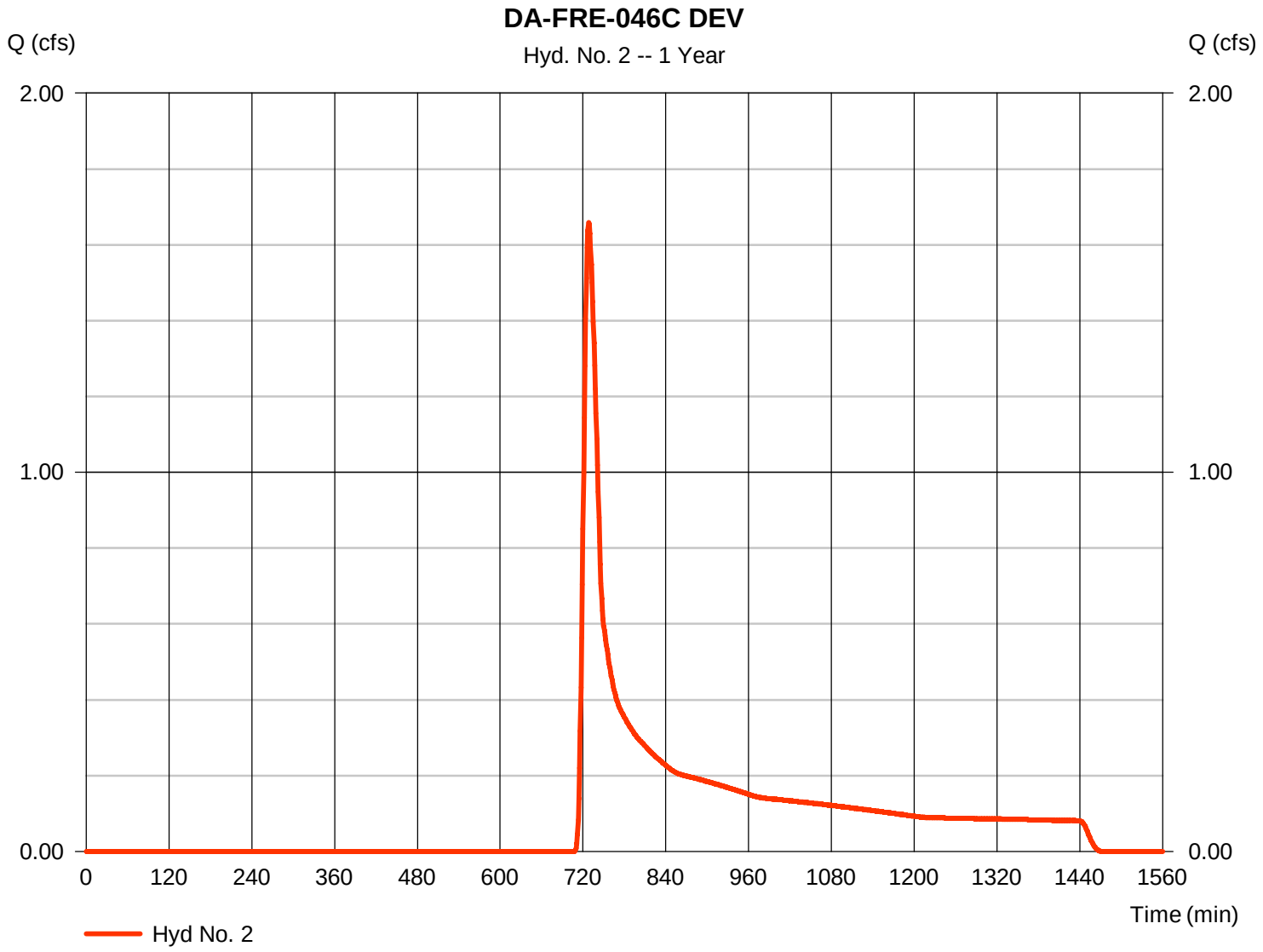
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 2

DA-FRE-046C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 1.658 cfs
Storm frequency	= 1 yrs	Time to peak	= 728 min
Time interval	= 1 min	Hyd. volume	= 8,505 cuft
Drainage area	= 5.690 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.80 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.013 x 48) + (1.300 x 58) + (1.142 x 71) + (0.036 x 100) + (3.177 x 55) + (0.021 x 70)] / 5.690



TR55 Tc Worksheet

Hyd. No. 2

DA-FRE-046C DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 3.11		0.00		0.00		
Travel Time (min)	**= 16.74**	**+**	**0.00**	**+**	**0.00**	**=**	**16.74**
Shallow Concentrated Flow							
Flow length (ft)	= 446.17		14.47		0.00		
Watercourse slope (%)	= 14.08		23.28		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=6.05		7.78		0.00		
Travel Time (min)	**= 1.23**	**+**	**0.03**	**+**	**0.00**	**=**	**1.26**
Channel Flow							
X sectional flow area (sqft)	= 0.99		2.00		0.00		
Wetted perimeter (ft)	= 5.77		4.47		0.00		
Channel slope (%)	= 13.97		5.00		0.00		
Manning's n-value	= 0.030		0.040		0.015		
Velocity (ft/s)	=5.70						
			4.86				
					0.00		
Flow length (ft)	({0})598.0		11.1		0.0		
Travel Time (min)	**= 1.75**	**+**	**0.04**	**+**	**0.00**	**=**	**1.79**

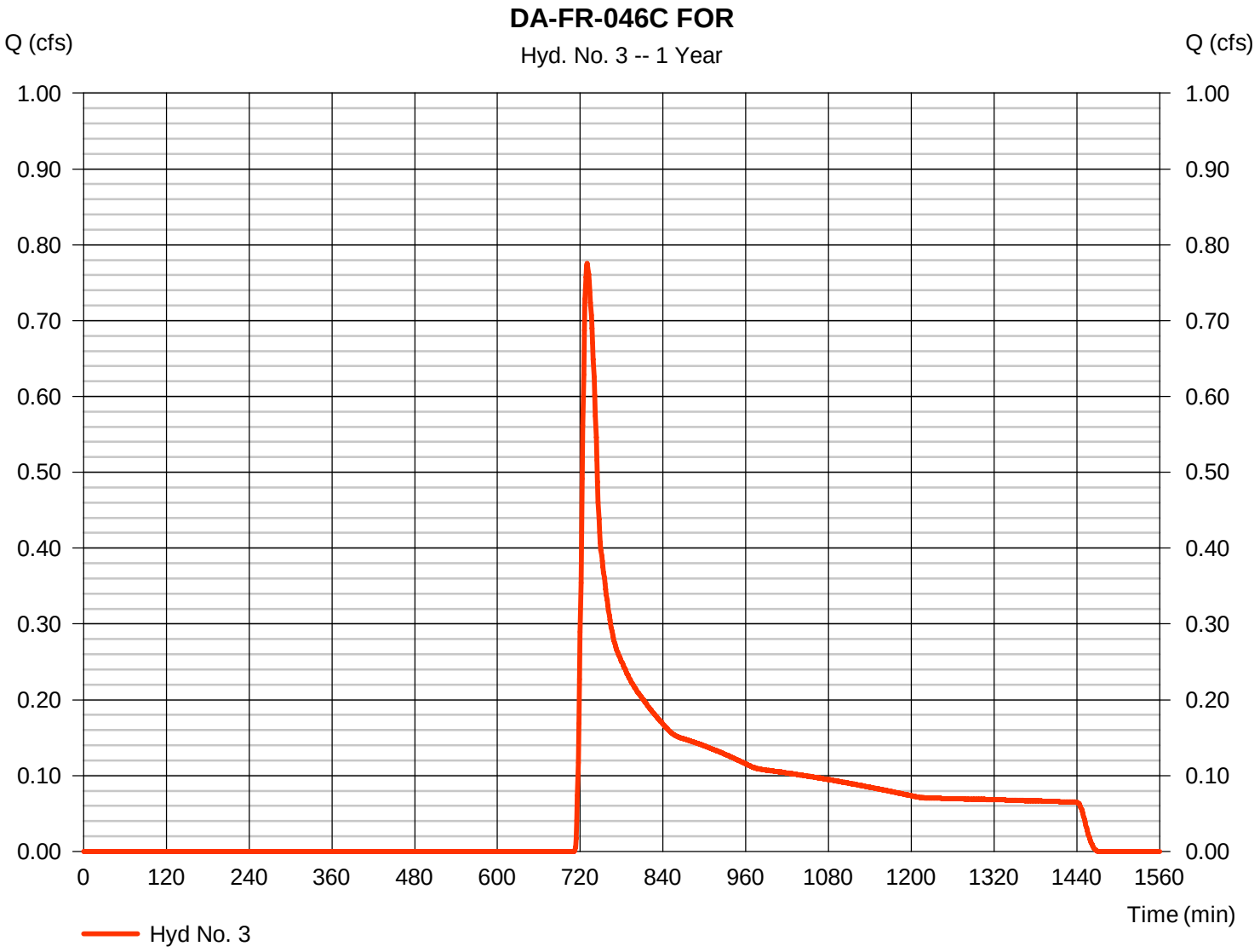
Total Travel Time, Tc ..... 19.80 min

Hydrograph Report

Hyd. No. 3

DA-FR-046C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.775 cfs
Storm frequency	= 1 yrs	Time to peak	= 730 min
Time interval	= 1 min	Hyd. volume	= 5,806 cuft
Drainage area	= 5.690 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.90 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-046C FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 3.11		0.00		0.00		
Travel Time (min)	**= 16.74**	**+**	**0.00**	**+**	**0.00**	**=**	**16.74**
Shallow Concentrated Flow							
Flow length (ft)	= 446.17		0.00		0.00		
Watercourse slope (%)	= 14.08		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.05		0.00		0.00		
Travel Time (min)	**= 1.23**	**+**	**0.00**	**+**	**0.00**	**=**	**1.23**
Channel Flow							
X sectional flow area (sqft)	= 0.99		0.00		0.00		
Wetted perimeter (ft)	= 5.77		0.00		0.00		
Channel slope (%)	= 13.90		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=5.68						
			0.00				
					0.00		
Flow length (ft)	({0})647.8		0.0		0.0		
Travel Time (min)	**= 1.90**	**+**	**0.00**	**+**	**0.00**	**=**	**1.90**

Total Travel Time, Tc ..... 19.90 min

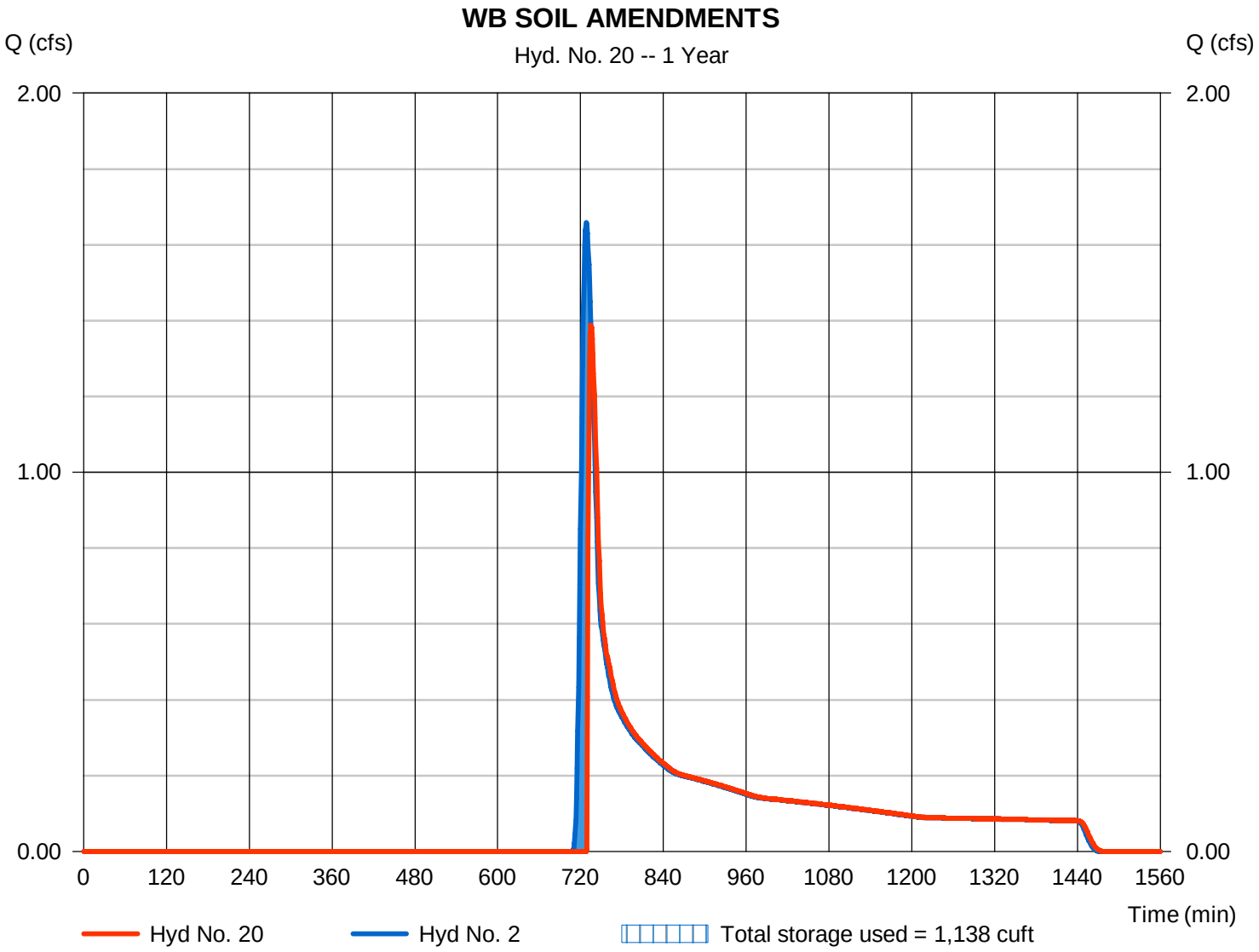
Hydrograph Report

Hyd. No. 20

WB SOIL AMENDMENTS

Hydrograph type	= Reservoir	Peak discharge	= 1.389 cfs
Storm frequency	= 1 yrs	Time to peak	= 735 min
Time interval	= 1 min	Hyd. volume	= 7,580 cuft
Inflow hyd. No.	= 2 - DA-FRE-046C DEV	Max. Elevation	= 101.60 ft
Reservoir name	= WATERBAR SOIL AMENDMENTS	Max. Storage	= 1,138 cuft

Storage Indication method used.



Pond No. 1 - WATERBAR SOIL AMENDMENTS

Pond Data

Pond storage is based on user-defined values.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	100.00	n/a	0	0
0.50	100.50	n/a	105	105
1.00	101.00	n/a	105	210
1.50	101.50	n/a	715	925
2.00	102.00	n/a	1,114	2,039

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 0.00	0.00	0.00	0.00
Span (in)	= 0.00	0.00	0.00	0.00
No. Barrels	= 0	0	0	0
Invert El. (ft)	= 0.00	0.00	0.00	0.00
Length (ft)	= 0.00	0.00	0.00	0.00
Slope (%)	= 0.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 14.00	0.00	0.00	0.00
Crest El. (ft)	= 101.50	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Rect	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	100.00	---	---	---	---	0.00	---	---	---	---	---	0.000
0.05	11	100.05	---	---	---	---	0.00	---	---	---	---	---	0.000
0.10	21	100.10	---	---	---	---	0.00	---	---	---	---	---	0.000
0.15	32	100.15	---	---	---	---	0.00	---	---	---	---	---	0.000
0.20	42	100.20	---	---	---	---	0.00	---	---	---	---	---	0.000
0.25	53	100.25	---	---	---	---	0.00	---	---	---	---	---	0.000
0.30	63	100.30	---	---	---	---	0.00	---	---	---	---	---	0.000
0.35	74	100.35	---	---	---	---	0.00	---	---	---	---	---	0.000
0.40	84	100.40	---	---	---	---	0.00	---	---	---	---	---	0.000
0.45	95	100.45	---	---	---	---	0.00	---	---	---	---	---	0.000
0.50	105	100.50	---	---	---	---	0.00	---	---	---	---	---	0.000
0.55	116	100.55	---	---	---	---	0.00	---	---	---	---	---	0.000
0.60	126	100.60	---	---	---	---	0.00	---	---	---	---	---	0.000
0.65	137	100.65	---	---	---	---	0.00	---	---	---	---	---	0.000
0.70	147	100.70	---	---	---	---	0.00	---	---	---	---	---	0.000
0.75	158	100.75	---	---	---	---	0.00	---	---	---	---	---	0.000
0.80	168	100.80	---	---	---	---	0.00	---	---	---	---	---	0.000
0.85	179	100.85	---	---	---	---	0.00	---	---	---	---	---	0.000
0.90	189	100.90	---	---	---	---	0.00	---	---	---	---	---	0.000
0.95	200	100.95	---	---	---	---	0.00	---	---	---	---	---	0.000
1.00	210	101.00	---	---	---	---	0.00	---	---	---	---	---	0.000
1.05	282	101.05	---	---	---	---	0.00	---	---	---	---	---	0.000
1.10	353	101.10	---	---	---	---	0.00	---	---	---	---	---	0.000
1.15	425	101.15	---	---	---	---	0.00	---	---	---	---	---	0.000
1.20	496	101.20	---	---	---	---	0.00	---	---	---	---	---	0.000
1.25	568	101.25	---	---	---	---	0.00	---	---	---	---	---	0.000
1.30	639	101.30	---	---	---	---	0.00	---	---	---	---	---	0.000
1.35	711	101.35	---	---	---	---	0.00	---	---	---	---	---	0.000
1.40	782	101.40	---	---	---	---	0.00	---	---	---	---	---	0.000
1.45	854	101.45	---	---	---	---	0.00	---	---	---	---	---	0.000
1.50	925	101.50	---	---	---	---	0.00	---	---	---	---	---	0.000
1.55	1,036	101.55	---	---	---	---	0.52	---	---	---	---	---	0.521
1.60	1,148	101.60	---	---	---	---	1.47	---	---	---	---	---	1.474
1.65	1,259	101.65	---	---	---	---	2.71	---	---	---	---	---	2.709
1.70	1,371	101.70	---	---	---	---	4.17	---	---	---	---	---	4.170
1.75	1,482	101.75	---	---	---	---	5.83	---	---	---	---	---	5.828
1.80	1,593	101.80	---	---	---	---	7.66	---	---	---	---	---	7.661
1.85	1,705	101.85	---	---	---	---	9.65	---	---	---	---	---	9.654
1.90	1,816	101.90	---	---	---	---	11.80	---	---	---	---	---	11.80

Continues on next page...

WATERBAR SOIL AMENDMENTS

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
1.95	1,928	101.95	---	---	---	---	14.07	---	---	---	---	---	14.07
2.00	2,039	102.00	---	---	---	---	16.48	---	---	---	---	---	16.48

...End

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.719	1	728	11,905	------	------	------	DA-FR-046C PRE
2	SCS Runoff	2.719	1	728	11,905	------	------	------	DA-FRE-046C DEV
3	SCS Runoff	1.530	1	729	8,584	------	------	------	DA-FR-046C FOR
20	Reservoir	2.588	1	730	10,980	2	101.65	1,248	WB SOIL AMENDMENTS

Hydrograph Report

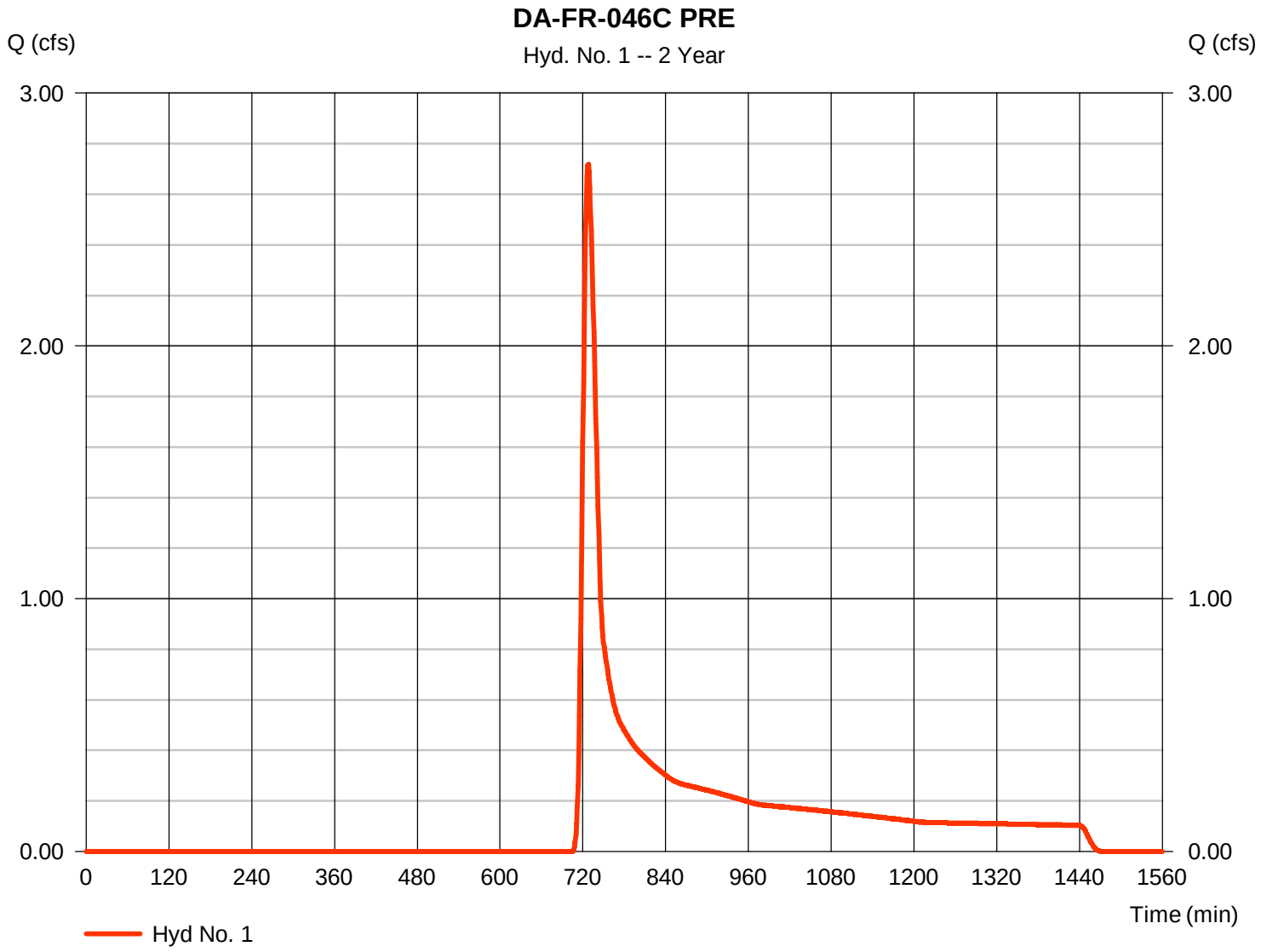
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 1

DA-FR-046C PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.719 cfs
Storm frequency	=	2 yrs	Time to peak	=	728 min
Time interval	=	1 min	Hyd. volume	=	11,905 cuft
Drainage area	=	5.690 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	19.90 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(1.273 x 58) + (1.121 x 71) + (0.035 x 100) + (3.217 x 55) + (0.042 x 70)] / 5.690



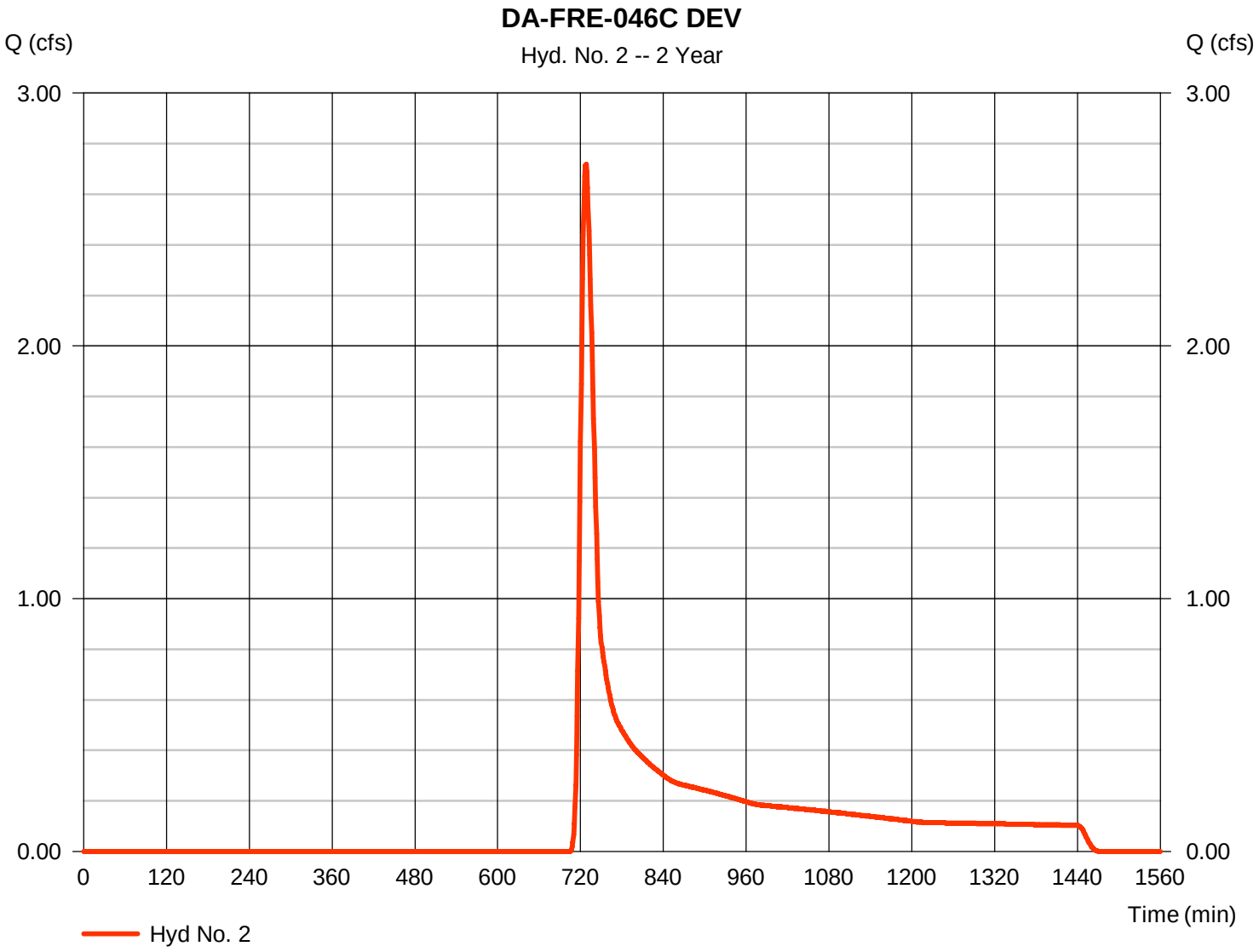
Hydrograph Report

Hyd. No. 2

DA-FRE-046C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 2.719 cfs
Storm frequency	= 2 yrs	Time to peak	= 728 min
Time interval	= 1 min	Hyd. volume	= 11,905 cuft
Drainage area	= 5.690 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.80 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.013 x 48) + (1.300 x 58) + (1.142 x 71) + (0.036 x 100) + (3.177 x 55) + (0.021 x 70)] / 5.690

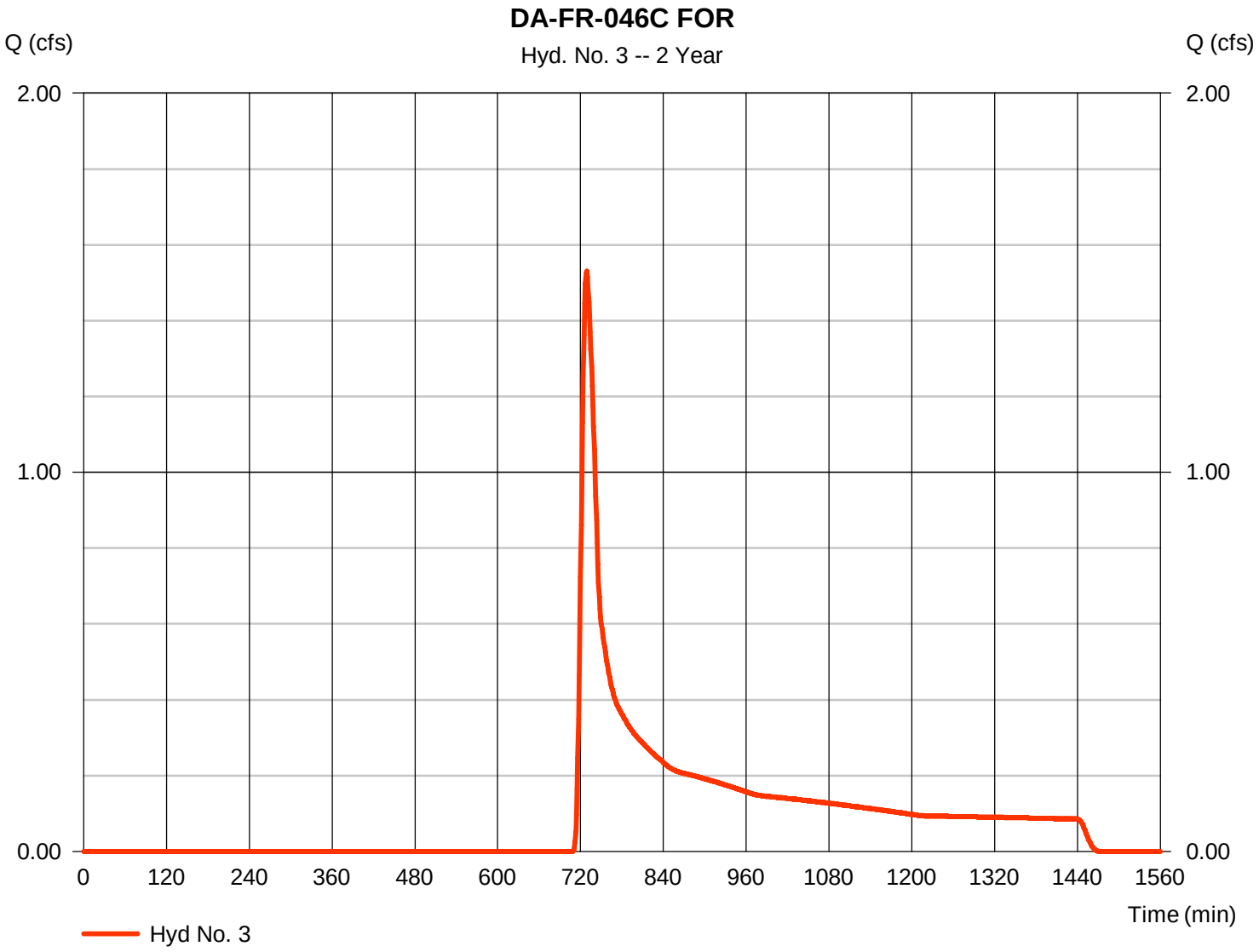


Hydrograph Report

Hyd. No. 3

DA-FR-046C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.530 cfs
Storm frequency	= 2 yrs	Time to peak	= 729 min
Time interval	= 1 min	Hyd. volume	= 8,584 cuft
Drainage area	= 5.690 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.90 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



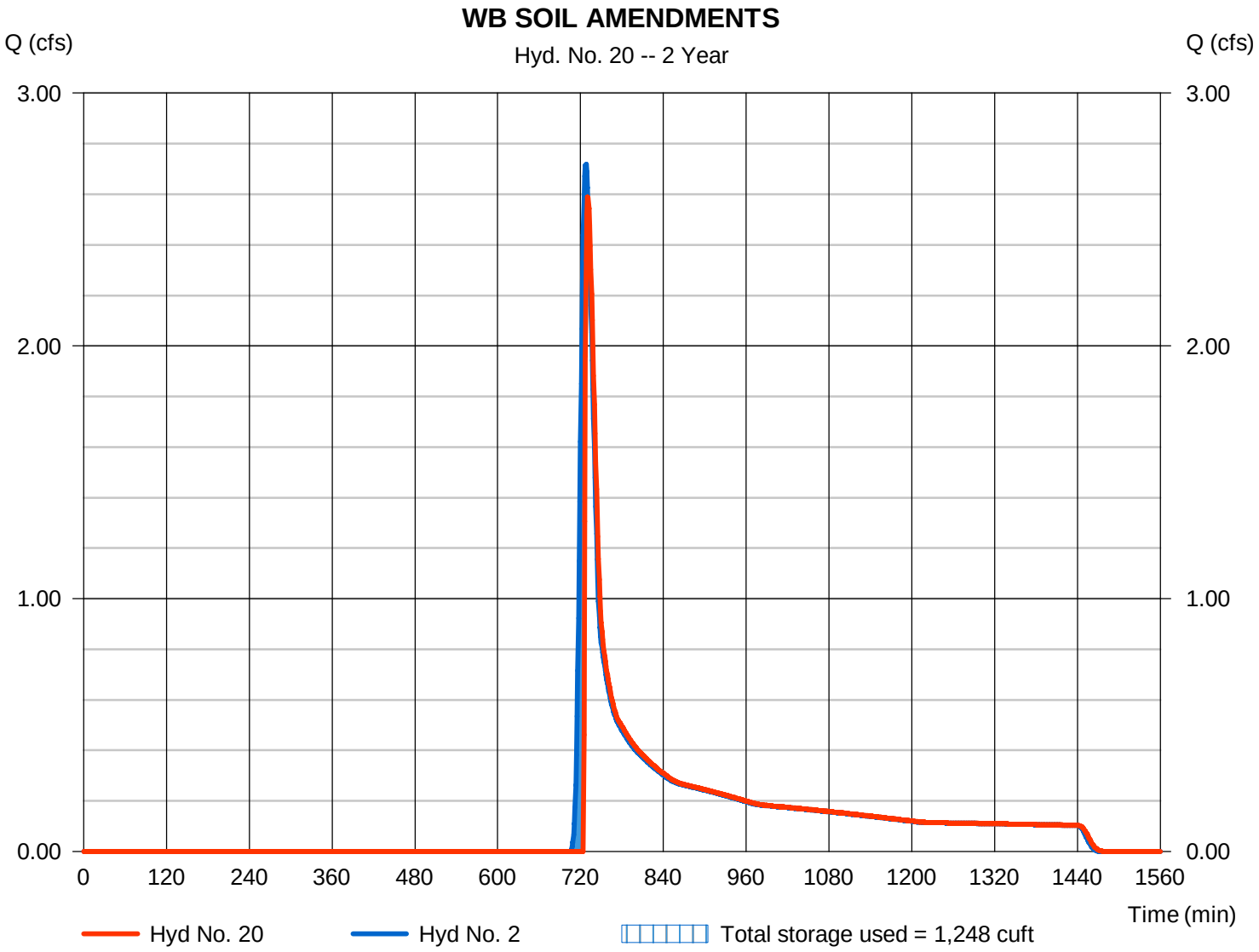
Hydrograph Report

Hyd. No. 20

WB SOIL AMENDMENTS

Hydrograph type	= Reservoir	Peak discharge	= 2.588 cfs
Storm frequency	= 2 yrs	Time to peak	= 730 min
Time interval	= 1 min	Hyd. volume	= 10,980 cuft
Inflow hyd. No.	= 2 - DA-FRE-046C DEV	Max. Elevation	= 101.65 ft
Reservoir name	= WATERBAR SOIL AMENDMENTS	Max. Storage	= 1,248 cuft

Storage Indication method used.



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	10.13	1	726	34,080	------	------	------	DA-FR-046C PRE
2	SCS Runoff	10.13	1	726	34,080	------	------	------	DA-FRE-046C DEV
3	SCS Runoff	7.802	1	726	27,853	------	------	------	DA-FR-046C FOR
20	Reservoir	10.07	1	727	33,155	2	101.86	1,726	WB SOIL AMENDMENTS

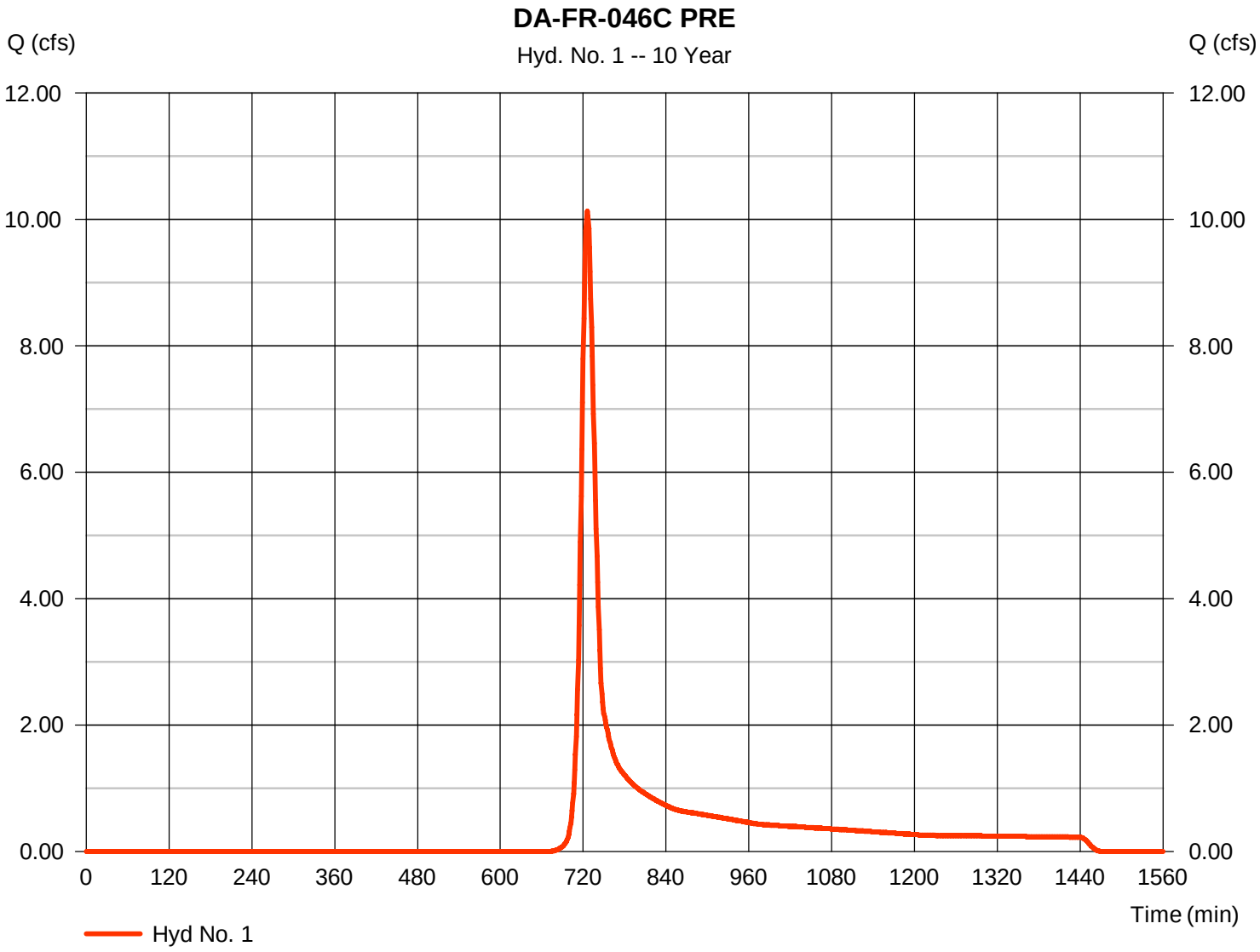
Hydrograph Report

Hyd. No. 1

DA-FR-046C PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	10.13 cfs
Storm frequency	=	10 yrs	Time to peak	=	726 min
Time interval	=	1 min	Hyd. volume	=	34,080 cuft
Drainage area	=	5.690 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	19.90 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(1.273 x 58) + (1.121 x 71) + (0.035 x 100) + (3.217 x 55) + (0.042 x 70)] / 5.690



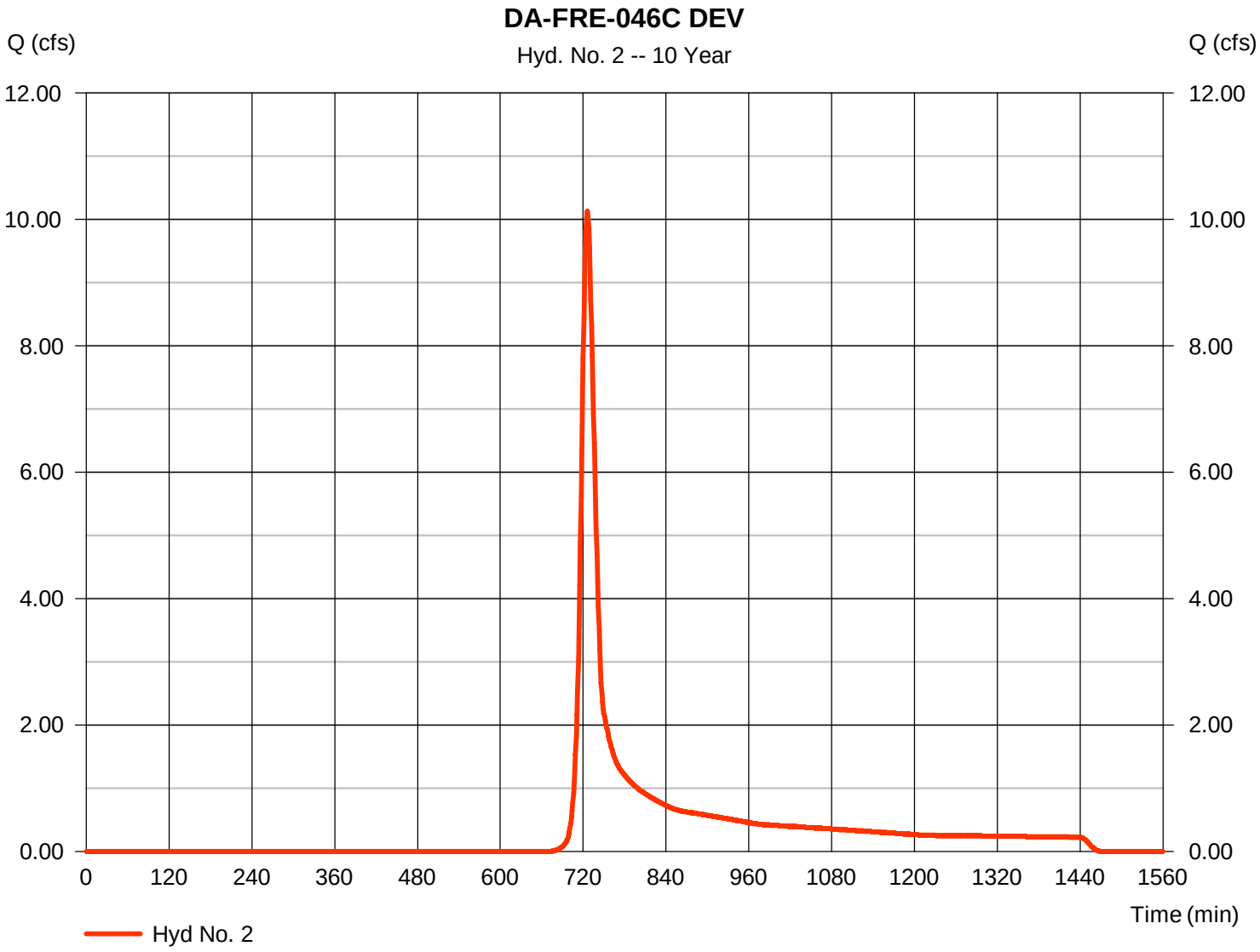
Hydrograph Report

Hyd. No. 2

DA-FRE-046C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 10.13 cfs
Storm frequency	= 10 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 34,080 cuft
Drainage area	= 5.690 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.80 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.013 x 48) + (1.300 x 58) + (1.142 x 71) + (0.036 x 100) + (3.177 x 55) + (0.021 x 70)] / 5.690

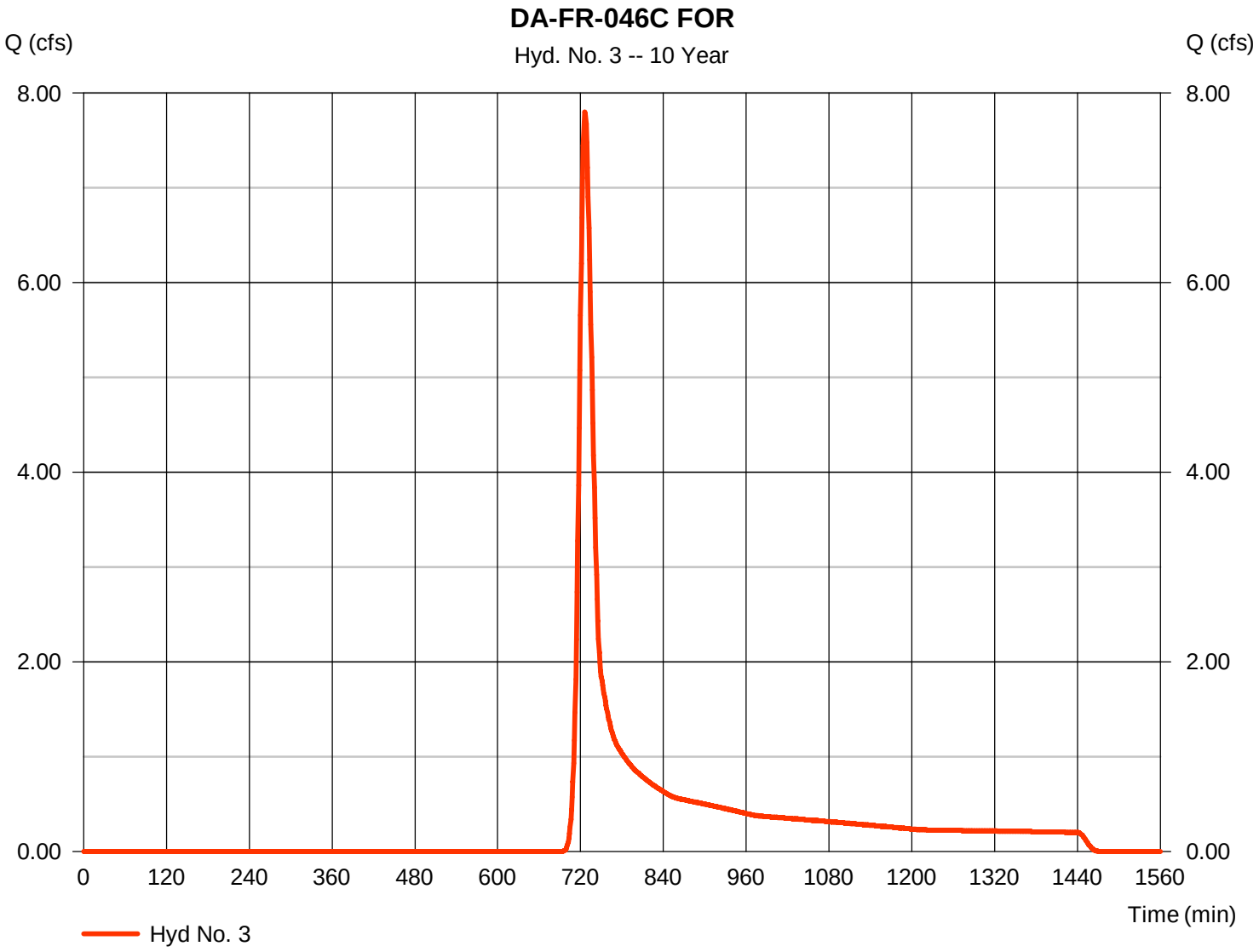


Hydrograph Report

Hyd. No. 3

DA-FR-046C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 7.802 cfs
Storm frequency	= 10 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 27,853 cuft
Drainage area	= 5.690 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 19.90 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



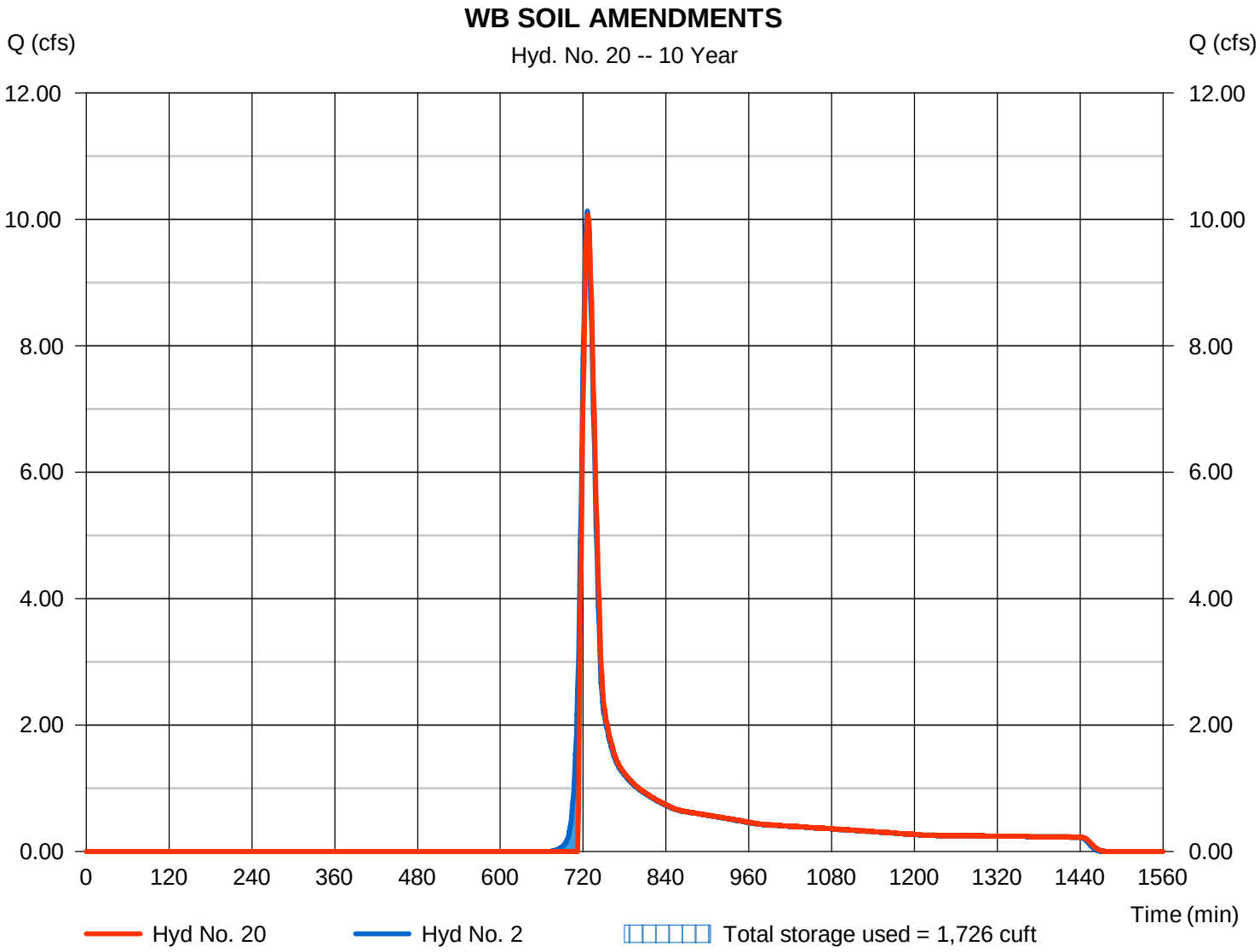
Hydrograph Report

Hyd. No. 20

WB SOIL AMENDMENTS

Hydrograph type	= Reservoir	Peak discharge	= 10.07 cfs
Storm frequency	= 10 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 33,155 cuft
Inflow hyd. No.	= 2 - DA-FRE-046C DEV	Max. Elevation	= 101.86 ft
Reservoir name	= WATERBAR SOIL AMENDMENTS	Max. Storage	= 1,726 cuft

Storage Indication method used.



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-046D

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.481	7288
Developed Condition	1.237	6643
Pre-Developed (Forest) Condition	0.810	5434

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	1.237	≤ OK	1.625
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	1.237	≤ OK	1.481
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	1.237	*shall not* be required to be ≤	0.663

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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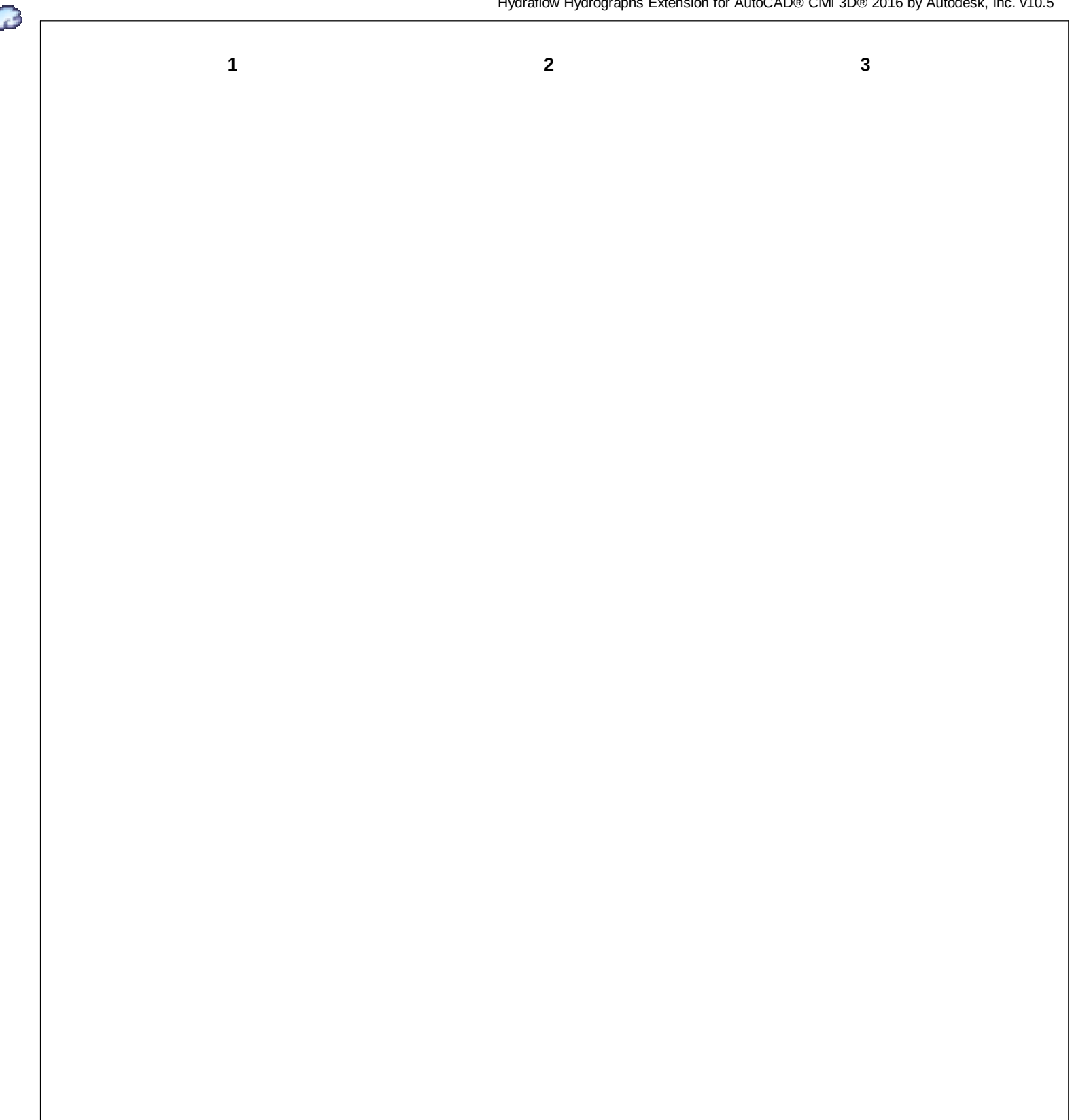
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-046D PRE
2	SCS Runoff	DA-FR-046D DEV
3	SCS Runoff	DA-FR-046D FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.481	2.519	-------	-------	9.903	-------	-------	-------	DA-FR-046D PRE
2	SCS Runoff	------	1.237	2.200	-------	-------	9.308	-------	-------	-------	DA-FR-046D DEV
3	SCS Runoff	------	0.810	1.607	-------	-------	8.129	-------	-------	-------	DA-FR-046D FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.481	1	726	7,288	------	------	------	DA-FR-046D PRE
2	SCS Runoff	1.237	1	727	6,643	------	------	------	DA-FR-046D DEV
3	SCS Runoff	0.810	1	727	5,434	------	------	------	DA-FR-046D FOR

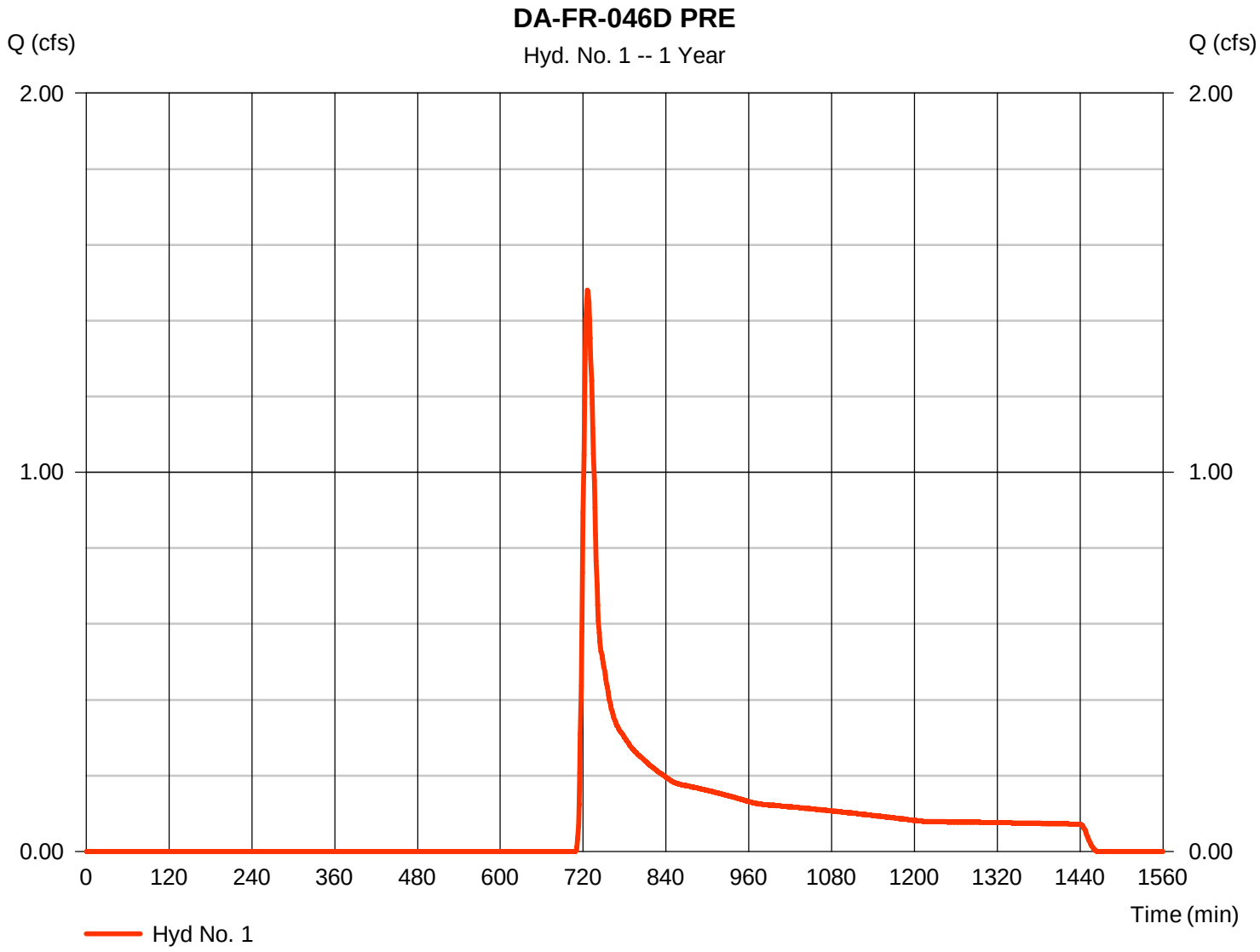
Hydrograph Report

Hyd. No. 1

DA-FR-046D PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 1.481 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 7,288 cuft
Drainage area	= 5.260 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(2.670 x 58) + (0.340 x 71) + (2.219 x 55) + (0.030 x 70)] / 5.260



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-046D PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.28		0.00		0.00		
Travel Time (min)	**= 13.54**	**+**	**0.00**	**+**	**0.00**	**=**	**13.54**
Shallow Concentrated Flow							
Flow length (ft)	= 644.42		0.00		0.00		
Watercourse slope (%)	= 15.05		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.26		0.00		0.00		
Travel Time (min)	**= 1.72**	**+**	**0.00**	**+**	**0.00**	**=**	**1.72**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.30 min

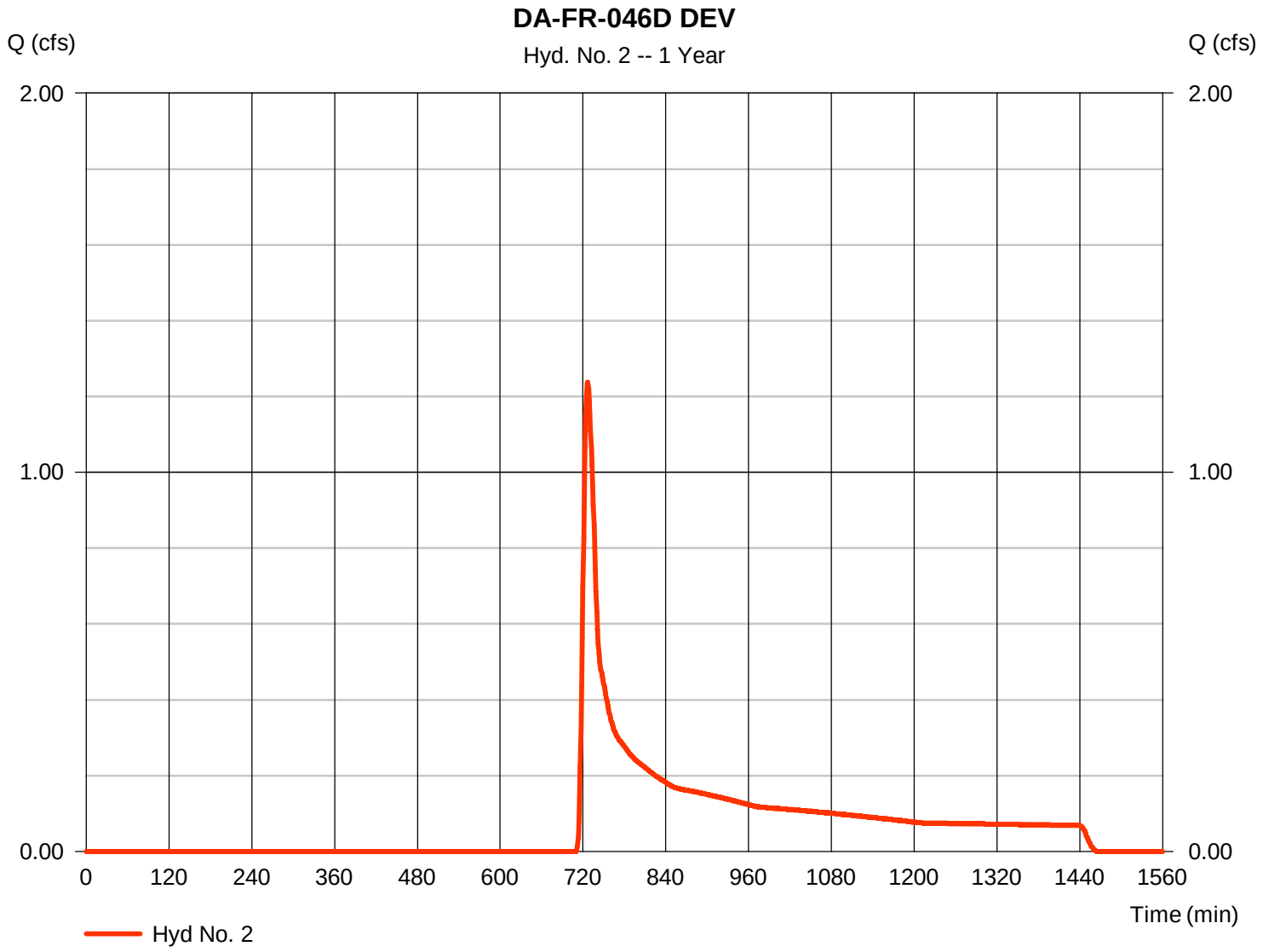
Hydrograph Report

Hyd. No. 2

DA-FR-046D DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 1.237 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 6,643 cuft
Drainage area	= 5.260 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.299 x 48) + (2.838 x 58) + (0.340 x 71) + (1.751 x 55) + (0.030 x 70)] / 5.260



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-046D DEV

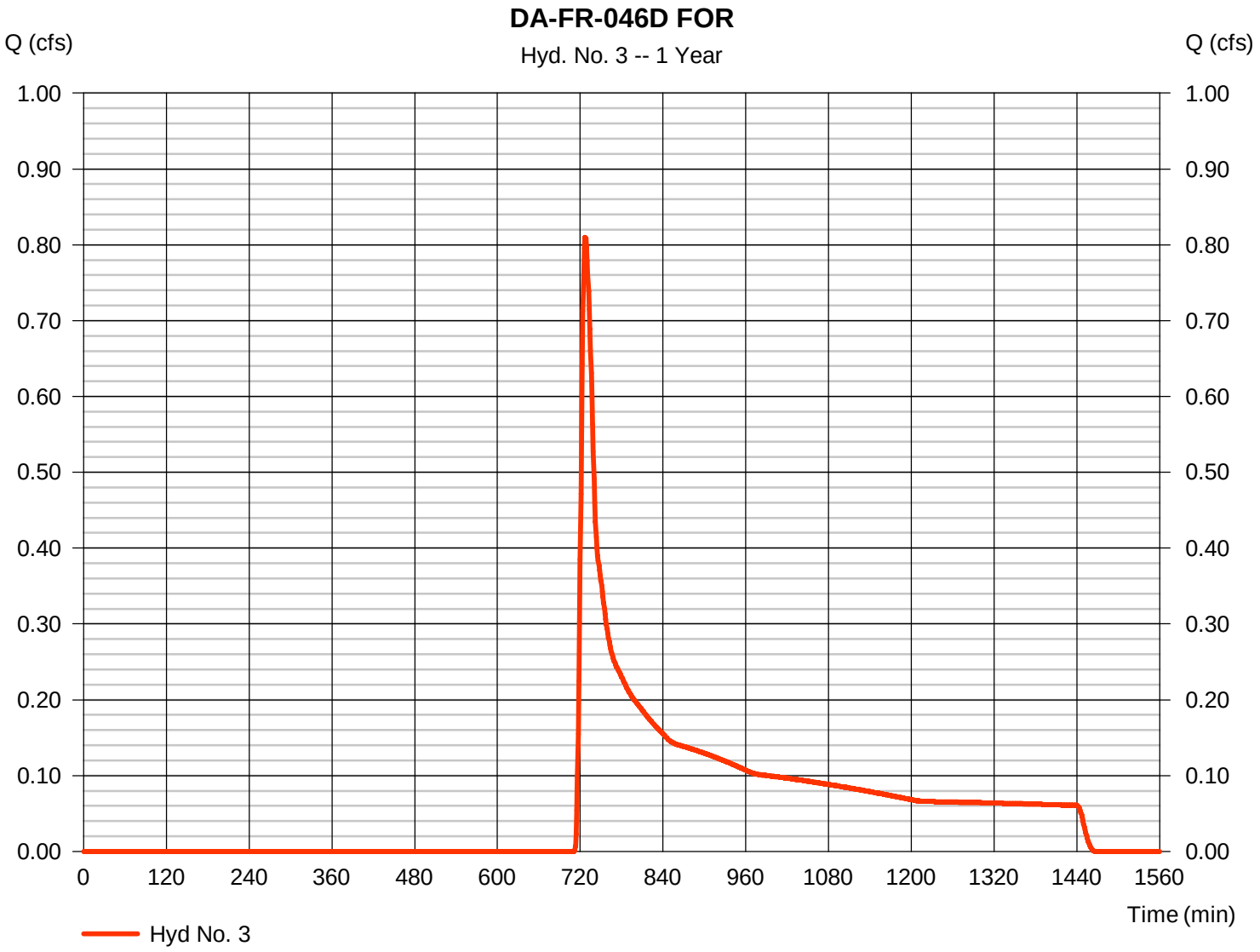
Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 5.28		0.00		0.00		
Travel Time (min)	**= 13.54**	**+**	**0.00**	**+**	**0.00**	**=**	**13.54**
Shallow Concentrated Flow							
Flow length (ft)	= 644.42		0.00		0.00		
Watercourse slope (%)	= 15.05		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.26		0.00		0.00		
Travel Time (min)	**= 1.72**	**+**	**0.00**	**+**	**0.00**	**=**	**1.72**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Total Travel Time, Tc							**15.30 min**

Hydrograph Report

Hyd. No. 3

DA-FR-046D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.810 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 5,434 cuft
Drainage area	= 5.260 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-046D FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.28		0.00		0.00		
Travel Time (min)	**= 13.54**	**+**	**0.00**	**+**	**0.00**	**=**	**13.54**
Shallow Concentrated Flow							
Flow length (ft)	= 644.42		0.00		0.00		
Watercourse slope (%)	= 15.05		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.26		0.00		0.00		
Travel Time (min)	**= 1.72**	**+**	**0.00**	**+**	**0.00**	**=**	**1.72**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.30 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.519	1	726	10,325	------	------	------	DA-FR-046D PRE
2	SCS Runoff	2.200	1	726	9,534	------	------	------	DA-FR-046D DEV
3	SCS Runoff	1.607	1	726	8,034	------	------	------	DA-FR-046D FOR

Hydrograph Report

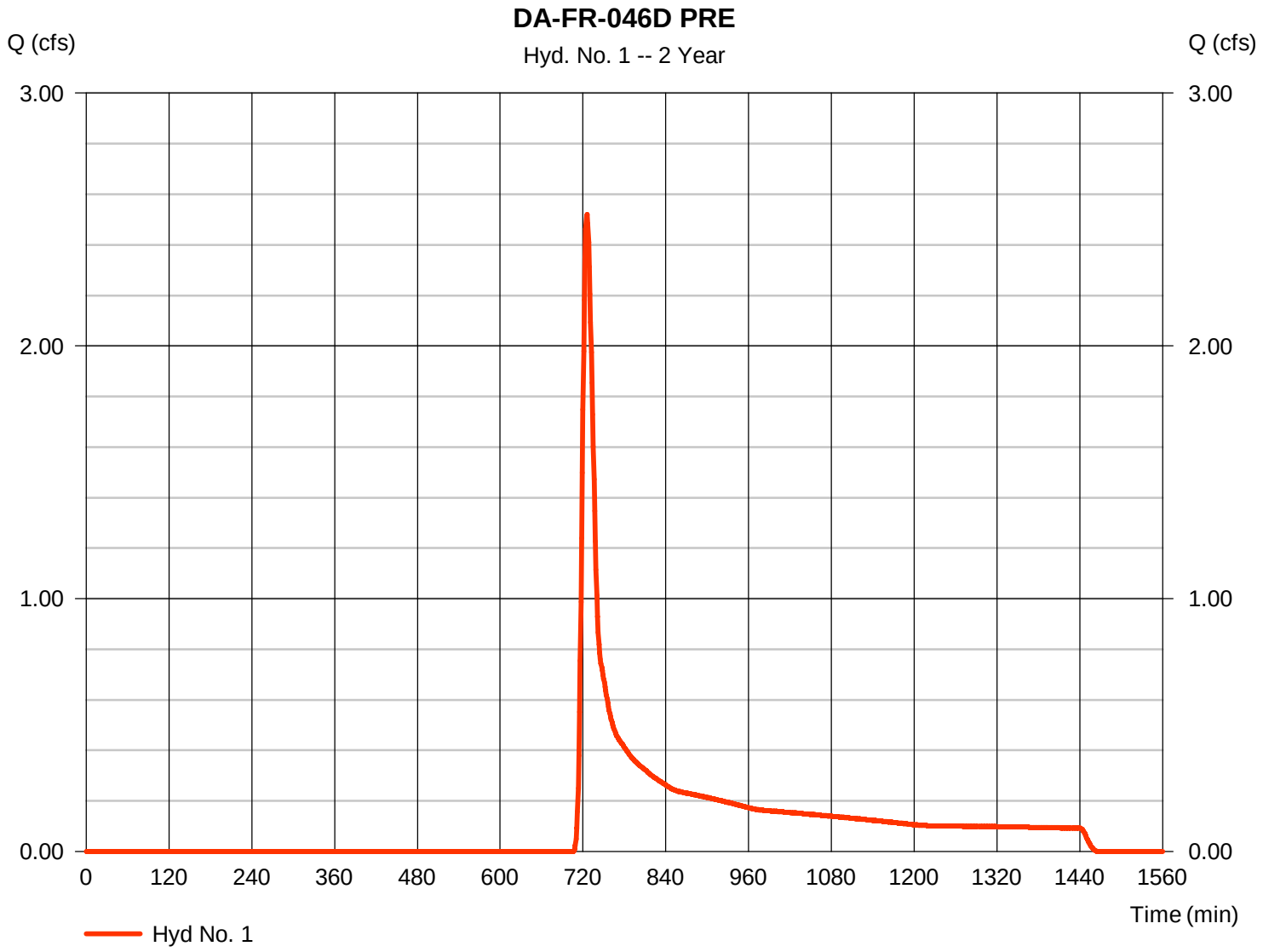
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 1

DA-FR-046D PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.519 cfs
Storm frequency	=	2 yrs	Time to peak	=	726 min
Time interval	=	1 min	Hyd. volume	=	10,325 cuft
Drainage area	=	5.260 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.30 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(2.670 x 58) + (0.340 x 71) + (2.219 x 55) + (0.030 x 70)] / 5.260



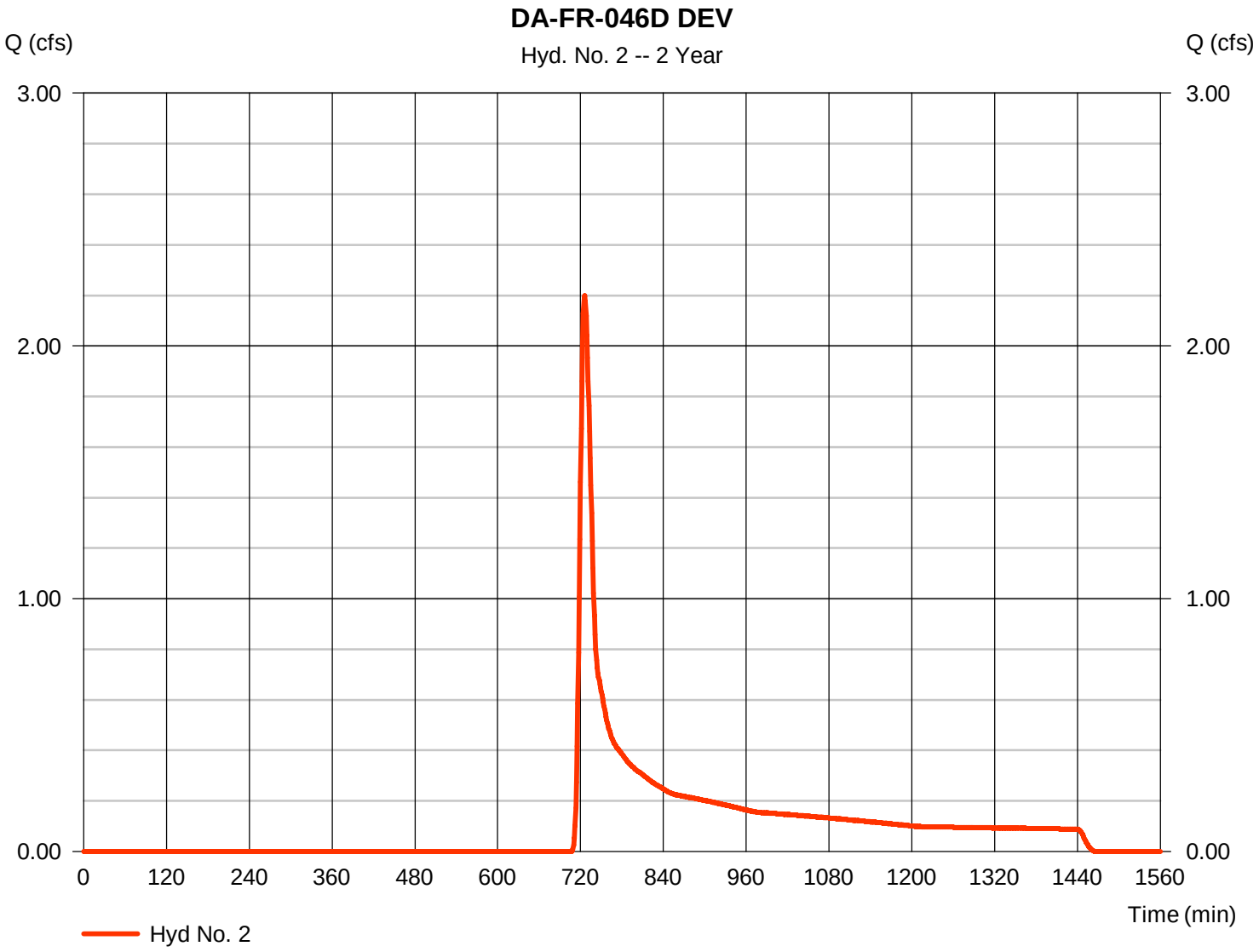
Hydrograph Report

Hyd. No. 2

DA-FR-046D DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 2.200 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 9,534 cuft
Drainage area	= 5.260 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.299 x 48) + (2.838 x 58) + (0.340 x 71) + (1.751 x 55) + (0.030 x 70)] / 5.260

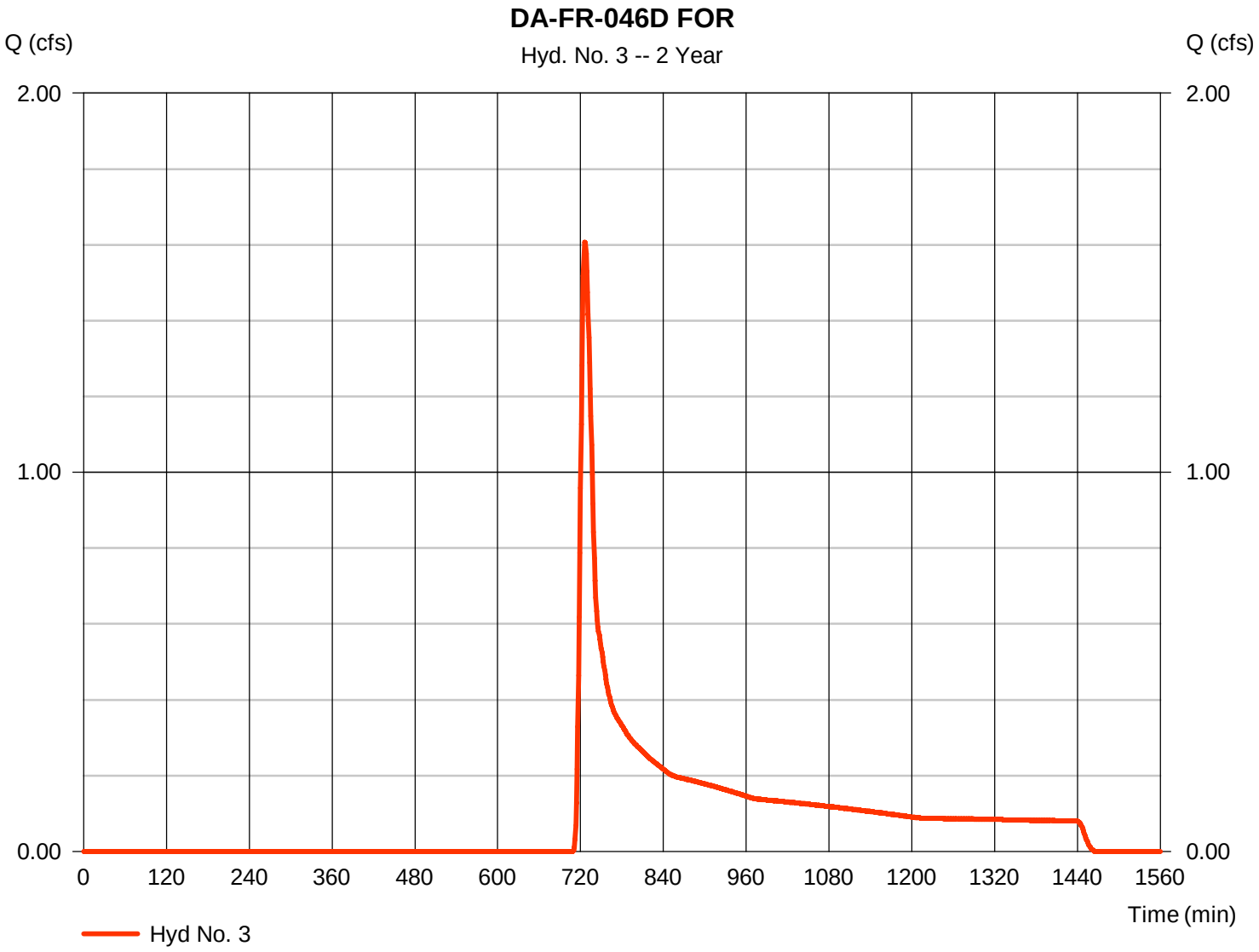


Hydrograph Report

Hyd. No. 3

DA-FR-046D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.607 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 8,034 cuft
Drainage area	= 5.260 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	9.903	1	724	30,407	------	------	------	DA-FR-046D PRE
2	SCS Runoff	9.308	1	724	28,939	------	------	------	DA-FR-046D DEV
3	SCS Runoff	8.129	1	724	26,070	------	------	------	DA-FR-046D FOR

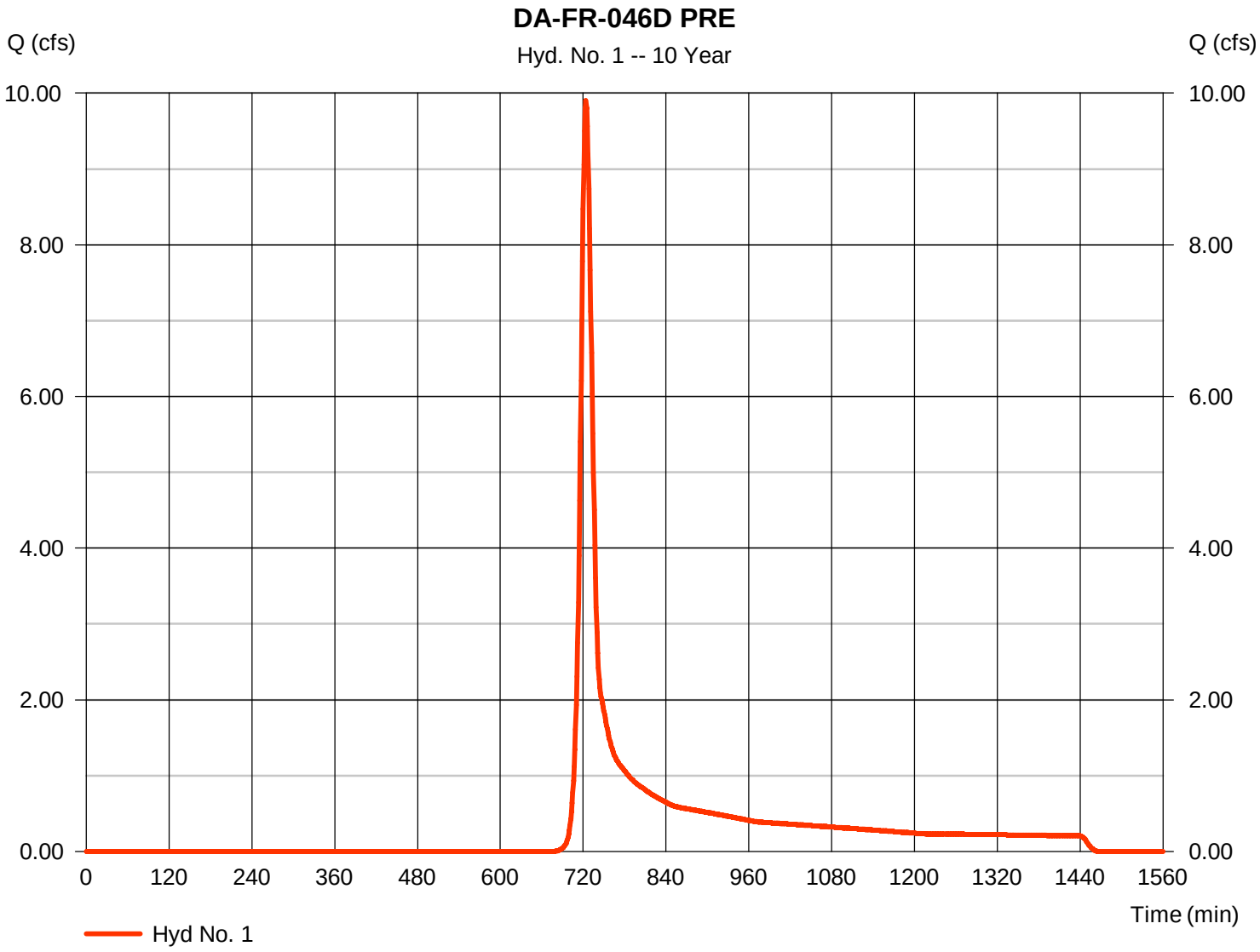
Hydrograph Report

Hyd. No. 1

DA-FR-046D PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	9.903 cfs
Storm frequency	=	10 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	30,407 cuft
Drainage area	=	5.260 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.30 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(2.670 x 58) + (0.340 x 71) + (2.219 x 55) + (0.030 x 70)] / 5.260



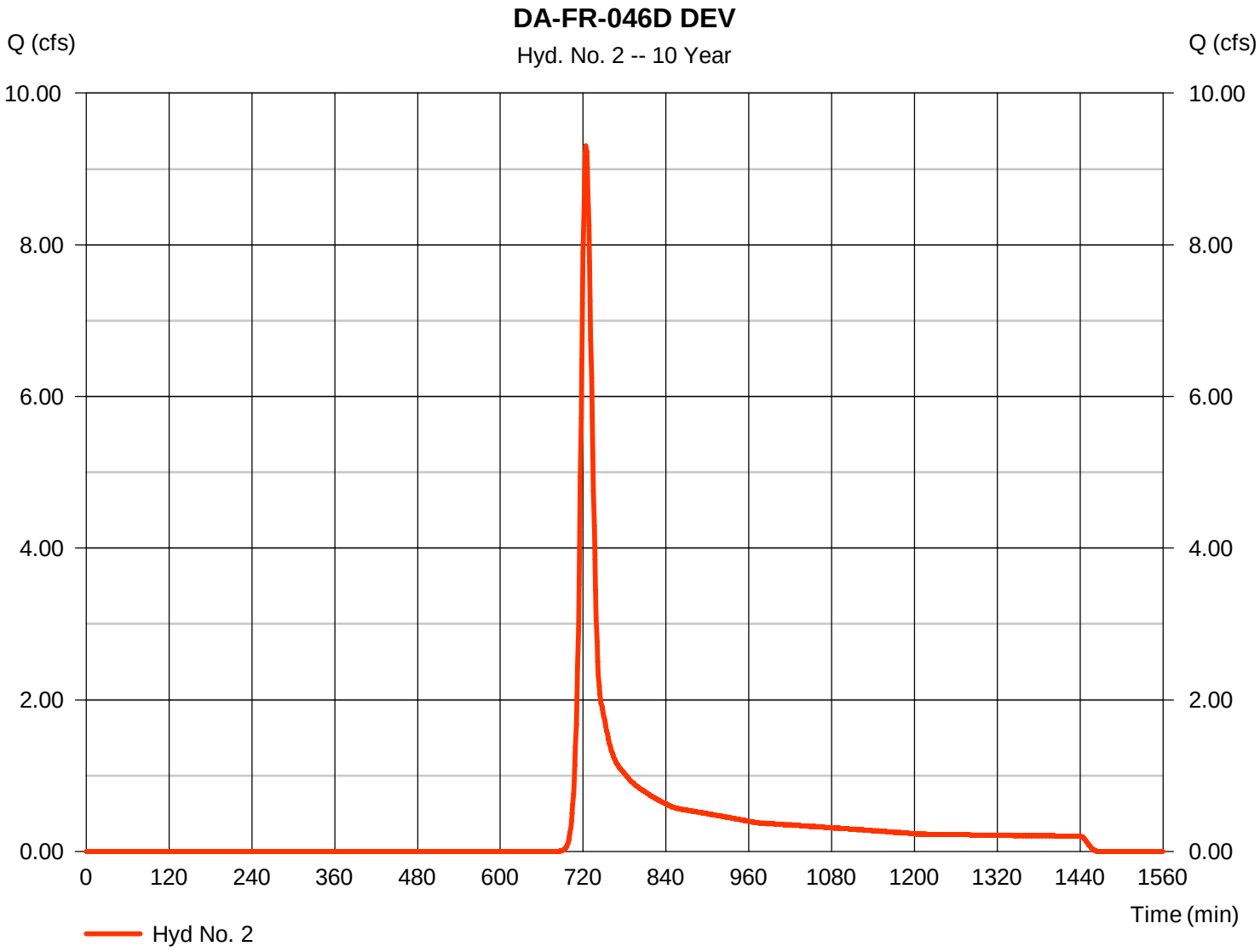
Hydrograph Report

Hyd. No. 2

DA-FR-046D DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	9.308 cfs
Storm frequency	=	10 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	28,939 cuft
Drainage area	=	5.260 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.30 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.299 x 48) + (2.838 x 58) + (0.340 x 71) + (1.751 x 55) + (0.030 x 70)] / 5.260

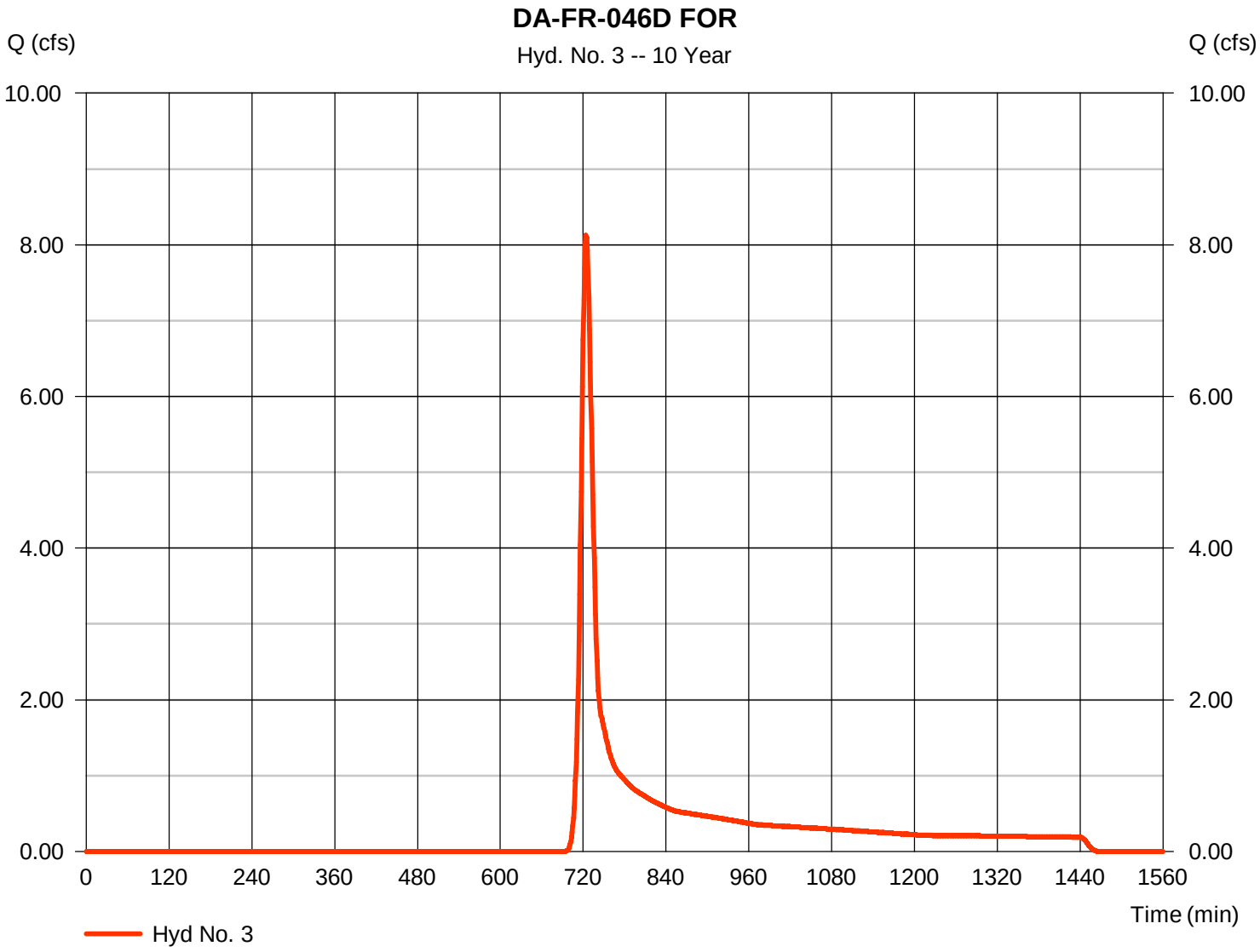


Hydrograph Report

Hyd. No. 3

DA-FR-046D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 8.129 cfs
Storm frequency	= 10 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 26,070 cuft
Drainage area	= 5.260 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-046E

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.332	1878
Developed Condition	0.256	1683
Pre-Developed (Forest) Condition	0.332	1878

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.256 ≤ 0.370

OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.256 ≤ 0.332

N/A - See Check #3

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.256 *shall not* be required to be ≤ 0.370

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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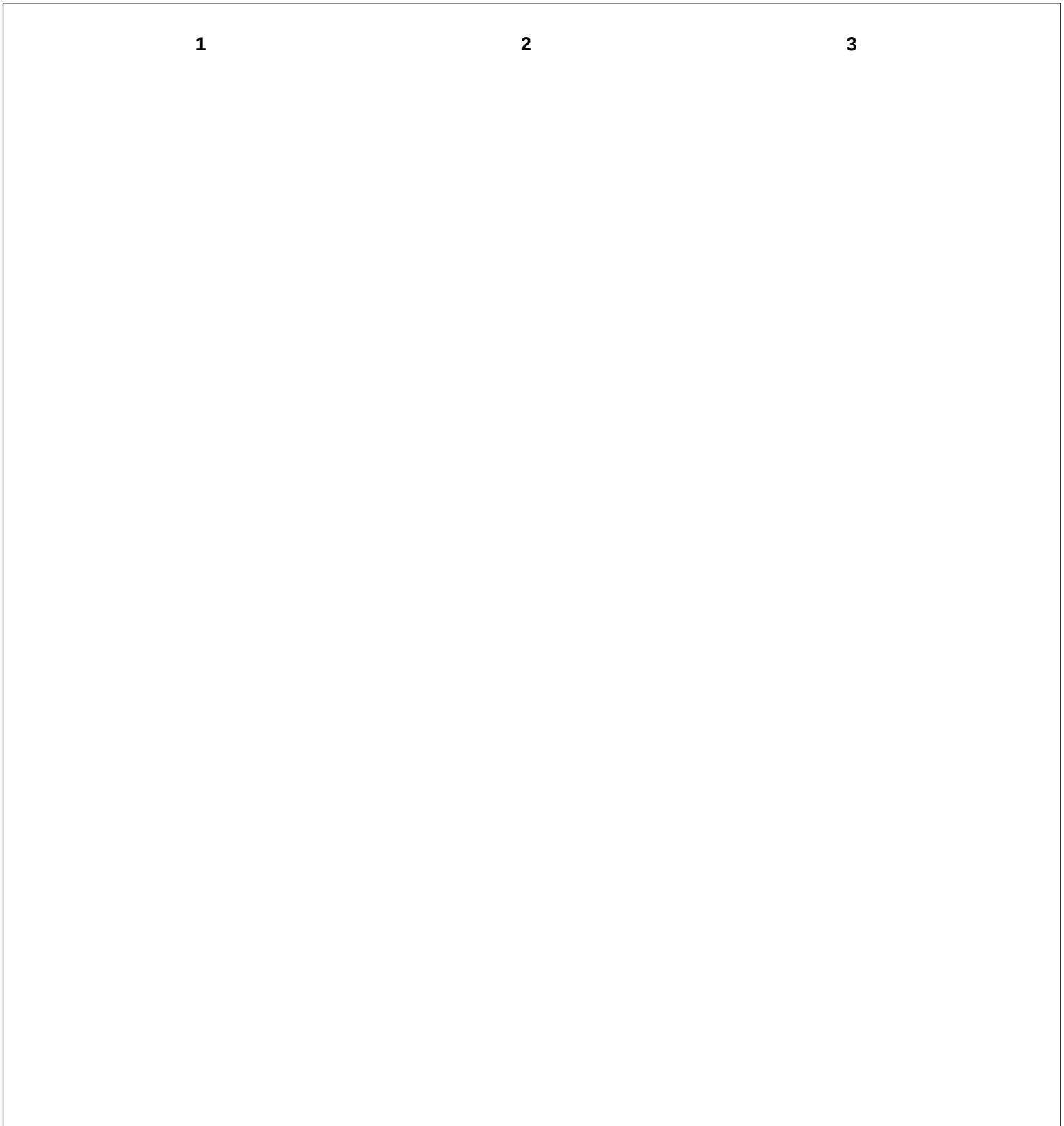
Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-046E PRE
2	SCS Runoff	DA-FR-046E DEV
3	SCS Runoff	DA-FR-046E FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.332	0.661	-------	-------	3.250	-------	-------	-------	DA-FR-046E PRE
2	SCS Runoff	------	0.256	0.551	-------	-------	3.026	-------	-------	-------	DA-FR-046E DEV
3	SCS Runoff	------	0.332	0.661	-------	-------	3.250	-------	-------	-------	DA-FR-046E FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.332	1	725	1,878	------	------	------	DA-FR-046E PRE
2	SCS Runoff	0.256	1	725	1,683	------	------	------	DA-FR-046E DEV
3	SCS Runoff	0.332	1	725	1,878	------	------	------	DA-FR-046E FOR

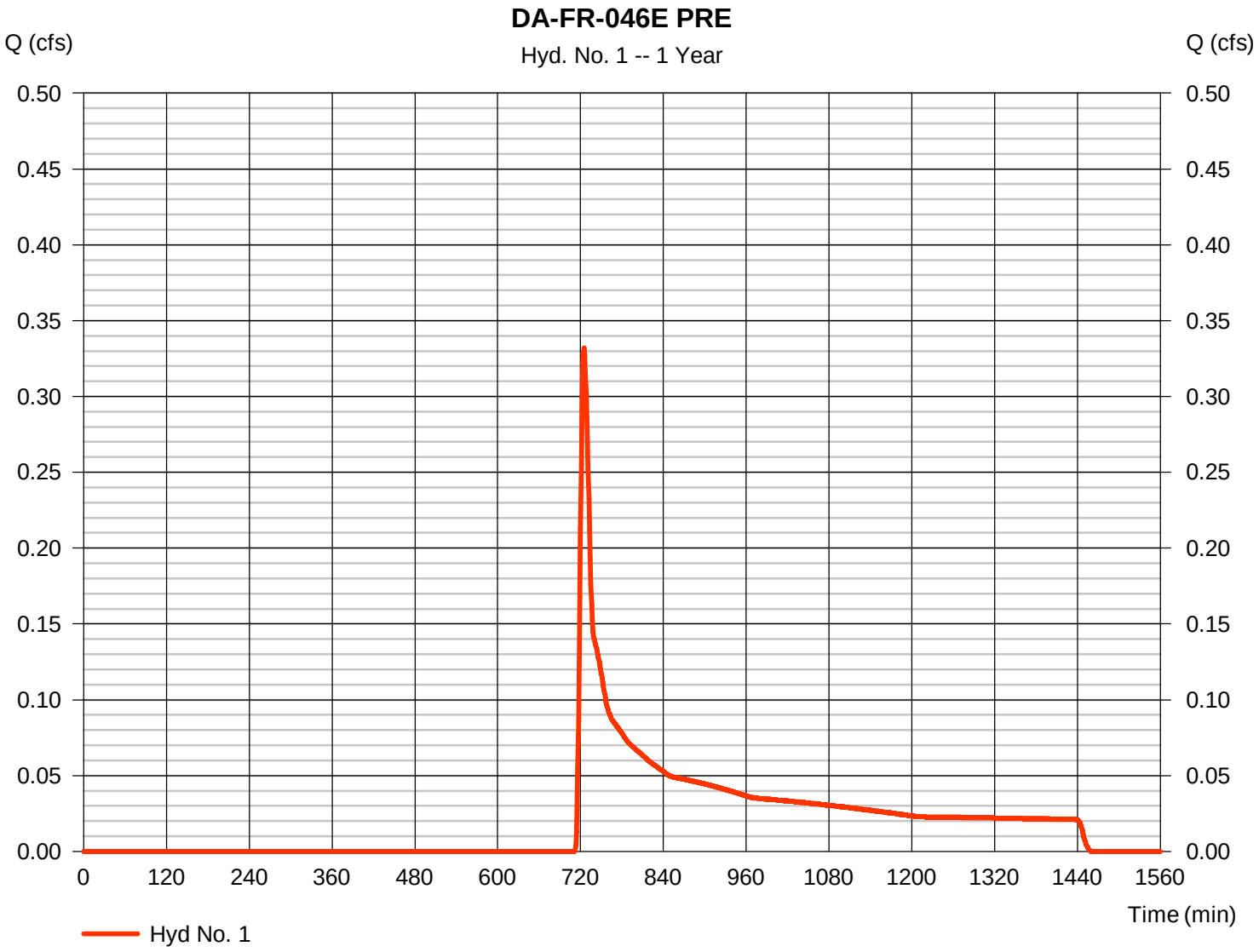
Hydrograph Report

Hyd. No. 1

DA-FR-046E PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.332 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 1,878 cuft
Drainage area	= 1.870 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.80 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.824 x 55) + (0.047 x 70)] / 1.870



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-046E PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 8.27		0.00		0.00		
Travel Time (min)	**= 11.32**	**+**	**0.00**	**+**	**0.00**	**=**	**11.32**
Shallow Concentrated Flow							
Flow length (ft)	= 457.05		0.00		0.00		
Watercourse slope (%)	= 10.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.14		0.00		0.00		
Travel Time (min)	**= 1.48**	**+**	**0.00**	**+**	**0.00**	**=**	**1.48**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 12.80 min

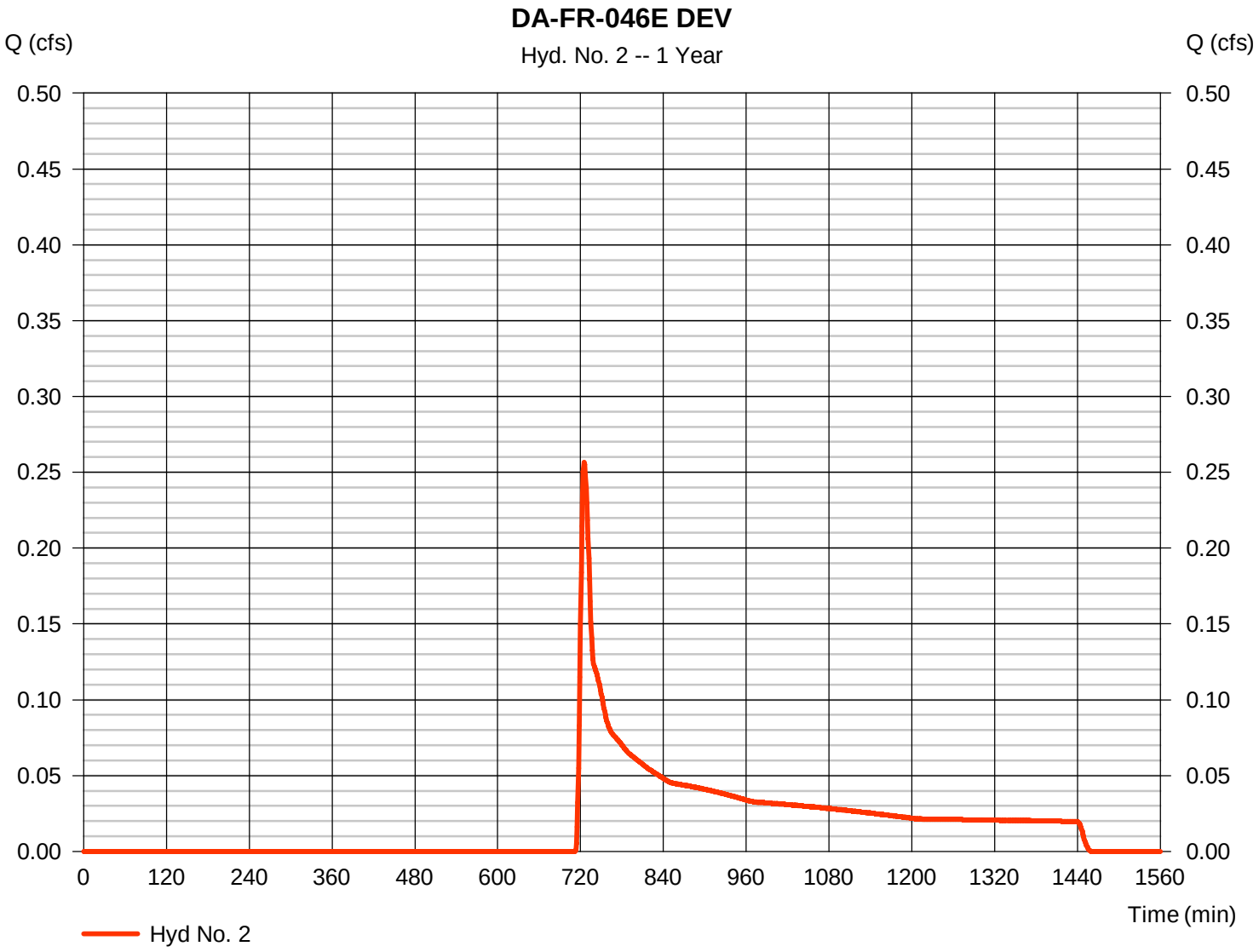
Hydrograph Report

Hyd. No. 2

DA-FR-046E DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.256 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 1,683 cuft
Drainage area	= 1.870 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.80 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.497 x 48) + (0.047 x 65) + (0.349 x 58) + (0.978 x 55)] / 1.870



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-046E DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 8.27		0.00		0.00		
Travel Time (min)	**= 11.32**	**+**	**0.00**	**+**	**0.00**	**=**	**11.32**
Shallow Concentrated Flow							
Flow length (ft)	= 457.06		0.00		0.00		
Watercourse slope (%)	= 10.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.14		0.00		0.00		
Travel Time (min)	**= 1.48**	**+**	**0.00**	**+**	**0.00**	**=**	**1.48**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

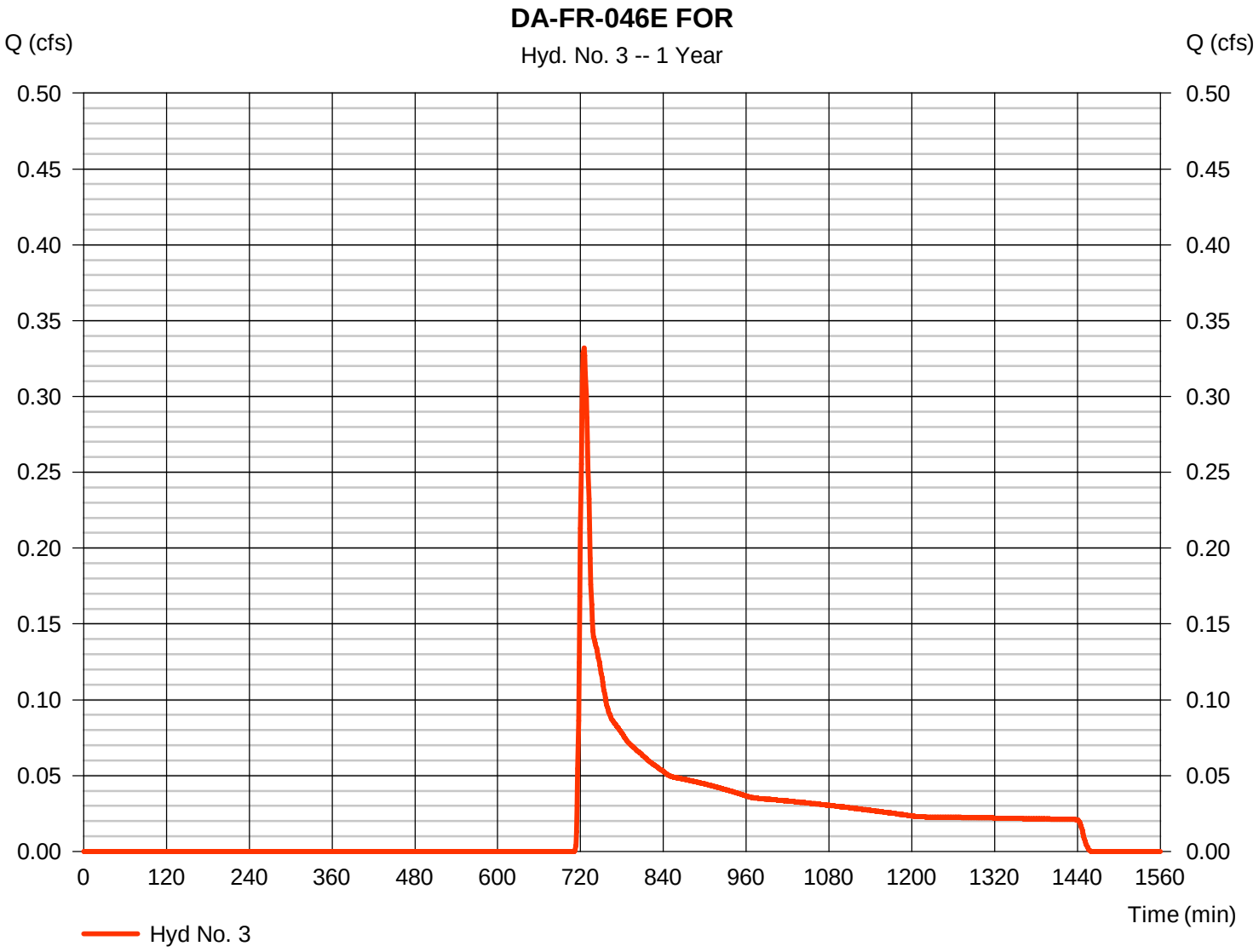
Total Travel Time, Tc ..... 12.80 min

Hydrograph Report

Hyd. No. 3

DA-FR-046E FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.332 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 1,878 cuft
Drainage area	= 1.870 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.80 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-046E FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 8.27		0.00		0.00		
Travel Time (min)	**= 11.32**	**+**	**0.00**	**+**	**0.00**	**=**	**11.32**
Shallow Concentrated Flow							
Flow length (ft)	= 457.05		0.00		0.00		
Watercourse slope (%)	= 10.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.14		0.00		0.00		
Travel Time (min)	**= 1.48**	**+**	**0.00**	**+**	**0.00**	**=**	**1.48**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 12.80 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.661	1	724	2,777	------	------	------	DA-FR-046E PRE
2	SCS Runoff	0.551	1	724	2,532	------	------	------	DA-FR-046E DEV
3	SCS Runoff	0.661	1	724	2,777	------	------	------	DA-FR-046E FOR

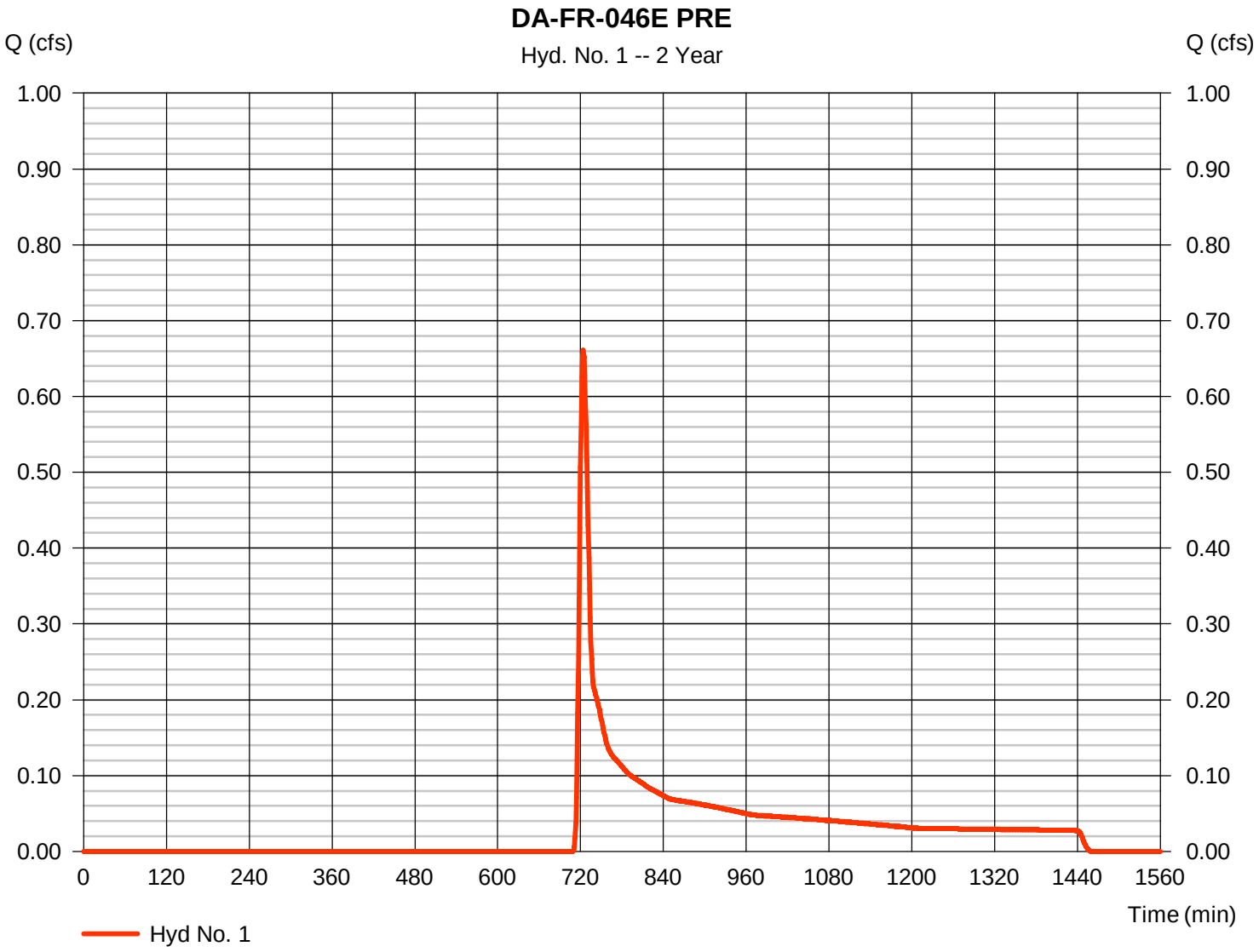
Hydrograph Report

Hyd. No. 1

DA-FR-046E PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.661 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 2,777 cuft
Drainage area	= 1.870 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.80 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.824 x 55) + (0.047 x 70)] / 1.870



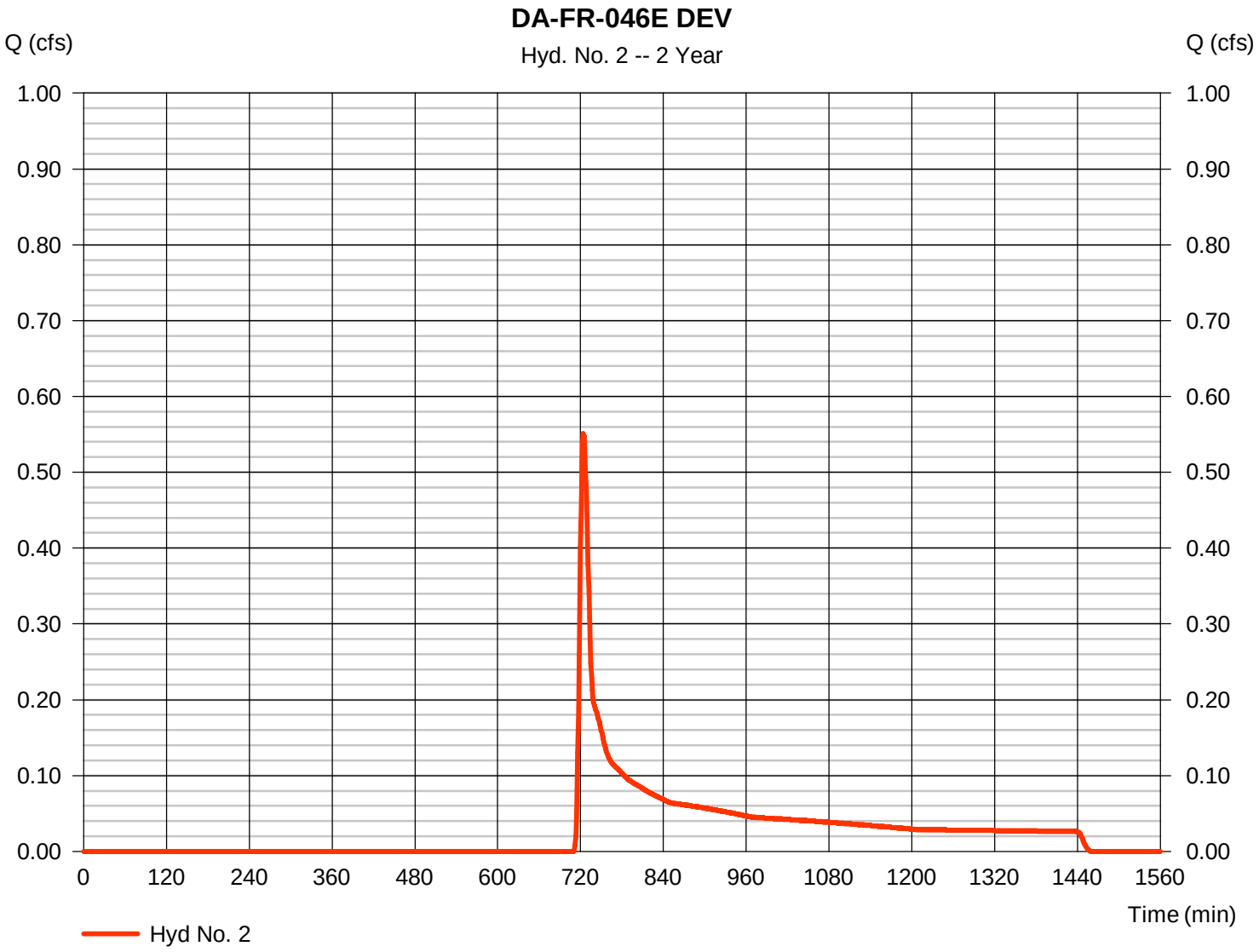
Hydrograph Report

Hyd. No. 2

DA-FR-046E DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.551 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 2,532 cuft
Drainage area	= 1.870 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.80 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.497 x 48) + (0.047 x 65) + (0.349 x 58) + (0.978 x 55)] / 1.870

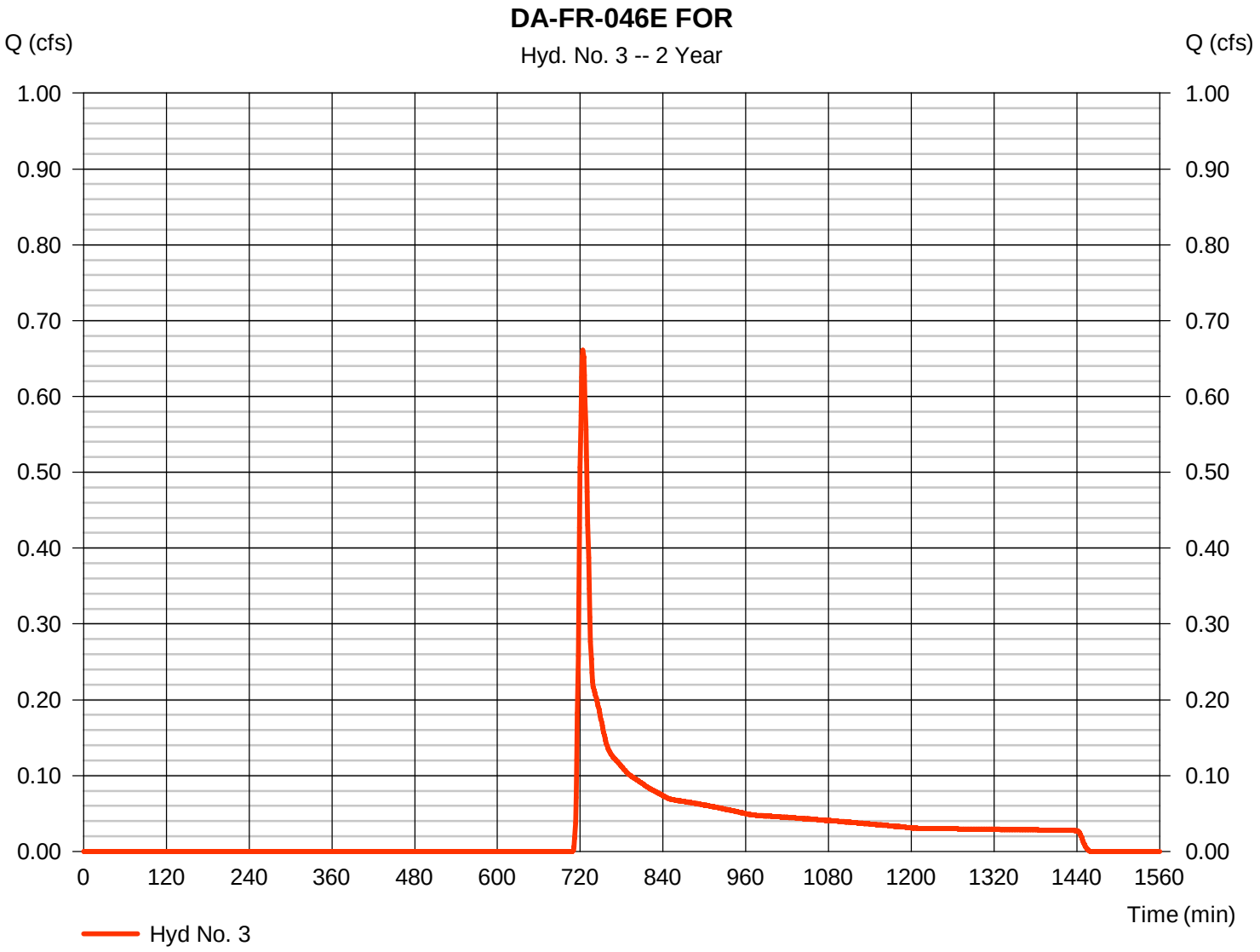


Hydrograph Report

Hyd. No. 3

DA-FR-046E FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.661 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 2,777 cuft
Drainage area	= 1.870 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.80 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	3.250	1	722	9,011	------	------	------	DA-FR-046E PRE
2	SCS Runoff	3.026	1	722	8,527	------	------	------	DA-FR-046E DEV
3	SCS Runoff	3.250	1	722	9,011	------	------	------	DA-FR-046E FOR

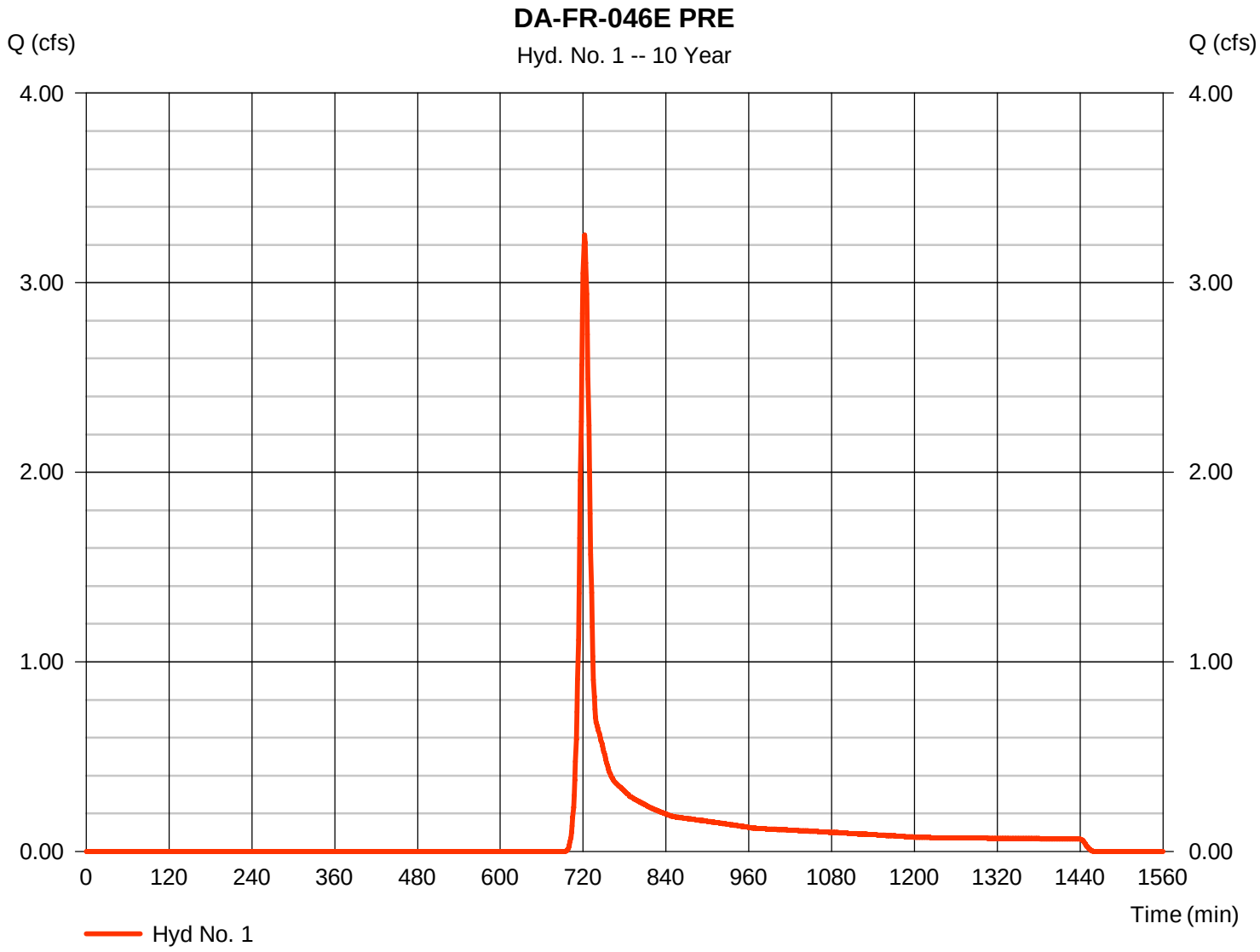
Hydrograph Report

Hyd. No. 1

DA-FR-046E PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.250 cfs
Storm frequency	=	10 yrs	Time to peak	=	722 min
Time interval	=	1 min	Hyd. volume	=	9,011 cuft
Drainage area	=	1.870 ac	Curve number	=	55*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	12.80 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(1.824 x 55) + (0.047 x 70)] / 1.870



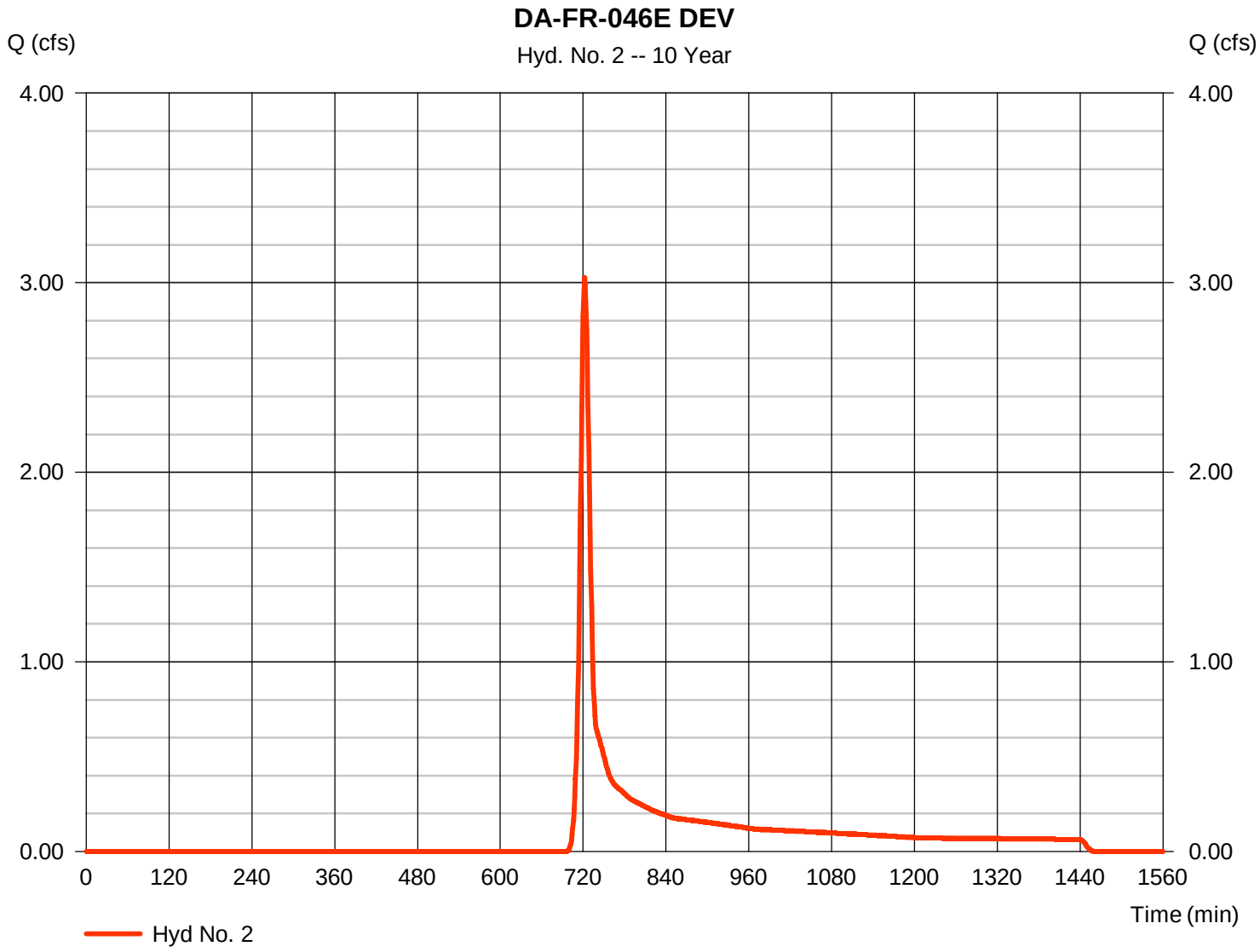
Hydrograph Report

Hyd. No. 2

DA-FR-046E DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.026 cfs
Storm frequency	=	10 yrs	Time to peak	=	722 min
Time interval	=	1 min	Hyd. volume	=	8,527 cuft
Drainage area	=	1.870 ac	Curve number	=	54*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	12.80 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.497 x 48) + (0.047 x 65) + (0.349 x 58) + (0.978 x 55)] / 1.870

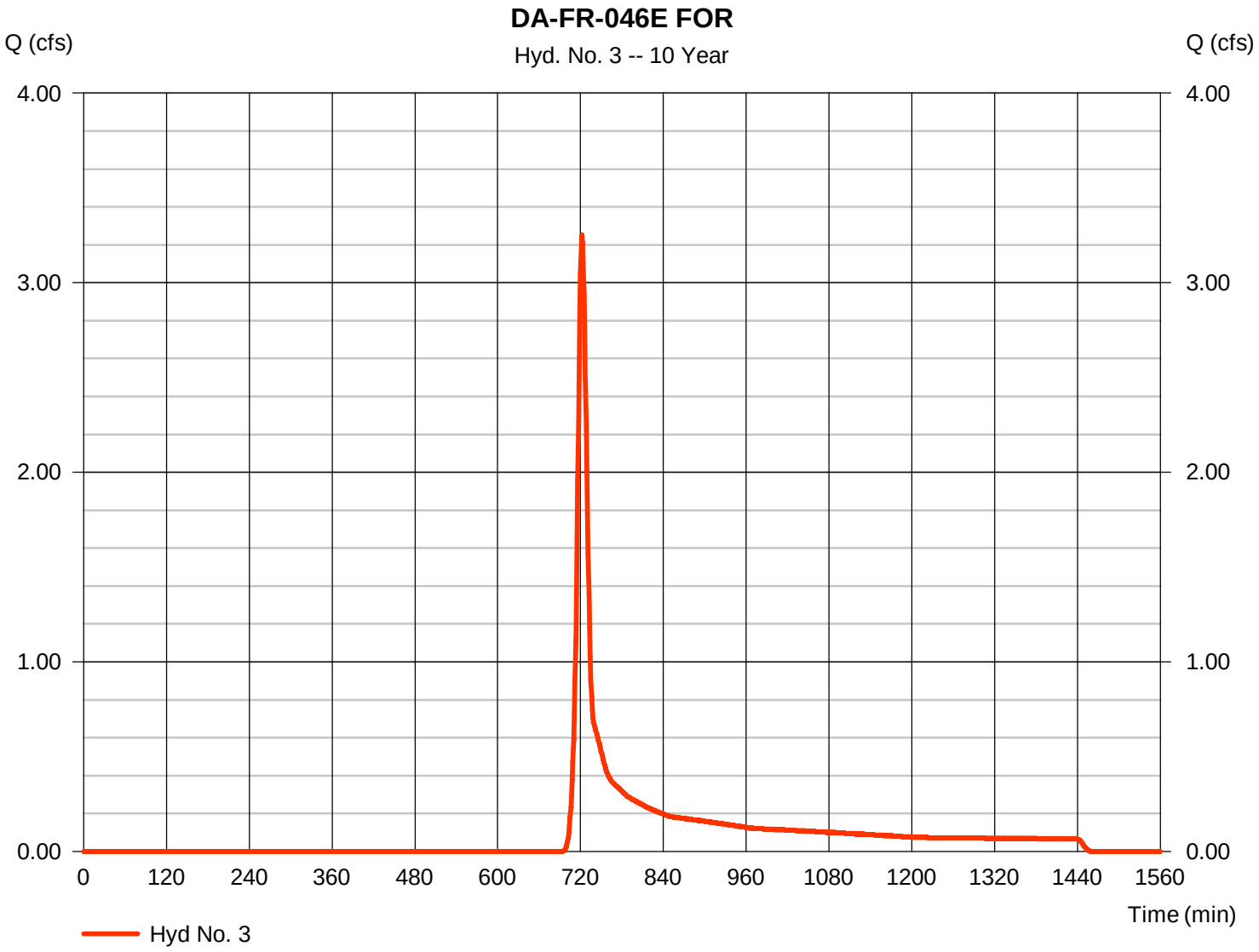


Hydrograph Report

Hyd. No. 3

DA-FR-046E FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 3.250 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 9,011 cuft
Drainage area	= 1.870 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.80 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-046F

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.276	726
Developed Condition	0.235	715
Pre-Developed (Forest) Condition	0.071	337

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.235 ≤ 0.280 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.235 ≤ 0.276 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.235 *shall not* be required to be ≤ 0.033

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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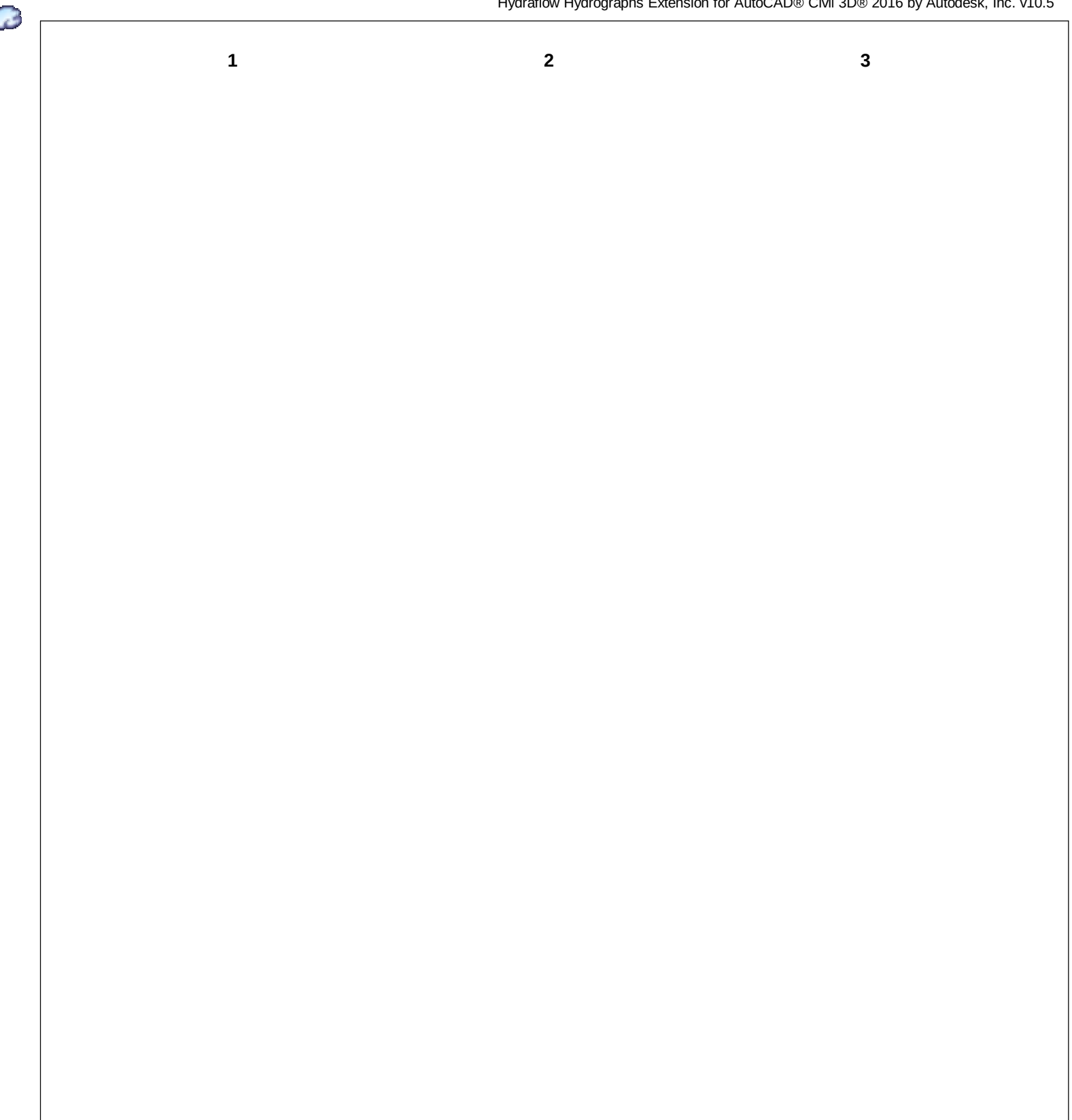
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-046E PRE
2	SCS Runoff	DA-FR-046F DEV
3	SCS Runoff	DA-FR-046F FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.276	0.391	-------	-------	1.079	-------	-------	-------	DA-FR-046E PRE
2	SCS Runoff	------	0.235	0.336	-------	-------	0.940	-------	-------	-------	DA-FR-046F DEV
3	SCS Runoff	------	0.071	0.140	-------	-------	0.667	-------	-------	-------	DA-FR-046F FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.276	1	720	726	------	------	------	DA-FR-046E PRE
2	SCS Runoff	0.235	1	723	715	------	------	------	DA-FR-046F DEV
3	SCS Runoff	0.071	1	723	337	------	------	------	DA-FR-046F FOR

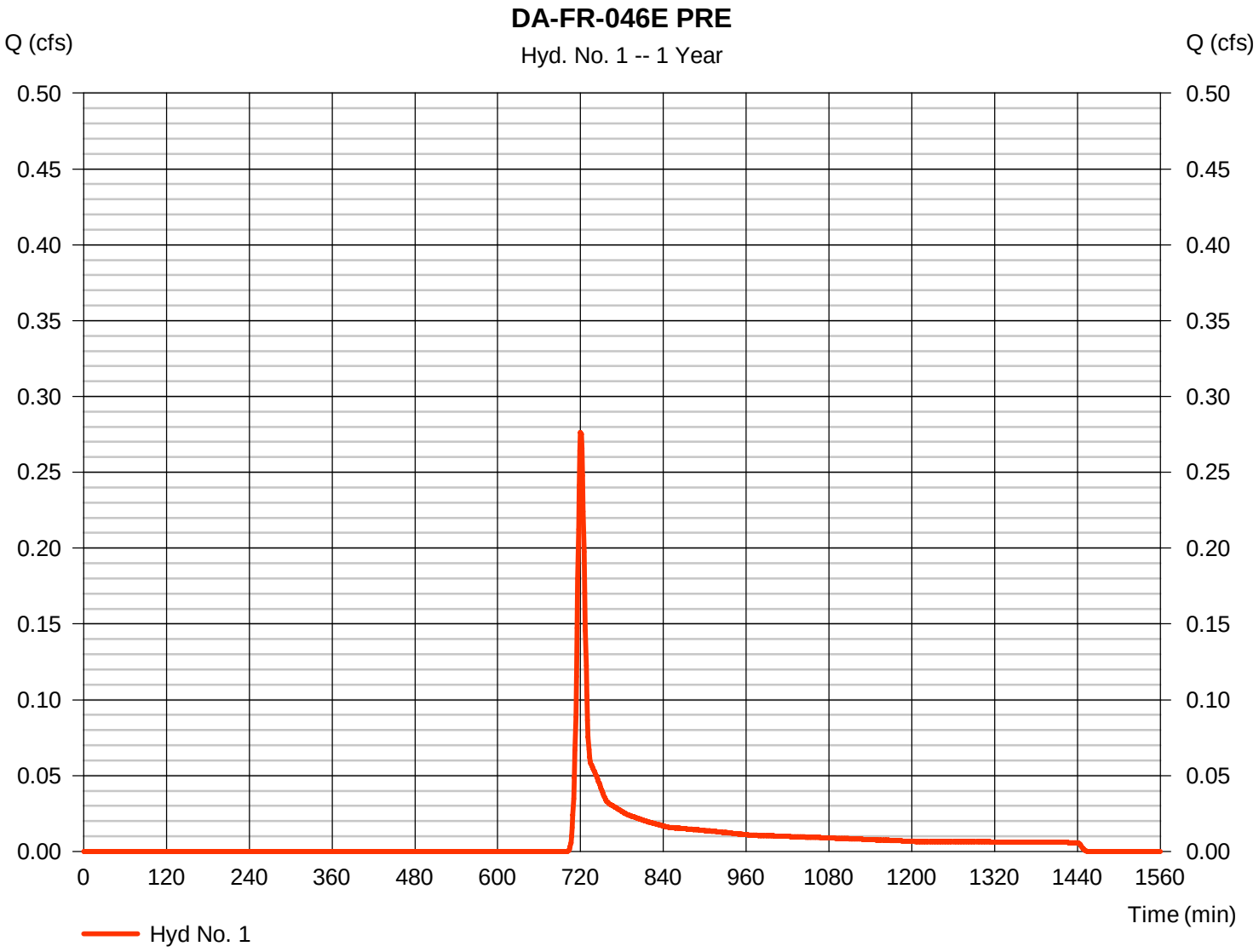
Hydrograph Report

Hyd. No. 1

DA-FR-046E PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.276 cfs
Storm frequency	= 1 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 726 cuft
Drainage area	= 0.330 ac	Curve number	= 64*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.40 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.128 x 55) + (0.201 x 70)] / 0.330



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-046E PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 80.8		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.67		0.00		0.00		
Travel Time (min)	**= 9.36**	**+**	**0.00**	**+**	**0.00**	**=**	**9.36**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.40 min

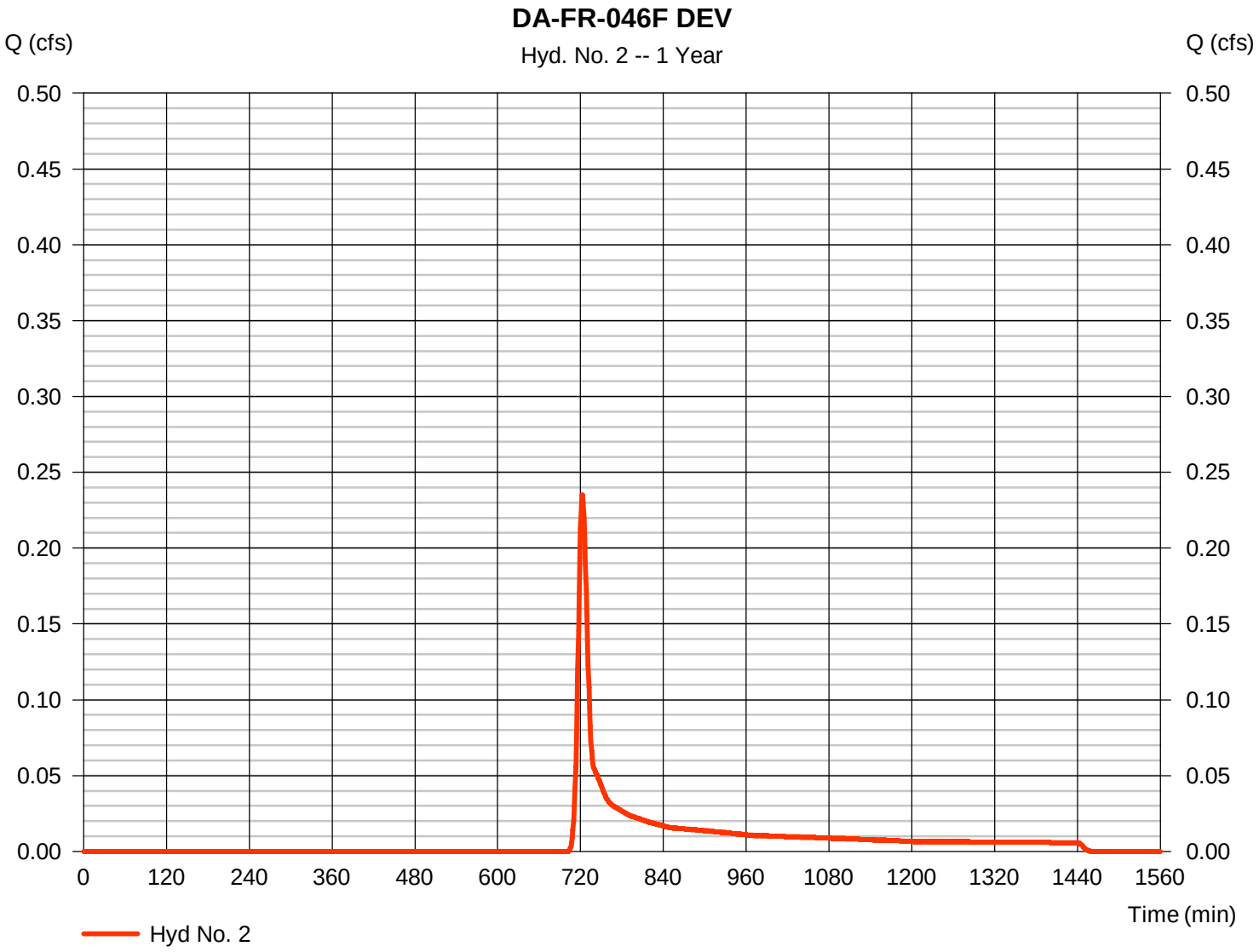
Hydrograph Report

Hyd. No. 2

DA-FR-046F DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.235 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 715 cuft
Drainage area	= 0.330 ac	Curve number	= 64*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.40 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.016 x 48) + (0.089 x 65) + (0.113 x 58) + (0.112 x 71)] / 0.330



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-046F DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.800		0.011		
Flow length (ft)	= 67.3		13.5		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 5.20		26.01		0.00		
Travel Time (min)	**= 9.93**	**+**	**2.50**	**+**	**0.00**	**=**	**12.43**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00		0.00		0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

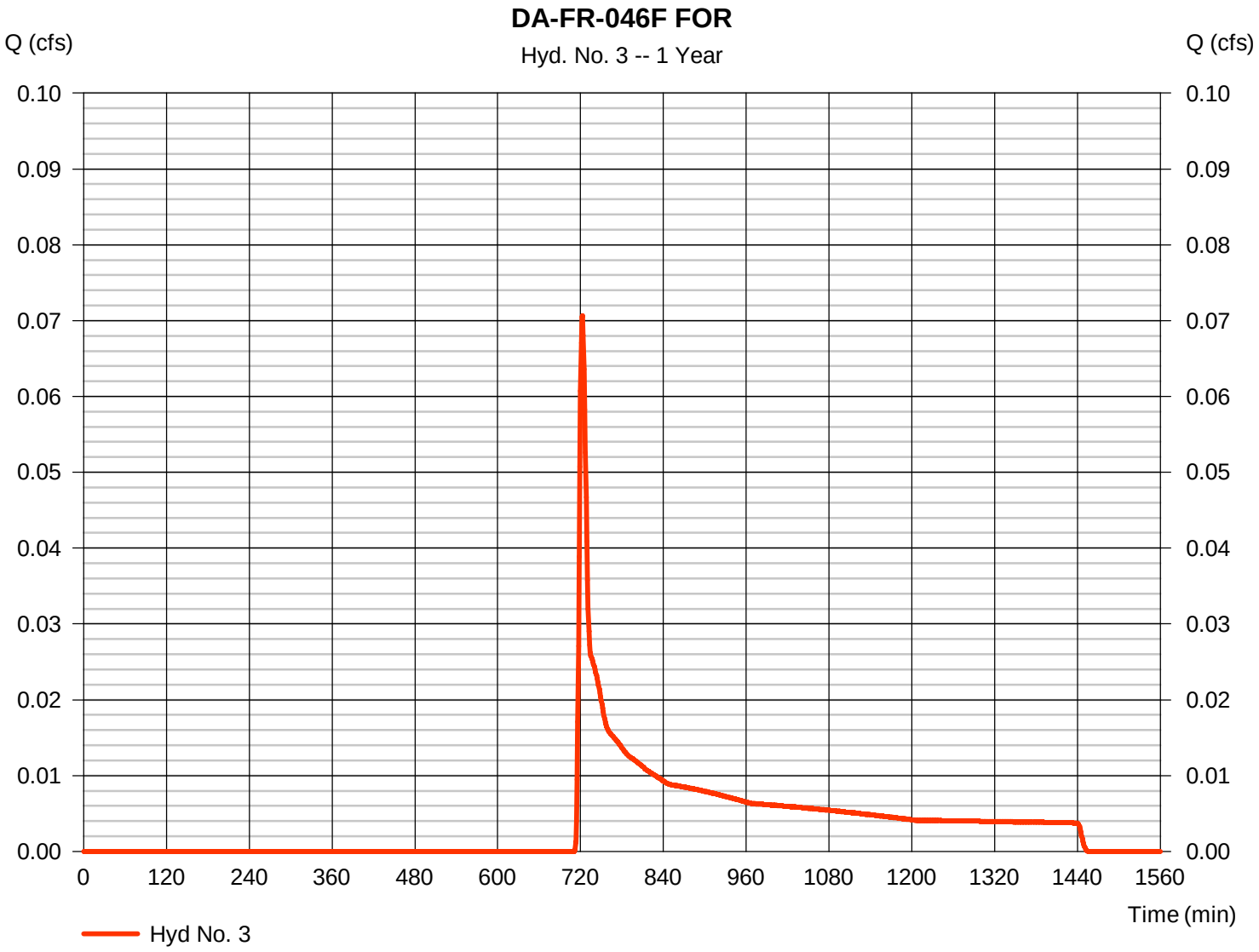
Total Travel Time, Tc ..... 12.40 min

Hydrograph Report

Hyd. No. 3

DA-FR-046F FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.071 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 337 cuft
Drainage area	= 0.330 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.40 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-046F FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 80.8		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.67		0.00		0.00		
Travel Time (min)	**= 9.36**	**+**	**0.00**	**+**	**0.00**	**=**	**9.36**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.40 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.391	1	720	969	------	------	------	DA-FR-046E PRE
2	SCS Runoff	0.336	1	722	953	------	------	------	DA-FR-046F DEV
3	SCS Runoff	0.140	1	722	498	------	------	------	DA-FR-046F FOR

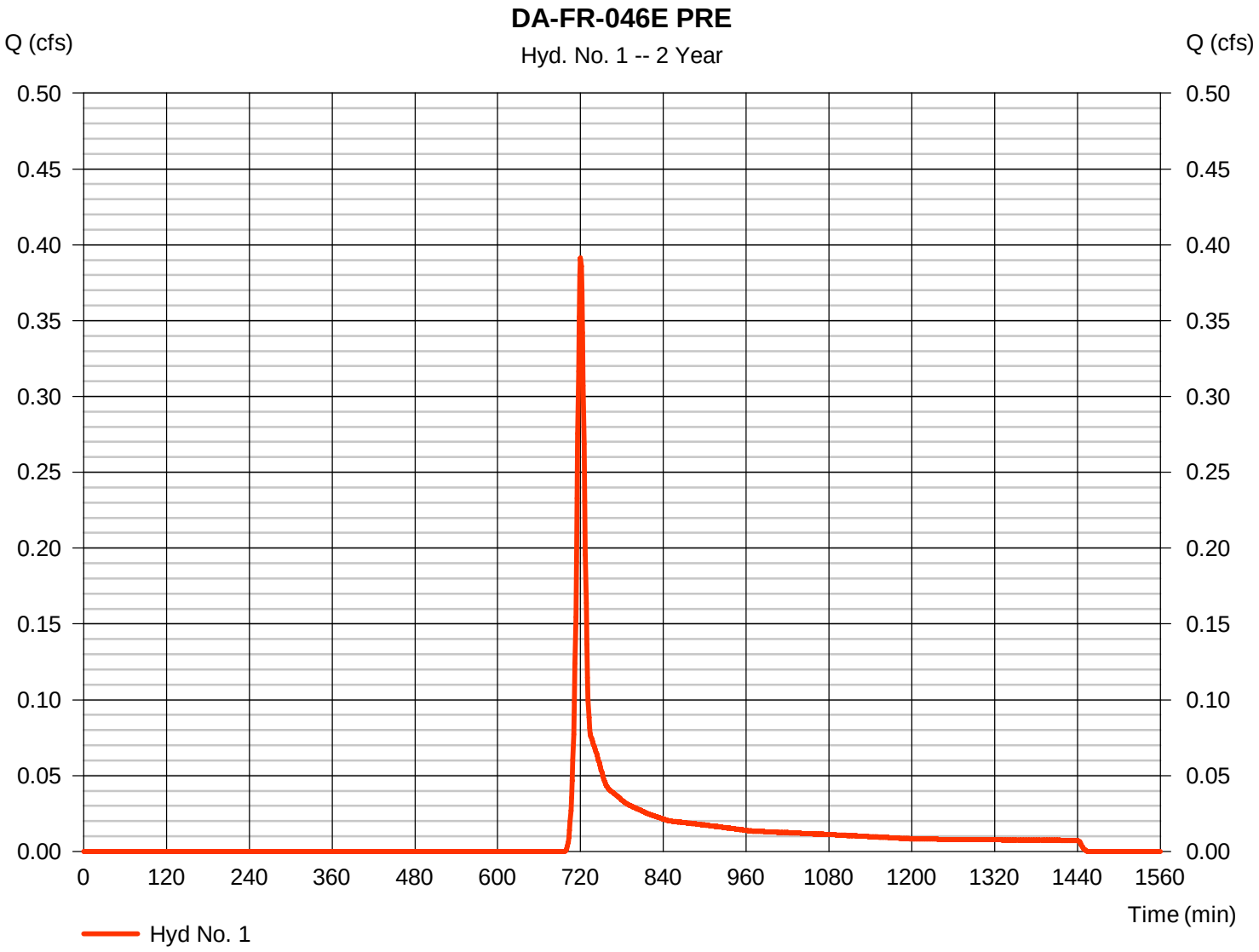
Hydrograph Report

Hyd. No. 1

DA-FR-046E PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.391 cfs
Storm frequency	= 2 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 969 cuft
Drainage area	= 0.330 ac	Curve number	= 64*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.128 x 55) + (0.201 x 70)] / 0.330



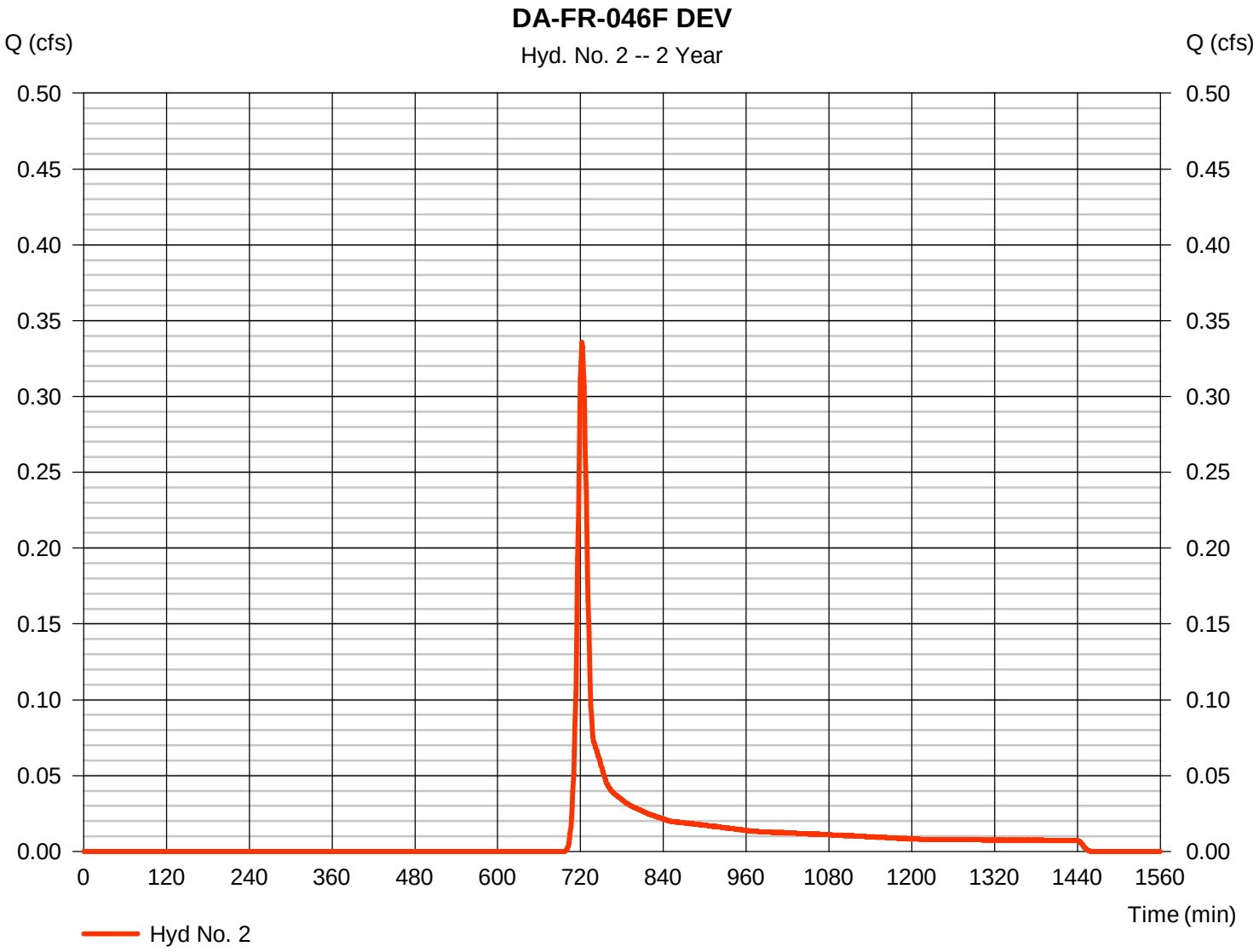
Hydrograph Report

Hyd. No. 2

DA-FR-046F DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.336 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 953 cuft
Drainage area	= 0.330 ac	Curve number	= 64*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.016 x 48) + (0.089 x 65) + (0.113 x 58) + (0.112 x 71)] / 0.330

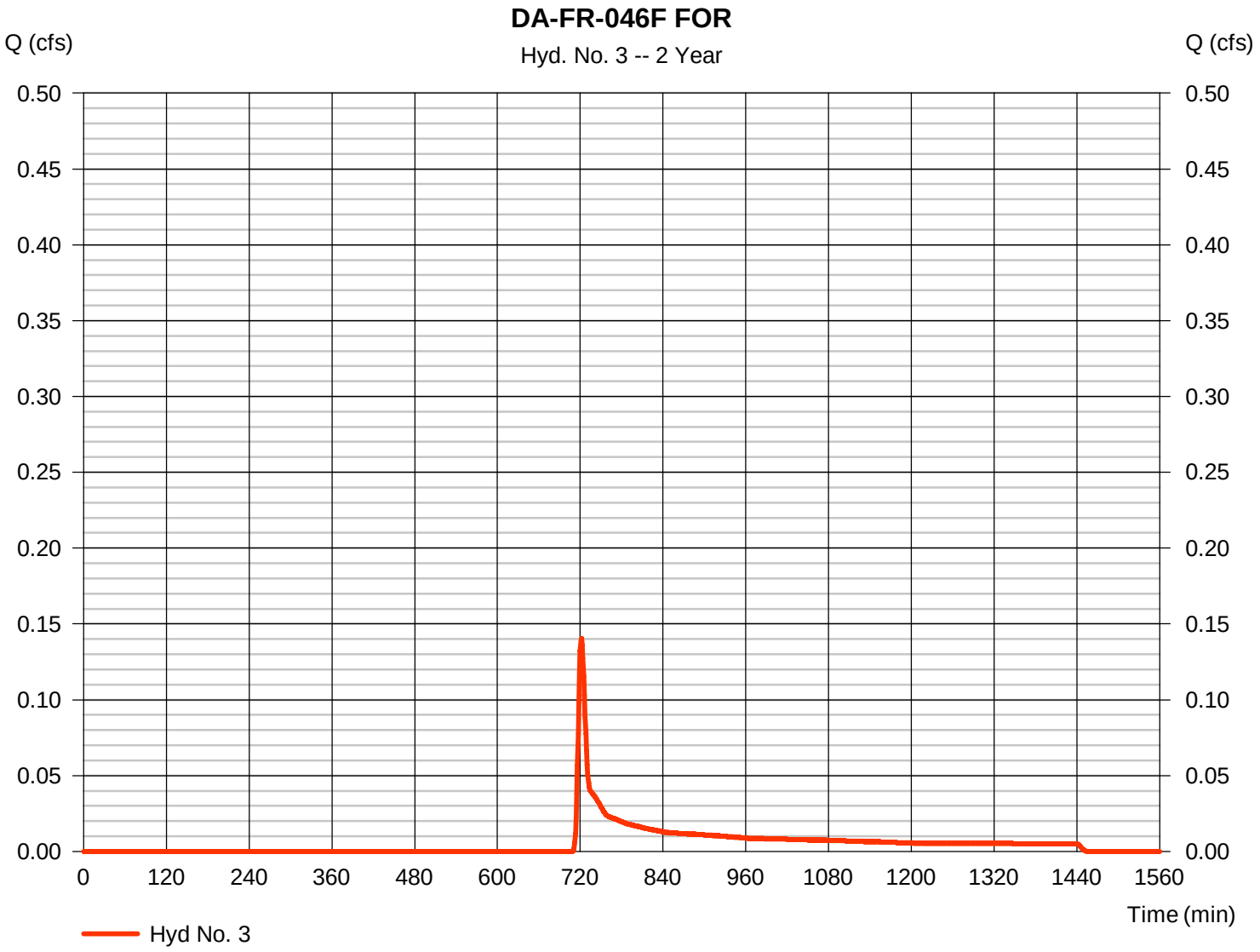


Hydrograph Report

Hyd. No. 3

DA-FR-046F FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.140 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 498 cuft
Drainage area	= 0.330 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.079	1	720	2,458	------	------	------	DA-FR-046E PRE
2	SCS Runoff	0.940	1	722	2,420	------	------	------	DA-FR-046F DEV
3	SCS Runoff	0.667	1	720	1,615	------	------	------	DA-FR-046F FOR

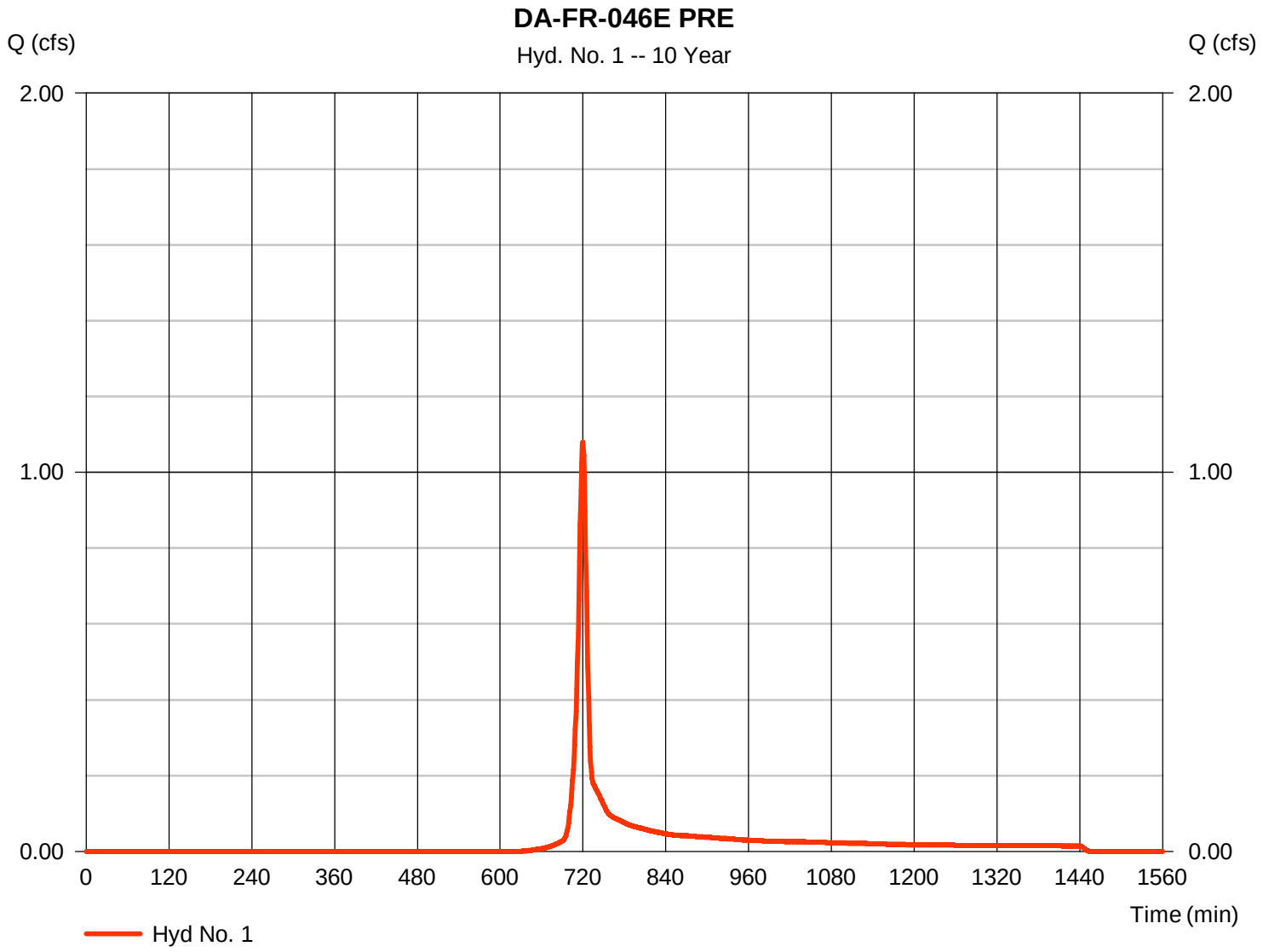
Hydrograph Report

Hyd. No. 1

DA-FR-046E PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.079 cfs
Storm frequency	=	10 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	2,458 cuft
Drainage area	=	0.330 ac	Curve number	=	64*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	9.40 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.128 x 55) + (0.201 x 70)] / 0.330



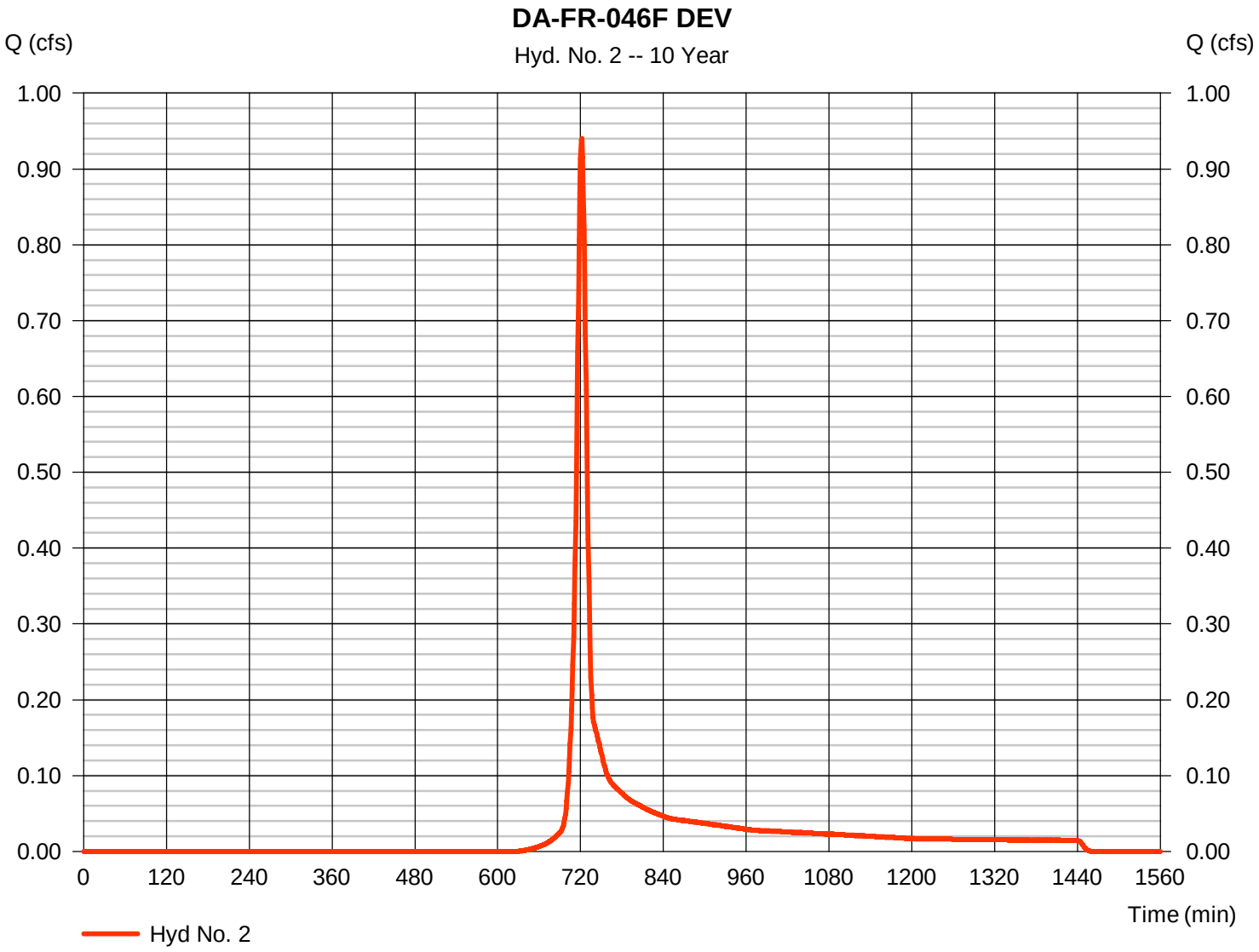
Hydrograph Report

Hyd. No. 2

DA-FR-046F DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.940 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 2,420 cuft
Drainage area	= 0.330 ac	Curve number	= 64*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.40 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.016 x 48) + (0.089 x 65) + (0.113 x 58) + (0.112 x 71)] / 0.330

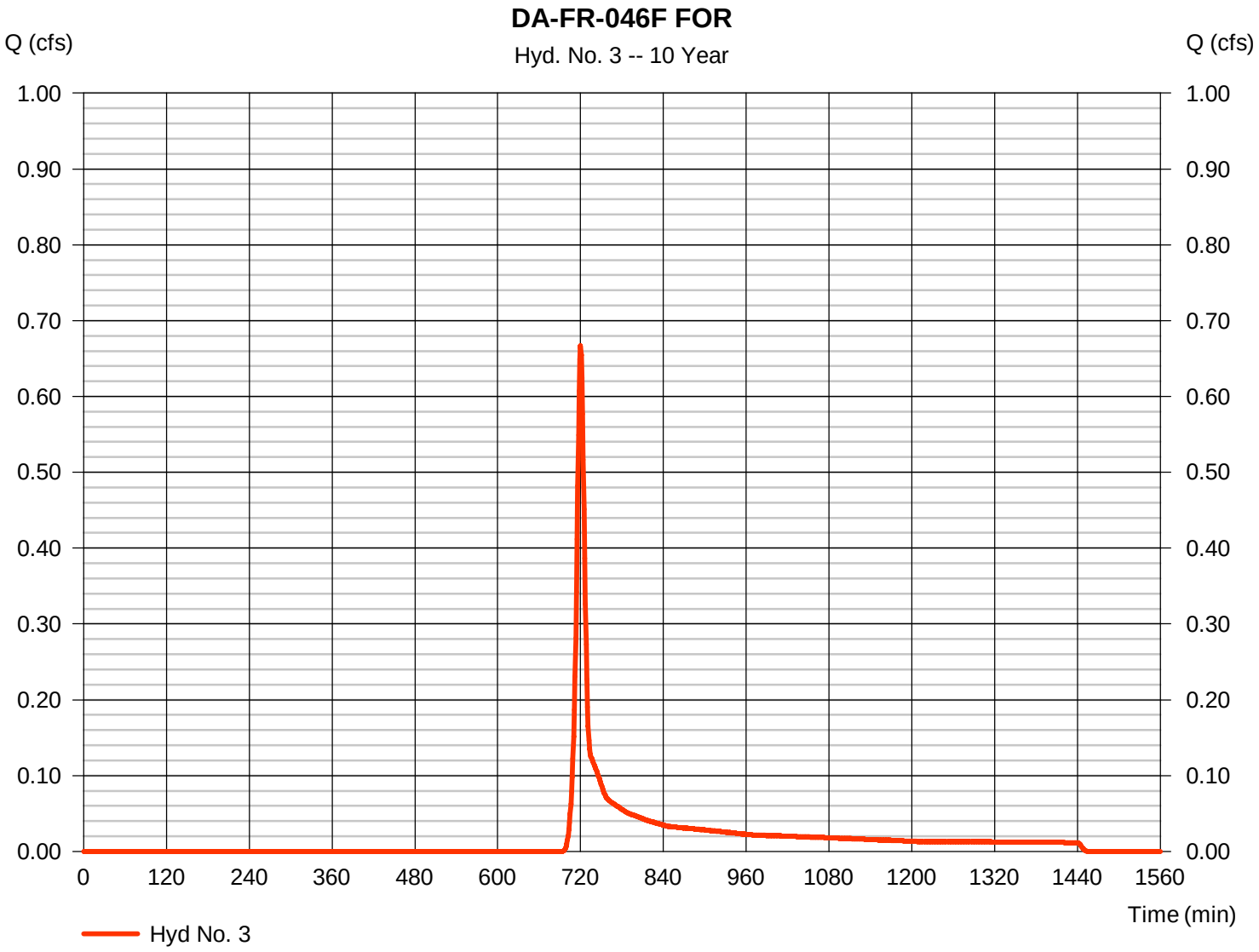


Hydrograph Report

Hyd. No. 3

DA-FR-046F FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.667 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 1,615 cuft
Drainage area	= 0.330 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.40 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-047

DA-FR-047 is located in a brush, meadow and forested areas with rolling slopes. A stream crosses the drainage area. No new impervious area is proposed within DA-FR-047. The total phosphorus load reduction required for DA-FR-047 is –0.25 lb/yr. Multiple points of analysis were evaluated within DA-FR-047 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-047 was sub-divided into three sub-drainage areas (sub-areas A through C).

Stormwater quantity is met via the energy balance method for each of the three sub-areas DA-FR-047A through DA-FR-047C. In addition, the Hydraflow Hydrograph's 10-year 24-hour peak discharge results indicate a reduction in flows ranging from 0.33 to 1.23 cfs for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-047A	0.87	0.54	-0.33
DA-FR-047B	3.33	2.10	-1.23
DA-FR-047C	3.49	2.85	-0.64

Figures and calculations for each of the sub-areas for DA-FR-047 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-047A
0.38 acres
Weighted CN =

DA-FR-047B
1.06 acres
Weighted CN =

DA-FR-047C
1.35 acres
Weighted CN =

259.7
259.8
259.9
260.0
1200
1150
S-EF3
S-EF4
C
B
Green Level Rd

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Waterbody
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:1,800

N
W E
S

150 75 0 150 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-047
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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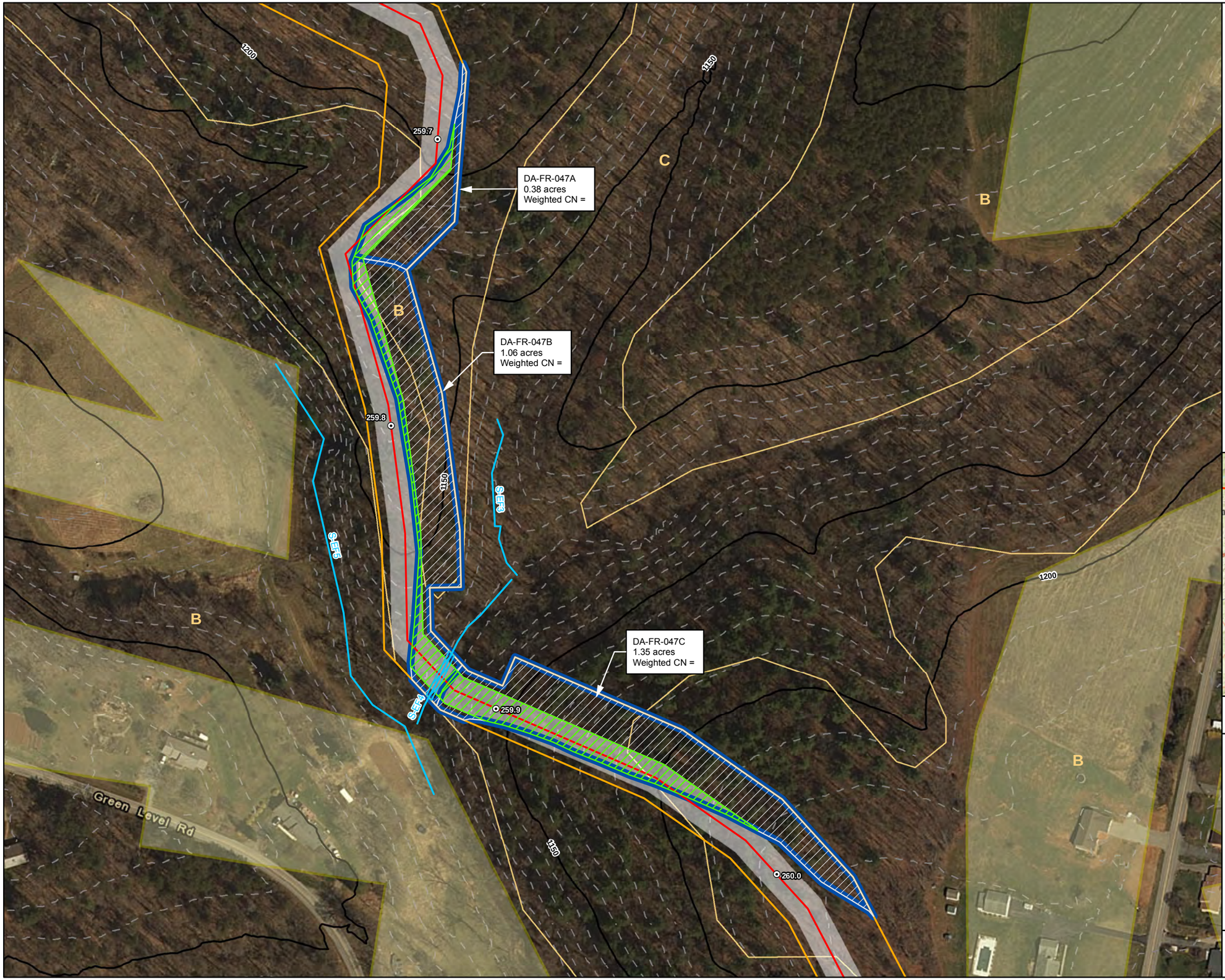

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Brush
- Meadow
- Waterbody
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:1,800

N W E S

150 75 0 150 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-047
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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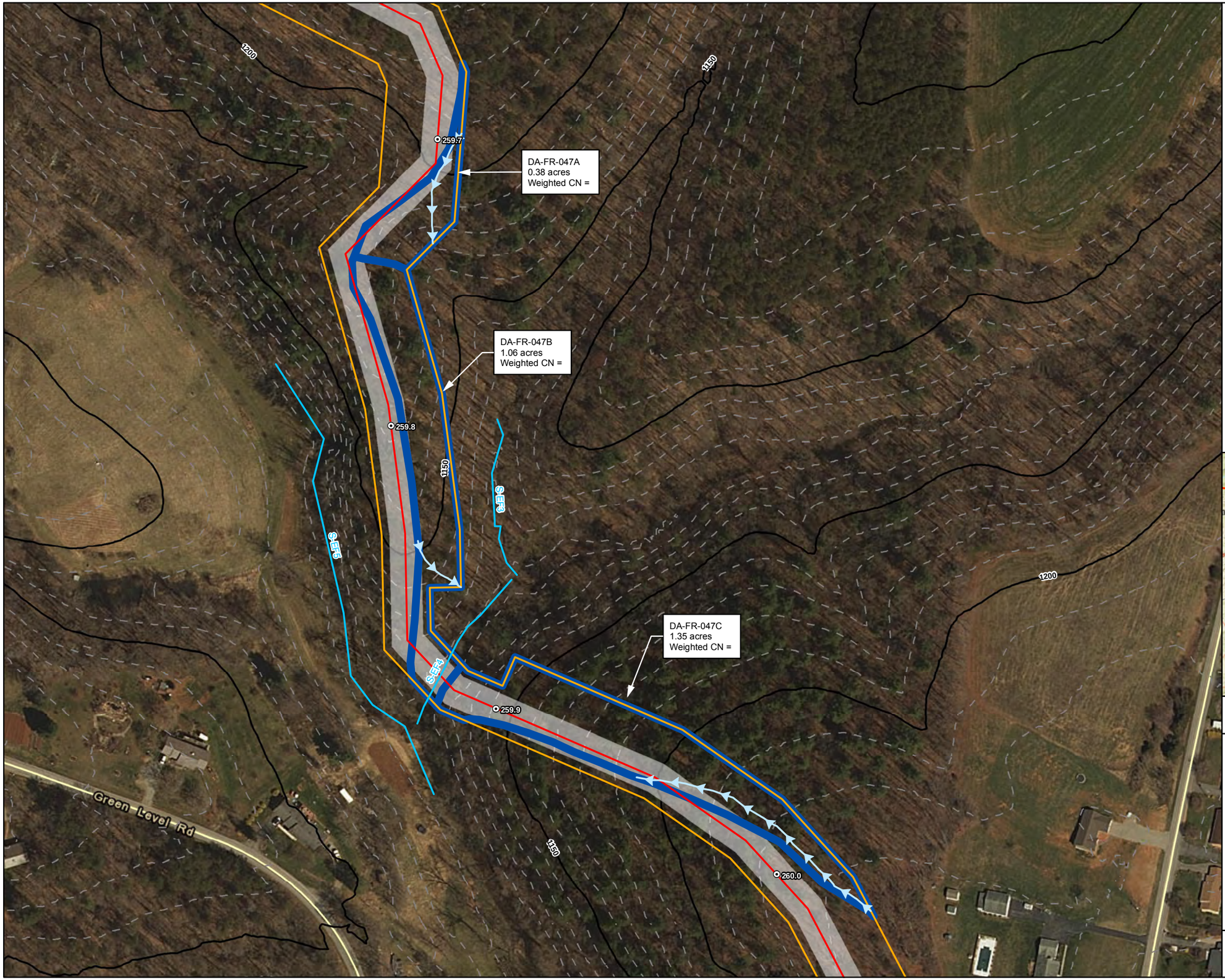


Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,800

N
W E
S

150 75 0 150 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration DA-FR-047 Spread 10

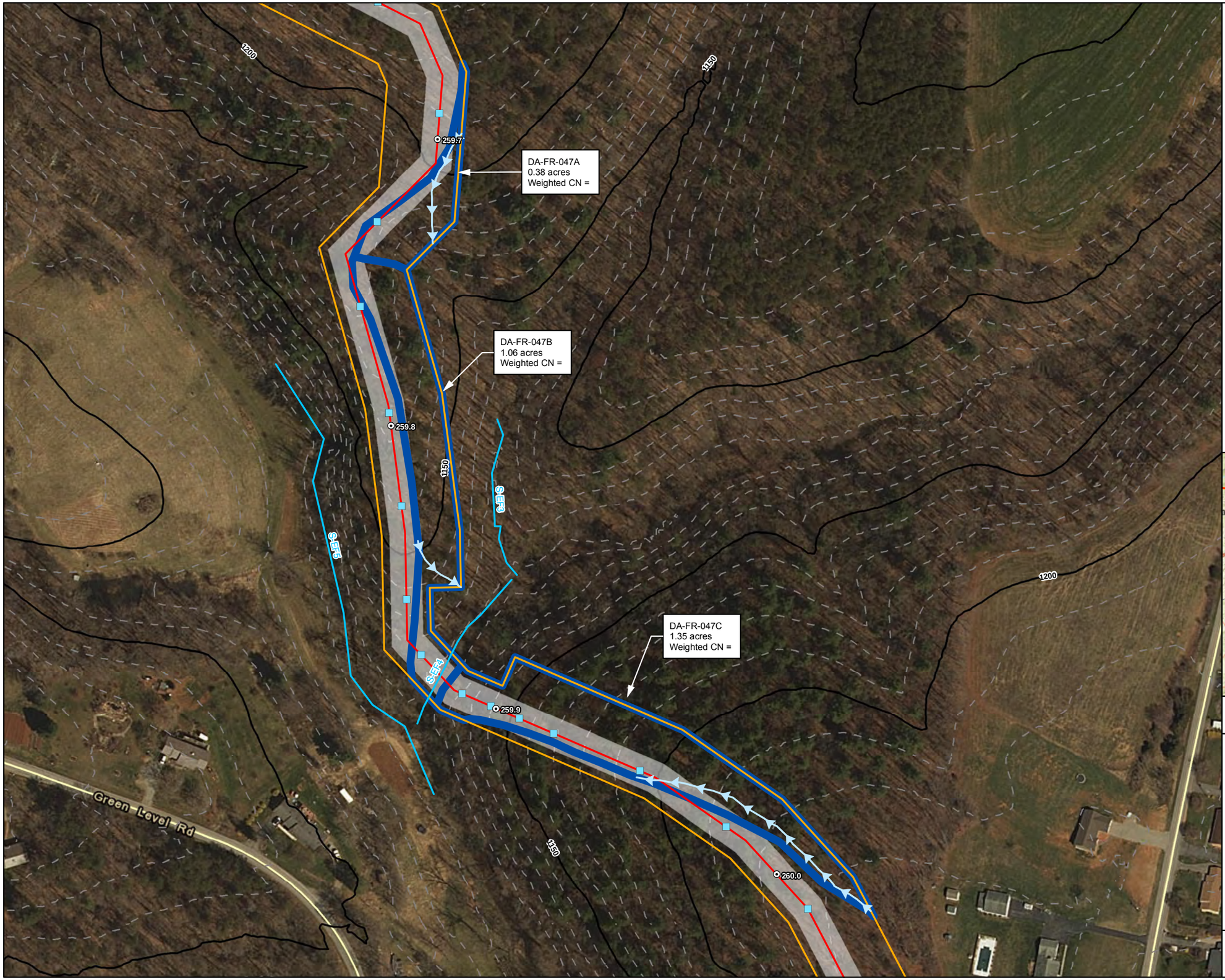
Figure 3

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-047_3.mxd



Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area
- Limit of Disturbance

NAD 1983 UTM 17N (feet)

1:1,800

150 75 0 150 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration DA-FR-047 Spread 10

Figure 4

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-047_4.mxd

Virginia Runoff Reduction Method New Development Worksheet - v2.8 - June 2014

Site Data Summary

Total Rainfall = 46 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.18	0.60	0.00	0.78	*100.00*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
					0.78	*100.00*

Site Rv	0.04
Post Development Treatment Volume (ft3)	107
Post Development TP Load (lb/yr)	0.07
Post Development TN Load (lb/yr)	0.51
Total TP Load Reduction Required (lb/yr)	-0.25

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0
Total TN Load Reduction Achieved (lb/yr)	0.00
Adjusted Post Development TP Load (lb/yr)	0.07
Remaining Phosphorous Load Reduction (Lb/yr) Required	0.00

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest (acres)	0.78	0.00	0.00	0.00	0.00	*0.78*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
						0.78

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*
TN Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*

DA-FR-047A

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.125	474
Developed Condition	0.036	309
Pre-Developed (Forest) Condition	0.081	388

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.9

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.036 ≤ 0.173 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.036 ≤ 0.125 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.036 *shall not* be required to be ≤ 0.102

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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DA-FR-047A.gpw

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

1 2 3

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-047A PRE
2	SCS Runoff	DA-FR-047A DEV
3	SCS Runoff	DA-FR-047A FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.125	0.219	-------	-------	0.871	-------	-------	-------	DA-FR-047A PRE
2	SCS Runoff	------	0.036	0.085	-------	-------	0.535	-------	-------	-------	DA-FR-047A DEV
3	SCS Runoff	------	0.081	0.162	-------	-------	0.768	-------	-------	-------	DA-FR-047A FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.125	1	722	474	------	------	------	DA-FR-047A PRE
2	SCS Runoff	0.036	1	727	309	------	------	------	DA-FR-047A DEV
3	SCS Runoff	0.081	1	723	388	------	------	------	DA-FR-047A FOR

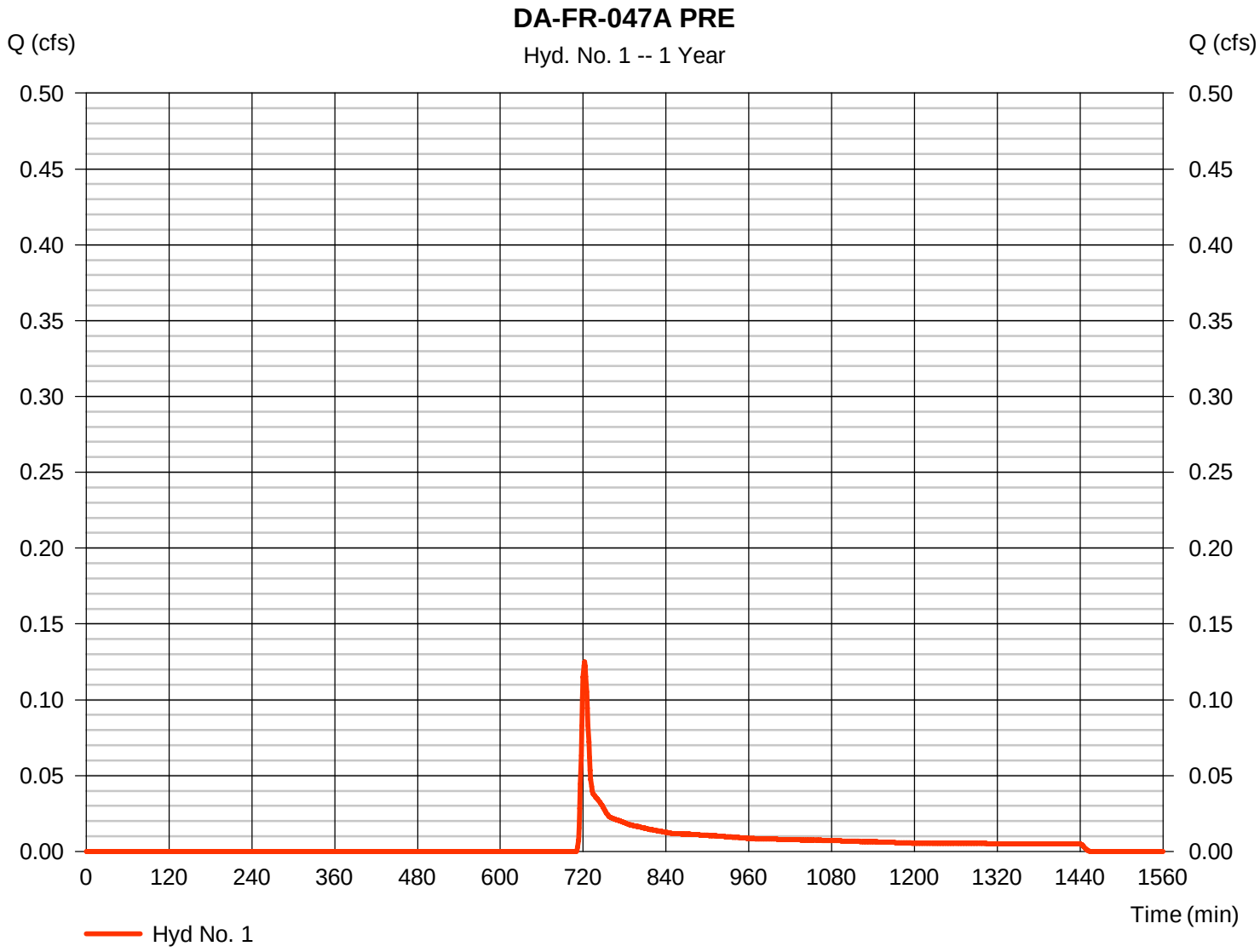
Hydrograph Report

Hyd. No. 1

DA-FR-047A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.125 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 474 cuft
Drainage area	= 0.380 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.90 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.328 x 55) + (0.055 x 70)] / 0.380



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-047A PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 12.07		0.00		0.00		
Travel Time (min)	**= 9.73**	**+**	**0.00**	**+**	**0.00**	**=**	**9.73**
Shallow Concentrated Flow							
Flow length (ft)	= 92.95		0.00		0.00		
Watercourse slope (%)	= 24.98		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.06		0.00		0.00		
Travel Time (min)	**= 0.19**	**+**	**0.00**	**+**	**0.00**	**=**	**0.19**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.90 min

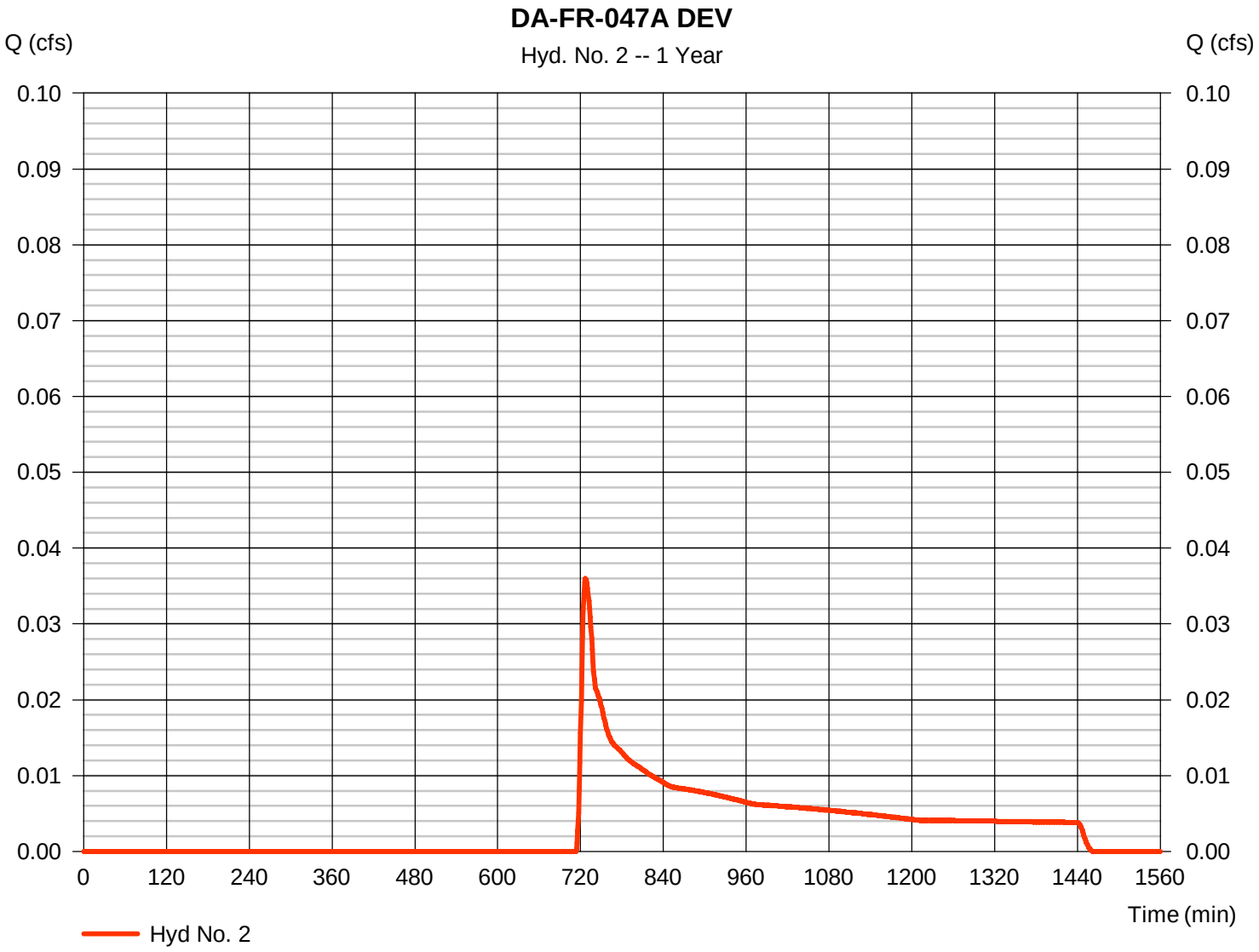
Hydrograph Report

Hyd. No. 2

DA-FR-047A DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.036 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 309 cuft
Drainage area	= 0.380 ac	Curve number	= 53*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.267 x 48) + (0.062 x 58) + (0.055 x 71)] / 0.380



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-047A DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.800		0.400		0.011		
Flow length (ft)	= 24.0		76.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 9.68		12.82		0.00		
Travel Time (min)	**= 5.91**	**+**	**7.62**	**+**	**0.00**	**=**	**13.54**
Shallow Concentrated Flow							
Flow length (ft)	= 92.95		0.00		0.00		
Watercourse slope (%)	= 24.98		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.06		0.00		0.00		
Travel Time (min)	**= 0.19**	**+**	**0.00**	**+**	**0.00**	**=**	**0.19**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

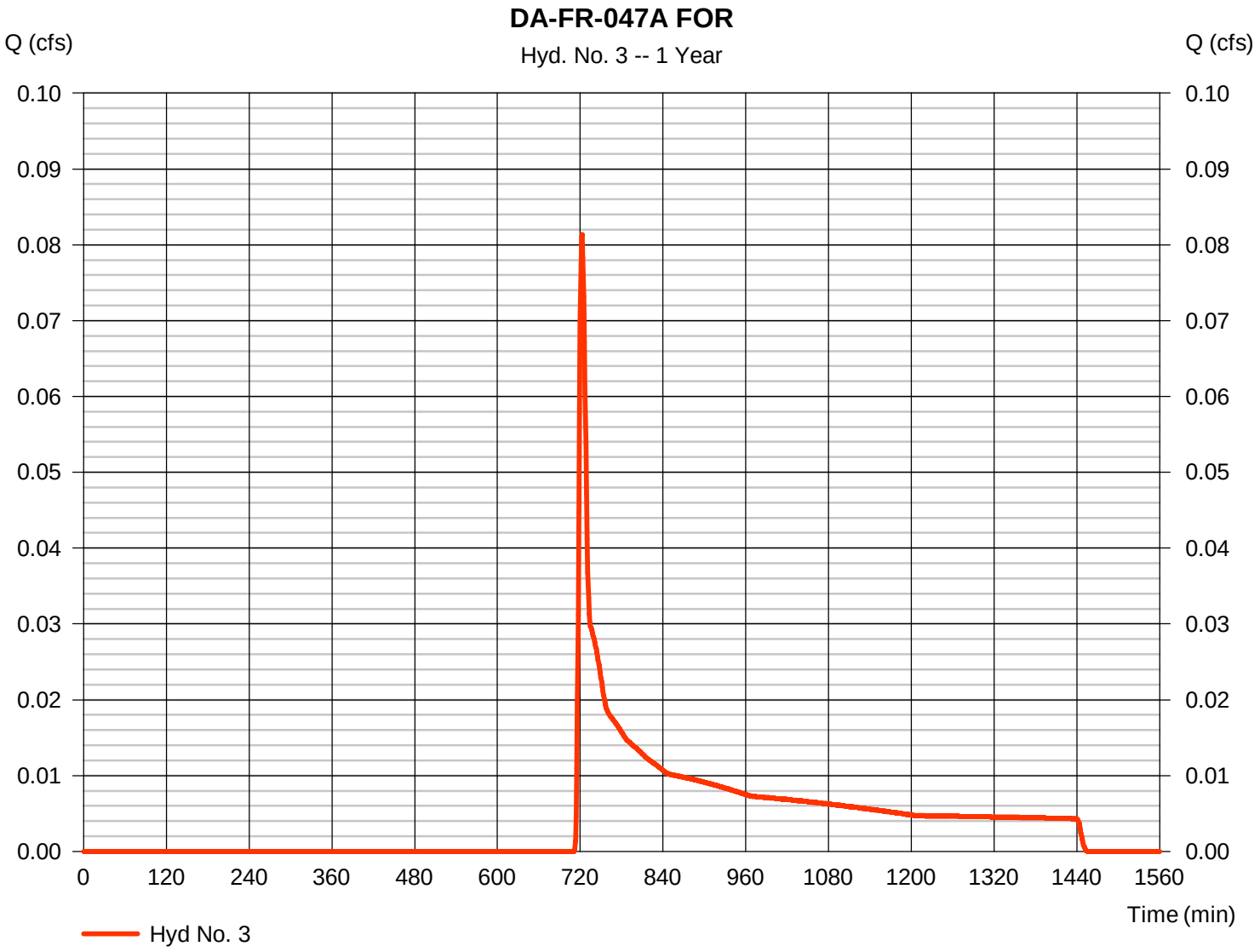
Total Travel Time, Tc ..... 13.70 min

Hydrograph Report

Hyd. No. 3

DA-FR-047A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.081 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 388 cuft
Drainage area	= 0.380 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.90 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-047A FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 12.07		0.00		0.00		
Travel Time (min)	**= 9.73**	**+**	**0.00**	**+**	**0.00**	**=**	**9.73**
Shallow Concentrated Flow							
Flow length (ft)	= 92.95		0.00		0.00		
Watercourse slope (%)	= 24.98		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.06		0.00		0.00		
Travel Time (min)	**= 0.19**	**+**	**0.00**	**+**	**0.00**	**=**	**0.19**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.90 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.219	1	721	680	------	------	------	DA-FR-047A PRE
2	SCS Runoff	0.085	1	726	474	------	------	------	DA-FR-047A DEV
3	SCS Runoff	0.162	1	722	573	------	------	------	DA-FR-047A FOR

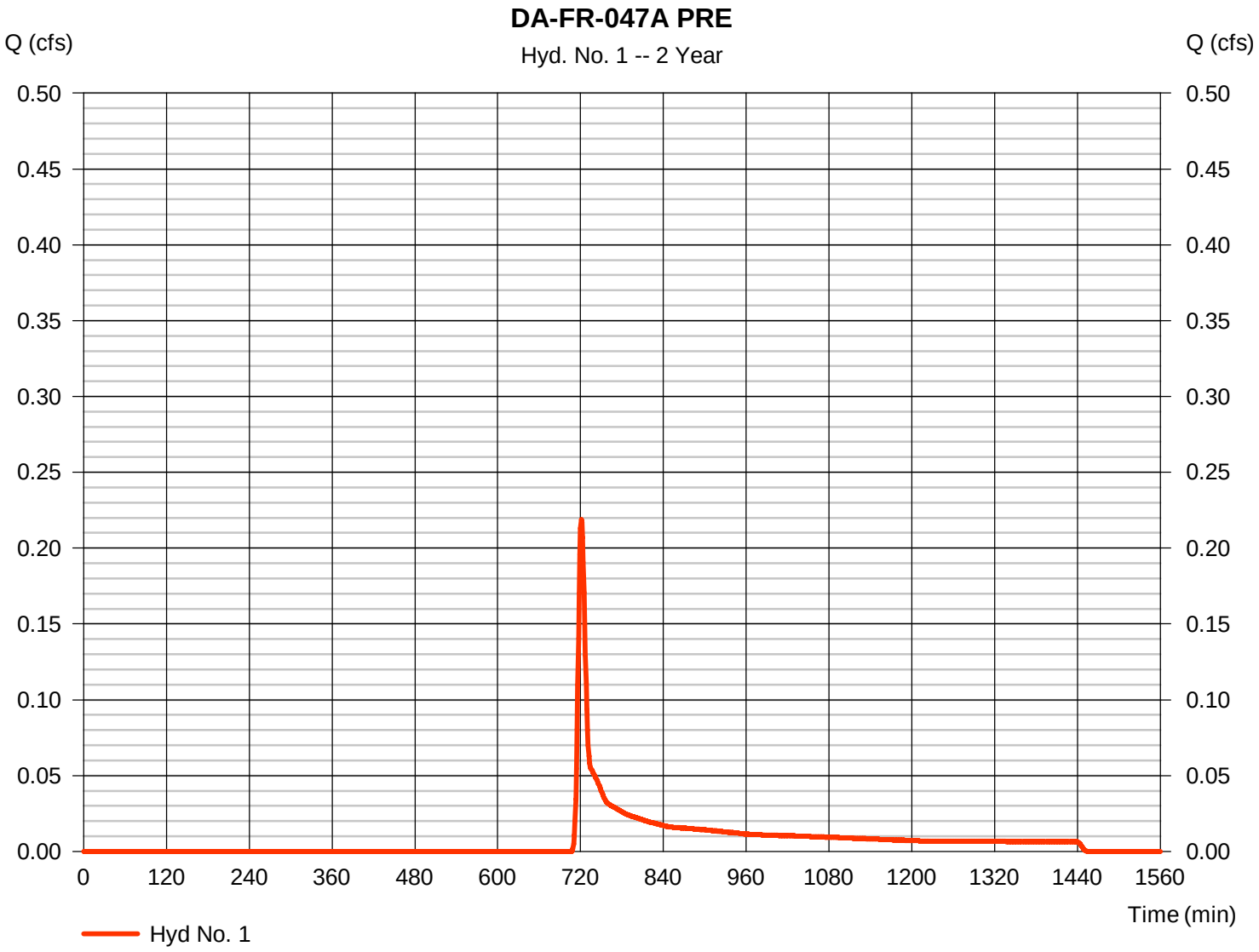
Hydrograph Report

Hyd. No. 1

DA-FR-047A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.219 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 680 cuft
Drainage area	= 0.380 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.90 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.328 x 55) + (0.055 x 70)] / 0.380



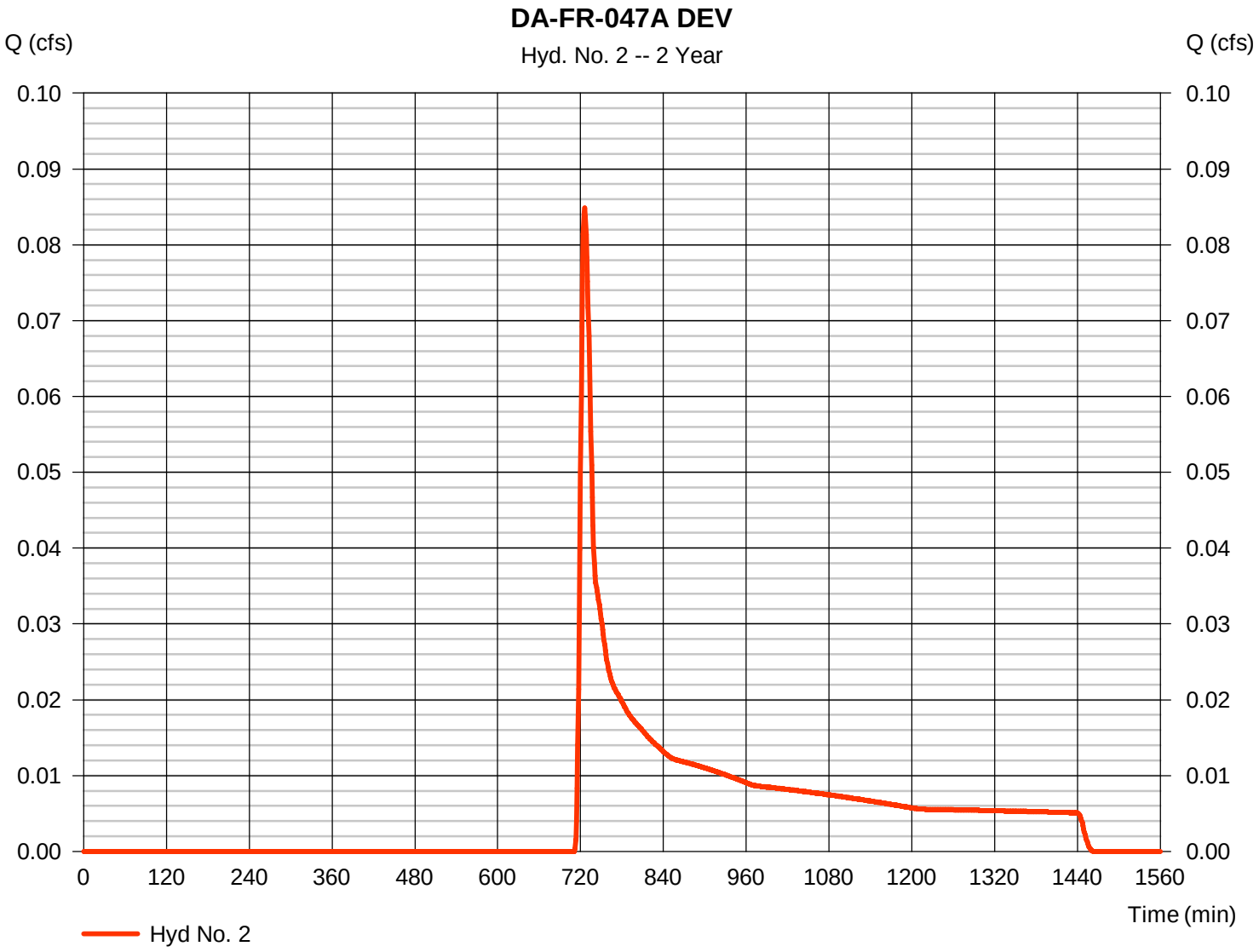
Hydrograph Report

Hyd. No. 2

DA-FR-047A DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.085 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 474 cuft
Drainage area	= 0.380 ac	Curve number	= 53*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.70 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.267 x 48) + (0.062 x 58) + (0.055 x 71)] / 0.380

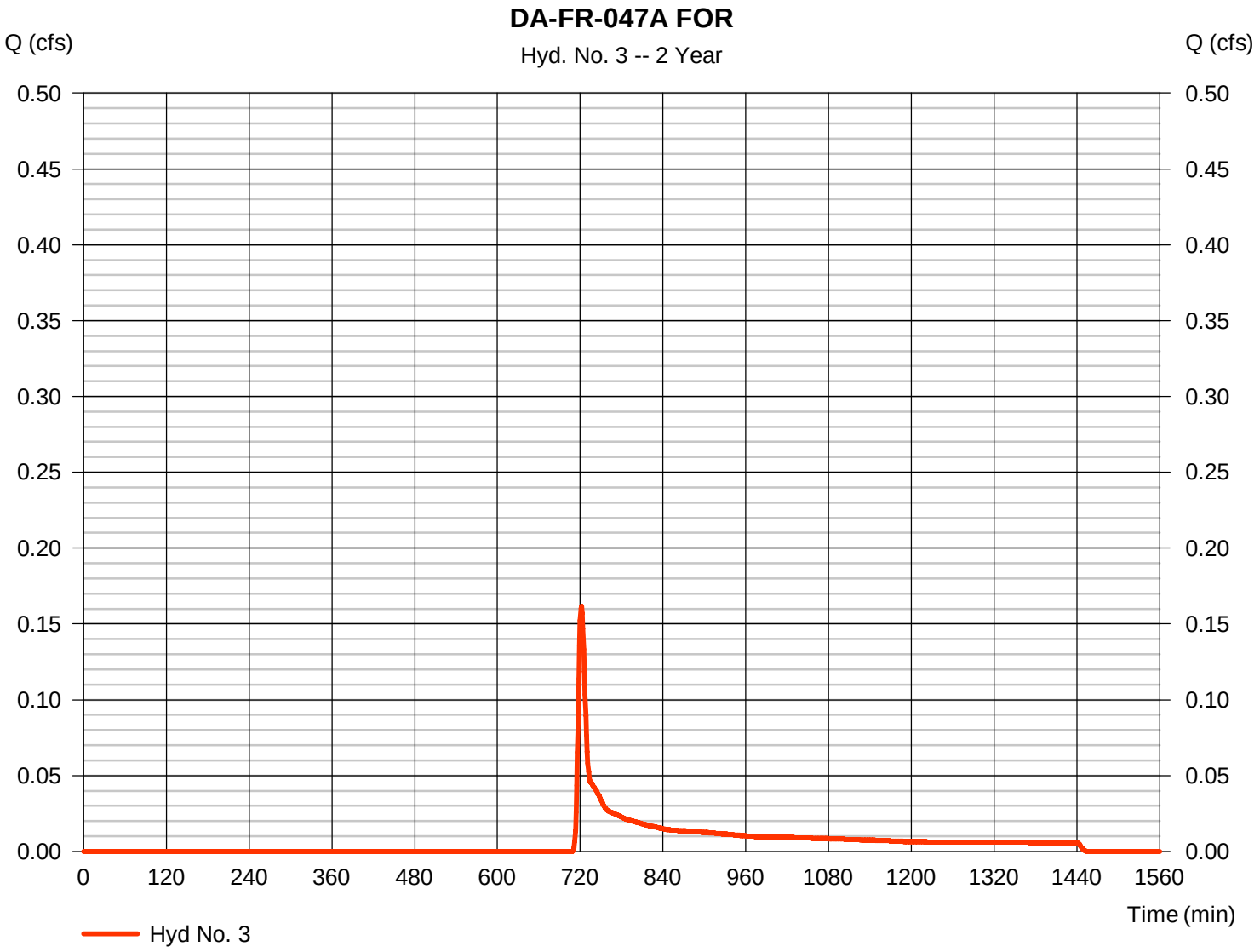


Hydrograph Report

Hyd. No. 3

DA-FR-047A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.162 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 573 cuft
Drainage area	= 0.380 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.90 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.871	1	720	2,065	------	------	------	DA-FR-047A PRE
2	SCS Runoff	0.535	1	723	1,662	------	------	------	DA-FR-047A DEV
3	SCS Runoff	0.768	1	720	1,860	------	------	------	DA-FR-047A FOR

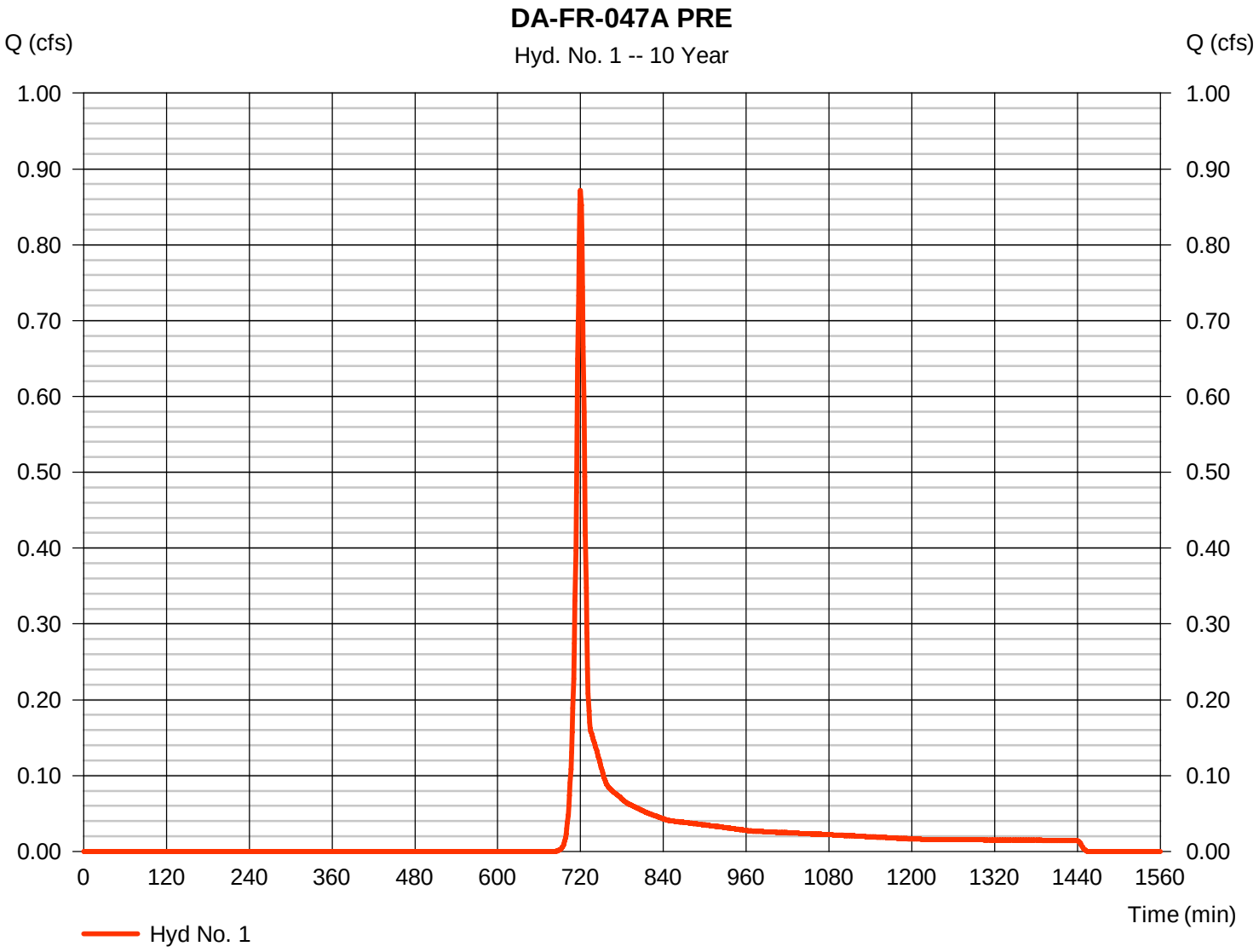
Hydrograph Report

Hyd. No. 1

DA-FR-047A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.871 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 2,065 cuft
Drainage area	= 0.380 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.90 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.328 x 55) + (0.055 x 70)] / 0.380



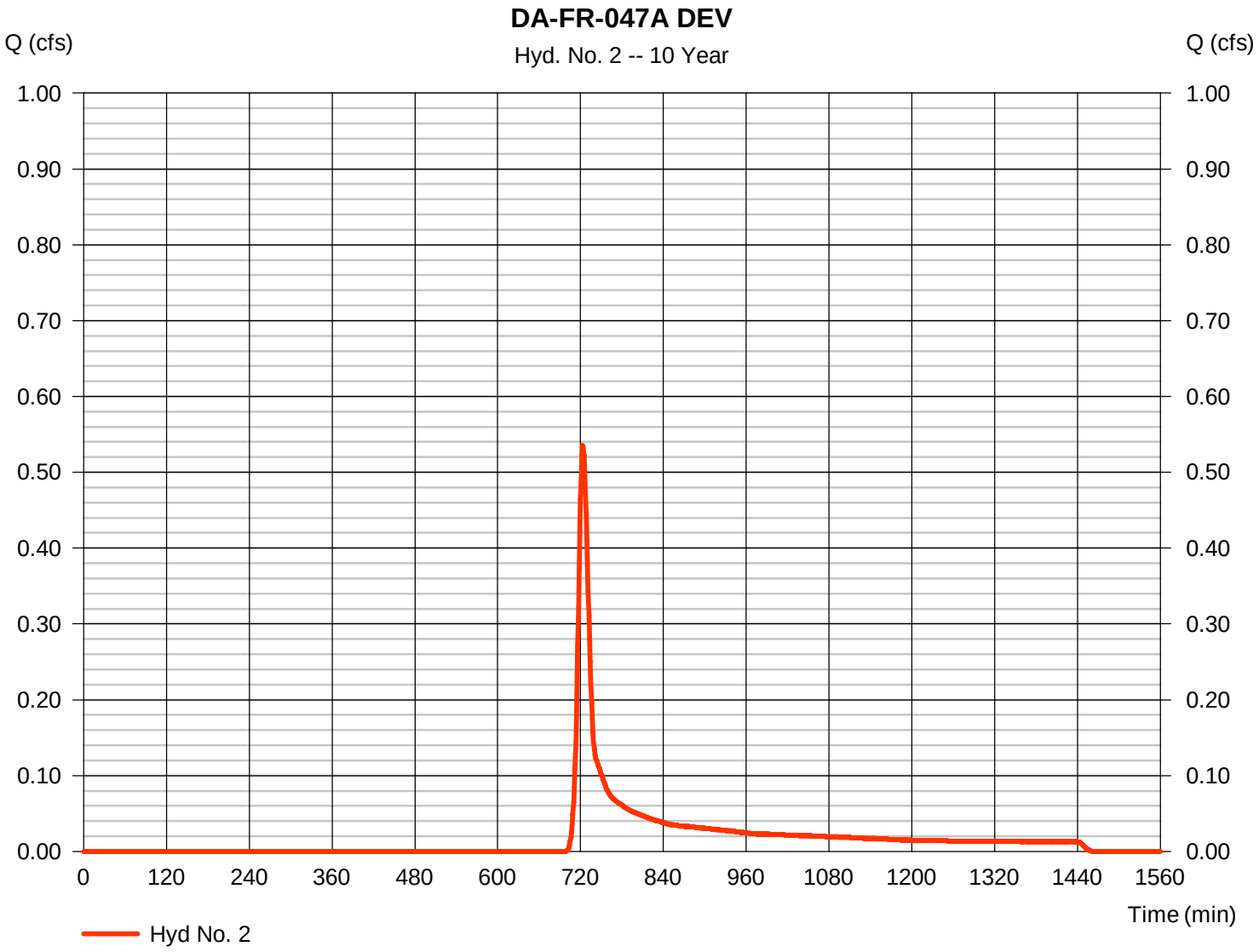
Hydrograph Report

Hyd. No. 2

DA-FR-047A DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.535 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 1,662 cuft
Drainage area	= 0.380 ac	Curve number	= 53*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.70 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.267 x 48) + (0.062 x 58) + (0.055 x 71)] / 0.380

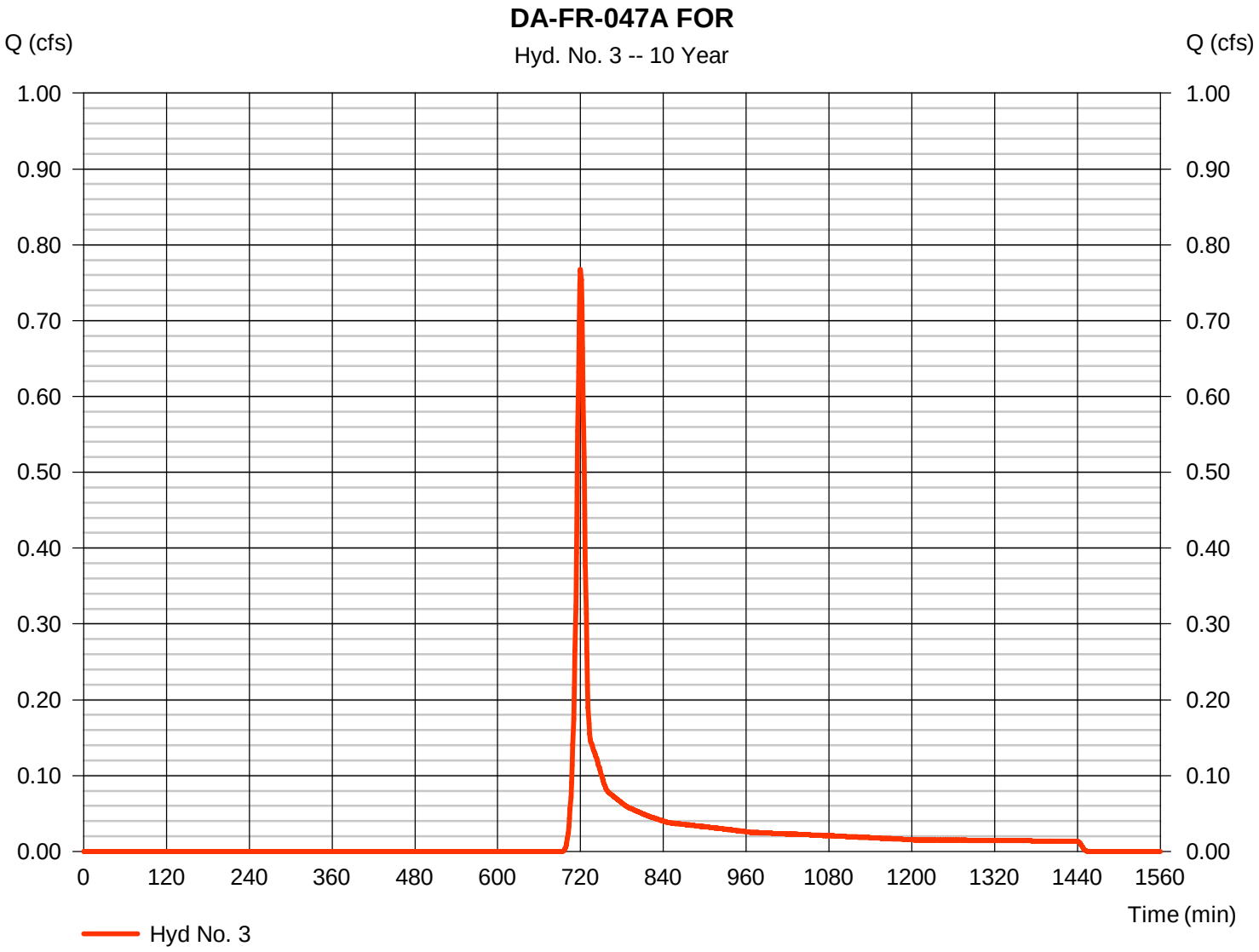


Hydrograph Report

Hyd. No. 3

DA-FR-047A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.768 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 1,860 cuft
Drainage area	= 0.380 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.90 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-047B

ENERGY BALANCE METHOD

Inputs:

	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.772	1967
Developed Condition	0.288	1301
Pre-Developed (Forest) Condition	0.252	**1055**

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.288 ≤ 0.934 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.288 ≤ 0.772 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.288 *shall not* be required to be ≤ 0.204

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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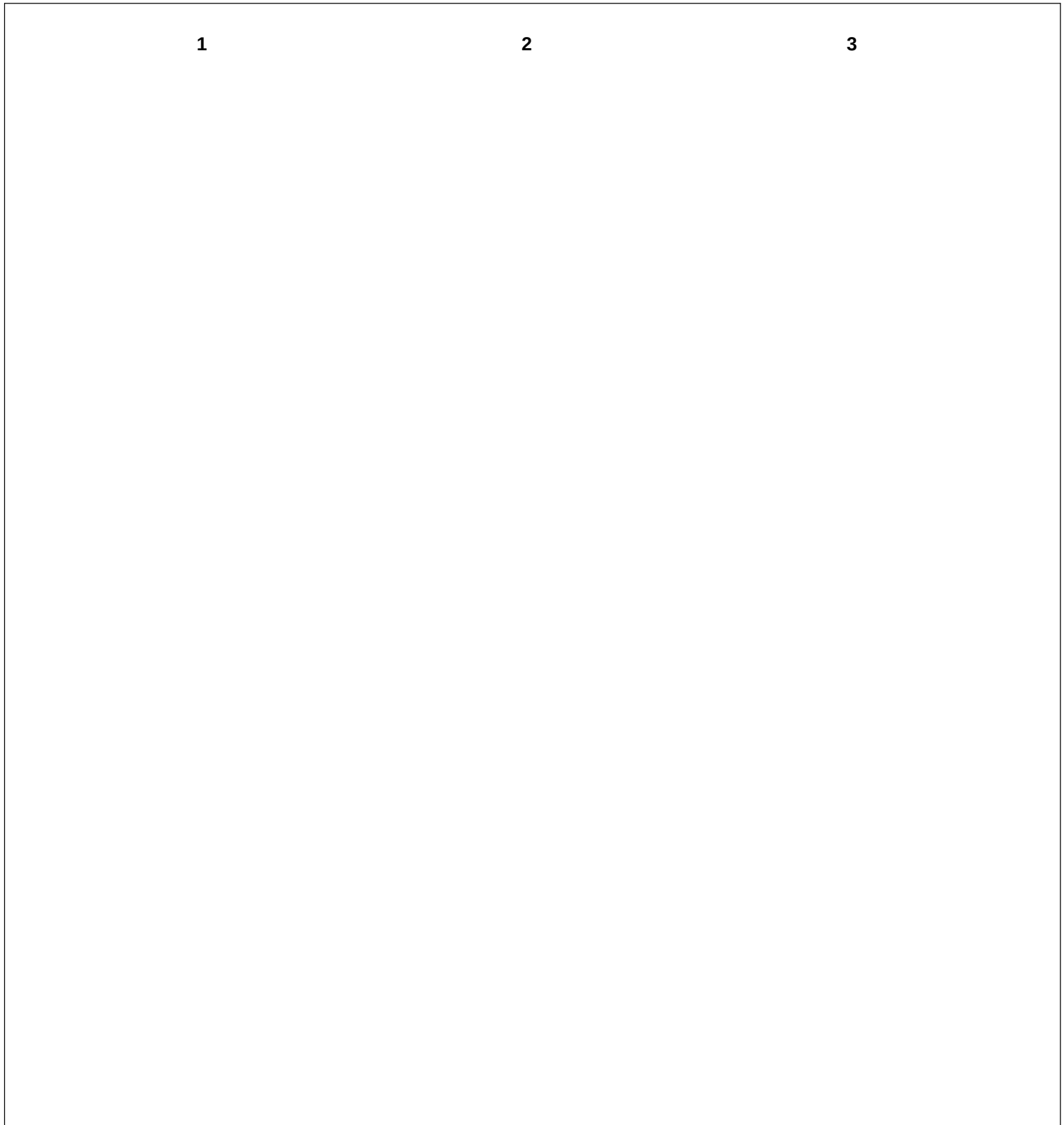
Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-047B PRE
2	SCS Runoff	DA-FR-047B DEV
3	SCS Runoff	DA-FR-047B FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.772	1.132	-------	-------	3.330	-------	-------	-------	DA-FR-047B PRE
2	SCS Runoff	------	0.288	0.509	-------	-------	2.099	-------	-------	-------	DA-FR-047B DEV
3	SCS Runoff	------	0.252	0.492	-------	-------	2.270	-------	-------	-------	DA-FR-047B FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.772	1	720	1,967	------	------	------	DA-FR-047B PRE
2	SCS Runoff	0.288	1	724	1,301	------	------	------	DA-FR-047B DEV
3	SCS Runoff	0.252	1	721	1,055	------	------	------	DA-FR-047B FOR

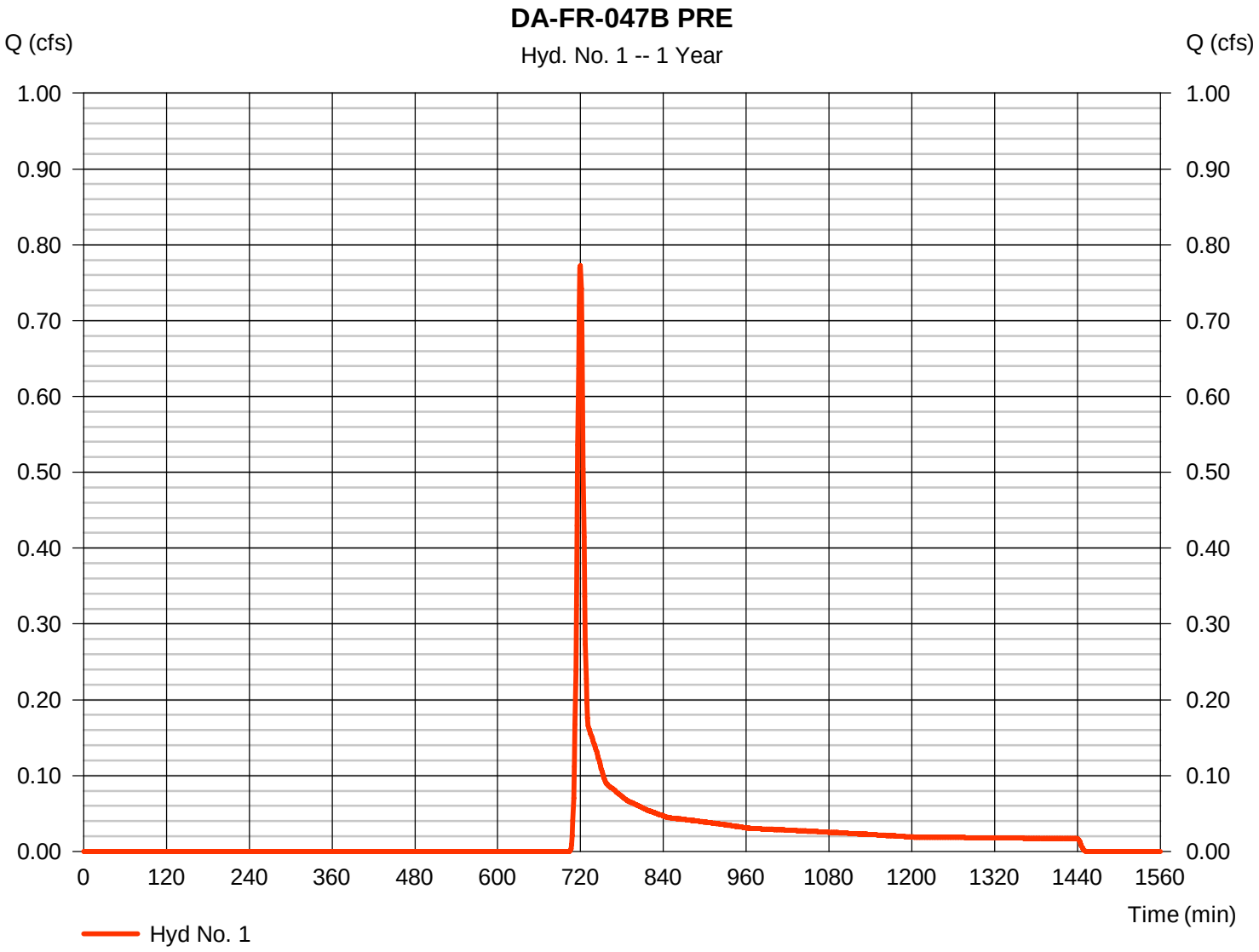
Hydrograph Report

Hyd. No. 1

DA-FR-047B PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	0.772 cfs
Storm frequency	=	1 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	1,967 cuft
Drainage area	=	1.060 ac	Curve number	=	62*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	7.50 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.020 x 100) + (0.617 x 55) + (0.421 x 70)] / 1.060



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-047B PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 23.45		0.00		0.00		
Travel Time (min)	**= 7.46**	**+**	**0.00**	**+**	**0.00**	**=**	**7.46**
Shallow Concentrated Flow							
Flow length (ft)	= 9.35		0.00		0.00		
Watercourse slope (%)	= 42.20		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=10.48		0.00		0.00		
Travel Time (min)	**= 0.01**	**+**	**0.00**	**+**	**0.00**	**=**	**0.01**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 7.50 min

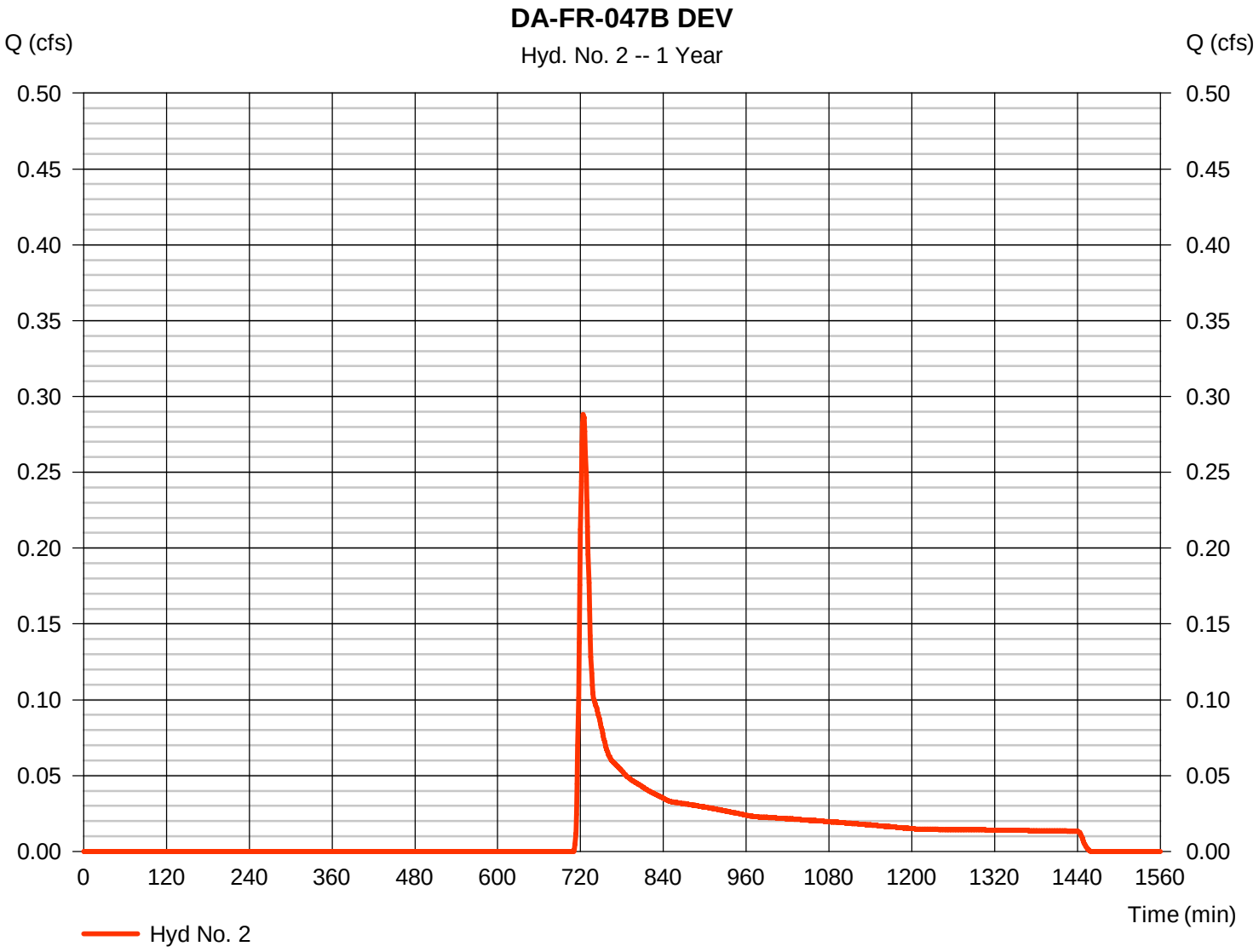
Hydrograph Report

Hyd. No. 2

DA-FR-047B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.288 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 1,301 cuft
Drainage area	= 1.060 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.596 x 48) + (0.219 x 65) + (0.021 x 58) + (0.202 x 71) + (0.020 x 100)] / 1.060



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-047B DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.800		0.011		
Flow length (ft)	= 19.4		80.6		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 17.11		24.98		0.00		
Travel Time (min)	**= 2.28**	**+**	**10.66**	**+**	**0.00**	**=**	**12.94**
Shallow Concentrated Flow							
Flow length (ft)	= 9.35		0.00		0.00		
Watercourse slope (%)	= 42.20		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=10.48		0.00		0.00		
Travel Time (min)	**= 0.01**	**+**	**0.00**	**+**	**0.00**	**=**	**0.01**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

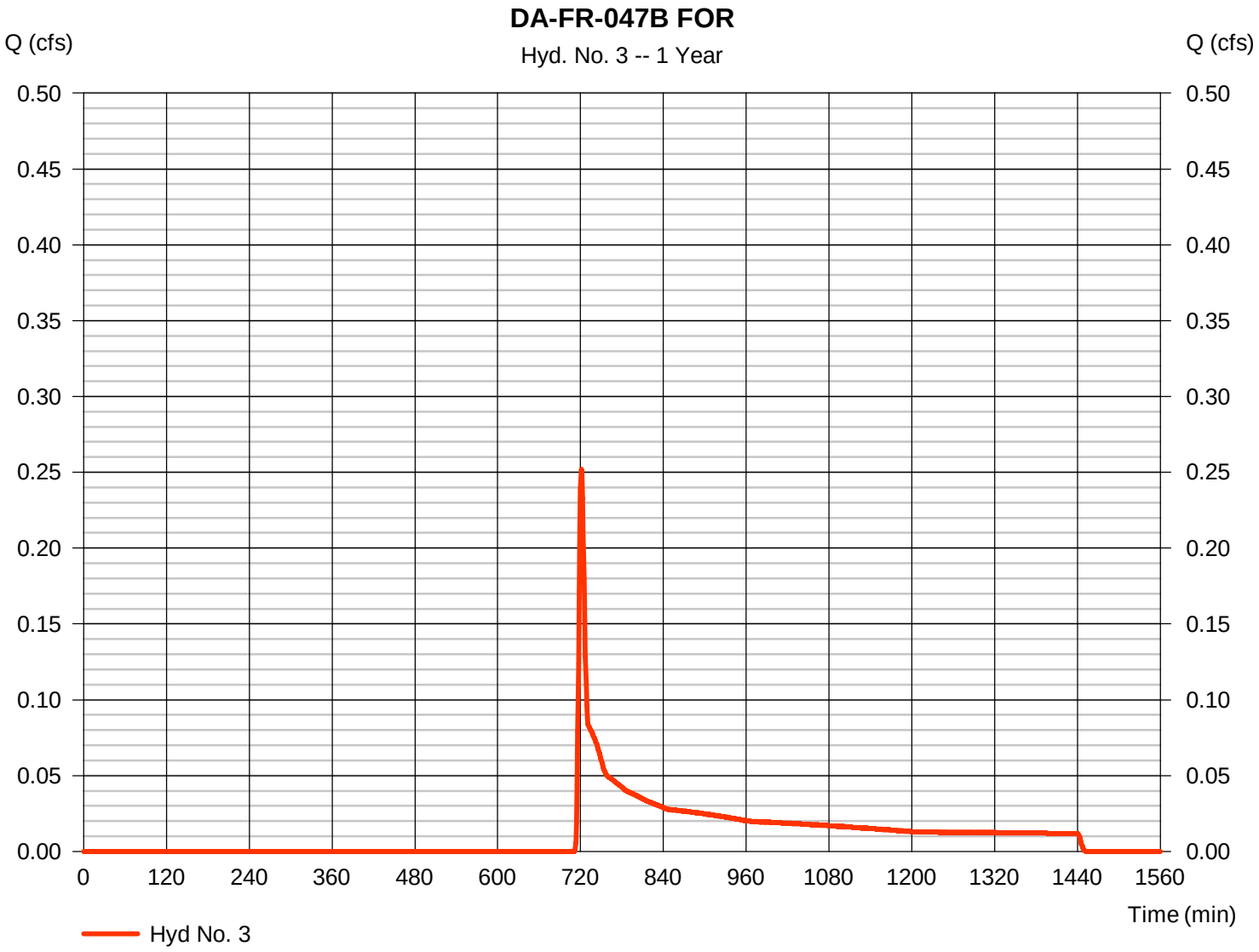
Total Travel Time, Tc ..... 13.00 min

Hydrograph Report

Hyd. No. 3

DA-FR-047B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.252 cfs
Storm frequency	= 1 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,055 cuft
Drainage area	= 1.060 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-047B FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 23.45		0.00		0.00		
Travel Time (min)	**= 7.46**	**+**	**0.00**	**+**	**0.00**	**=**	**7.46**
Shallow Concentrated Flow							
Flow length (ft)	= 9.35		0.00		0.00		
Watercourse slope (%)	= 42.20		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=10.48		0.00		0.00		
Travel Time (min)	**= 0.01**	**+**	**0.00**	**+**	**0.00**	**=**	**0.01**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 7.50 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.132	1	719	2,669	------	------	------	DA-FR-047B PRE
2	SCS Runoff	0.509	1	723	1,868	------	------	------	DA-FR-047B DEV
3	SCS Runoff	0.492	1	721	1,559	------	------	------	DA-FR-047B FOR

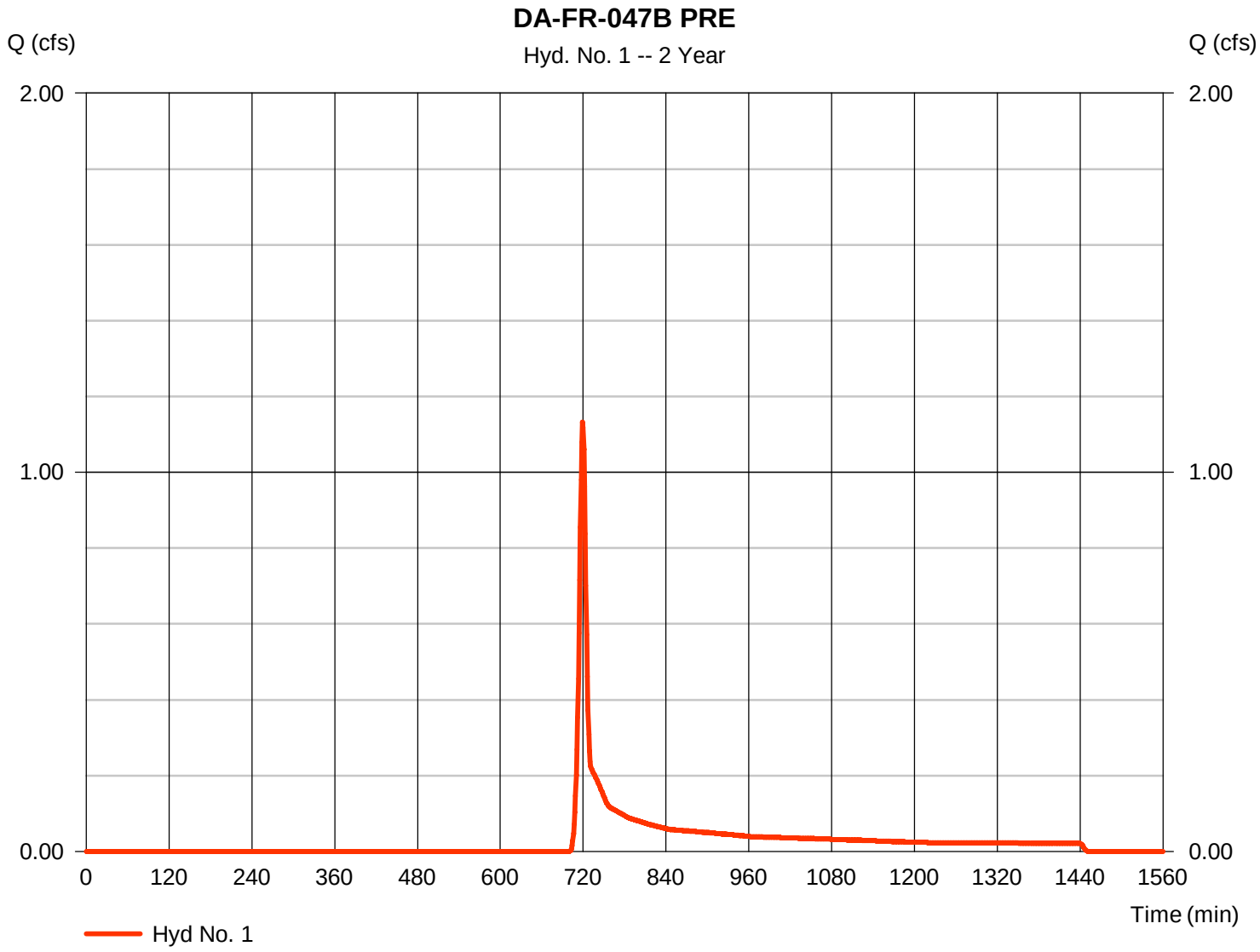
Hydrograph Report

Hyd. No. 1

DA-FR-047B PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.132 cfs
Storm frequency	=	2 yrs	Time to peak	=	719 min
Time interval	=	1 min	Hyd. volume	=	2,669 cuft
Drainage area	=	1.060 ac	Curve number	=	62*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	7.50 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.020 x 100) + (0.617 x 55) + (0.421 x 70)] / 1.060



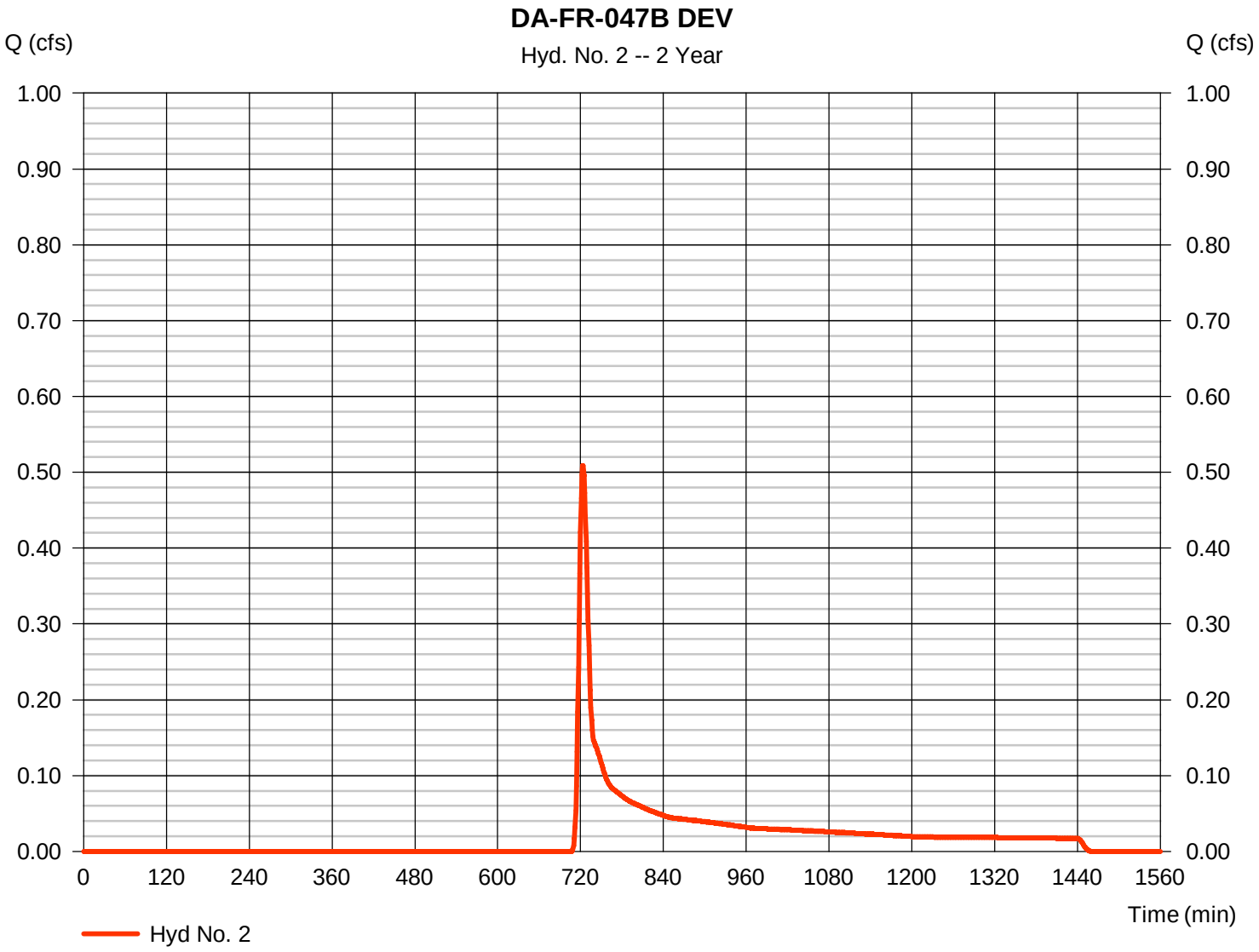
Hydrograph Report

Hyd. No. 2

DA-FR-047B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.509 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 1,868 cuft
Drainage area	= 1.060 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.596 x 48) + (0.219 x 65) + (0.021 x 58) + (0.202 x 71) + (0.020 x 100)] / 1.060

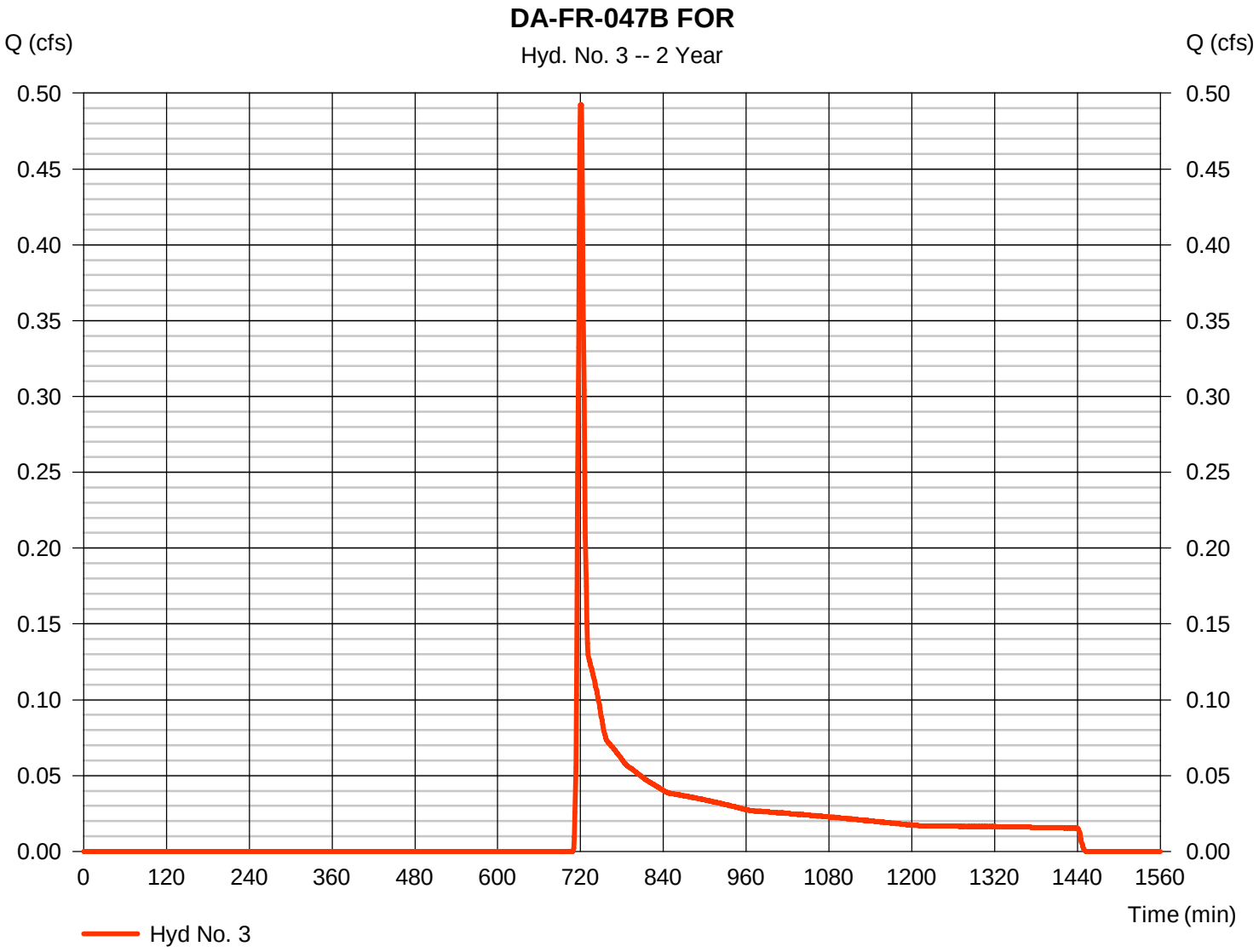


Hydrograph Report

Hyd. No. 3

DA-FR-047B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.492 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,559 cuft
Drainage area	= 1.060 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	3.330	1	719	7,083	------	------	------	DA-FR-047B PRE
2	SCS Runoff	2.099	1	722	5,670	------	------	------	DA-FR-047B DEV
3	SCS Runoff	2.270	1	719	5,059	------	------	------	DA-FR-047B FOR

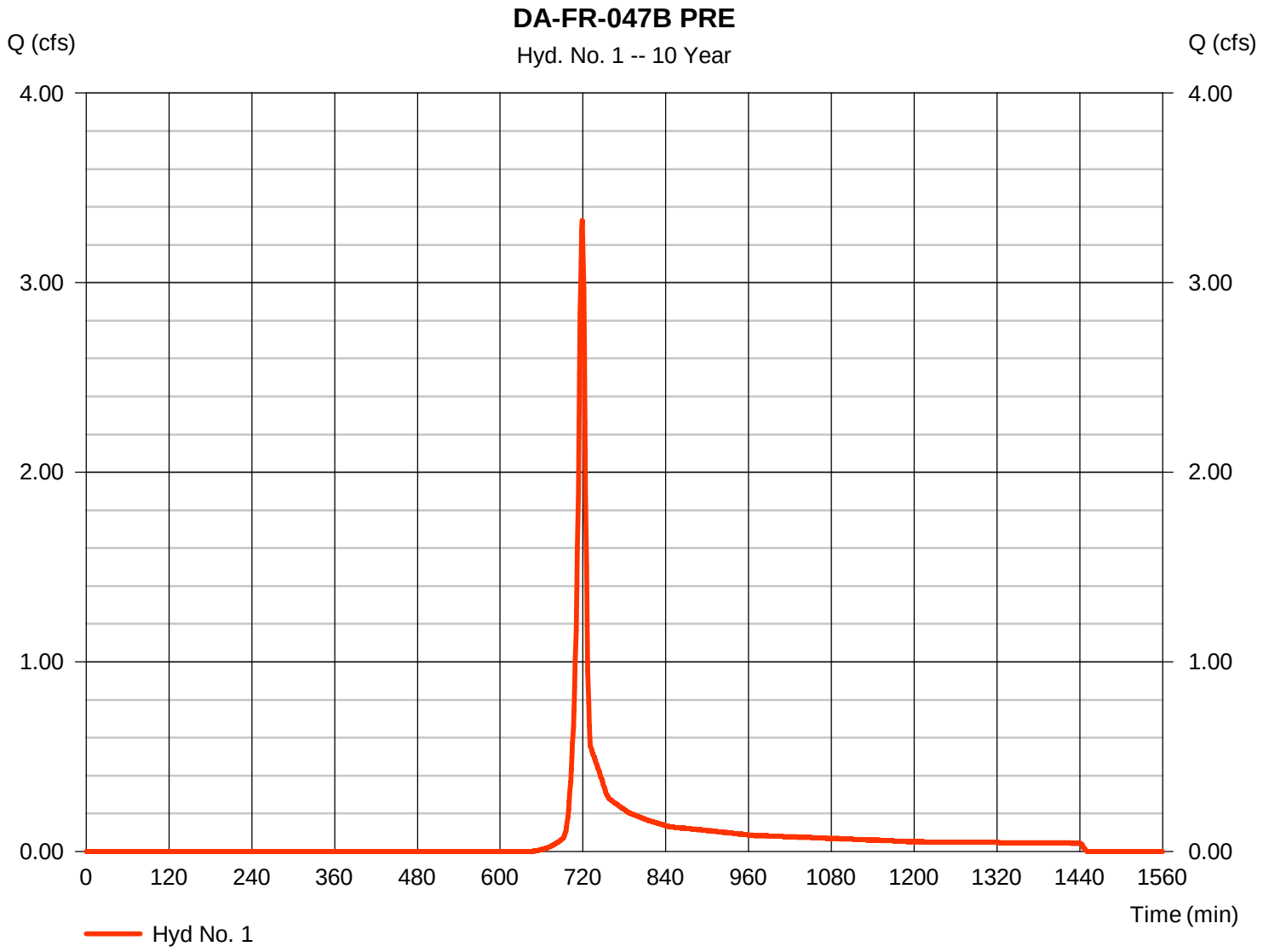
Hydrograph Report

Hyd. No. 1

DA-FR-047B PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.330 cfs
Storm frequency	=	10 yrs	Time to peak	=	719 min
Time interval	=	1 min	Hyd. volume	=	7,083 cuft
Drainage area	=	1.060 ac	Curve number	=	62*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	7.50 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.020 x 100) + (0.617 x 55) + (0.421 x 70)] / 1.060



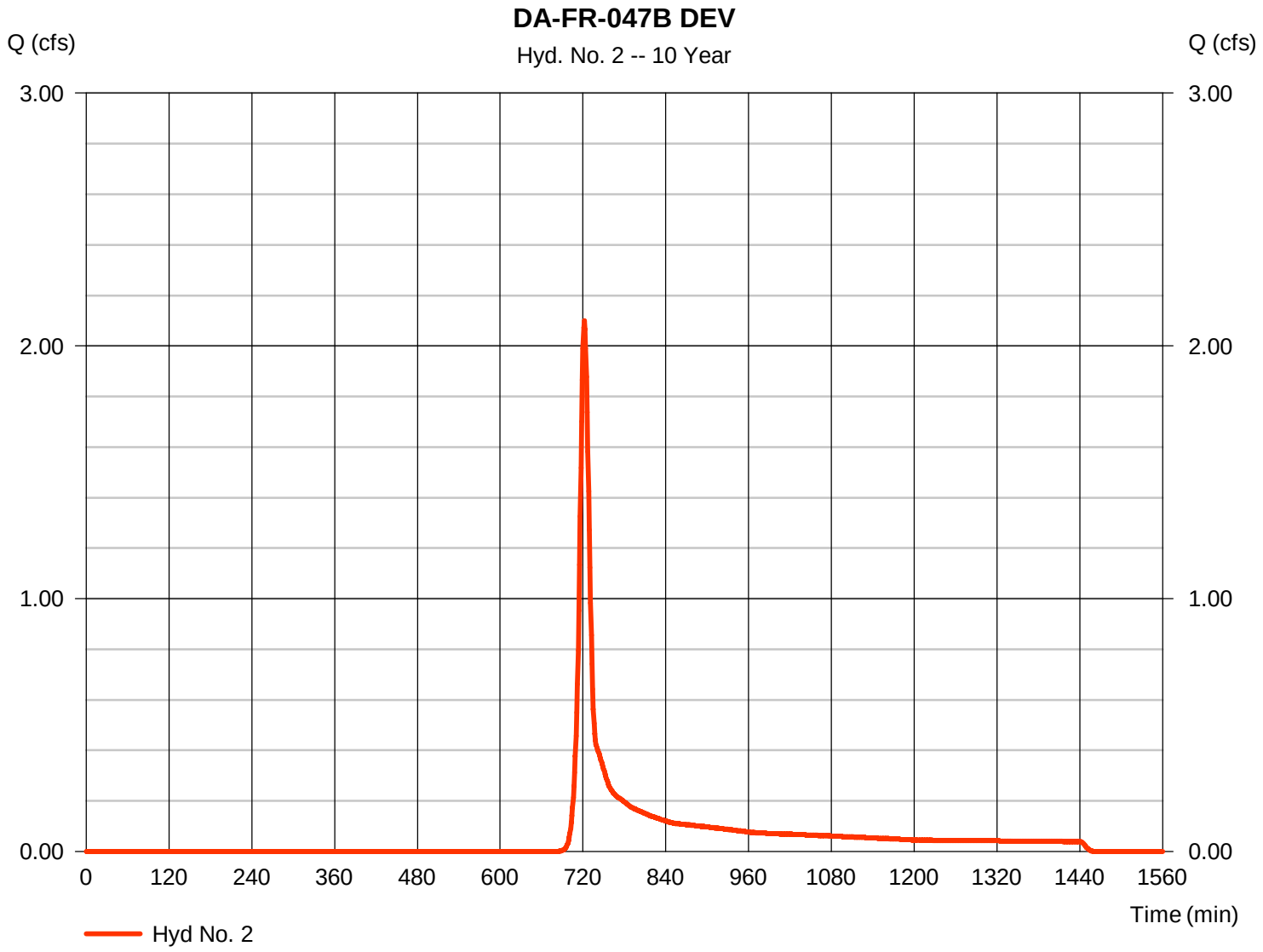
Hydrograph Report

Hyd. No. 2

DA-FR-047B DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.099 cfs
Storm frequency	=	10 yrs	Time to peak	=	722 min
Time interval	=	1 min	Hyd. volume	=	5,670 cuft
Drainage area	=	1.060 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.00 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.596 x 48) + (0.219 x 65) + (0.021 x 58) + (0.202 x 71) + (0.020 x 100)] / 1.060

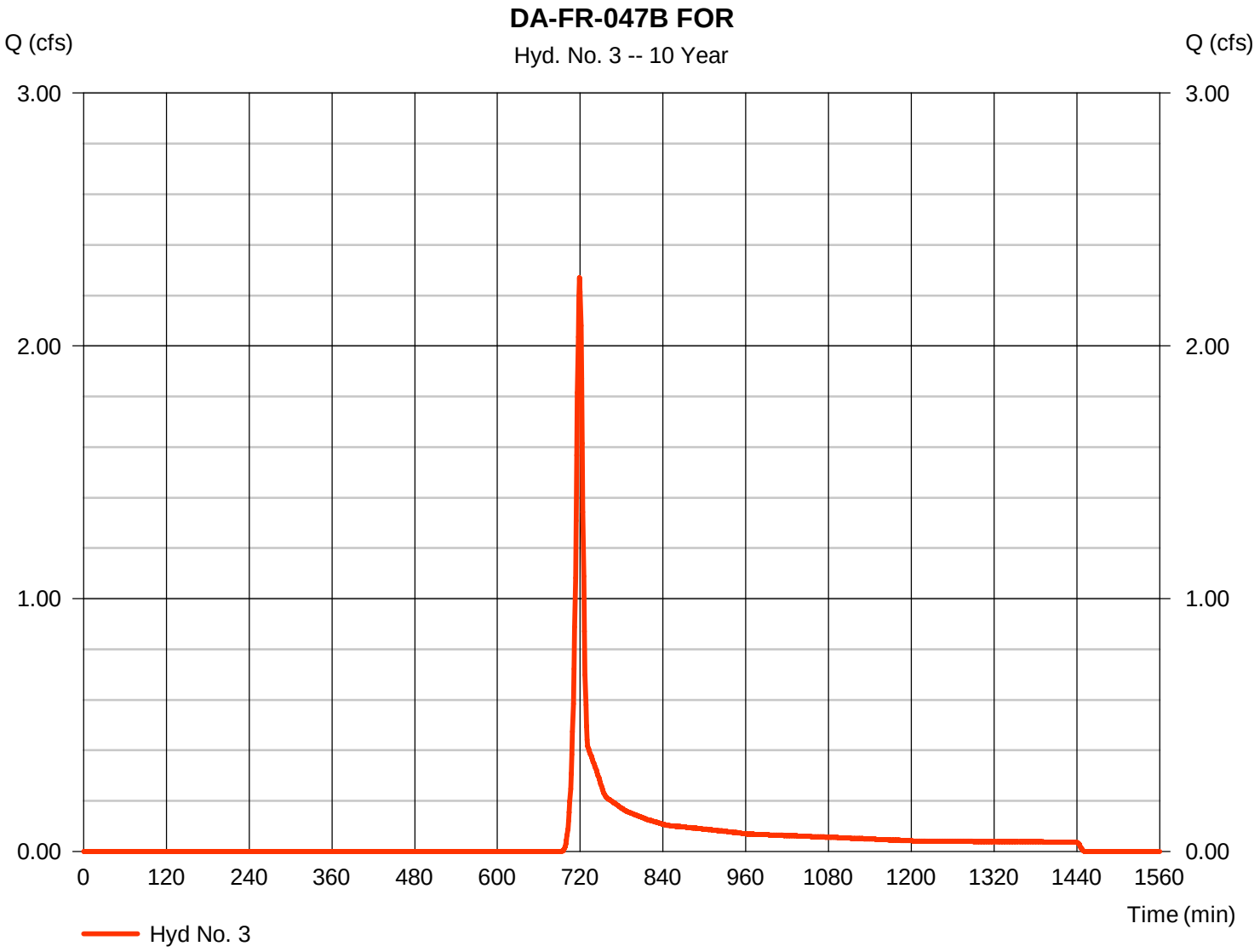


Hydrograph Report

Hyd. No. 3

DA-FR-047B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 2.270 cfs
Storm frequency	= 10 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 5,059 cuft
Drainage area	= 1.060 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.50 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-047C

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.811	2768
Developed Condition	0.480	2018
Pre-Developed (Forest) Condition	0.223	1377

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.480 ≤ 0.890

OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.480 ≤ 0.811

OK

Check #3: $Q_{developed}$ *shall not* be required to be $\leq (Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.480 *shall not* be required to be ≤ 0.152

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.480 ≤ 0.890

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.480 ≤ 0.811

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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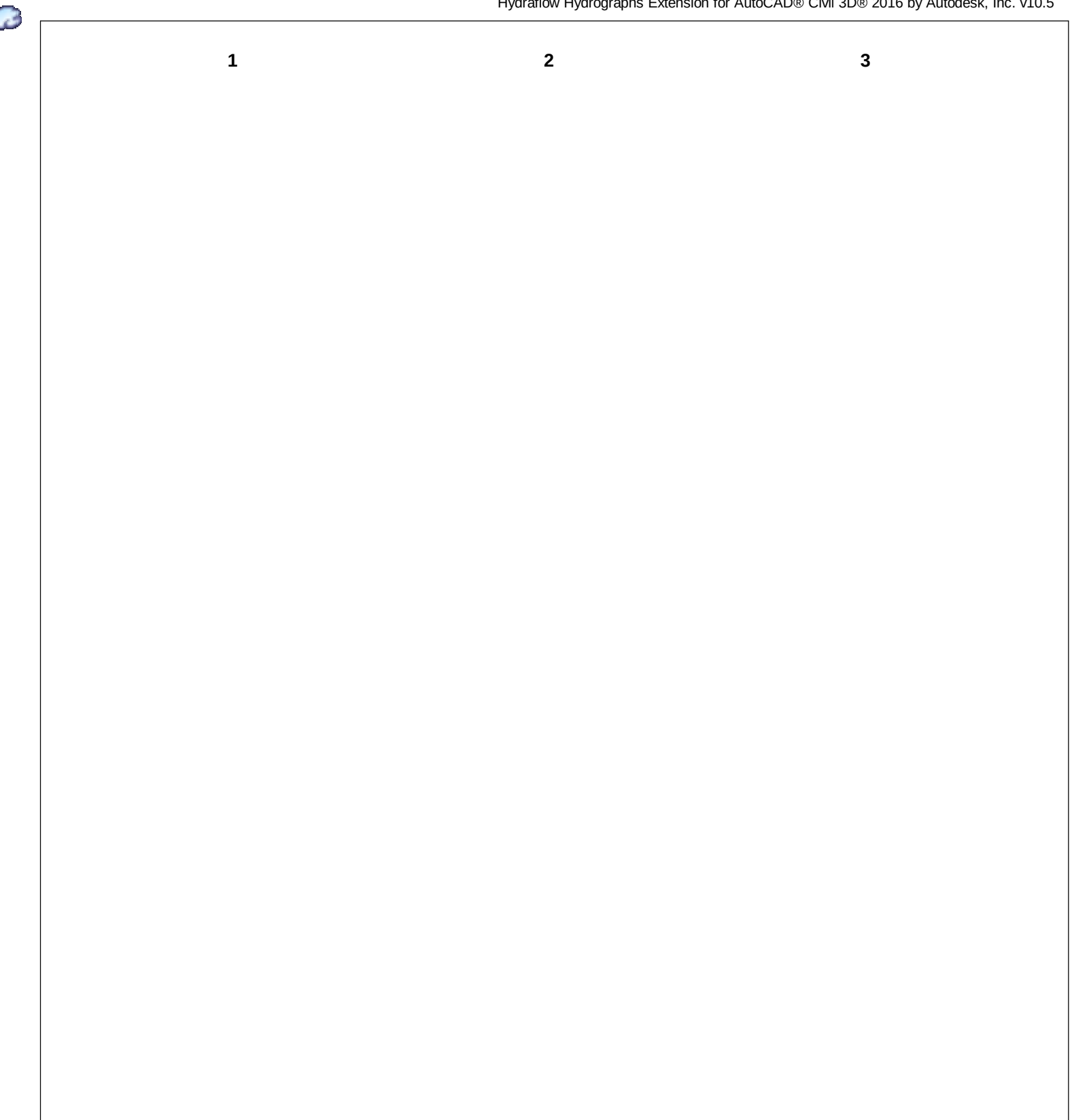
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-047C PRE
2	SCS Runoff	DA-FR-047C DEV
3	SCS Runoff	DA-FR-047C FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.811	1.184	-------	-------	3.492	-------	-------	-------	DA-FR-047C PRE
2	SCS Runoff	------	0.480	0.784	-------	-------	2.845	-------	-------	-------	DA-FR-047C DEV
3	SCS Runoff	------	0.223	0.443	-------	-------	2.211	-------	-------	-------	DA-FR-047C FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.811	1	724	2,768	------	------	------	DA-FR-047C PRE
2	SCS Runoff	0.480	1	725	2,018	------	------	------	DA-FR-047C DEV
3	SCS Runoff	0.223	1	726	1,377	------	------	------	DA-FR-047C FOR

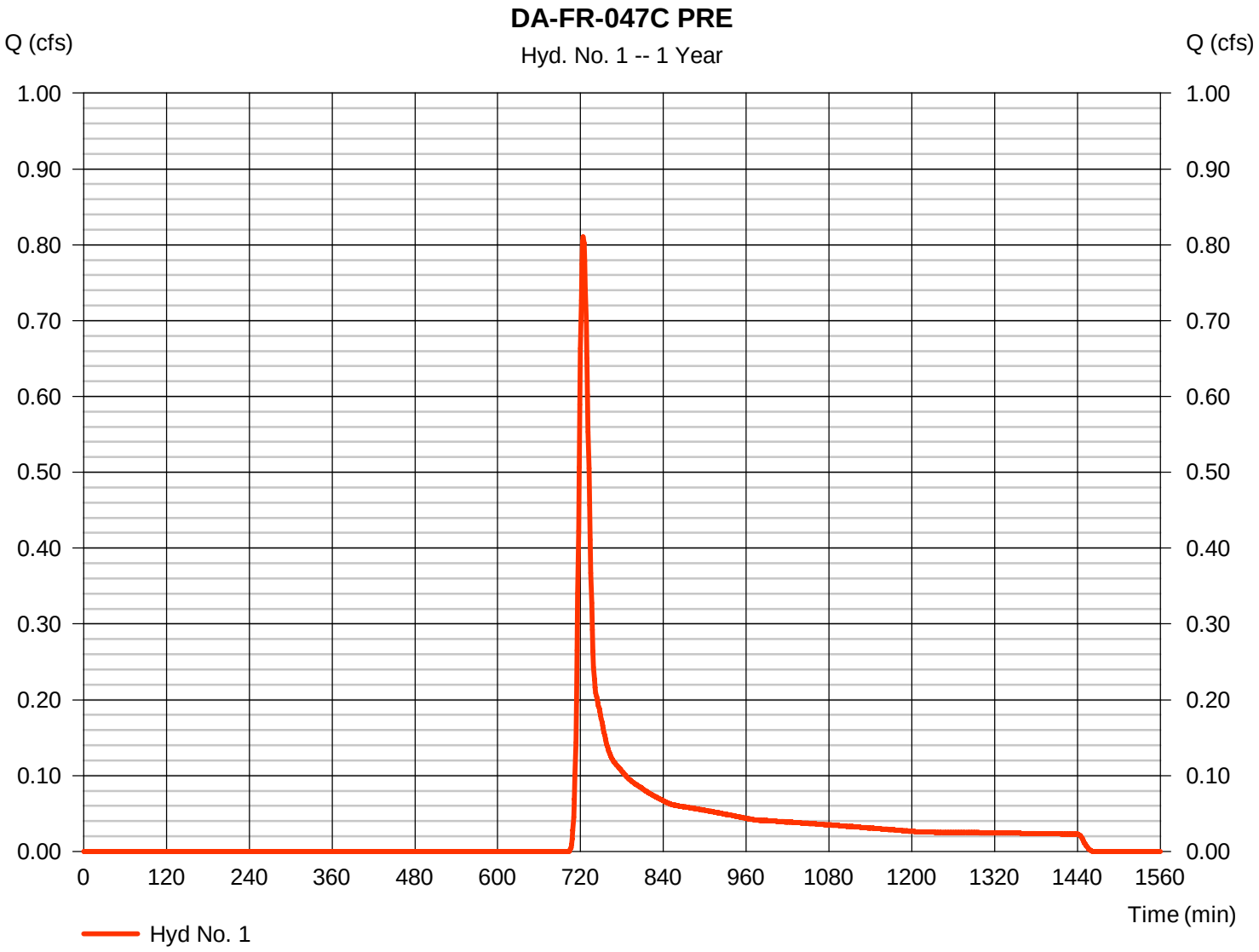
Hydrograph Report

Hyd. No. 1

DA-FR-047C PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.811 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 2,768 cuft
Drainage area	= 1.350 ac	Curve number	= 63*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.668 x 55) + (0.680 x 70)] / 1.350



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-047C PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.01		0.00		0.00		
Travel Time (min)	**= 13.83**	**+**	**0.00**	**+**	**0.00**	**=**	**13.83**
Shallow Concentrated Flow							
Flow length (ft)	= 349.23		0.00		0.00		
Watercourse slope (%)	= 9.64		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.01		0.00		0.00		
Travel Time (min)	**= 1.16**	**+**	**0.00**	**+**	**0.00**	**=**	**1.16**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.00 min

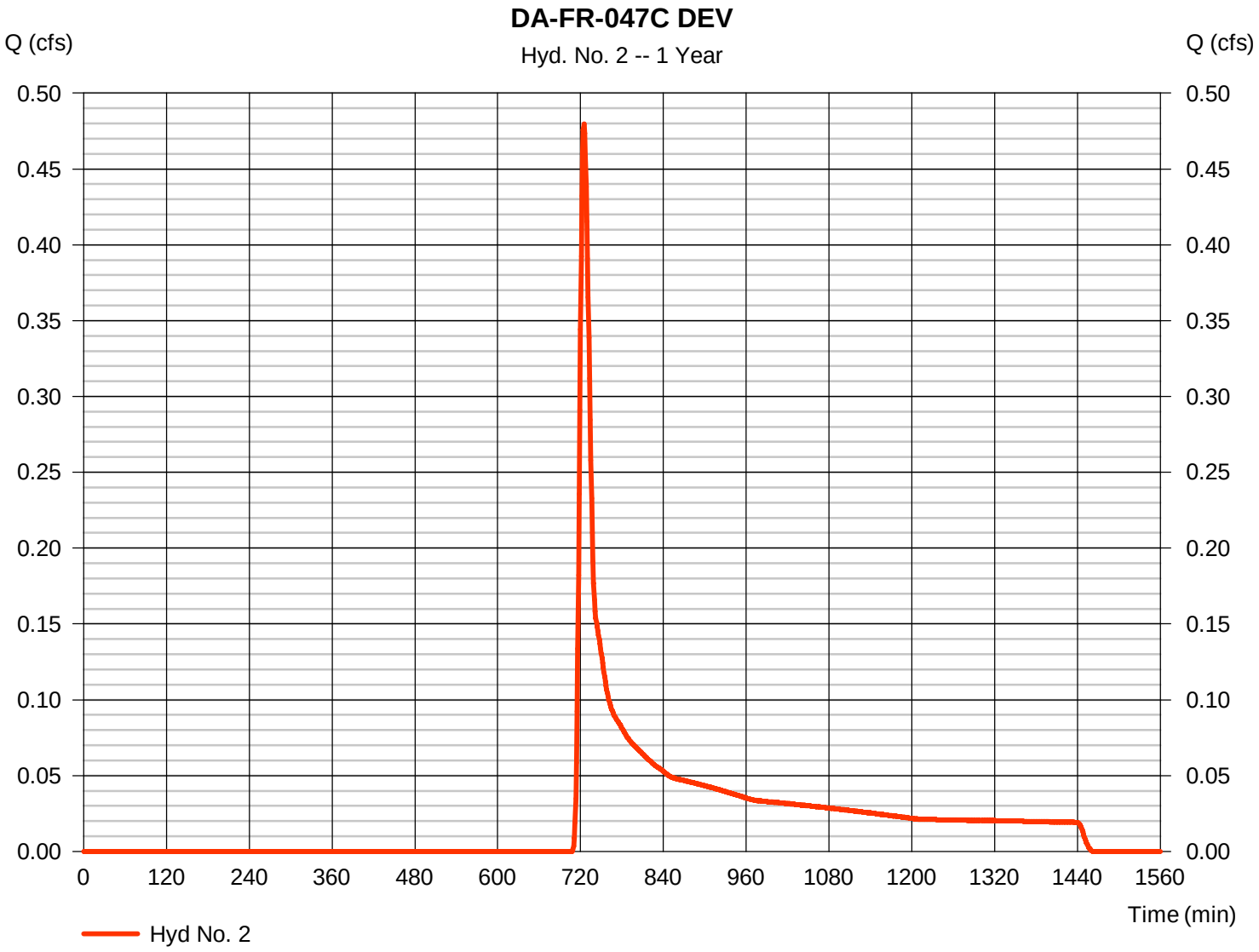
Hydrograph Report

Hyd. No. 2

DA-FR-047C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.480 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 2,018 cuft
Drainage area	= 1.350 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.574 x 48) + (0.354 x 65) + (0.094 x 58) + (0.326 x 71)] / 1.350



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-047C DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.01		0.00		0.00		
Travel Time (min)	**= 13.83**	**+**	**0.00**	**+**	**0.00**	**=**	**13.83**
Shallow Concentrated Flow							
Flow length (ft)	= 349.23		0.00		0.00		
Watercourse slope (%)	= 9.64		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.01		0.00		0.00		
Travel Time (min)	**= 1.16**	**+**	**0.00**	**+**	**0.00**	**=**	**1.16**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

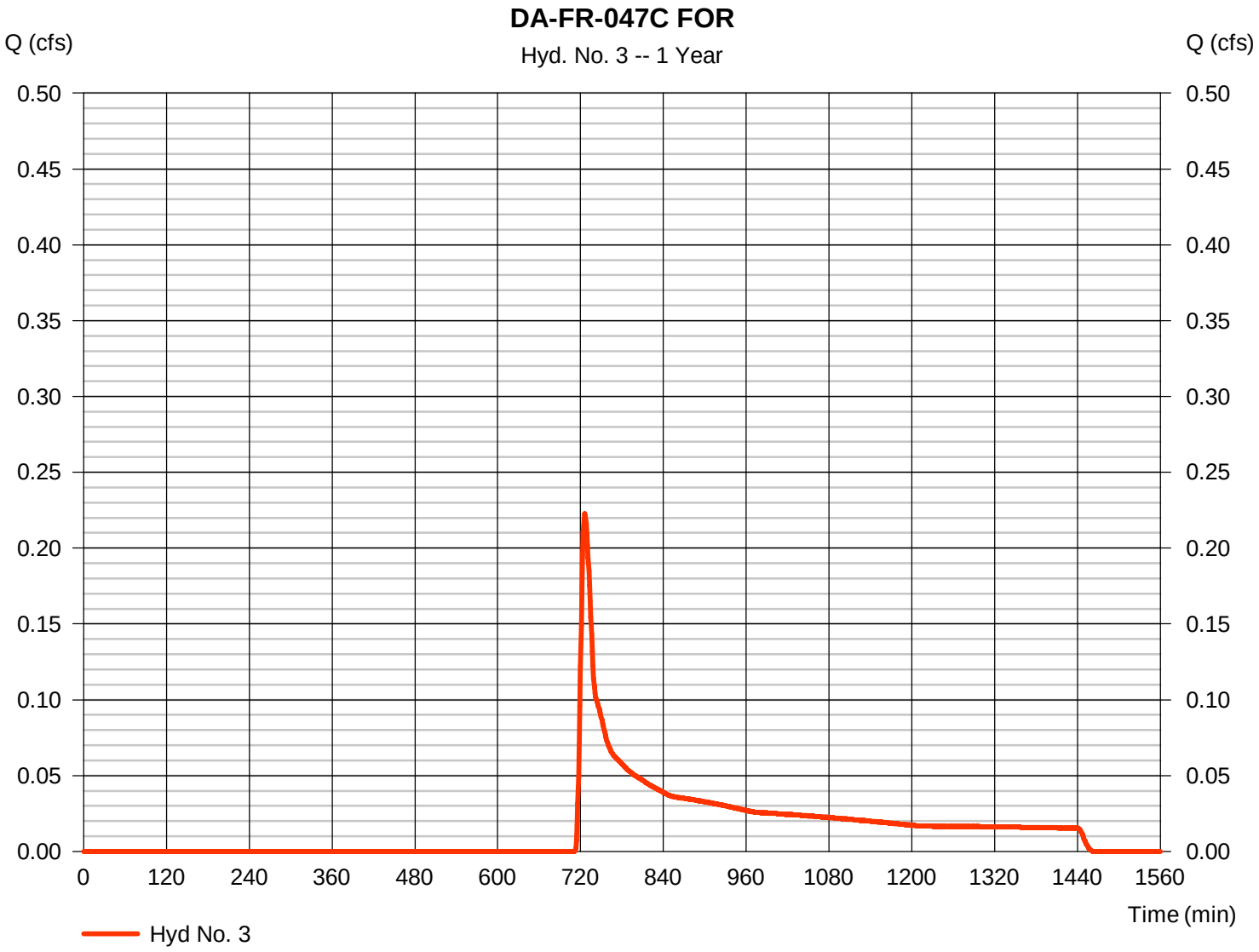
Total Travel Time, Tc ..... 15.00 min

Hydrograph Report

Hyd. No. 3

DA-FR-047C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.223 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 1,377 cuft
Drainage area	= 1.350 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-047C FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.01		0.00		0.00		
Travel Time (min)	**= 13.83**	**+**	**0.00**	**+**	**0.00**	**=**	**13.83**
Shallow Concentrated Flow							
Flow length (ft)	= 349.23		0.00		0.00		
Watercourse slope (%)	= 9.64		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.01		0.00		0.00		
Travel Time (min)	**= 1.16**	**+**	**0.00**	**+**	**0.00**	**=**	**1.16**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.00 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.184	1	723	3,721	------	------	------	DA-FR-047C PRE
2	SCS Runoff	0.784	1	724	2,825	------	------	------	DA-FR-047C DEV
3	SCS Runoff	0.443	1	725	2,037	------	------	------	DA-FR-047C FOR

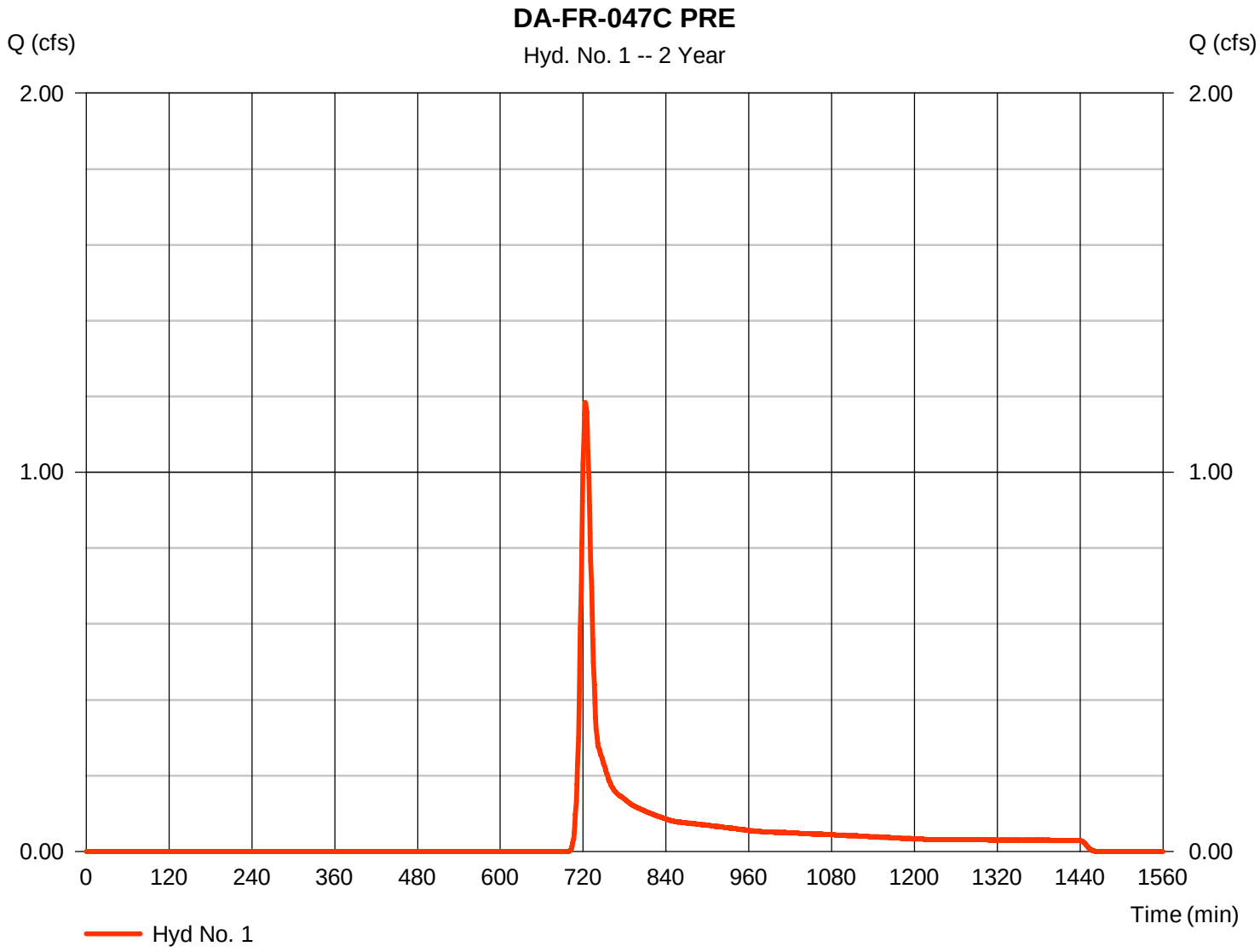
Hydrograph Report

Hyd. No. 1

DA-FR-047C PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.184 cfs
Storm frequency	=	2 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	3,721 cuft
Drainage area	=	1.350 ac	Curve number	=	63*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.00 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.668 x 55) + (0.680 x 70)] / 1.350



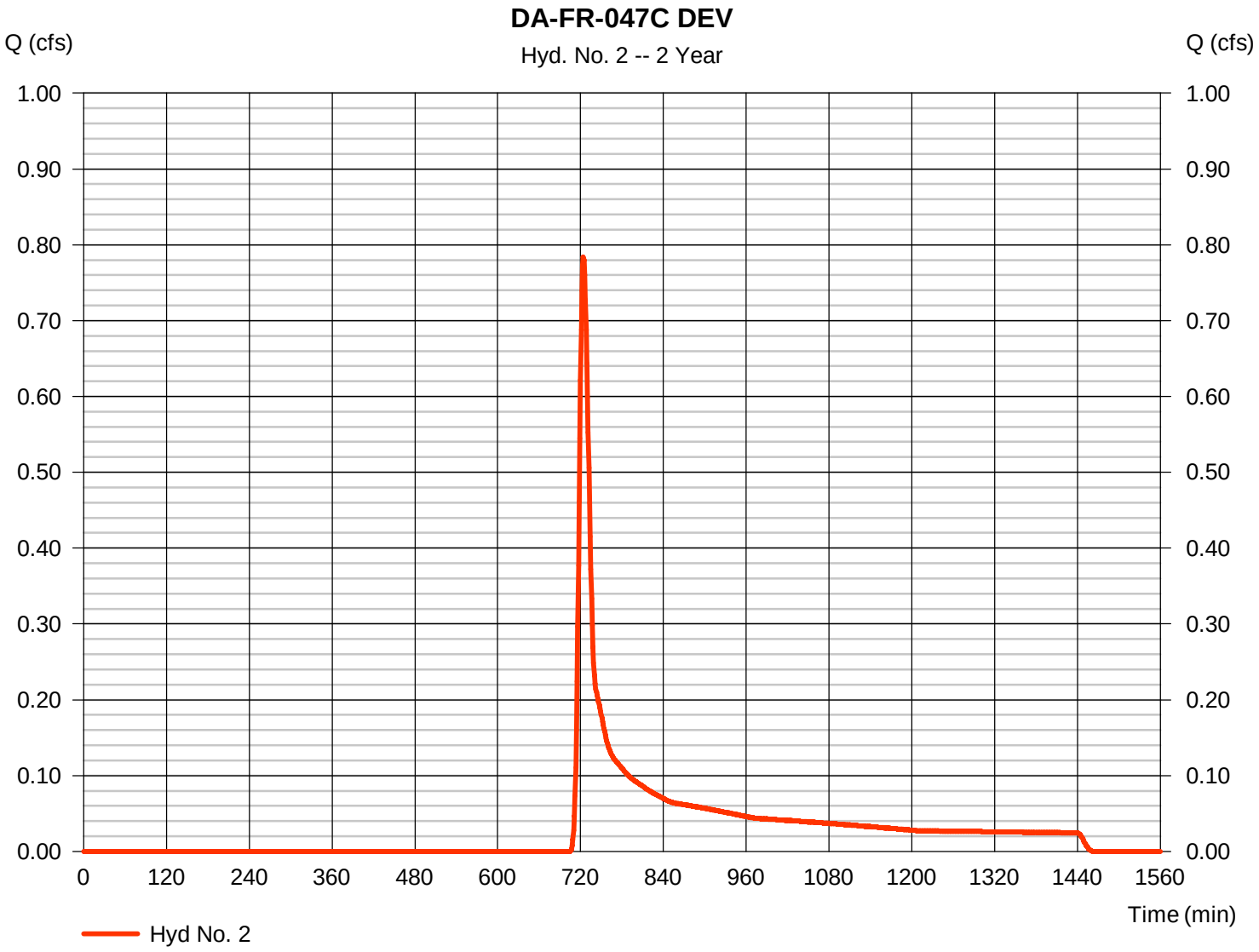
Hydrograph Report

Hyd. No. 2

DA-FR-047C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.784 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 2,825 cuft
Drainage area	= 1.350 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.574 x 48) + (0.354 x 65) + (0.094 x 58) + (0.326 x 71)] / 1.350

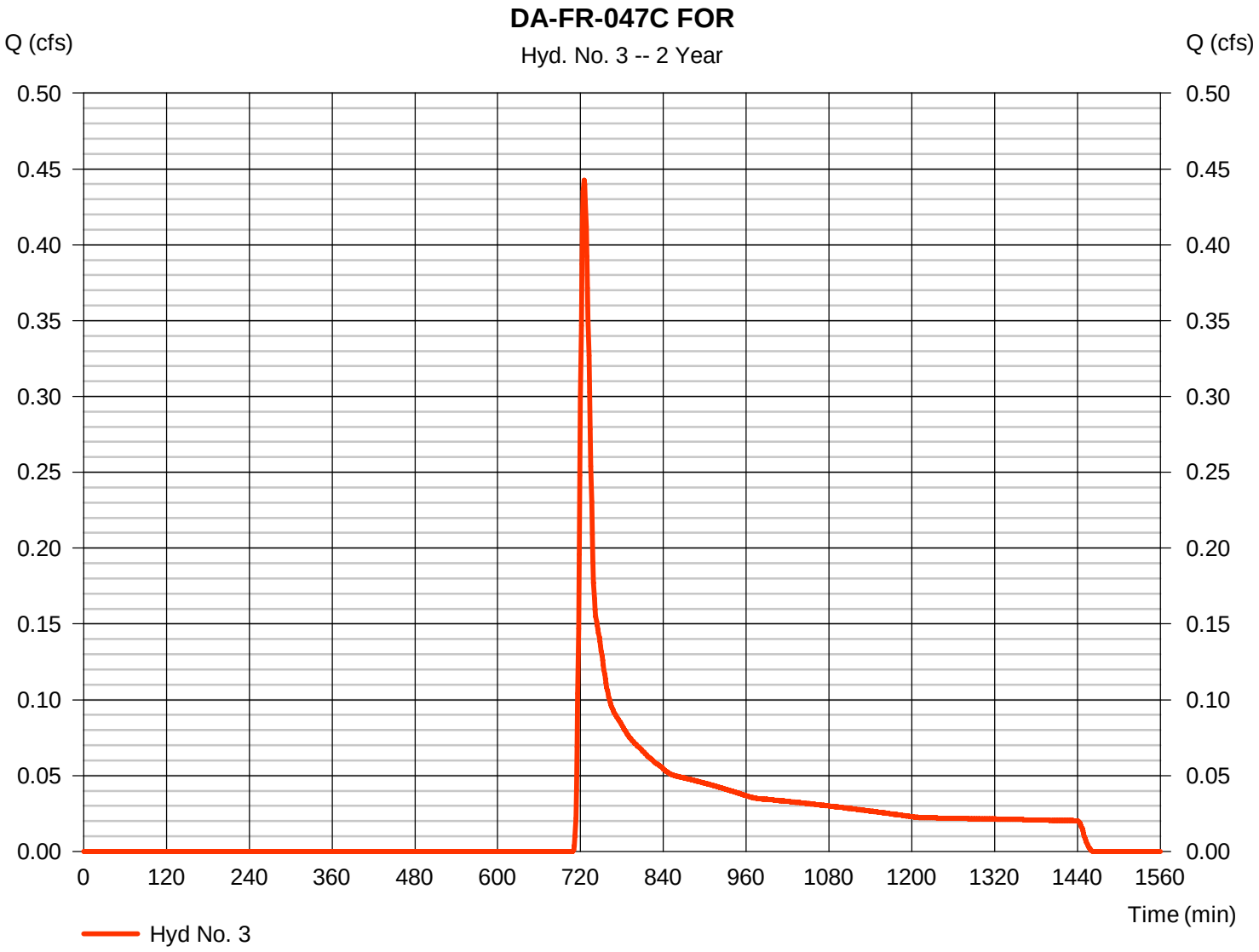


Hydrograph Report

Hyd. No. 3

DA-FR-047C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.443 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 2,037 cuft
Drainage area	= 1.350 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	3.492	1	723	9,651	------	------	------	DA-FR-047C PRE
2	SCS Runoff	2.845	1	723	8,086	------	------	------	DA-FR-047C DEV
3	SCS Runoff	2.211	1	723	6,608	------	------	------	DA-FR-047C FOR

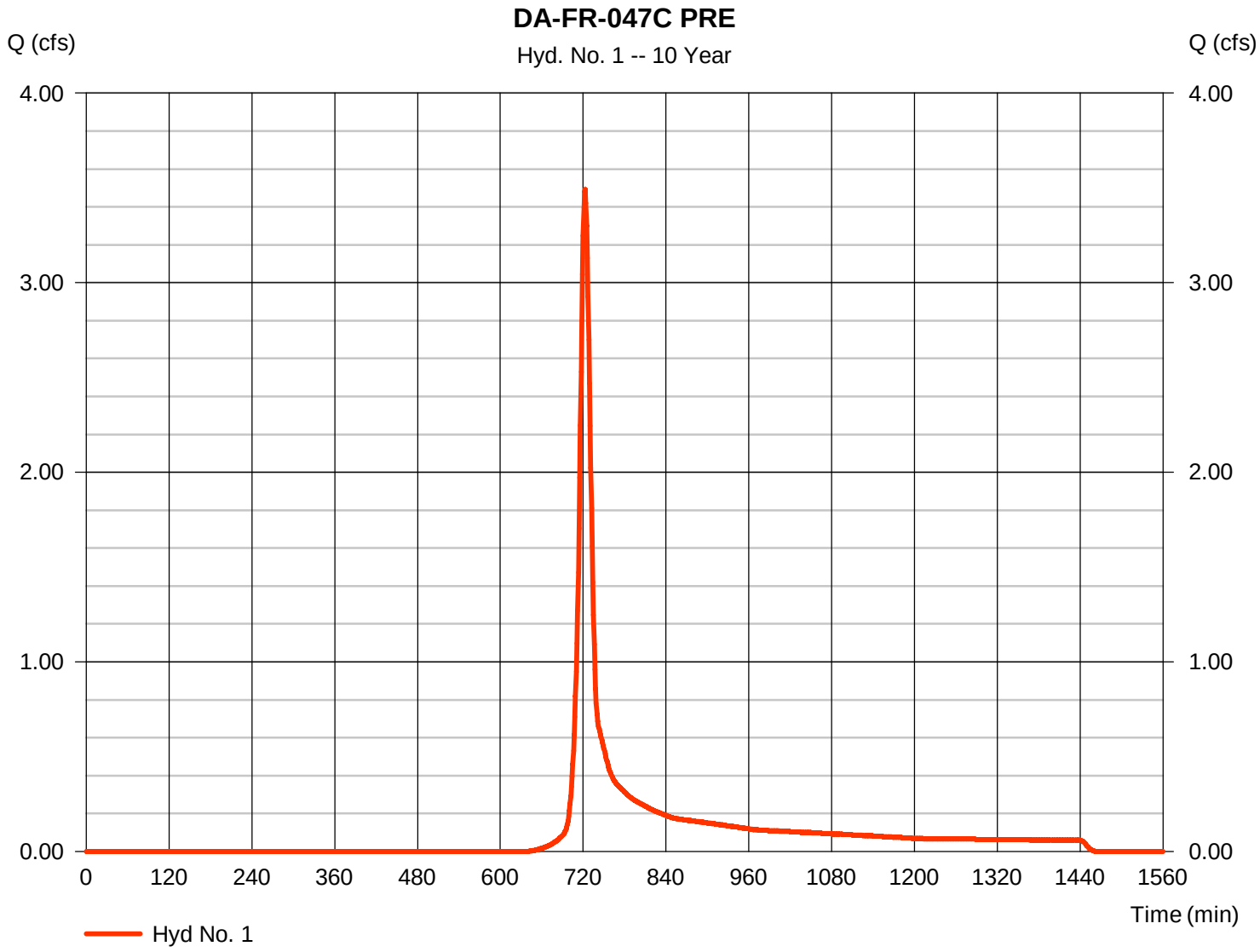
Hydrograph Report

Hyd. No. 1

DA-FR-047C PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	3.492 cfs
Storm frequency	=	10 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	9,651 cuft
Drainage area	=	1.350 ac	Curve number	=	63*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.00 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.668 x 55) + (0.680 x 70)] / 1.350



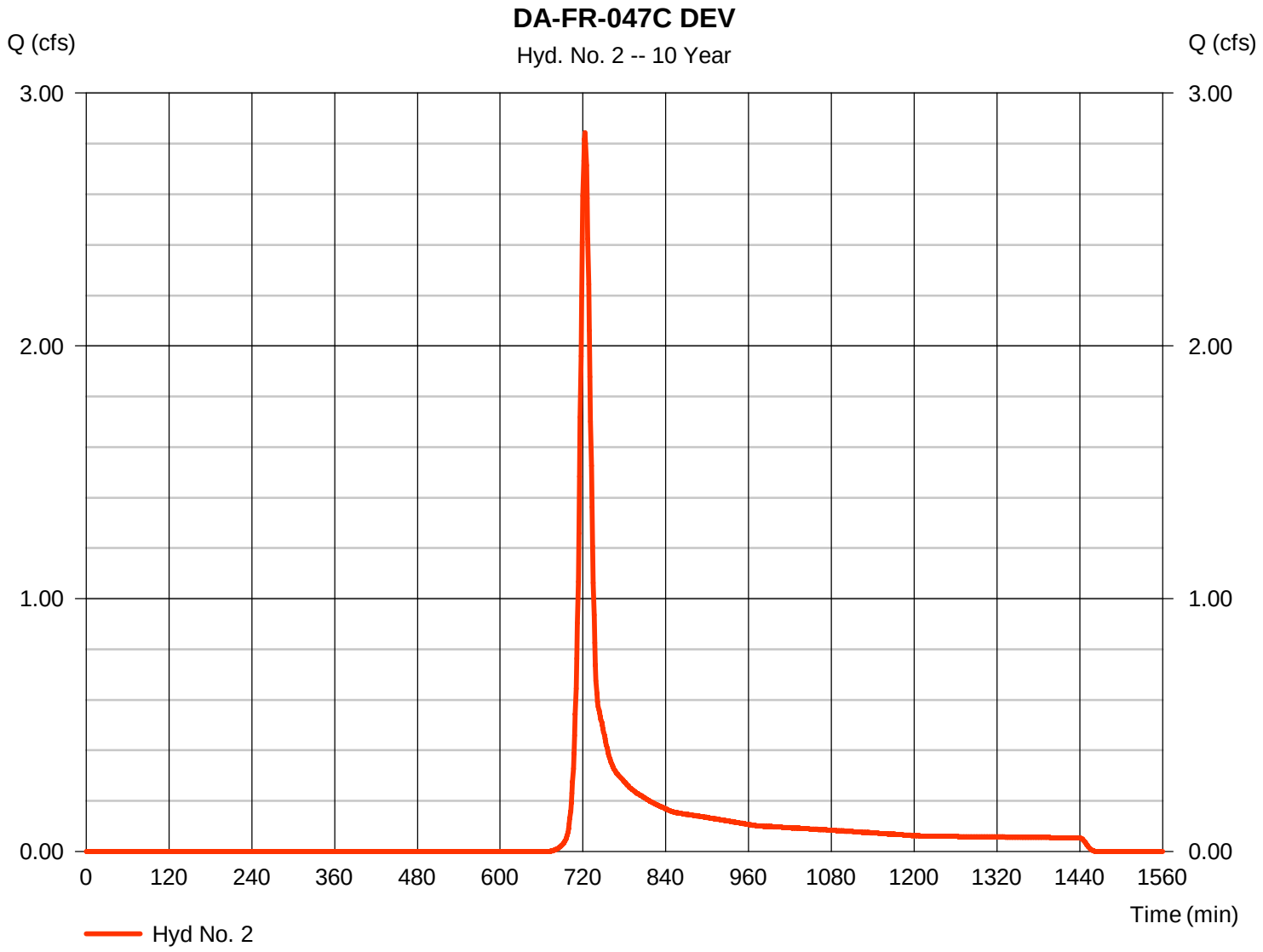
Hydrograph Report

Hyd. No. 2

DA-FR-047C DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.845 cfs
Storm frequency	=	10 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	8,086 cuft
Drainage area	=	1.350 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.00 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.574 x 48) + (0.354 x 65) + (0.094 x 58) + (0.326 x 71)] / 1.350

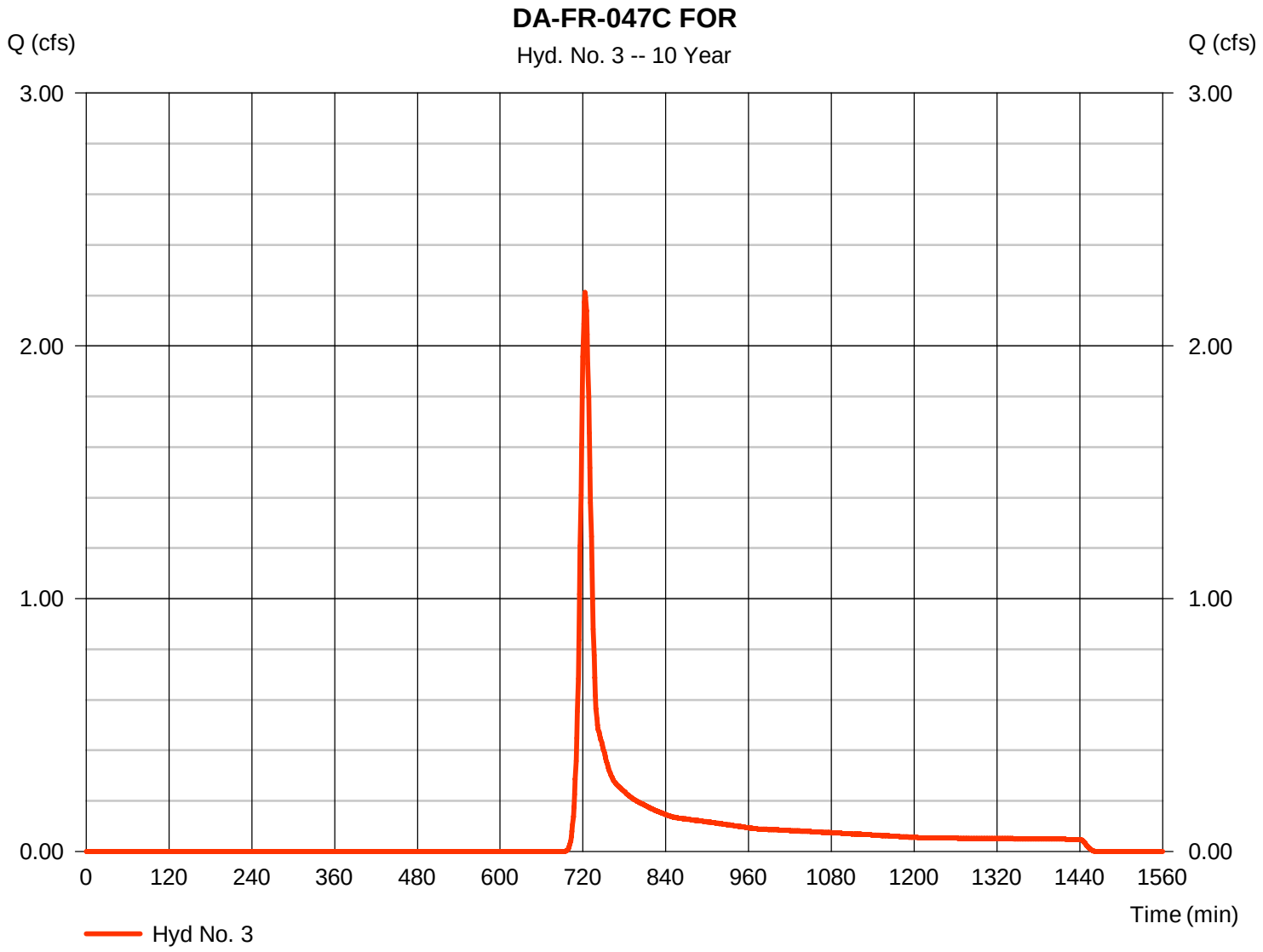


Hydrograph Report

Hyd. No. 3

DA-FR-047C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 2.211 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 6,608 cuft
Drainage area	= 1.350 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-049

DA-FR-049 is located in a brush, meadow and forested areas with rolling slopes. A stream crosses the drainage area. No new impervious area is proposed within DA-FR-049. The total phosphorus load reduction required for DA-FR-049 is –0.20 lb/yr. Multiple points of analysis were evaluated within DA-FR-049 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-049 was sub-divided into two sub-drainage areas (sub-areas A and B).

Sub-area 049A contains both agricultural and non-agricultural areas within the limits of disturbance (LOD). Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction. In non-agricultural areas, land use will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. For SWM quality, agricultural areas within the LOD are considered/included and the total permanent ROW is analyzed via VRRM; agricultural areas are considered “Forest/Open Space” in these calculations.

Stormwater quantity is met via the energy balance method for each of the two sub-areas DA-FR-049A and DA-FR-049B. Agricultural areas within the study area are included in the SWM analysis, but an Improvement Factor (IF) of 1.0 is used when applying the Energy Balance Method. This improvement factor is used to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate no reduction in flows for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-049A	1.65	1.65	0.00
DA-FR-049B	1.70	1.70	0.00

Figures and calculations for each of the sub-areas for DA-FR-049 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-049A
0.68 acres
Weighted CN =

DA-FR-049B
0.79 acres
Weighted CN =

S-D21

S-D22

261.1

261.2

1100

B

Legend

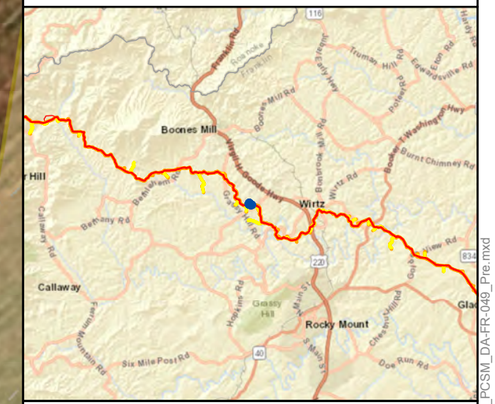
- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Meadow
- Waterbody
- Woods
- Drainage Area
- Hydrologic Soil Groups
- Agricultural Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:720

60 30 0 60 Feet



Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-049
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-049_Pre.mxd

DA-FR-049A
0.68 acres
Weighted CN =

DA-FR-049B
0.79 acres
Weighted CN =

S-D21

S-D22

1100

261.1

261.2

B

Legend

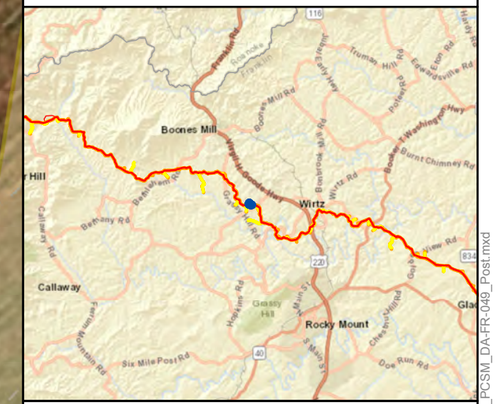
- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Meadow
- Waterbody
- Drainage Area
- Hydrologic Soil Groups
- Agricultural Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:720

60 30 0 60 Feet



Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-049
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-049_Post.mxd

DA-FR-049A
0.68 acres
Weighted CN =

DA-FR-049B
0.79 acres
Weighted CN =

S-D21

S-D22

261.1

261.2

1100

Legend

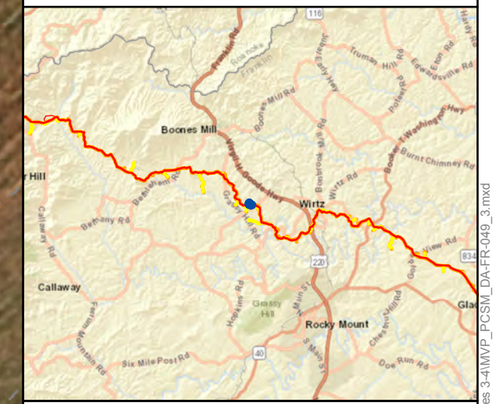
- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:720

N
W E
S

60 30 0 60 Feet



Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration DA-FR-049 Spread 10

Figure 3
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-049_3.mxd

DA-FR-049A
0.68 acres
Weighted CN =

DA-FR-049B
0.79 acres
Weighted CN =

S-D21

S-D22

261.1

261.2

4100

Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:720

N
W E
S

60 30 0 60 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration DA-FR-049 Spread 10

Figure 4

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-049_4.mxd

Virginia Runoff Reduction Method New Development Worksheet - v2.8 - June 2014

Site Data Summary

Total Rainfall = 46 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.58	0.00	0.00	0.58	*100.00*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
					0.58	*100.00*

Site Rv	0.03
Post Development Treatment Volume (ft3)	63
Post Development TP Load (lb/yr)	0.04
Post Development TN Load (lb/yr)	0.30
Total TP Load Reduction Required (lb/yr)	-0.20

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0
Total TN Load Reduction Achieved (lb/yr)	0.00
Adjusted Post Development TP Load (lb/yr)	0.04
Remaining Phosphorous Load Reduction (Lb/yr) Required	0.00

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest (acres)	0.58	0.00	0.00	0.00	0.00	*0.58*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
						0.58

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*
TN Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*

DA-FR-049A

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.266	931
Developed Condition	0.266	931
Pre-Developed (Forest) Condition	0.146	694

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.266 ≤ 0.266 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.266 ≤ 0.266 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.266 *shall not* be required to be ≤ 0.109

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
5	SCS Runoff	DA-FR-049A PRE
6	SCS Runoff	DA-FR-049A DEV
7	SCS Runoff	DA-FR-049A FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
5	SCS Runoff	------	0.266	0.447	-------	-------	1.653	-------	-------	-------	DA-FR-049A PRE
6	SCS Runoff	------	0.266	0.447	-------	-------	1.653	-------	-------	-------	DA-FR-049A DEV
7	SCS Runoff	------	0.146	0.289	-------	-------	1.374	-------	-------	-------	DA-FR-049A FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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
5	SCS Runoff	0.266	1	722	931	------	------	------	DA-FR-049A PRE
6	SCS Runoff	0.266	1	722	931	------	------	------	DA-FR-049A DEV
7	SCS Runoff	0.146	1	723	694	------	------	------	DA-FR-049A FOR

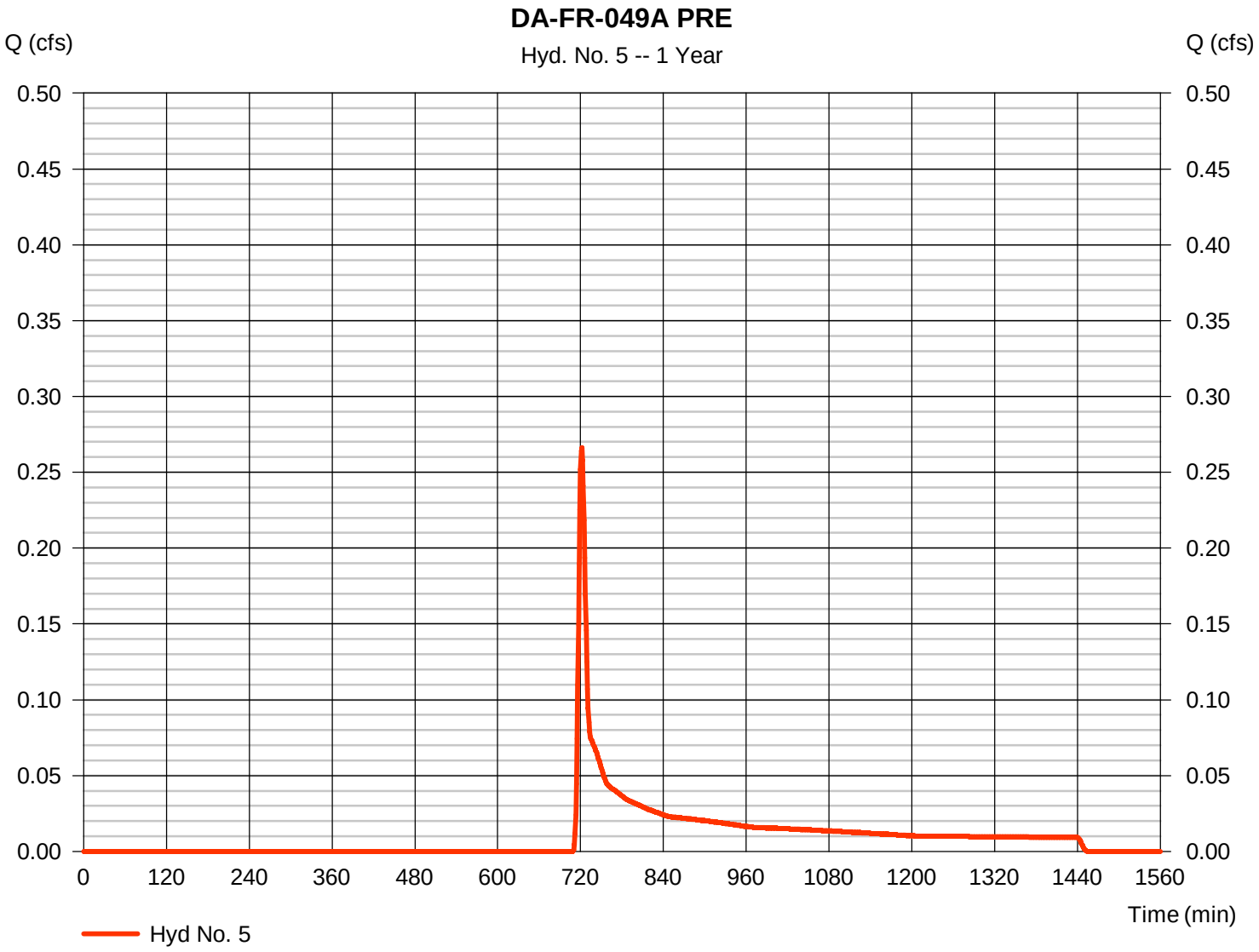
Hydrograph Report

Hyd. No. 5

DA-FR-049A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.266 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 931 cuft
Drainage area	= 0.680 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.680 x 58) + (0.004 x 100)] / 0.680



TR55 Tc Worksheet

Hyd. No. 5

DA-FR-049A PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 14.83		0.00		0.00		
Travel Time (min)	**= 8.96**	**+**	**0.00**	**+**	**0.00**	**=**	**8.96**
Shallow Concentrated Flow							
Flow length (ft)	= 152.90		0.00		0.00		
Watercourse slope (%)	= 19.26		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.08		0.00		0.00		
Travel Time (min)	**= 0.36**	**+**	**0.00**	**+**	**0.00**	**=**	**0.36**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.30 min

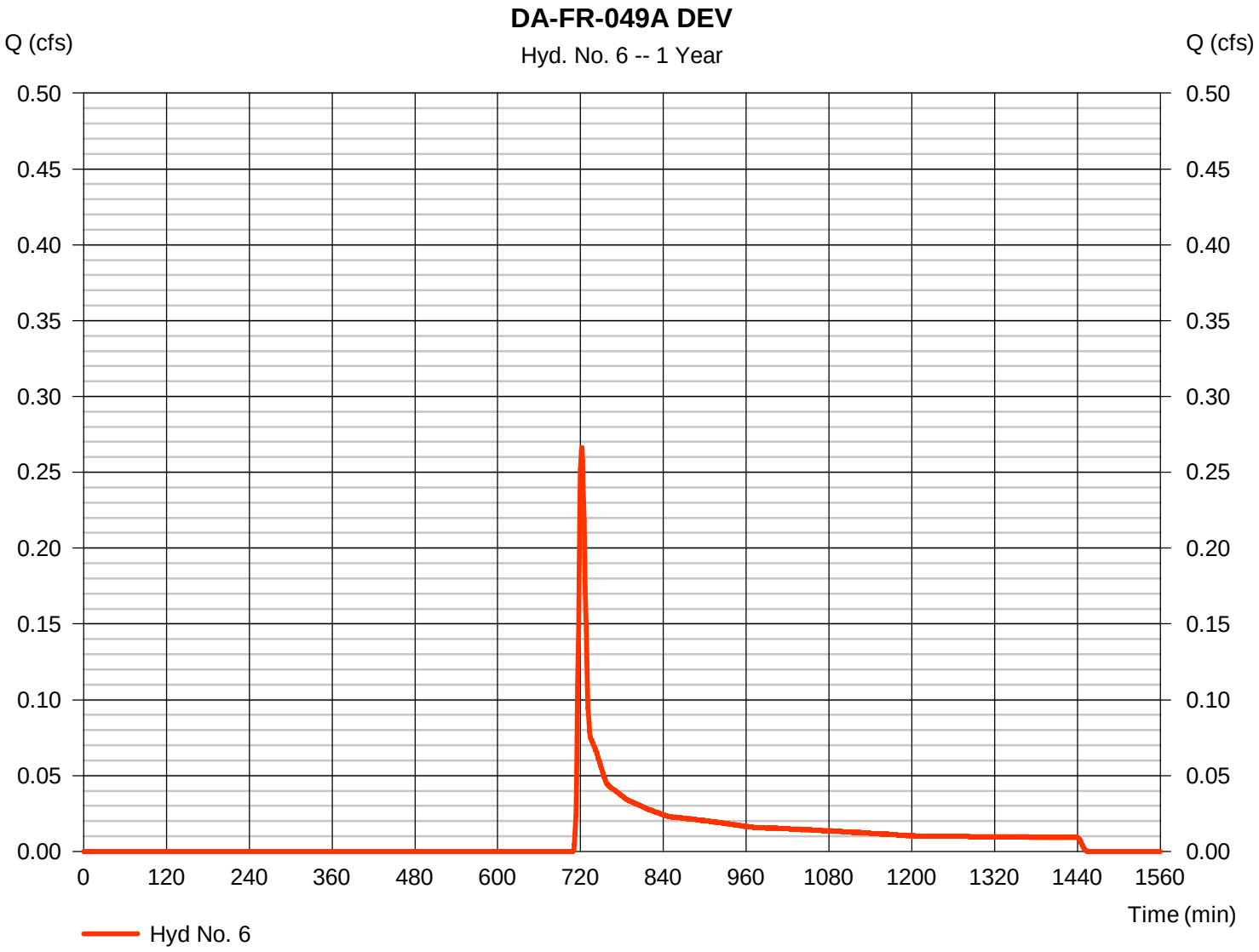
Hydrograph Report

Hyd. No. 6

DA-FR-049A DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.266 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 931 cuft
Drainage area	= 0.680 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.680 x 58) + (0.004 x 100)] / 0.680



TR55 Tc Worksheet

Hyd. No. 6

DA-FR-049A DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 14.83		0.00		0.00		
Travel Time (min)	**= 8.96**	**+**	**0.00**	**+**	**0.00**	**=**	**8.96**
Shallow Concentrated Flow							
Flow length (ft)	= 152.90		0.00		0.00		
Watercourse slope (%)	= 19.26		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.08		0.00		0.00		
Travel Time (min)	**= 0.36**	**+**	**0.00**	**+**	**0.00**	**=**	**0.36**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

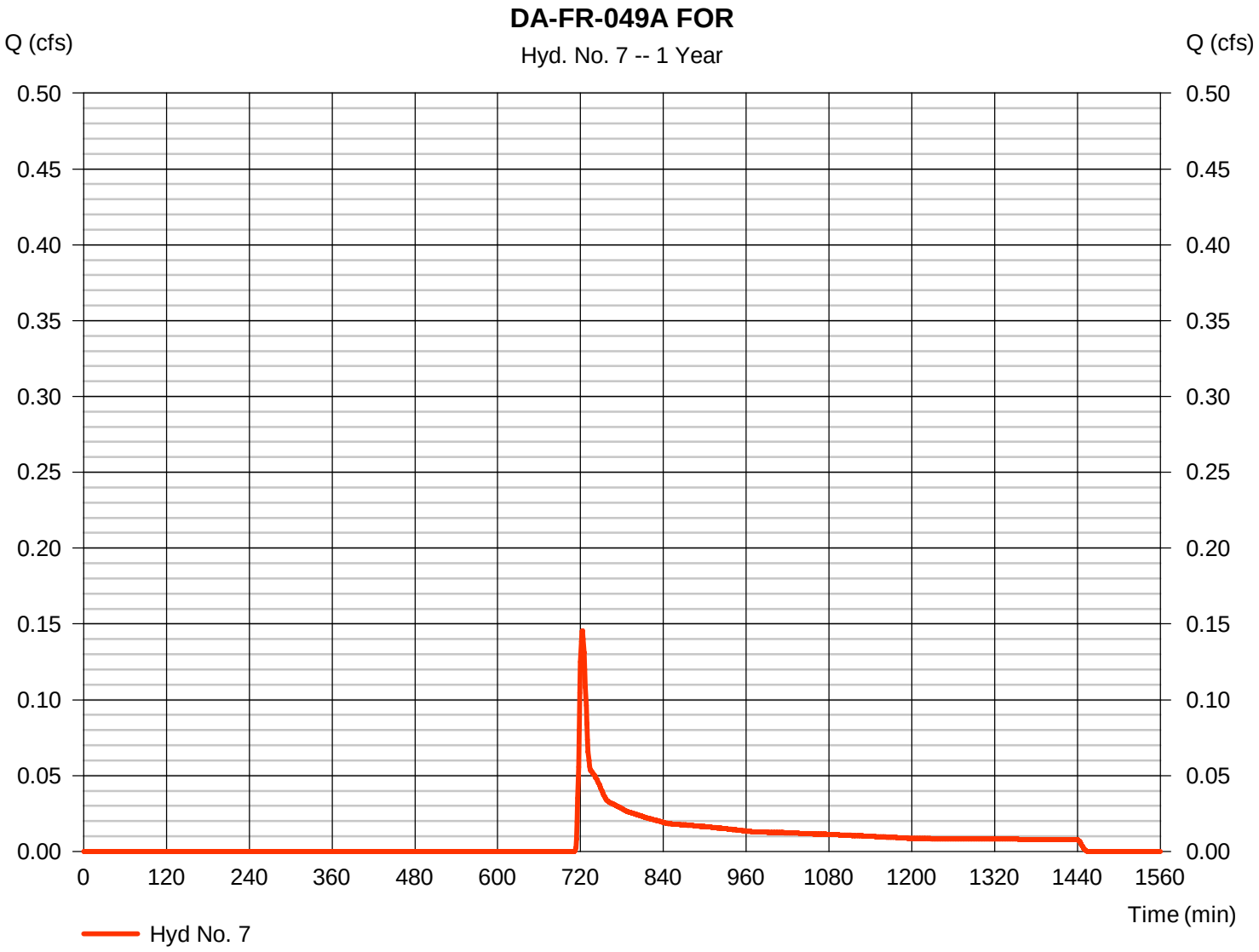
Total Travel Time, Tc ..... 9.30 min

Hydrograph Report

Hyd. No. 7

DA-FR-049A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.146 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 694 cuft
Drainage area	= 0.680 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 7

DA-FR-049A FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 14.83		0.00		0.00		
Travel Time (min)	**= 8.96**	**+**	**0.00**	**+**	**0.00**	**=**	**8.96**
Shallow Concentrated Flow							
Flow length (ft)	= 152.90		0.00		0.00		
Watercourse slope (%)	= 19.26		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.08		0.00		0.00		
Travel Time (min)	**= 0.36**	**+**	**0.00**	**+**	**0.00**	**=**	**0.36**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.30 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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
5	SCS Runoff	0.447	1	721	1,318	------	------	------	DA-FR-049A PRE
6	SCS Runoff	0.447	1	721	1,318	------	------	------	DA-FR-049A DEV
7	SCS Runoff	0.289	1	722	1,026	------	------	------	DA-FR-049A FOR

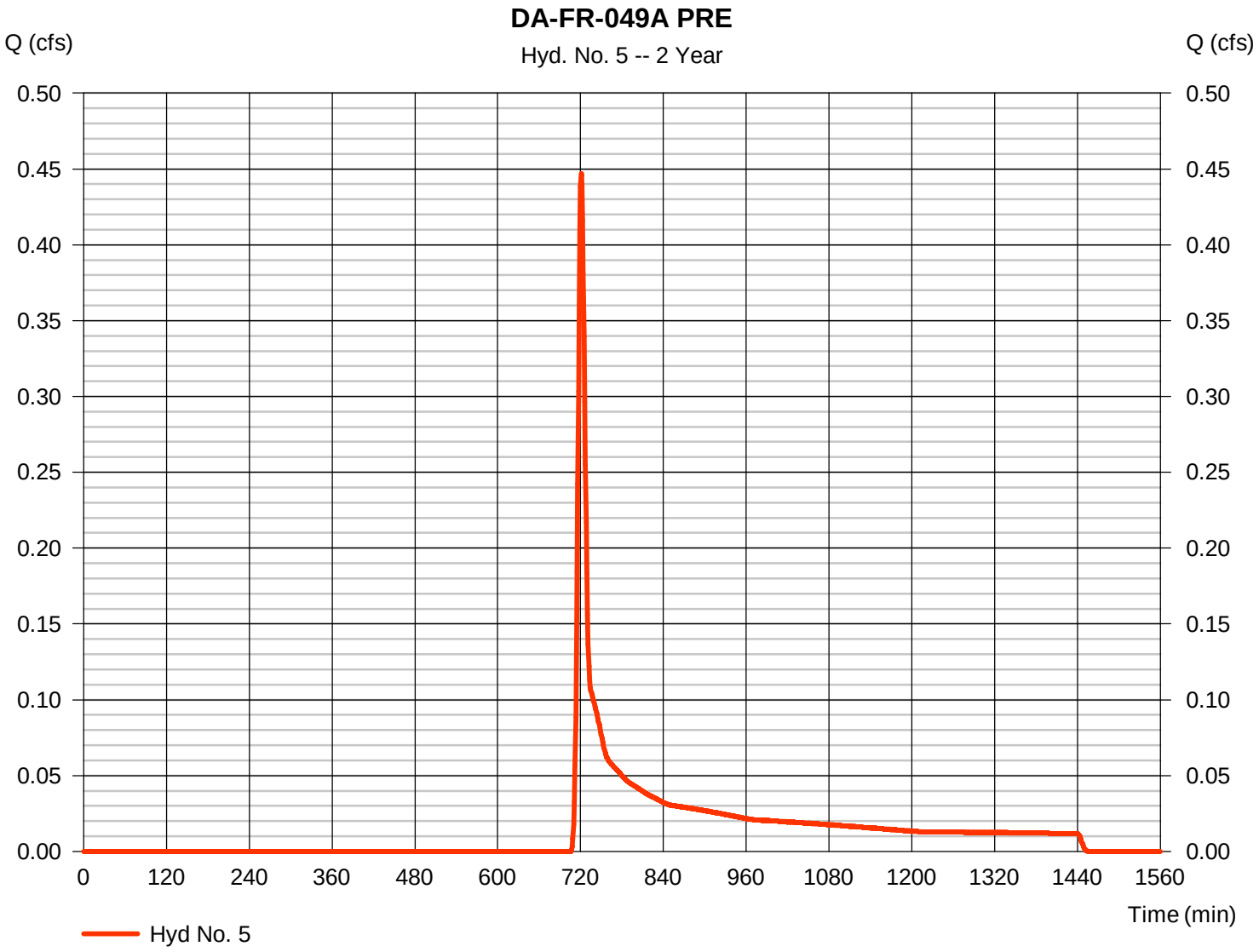
Hydrograph Report

Hyd. No. 5

DA-FR-049A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.447 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,318 cuft
Drainage area	= 0.680 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.680 x 58) + (0.004 x 100)] / 0.680



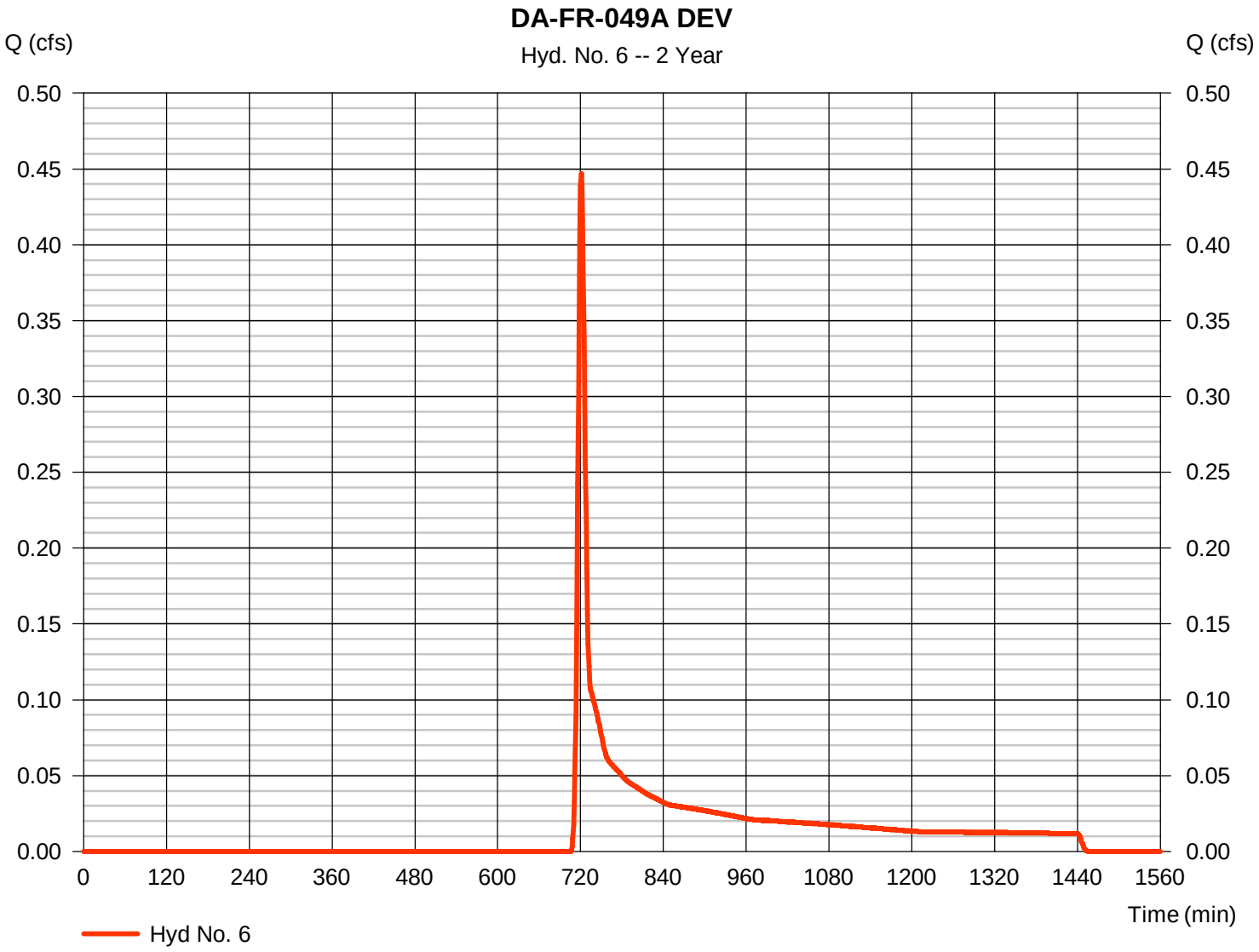
Hydrograph Report

Hyd. No. 6

DA-FR-049A DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	0.447 cfs
Storm frequency	=	2 yrs	Time to peak	=	721 min
Time interval	=	1 min	Hyd. volume	=	1,318 cuft
Drainage area	=	0.680 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	9.30 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.680 x 58) + (0.004 x 100)] / 0.680

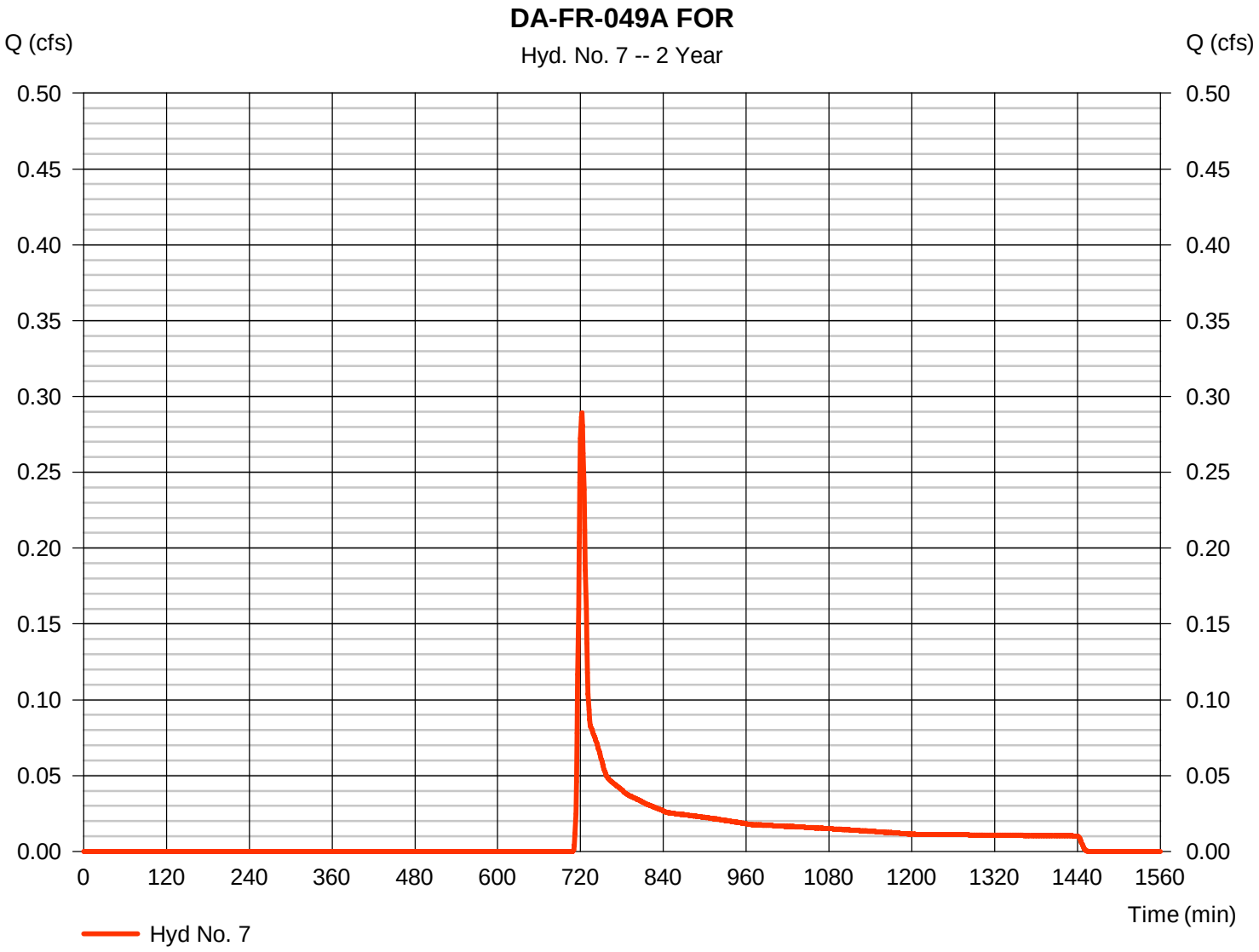


Hydrograph Report

Hyd. No. 7

DA-FR-049A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.289 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 1,026 cuft
Drainage area	= 0.680 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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
5	SCS Runoff	1.653	1	720	3,882	------	------	------	DA-FR-049A PRE
6	SCS Runoff	1.653	1	720	3,882	------	------	------	DA-FR-049A DEV
7	SCS Runoff	1.374	1	720	3,329	------	------	------	DA-FR-049A FOR

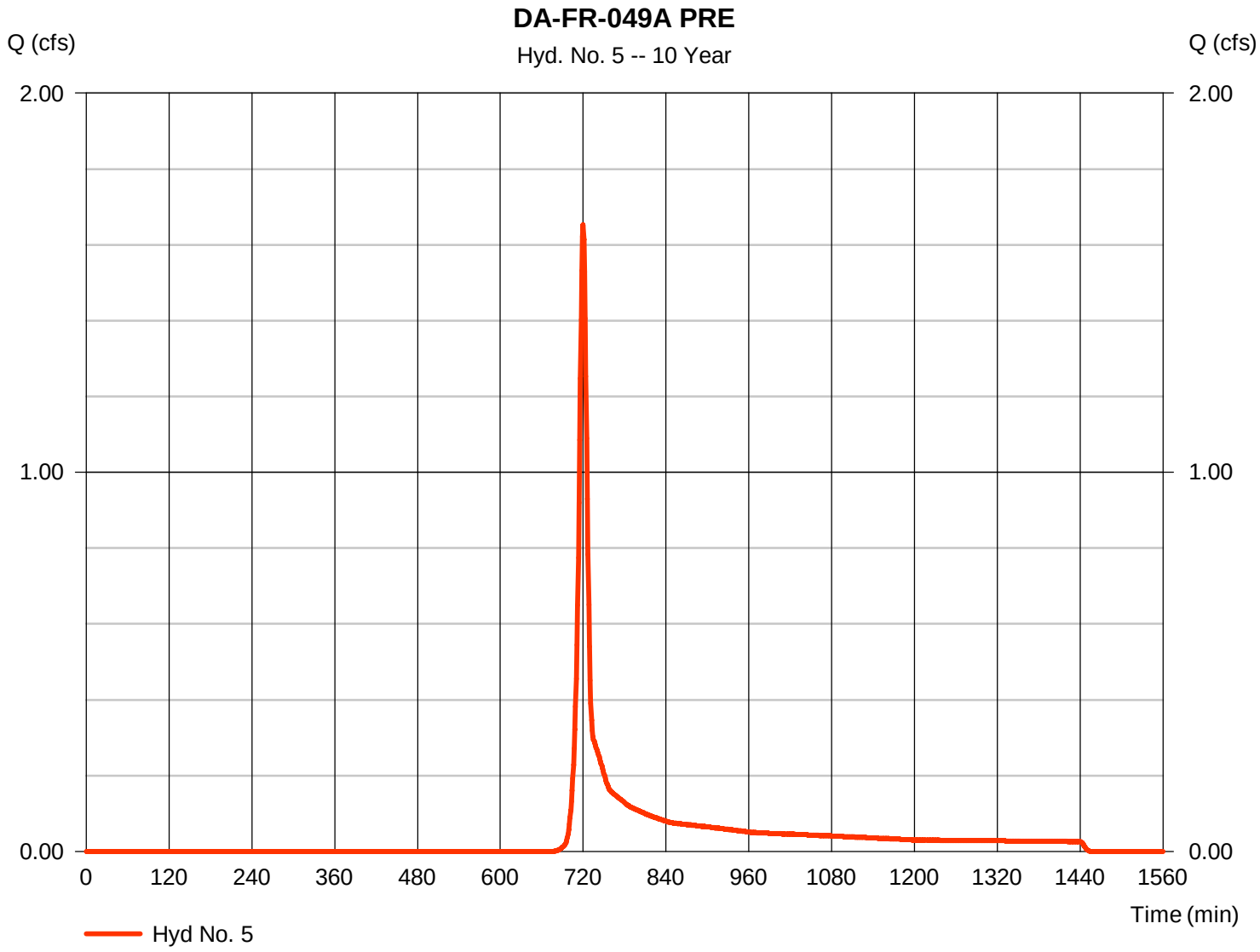
Hydrograph Report

Hyd. No. 5

DA-FR-049A PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.653 cfs
Storm frequency	=	10 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	3,882 cuft
Drainage area	=	0.680 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	9.30 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.680 x 58) + (0.004 x 100)] / 0.680



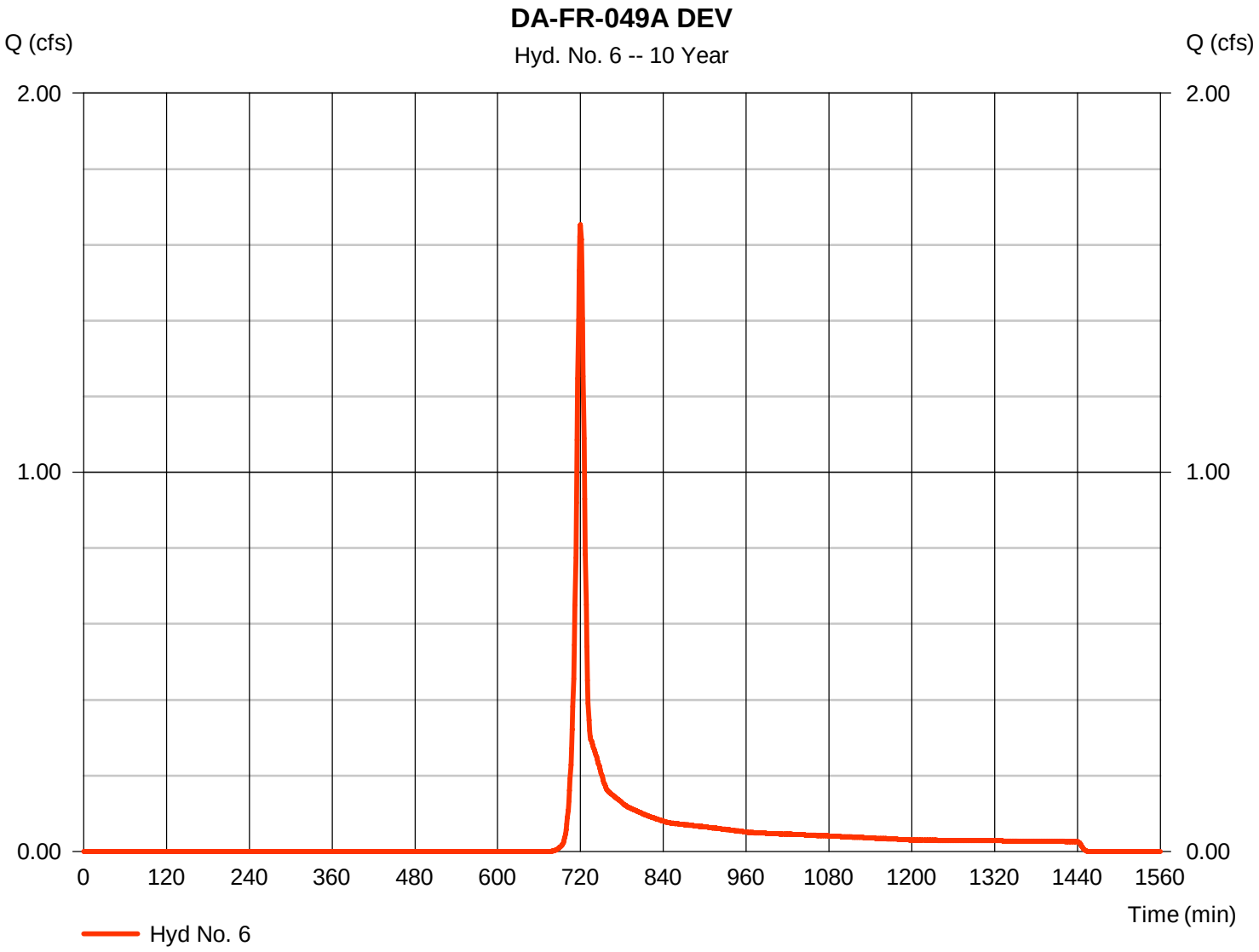
Hydrograph Report

Hyd. No. 6

DA-FR-049A DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.653 cfs
Storm frequency	=	10 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	3,882 cuft
Drainage area	=	0.680 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	9.30 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.680 x 58) + (0.004 x 100)] / 0.680

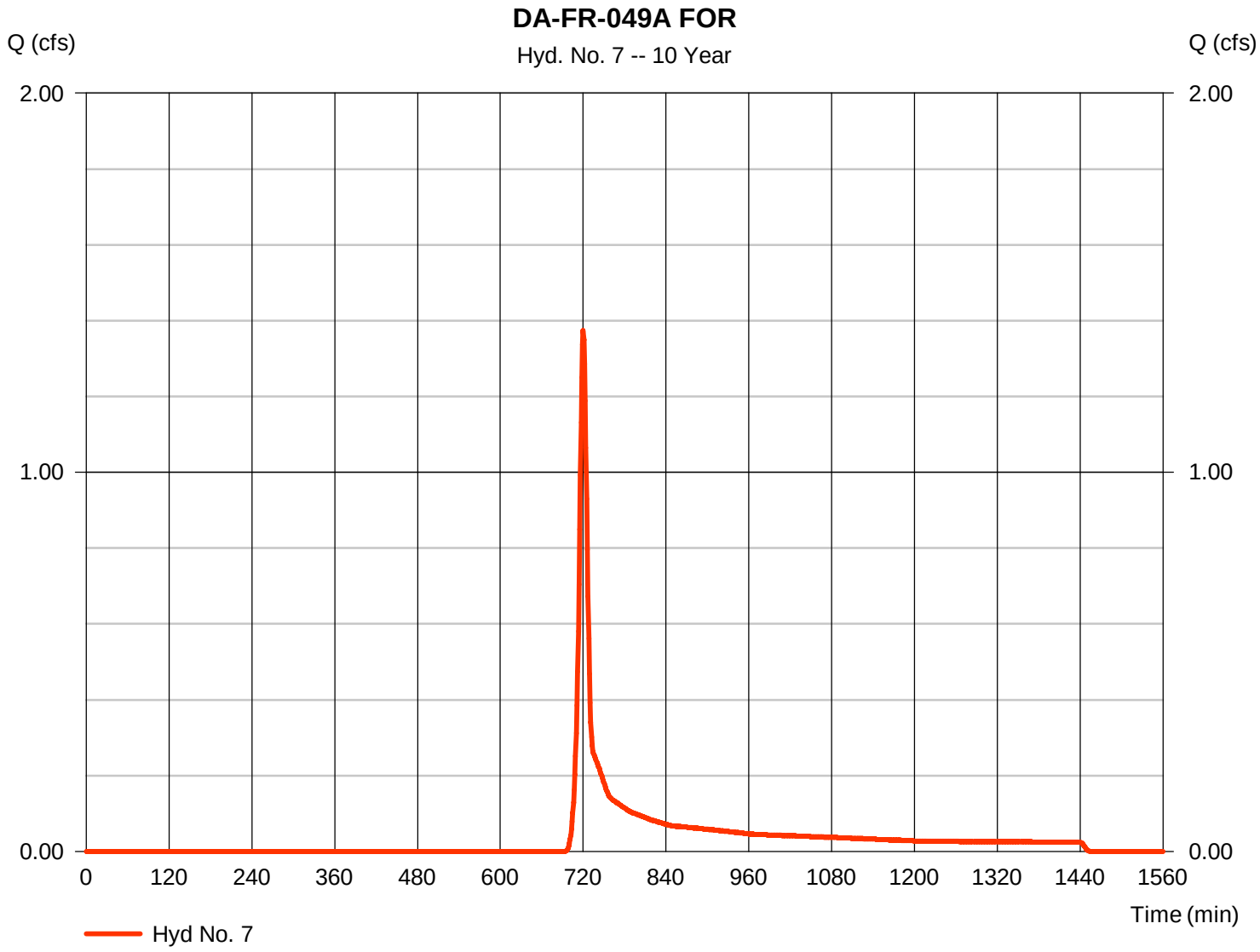


Hydrograph Report

Hyd. No. 7

DA-FR-049A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.374 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 3,329 cuft
Drainage area	= 0.680 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-049B

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.237	1003
Developed Condition	0.213	894
Pre-Developed (Forest) Condition	0.154	820

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = **0.9**

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.213 ≤ 0.239 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.213 ≤ 0.237 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.213 *shall not* be required to be ≤ 0.141

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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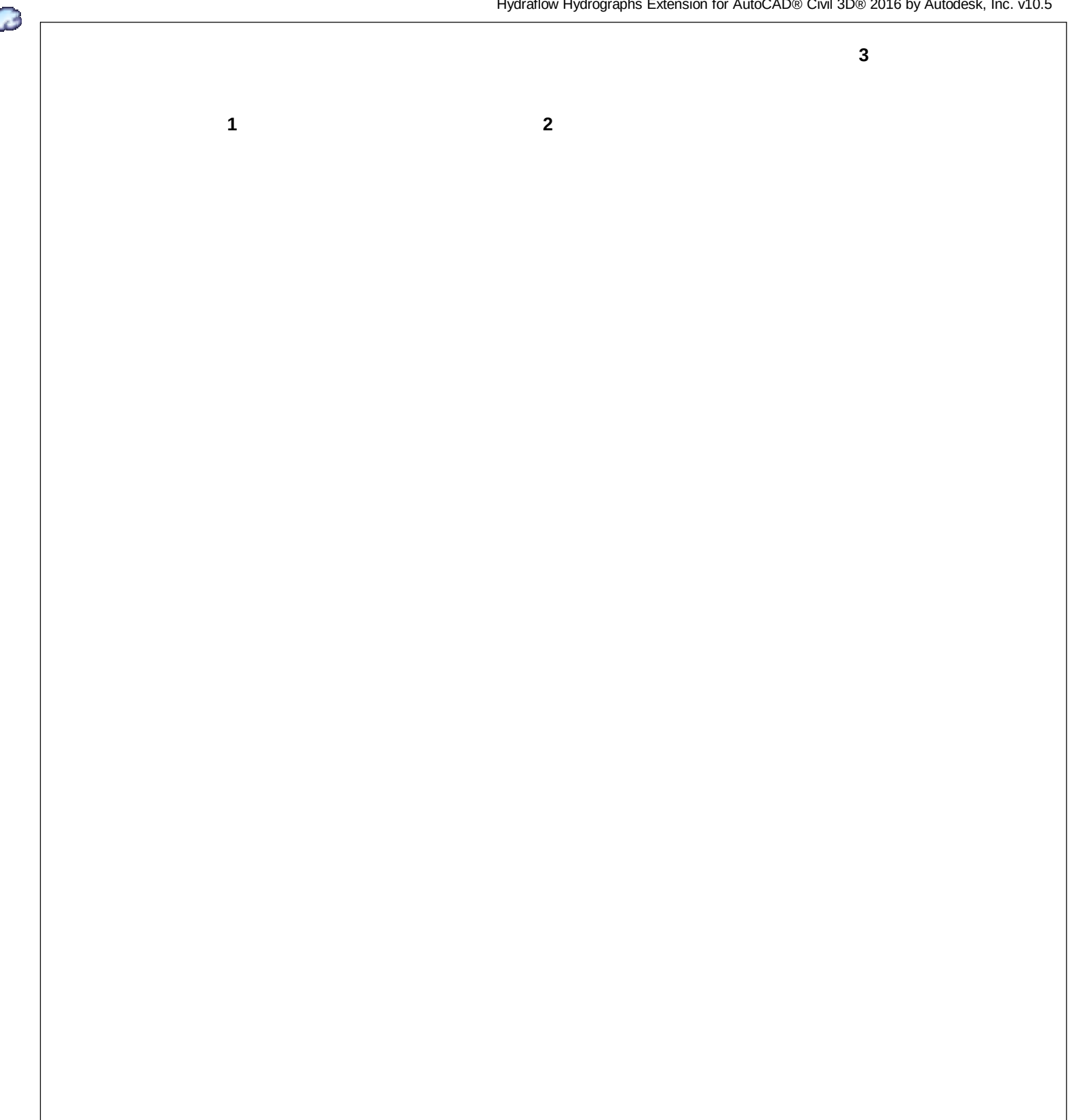
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-049B PRE
2	SCS Runoff	DA-FR-049B DEV
3	SCS Runoff	DA-FR-049B FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.237	0.417	-------	-------	1.703	-------	-------	-------	DA-FR-049B PRE
2	SCS Runoff	------	0.213	0.393	-------	-------	1.703	-------	-------	-------	DA-FR-049B DEV
3	SCS Runoff	------	0.154	0.308	-------	-------	1.496	-------	-------	-------	DA-FR-049B FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.237	1	723	1,003	------	------	------	DA-FR-049B PRE
2	SCS Runoff	0.213	1	722	894	------	------	------	DA-FR-049B DEV
3	SCS Runoff	0.154	1	724	820	------	------	------	DA-FR-049B FOR

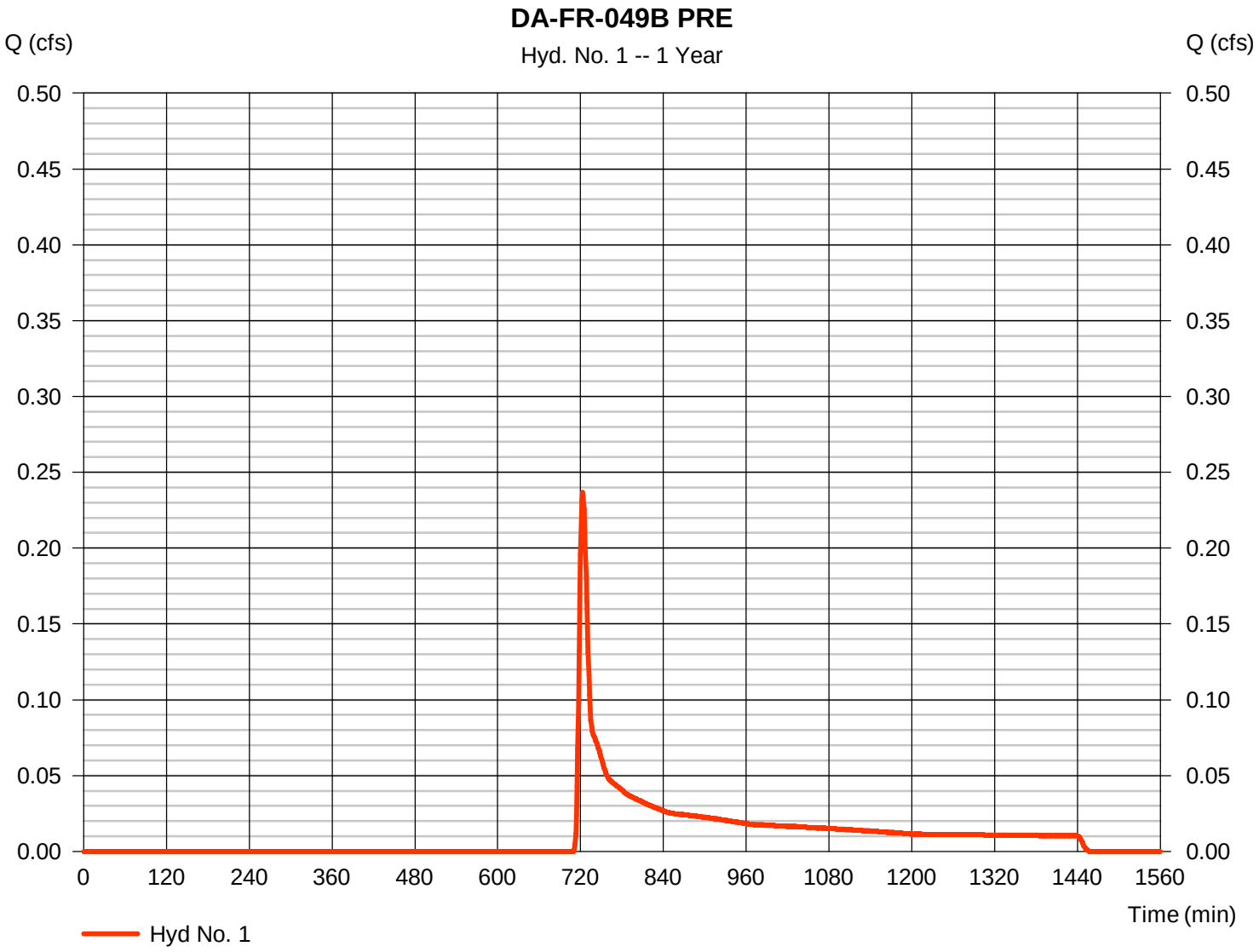
Hydrograph Report

Hyd. No. 1

DA-FR-049B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.237 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 1,003 cuft
Drainage area	= 0.790 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.213 x 58) + (0.027 x 100) + (0.548 x 55)] / 0.790



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-049B PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.400		0.011		
Flow length (ft)	= 66.3		33.7		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 12.81		15.43		0.00		
Travel Time (min)	**= 6.84**	**+**	**3.70**	**+**	**0.00**	**=**	**10.53**
Shallow Concentrated Flow							
Flow length (ft)	= 262.14		0.00		0.00		
Watercourse slope (%)	= 17.96		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.84		0.00		0.00		
Travel Time (min)	**= 0.64**	**+**	**0.00**	**+**	**0.00**	**=**	**0.64**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 11.20 min

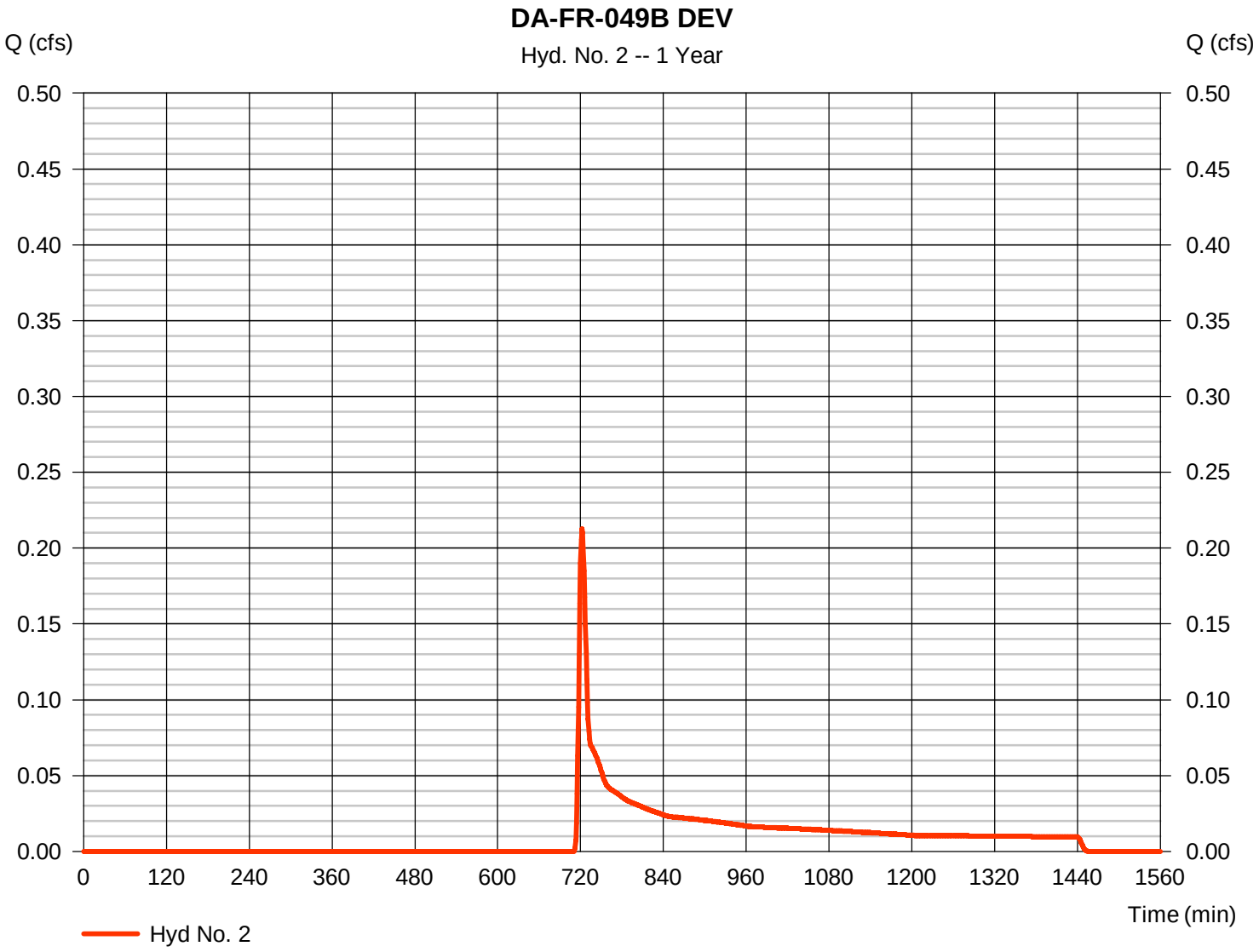
Hydrograph Report

Hyd. No. 2

DA-FR-049B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.213 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 894 cuft
Drainage area	= 0.790 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.296 x 48) + (0.465 x 58) + (0.027 x 100)] / 0.790



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-049B DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 13.70		0.00		0.00		
Travel Time (min)	**= 9.25**	**+**	**0.00**	**+**	**0.00**	**=**	**9.25**
Shallow Concentrated Flow							
Flow length (ft)	= 48.40		210.15		0.00		
Watercourse slope (%)	= 15.83		18.34		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=6.42		6.91		0.00		
Travel Time (min)	**= 0.13**	**+**	**0.51**	**+**	**0.00**	**=**	**0.63**
Channel Flow							
X sectional flow area (sqft)	= 2.00		0.00		0.00		
Wetted perimeter (ft)	= 4.47		0.00		0.00		
Channel slope (%)	= 5.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=4.86						
			0.00				
					0.00		
Flow length (ft)	({0})25.0		0.0		0.0		
Travel Time (min)	**= 0.09**	**+**	**0.00**	**+**	**0.00**	**=**	**0.09**

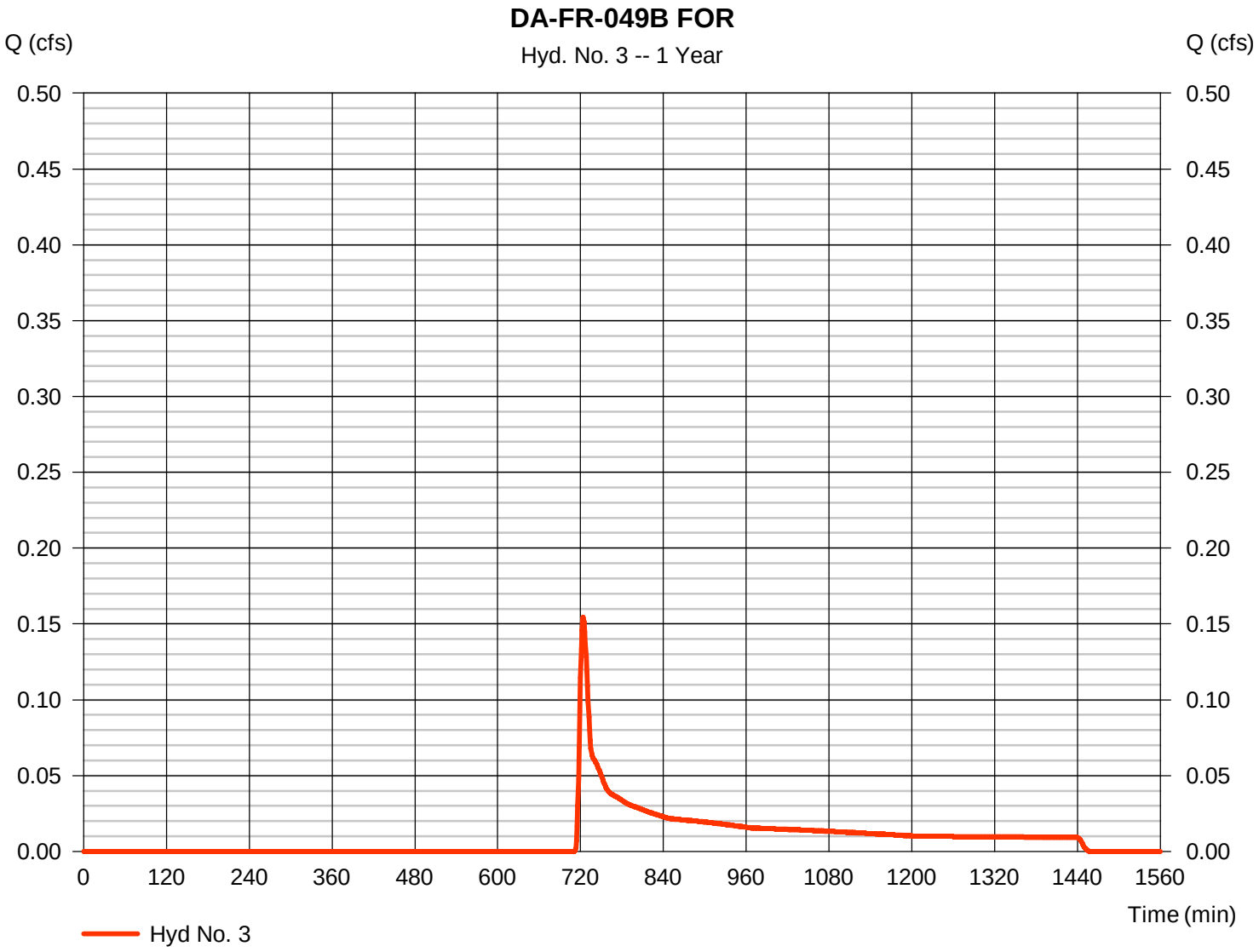
Total Travel Time, Tc ..... 10.00 min

Hydrograph Report

Hyd. No. 3

DA-FR-049B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.154 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 820 cuft
Drainage area	= 0.790 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-049B FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.400		0.011		
Flow length (ft)	= 66.3		33.7		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 12.81		15.43		0.00		
Travel Time (min)	**= 6.84**	**+**	**3.70**	**+**	**0.00**	**=**	**10.53**
Shallow Concentrated Flow							
Flow length (ft)	= 262.14		0.00		0.00		
Watercourse slope (%)	= 17.96		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.84		0.00		0.00		
Travel Time (min)	**= 0.64**	**+**	**0.00**	**+**	**0.00**	**=**	**0.64**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 11.20 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.417	1	722	1,439	------	------	------	DA-FR-049B PRE
2	SCS Runoff	0.393	1	721	1,301	------	------	------	DA-FR-049B DEV
3	SCS Runoff	0.308	1	723	1,213	------	------	------	DA-FR-049B FOR

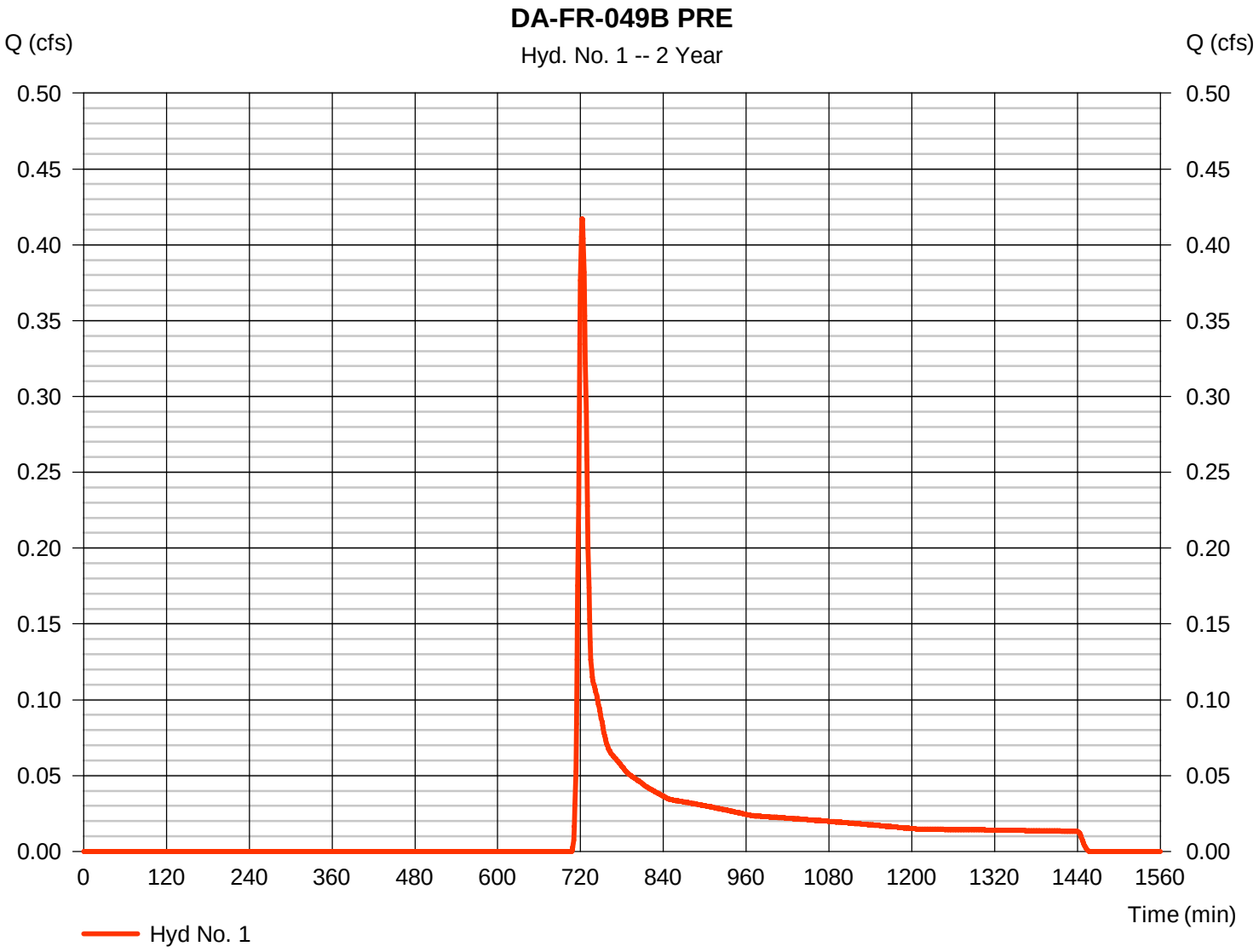
Hydrograph Report

Hyd. No. 1

DA-FR-049B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.417 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 1,439 cuft
Drainage area	= 0.790 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.213 x 58) + (0.027 x 100) + (0.548 x 55)] / 0.790



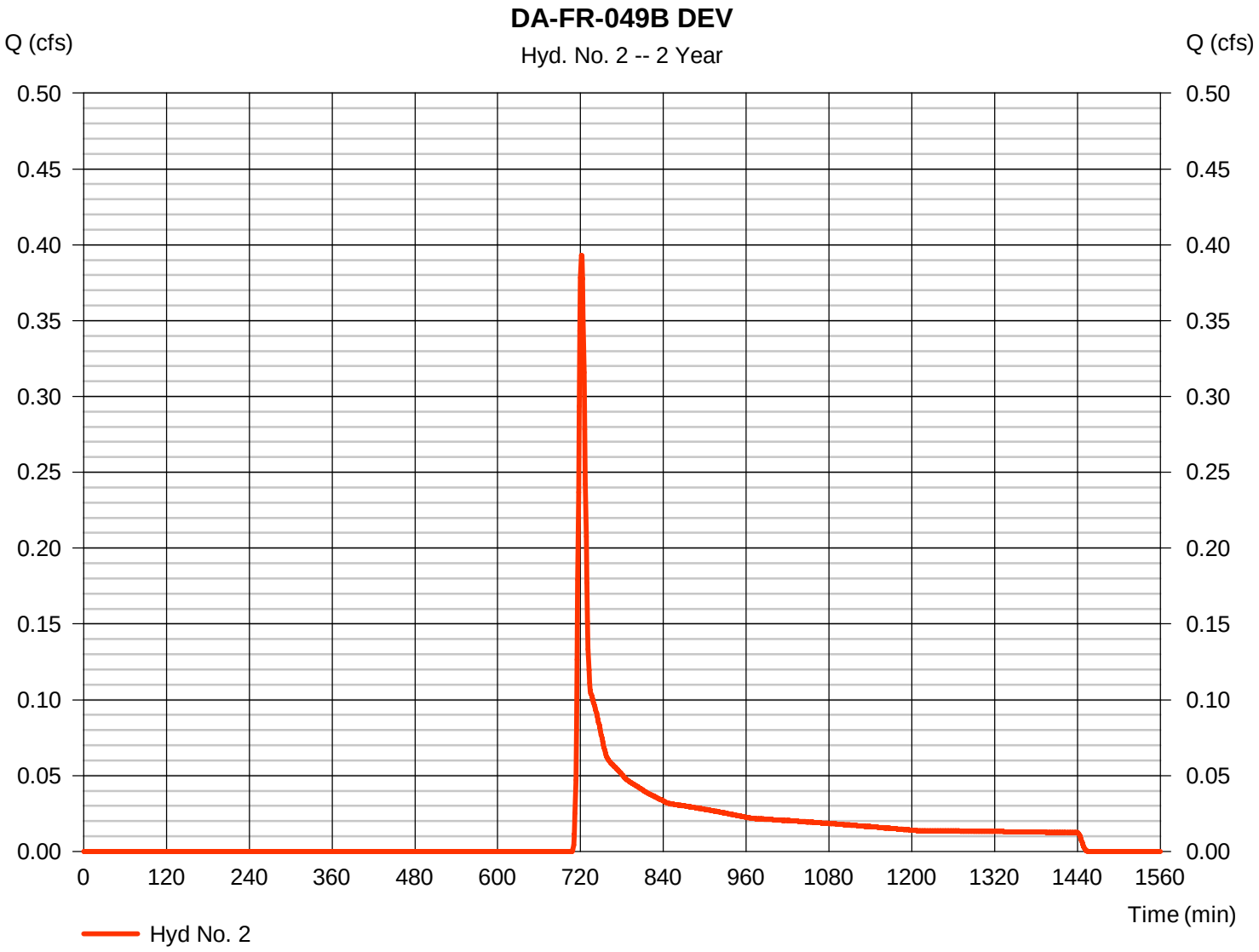
Hydrograph Report

Hyd. No. 2

DA-FR-049B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.393 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,301 cuft
Drainage area	= 0.790 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.296 x 48) + (0.465 x 58) + (0.027 x 100)] / 0.790

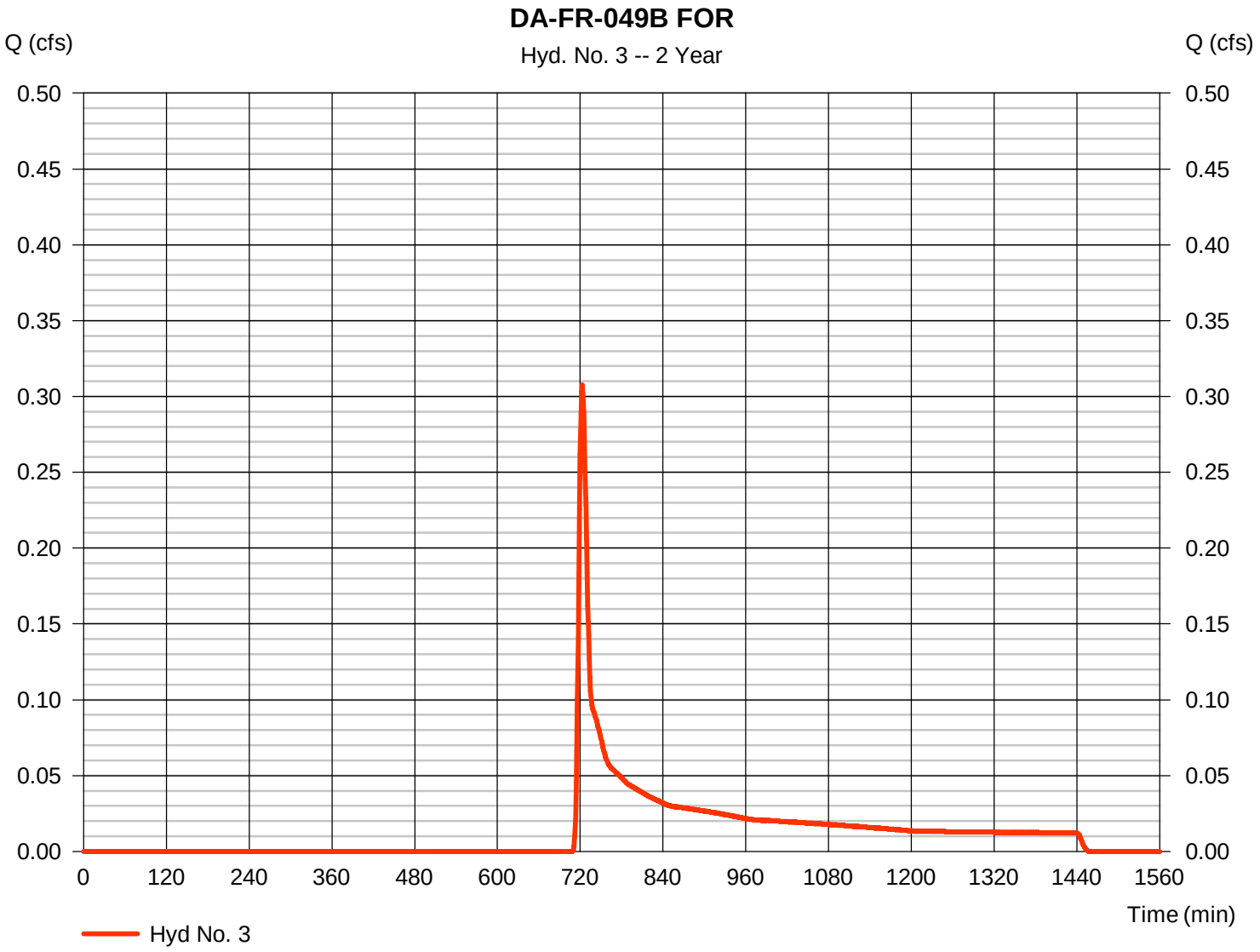


Hydrograph Report

Hyd. No. 3

DA-FR-049B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.308 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 1,213 cuft
Drainage area	= 0.790 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.703	1	721	4,369	------	------	------	DA-FR-049B PRE
2	SCS Runoff	1.703	1	720	4,078	------	------	------	DA-FR-049B DEV
3	SCS Runoff	1.496	1	721	3,936	------	------	------	DA-FR-049B FOR

Hydrograph Report

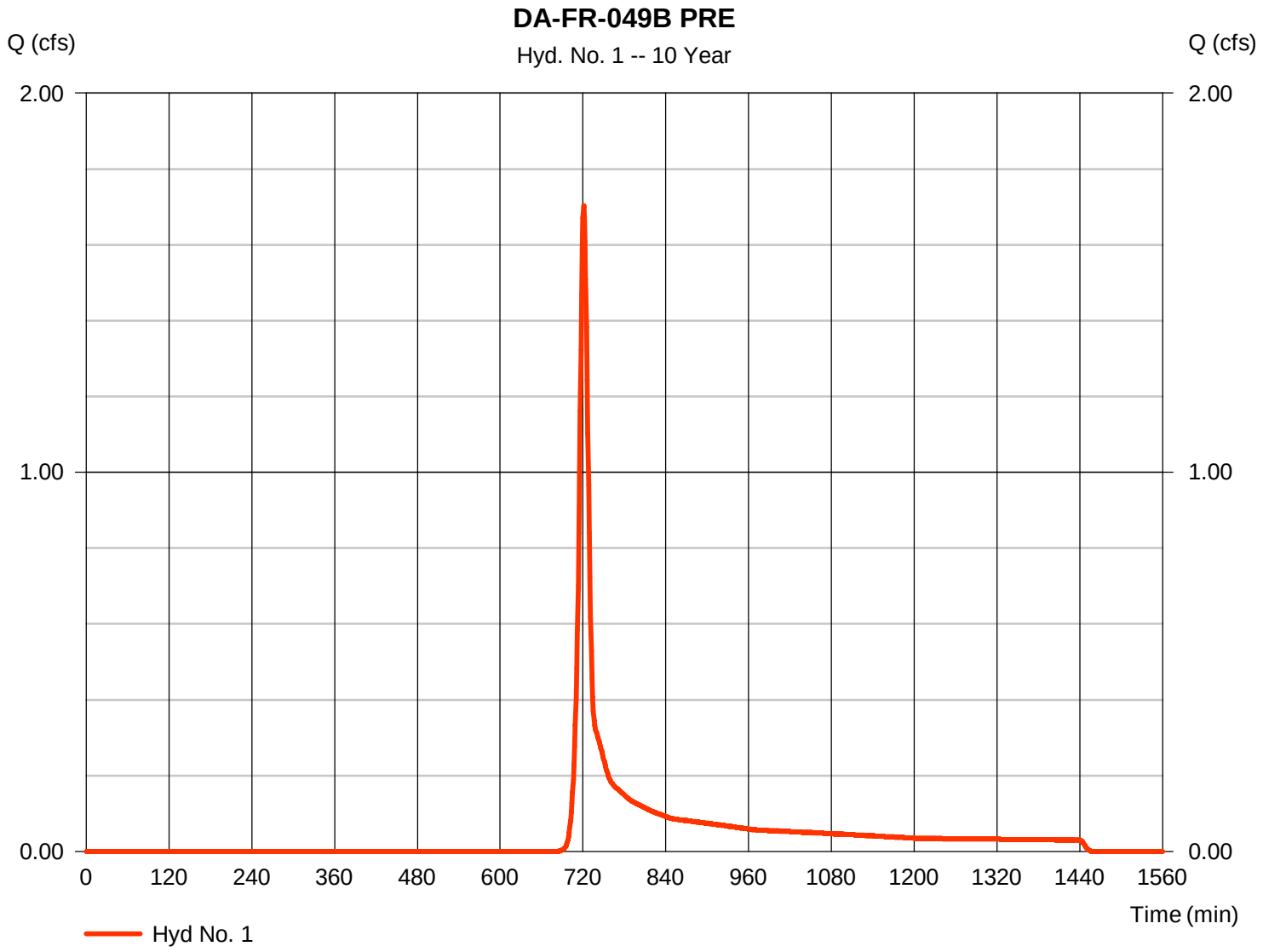
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 1

DA-FR-049B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 1.703 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 4,369 cuft
Drainage area	= 0.790 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.213 x 58) + (0.027 x 100) + (0.548 x 55)] / 0.790



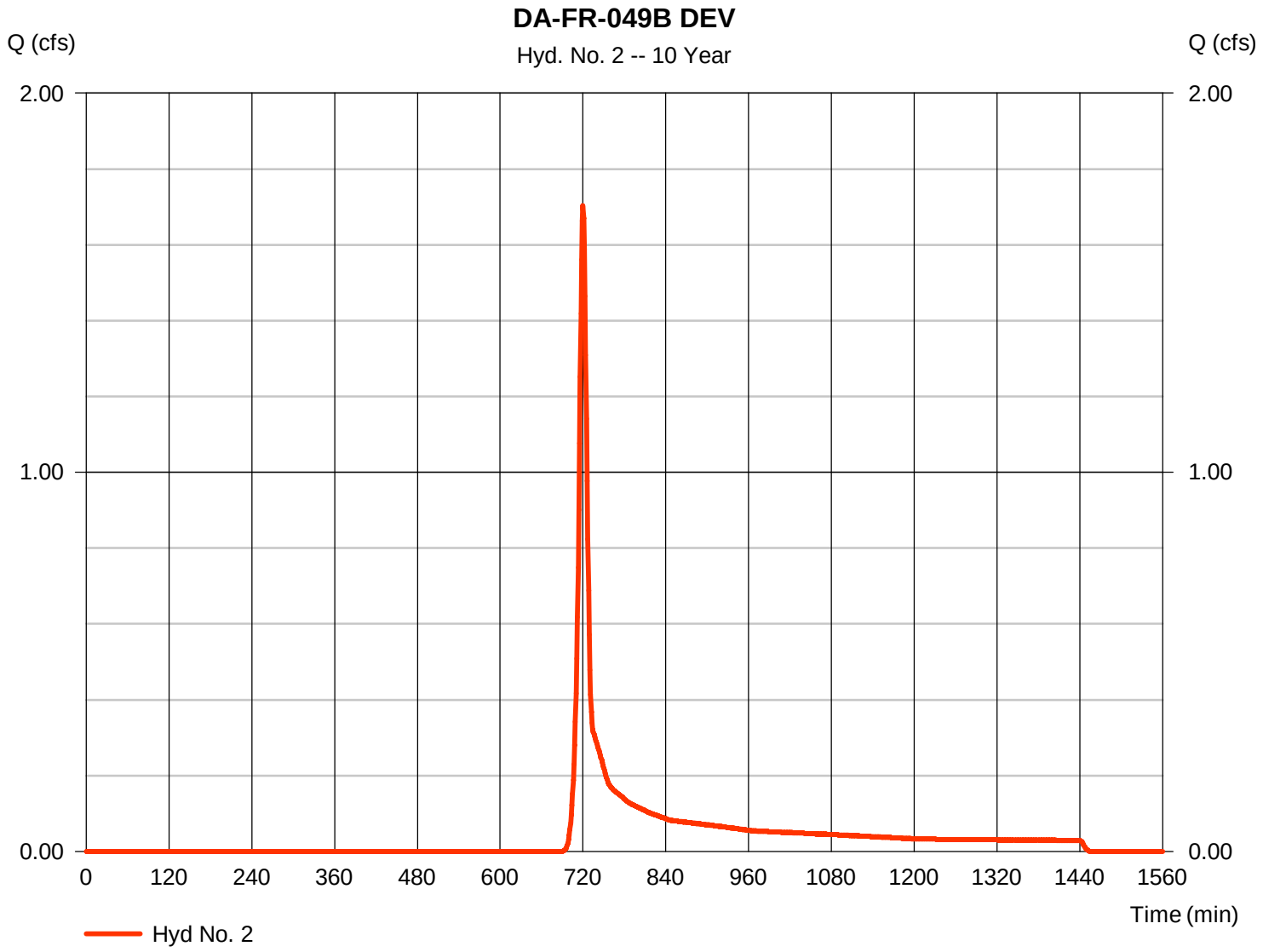
Hydrograph Report

Hyd. No. 2

DA-FR-049B DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.703 cfs
Storm frequency	=	10 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	4,078 cuft
Drainage area	=	0.790 ac	Curve number	=	56*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	10.00 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.296 x 48) + (0.465 x 58) + (0.027 x 100)] / 0.790

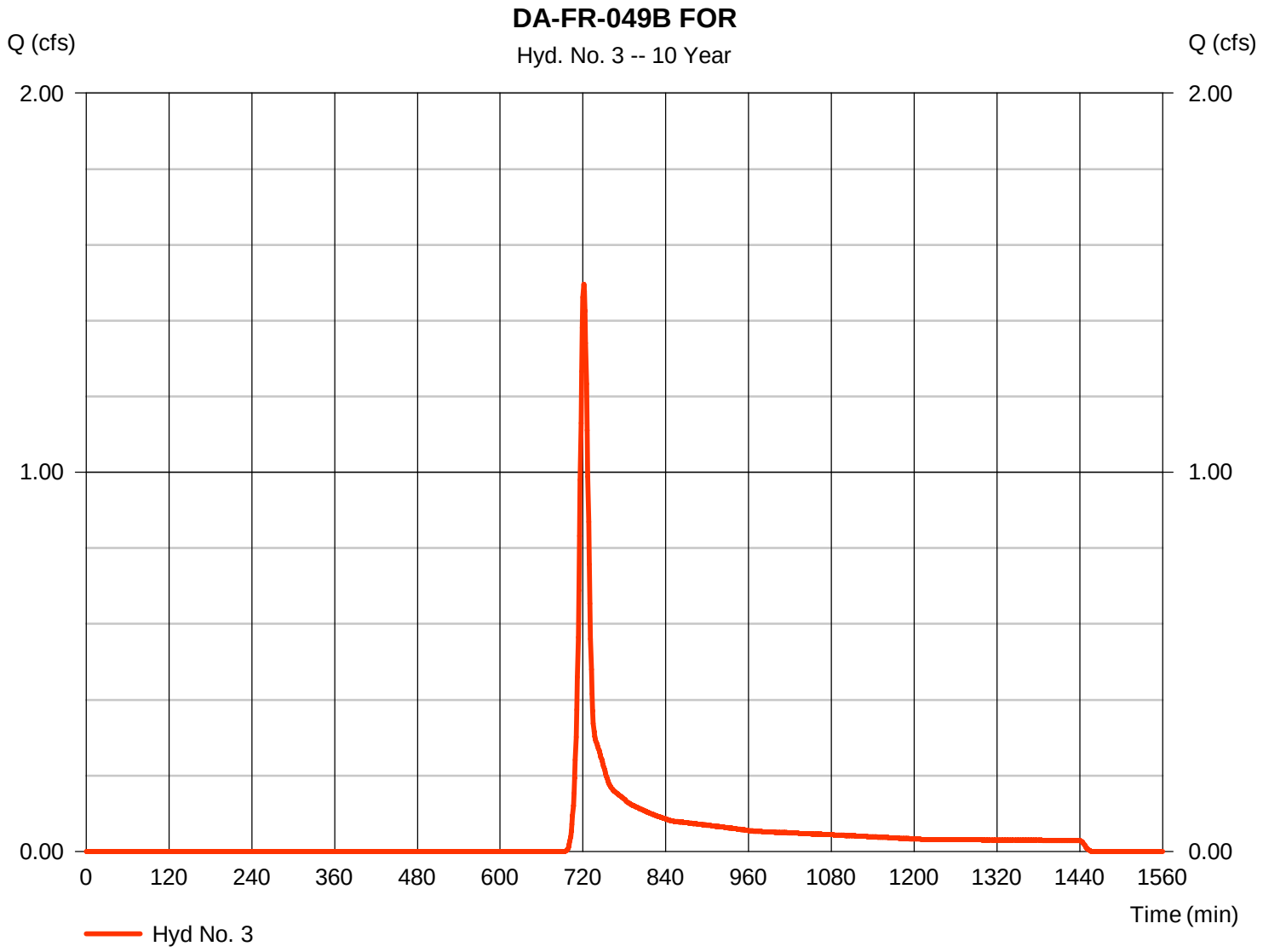


Hydrograph Report

Hyd. No. 3

DA-FR-049B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.496 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 3,936 cuft
Drainage area	= 0.790 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

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Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-050

DA-FR-050 is located in a meadow and forested areas with rolling slopes and some agricultural land. The pipeline crosses Brick Church Road (paved) at the eastern end of this drainage area. No new impervious area is proposed within DA-FR-050. The total phosphorus load reduction required for DA-FR-050 is –0.53 lb/yr. Multiple points of analysis were evaluated within DA-FR-050 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-050 was sub-divided into five sub-drainage areas (sub-areas A through E).

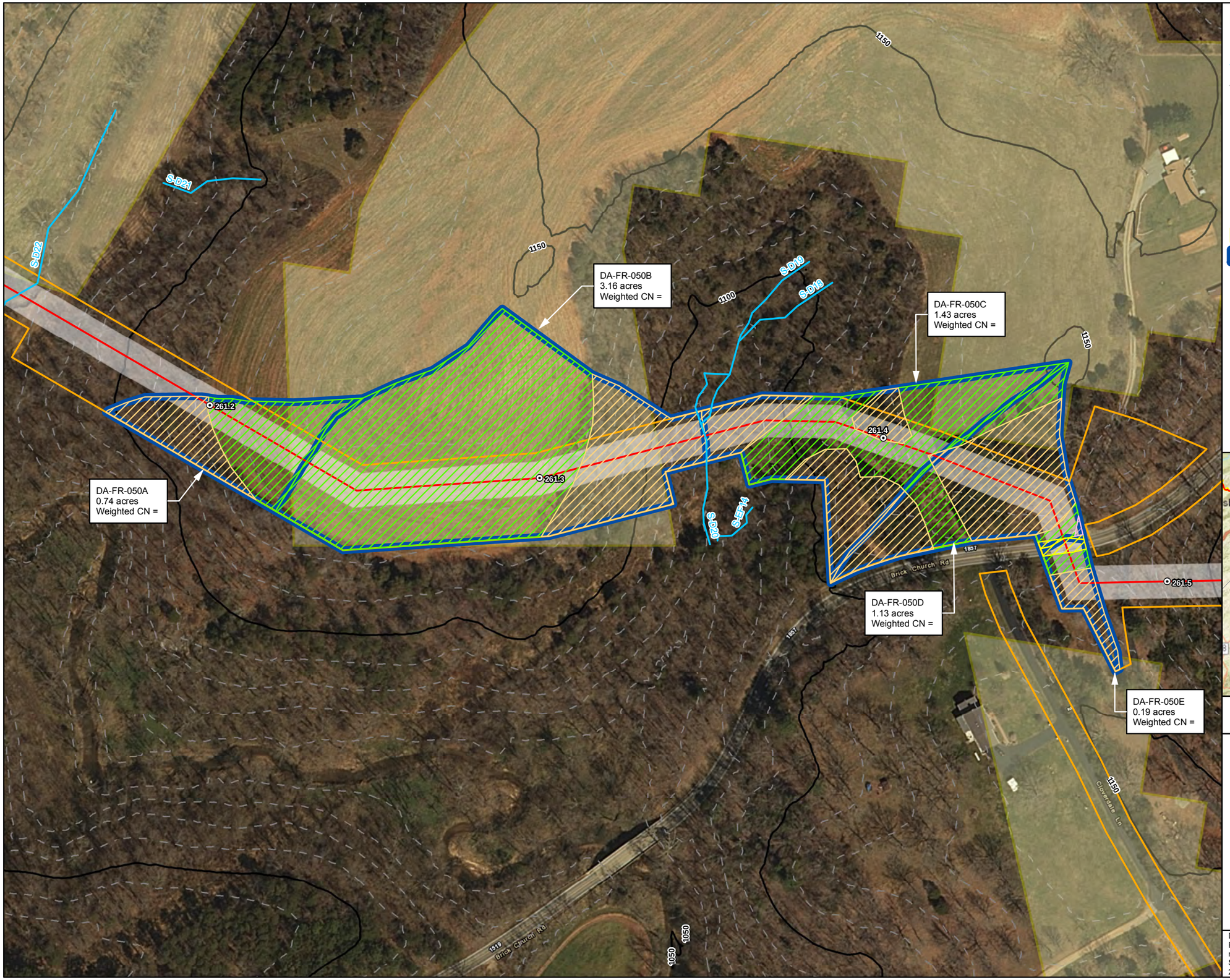
Sub-area 050B contains both agricultural and non-agricultural areas within the limits of disturbance (LOD). Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction. In non-agricultural areas, land use will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. For SWM quality, agricultural areas within the LOD are considered/included and the total permanent ROW is analyzed via VRRM; agricultural areas are considered “Forest/Open Space” in these calculations.

Stormwater quantity is met via the energy balance method for each of the five sub-areas DA-FR-050A through DA-FR-050E. Agricultural areas within the study area are included in the SWM analysis, but an Improvement Factor (IF) of 1.0 is used when applying the Energy Balance Method. This improvement factor is used to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate a reduction in flows ranging from 0.00 to 0.32 cfs for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-050A	1.39	1.14	-0.25
DA-FR-050B	5.59	5.59	0.00
DA-FR-050C	2.53	2.21	-0.32
DA-FR-050D	1.98	1.72	-0.26
DA-FR-050E	0.54	0.45	-0.09

Figures and calculations for each of the sub-areas for DA-FR-050 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.



Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Dirt Road
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:1,680

N W E S

140 70 0 140 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-050
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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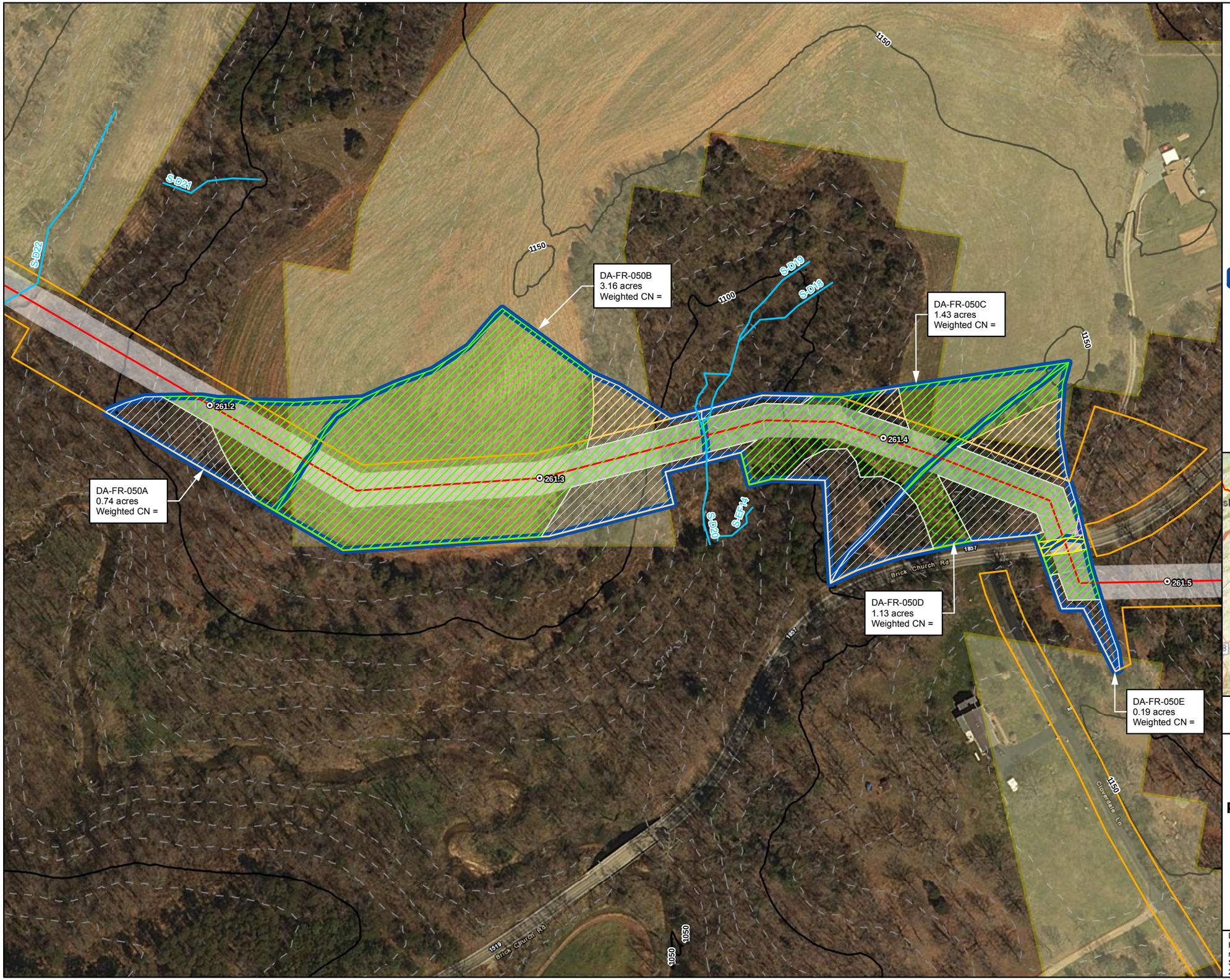

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Brush
- Dirt Road
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:1,680

N
W E
S

140 70 0 140 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-050
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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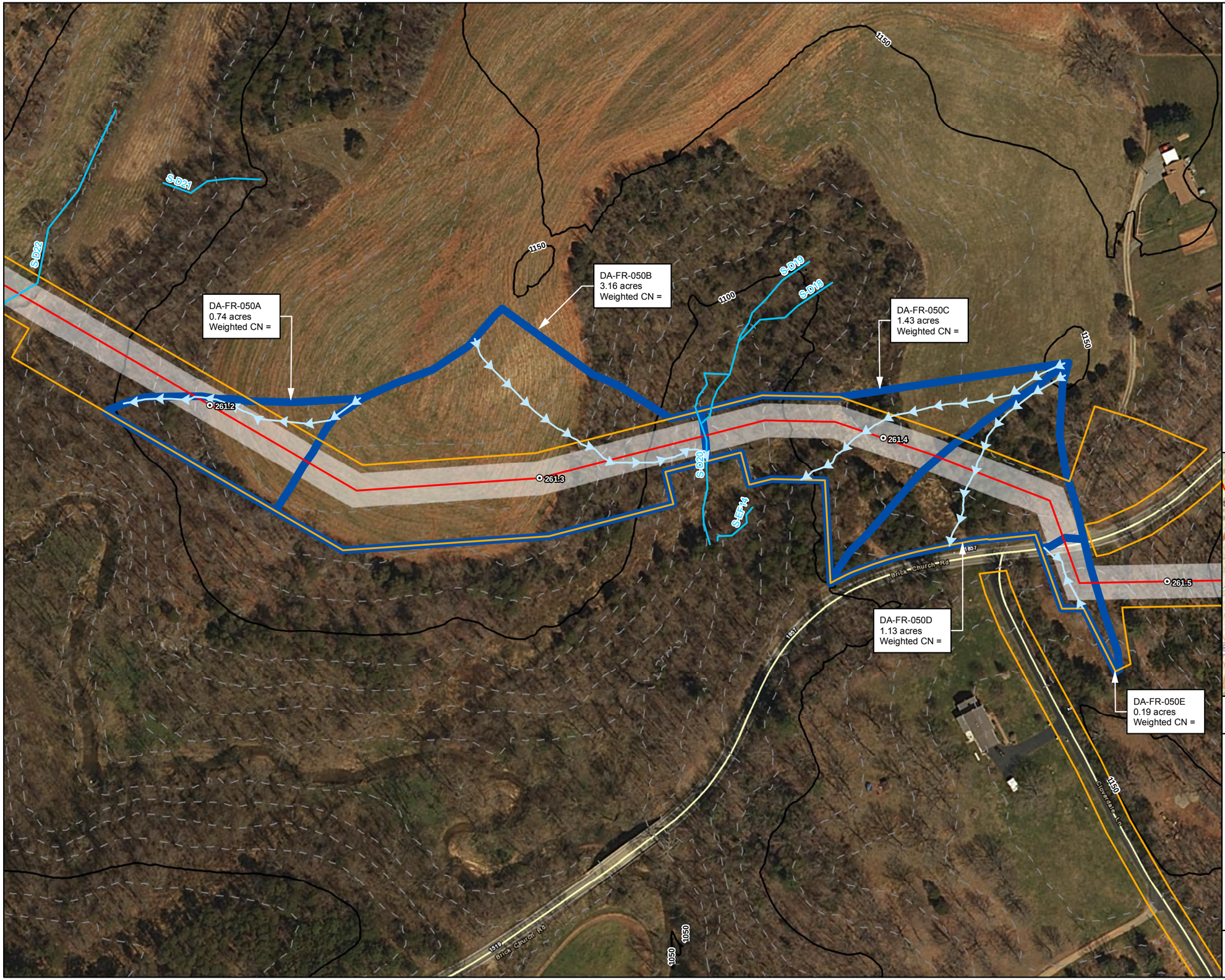


Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,680

N
W E
S

140 70 0 140 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration
DA-FR-050
Spread 10

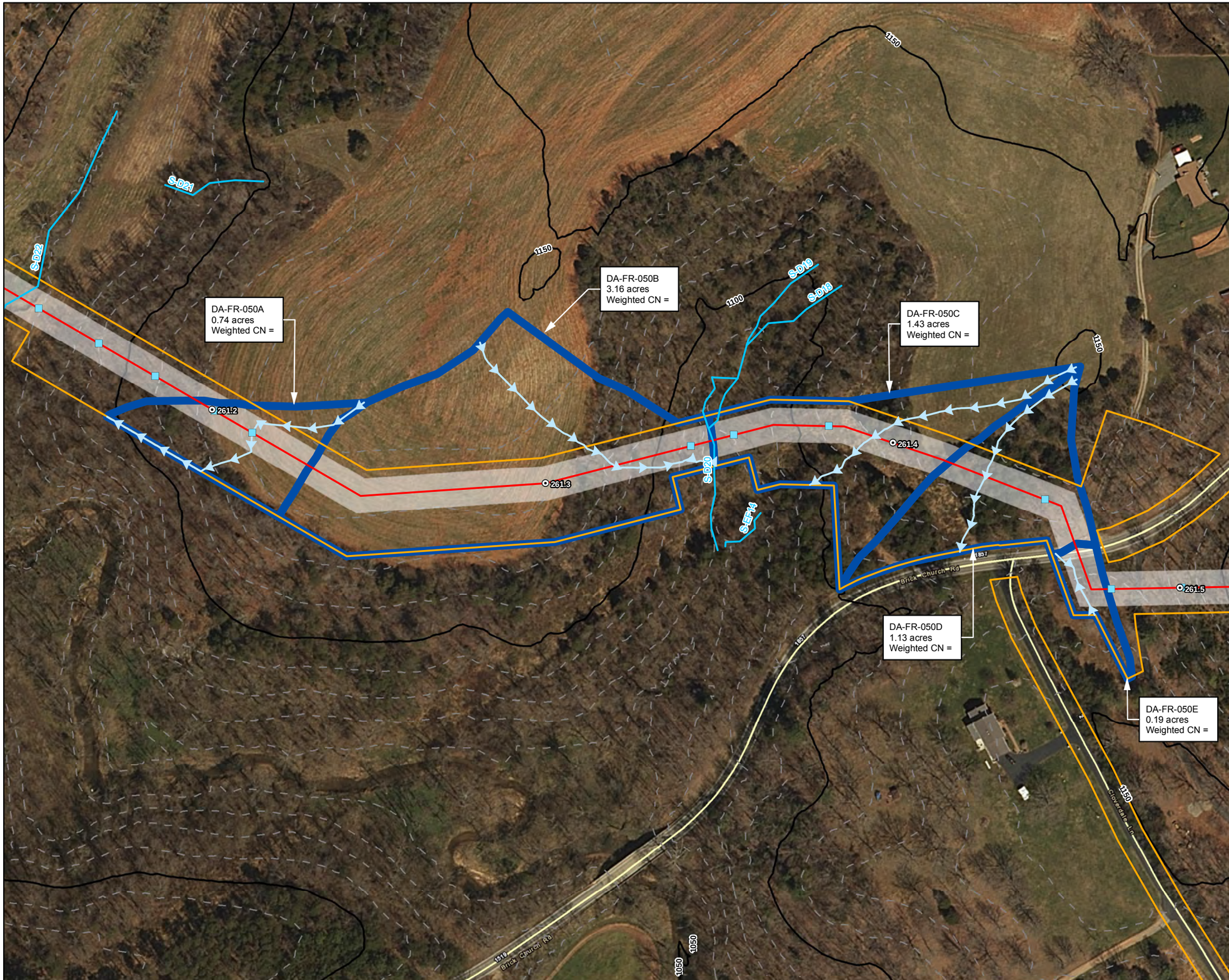
Figure 3

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-050_3.mxd



Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,680

140 70 0 140 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration
DA-FR-050
Spread 10

Figure 4
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-050_4.mxd

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary - Linear Development Project***

Total Rainfall (in):	**43**
Total Disturbed Acreage:	**1.73**

Site Land Cover Summary

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	1.70	0.00	0.00	1.70	98
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.03	0.00	0.00	0.03	2
					1.73	100

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total	
Forest/Open (acres)	0.00	1.70	0.00	0.00	1.70	98	*
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0	
Impervious Cover (acres)	0.00	0.03	0.00	0.00	0.03	2	
					1.73	100	

*** Forest/Open Space areas must be protected in accordance with the Virginia Runoff Reduction Method**

Site Tv and Land Cover Nutrient Loads

	Final Post-Development (Post-ReDevelopment & New Impervious)	Post-ReDevelopment	Post-Development (New Impervious)	Adjusted Pre-ReDevelopment
Site Rv	0.05	0.05	--	0.05
Treatment Volume (ft^3)	289	289	--	289
TP Load (lb/yr)	0.18	0.18	--	0.18

Baseline TP Load (lb/yr): 0.7093* **Reduction below new development load limitation not required*

Pre-ReDevelopment TP Load per acre (lb/acre/yr)	Final Post-Development TP Load per acre (lb/acre/yr)	Post-ReDevelopment TP Load per acre (lb/acre/yr)
0.10	**0.10**	**0.10**

Total TP Load Reduction Required (lb/yr)	**-0.53**	N/A***	N/A***

******This is a linear development project***

	Final Post-Development Load (Post-ReDevelopment & New Impervious)	Pre-ReDevelopment
TN Load (lb/yr)	1.30	1.30

Site Compliance Summary - ***Linear Development Project

Maximum % Reduction Required Below Pre-ReDevelopment Load	20%

** Note: % Reduction will reduce post-development TP load to less than or equal to baseline load of 0.71 lb/yr (0.41 lb/ac/yr)*
[Post-Dev Reduction Requirement = Post-Dev TP load - baseline load of 0.71 lb/yr], baseline load = site area x 0.41 lb/ac/yr

Total Runoff Volume Reduction (ft^3)	0

Total TP Load Reduction Achieved (lb/yr)	0.00
Total TN Load Reduction Achieved (lb/yr)	0.00
Remaining Post Development TP Load (lb/yr)	0.18
Remaining TP Load Reduction (lb/yr) Required	**0.00**

**** TARGET TP REDUCTION EXCEEDED BY 0.53 LB/YEAR ****

**Reduction below new development load limitation not required*

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	1.70	0.00	0.00	0.00	0.00	1.70
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.03	0.00	0.00	0.00	0.00	0.03
Total Area (acres)	**1.73**	**0.00**	**0.00**	**0.00**	**0.00**	**1.73**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TN Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	1.70	0.00	0.00	1.70	98
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.03	0.00	0.00	0.03	2
					1.73	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	0.00
Total Turf Area Treated (acres)	0.00
Total TP Load Reduction Achieved in D.A. (lb/yr)	0.00
Total TN Load Reduction Achieved in D.A. (lb/yr)	0.00

DA-FR-050A

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.186	923
Developed Condition	0.114	764
Pre-Developed (Forest) Condition	0.122	755

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.9

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.114 ≤ 0.202 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.114 ≤ 0.186 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.114 *shall not* be required to be ≤ 0.121

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-050A PRE
2	SCS Runoff	DA-FR-050 DEV
3	SCS Runoff	DA-FR-050A FOR

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.186	0.331	-------	-------	1.385	-------	-------	-------	DA-FR-050A PRE
2	SCS Runoff	------	0.114	0.226	-------	-------	1.144	-------	-------	-------	DA-FR-050 DEV
3	SCS Runoff	------	0.122	0.243	-------	-------	1.212	-------	-------	-------	DA-FR-050A FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.186	1	725	923	------	------	------	DA-FR-050A PRE
2	SCS Runoff	0.114	1	727	764	------	------	------	DA-FR-050 DEV
3	SCS Runoff	0.122	1	726	755	------	------	------	DA-FR-050A FOR

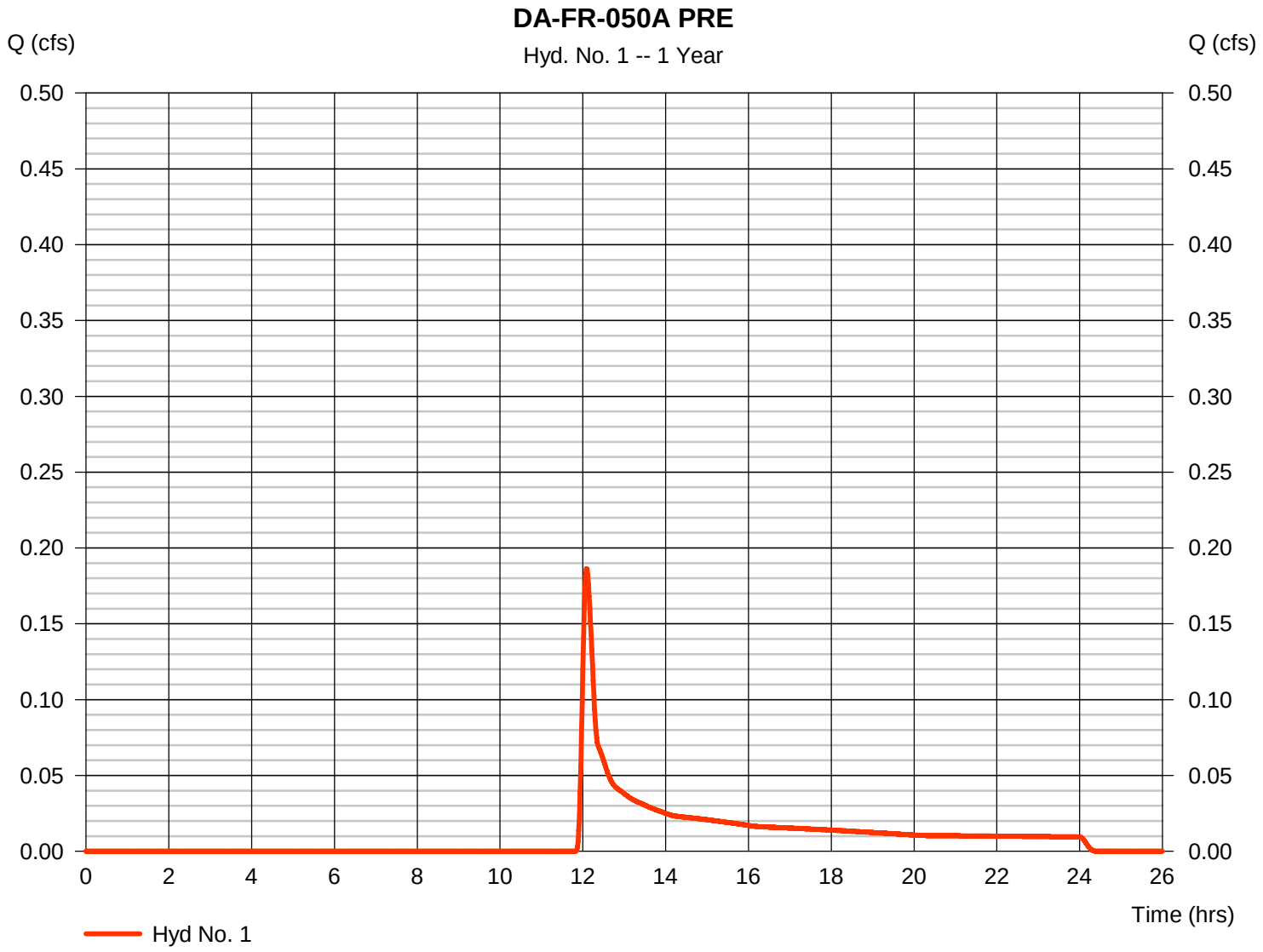
Hydrograph Report

Hyd. No. 1

DA-FR-050A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.186 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.08 hrs
Time interval	= 1 min	Hyd. volume	= 923 cuft
Drainage area	= 0.740 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.464 x 58) + (0.278 x 55)] / 0.740



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-050A PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.67		0.00		0.00		
Travel Time (min)	**= 14.23**	**+**	**0.00**	**+**	**0.00**	**=**	**14.23**
Shallow Concentrated Flow							
Flow length (ft)	= 277.74		0.00		0.00		
Watercourse slope (%)	= 13.51		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.93		0.00		0.00		
Travel Time (min)	**= 0.78**	**+**	**0.00**	**+**	**0.00**	**=**	**0.78**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.00 min

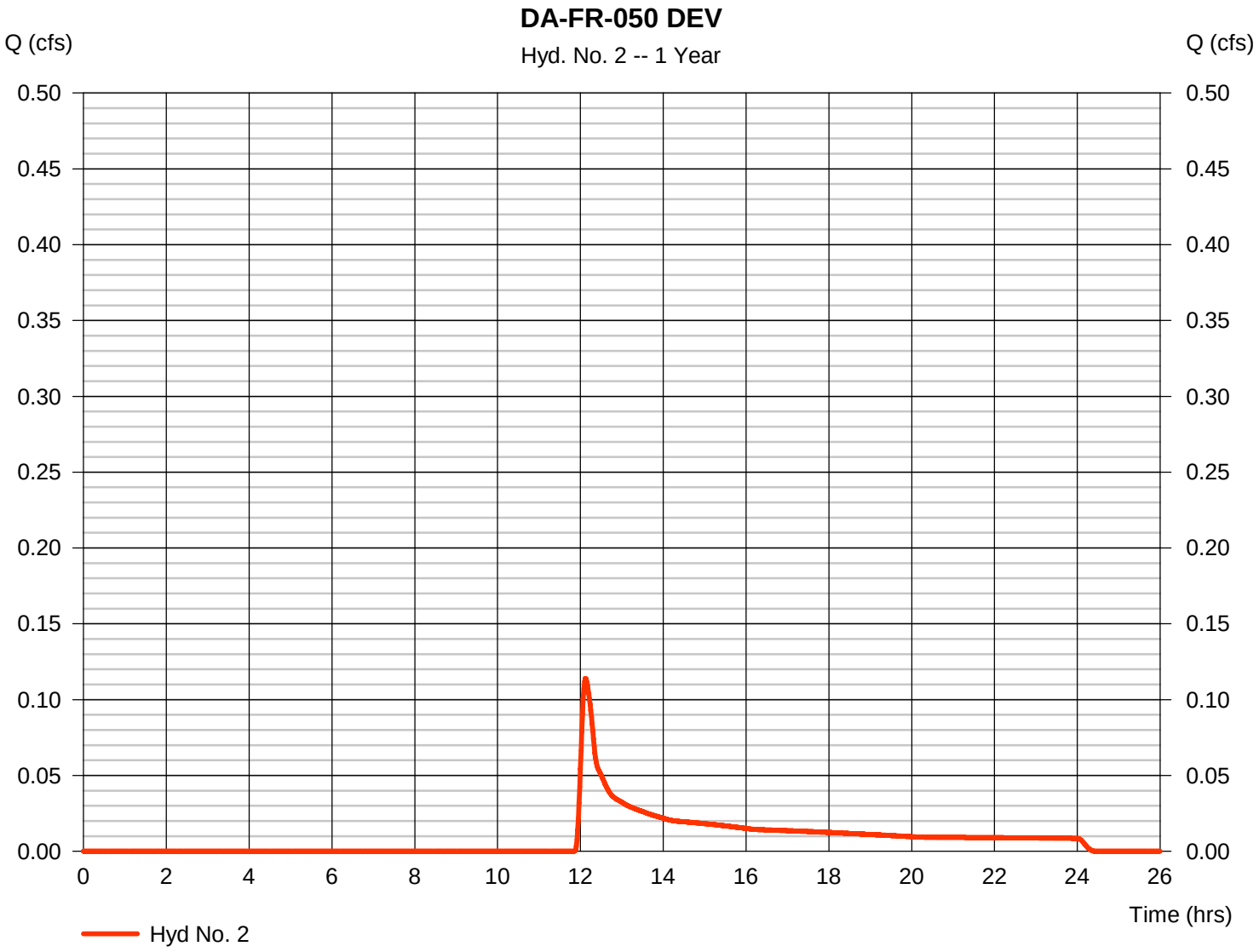
Hydrograph Report

Hyd. No. 2

DA-FR-050 DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.114 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.12 hrs
Time interval	= 1 min	Hyd. volume	= 764 cuft
Drainage area	= 0.740 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.245 x 48) + (0.497 x 58)] / 0.740



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-050 DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.67		0.00		0.00		
Travel Time (min)	**= 14.23**	**+**	**0.00**	**+**	**0.00**	**=**	**14.23**
Shallow Concentrated Flow							
Flow length (ft)	= 67.65		243.72		0.00		
Watercourse slope (%)	= 9.37		13.73		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=4.94		5.98		0.00		
Travel Time (min)	**= 0.23**	**+**	**0.68**	**+**	**0.00**	**=**	**0.91**
Channel Flow							
X sectional flow area (sqft)	= 2.00		0.00		0.00		
Wetted perimeter (ft)	= 4.47		0.00		0.00		
Channel slope (%)	= 5.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=4.86						
			0.00				
					0.00		
Flow length (ft)	({0})47.6		0.0		0.0		
Travel Time (min)	**= 0.16**	**+**	**0.00**	**+**	**0.00**	**=**	**0.16**

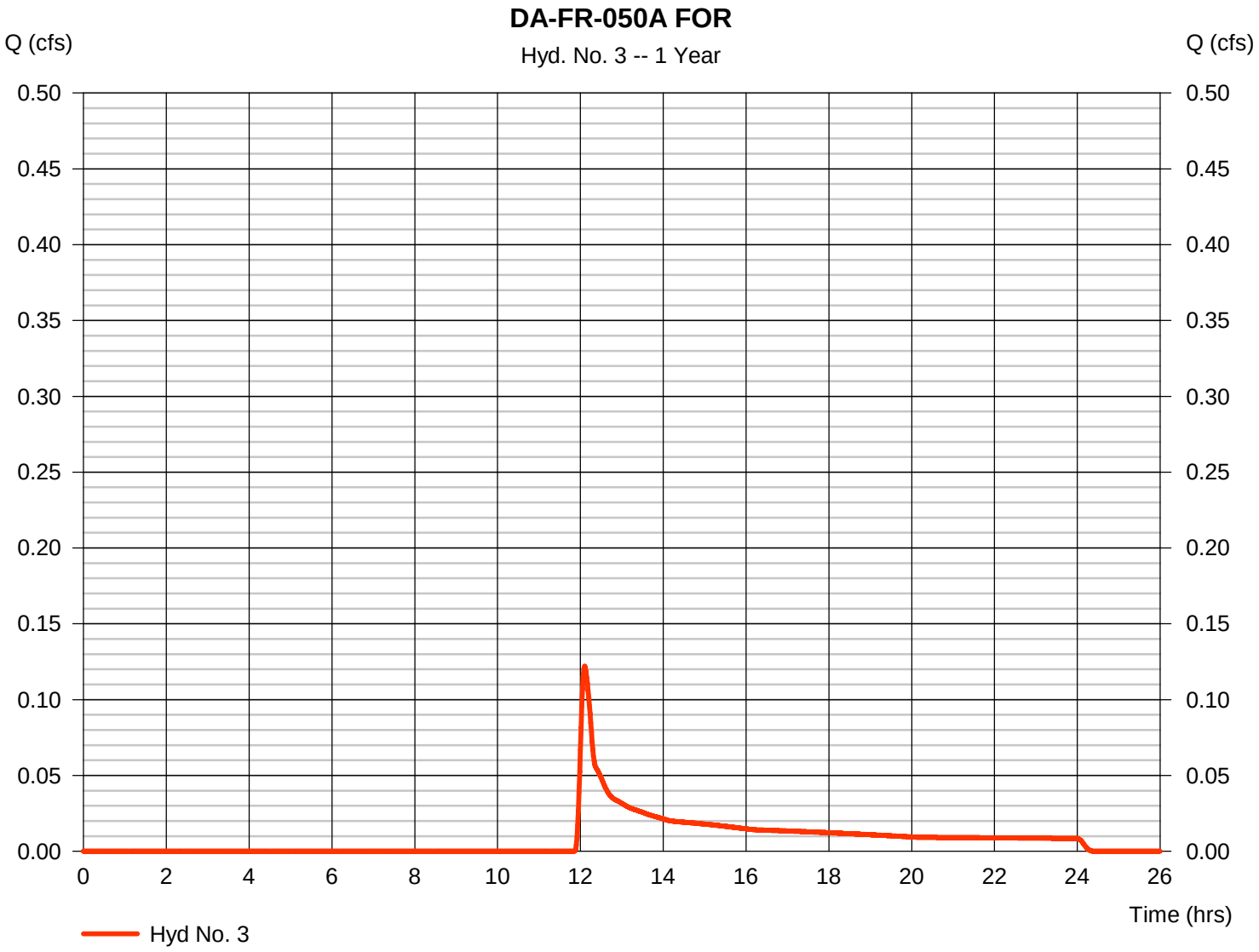
Total Travel Time, Tc ..... 15.30 min

Hydrograph Report

Hyd. No. 3

DA-FR-050A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.122 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.10 hrs
Time interval	= 1 min	Hyd. volume	= 755 cuft
Drainage area	= 0.740 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-050A FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.67		0.00		0.00		
Travel Time (min)	**= 14.23**	**+**	**0.00**	**+**	**0.00**	**=**	**14.23**
Shallow Concentrated Flow							
Flow length (ft)	= 277.74		0.00		0.00		
Watercourse slope (%)	= 13.51		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.93		0.00		0.00		
Travel Time (min)	**= 0.78**	**+**	**0.00**	**+**	**0.00**	**=**	**0.78**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.00 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.331	1	725	1,325	------	------	------	DA-FR-050A PRE
2	SCS Runoff	0.226	1	726	1,130	------	------	------	DA-FR-050 DEV
3	SCS Runoff	0.243	1	725	1,116	------	------	------	DA-FR-050A FOR

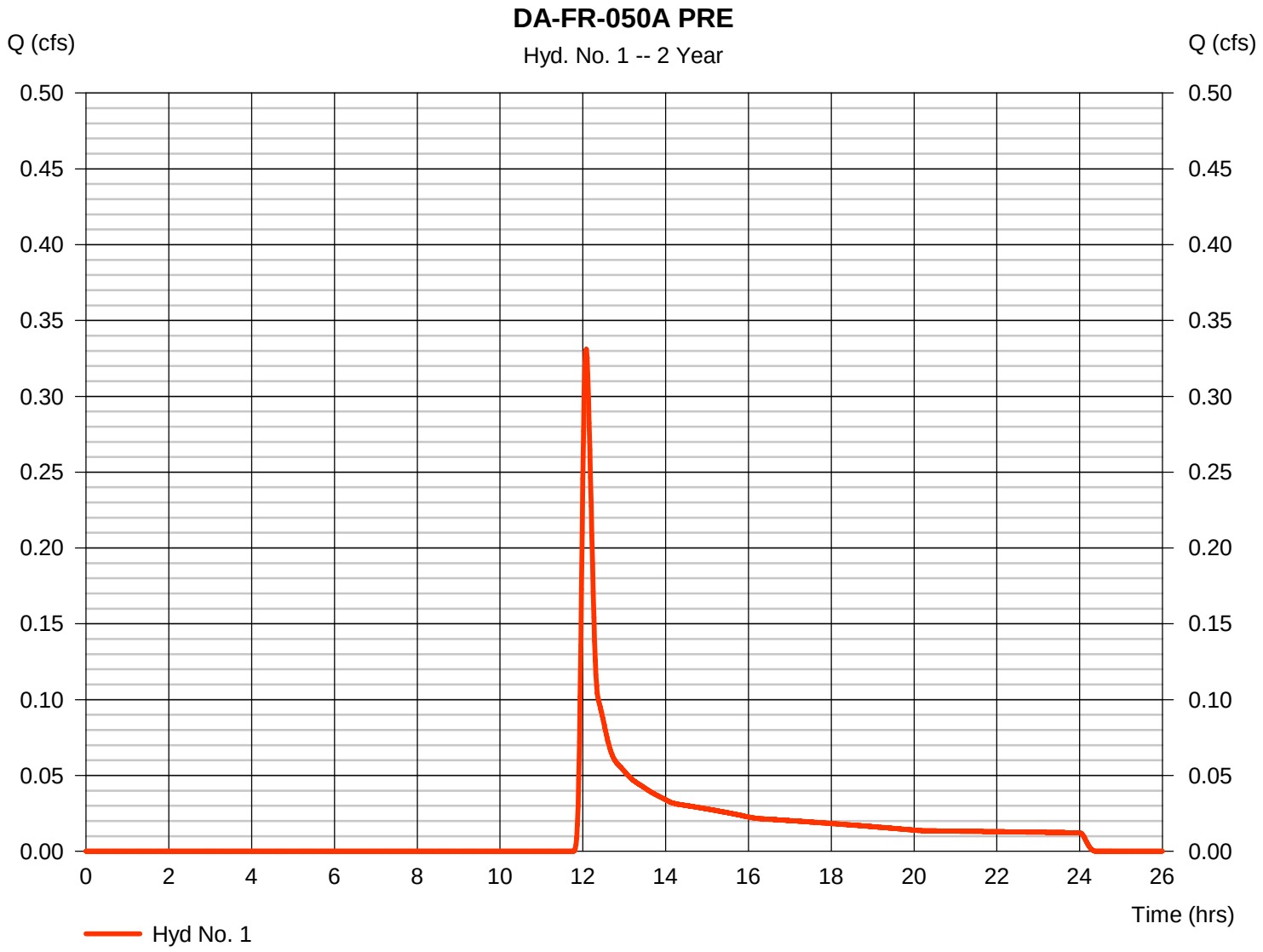
Hydrograph Report

Hyd. No. 1

DA-FR-050A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.331 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.08 hrs
Time interval	= 1 min	Hyd. volume	= 1,325 cuft
Drainage area	= 0.740 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.464 x 58) + (0.278 x 55)] / 0.740



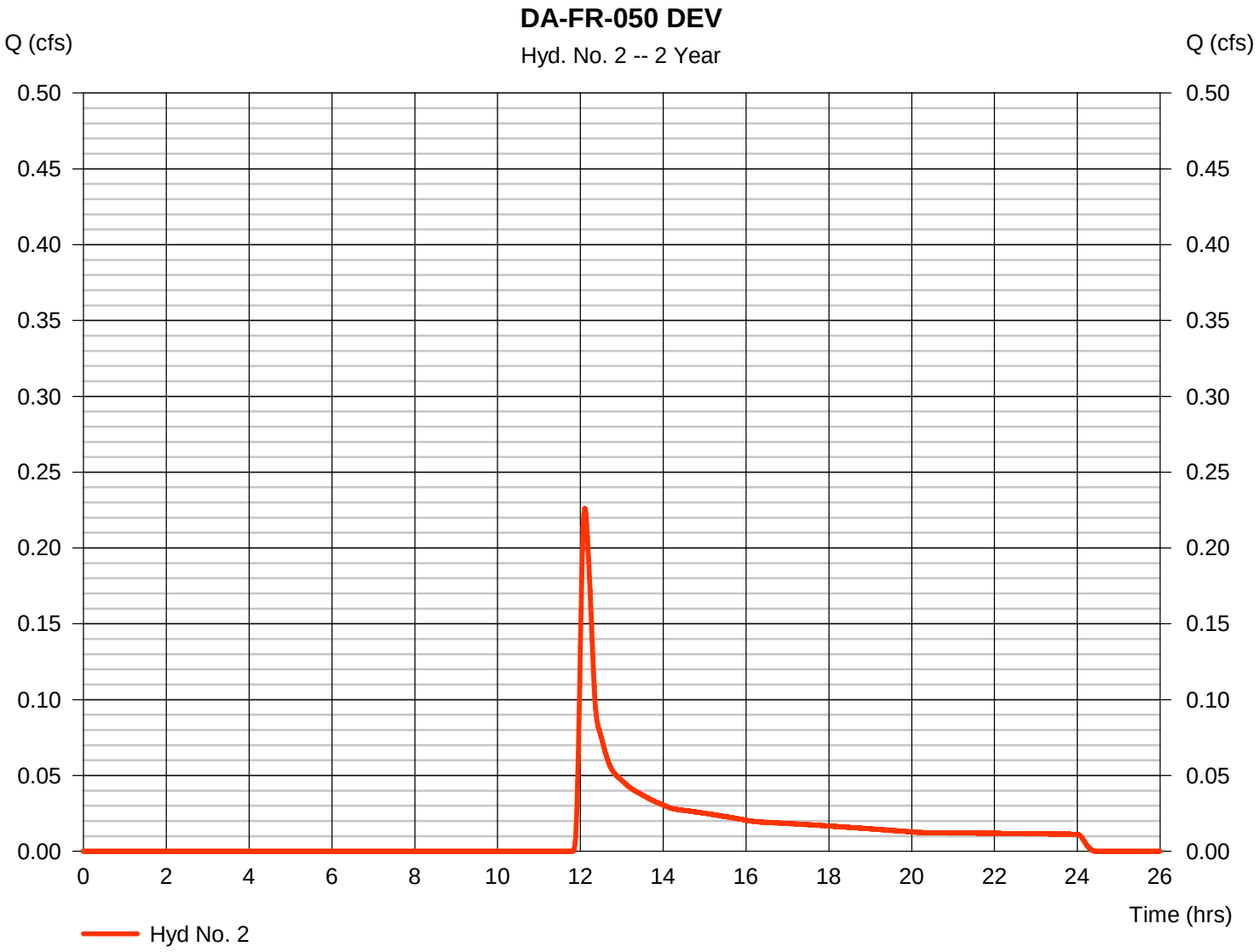
Hydrograph Report

Hyd. No. 2

DA-FR-050 DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.226 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.10 hrs
Time interval	= 1 min	Hyd. volume	= 1,130 cuft
Drainage area	= 0.740 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.245 x 48) + (0.497 x 58)] / 0.740

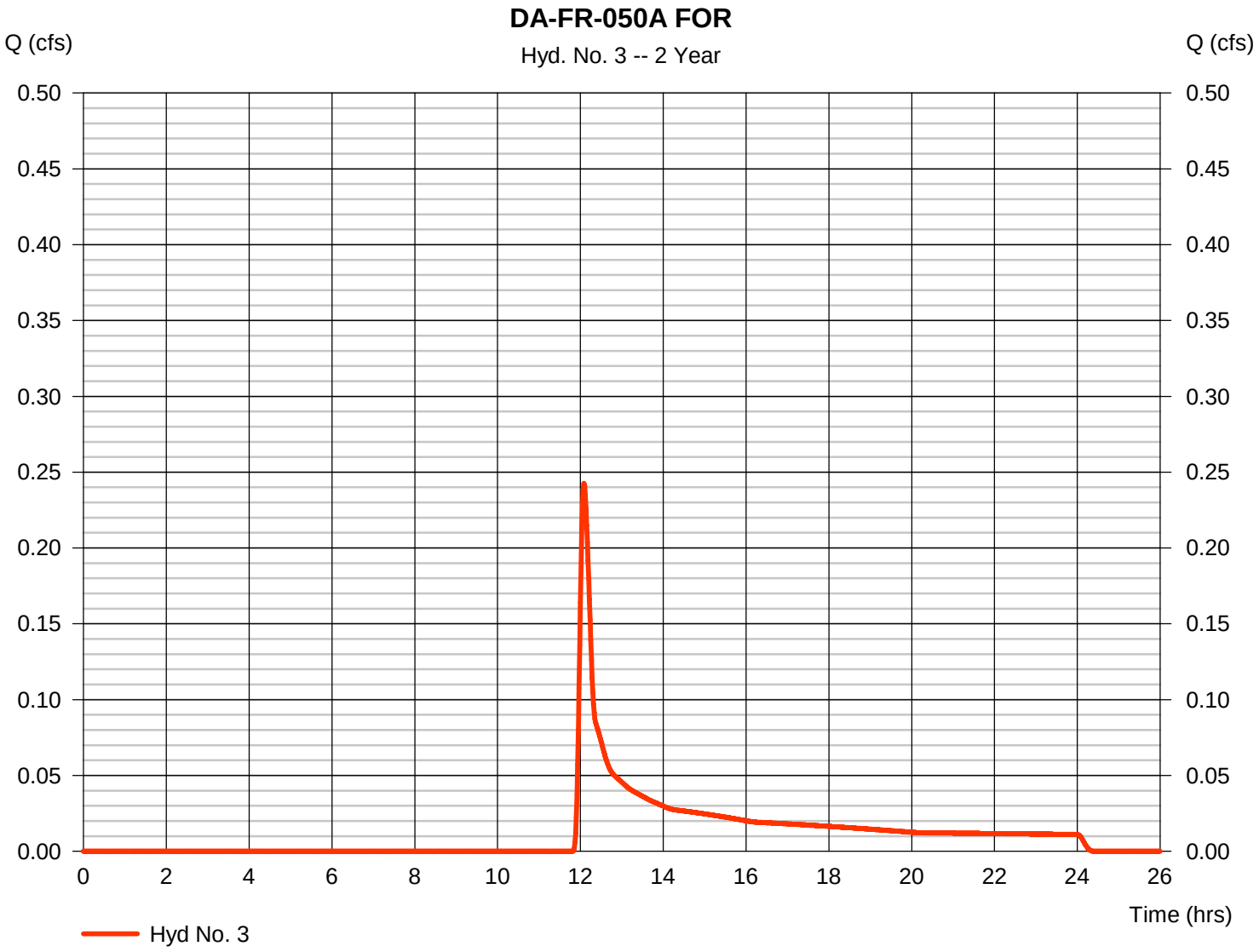


Hydrograph Report

Hyd. No. 3

DA-FR-050A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.243 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.08 hrs
Time interval	= 1 min	Hyd. volume	= 1,116 cuft
Drainage area	= 0.740 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.385	1	723	4,021	------	------	------	DA-FR-050A PRE
2	SCS Runoff	1.144	1	724	3,668	------	------	------	DA-FR-050 DEV
3	SCS Runoff	1.212	1	723	3,622	------	------	------	DA-FR-050A FOR

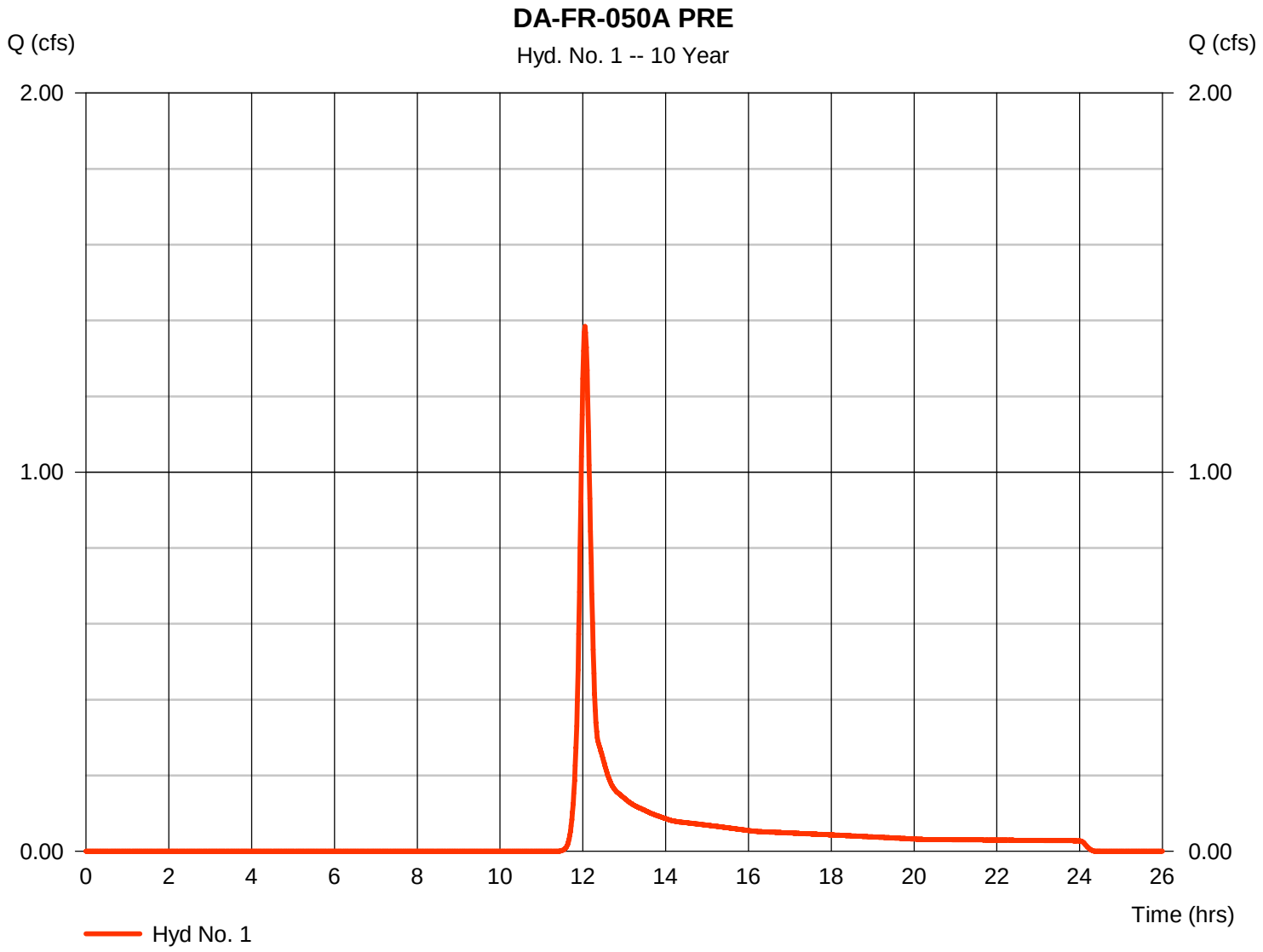
Hydrograph Report

Hyd. No. 1

DA-FR-050A PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.385 cfs
Storm frequency	=	10 yrs	Time to peak	=	12.05 hrs
Time interval	=	1 min	Hyd. volume	=	4,021 cuft
Drainage area	=	0.740 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.00 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.464 x 58) + (0.278 x 55)] / 0.740



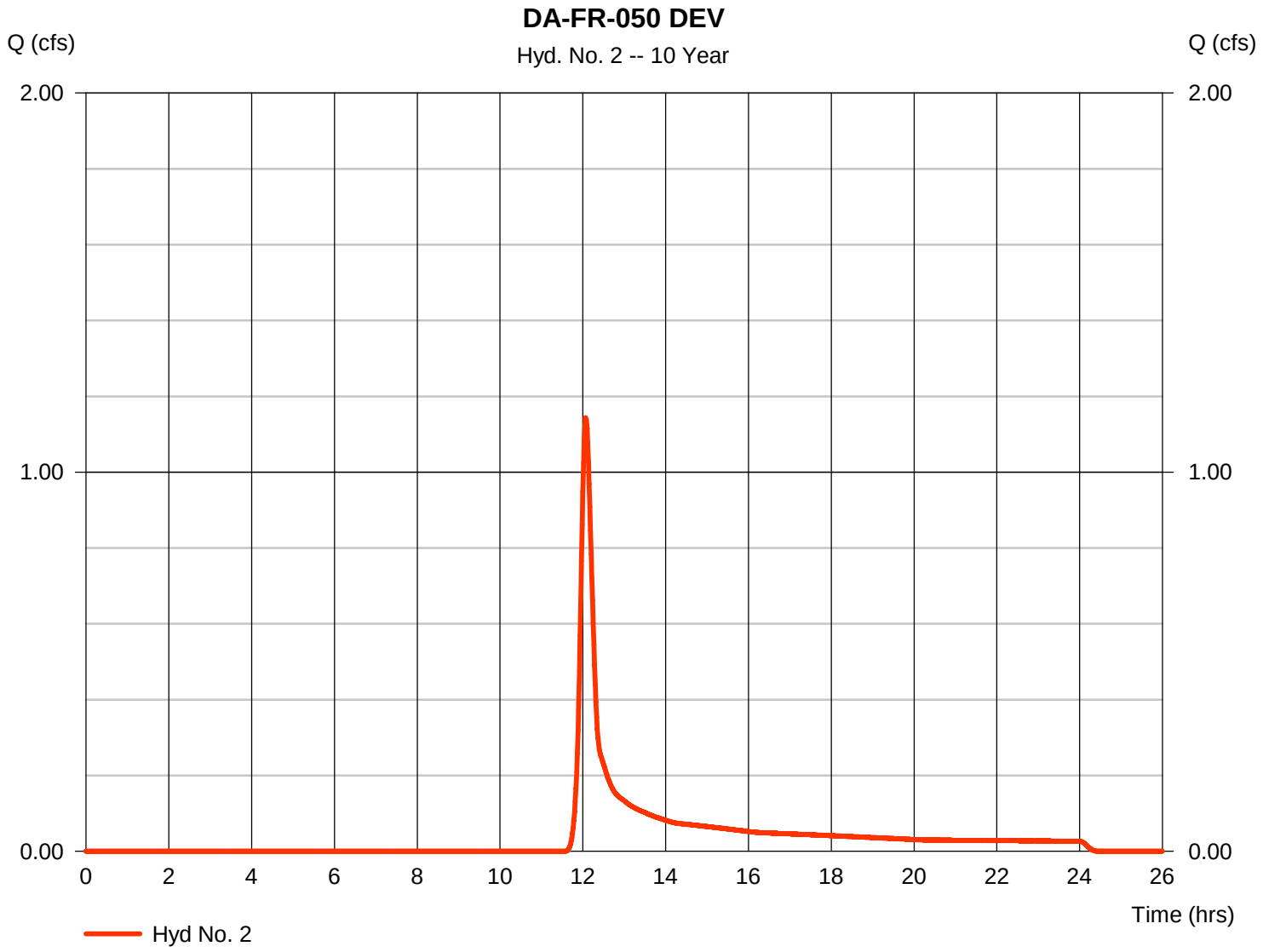
Hydrograph Report

Hyd. No. 2

DA-FR-050 DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.144 cfs
Storm frequency	=	10 yrs	Time to peak	=	12.07 hrs
Time interval	=	1 min	Hyd. volume	=	3,668 cuft
Drainage area	=	0.740 ac	Curve number	=	55*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.30 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.245 x 48) + (0.497 x 58)] / 0.740

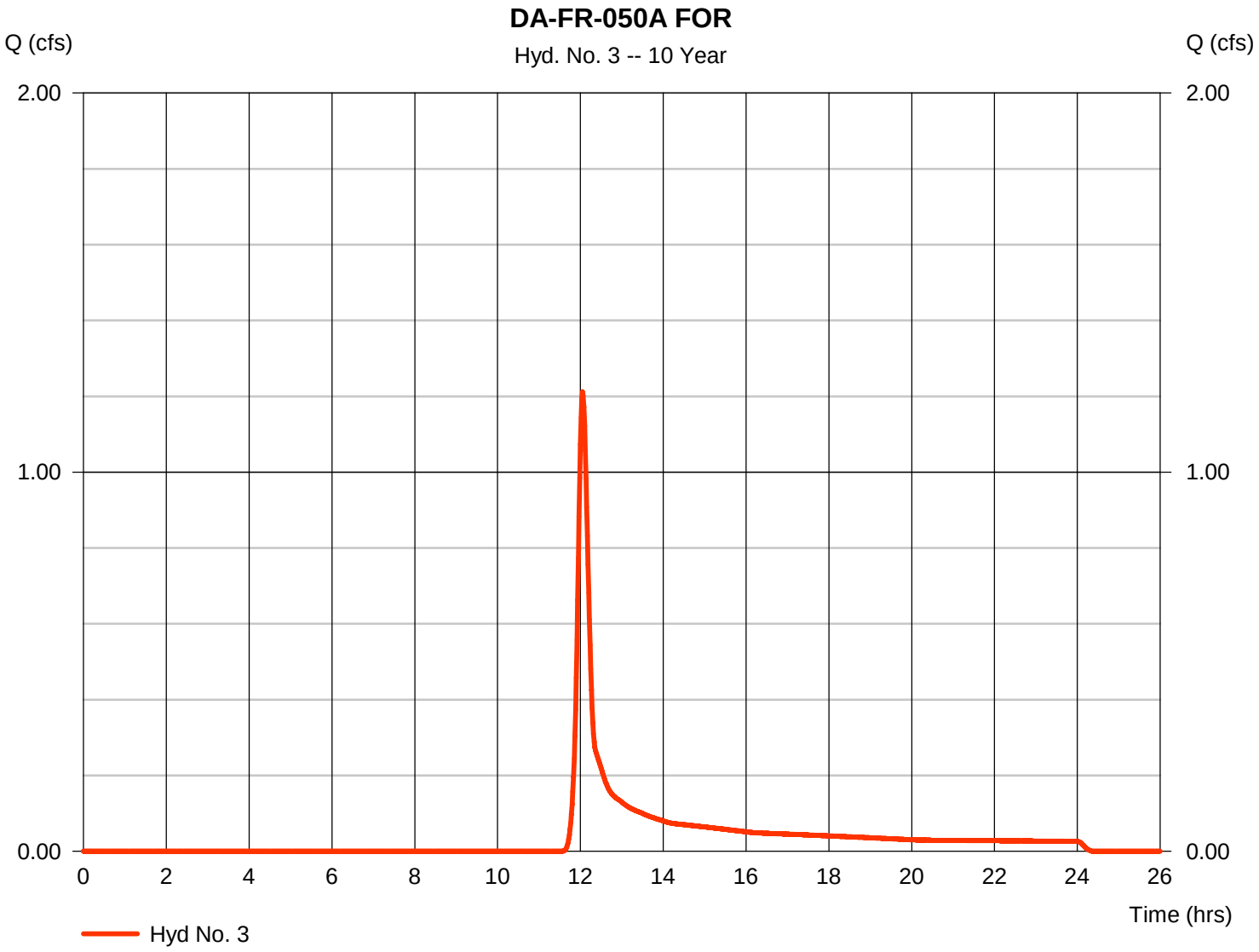


Hydrograph Report

Hyd. No. 3

DA-FR-050A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.212 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.05 hrs
Time interval	= 1 min	Hyd. volume	= 3,622 cuft
Drainage area	= 0.740 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.p

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-050B

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.743	3991
Developed Condition	0.743	3991
Pre-Developed (Forest) Condition	0.486	3265

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.743 ≤ 0.743 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.743 ≤ 0.743 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.743 *shall not* be required to be ≤ 0.398

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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Watershed Model Schematic

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-050B PRE
2	SCS Runoff	DA-FR-050B DEV
3	SCS Runoff	DA-FR-050B FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.743	1.322	-------	-------	5.592	-------	-------	-------	DA-FR-050B PRE
2	SCS Runoff	------	0.743	1.322	-------	-------	5.592	-------	-------	-------	DA-FR-050B DEV
3	SCS Runoff	------	0.486	0.966	-------	-------	4.883	-------	-------	-------	DA-FR-050B FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.743	1	727	3,991	------	------	------	DA-FR-050B PRE
2	SCS Runoff	0.743	1	727	3,991	------	------	------	DA-FR-050B DEV
3	SCS Runoff	0.486	1	727	3,265	------	------	------	DA-FR-050B FOR

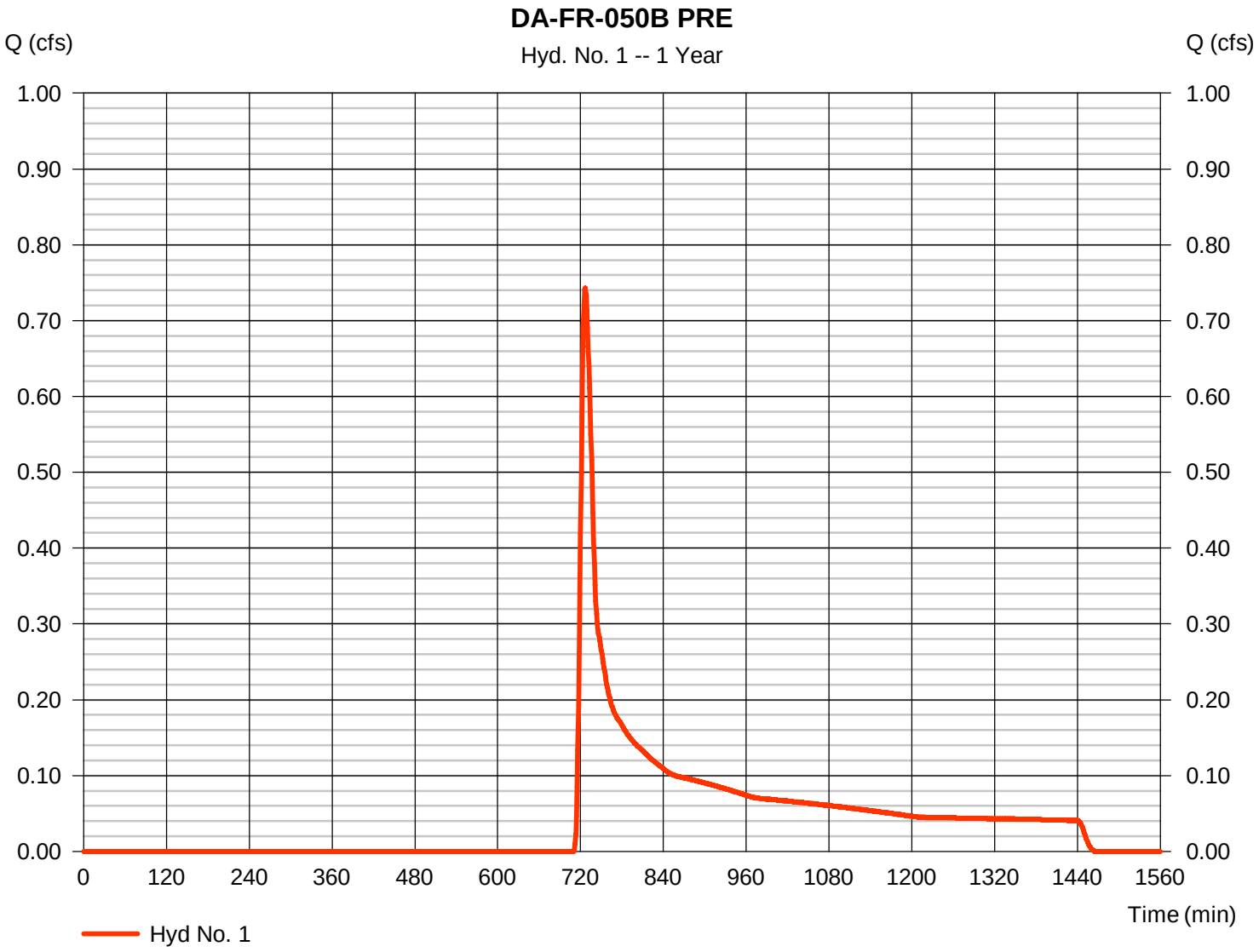
Hydrograph Report

Hyd. No. 1

DA-FR-050B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.743 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 3,991 cuft
Drainage area	= 3.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 16.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(2.482 x 58) + (0.675 x 55)] / 3.160



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-050B PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 3.57		0.00		0.00		
Travel Time (min)	**= 15.84**	**+**	**0.00**	**+**	**0.00**	**=**	**15.84**
Shallow Concentrated Flow							
Flow length (ft)	= 353.27		0.00		0.00		
Watercourse slope (%)	= 20.09		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.23		0.00		0.00		
Travel Time (min)	**= 0.81**	**+**	**0.00**	**+**	**0.00**	**=**	**0.81**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 16.70 min

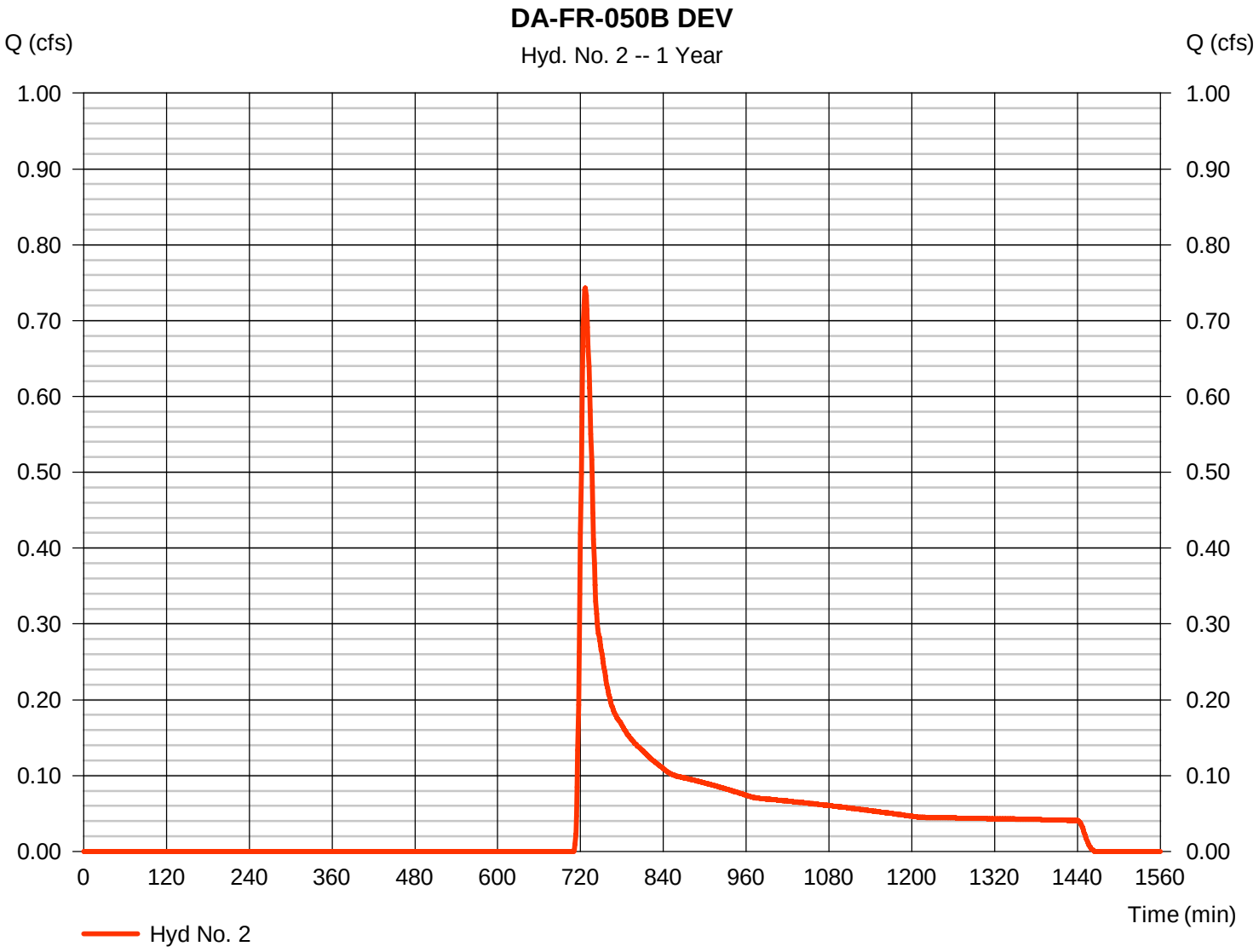
Hydrograph Report

Hyd. No. 2

DA-FR-050B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.743 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 3,991 cuft
Drainage area	= 3.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 16.60 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.318 x 48) + (2.703 x 58) + (0.135 x 55)] / 3.160



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-050B DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 3.57		0.00		0.00		
Travel Time (min)	**= 15.84**	**+**	**0.00**	**+**	**0.00**	**=**	**15.84**
Shallow Concentrated Flow							
Flow length (ft)	= 300.79		35.78		0.00		
Watercourse slope (%)	= 19.65		32.07		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=7.15		9.14		0.00		
Travel Time (min)	**= 0.70**	**+**	**0.07**	**+**	**0.00**	**=**	**0.77**
Channel Flow							
X sectional flow area (sqft)	= 2.00		0.00		0.00		
Wetted perimeter (ft)	= 4.47		0.00		0.00		
Channel slope (%)	= 5.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=4.86						
			0.00				
					0.00		
Flow length (ft)	({0})10.5		0.0		0.0		
Travel Time (min)	**= 0.04**	**+**	**0.00**	**+**	**0.00**	**=**	**0.04**

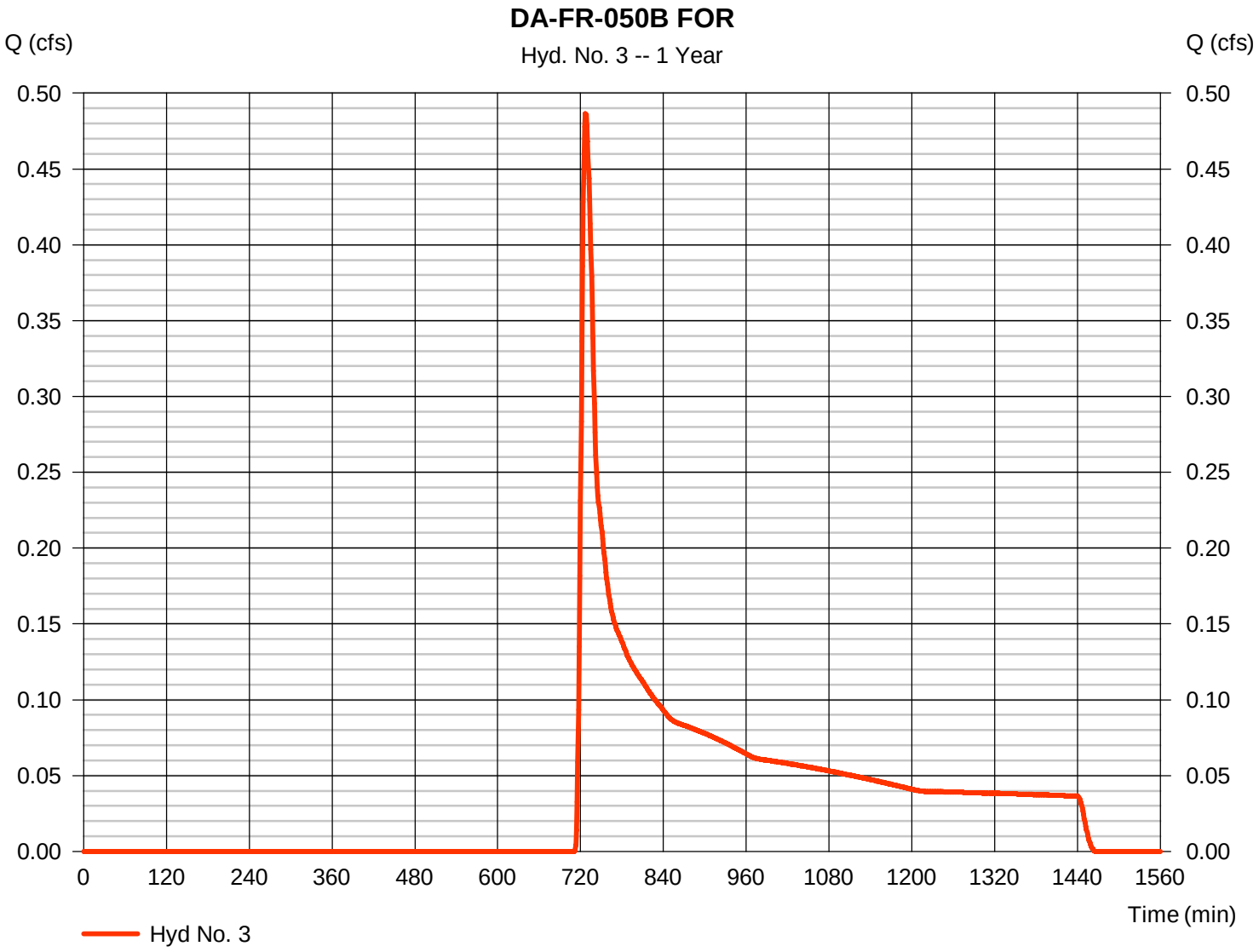
Total Travel Time, Tc ..... 16.60 min

Hydrograph Report

Hyd. No. 3

DA-FR-050B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.486 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 3,265 cuft
Drainage area	= 3.160 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 16.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-050B FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 3.57		0.00		0.00		
Travel Time (min)	**= 15.84**	**+**	**0.00**	**+**	**0.00**	**=**	**15.84**
Shallow Concentrated Flow							
Flow length (ft)	= 353.27		0.00		0.00		
Watercourse slope (%)	= 20.09		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.23		0.00		0.00		
Travel Time (min)	**= 0.81**	**+**	**0.00**	**+**	**0.00**	**=**	**0.81**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 16.70 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.322	1	726	5,727	------	------	------	DA-FR-050B PRE
2	SCS Runoff	1.322	1	726	5,727	------	------	------	DA-FR-050B DEV
3	SCS Runoff	0.966	1	726	4,827	------	------	------	DA-FR-050B FOR

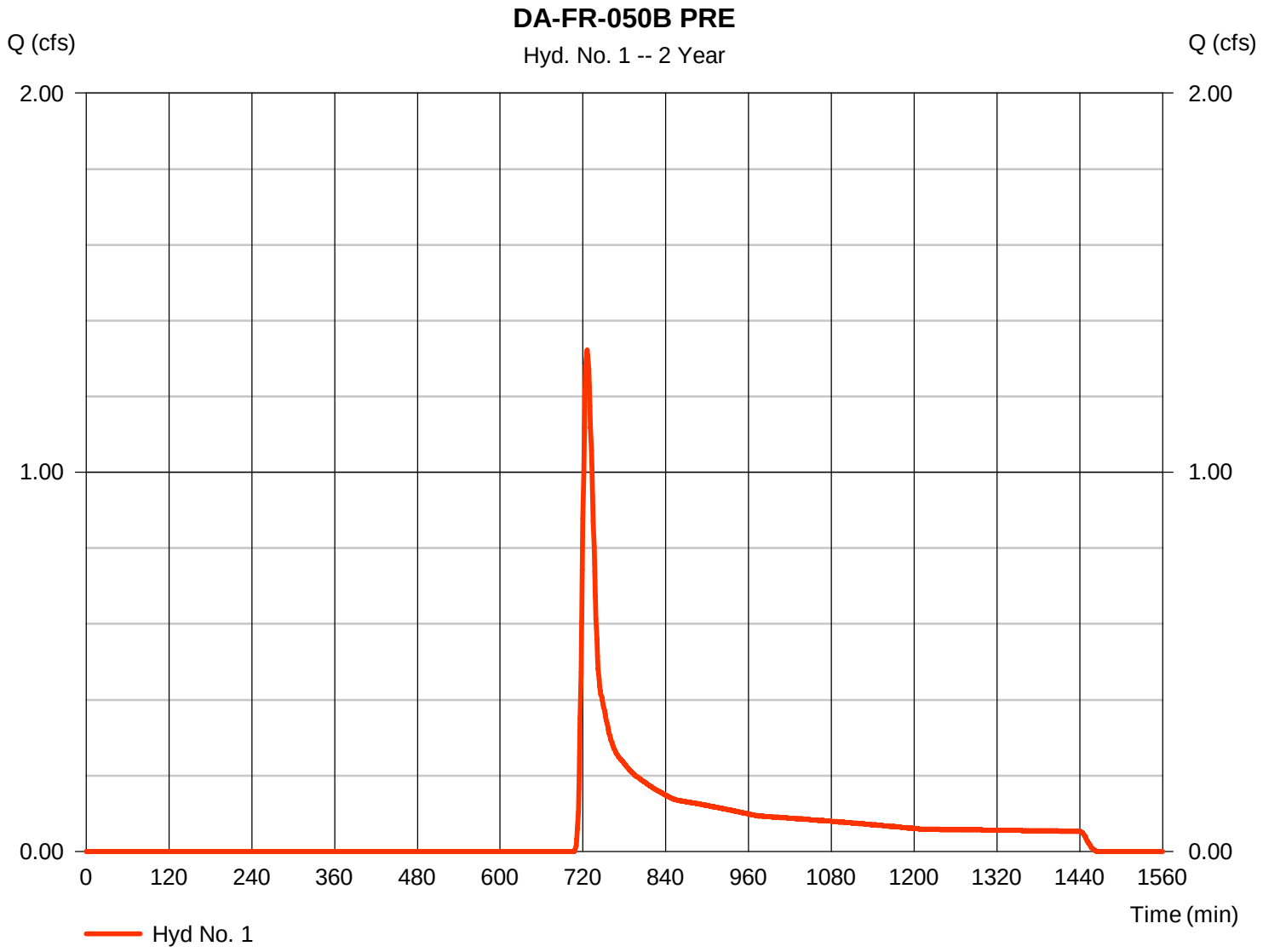
Hydrograph Report

Hyd. No. 1

DA-FR-050B PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.322 cfs
Storm frequency	=	2 yrs	Time to peak	=	726 min
Time interval	=	1 min	Hyd. volume	=	5,727 cuft
Drainage area	=	3.160 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	16.70 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(2.482 x 58) + (0.675 x 55)] / 3.160



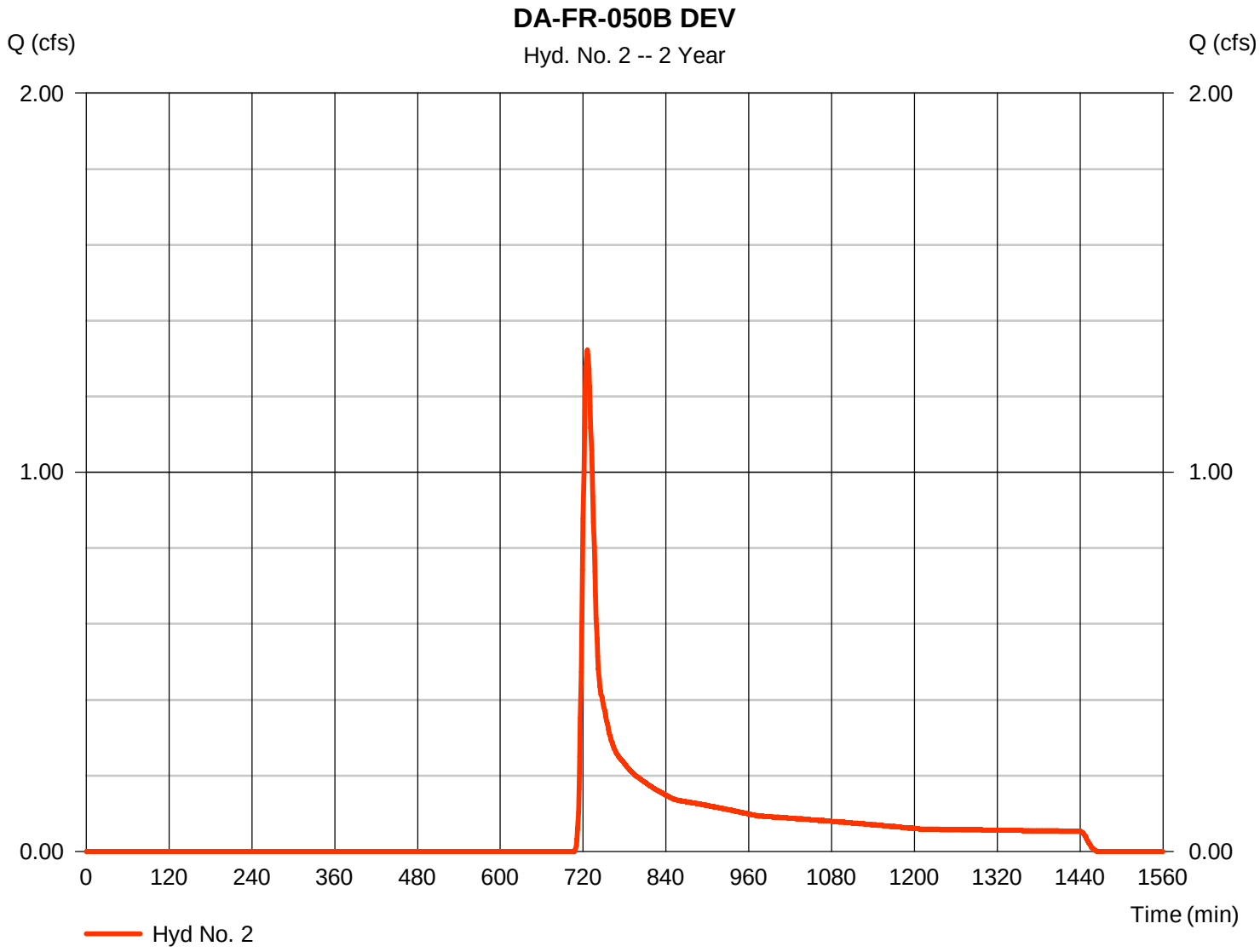
Hydrograph Report

Hyd. No. 2

DA-FR-050B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 1.322 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 5,727 cuft
Drainage area	= 3.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 16.60 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.318 x 48) + (2.703 x 58) + (0.135 x 55)] / 3.160

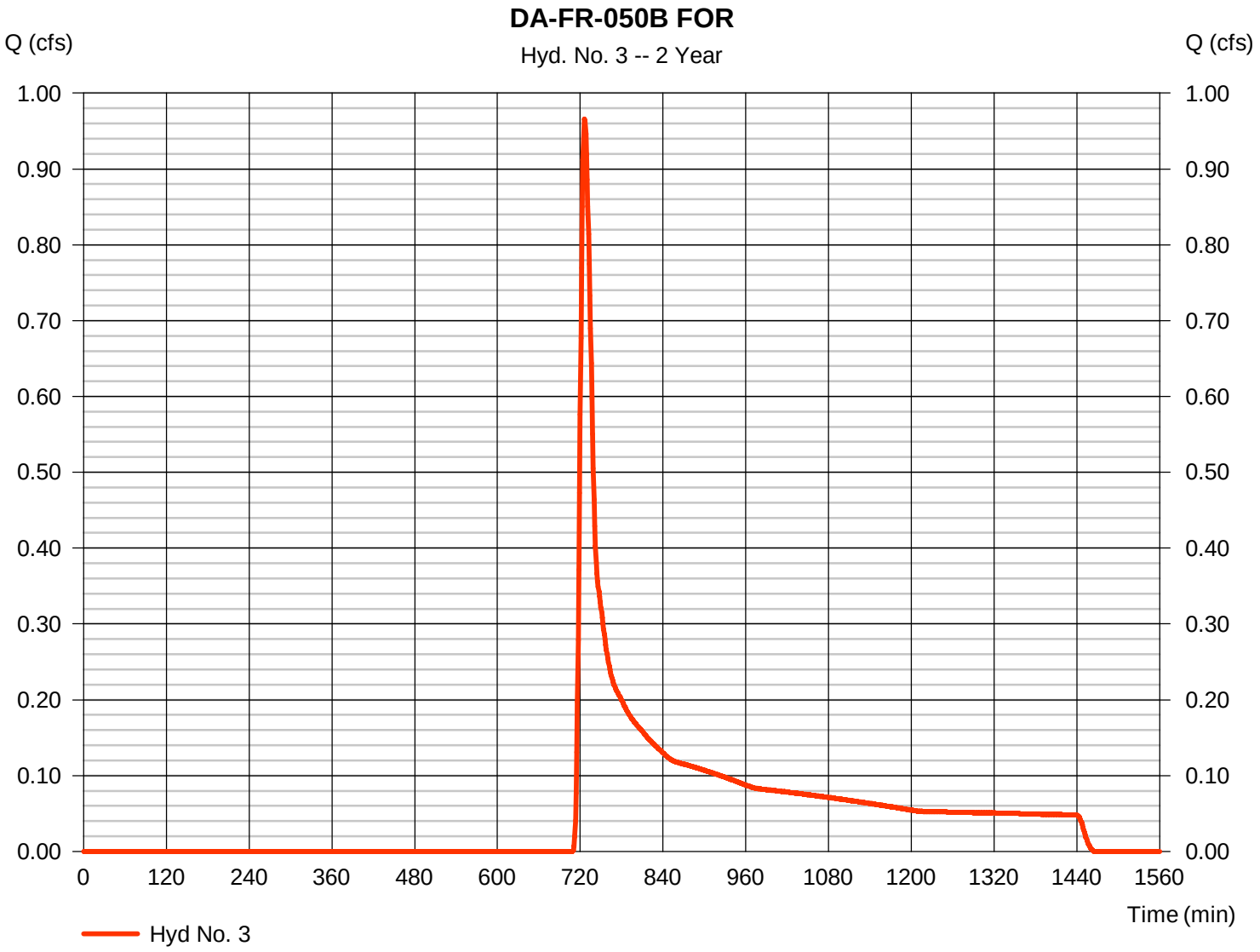


Hydrograph Report

Hyd. No. 3

DA-FR-050B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.966 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 4,827 cuft
Drainage area	= 3.160 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 16.70 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	5.592	1	724	17,385	------	------	------	DA-FR-050B PRE
2	SCS Runoff	5.592	1	724	17,385	------	------	------	DA-FR-050B DEV
3	SCS Runoff	4.883	1	724	15,662	------	------	------	DA-FR-050B FOR

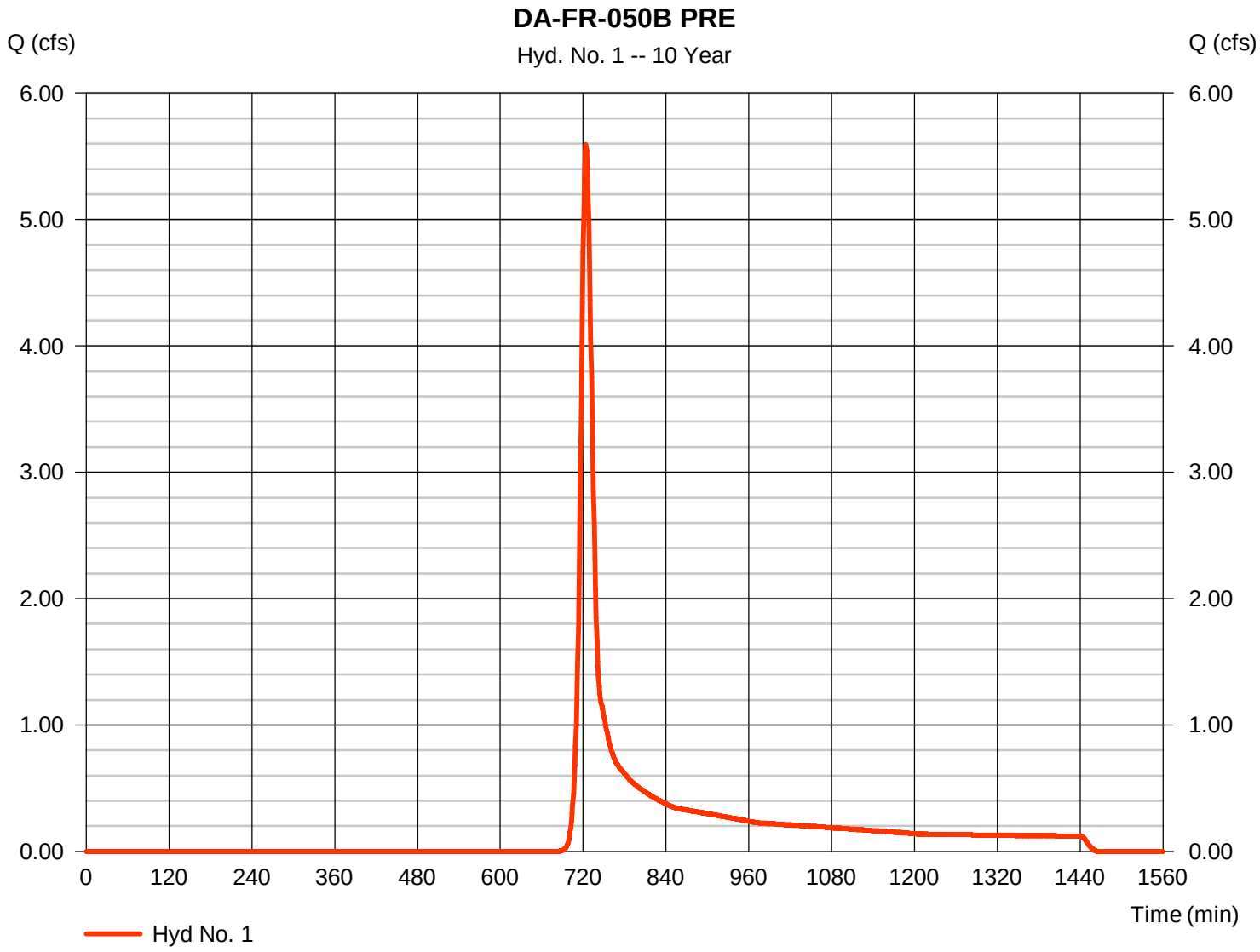
Hydrograph Report

Hyd. No. 1

DA-FR-050B PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.592 cfs
Storm frequency	=	10 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	17,385 cuft
Drainage area	=	3.160 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	16.70 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(2.482 x 58) + (0.675 x 55)] / 3.160



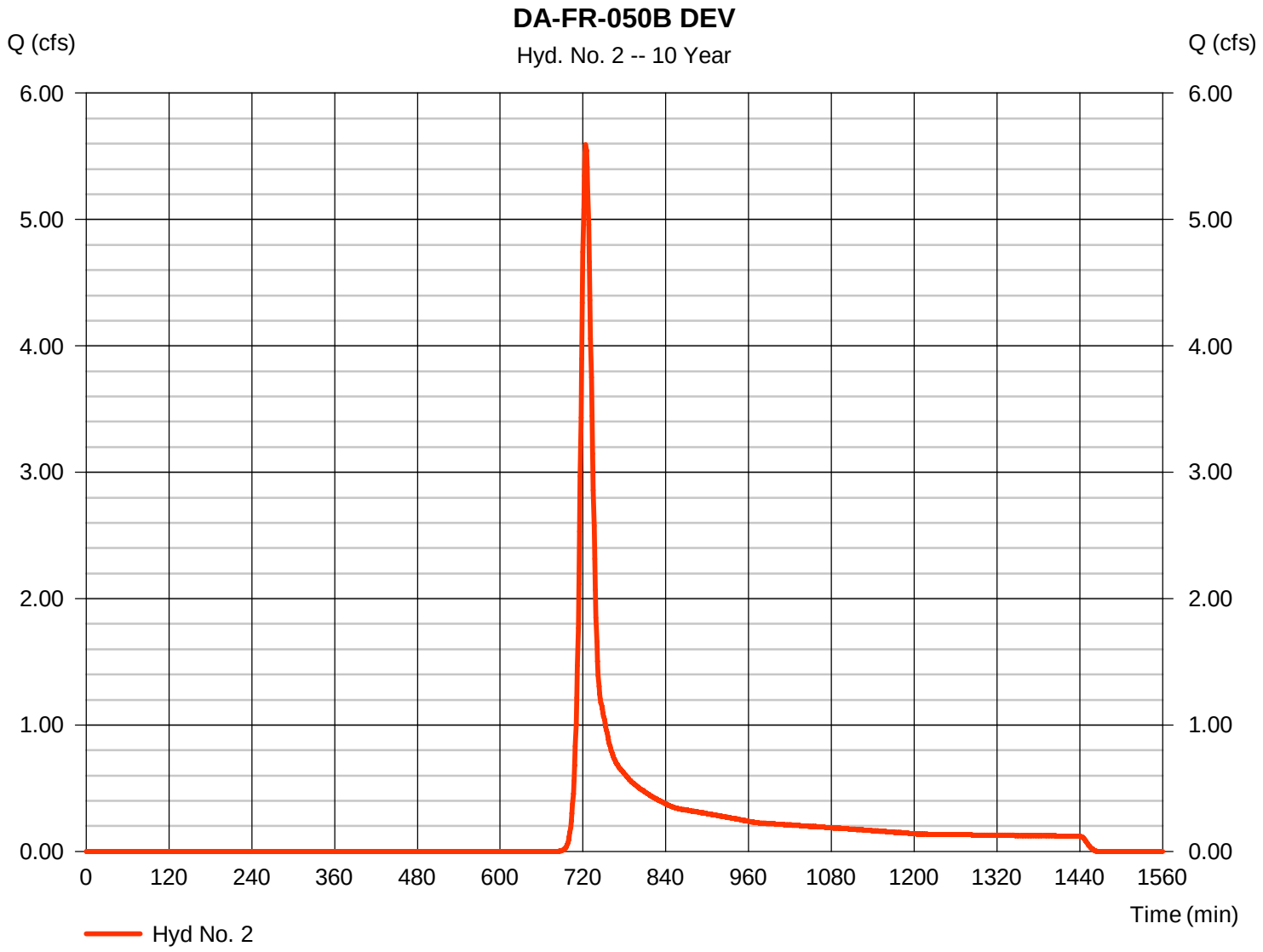
Hydrograph Report

Hyd. No. 2

DA-FR-050B DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.592 cfs
Storm frequency	=	10 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	17,385 cuft
Drainage area	=	3.160 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	16.60 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.318 x 48) + (2.703 x 58) + (0.135 x 55)] / 3.160

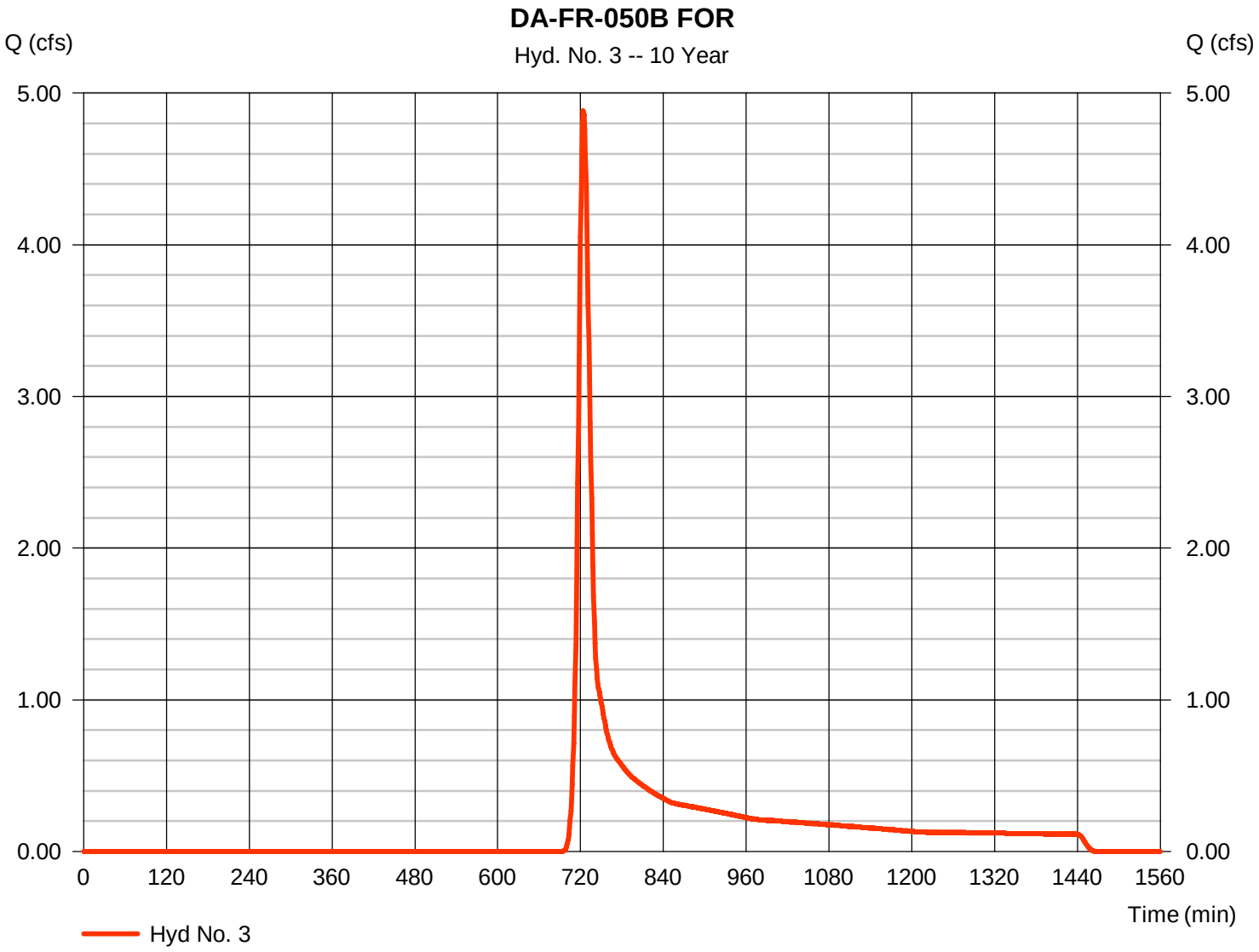


Hydrograph Report

Hyd. No. 3

DA-FR-050B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 4.883 cfs
Storm frequency	= 10 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 15,662 cuft
Drainage area	= 3.160 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 16.70 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-050C

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.336	1806
Developed Condition	0.220	1477
Pre-Developed (Forest) Condition	0.220	1477

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.220 ≤ 0.329 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.220 ≤ 0.336 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.220 *shall not* be required to be ≤ 0.220

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-050C PRE
2	SCS Runoff	DA-FR-050C DEV
3	SCS Runoff	DA-FR-050C FOR

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.336	0.598	-------	-------	2.530	-------	-------	-------	DA-FR-050C PRE
2	SCS Runoff	------	0.220	0.437	-------	-------	2.210	-------	-------	-------	DA-FR-050C DEV
3	SCS Runoff	------	0.220	0.437	-------	-------	2.210	-------	-------	-------	DA-FR-050C FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.336	1	727	1,806	------	------	------	DA-FR-050C PRE
2	SCS Runoff	0.220	1	727	1,477	------	------	------	DA-FR-050C DEV
3	SCS Runoff	0.220	1	727	1,477	------	------	------	DA-FR-050C FOR

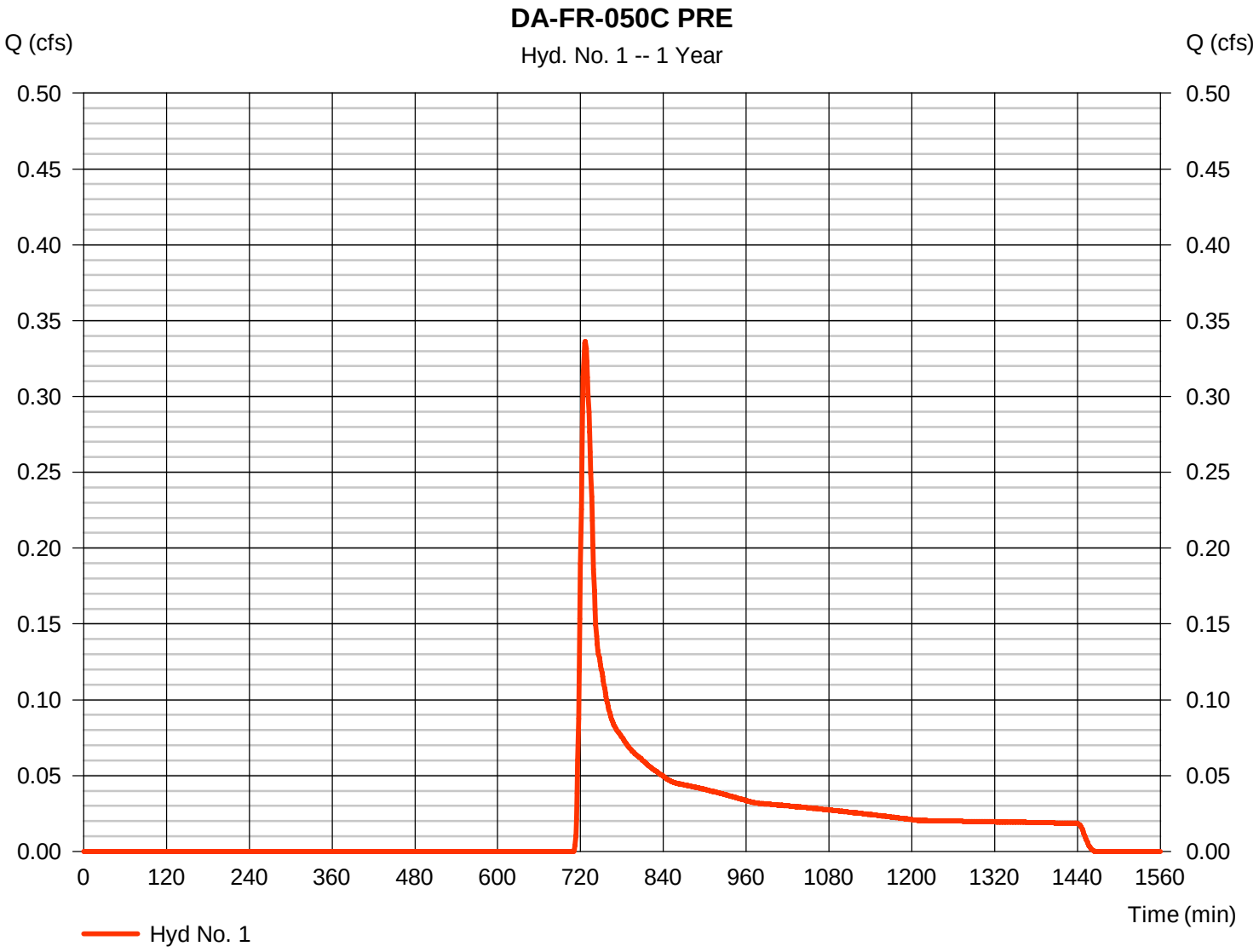
Hydrograph Report

Hyd. No. 1

DA-FR-050C PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.336 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 1,806 cuft
Drainage area	= 1.430 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.811 x 58) + (0.616 x 55)] / 1.430



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-050C PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.38		0.00		0.00		
Travel Time (min)	**= 14.60**	**+**	**0.00**	**+**	**0.00**	**=**	**14.60**
Shallow Concentrated Flow							
Flow length (ft)	= 348.16		0.00		0.00		
Watercourse slope (%)	= 14.89		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.23		0.00		0.00		
Travel Time (min)	**= 0.93**	**+**	**0.00**	**+**	**0.00**	**=**	**0.93**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.50 min

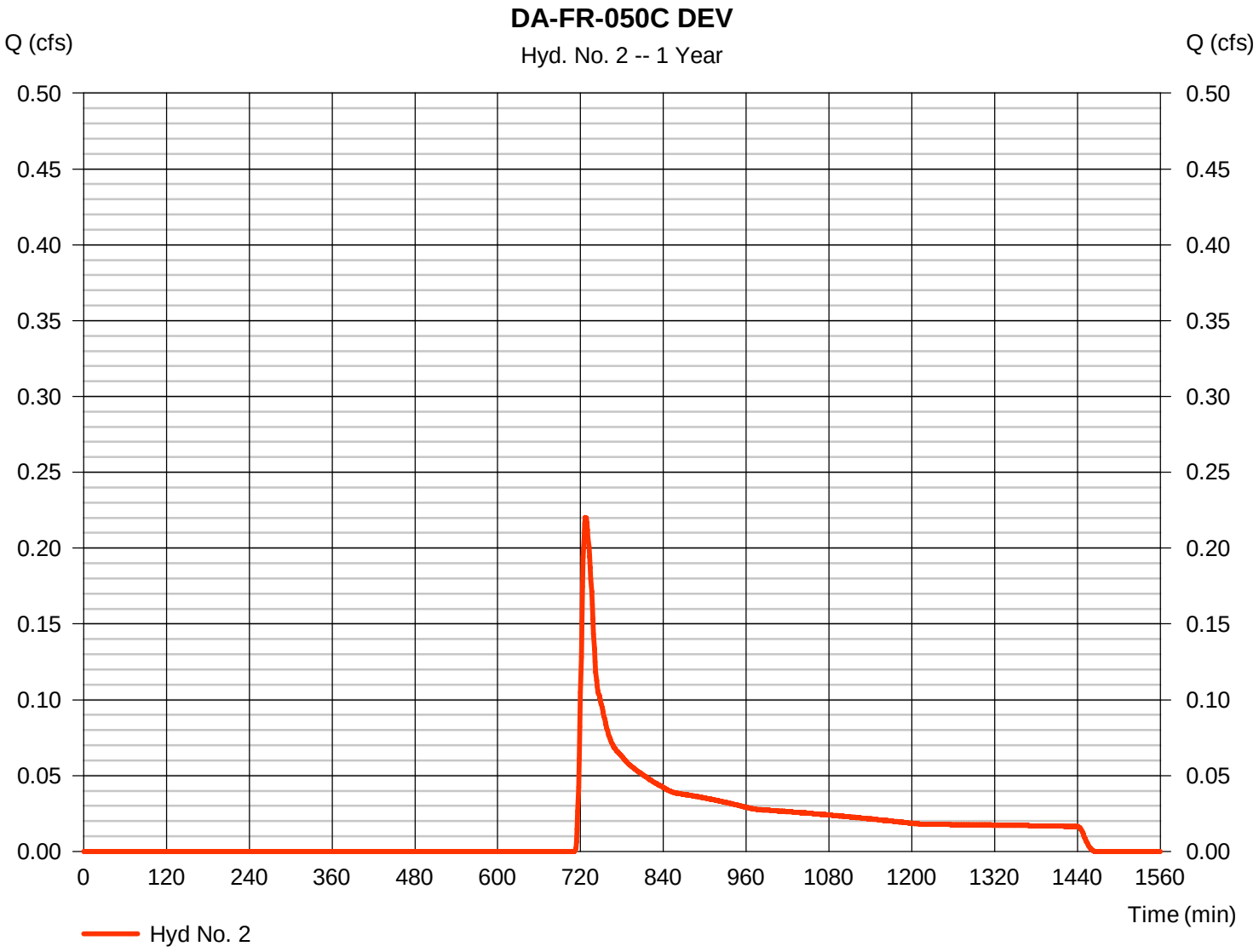
Hydrograph Report

Hyd. No. 2

DA-FR-050C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.220 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 1,477 cuft
Drainage area	= 1.430 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.391 x 48) + (1.001 x 58) + (0.034 x 55)] / 1.430



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-050C DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.38		0.00		0.00		
Travel Time (min)	**= 14.60**	**+**	**0.00**	**+**	**0.00**	**=**	**14.60**
Shallow Concentrated Flow							
Flow length (ft)	= 348.16		0.00		0.00		
Watercourse slope (%)	= 14.89		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.23		0.00		0.00		
Travel Time (min)	**= 0.93**	**+**	**0.00**	**+**	**0.00**	**=**	**0.93**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

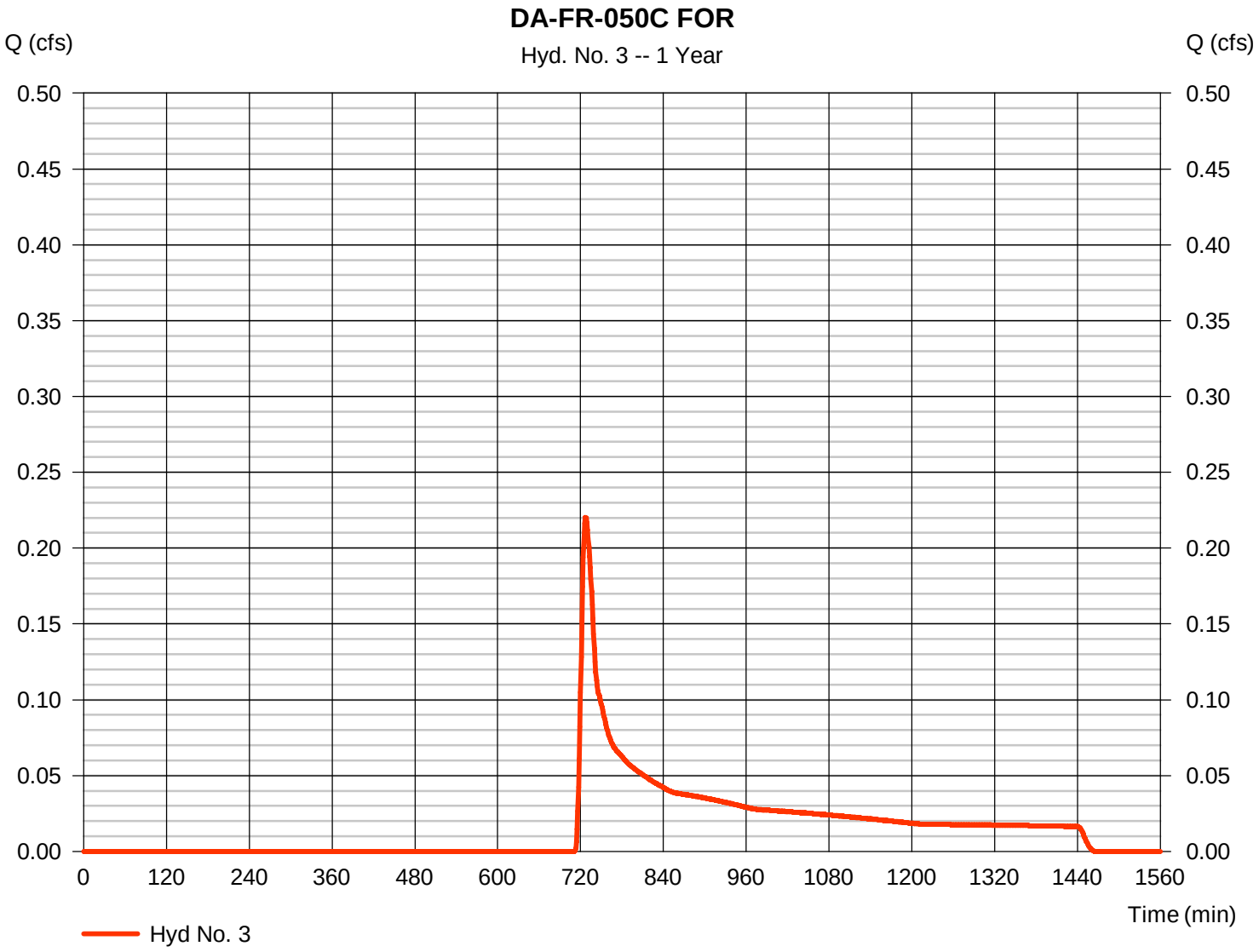
Total Travel Time, Tc ..... 15.50 min

Hydrograph Report

Hyd. No. 3

DA-FR-050C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.220 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 1,477 cuft
Drainage area	= 1.430 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-050C FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.38		0.00		0.00		
Travel Time (min)	**= 14.60**	**+**	**0.00**	**+**	**0.00**	**=**	**14.60**
Shallow Concentrated Flow							
Flow length (ft)	= 348.16		0.00		0.00		
Watercourse slope (%)	= 14.89		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.23		0.00		0.00		
Travel Time (min)	**= 0.93**	**+**	**0.00**	**+**	**0.00**	**=**	**0.93**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.50 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.598	1	726	2,592	------	------	------	DA-FR-050C PRE
2	SCS Runoff	0.437	1	726	2,184	------	------	------	DA-FR-050C DEV
3	SCS Runoff	0.437	1	726	2,184	------	------	------	DA-FR-050C FOR

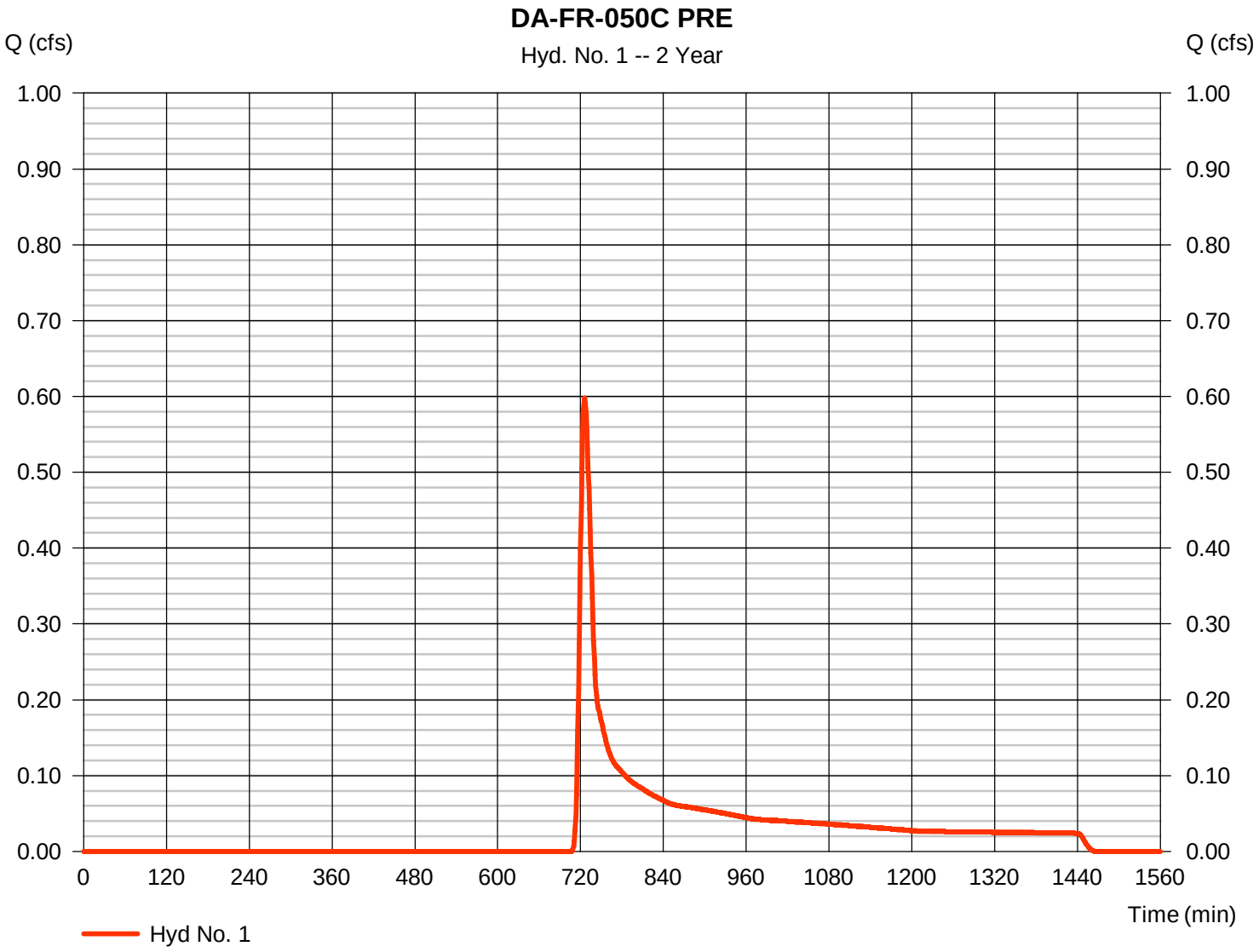
Hydrograph Report

Hyd. No. 1

DA-FR-050C PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.598 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 2,592 cuft
Drainage area	= 1.430 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.811 x 58) + (0.616 x 55)] / 1.430



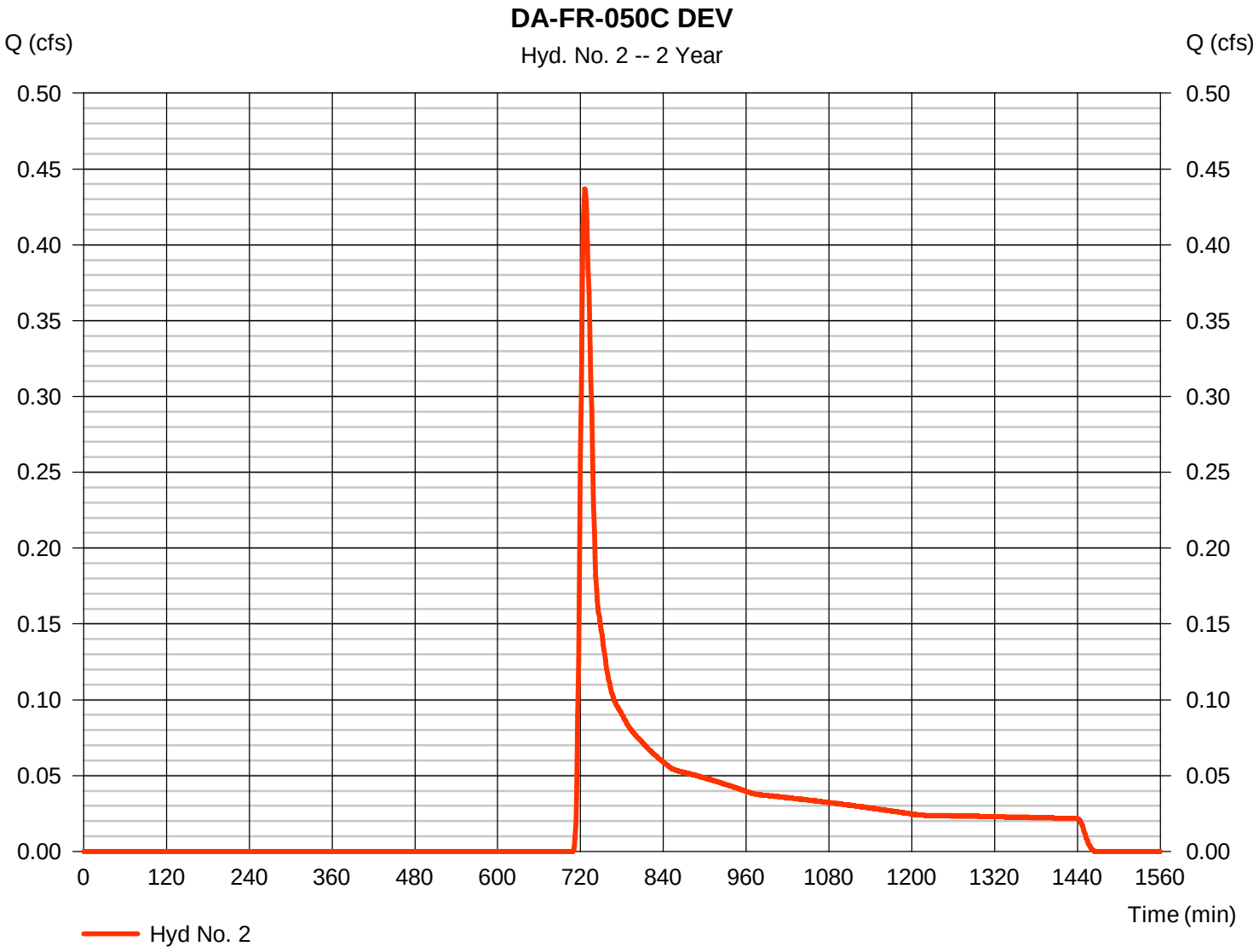
Hydrograph Report

Hyd. No. 2

DA-FR-050C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.437 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 2,184 cuft
Drainage area	= 1.430 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.391 x 48) + (1.001 x 58) + (0.034 x 55)] / 1.430

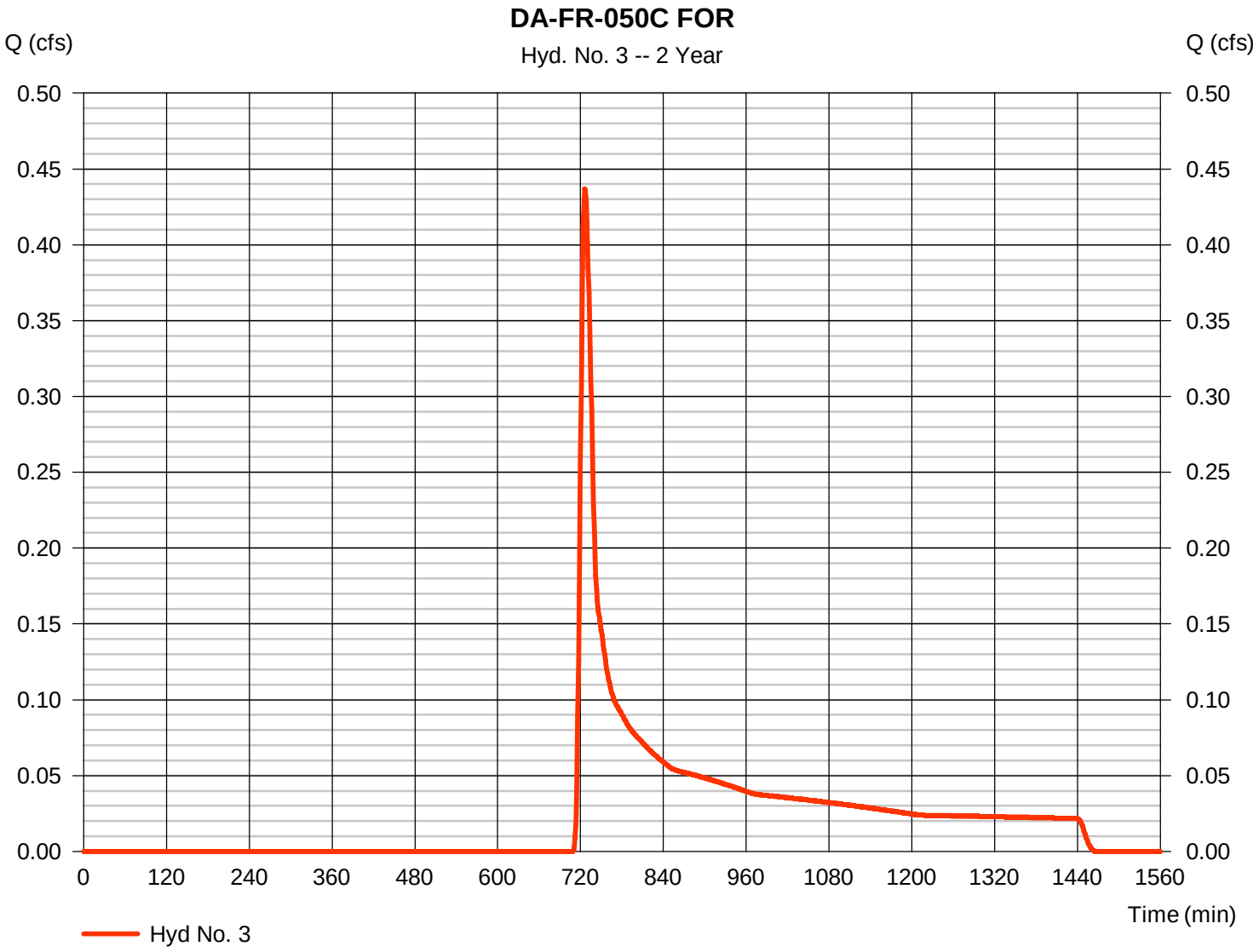


Hydrograph Report

Hyd. No. 3

DA-FR-050C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.437 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 2,184 cuft
Drainage area	= 1.430 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.530	1	724	7,867	------	------	------	DA-FR-050C PRE
2	SCS Runoff	2.210	1	724	7,087	------	------	------	DA-FR-050C DEV
3	SCS Runoff	2.210	1	724	7,087	------	------	------	DA-FR-050C FOR

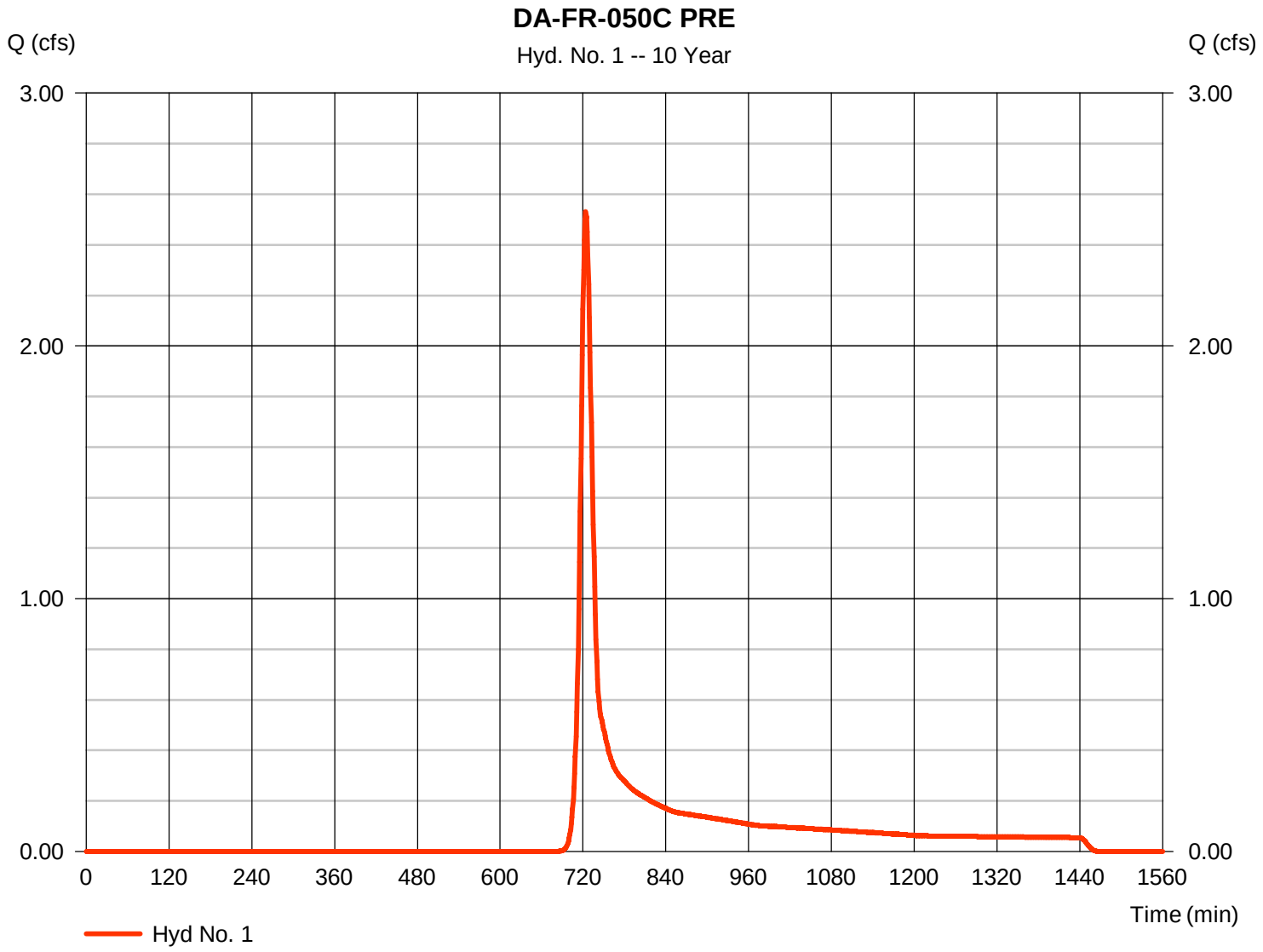
Hydrograph Report

Hyd. No. 1

DA-FR-050C PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 2.530 cfs
Storm frequency	= 10 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 7,867 cuft
Drainage area	= 1.430 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.811 x 58) + (0.616 x 55)] / 1.430



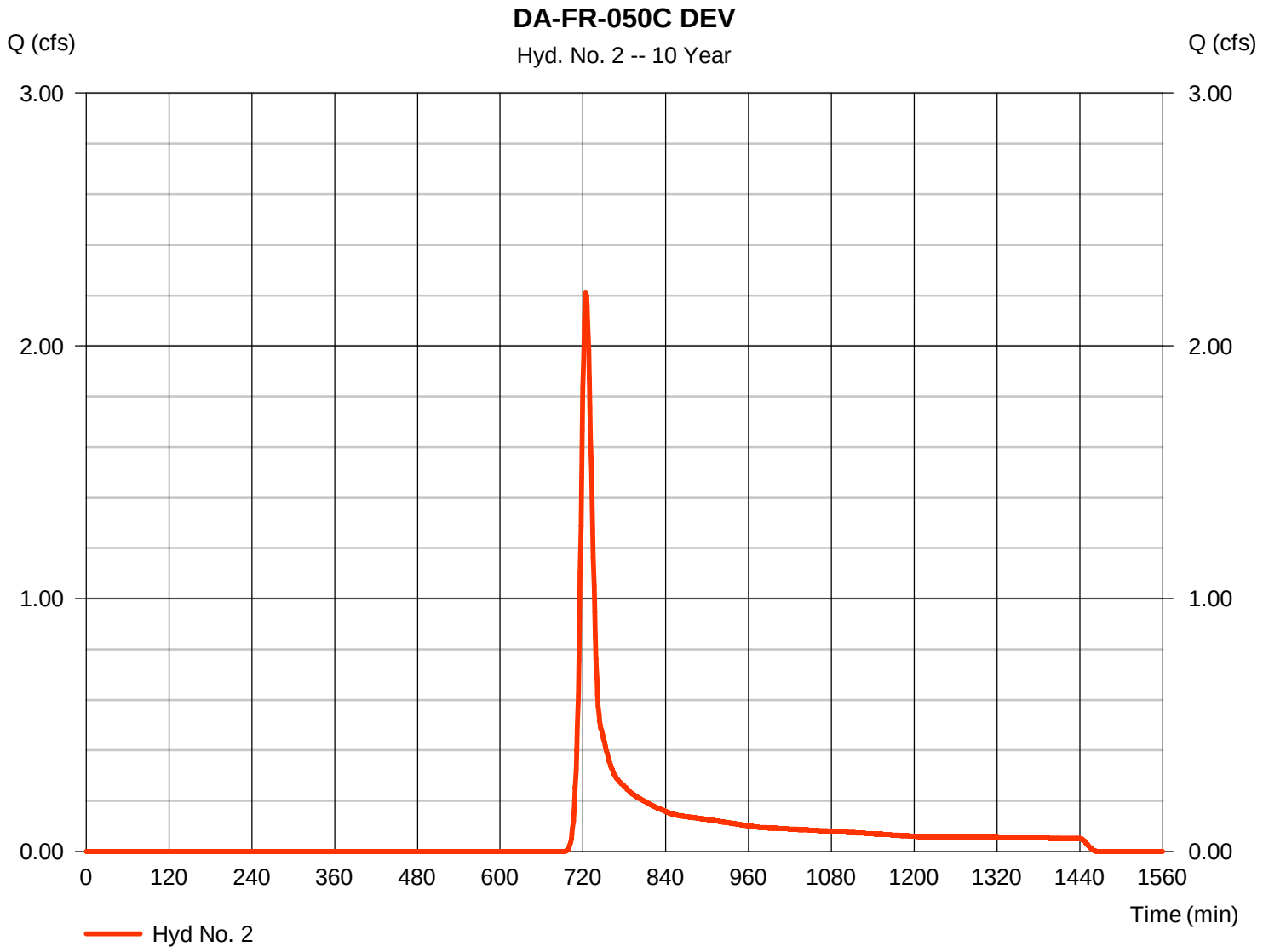
Hydrograph Report

Hyd. No. 2

DA-FR-050C DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.210 cfs
Storm frequency	=	10 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	7,087 cuft
Drainage area	=	1.430 ac	Curve number	=	55*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.50 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.391 x 48) + (1.001 x 58) + (0.034 x 55)] / 1.430

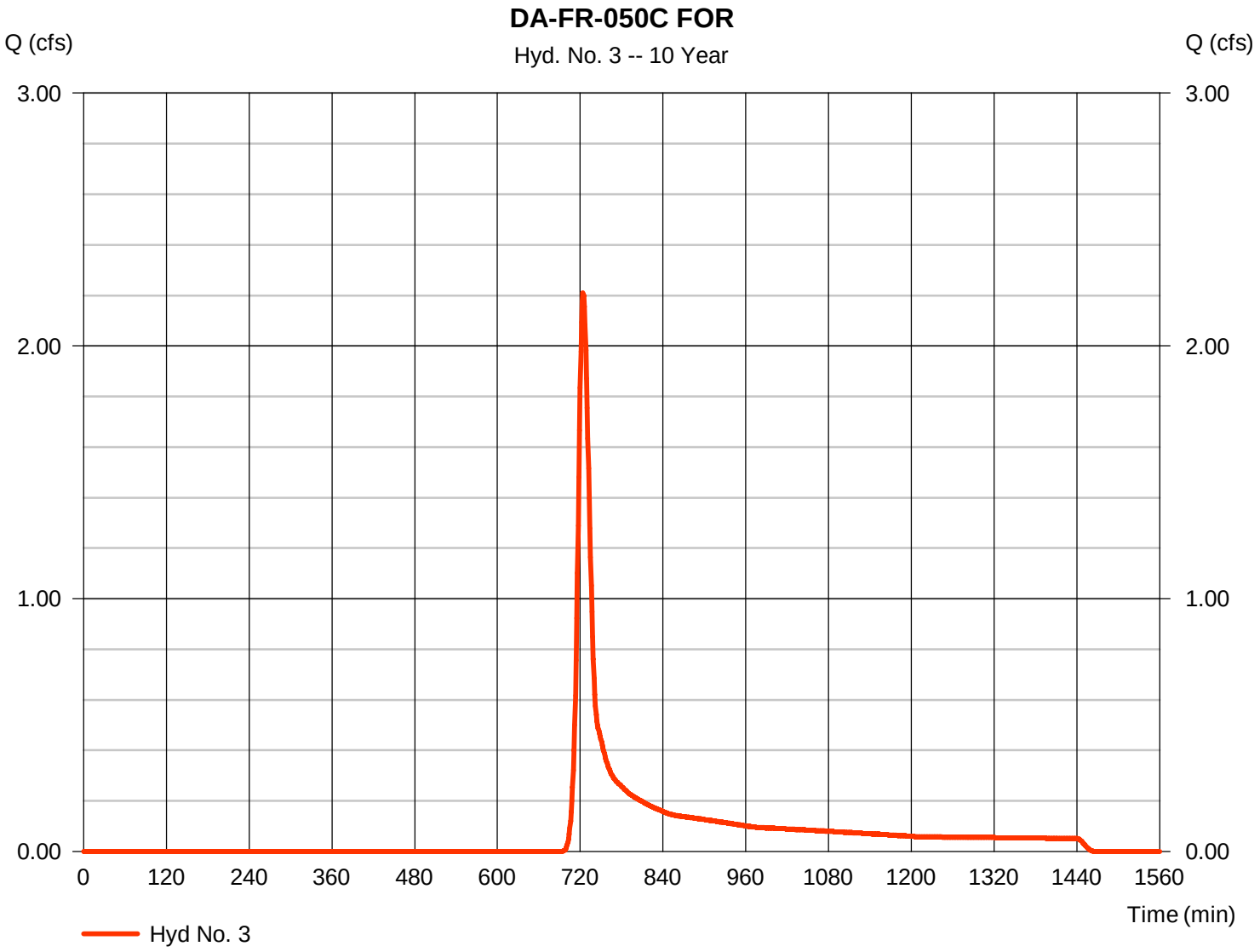


Hydrograph Report

Hyd. No. 3

DA-FR-050C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 2.210 cfs
Storm frequency	= 10 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 7,087 cuft
Drainage area	= 1.430 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-050D

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.233	1278
Developed Condition	0.144	1033
Pre-Developed (Forest) Condition	0.186	1153

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.144	≤ OK	0.231
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.144	≤ OK	0.233
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.144	*shall not* be required to be ≤	0.208

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-050D PRE
2	SCS Runoff	DA-FR-050D DEV
3	SCS Runoff	DA-FR-050D FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.233	0.436	-------	-------	1.982	-------	-------	-------	DA-FR-050D PRE
2	SCS Runoff	------	0.144	0.308	-------	-------	1.720	-------	-------	-------	DA-FR-050D DEV
3	SCS Runoff	------	0.186	0.370	-------	-------	1.851	-------	-------	-------	DA-FR-050D FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.233	1	726	1,278	------	------	------	DA-FR-050D PRE
2	SCS Runoff	0.144	1	727	1,033	------	------	------	DA-FR-050D DEV
3	SCS Runoff	0.186	1	726	1,153	------	------	------	DA-FR-050D FOR

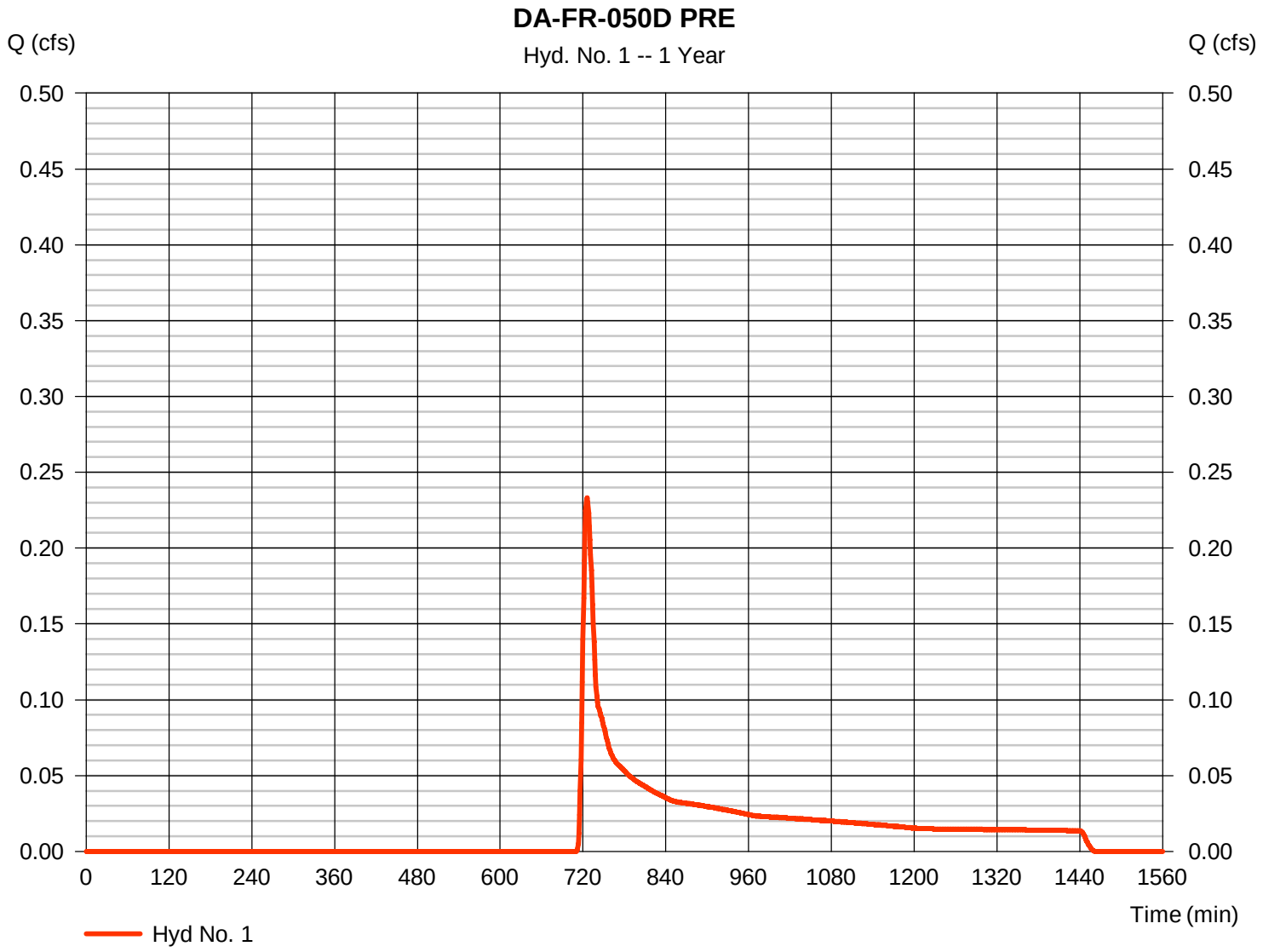
Hydrograph Report

Hyd. No. 1

DA-FR-050D PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.233 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 1,278 cuft
Drainage area	= 1.130 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.004 x 82) + (0.008 x 98) + (0.272 x 58) + (0.851 x 55)] / 1.130



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-050D PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.06		0.00		0.00		
Travel Time (min)	**= 13.78**	**+**	**0.00**	**+**	**0.00**	**=**	**13.78**
Shallow Concentrated Flow							
Flow length (ft)	= 227.43		0.00		0.00		
Watercourse slope (%)	= 12.35		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.67		0.00		0.00		
Travel Time (min)	**= 0.67**	**+**	**0.00**	**+**	**0.00**	**=**	**0.67**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.40 min

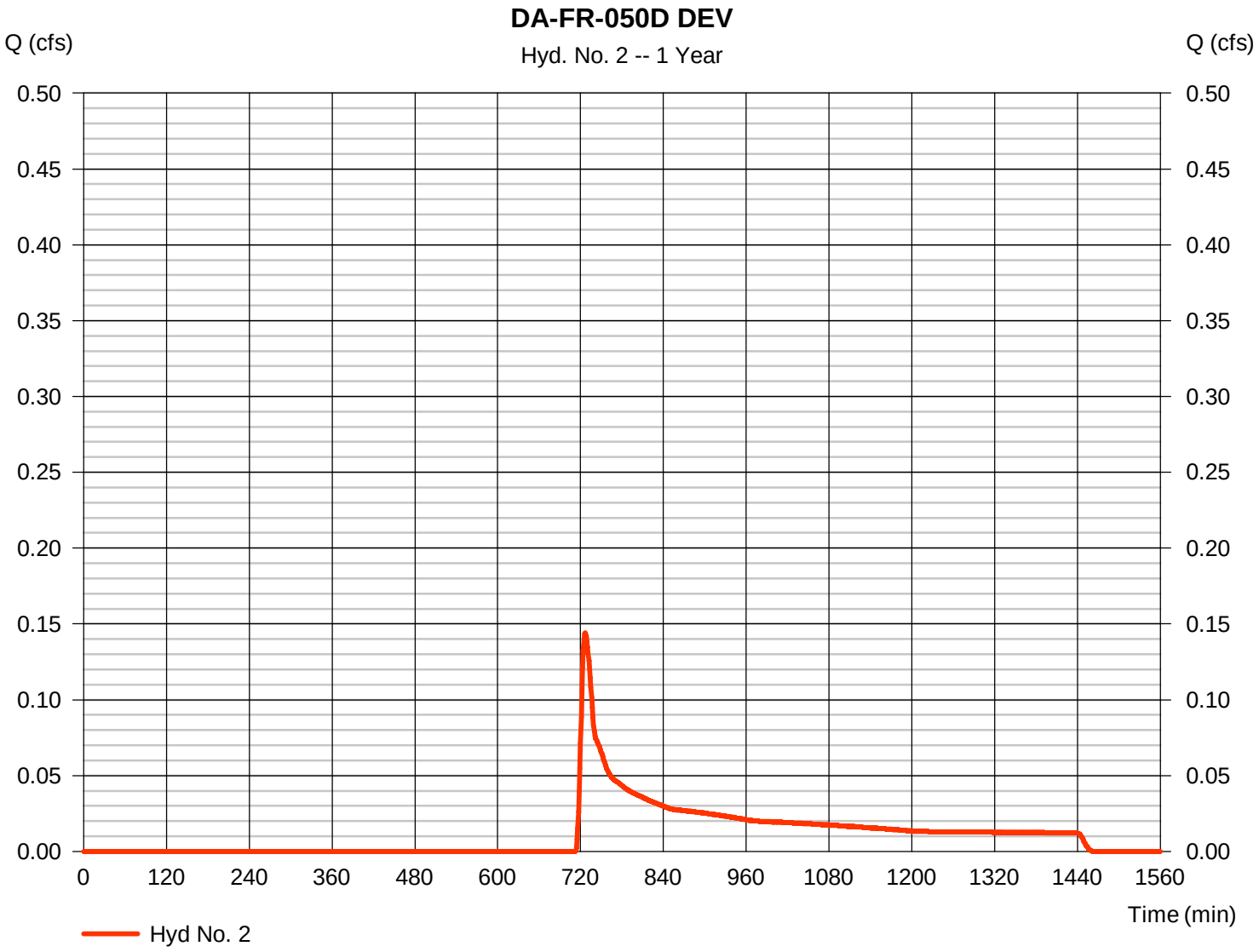
Hydrograph Report

Hyd. No. 2

DA-FR-050D DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.144 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 1,033 cuft
Drainage area	= 1.130 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.412 x 48) + (0.004 x 82) + (0.008 x 98) + (0.513 x 58) + (0.197 x 55)] / 1.130



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-050D DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.06		0.00		0.00		
Travel Time (min)	**= 13.78**	**+**	**0.00**	**+**	**0.00**	**=**	**13.78**
Shallow Concentrated Flow							
Flow length (ft)	= 227.43		0.00		0.00		
Watercourse slope (%)	= 12.35		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.67		0.00		0.00		
Travel Time (min)	**= 0.67**	**+**	**0.00**	**+**	**0.00**	**=**	**0.67**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

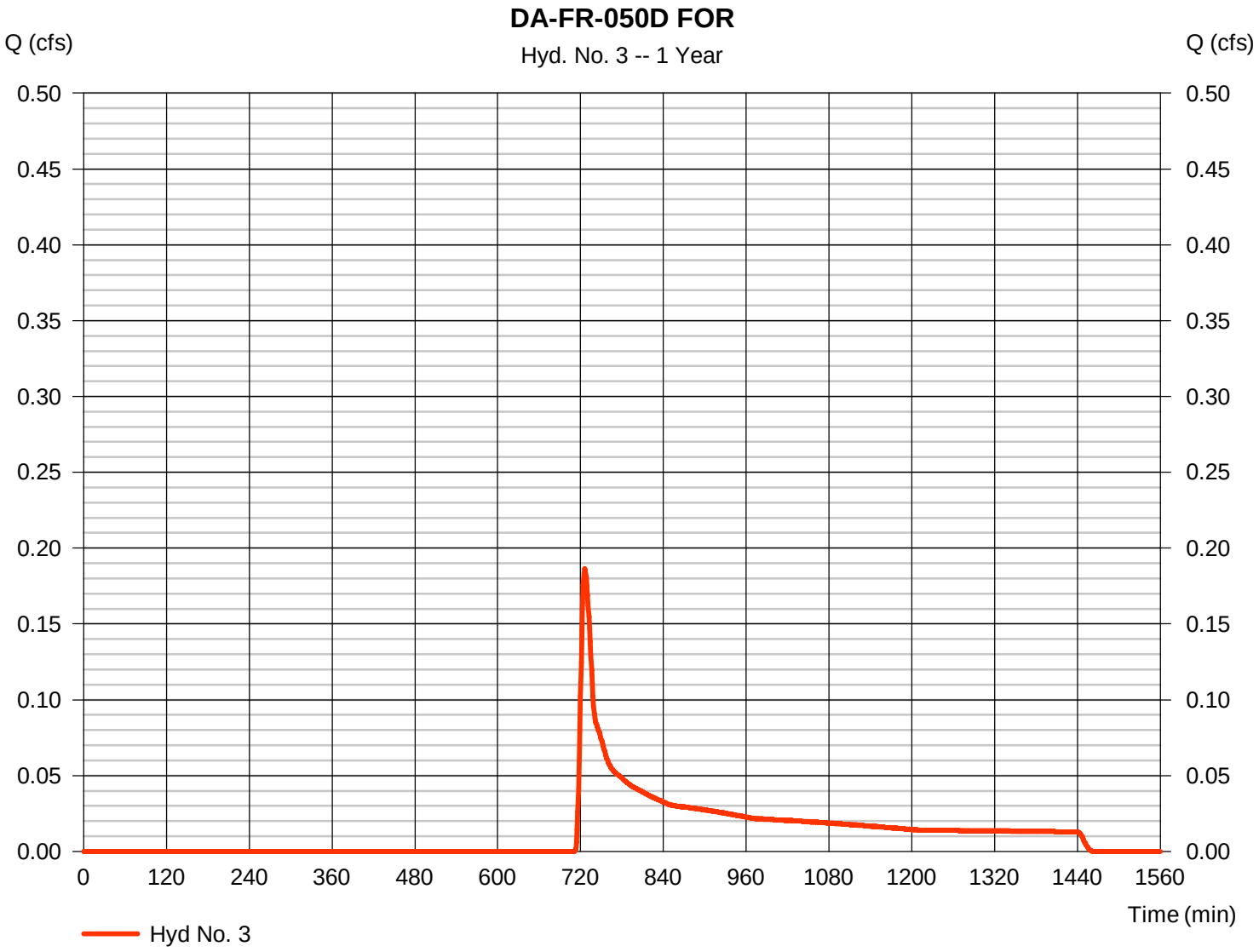
Total Travel Time, Tc ..... 14.40 min

Hydrograph Report

Hyd. No. 3

DA-FR-050D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.186 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 1,153 cuft
Drainage area	= 1.130 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-050D FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.06		0.00		0.00		
Travel Time (min)	**= 13.78**	**+**	**0.00**	**+**	**0.00**	**=**	**13.78**
Shallow Concentrated Flow							
Flow length (ft)	= 227.43		0.00		0.00		
Watercourse slope (%)	= 12.35		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.67		0.00		0.00		
Travel Time (min)	**= 0.67**	**+**	**0.00**	**+**	**0.00**	**=**	**0.67**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.40 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.436	1	725	1,861	------	------	------	DA-FR-050D PRE
2	SCS Runoff	0.308	1	725	1,554	------	------	------	DA-FR-050D DEV
3	SCS Runoff	0.370	1	725	1,705	------	------	------	DA-FR-050D FOR

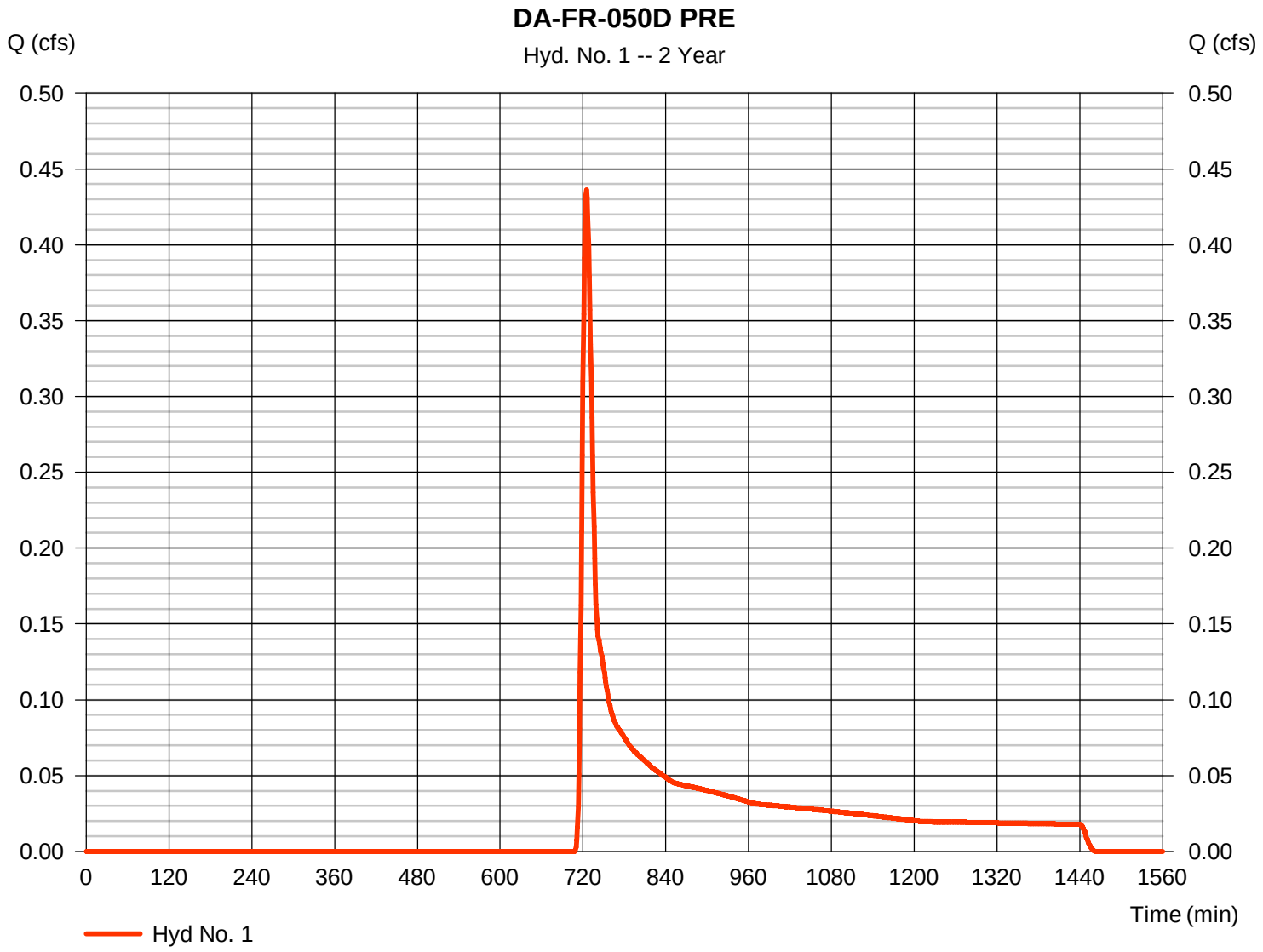
Hydrograph Report

Hyd. No. 1

DA-FR-050D PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.436 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 1,861 cuft
Drainage area	= 1.130 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.004 x 82) + (0.008 x 98) + (0.272 x 58) + (0.851 x 55)] / 1.130



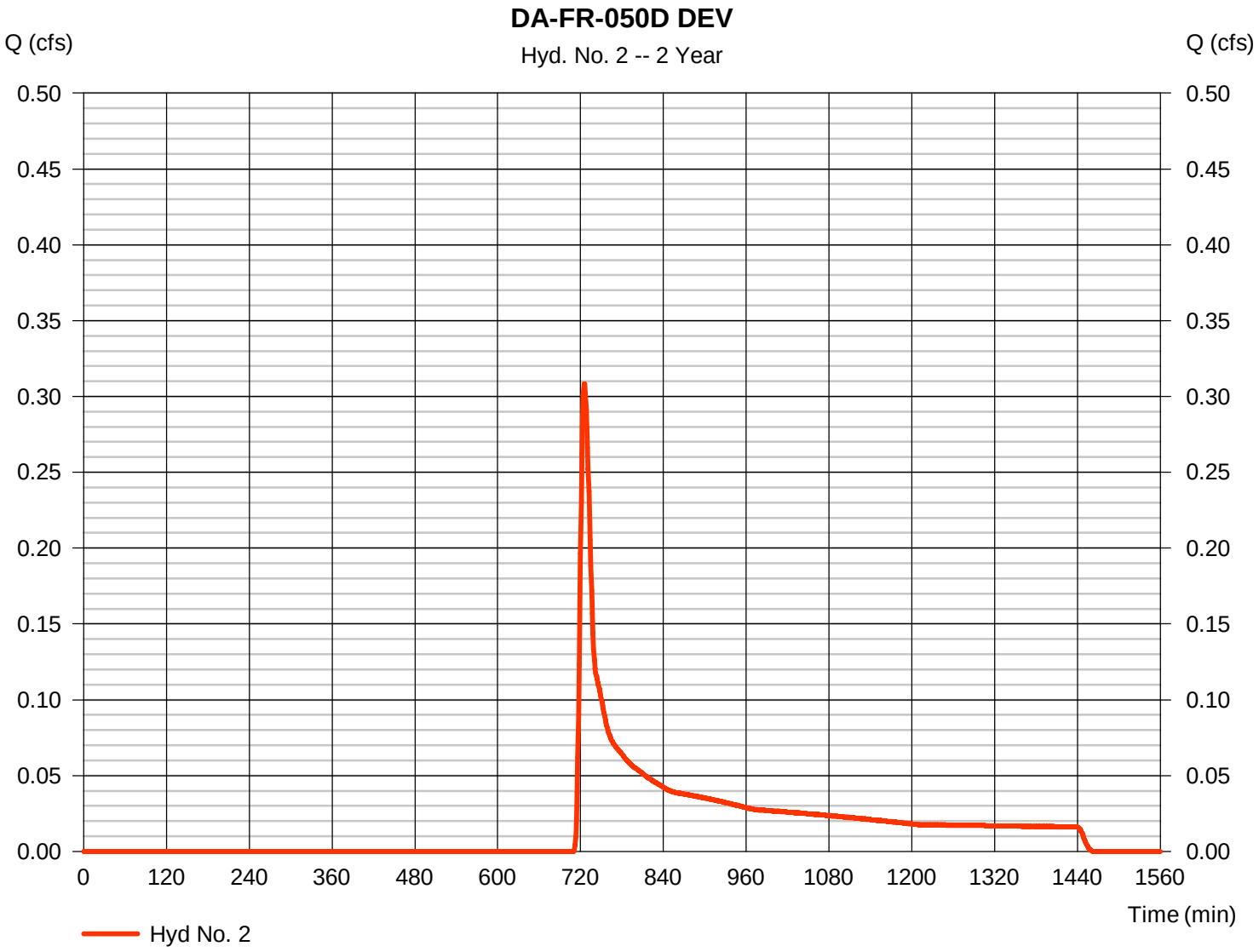
Hydrograph Report

Hyd. No. 2

DA-FR-050D DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.308 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 1,554 cuft
Drainage area	= 1.130 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.412 x 48) + (0.004 x 82) + (0.008 x 98) + (0.513 x 58) + (0.197 x 55)] / 1.130

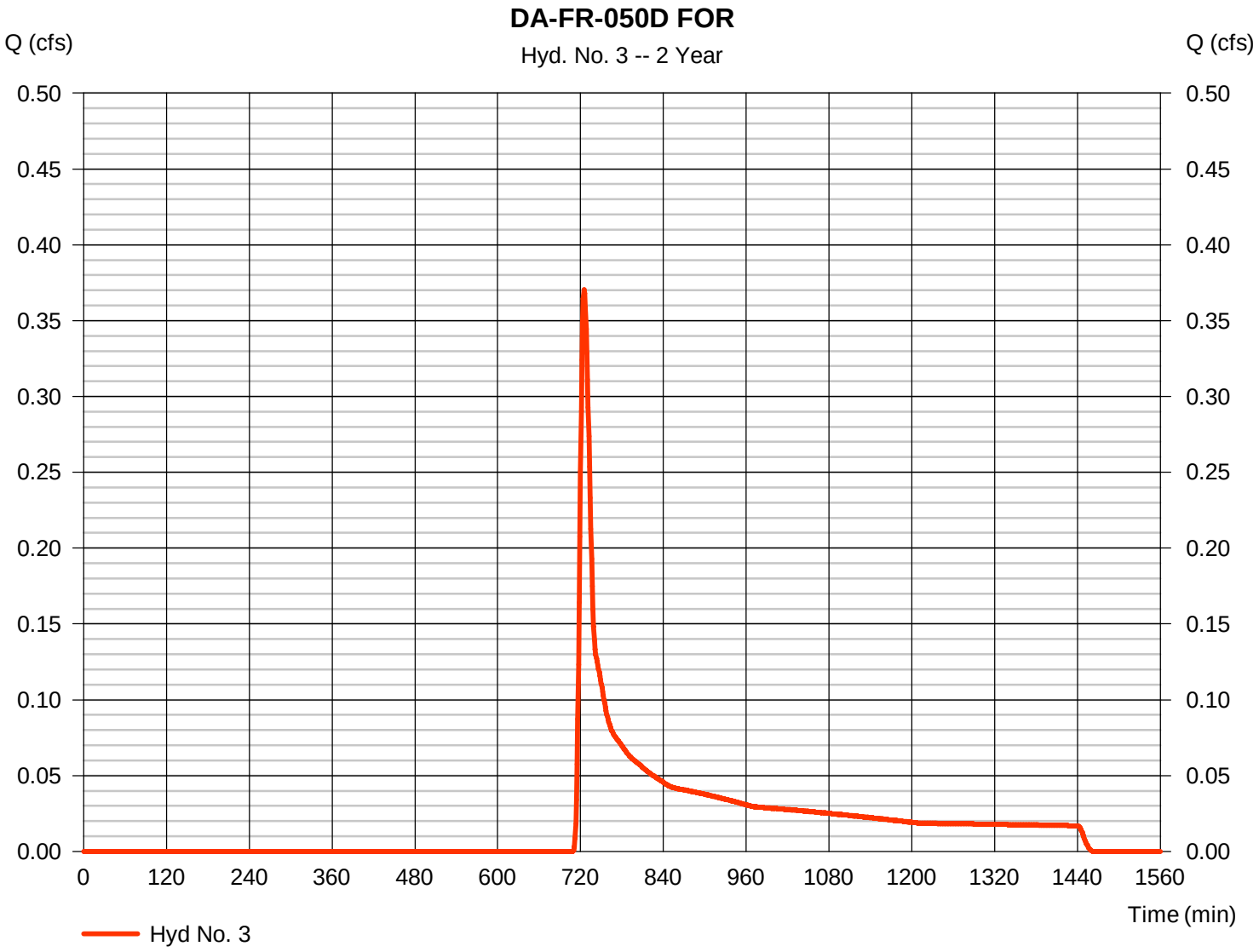


Hydrograph Report

Hyd. No. 3

DA-FR-050D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.370 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 1,705 cuft
Drainage area	= 1.130 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.982	1	723	5,833	------	------	------	DA-FR-050D PRE
2	SCS Runoff	1.720	1	723	5,234	------	------	------	DA-FR-050D DEV
3	SCS Runoff	1.851	1	723	5,531	------	------	------	DA-FR-050D FOR

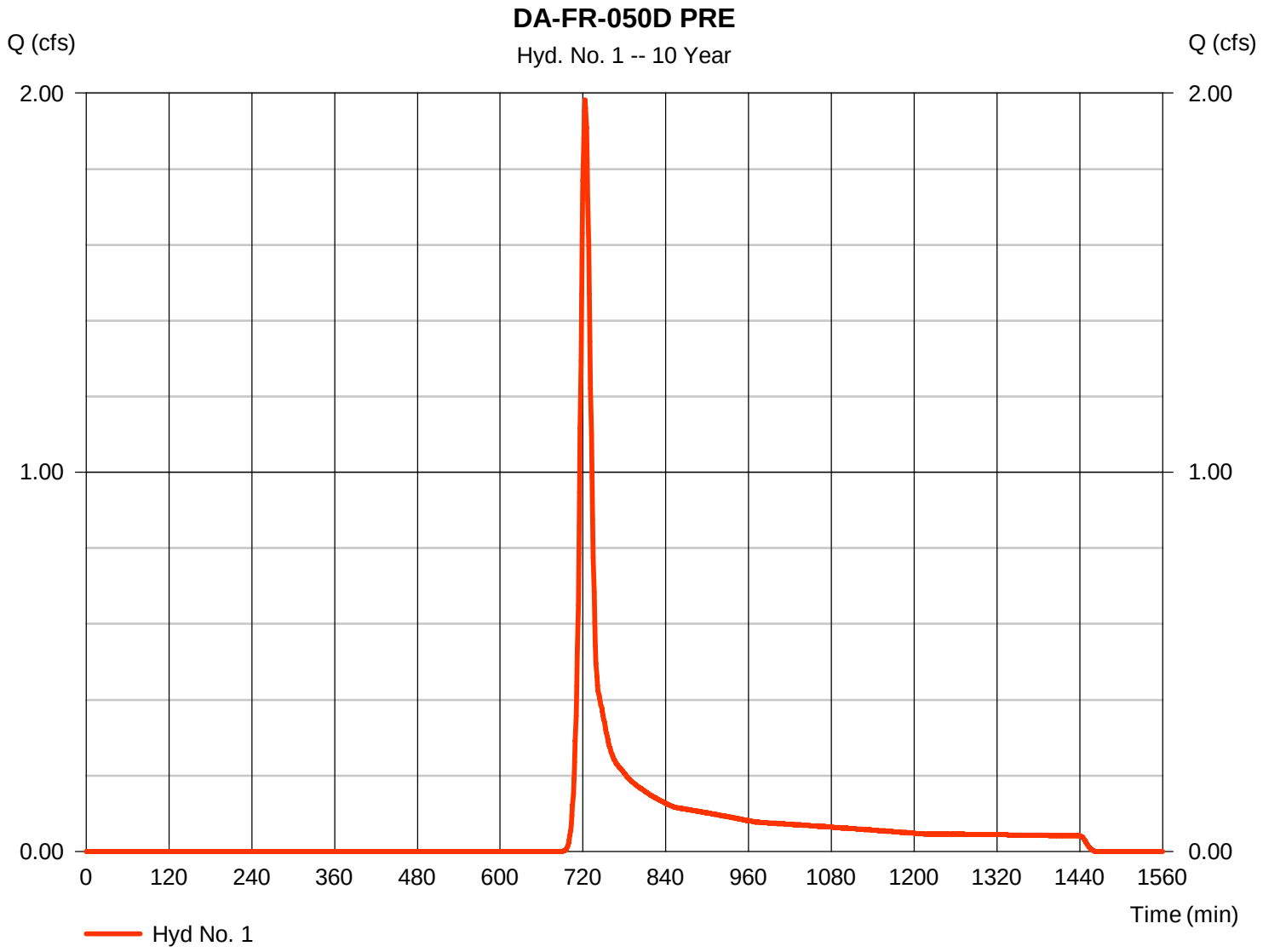
Hydrograph Report

Hyd. No. 1

DA-FR-050D PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 1.982 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 5,833 cuft
Drainage area	= 1.130 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.004 x 82) + (0.008 x 98) + (0.272 x 58) + (0.851 x 55)] / 1.130



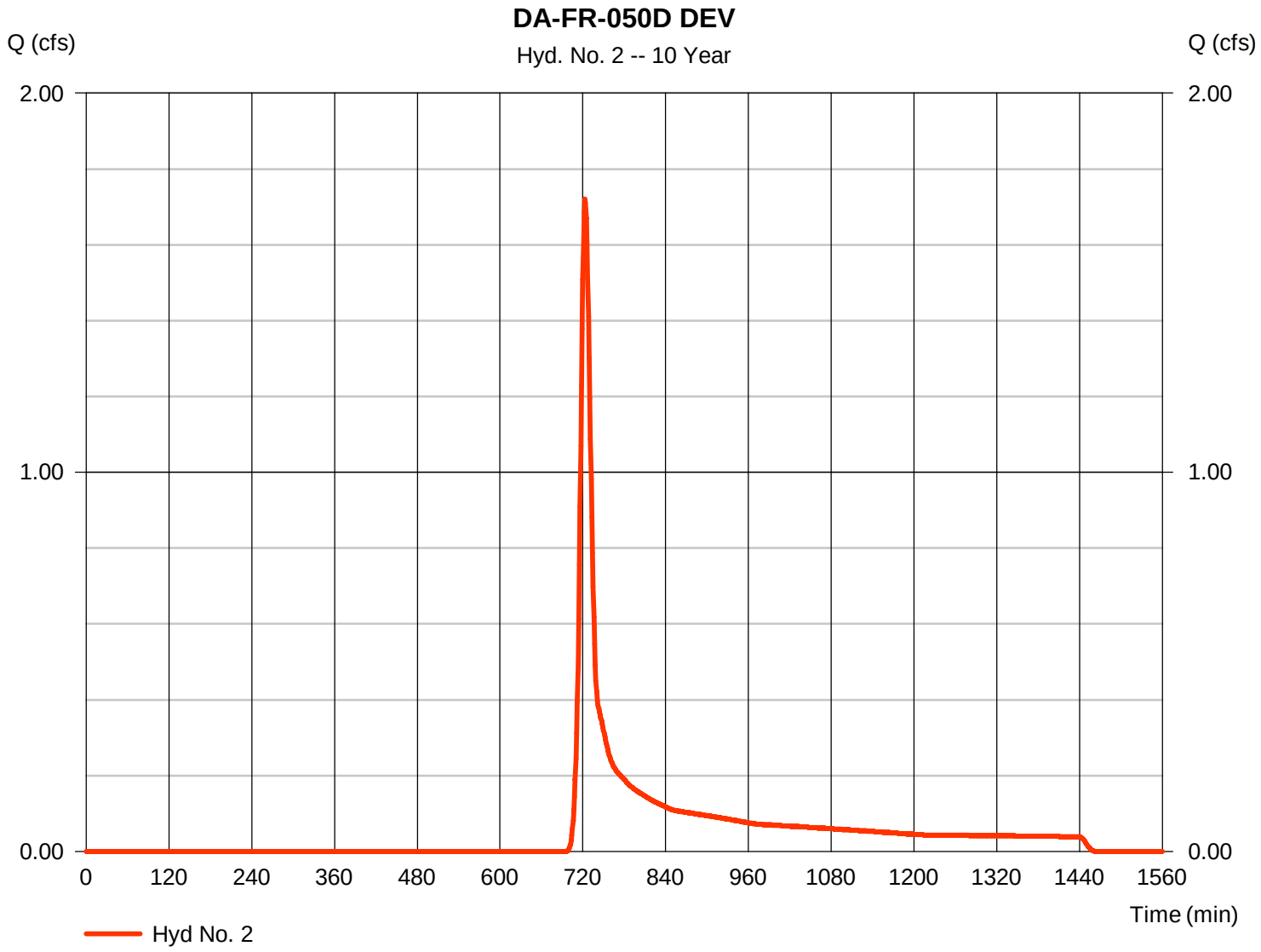
Hydrograph Report

Hyd. No. 2

DA-FR-050D DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.720 cfs
Storm frequency	=	10 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	5,234 cuft
Drainage area	=	1.130 ac	Curve number	=	54*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.40 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.412 x 48) + (0.004 x 82) + (0.008 x 98) + (0.513 x 58) + (0.197 x 55)] / 1.130

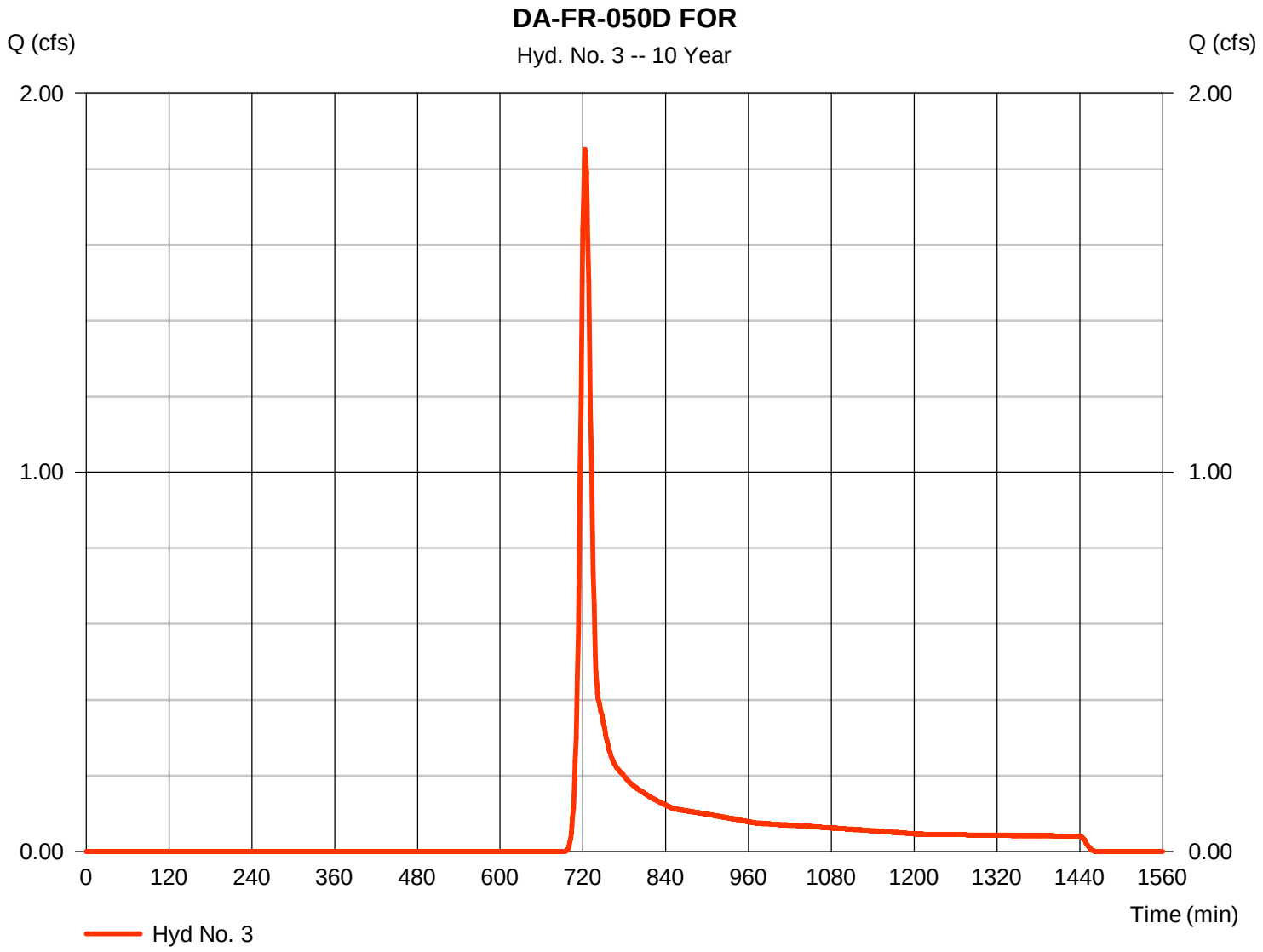


Hydrograph Report

Hyd. No. 3

DA-FR-050D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.851 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 5,531 cuft
Drainage area	= 1.130 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-050E

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.120	368
Developed Condition	0.084	304
Pre-Developed (Forest) Condition	0.037	197

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.9

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.084 ≤ 0.131 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.084 ≤ 0.120 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.084 *shall not* be required to be ≤ 0.024

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-050E PRE
2	SCS Runoff	DA-FR-050E DEV
3	SCS Runoff	DA-FR-050E FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.120	0.177	-------	-------	0.536	-------	-------	-------	DA-FR-050E PRE
2	SCS Runoff	------	0.084	0.133	-------	-------	0.446	-------	-------	-------	DA-FR-050E DEV
3	SCS Runoff	------	0.037	0.074	-------	-------	0.360	-------	-------	-------	DA-FR-050E FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.120	1	722	368	------	------	------	DA-FR-050E PRE
2	SCS Runoff	0.084	1	723	304	------	------	------	DA-FR-050E DEV
3	SCS Runoff	0.037	1	724	197	------	------	------	DA-FR-050E FOR

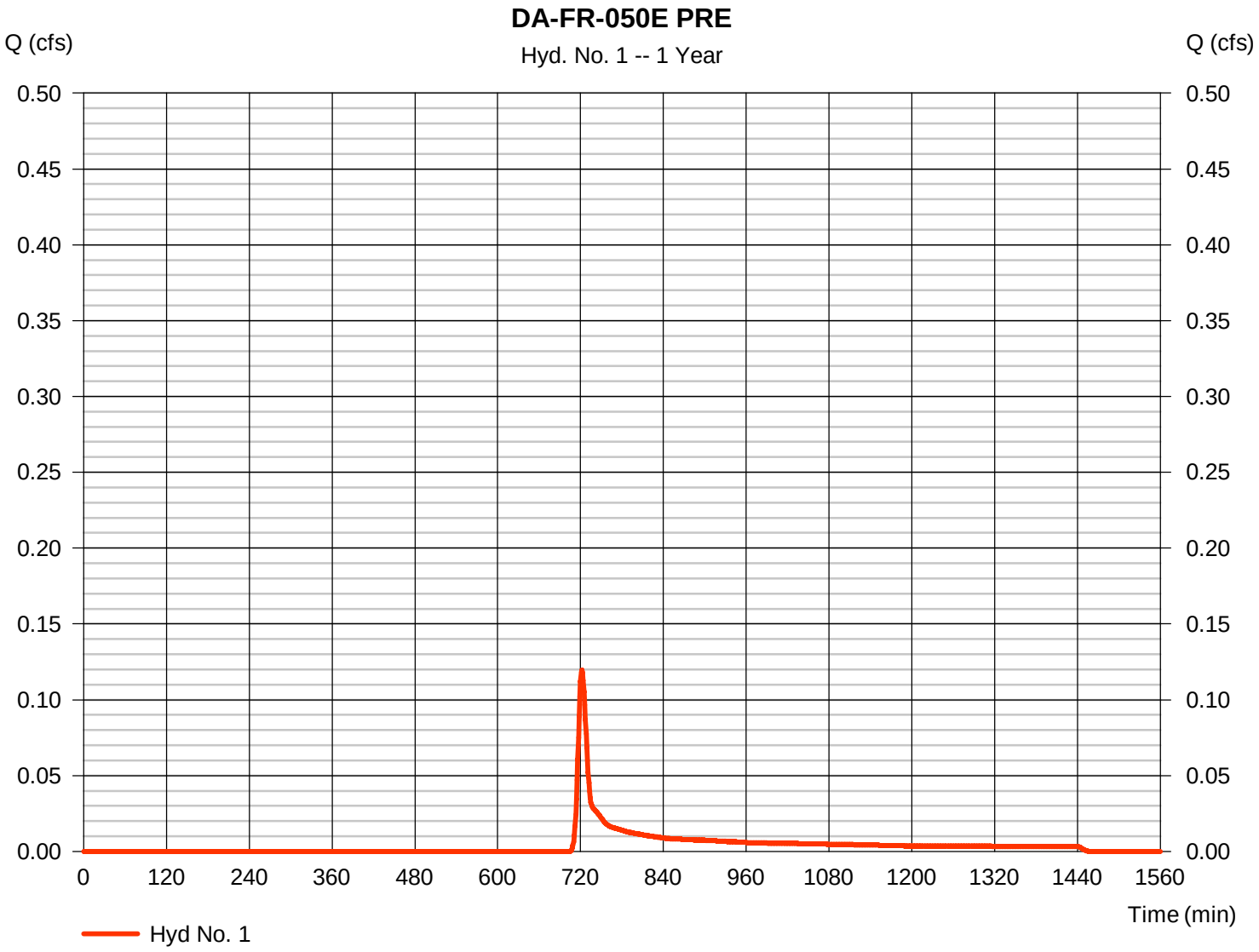
Hydrograph Report

Hyd. No. 1

DA-FR-050E PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.120 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 368 cuft
Drainage area	= 0.190 ac	Curve number	= 62*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.90 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.026 x 98) + (0.042 x 58) + (0.122 x 55)] / 0.190



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-050E PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.400		0.011		
Flow length (ft)	= 60.4		37.7		6.2		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 10.93		16.07		1.90		
Travel Time (min)	**= 6.76**	**+**	**3.98**	**+**	**0.12**	**=**	**10.86**
Shallow Concentrated Flow							
Flow length (ft)	= 13.70		0.00		0.00		
Watercourse slope (%)	= 6.11		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=5.02		0.00		0.00		
Travel Time (min)	**= 0.05**	**+**	**0.00**	**+**	**0.00**	**=**	**0.05**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 10.90 min

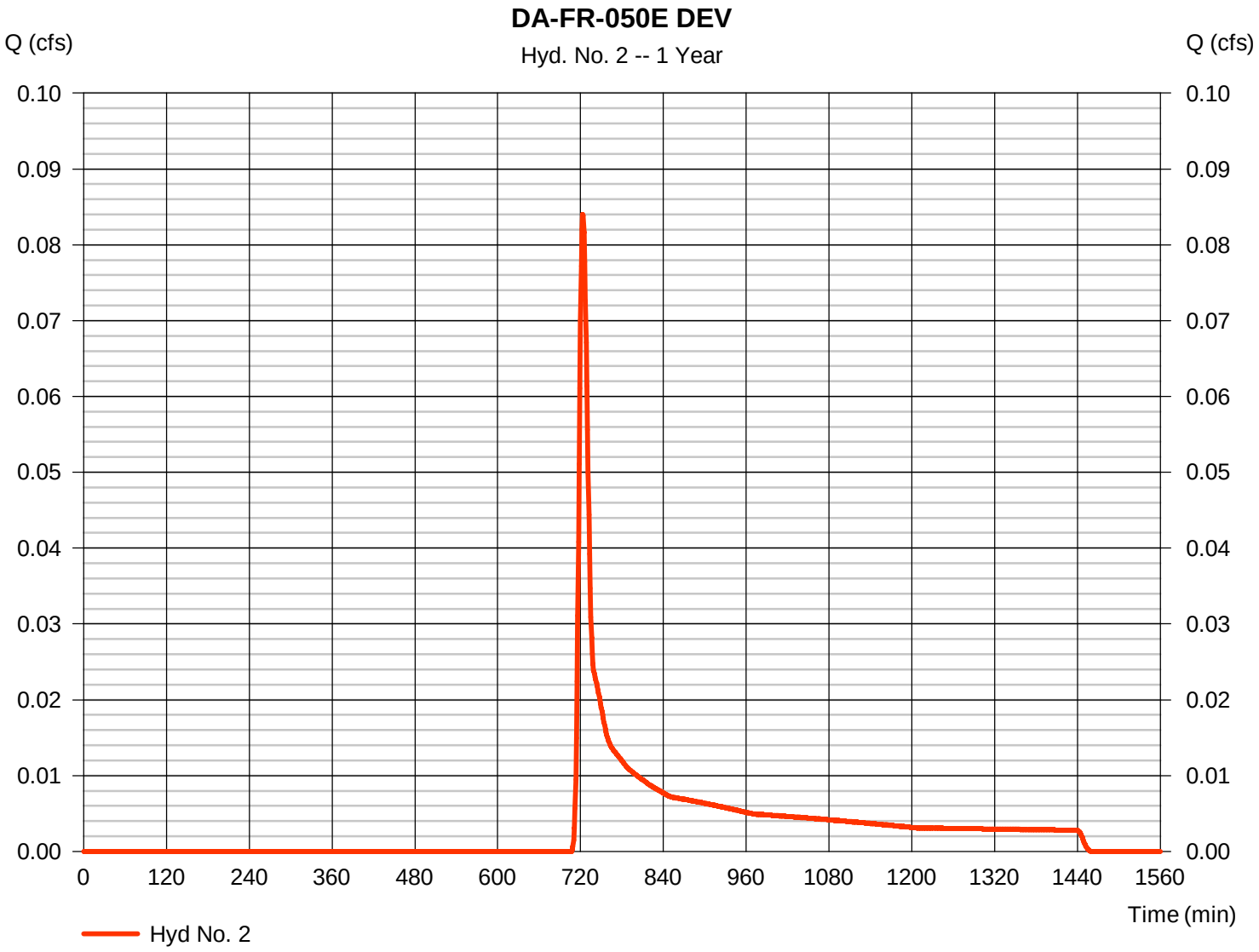
Hydrograph Report

Hyd. No. 2

DA-FR-050E DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.084 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 304 cuft
Drainage area	= 0.190 ac	Curve number	= 60*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.40 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.073 x 48) + (0.026 x 98) + (0.092 x 58)] / 0.190



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-050E DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.800		0.400		0.011		
Flow length (ft)	= 14.0		84.1		1.9		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 7.32		13.84		6.17		
Travel Time (min)	**= 4.29**	**+**	**8.02**	**+**	**0.03**	**=**	**12.34**
Shallow Concentrated Flow							
Flow length (ft)	= 13.70		0.00		0.00		
Watercourse slope (%)	= 6.11		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=5.02		0.00		0.00		
Travel Time (min)	**= 0.05**	**+**	**0.00**	**+**	**0.00**	**=**	**0.05**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

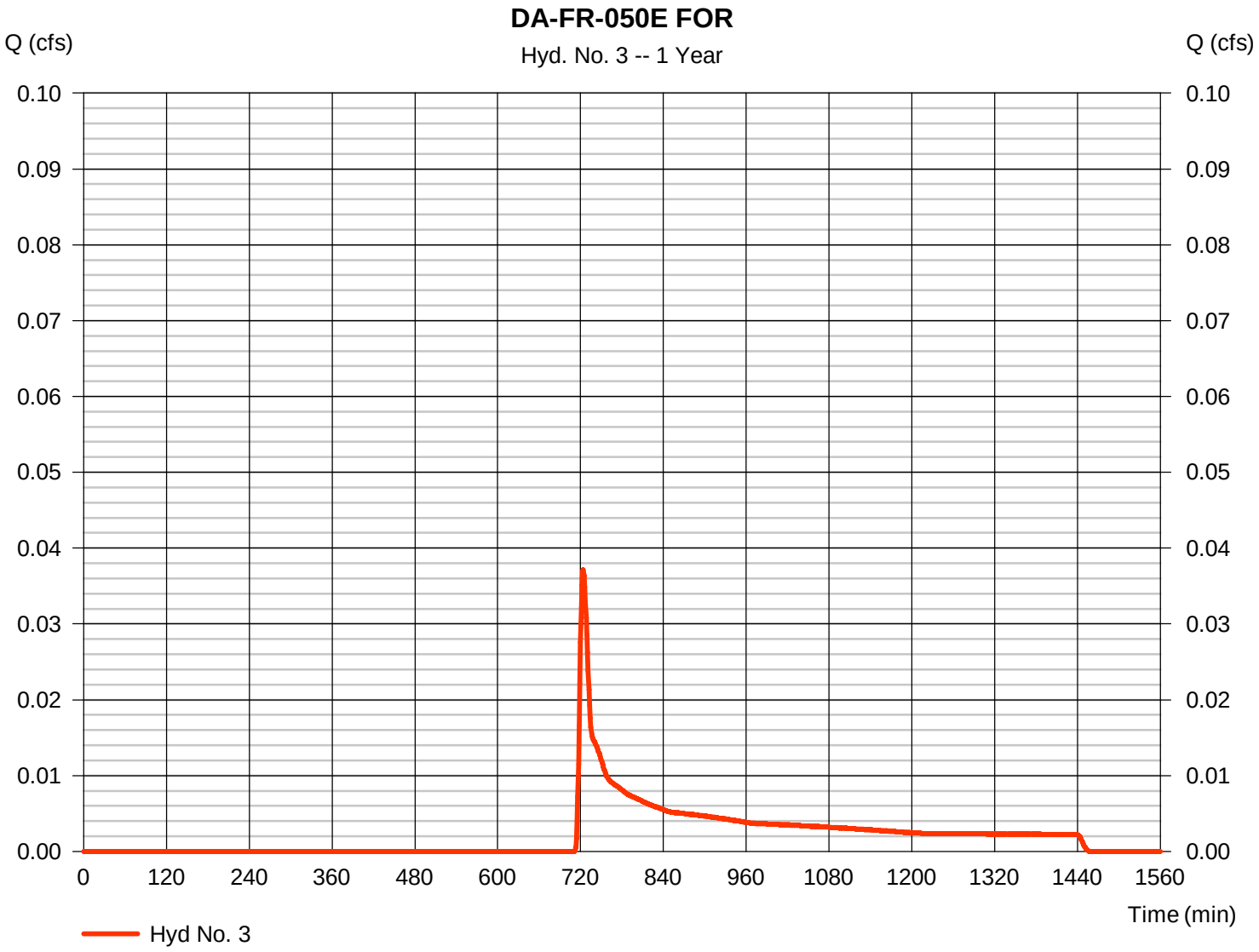
Total Travel Time, Tc ..... 12.40 min

Hydrograph Report

Hyd. No. 3

DA-FR-050E FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.037 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 197 cuft
Drainage area	= 0.190 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-050E FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.400		0.400		
Flow length (ft)	= 60.4		37.7		1.9		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 10.93		16.07		6.17		
Travel Time (min)	**= 6.76**	**+**	**3.98**	**+**	**0.53**	**=**	**11.27**
Shallow Concentrated Flow							
Flow length (ft)	= 13.70		0.00		0.00		
Watercourse slope (%)	= 6.11		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=3.99		0.00		0.00		
Travel Time (min)	**= 0.06**	**+**	**0.00**	**+**	**0.00**	**=**	**0.06**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 11.30 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.177	1	721	499	------	------	------	DA-FR-050E PRE
2	SCS Runoff	0.133	1	723	421	------	------	------	DA-FR-050E DEV
3	SCS Runoff	0.074	1	723	292	------	------	------	DA-FR-050E FOR

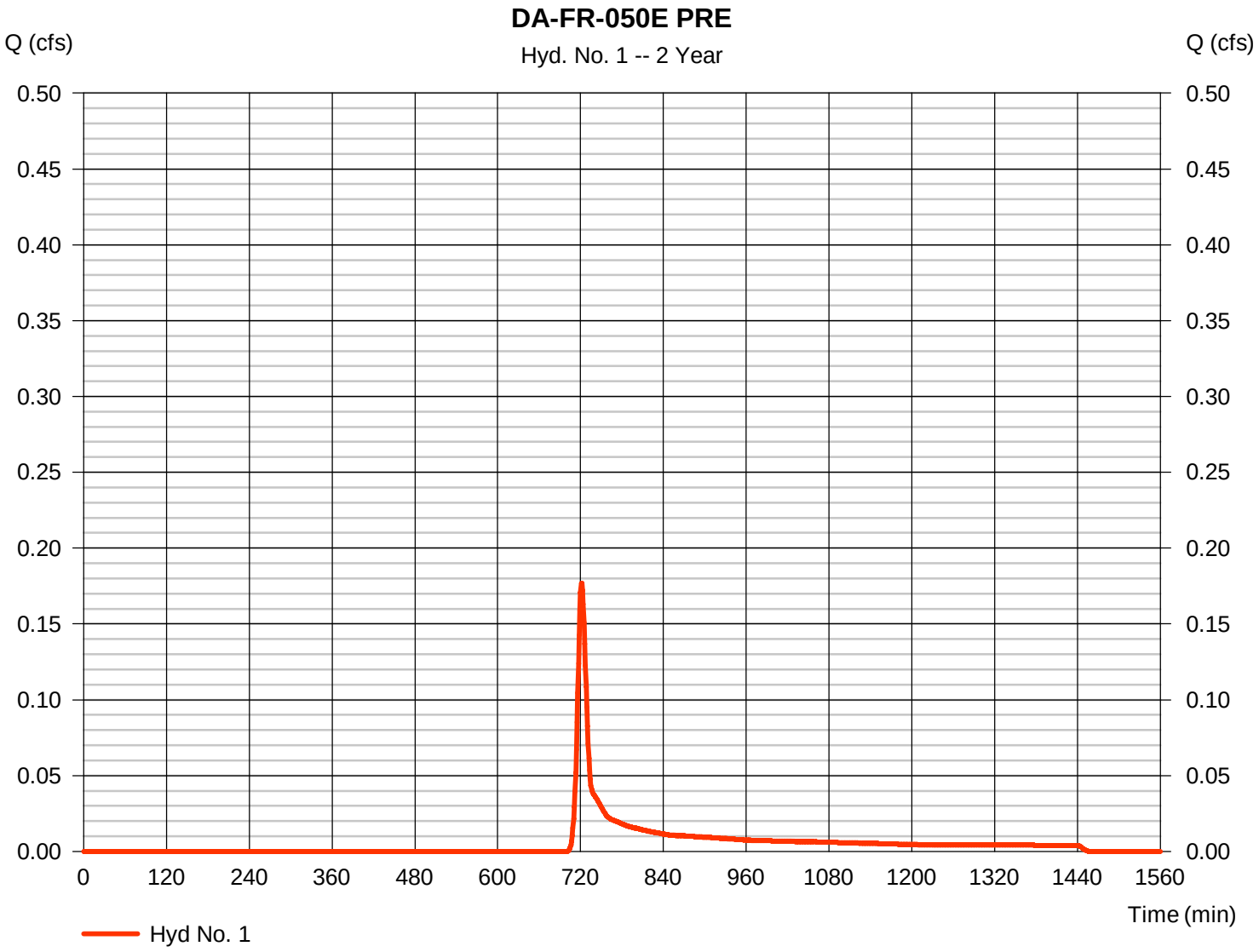
Hydrograph Report

Hyd. No. 1

DA-FR-050E PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.177 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 499 cuft
Drainage area	= 0.190 ac	Curve number	= 62*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.90 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.026 x 98) + (0.042 x 58) + (0.122 x 55)] / 0.190



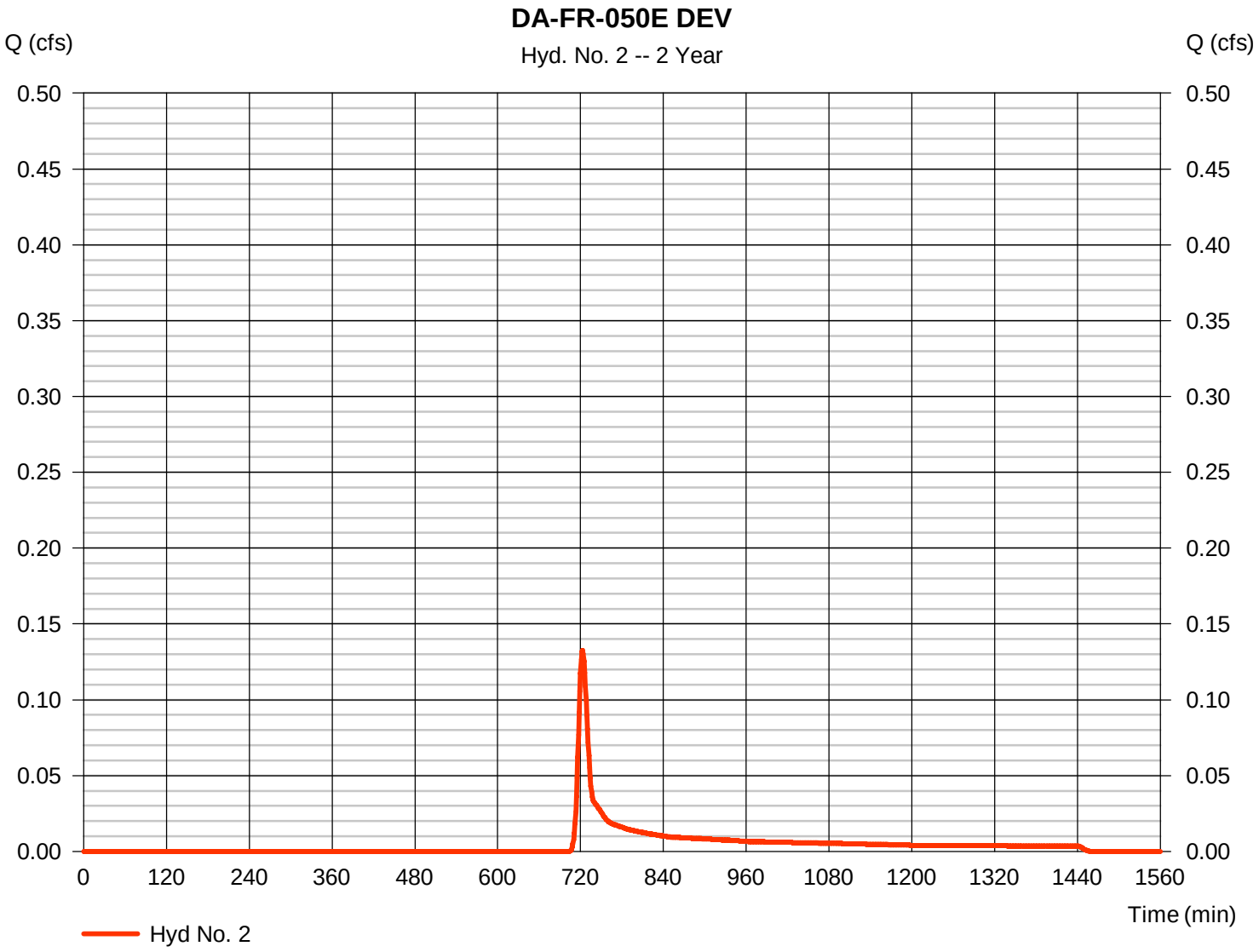
Hydrograph Report

Hyd. No. 2

DA-FR-050E DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.133 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 421 cuft
Drainage area	= 0.190 ac	Curve number	= 60*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.073 x 48) + (0.026 x 98) + (0.092 x 58)] / 0.190

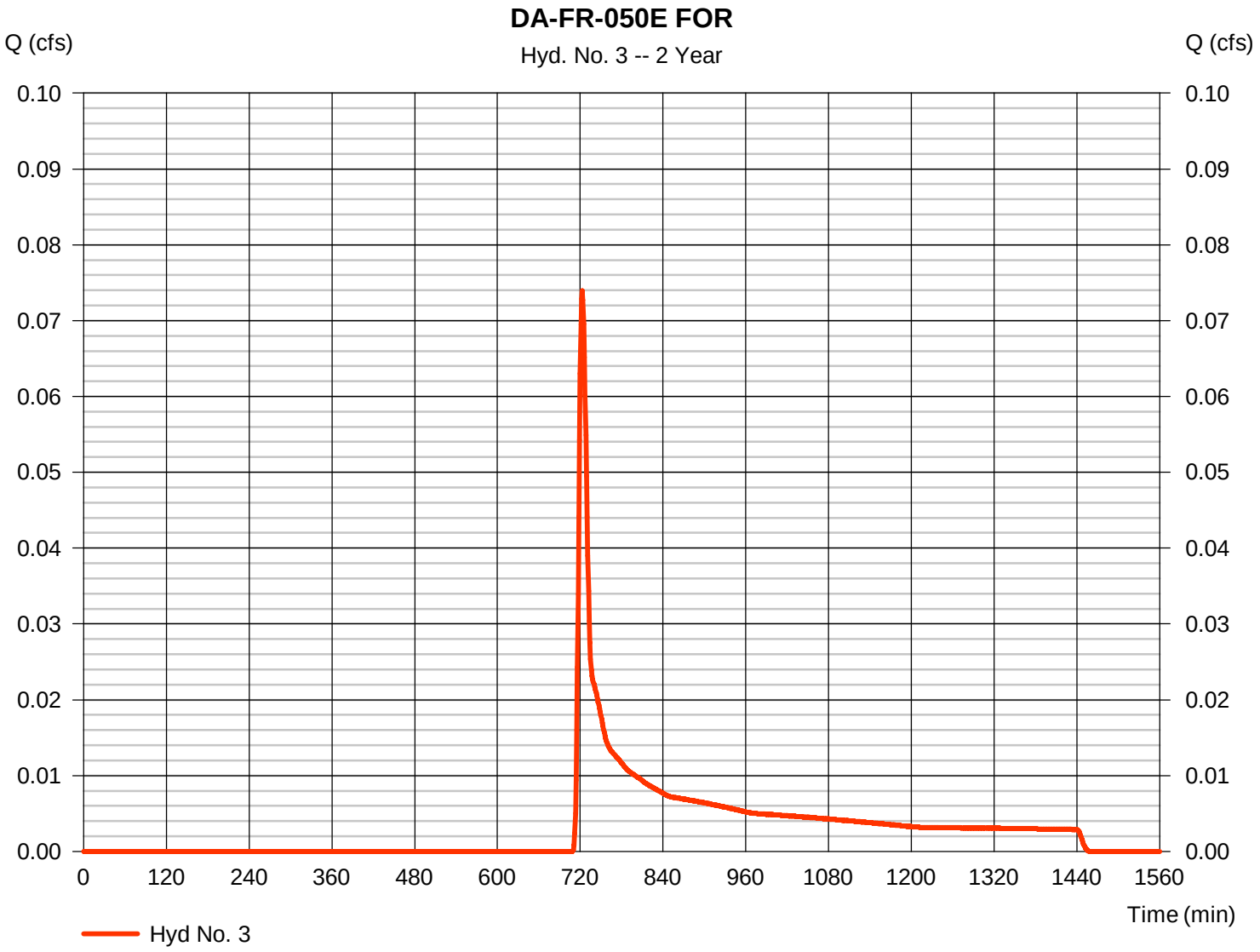


Hydrograph Report

Hyd. No. 3

DA-FR-050E FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.074 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 292 cuft
Drainage area	= 0.190 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.536	1	721	1,325	------	------	------	DA-FR-050E PRE
2	SCS Runoff	0.446	1	722	1,173	------	------	------	DA-FR-050E DEV
3	SCS Runoff	0.360	1	721	947	------	------	------	DA-FR-050E FOR

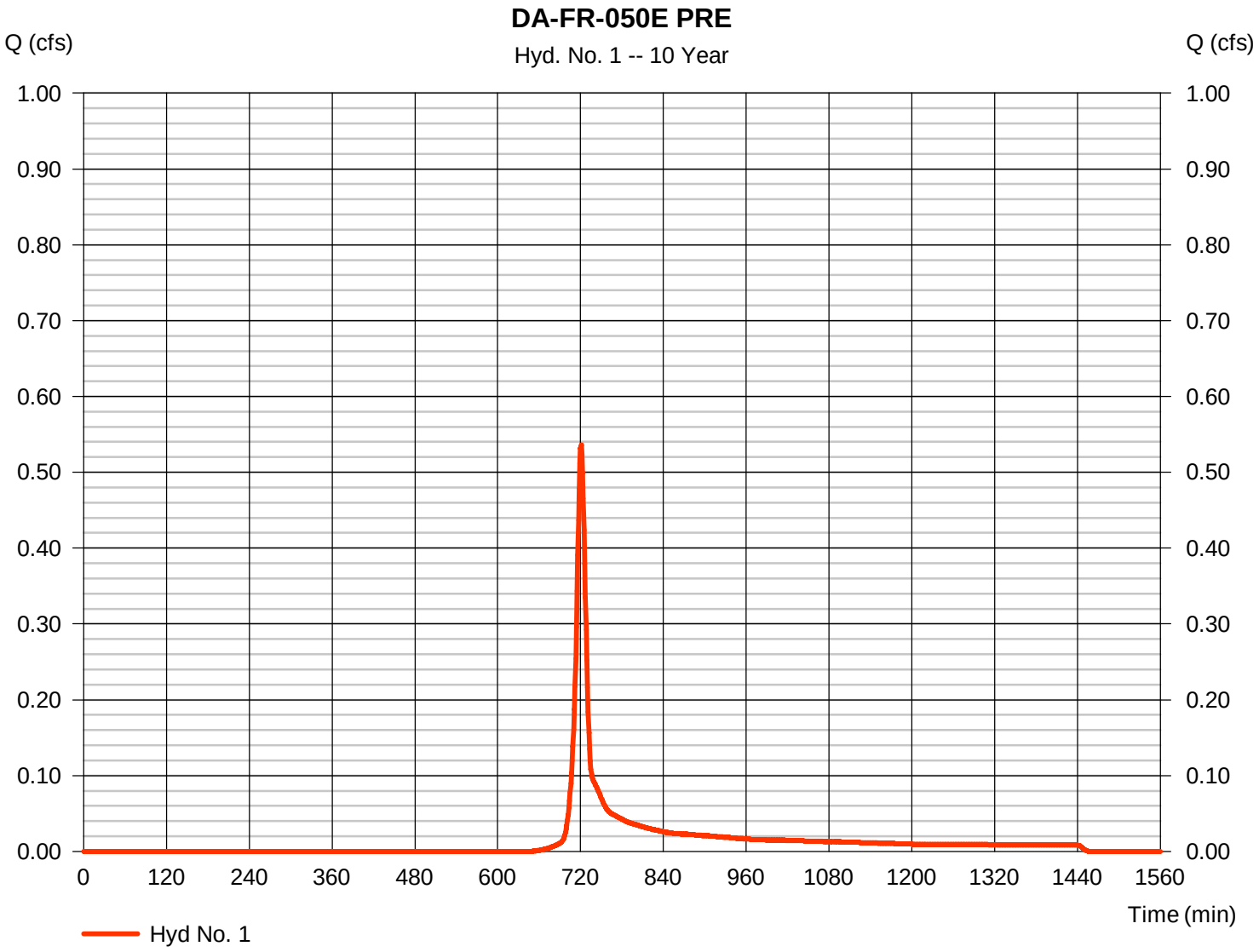
Hydrograph Report

Hyd. No. 1

DA-FR-050E PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.536 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,325 cuft
Drainage area	= 0.190 ac	Curve number	= 62*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.90 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.026 x 98) + (0.042 x 58) + (0.122 x 55)] / 0.190



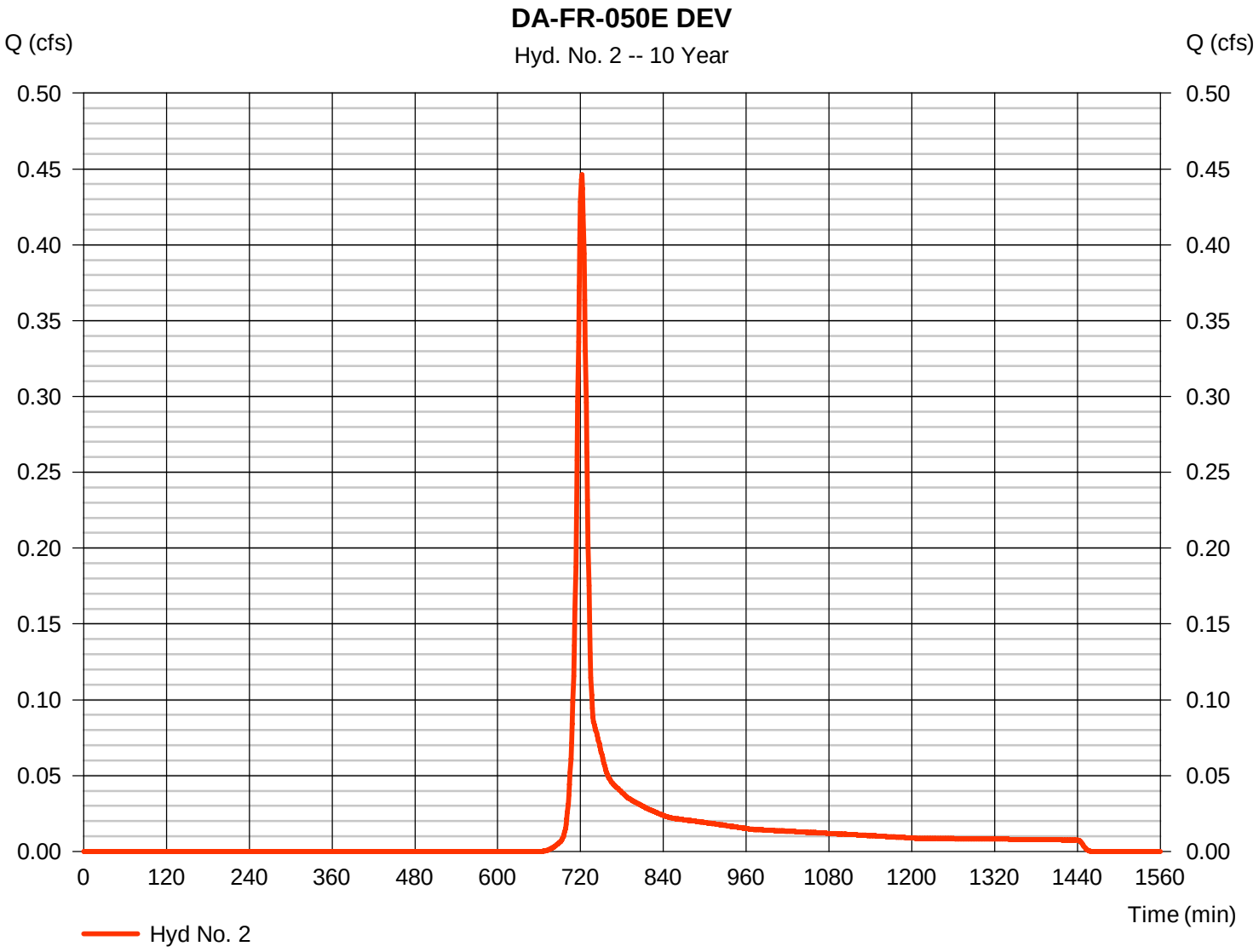
Hydrograph Report

Hyd. No. 2

DA-FR-050E DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.446 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 1,173 cuft
Drainage area	= 0.190 ac	Curve number	= 60*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.40 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.073 x 48) + (0.026 x 98) + (0.092 x 58)] / 0.190

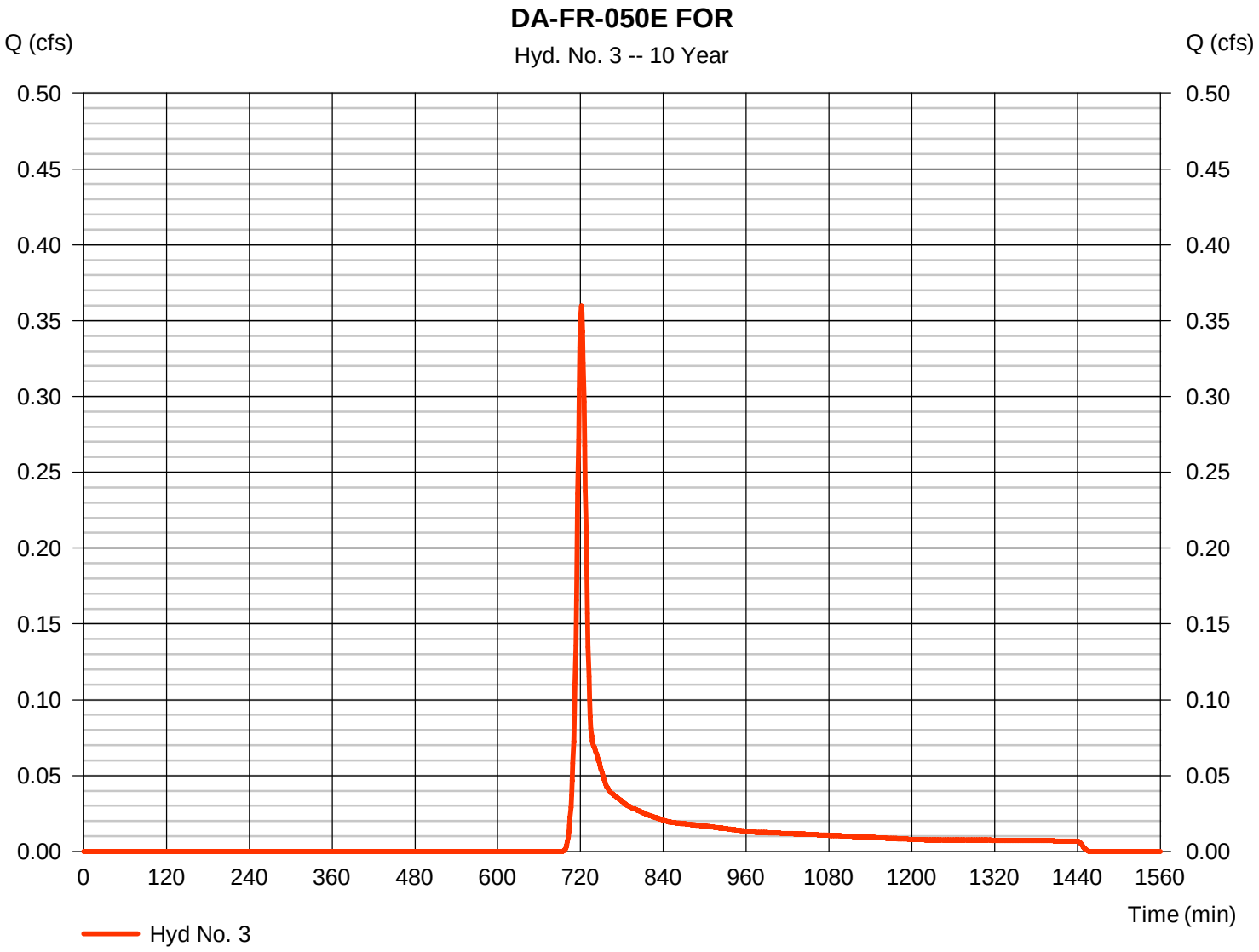


Hydrograph Report

Hyd. No. 3

DA-FR-050E FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.360 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 947 cuft
Drainage area	= 0.190 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-051

DA-FR-051 is located in a brush, meadow and forested areas with rolling slopes, and contains existing gravel and paved roads. A stream crosses a corner of the drainage area. No new impervious area is proposed within DA-FR-051. The total phosphorus load reduction required for DA-FR-051 is –0.67 lb/yr. Multiple points of analysis were evaluated within DA-FR-051 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-051 was sub-divided into four sub-drainage areas (sub areas A through D).

Sub-area 051D contains both agricultural and non-agricultural areas within the limits of disturbance (LOD). Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction. In non-agricultural areas, land use will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. For SWM quality, agricultural areas within the LOD are considered/ included and the total permanent ROW is analyzed via VRRM; agricultural areas are considered “Forest/Open Space” in these calculations.

Stormwater quantity is met via the energy balance method for each of the four sub-areas DA-FR-051A through DA-FR-051D. Agricultural areas within the study area are included in the SWM analysis, but an Improvement Factor (IF) of 1.0 is used when applying the Energy Balance Method. This improvement factor is used to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate a reduction in flows ranging from 0.00 to 0.52 cfs for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-051A	1.31	0.79	-0.52
DA-FR-051B	7.46	7.00	-0.46
DA-FR-051C	4.38	4.14	-0.24
DA-FR-051D	0.67	0.67	0.00

Figures and calculations for each of the sub-areas for DA-FR-051 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-051A
0.57 acres
Weighted CN =

DA-FR-051B
3.46 acres
Weighted CN =

DA-FR-051C
2.08 acres
Weighted CN =

DA-FR-051D
4.47 acres
Weighted CN =

S-D18
S-D20
S-EF14
S-EF13
S-C11
S-C12
S-C14
S-C13
Brick Church Rd
Cloverdale Ln
261.3
261.4
261.5
261.6
261.7
261.8
261.9
1150
1100
1050
1510
1457
B

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Dirt Road
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:2,640

N W E S

225 112.5 0 225 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-051
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-051_Pre.mxd

DA-FR-051A
0.57 acres
Weighted CN =

DA-FR-051B
3.46 acres
Weighted CN =

DA-FR-051C
2.08 acres
Weighted CN =

DA-FR-051D
4.47 acres
Weighted CN =

S-D18
S-D20
S-EF14
S-EF13
S-C11
S-C12
S-C14
S-C13

261.3
261.4
261.5
261.6
261.7
261.8
261.9

1150
1100
1050
1510
1457

Brick Church Rd
Cloverdale Ln

B

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Dirt Road
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:2,640

N
W E
S

225 112.5 0 225 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

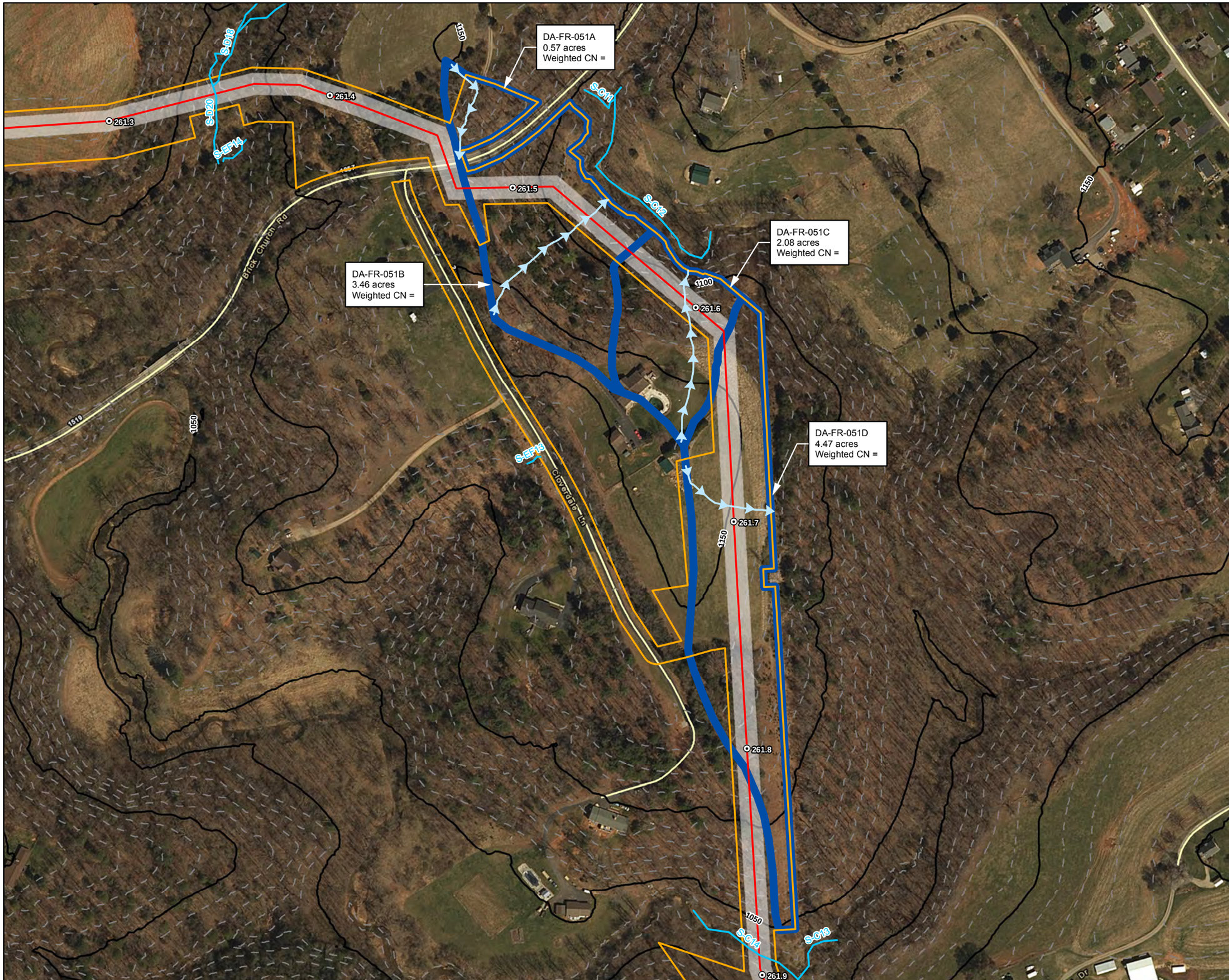
Post-Construction Drainage Area Map
DA-FR-051
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-051_Post.mxd



Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:2,640

220 110 0 220 Feet

N W E S

Mountain Valley Pipeline Project

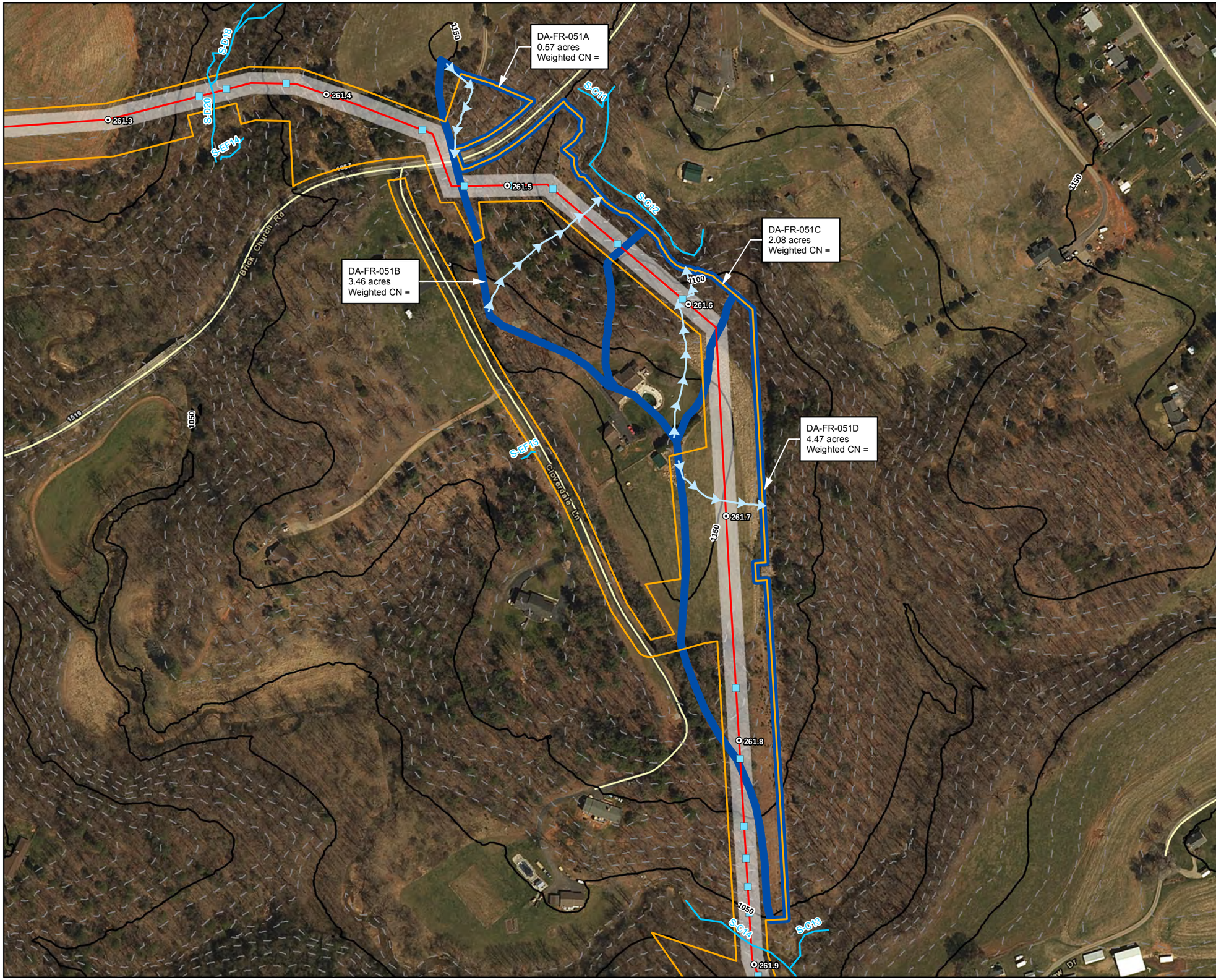
Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration
DA-FR-051
Spread 10

Figure 3
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-051_3.mxd



Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:2,640

220 110 0 220 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration
DA-FR-051
Spread 10

Figure 4
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-051_4.mxd

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary - Linear Development Project***

Total Rainfall (in):	**43**
Total Disturbed Acreage:	**2.02**

Site Land Cover Summary

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	2.01	0.00	0.00	2.01	100
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.01	0.00	0.00	0.01	0
					2.02	100

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	2.01	0.00	0.00	2.01	100 *
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.01	0.00	0.00	0.01	0
					2.02	100

*** Forest/Open Space areas must be protected in accordance with the Virginia Runoff Reduction Method**

Site Tv and Land Cover Nutrient Loads

	Final Post-Development (Post-ReDevelopment & New Impervious)	Post-ReDevelopment	Post-Development (New Impervious)	Adjusted Pre-ReDevelopment
Site Rv	0.03	0.03	--	0.03
Treatment Volume (ft^3)	253	253	--	253
TP Load (lb/yr)	0.16	0.16	--	0.16

Baseline TP Load (lb/yr): 0.8282* **Reduction below new development load limitation not required*

Pre-ReDevelopment TP Load per acre (lb/acre/yr)	Final Post-Development TP Load per acre (lb/acre/yr)	Post-ReDevelopment TP Load per acre (lb/acre/yr)
0.08	**0.08**	**0.08**

Total TP Load Reduction Required (lb/yr)	**-0.67**	N/A***	N/A***

******This is a linear development project***

	Final Post-Development Load (Post-ReDevelopment & New Impervious)	Pre-ReDevelopment
TN Load (lb/yr)	1.14	1.14

Site Compliance Summary - ***Linear Development Project

Maximum % Reduction Required Below Pre-ReDevelopment Load	20%

** Note: % Reduction will reduce post-development TP load to less than or equal to baseline load of 0.83 lb/yr (0.41 lb/ac/yr)*
[Post-Dev Reduction Requirement = Post-Dev TP load - baseline load of 0.83 lb/yr], baseline load = site area x 0.41 lb/ac/yr

Total Runoff Volume Reduction (ft^3)	0

Total TP Load Reduction Achieved (lb/yr)	0.00
Total TN Load Reduction Achieved (lb/yr)	0.00
Remaining Post Development TP Load (lb/yr)	0.16
Remaining TP Load Reduction (lb/yr) Required	**0.00**

**** TARGET TP REDUCTION EXCEEDED BY 0.67 LB/YEAR ****

**Reduction below new development load limitation not required*

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	2.01	0.00	0.00	0.00	0.00	2.01
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.01	0.00	0.00	0.00	0.00	0.01
Total Area (acres)	**2.02**	**0.00**	**0.00**	**0.00**	**0.00**	**2.02**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TN Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	2.01	0.00	0.00	2.01	100
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.01	0.00	0.00	0.01	0
					2.02	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	0.00
Total Turf Area Treated (acres)	0.00
Total TP Load Reduction Achieved in D.A. (lb/yr)	0.00
Total TN Load Reduction Achieved in D.A. (lb/yr)	0.00

DA-FR-051A

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.187	711
Developed Condition	0.040	403
Pre-Developed (Forest) Condition	0.101	572

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.9

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.040 ≤ 0.297 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.040 ≤ 0.187 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.040 *shall not* be required to be ≤ 0.143

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-051A PRE
2	SCS Runoff	DA-FR-051 DEV
3	SCS Runoff	DA-FR-051A FOR

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.187	0.328	-------	-------	1.307	-------	-------	-------	DA-FR-051A PRE
2	SCS Runoff	------	0.040	0.109	-------	-------	0.787	-------	-------	-------	DA-FR-051 DEV
3	SCS Runoff	------	0.101	0.201	-------	-------	0.991	-------	-------	-------	DA-FR-051A FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.187	1	722	711	------	------	------	DA-FR-051A PRE
2	SCS Runoff	0.040	1	727	403	------	------	------	DA-FR-051 DEV
3	SCS Runoff	0.101	1	725	572	------	------	------	DA-FR-051A FOR

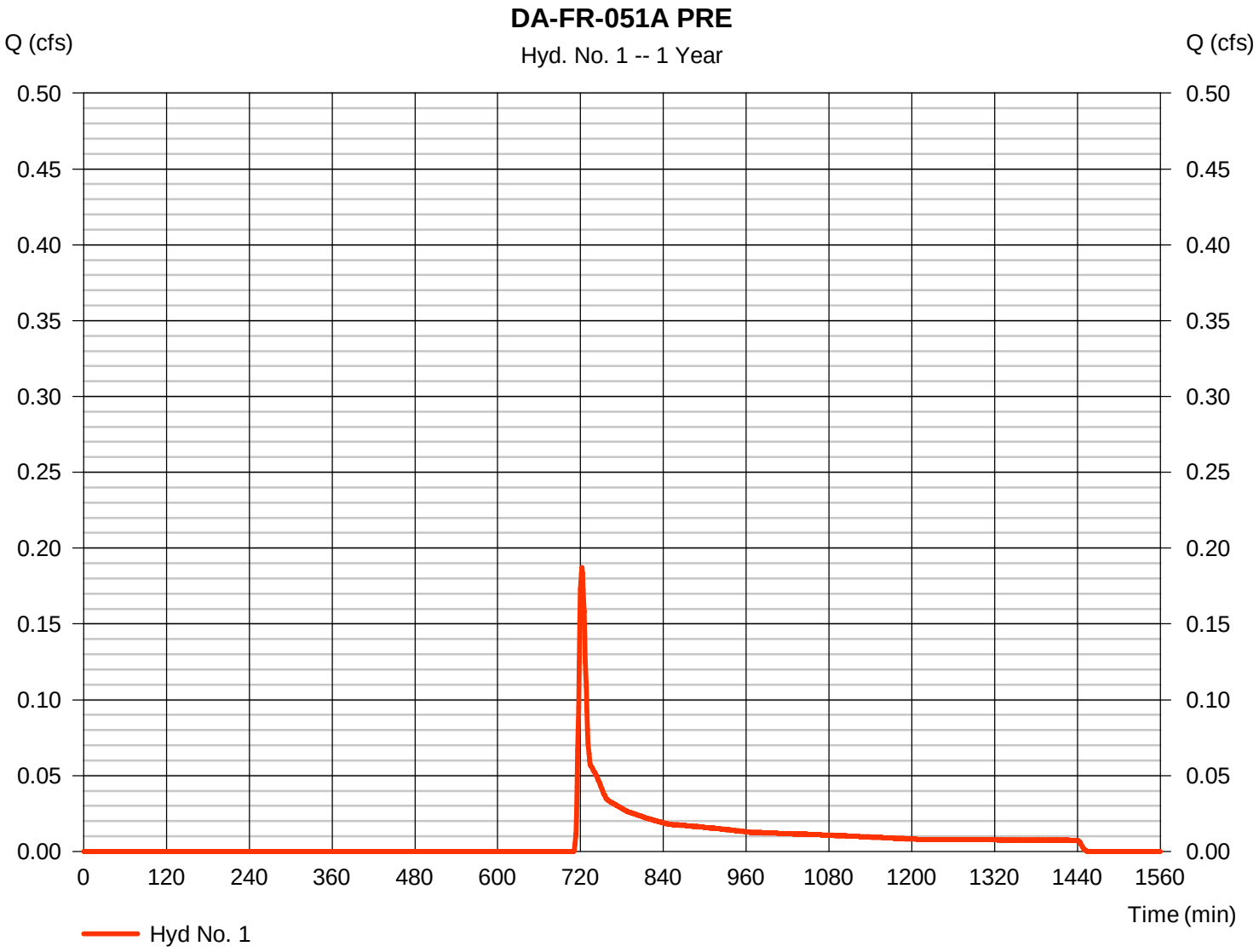
Hydrograph Report

Hyd. No. 1

DA-FR-051A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.187 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 711 cuft
Drainage area	= 0.570 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.038 x 82) + (0.001 x 98) + (0.006 x 58) + (0.522 x 55)] / 0.570



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-051A PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.400		0.011		
Flow length (ft)	= 5.4		75.6		19.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 6.68		14.27		3.65		
Travel Time (min)	**= 1.19**	**+**	**7.27**	**+**	**0.24**	**=**	**8.70**
Shallow Concentrated Flow							
Flow length (ft)	= 163.31		0.00		0.00		
Watercourse slope (%)	= 8.38		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.67		0.00		0.00		
Travel Time (min)	**= 0.58**	**+**	**0.00**	**+**	**0.00**	**=**	**0.58**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.30 min

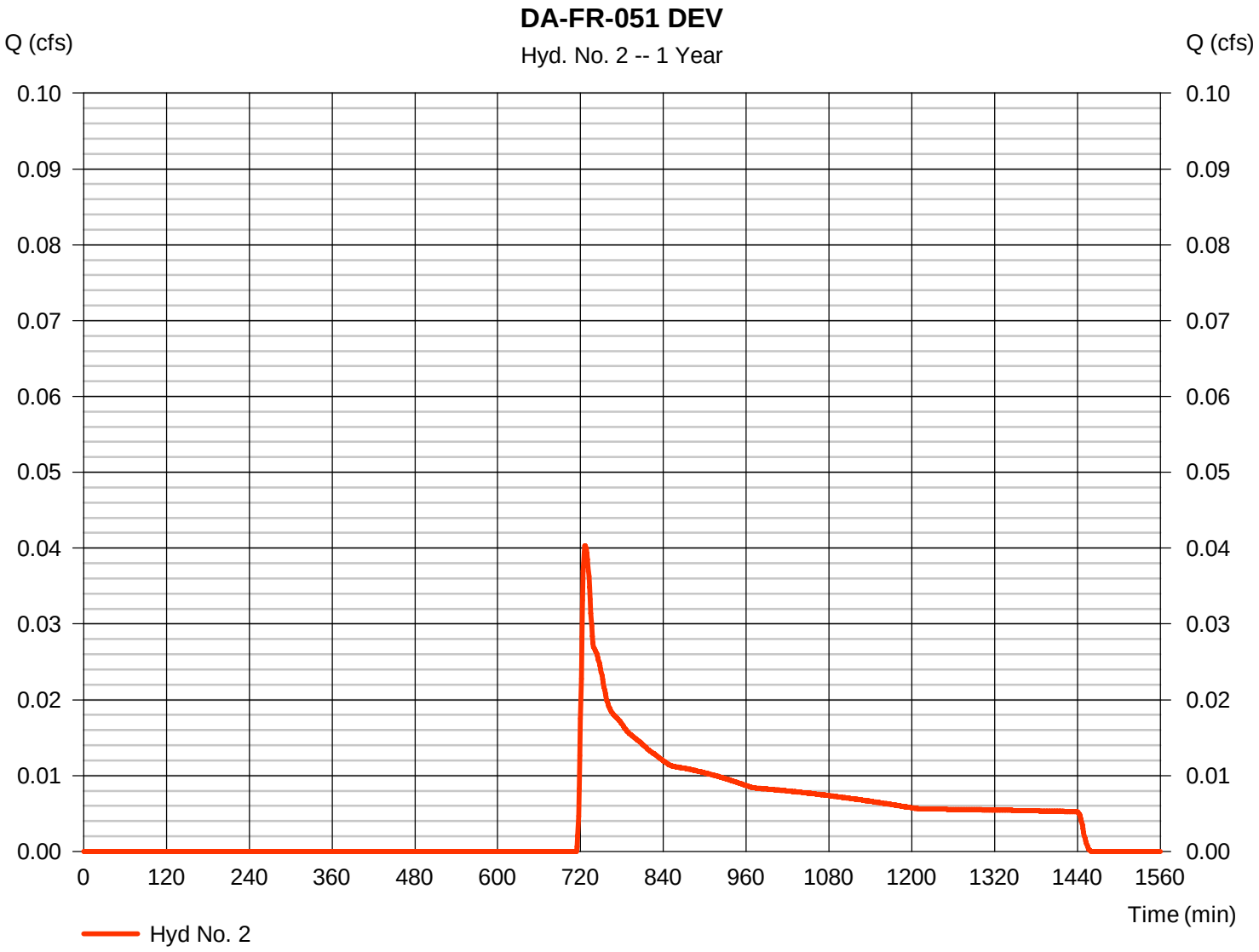
Hydrograph Report

Hyd. No. 2

DA-FR-051 DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.040 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 403 cuft
Drainage area	= 0.570 ac	Curve number	= 52*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.90 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.432 x 48) + (0.038 x 82) + (0.001 x 98) + (0.006 x 58) + (0.090 x 55)] / 0.570



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-051 DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.800		0.011		
Flow length (ft)	= 44.2		36.8		19.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 8.17		20.50		3.65		
Travel Time (min)	**= 5.92**	**+**	**6.16**	**+**	**0.24**	**=**	**12.31**
Shallow Concentrated Flow							
Flow length (ft)	= 163.31		0.00		0.00		
Watercourse slope (%)	= 8.38		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.67		0.00		0.00		
Travel Time (min)	**= 0.58**	**+**	**0.00**	**+**	**0.00**	**=**	**0.58**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

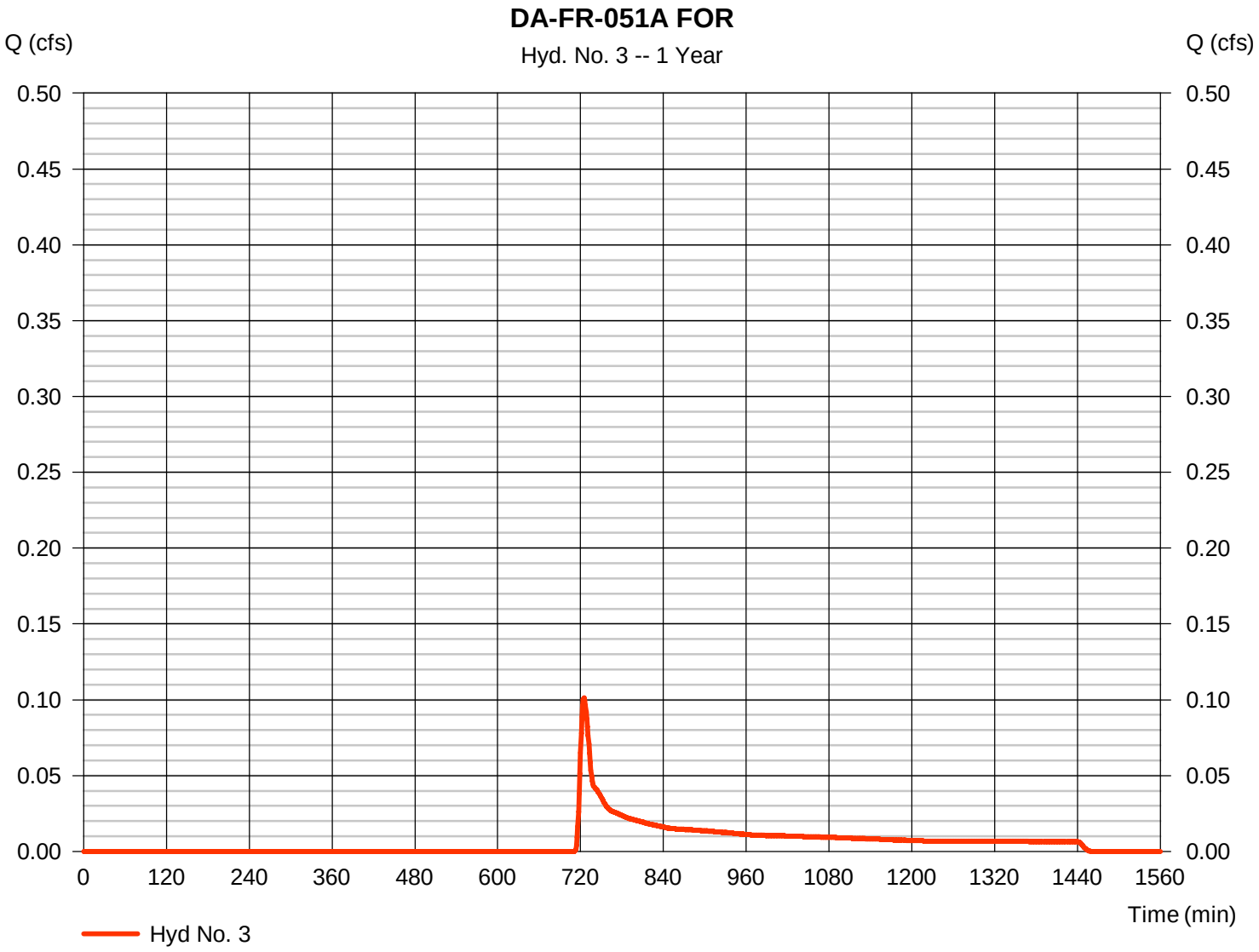
Total Travel Time, Tc ..... 12.90 min

Hydrograph Report

Hyd. No. 3

DA-FR-051A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.101 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 572 cuft
Drainage area	= 0.570 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-051A FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.400		0.400		
Flow length (ft)	= 5.4		75.6		19.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 6.68		14.27		3.65		
Travel Time (min)	**= 1.19**	**+**	**7.27**	**+**	**4.16**	**=**	**12.63**
Shallow Concentrated Flow							
Flow length (ft)	= 163.31		0.00		0.00		
Watercourse slope (%)	= 8.38		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.67		0.00		0.00		
Travel Time (min)	**= 0.58**	**+**	**0.00**	**+**	**0.00**	**=**	**0.58**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 13.20 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.328	1	721	1,020	------	------	------	DA-FR-051A PRE
2	SCS Runoff	0.109	1	725	631	------	------	------	DA-FR-051 DEV
3	SCS Runoff	0.201	1	724	846	------	------	------	DA-FR-051A FOR

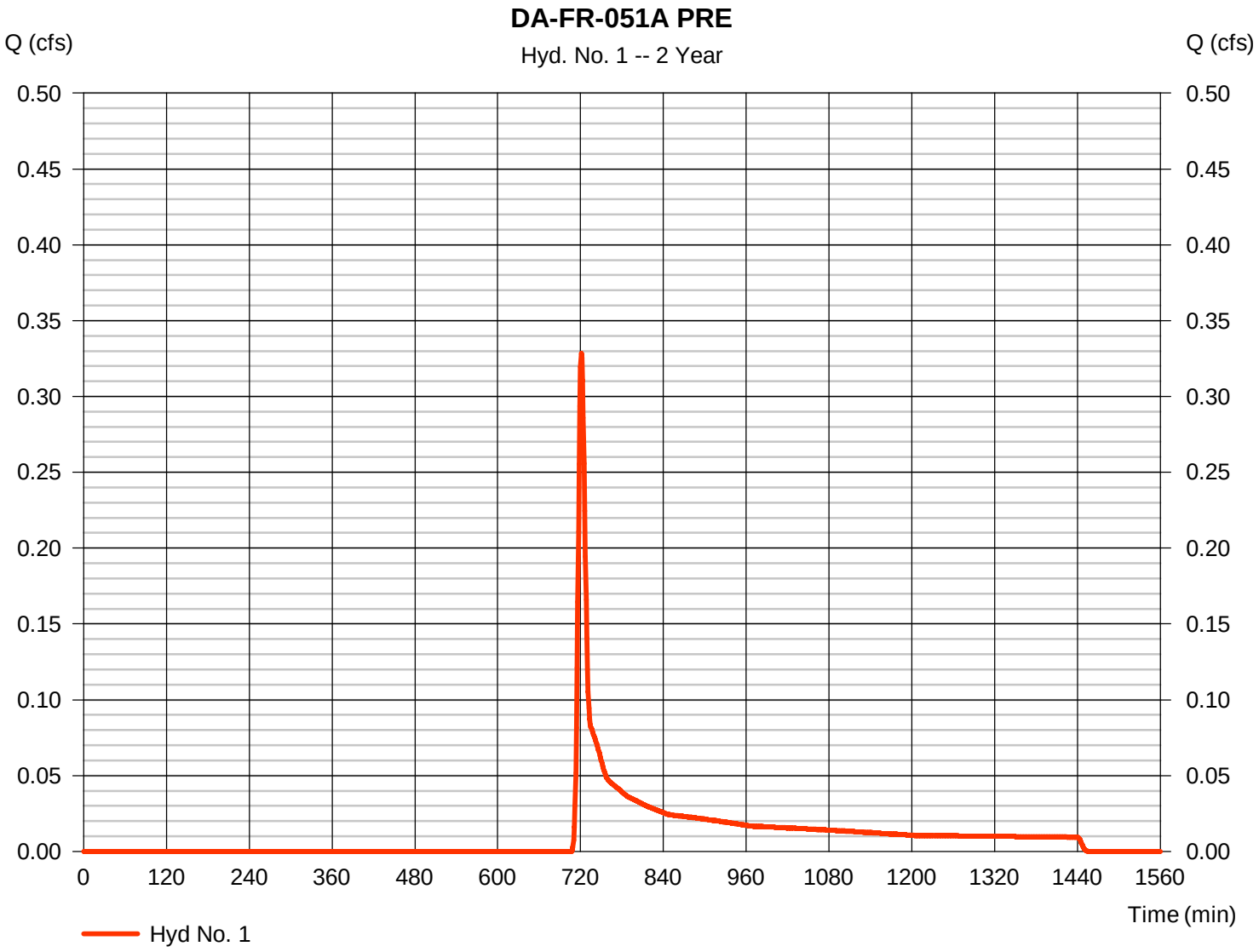
Hydrograph Report

Hyd. No. 1

DA-FR-051A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.328 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,020 cuft
Drainage area	= 0.570 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.038 x 82) + (0.001 x 98) + (0.006 x 58) + (0.522 x 55)] / 0.570



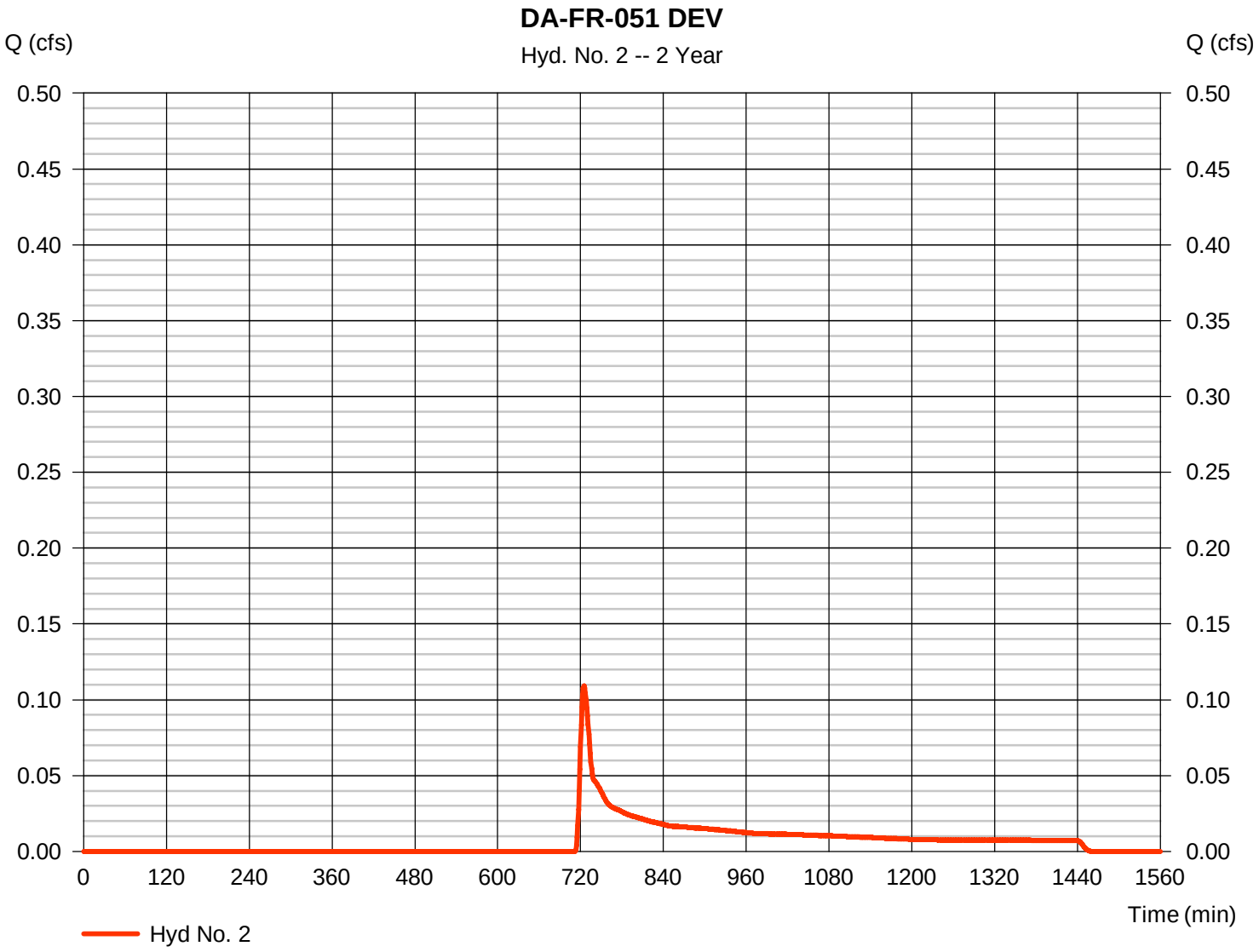
Hydrograph Report

Hyd. No. 2

DA-FR-051 DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.109 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 631 cuft
Drainage area	= 0.570 ac	Curve number	= 52*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.90 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.432 x 48) + (0.038 x 82) + (0.001 x 98) + (0.006 x 58) + (0.090 x 55)] / 0.570

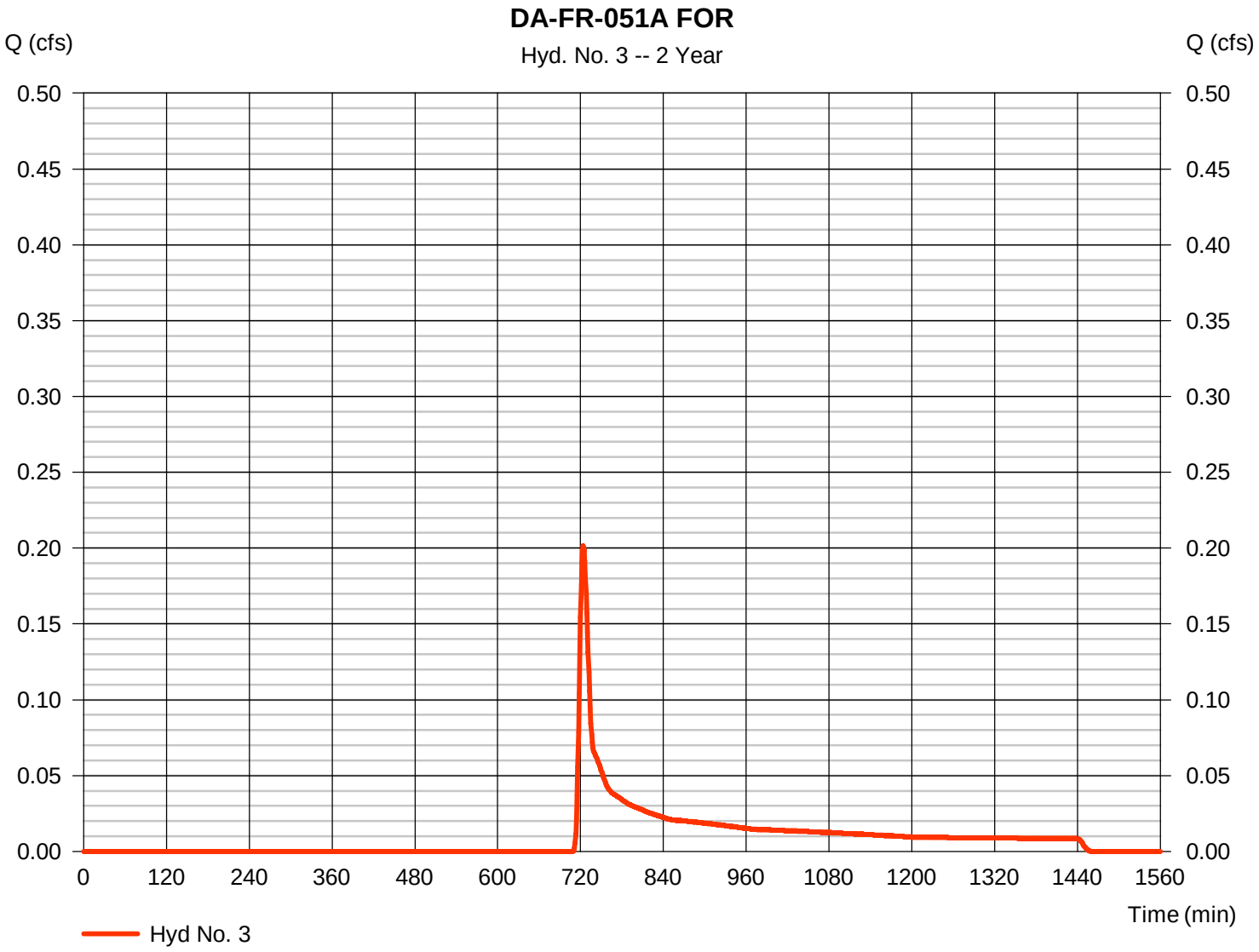


Hydrograph Report

Hyd. No. 3

DA-FR-051A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.201 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 846 cuft
Drainage area	= 0.570 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.307	1	720	3,097	------	------	------	DA-FR-051A PRE
2	SCS Runoff	0.787	1	722	2,312	------	------	------	DA-FR-051 DEV
3	SCS Runoff	0.991	1	722	2,747	------	------	------	DA-FR-051A FOR

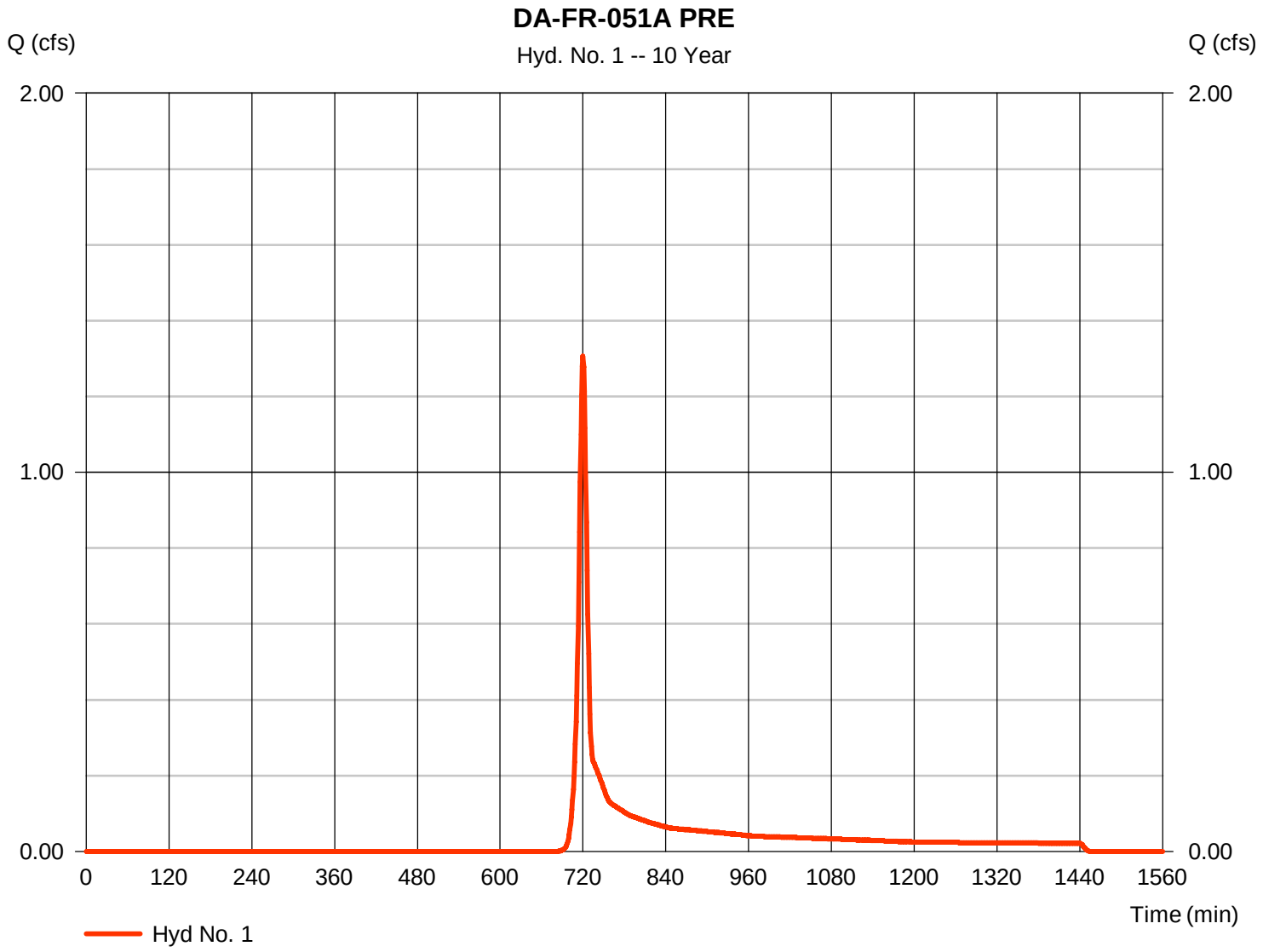
Hydrograph Report

Hyd. No. 1

DA-FR-051A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 1.307 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 3,097 cuft
Drainage area	= 0.570 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.038 x 82) + (0.001 x 98) + (0.006 x 58) + (0.522 x 55)] / 0.570



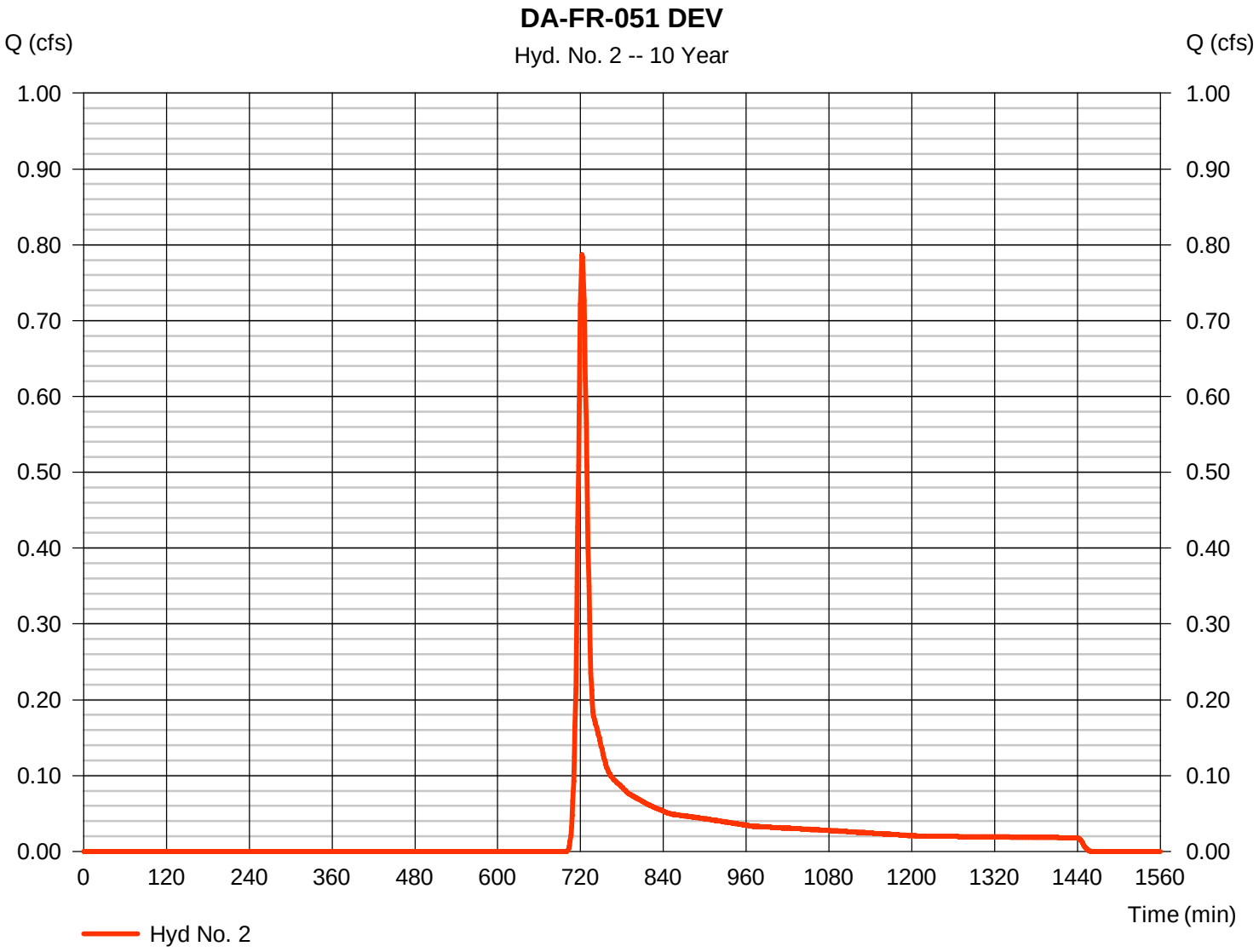
Hydrograph Report

Hyd. No. 2

DA-FR-051 DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.787 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 2,312 cuft
Drainage area	= 0.570 ac	Curve number	= 52*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.90 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.432 x 48) + (0.038 x 82) + (0.001 x 98) + (0.006 x 58) + (0.090 x 55)] / 0.570

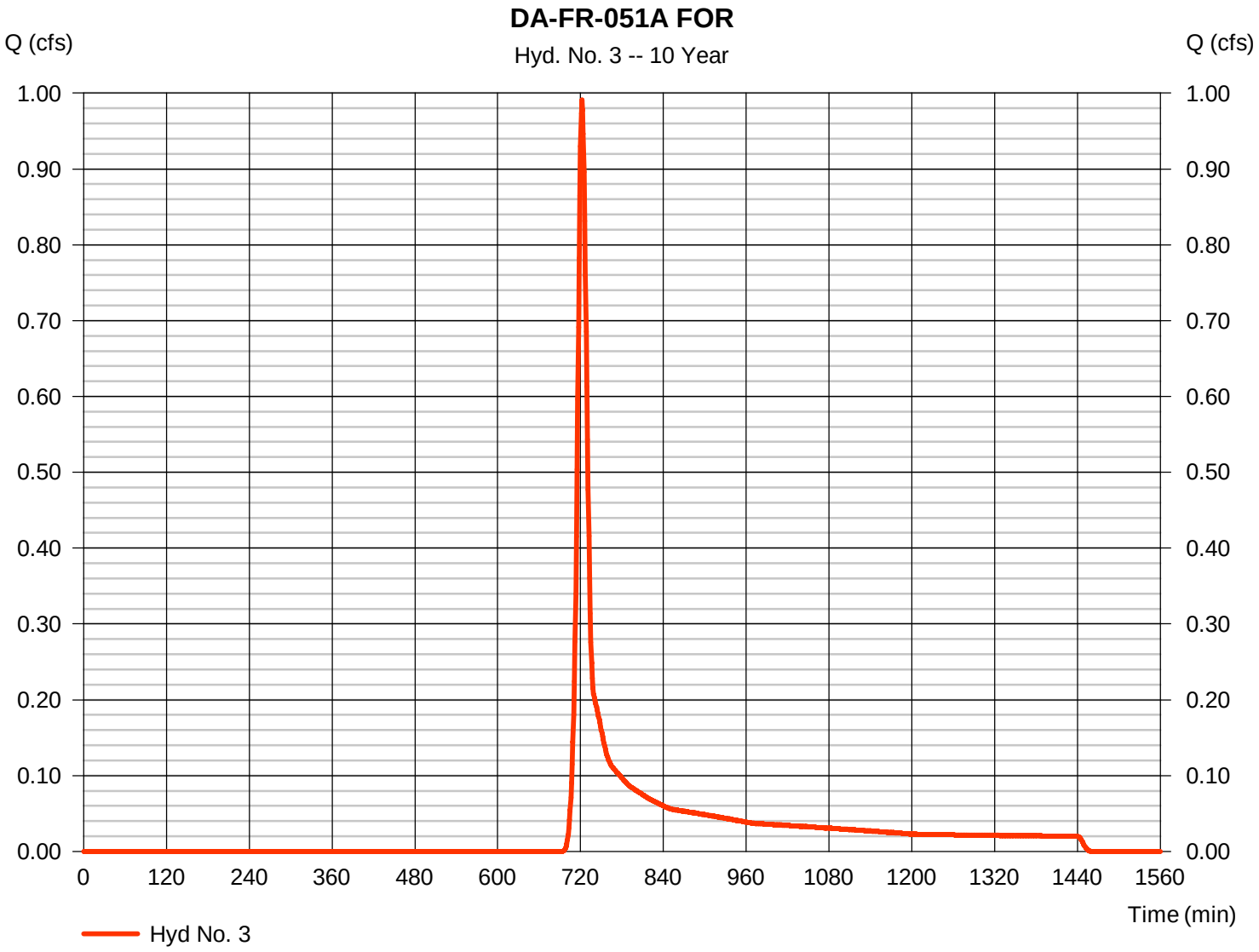


Hydrograph Report

Hyd. No. 3

DA-FR-051A FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.991 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 2,747 cuft
Drainage area	= 0.570 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-051B

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.036	4393
Developed Condition	0.846	3984
Pre-Developed (Forest) Condition	0.676	3593

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.846	≤ OK	0.914
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.846	≤ OK	1.036
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.846	*shall not* be required to be ≤	0.610

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-051B PRE
2	SCS Runoff	DA-FR-051B DEV
3	SCS Runoff	DA-FR-051B FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.036	1.827	-------	-------	7.457	-------	-------	-------	DA-FR-051B PRE
2	SCS Runoff	------	0.846	1.581	-------	-------	7.003	-------	-------	-------	DA-FR-051B DEV
3	SCS Runoff	------	0.676	1.347	-------	-------	6.551	-------	-------	-------	DA-FR-051B FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.036	1	723	4,393	------	------	------	DA-FR-051B PRE
2	SCS Runoff	0.846	1	723	3,984	------	------	------	DA-FR-051B DEV
3	SCS Runoff	0.676	1	724	3,593	------	------	------	DA-FR-051B FOR

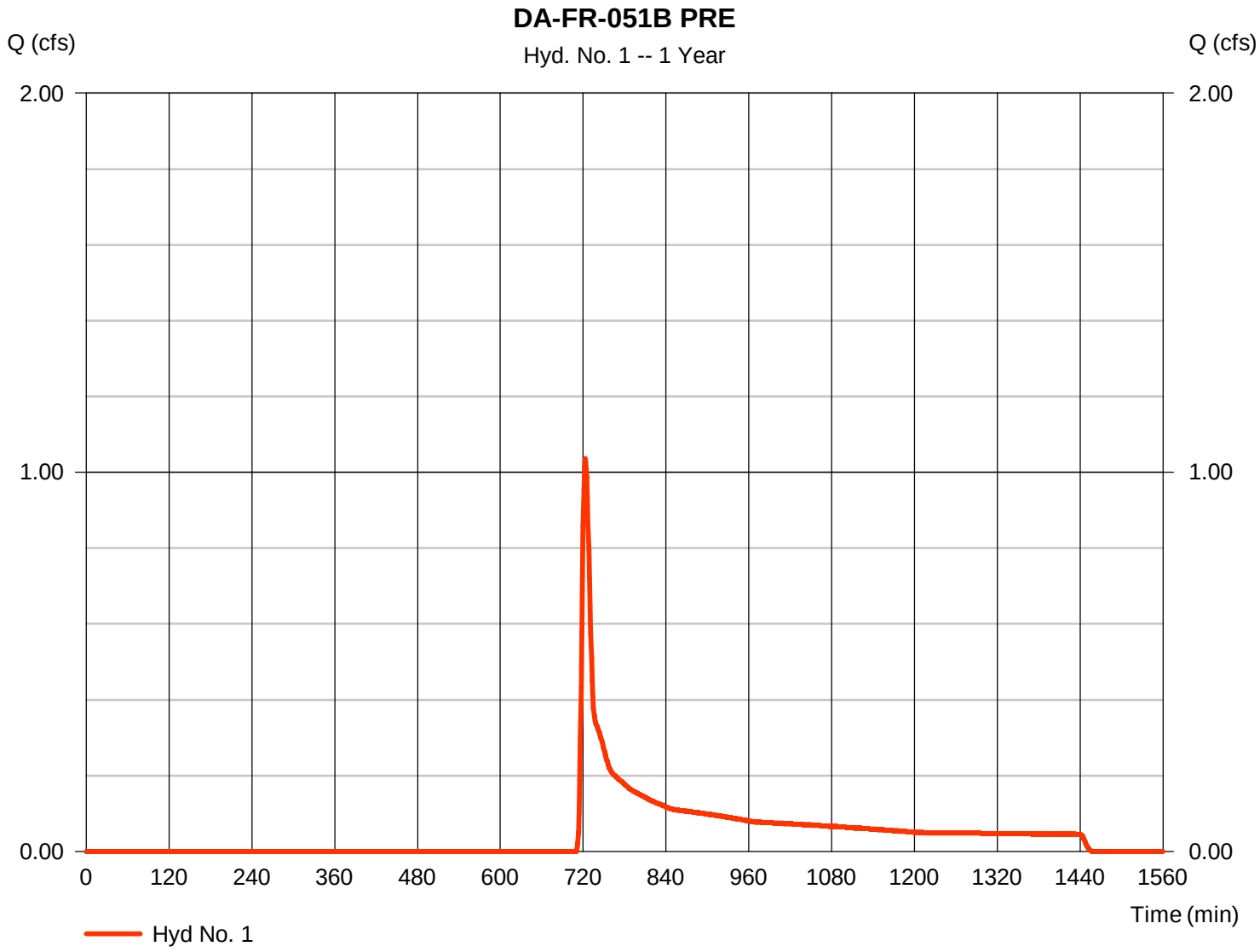
Hydrograph Report

Hyd. No. 1

DA-FR-051B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 1.036 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 4,393 cuft
Drainage area	= 3.460 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.133 x 98) + (0.213 x 58) + (3.115 x 55)] / 3.460



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-051B PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.400		
Flow length (ft)	= 80.3		12.5		7.3		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 8.56		6.90		13.92		
Travel Time (min)	**= 9.36**	**+**	**0.13**	**+**	**1.13**	**=**	**10.62**
Shallow Concentrated Flow							
Flow length (ft)	= 297.14		0.00		0.00		
Watercourse slope (%)	= 23.21		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.77		0.00		0.00		
Travel Time (min)	**= 0.64**	**+**	**0.00**	**+**	**0.00**	**=**	**0.64**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 11.30 min

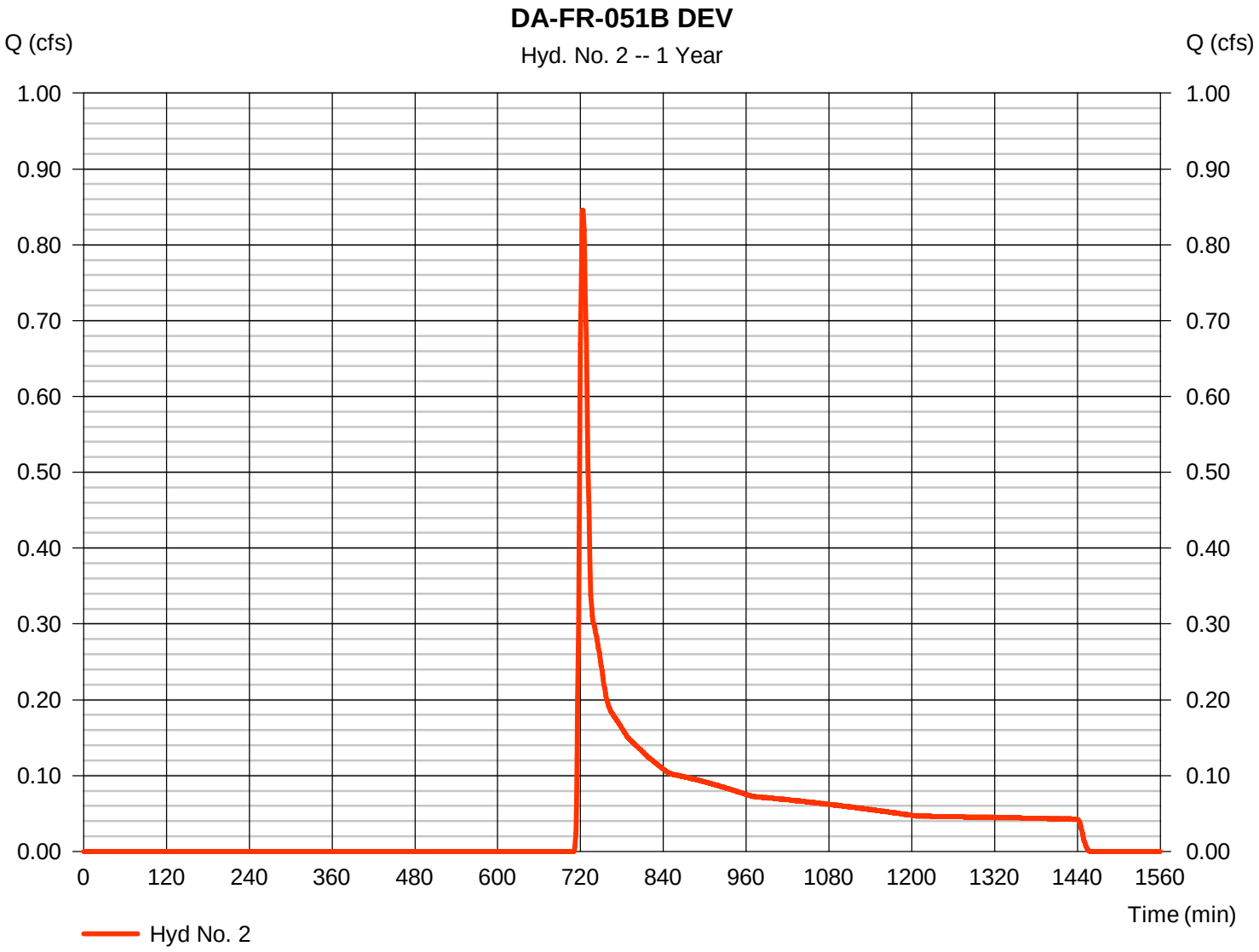
Hydrograph Report

Hyd. No. 2

DA-FR-051B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.846 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 3,984 cuft
Drainage area	= 3.460 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.757 x 48) + (0.133 x 98) + (0.693 x 58) + (1.878 x 55)] / 3.460



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-051B DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.400		
Flow length (ft)	= 80.3		12.5		7.3		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 8.56		6.90		13.92		
Travel Time (min)	**= 9.36**	**+**	**0.13**	**+**	**1.13**	**=**	**10.62**
Shallow Concentrated Flow							
Flow length (ft)	= 297.14		0.00		0.00		
Watercourse slope (%)	= 23.21		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.77		0.00		0.00		
Travel Time (min)	**= 0.64**	**+**	**0.00**	**+**	**0.00**	**=**	**0.64**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 11.30 min

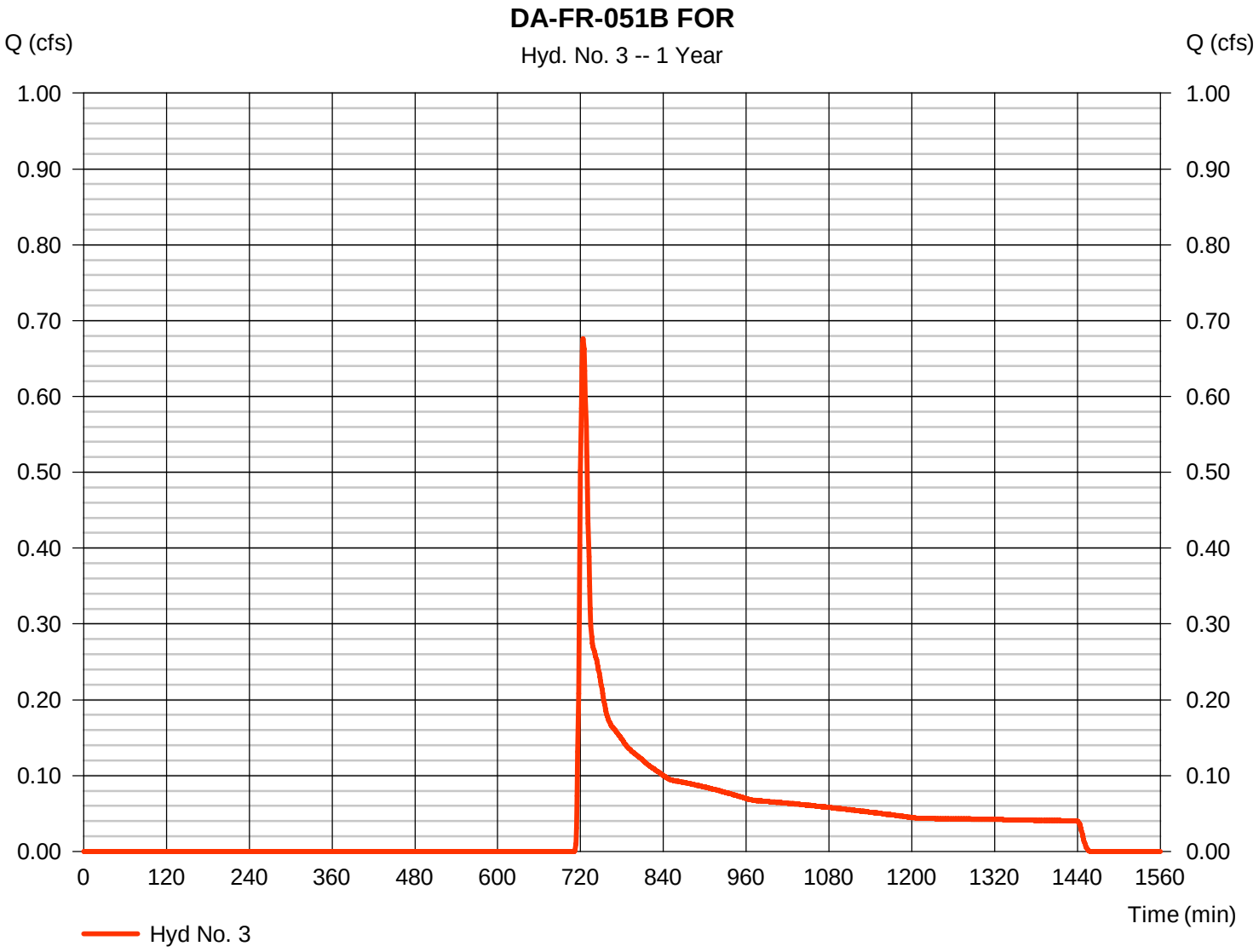
Hydrograph Report

Hyd. No. 3

DA-FR-051B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.676 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 3,593 cuft
Drainage area	= 3.460 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.133 x 98) + (0.213 x 58) + (3.115 x 55)] / 3.460



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-051B FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.400		
Flow length (ft)	= 80.3		12.5		7.3		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 8.56		6.90		13.92		
Travel Time (min)	**= 9.36**	**+**	**0.13**	**+**	**1.13**	**=**	**10.62**
Shallow Concentrated Flow							
Flow length (ft)	= 297.14		0.00		0.00		
Watercourse slope (%)	= 23.21		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.77		0.00		0.00		
Travel Time (min)	**= 0.64**	**+**	**0.00**	**+**	**0.00**	**=**	**0.64**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 11.30 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.827	1	722	6,304	------	------	------	DA-FR-051B PRE
2	SCS Runoff	1.581	1	723	5,800	------	------	------	DA-FR-051B DEV
3	SCS Runoff	1.347	1	723	5,313	------	------	------	DA-FR-051B FOR

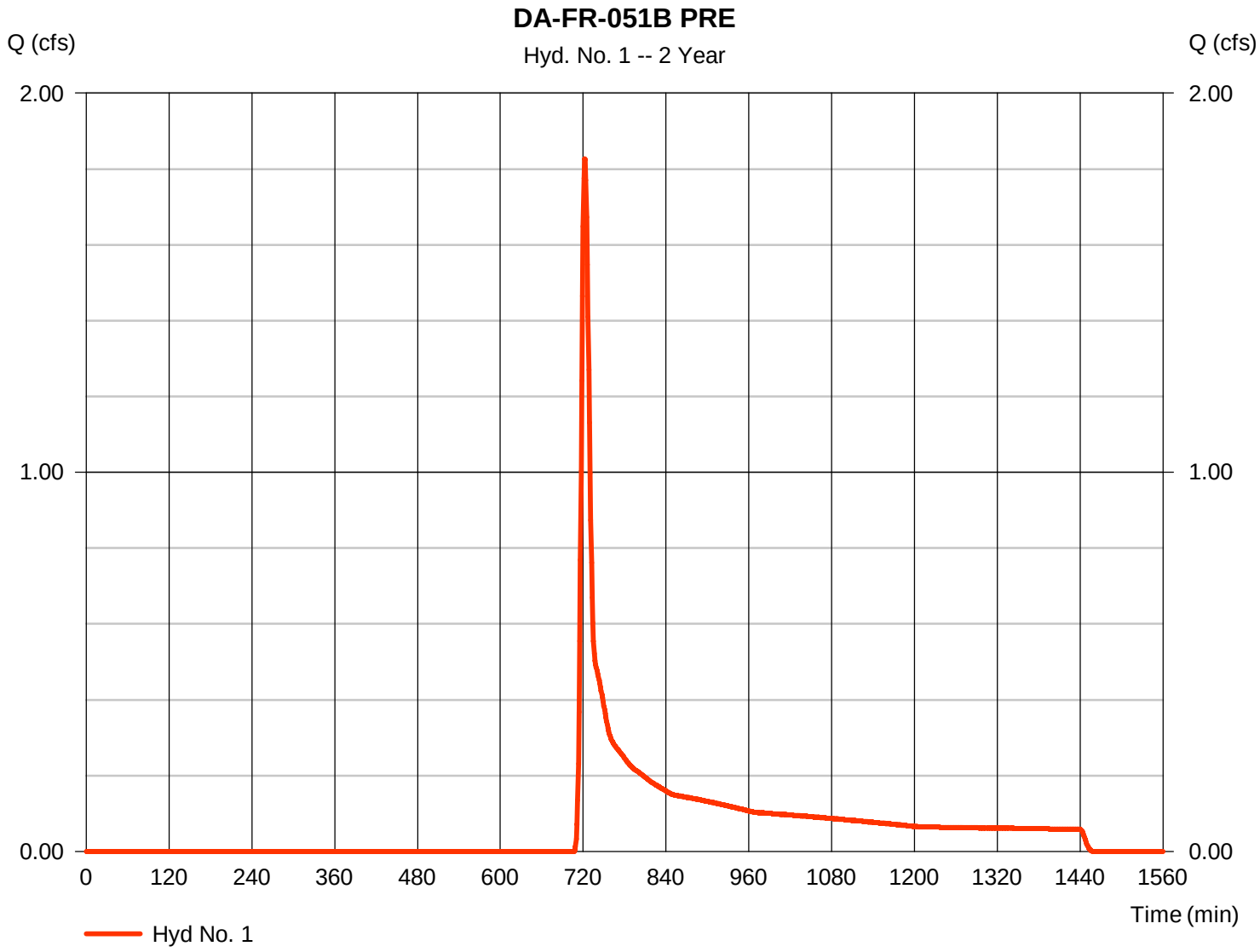
Hydrograph Report

Hyd. No. 1

DA-FR-051B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 1.827 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 6,304 cuft
Drainage area	= 3.460 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.133 x 98) + (0.213 x 58) + (3.115 x 55)] / 3.460



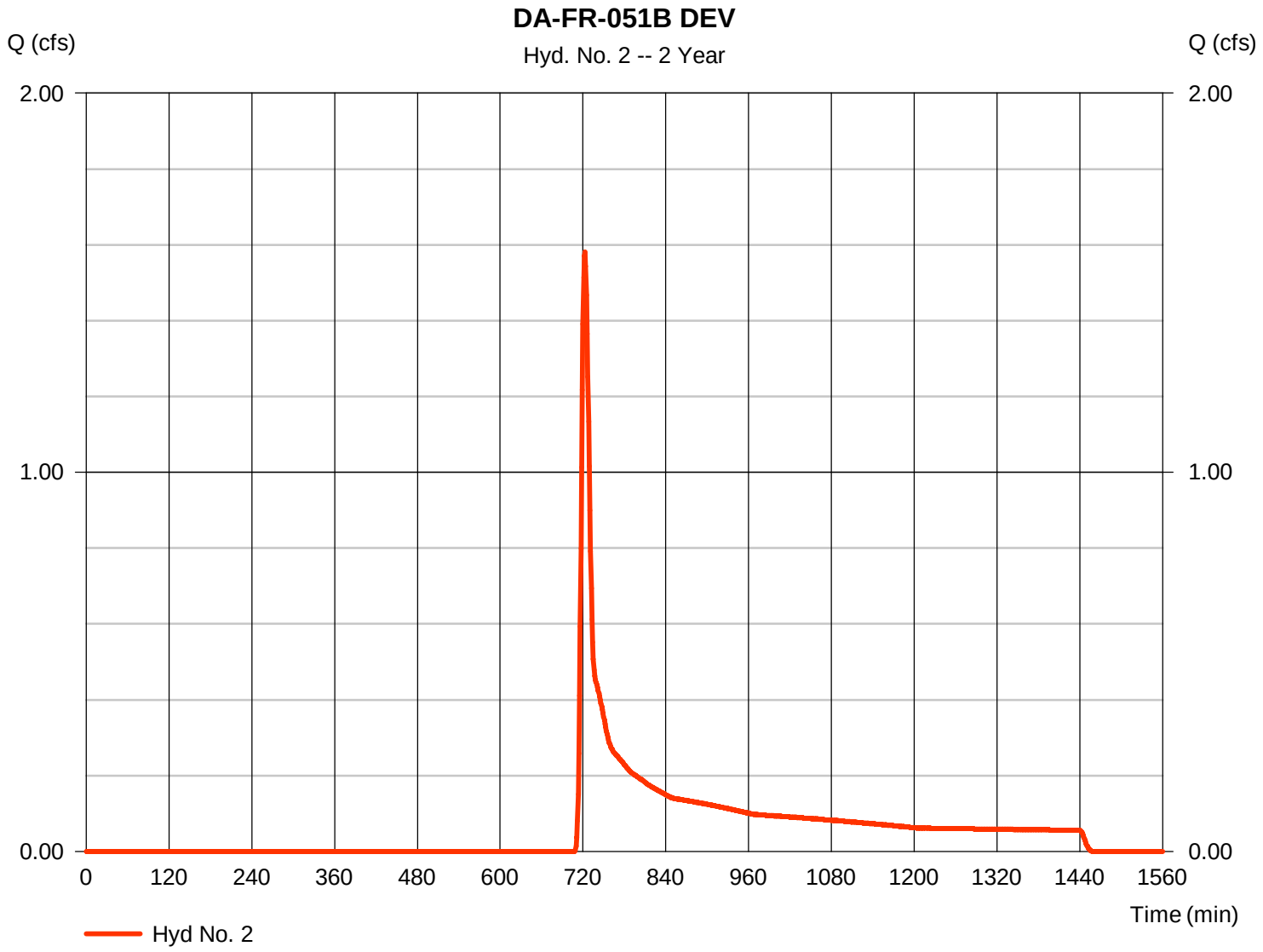
Hydrograph Report

Hyd. No. 2

DA-FR-051B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 1.581 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 5,800 cuft
Drainage area	= 3.460 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.757 x 48) + (0.133 x 98) + (0.693 x 58) + (1.878 x 55)] / 3.460



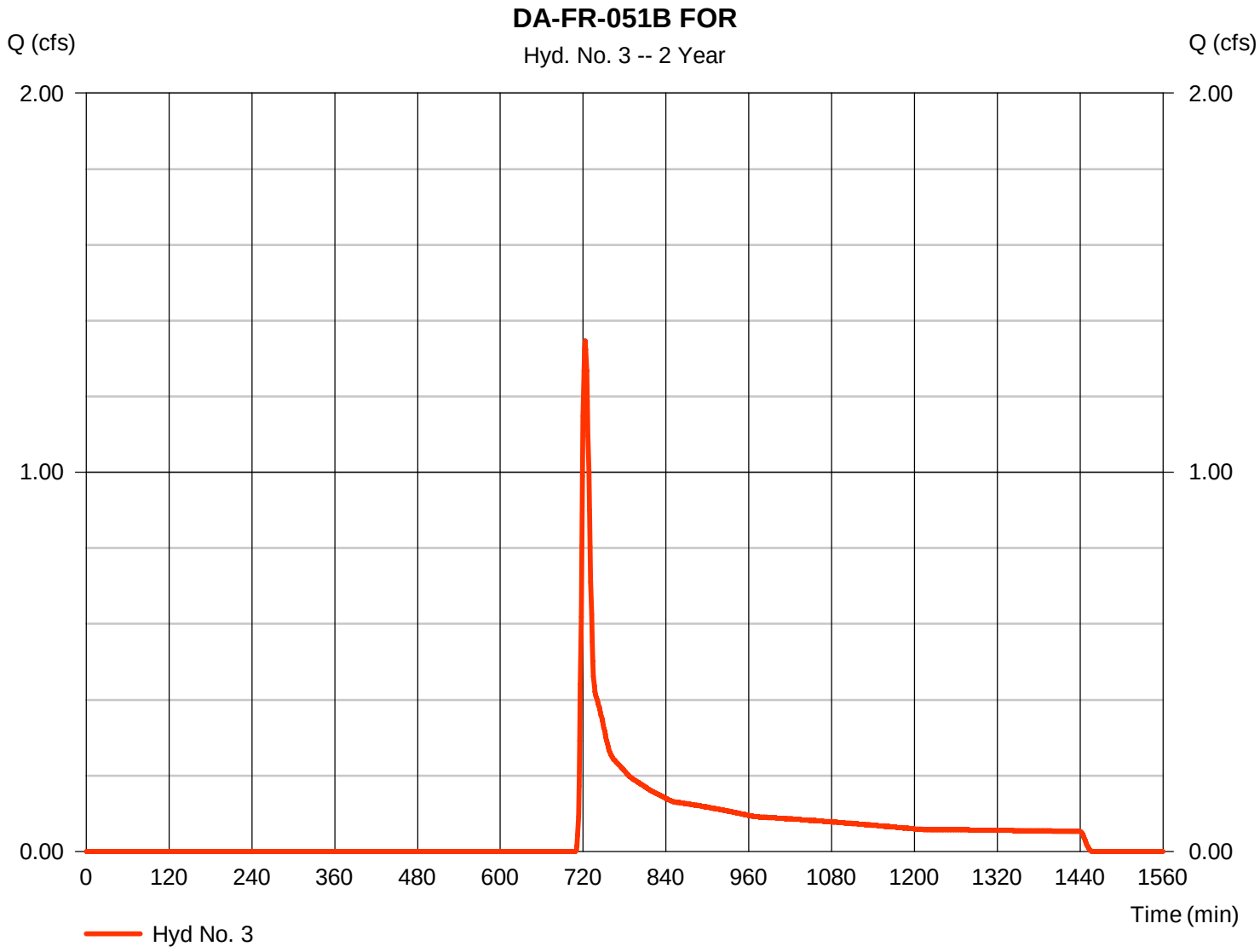
Hydrograph Report

Hyd. No. 3

DA-FR-051B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 1.347 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 5,313 cuft
Drainage area	= 3.460 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.133 x 98) + (0.213 x 58) + (3.115 x 55)] / 3.460



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	7.457	1	721	19,137	------	------	------	DA-FR-051B PRE
2	SCS Runoff	7.003	1	721	18,180	------	------	------	DA-FR-051B DEV
3	SCS Runoff	6.551	1	721	17,239	------	------	------	DA-FR-051B FOR

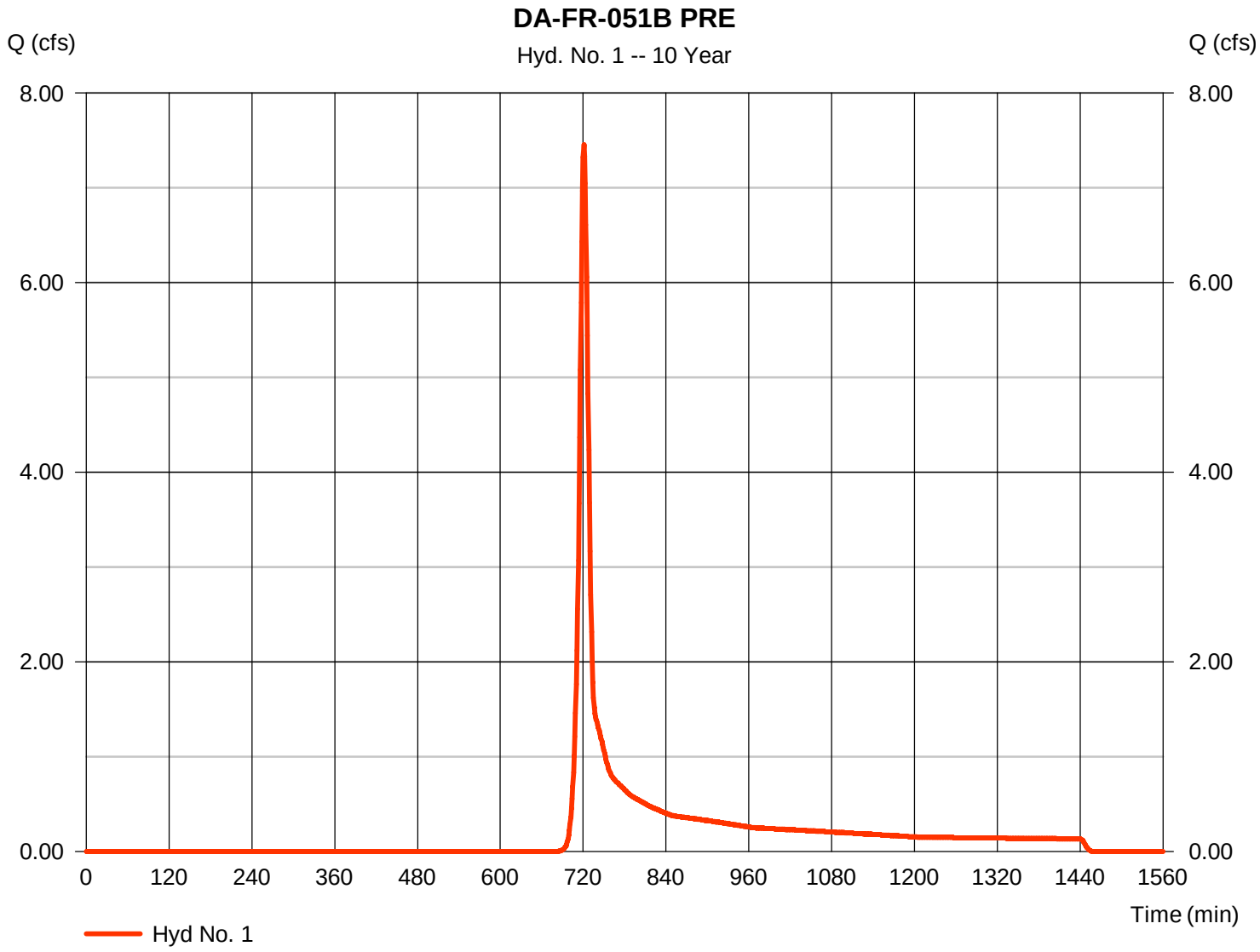
Hydrograph Report

Hyd. No. 1

DA-FR-051B PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 7.457 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 19,137 cuft
Drainage area	= 3.460 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.133 x 98) + (0.213 x 58) + (3.115 x 55)] / 3.460



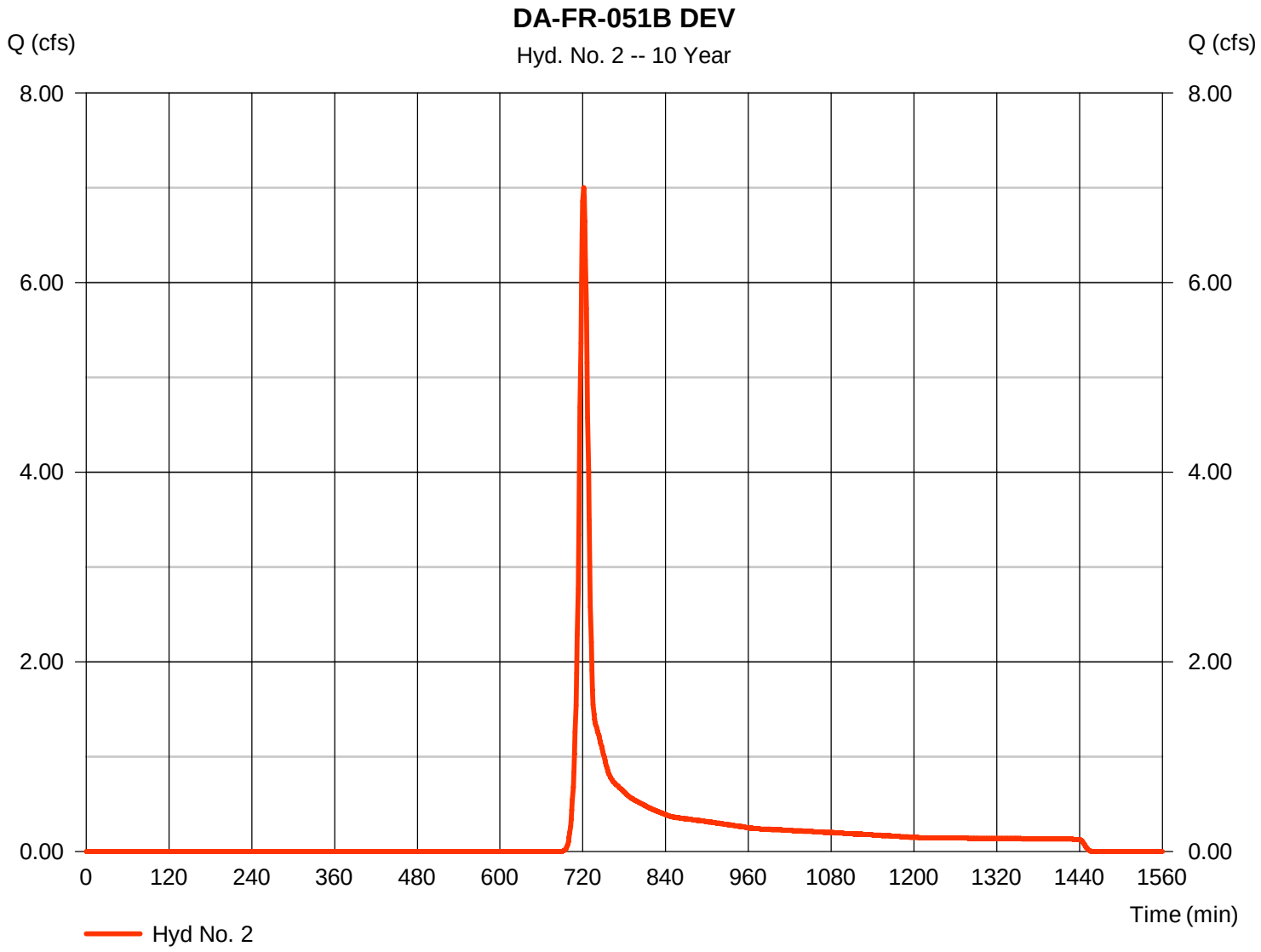
Hydrograph Report

Hyd. No. 2

DA-FR-051B DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 7.003 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 18,180 cuft
Drainage area	= 3.460 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.757 x 48) + (0.133 x 98) + (0.693 x 58) + (1.878 x 55)] / 3.460



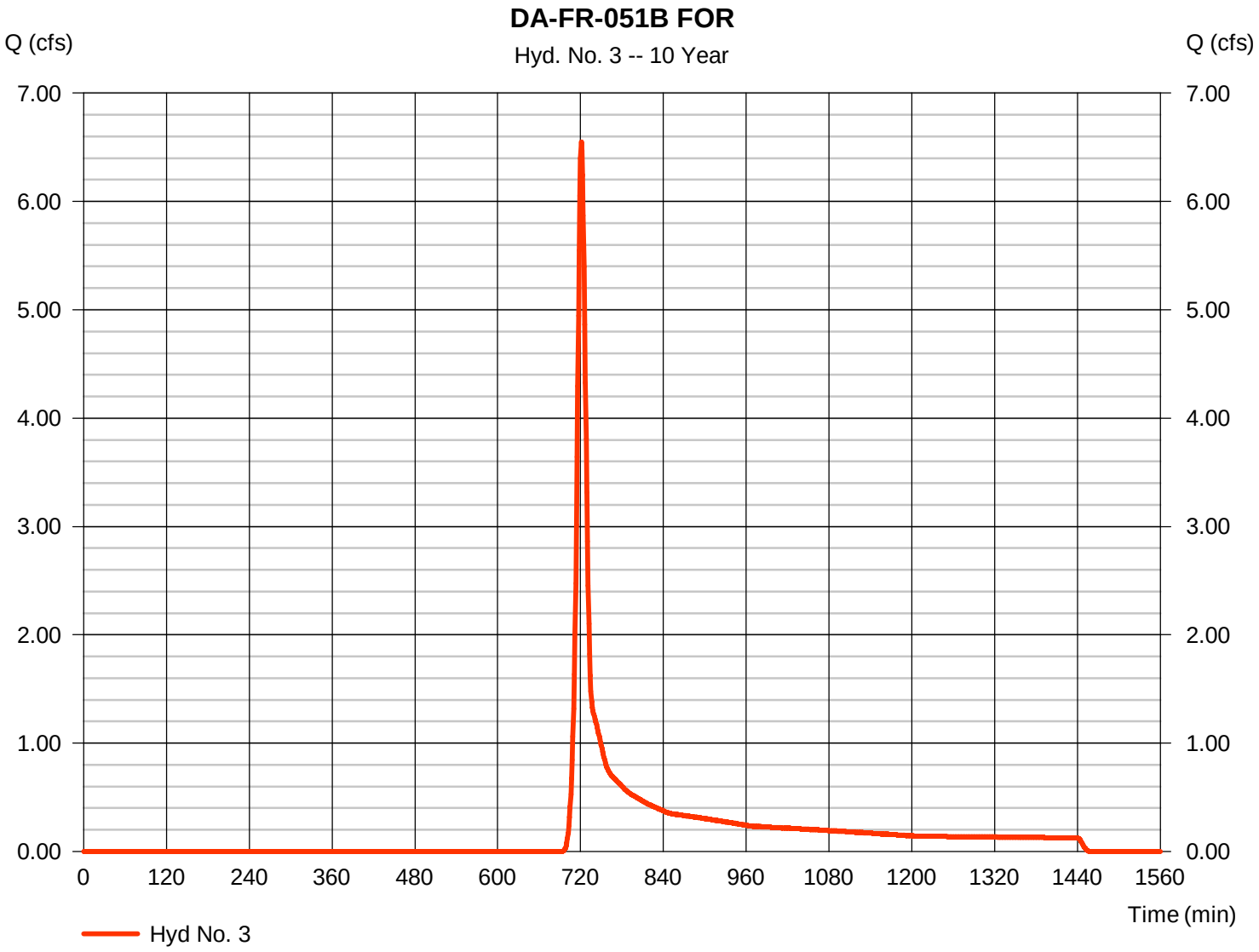
Hydrograph Report

Hyd. No. 3

DA-FR-051B FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 6.551 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 17,239 cuft
Drainage area	= 3.460 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 11.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.133 x 98) + (0.213 x 58) + (3.115 x 55)] / 3.460



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-051C

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.739	3109
Developed Condition	0.628	2846
Pre-Developed (Forest) Condition	0.343	2122

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.628	≤ OK	0.646
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.628	≤ OK	0.739
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.628	*shall not* be required to be ≤	0.256

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-051C PRE
2	SCS Runoff	DA-FR-051C DEV
3	SCS Runoff	DA-FR-051C FOR

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.739	1.208	-------	-------	4.383	-------	-------	-------	DA-FR-051C PRE
2	SCS Runoff	------	0.628	1.065	-------	-------	4.137	-------	-------	-------	DA-FR-051C DEV
3	SCS Runoff	------	0.343	0.682	-------	-------	3.407	-------	-------	-------	DA-FR-051C FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.739	1	725	3,109	------	------	------	DA-FR-051C PRE
2	SCS Runoff	0.628	1	725	2,846	------	------	------	DA-FR-051C DEV
3	SCS Runoff	0.343	1	726	2,122	------	------	------	DA-FR-051C FOR

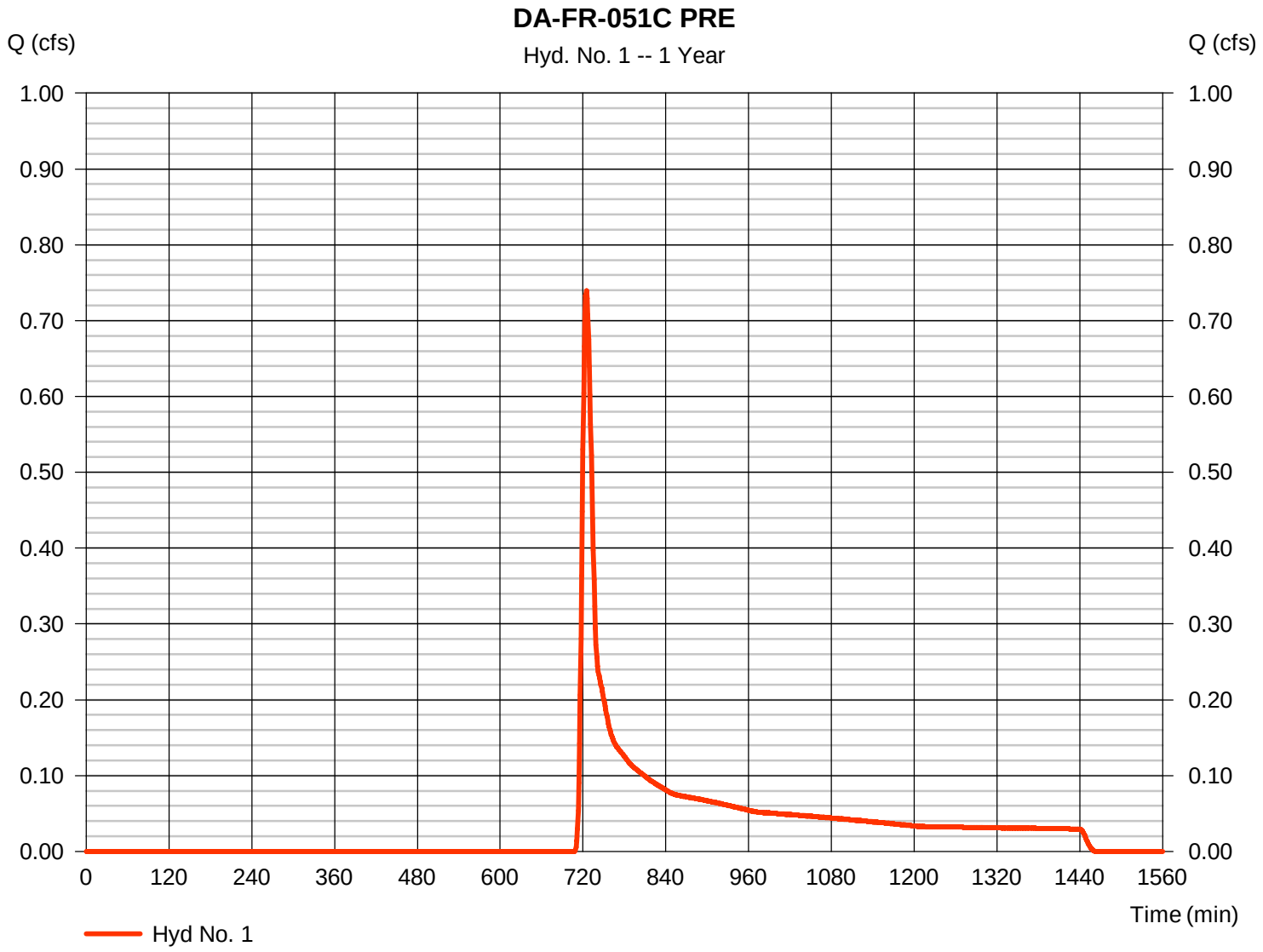
Hydrograph Report

Hyd. No. 1

DA-FR-051C PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.739 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 3,109 cuft
Drainage area	= 2.080 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.137 x 98) + (0.716 x 58) + (1.230 x 55)] / 2.080



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-051C PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.34		0.00		0.00		
Travel Time (min)	**= 13.48**	**+**	**0.00**	**+**	**0.00**	**=**	**13.48**
Shallow Concentrated Flow							
Flow length (ft)	= 322.11		0.00		0.00		
Watercourse slope (%)	= 23.62		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.84		0.00		0.00		
Travel Time (min)	**= 0.68**	**+**	**0.00**	**+**	**0.00**	**=**	**0.68**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.20 min

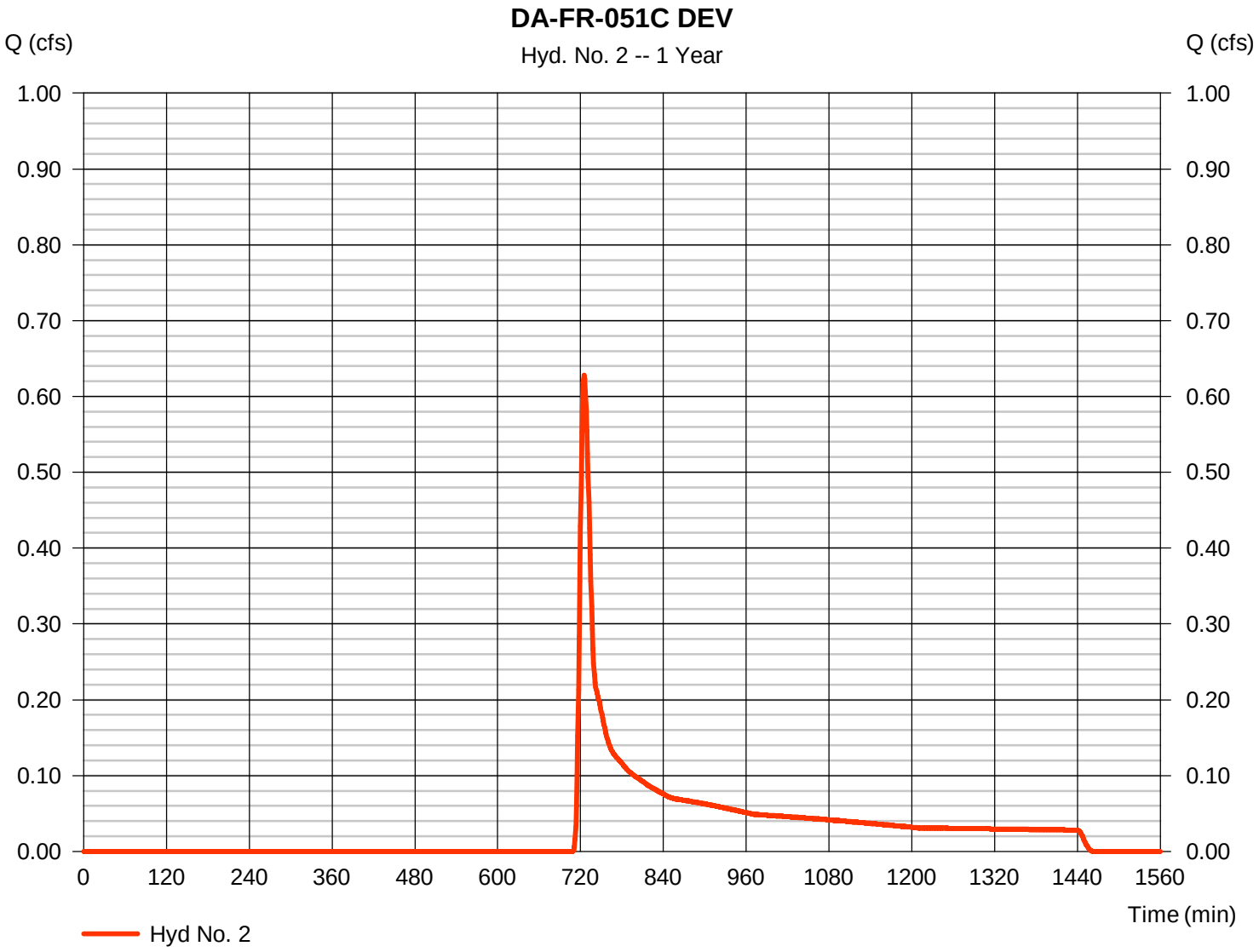
Hydrograph Report

Hyd. No. 2

DA-FR-051C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.628 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 2,846 cuft
Drainage area	= 2.080 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.369 x 48) + (1.060 x 58) + (0.137 x 98) + (0.518 x 55)] / 2.080



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-051C DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.34		0.00		0.00		
Travel Time (min)	**= 13.48**	**+**	**0.00**	**+**	**0.00**	**=**	**13.48**
Shallow Concentrated Flow							
Flow length (ft)	= 233.59		74.80		0.00		
Watercourse slope (%)	= 15.81		48.49		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=6.42		11.24		0.00		
Travel Time (min)	**= 0.61**	**+**	**0.11**	**+**	**0.00**	**=**	**0.72**
Channel Flow							
X sectional flow area (sqft)	= 2.00		0.00		0.00		
Wetted perimeter (ft)	= 4.47		0.00		0.00		
Channel slope (%)	= 5.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=4.86						
			0.00				
					0.00		
Flow length (ft)	({0})39.4		0.0		0.0		
Travel Time (min)	**= 0.14**	**+**	**0.00**	**+**	**0.00**	**=**	**0.14**

Total Travel Time, Tc ..... 14.30 min

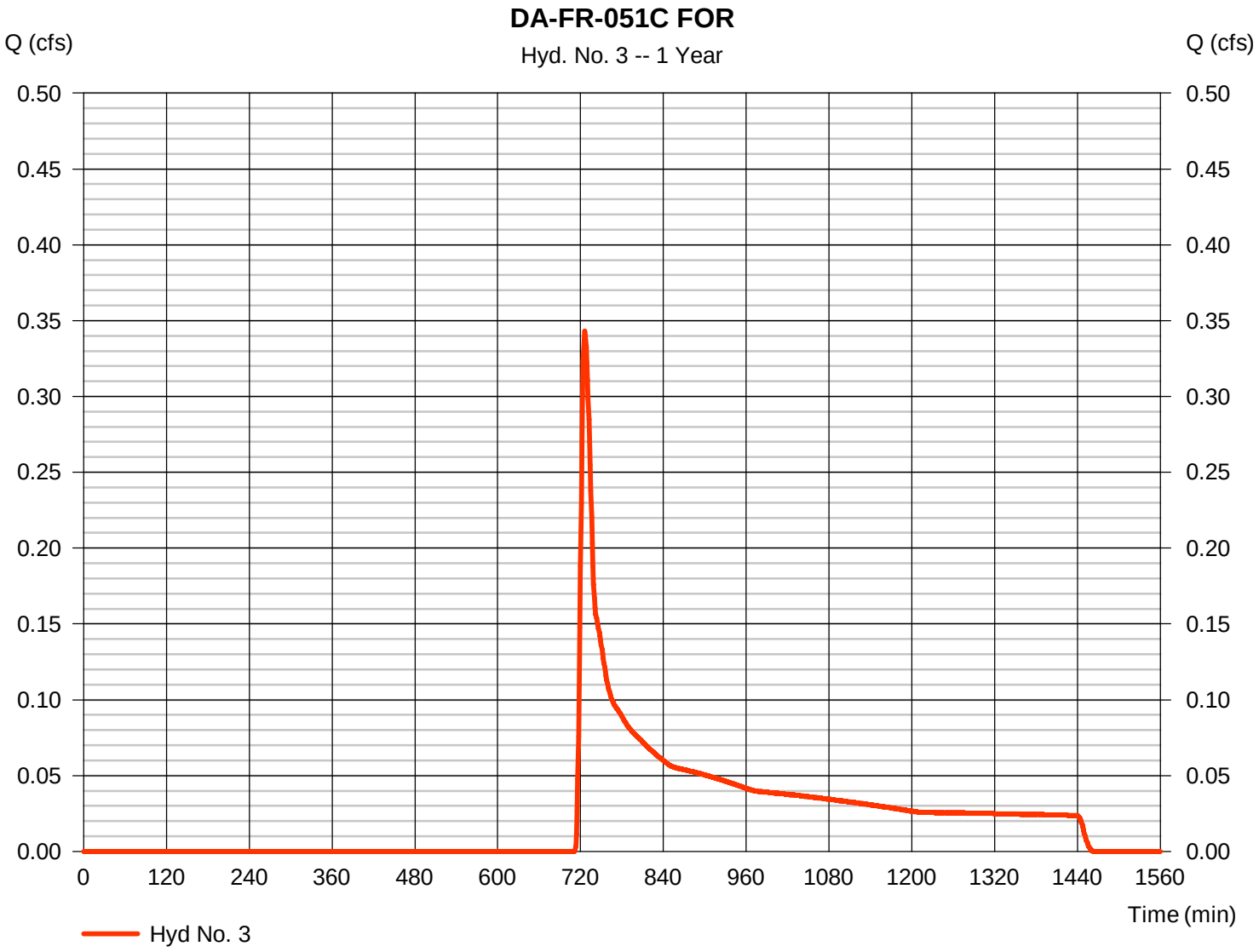
Hydrograph Report

Hyd. No. 3

DA-FR-051C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.343 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 2,122 cuft
Drainage area	= 2.080 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.137 x 98) + (0.716 x 58) + (1.230 x 55)] / 2.080



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-051C FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 5.34		0.00		0.00		
Travel Time (min)	**= 13.48**	**+**	**0.00**	**+**	**0.00**	**=**	**13.48**
Shallow Concentrated Flow							
Flow length (ft)	= 322.11		0.00		0.00		
Watercourse slope (%)	= 23.62		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=7.84		0.00		0.00		
Travel Time (min)	**= 0.68**	**+**	**0.00**	**+**	**0.00**	**=**	**0.68**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.20 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.208	1	724	4,352	------	------	------	DA-FR-051C PRE
2	SCS Runoff	1.065	1	724	4,032	------	------	------	DA-FR-051C DEV
3	SCS Runoff	0.682	1	725	3,138	------	------	------	DA-FR-051C FOR

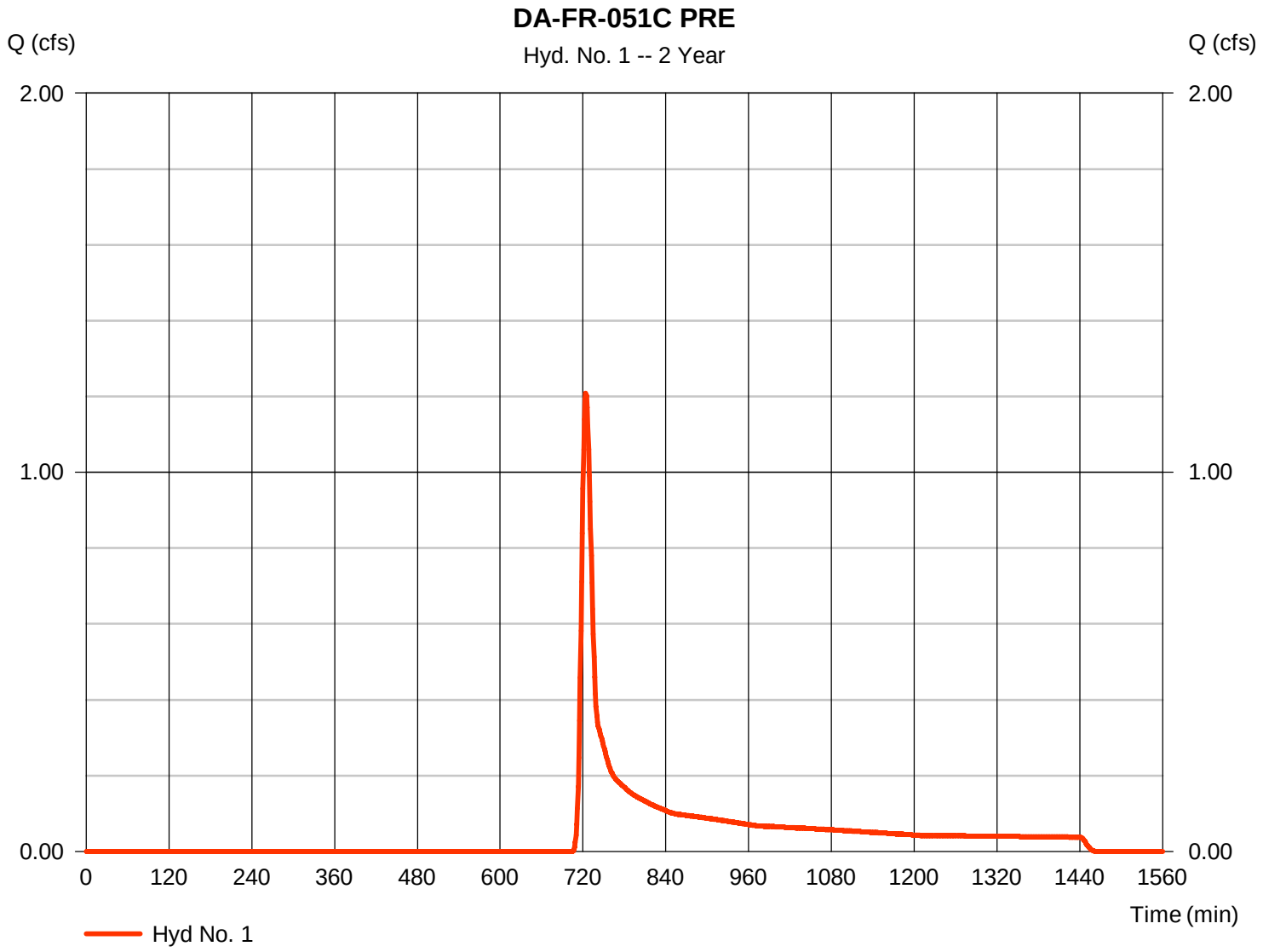
Hydrograph Report

Hyd. No. 1

DA-FR-051C PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.208 cfs
Storm frequency	=	2 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	4,352 cuft
Drainage area	=	2.080 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.20 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.137 x 98) + (0.716 x 58) + (1.230 x 55)] / 2.080



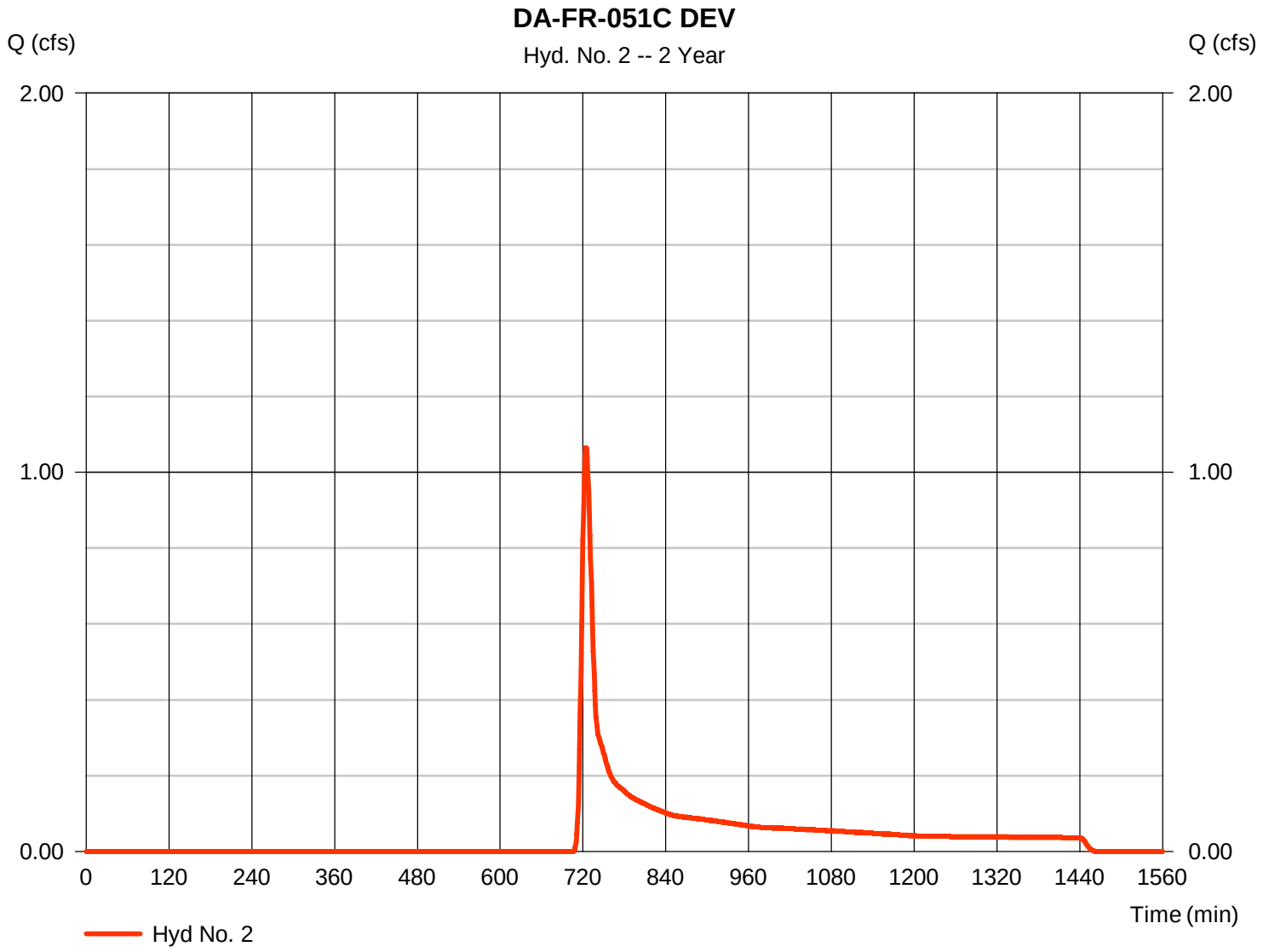
Hydrograph Report

Hyd. No. 2

DA-FR-051C DEV

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.065 cfs
Storm frequency	=	2 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	4,032 cuft
Drainage area	=	2.080 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.30 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.369 x 48) + (1.060 x 58) + (0.137 x 98) + (0.518 x 55)] / 2.080



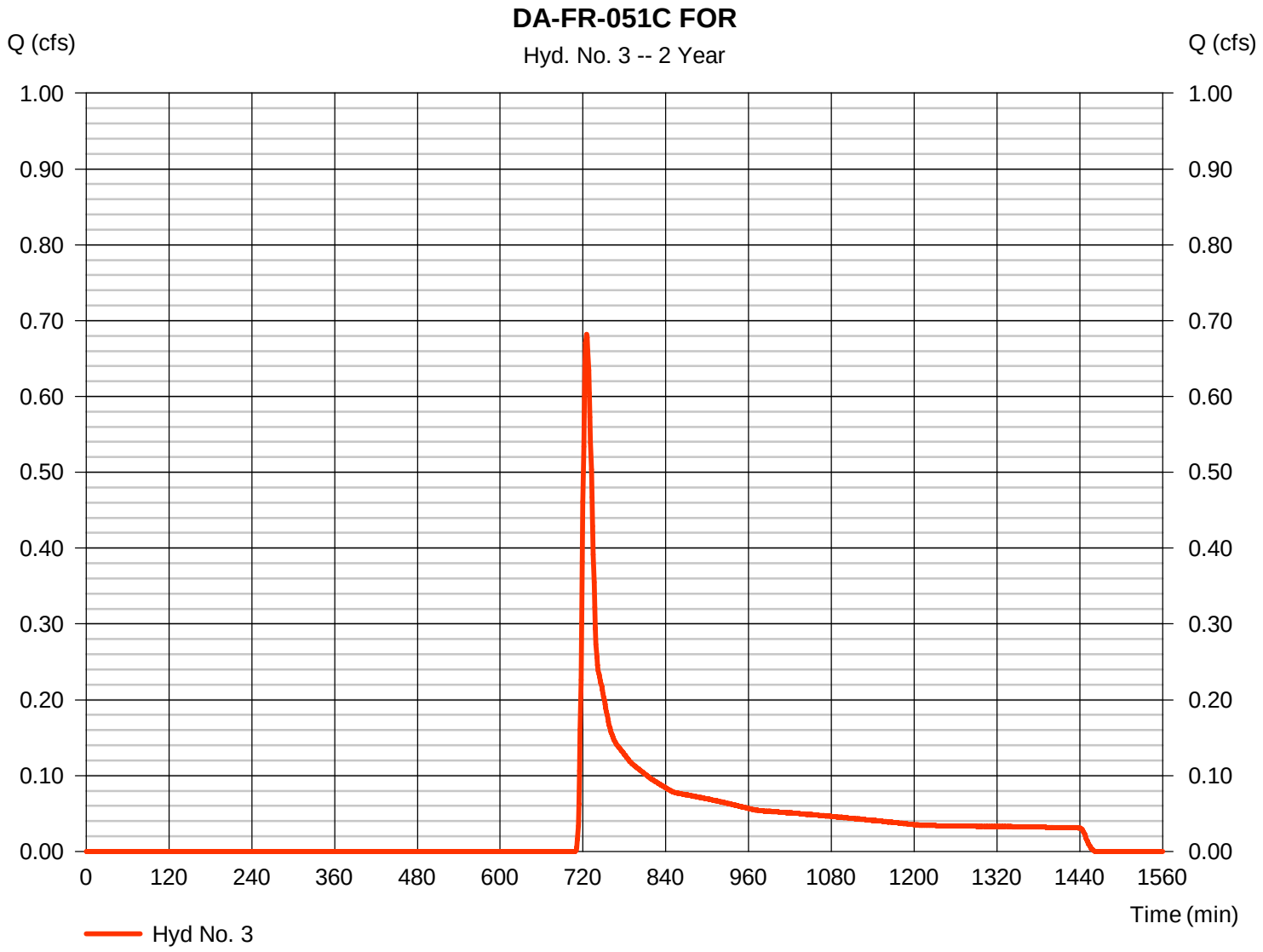
Hydrograph Report

Hyd. No. 3

DA-FR-051C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.682 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 3,138 cuft
Drainage area	= 2.080 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.137 x 98) + (0.716 x 58) + (1.230 x 55)] / 2.080



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	4.383	1	723	12,458	------	------	------	DA-FR-051C PRE
2	SCS Runoff	4.137	1	723	11,876	------	------	------	DA-FR-051C DEV
3	SCS Runoff	3.407	1	723	10,182	------	------	------	DA-FR-051C FOR

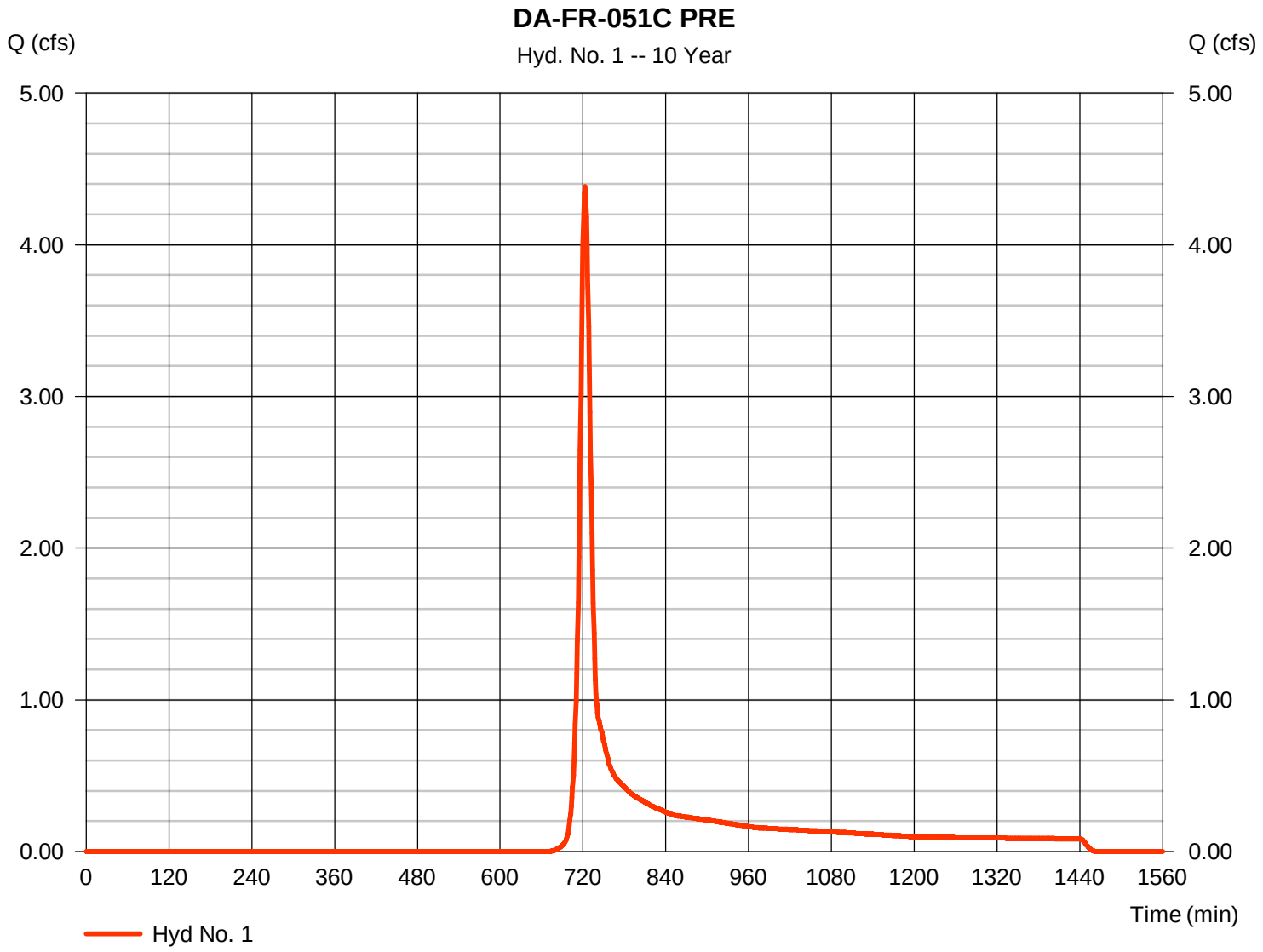
Hydrograph Report

Hyd. No. 1

DA-FR-051C PRE

Hydrograph type	=	SCS Runoff	Peak discharge	=	4.383 cfs
Storm frequency	=	10 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	12,458 cuft
Drainage area	=	2.080 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.20 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.137 x 98) + (0.716 x 58) + (1.230 x 55)] / 2.080



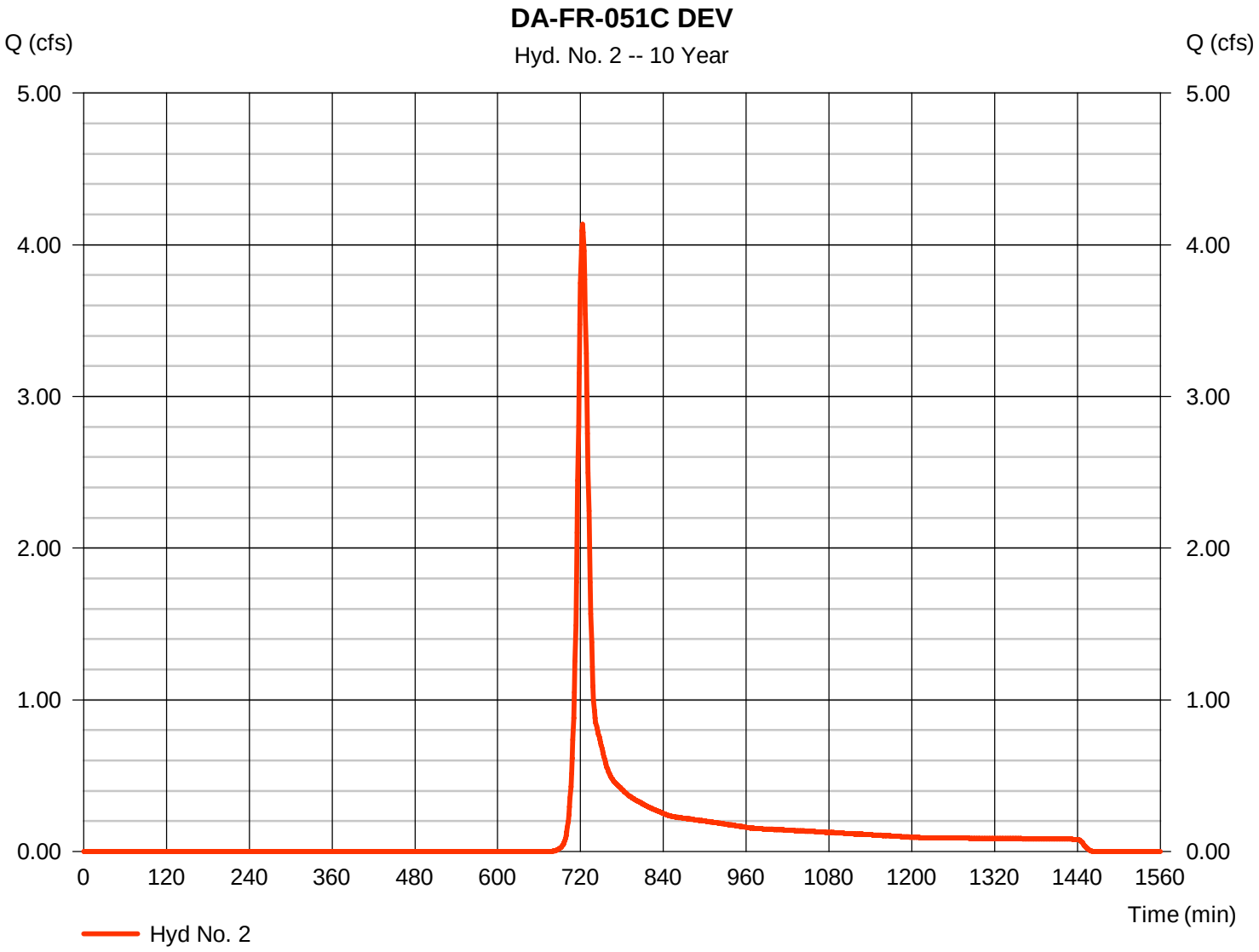
Hydrograph Report

Hyd. No. 2

DA-FR-051C DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 4.137 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 11,876 cuft
Drainage area	= 2.080 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.369 x 48) + (1.060 x 58) + (0.137 x 98) + (0.518 x 55)] / 2.080



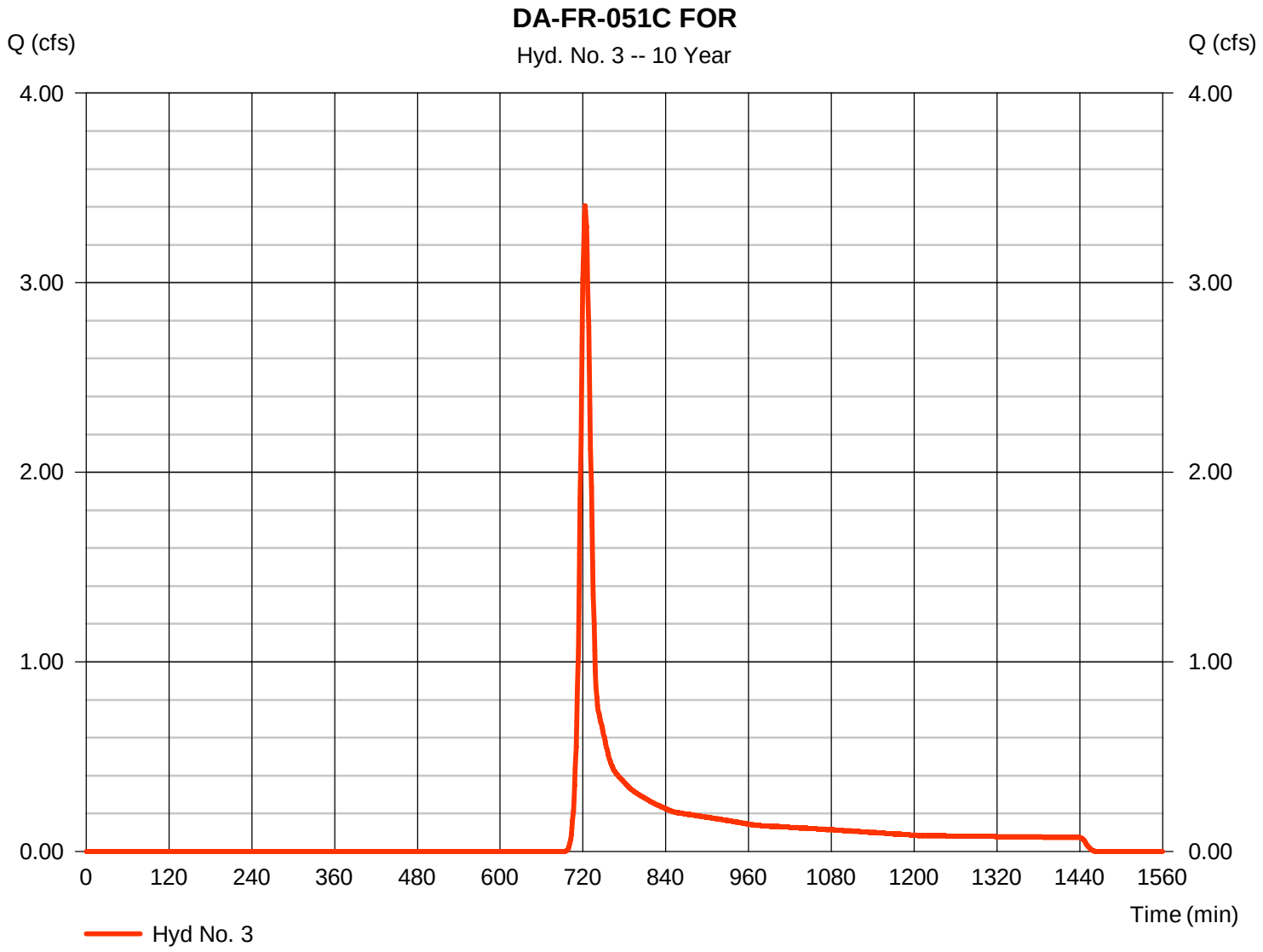
Hydrograph Report

Hyd. No. 3

DA-FR-051C FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 3.407 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 10,182 cuft
Drainage area	= 2.080 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.137 x 98) + (0.716 x 58) + (1.230 x 55)] / 2.080



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-051D

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.056	402
Developed Condition	0.056	402
Pre-Developed (Forest) Condition	0.073	449

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.056 ≤ N/A - See Check #3 0.056

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.056 ≤ N/A - See Check #3 0.056

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.056 *shall not* be required to be ≤ 0.082

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-051D PRE
2	SCS Runoff	DA-FR-051D DEV
3	SCS Runoff	DA-FR-051D FOR

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.056	0.120	-------	-------	0.670	-------	-------	-------	DA-FR-051D PRE
2	SCS Runoff	------	0.056	0.120	-------	-------	0.670	-------	-------	-------	DA-FR-051D DEV
3	SCS Runoff	------	0.073	0.144	-------	-------	0.721	-------	-------	-------	DA-FR-051D FOR

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.056	1	727	402	------	------	------	DA-FR-051D PRE
2	SCS Runoff	0.056	1	727	402	------	------	------	DA-FR-051D DEV
3	SCS Runoff	0.073	1	726	449	------	------	------	DA-FR-051D FOR

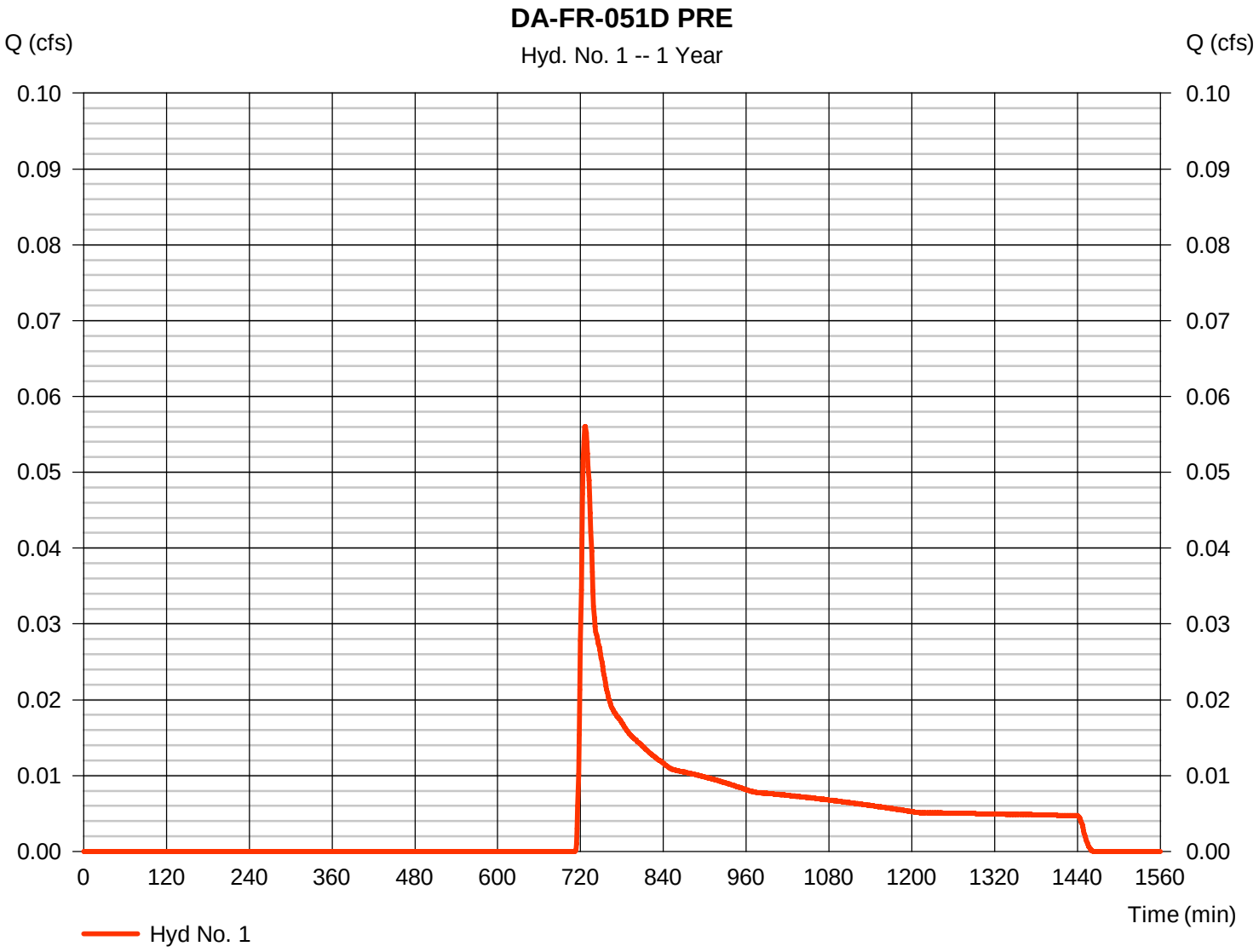
Hydrograph Report

Hyd. No. 1

DA-FR-051D PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.056 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 402 cuft
Drainage area	= 0.440 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.108 x 48) + (0.174 x 58) + (0.163 x 55)] / 0.440



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-051D PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.35		0.00		0.00		
Travel Time (min)	**= 14.64**	**+**	**0.00**	**+**	**0.00**	**=**	**14.64**
Shallow Concentrated Flow							
Flow length (ft)	= 148.54		0.00		0.00		
Watercourse slope (%)	= 13.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.85		0.00		0.00		
Travel Time (min)	**= 0.42**	**+**	**0.00**	**+**	**0.00**	**=**	**0.42**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.10 min

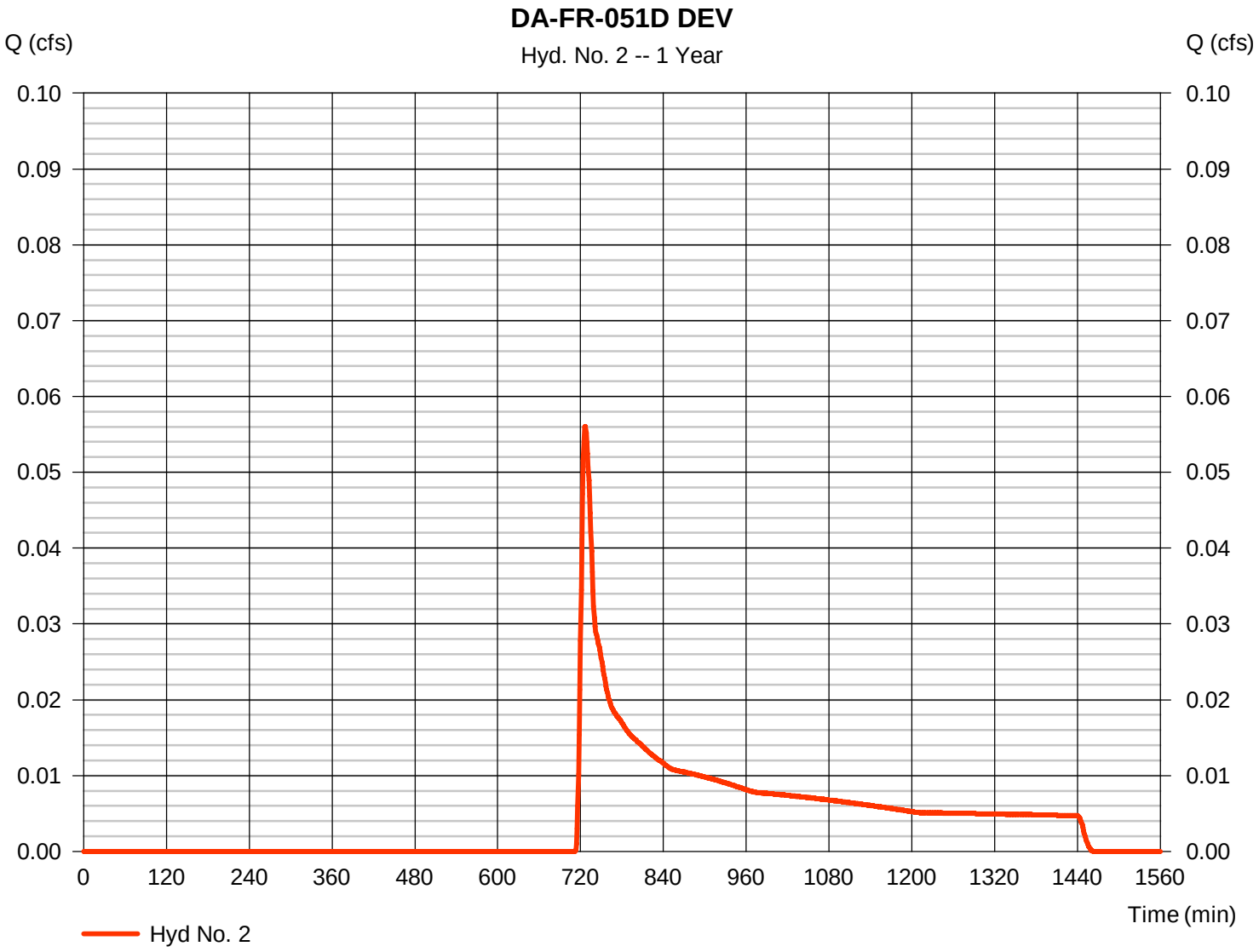
Hydrograph Report

Hyd. No. 2

DA-FR-051D DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.056 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 402 cuft
Drainage area	= 0.440 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.182 x 48) + (0.242 x 58) + (0.021 x 55)] / 0.440



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-051D DEV

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.35		0.00		0.00		
Travel Time (min)	**= 14.64**	**+**	**0.00**	**+**	**0.00**	**=**	**14.64**
Shallow Concentrated Flow							
Flow length (ft)	= 148.54		0.00		0.00		
Watercourse slope (%)	= 13.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.85		0.00		0.00		
Travel Time (min)	**= 0.42**	**+**	**0.00**	**+**	**0.00**	**=**	**0.42**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.10 min

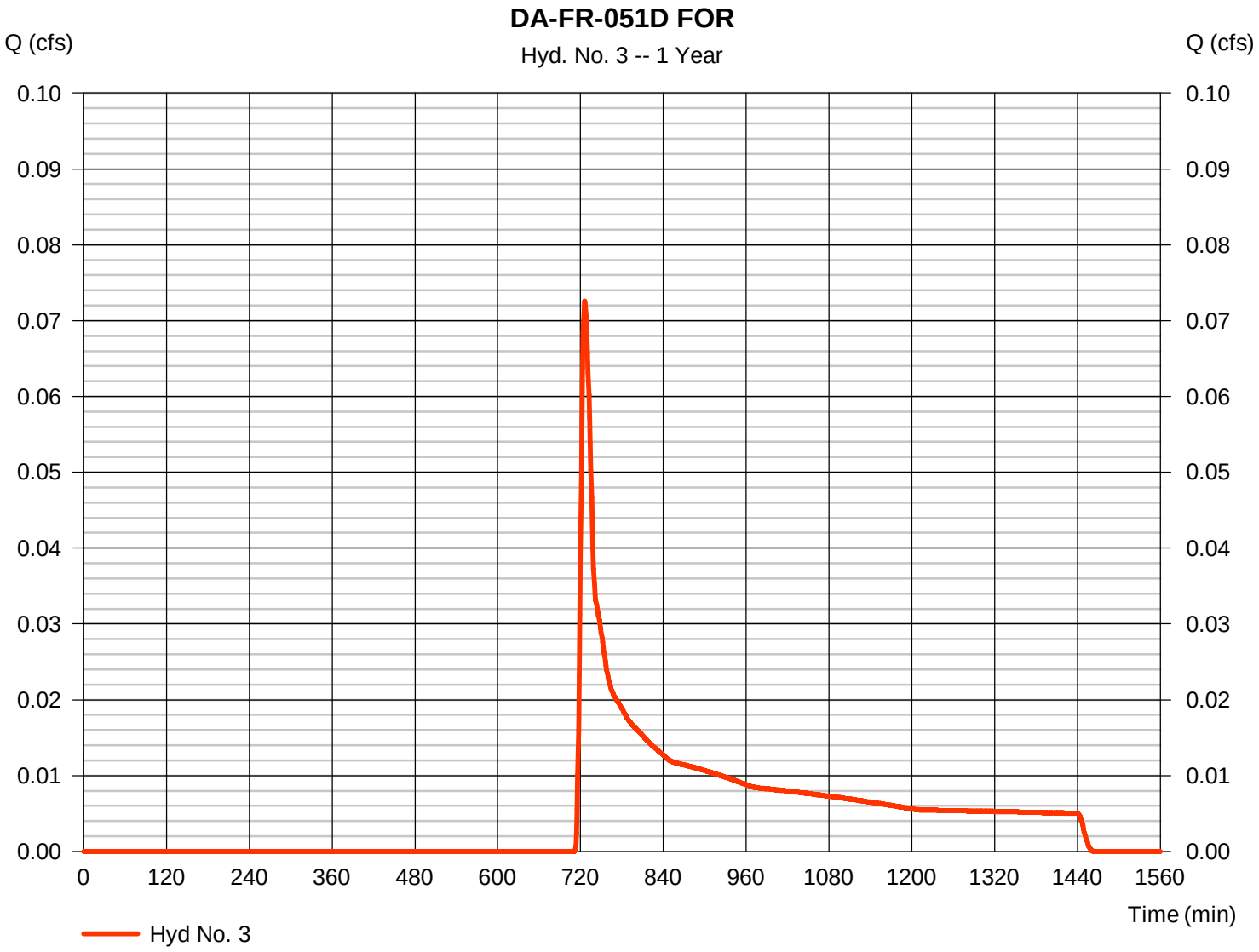
Hydrograph Report

Hyd. No. 3

DA-FR-051D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.073 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 449 cuft
Drainage area	= 0.440 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.108 x 48) + (0.174 x 58) + (0.163 x 55)] / 0.440



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-051D FOR

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.35		0.00		0.00		
Travel Time (min)	**= 14.64**	**+**	**0.00**	**+**	**0.00**	**=**	**14.64**
Shallow Concentrated Flow							
Flow length (ft)	= 148.54		0.00		0.00		
Watercourse slope (%)	= 13.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.85		0.00		0.00		
Travel Time (min)	**= 0.42**	**+**	**0.00**	**+**	**0.00**	**=**	**0.42**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.10 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.120	1	725	605	------	------	------	DA-FR-051D PRE
2	SCS Runoff	0.120	1	725	605	------	------	------	DA-FR-051D DEV
3	SCS Runoff	0.144	1	725	664	------	------	------	DA-FR-051D FOR

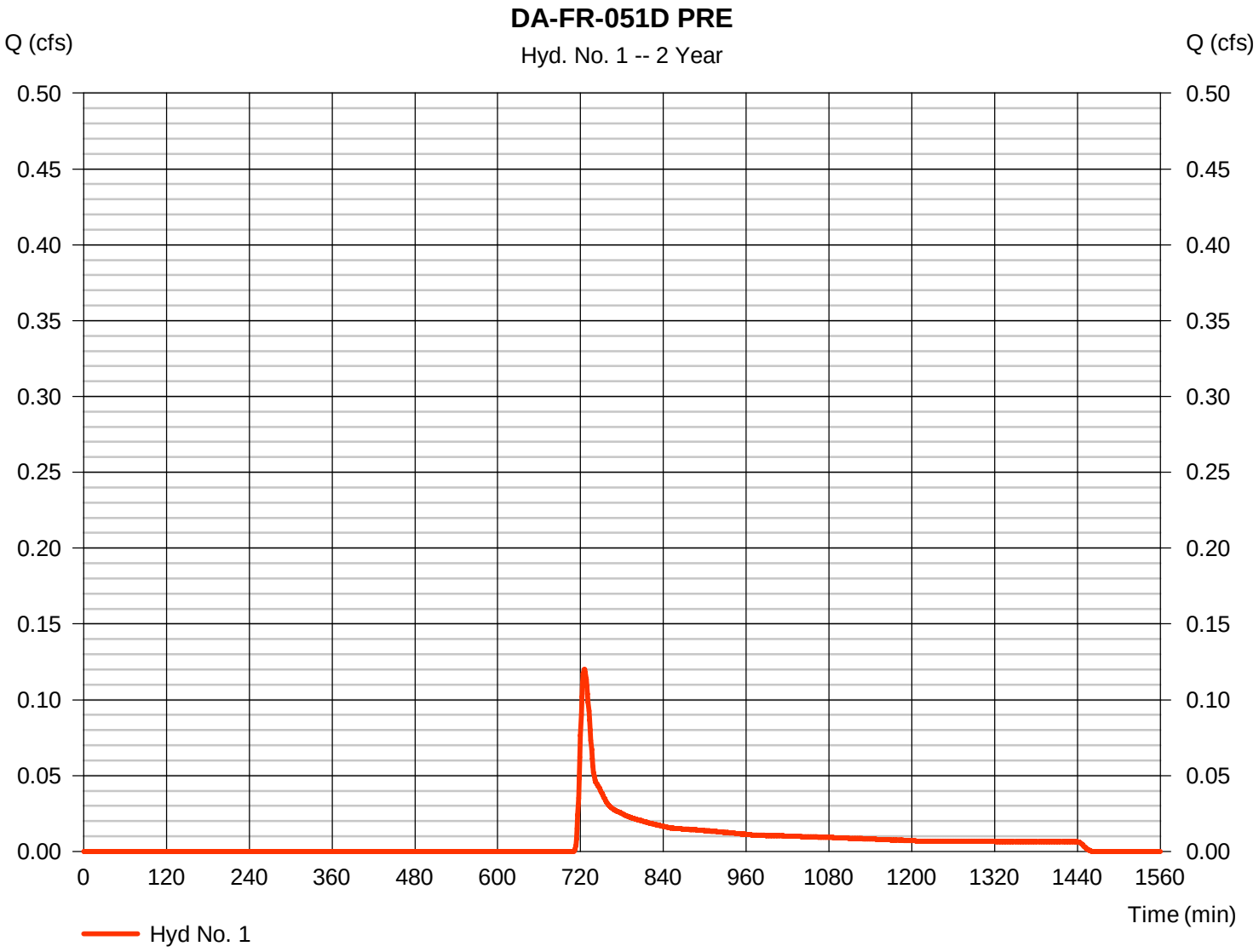
Hydrograph Report

Hyd. No. 1

DA-FR-051D PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.120 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 605 cuft
Drainage area	= 0.440 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.108 x 48) + (0.174 x 58) + (0.163 x 55)] / 0.440



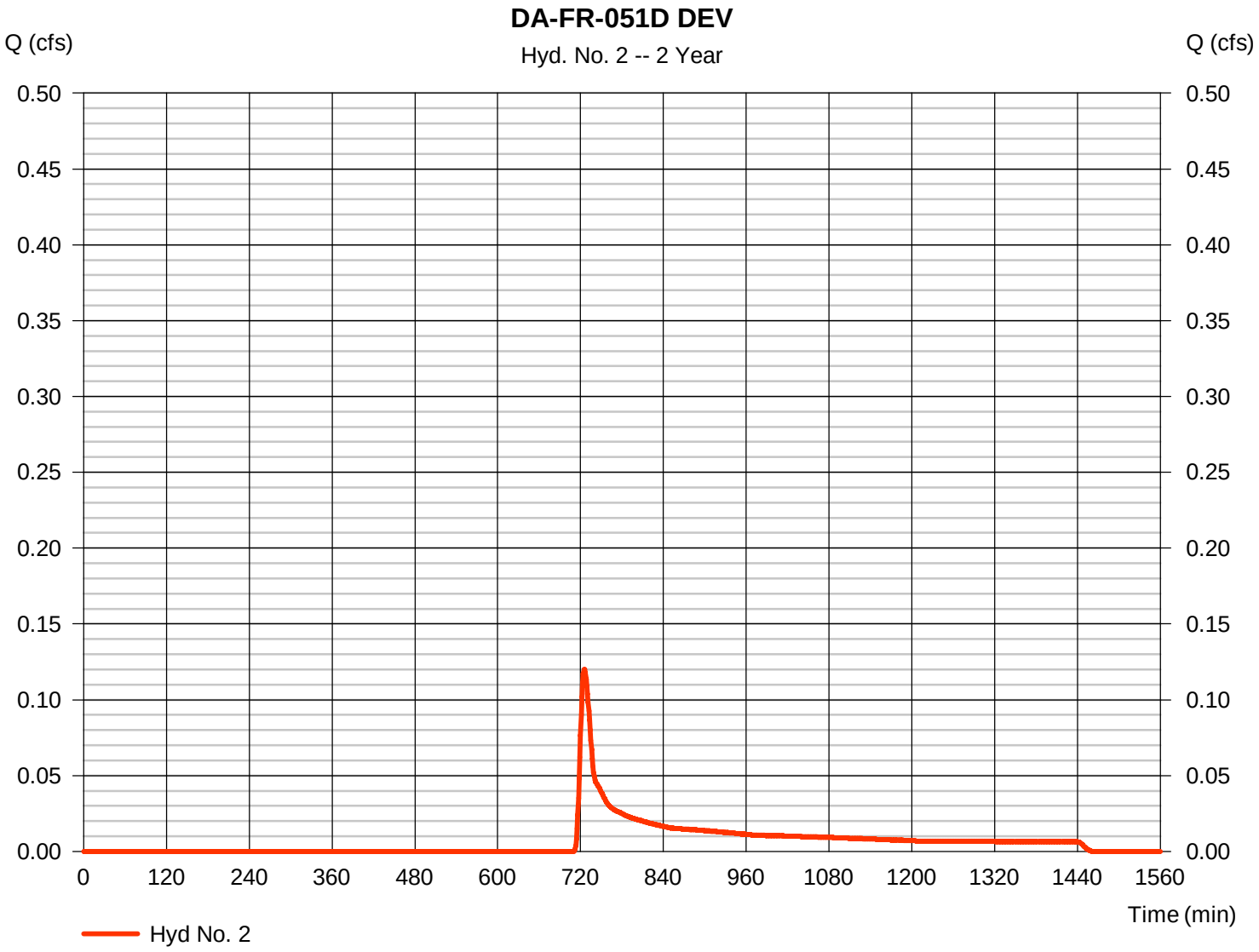
Hydrograph Report

Hyd. No. 2

DA-FR-051D DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.120 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 605 cuft
Drainage area	= 0.440 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.182 x 48) + (0.242 x 58) + (0.021 x 55)] / 0.440



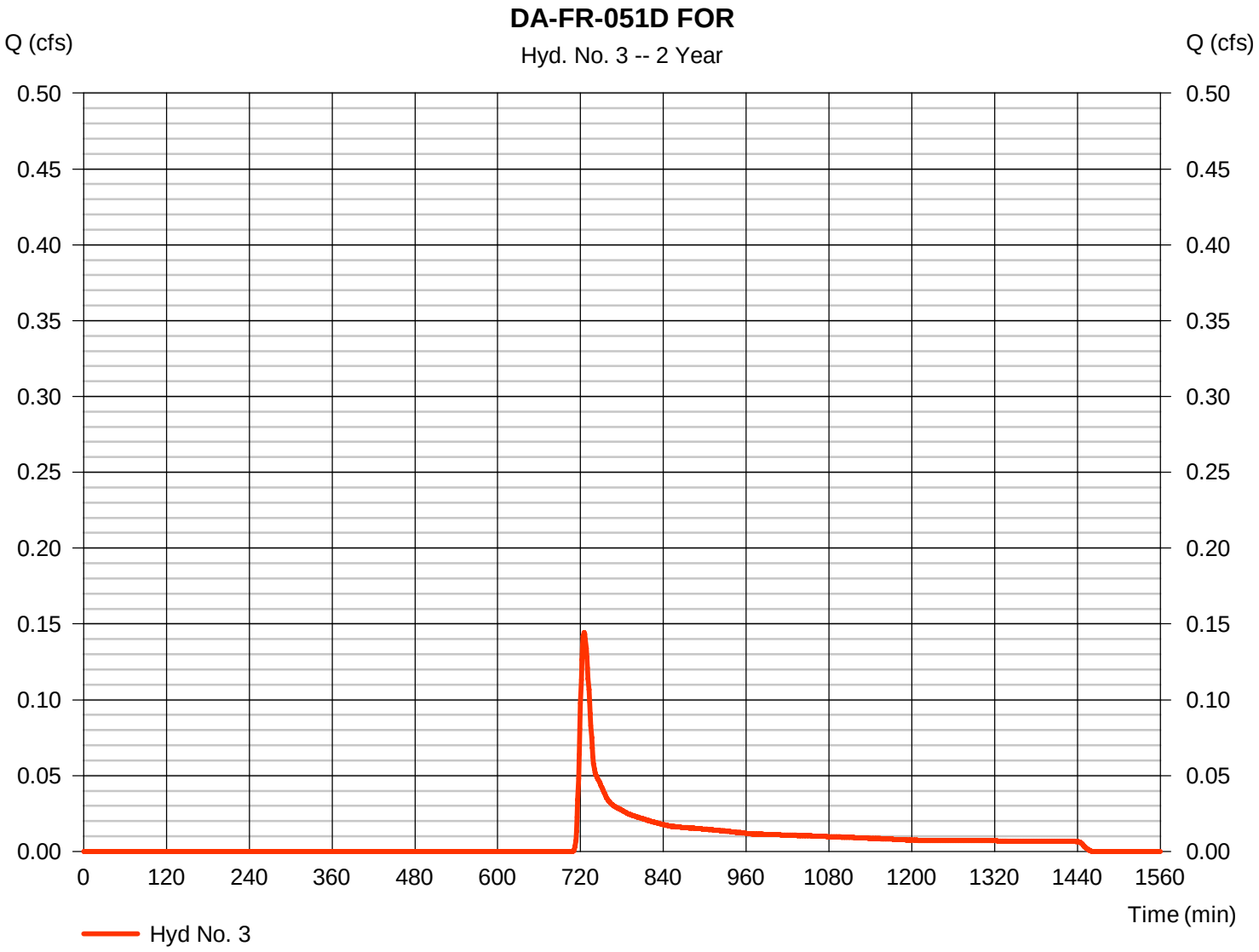
Hydrograph Report

Hyd. No. 3

DA-FR-051D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.144 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 664 cuft
Drainage area	= 0.440 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.108 x 48) + (0.174 x 58) + (0.163 x 55)] / 0.440



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.670	1	723	2,038	------	------	------	DA-FR-051D PRE
2	SCS Runoff	0.670	1	723	2,038	------	------	------	DA-FR-051D DEV
3	SCS Runoff	0.721	1	723	2,154	------	------	------	DA-FR-051D FOR

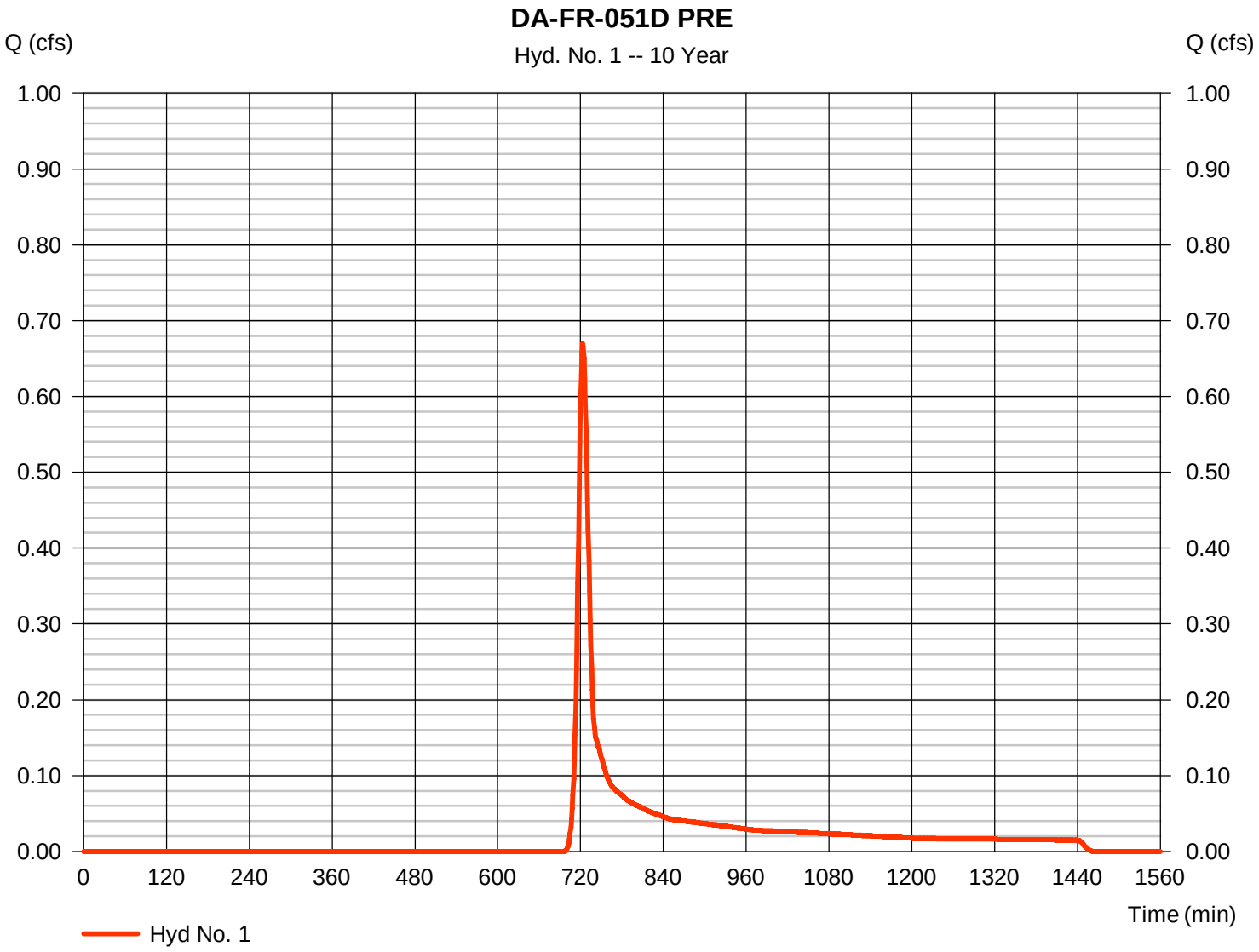
Hydrograph Report

Hyd. No. 1

DA-FR-051D PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.670 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 2,038 cuft
Drainage area	= 0.440 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.108 x 48) + (0.174 x 58) + (0.163 x 55)] / 0.440



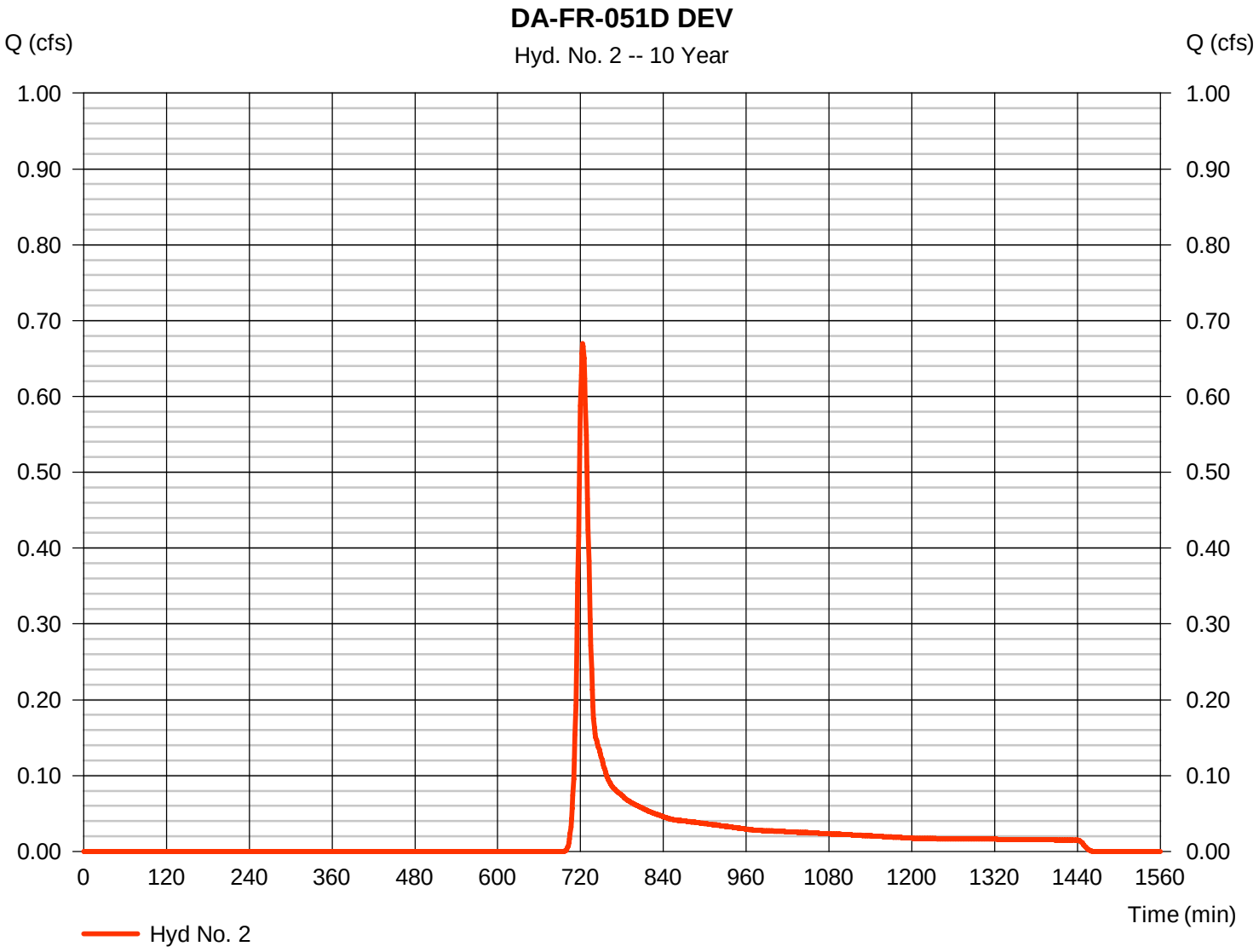
Hydrograph Report

Hyd. No. 2

DA-FR-051D DEV

Hydrograph type	= SCS Runoff	Peak discharge	= 0.670 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 2,038 cuft
Drainage area	= 0.440 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.182 x 48) + (0.242 x 58) + (0.021 x 55)] / 0.440



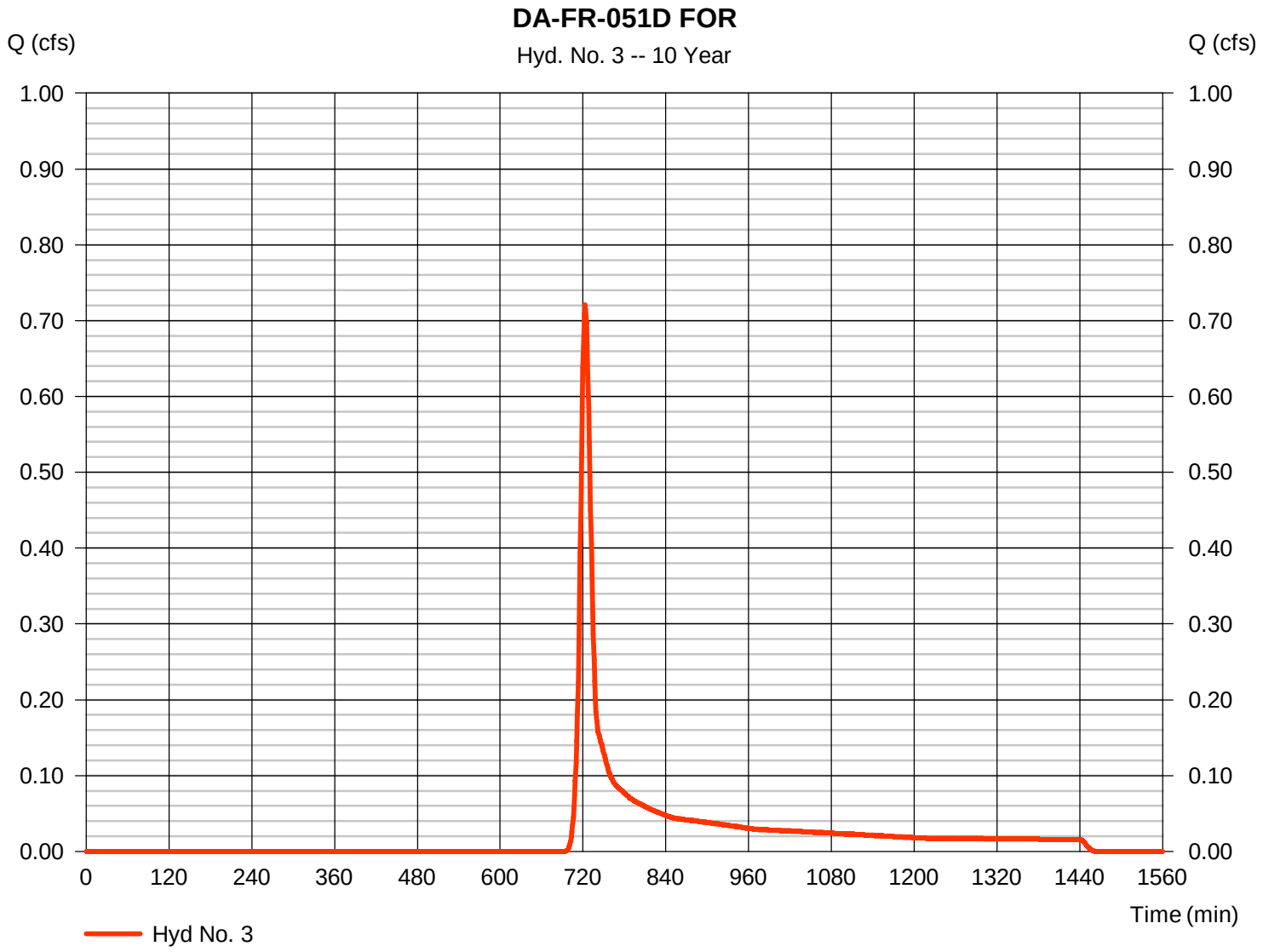
Hydrograph Report

Hyd. No. 3

DA-FR-051D FOR

Hydrograph type	= SCS Runoff	Peak discharge	= 0.721 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 2,154 cuft
Drainage area	= 0.440 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.10 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.108 x 48) + (0.174 x 58) + (0.163 x 55)] / 0.440



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ng\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pc

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-052

DA-FR-052 is located in a brush, meadow and forested areas with rolling slopes, and also includes impervious areas (housing areas). A stream crosses the drainage area. The total impervious area is approximately 5.7% of the overall drainage area. No new impervious area is proposed within DA-FR-052. The total phosphorus load reduction required for DA-FR-052 is –0.22 lb/yr. Multiple points of analysis were evaluated within DA-FR-052 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-052 was sub-divided into two sub-drainage areas (sub areas A and B).

Stormwater quantity is met via the energy balance method for each of the two sub-areas DA-FR-052A and DA-FR-052B. In addition, the Hydraflow Hydrograph's 10-year 24-hour peak discharge results indicate a reduction in flows ranging from 0.12 to 0.76 cfs for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-052A	1.55	1.43	-0.12
DA-FR-052B	6.88	6.12	-0.76

Figures and calculations for each of the sub-areas for DA-FR-052 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-052A
0.72 acres
Weighted CN =

DA-FR-052B
3.09 acres
Weighted CN =

261.8
261.9
262.0
S-013
S-015
S-014
1100
1050
B
Teel Brooke Rd
Teel Brooke Rd

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Impervious
- Meadow
- Waterbody
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,440

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-052
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\MapdocsIDrainage\MXD\Franklin\MVP_PCSM_DA-FR-052_Pre.mxd

DA-FR-052A
0.72 acres
Weighted CN =

DA-FR-052B
3.09 acres
Weighted CN =

261.8

261.9

262.0

S-013

S-015

S-014

1100

1050

B

Teel Brooke Rd

Teel Brooke Rd

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Impervious
- Meadow
- Waterbody
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,440

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-052
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-052_Post.mxd

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,440

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration
DA-FR-052
Spread 10

Figure 3

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-052_3.mxd

Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,440

N
W E
S

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration DA-FR-052 Spread 10

Figure 4

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-052_4.mxd

Virginia Runoff Reduction Method New Development Worksheet - v2.8 - June 2014

Site Data Summary

Total Rainfall = 46 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.66	0.00	0.00	0.66	*100.00*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
					0.66	*100.00*

Site Rv	0.03
Post Development Treatment Volume (ft3)	72
Post Development TP Load (lb/yr)	0.05
Post Development TN Load (lb/yr)	0.35
Total TP Load Reduction Required (lb/yr)	-0.22

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0
Total TN Load Reduction Achieved (lb/yr)	0.00
Adjusted Post Development TP Load (lb/yr)	0.05
Remaining Phosphorous Load Reduction (Lb/yr) Required	0.00

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest (acres)	0.66	0.00	0.00	0.00	0.00	*0.66*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
						0.66

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*
TN Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*

DA-FR-052A

STORAGE VOLUME OF WATERBAR WITH SOIL COMPOST AMENDMENT AREA

Equations Used:

[1]Vgravel storage = L*W*D_{gravel}*(40/100)

[2]Vsoil storage = L*W*D_{soil}*(20/100)

[3]Vsurface storage = [W*S*D^2]+[L*S*D^2]+[W*L*D]+[((2*S*D)^2*D)/3]

[1]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that gravel is made up of 40% voids.

[2]Equation #2b under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, assuming that soil compost amendment is made up of 20% voids.

[3]Equation #1 under "Volume Reduction Calculations" in Section 6.4.5 of PA BMP Manual, but calculation also takes into account surface side slopes.

Inputs:

Depth of Gravel Layer, D_{gravel} (ft) =	0	
Depth of Soil Amendment Area, D_{soil} (ft) =	1	Refer to Table 4.3 in VA DEQ Stormwater Design Specification No. 4; Note that compost amendment may not be necessary for HSG A/B soils
Length of Waterbar Soil Amendment Area, L (ft) =	50	Assume max. length of 50' for waterbar soil amendment areas (i.e., limited to permanent ROW)
Width of Waterbar Soil Amendment Area, W (ft) =	3	
Inside Embankment Side Slopes, S (H:V) =	2	Assume 2H:1V surface side slopes for waterbars
Number of Perm. Waterbars in Drainage Area, n =	1	
Design Infiltration Rate, IR (in/hr) =	0.2	Min. rate of 0.30 in/hr for HSG A soils and 0.15-0.30 in/hr for HSG B soils (see Chap. 4, p. 4-30 in VA Stormwater Management Handbook Volume II (First Edition, 1999)
Surface Ponding Depth, D (ft) =	0.5	Assume 0.5' CFS height at the end of waterbars

Calculations:

Total Storage Depth per BMP (ft) =	1.5
Surface Storage Volume per BMP (cf) =	102
Subsurface Storage Volume per BMP (cf) =	30
Total Storage Volume per BMP (cf) =	132
Total BMP Storage Volume in Drainage Area (cf) =	132
Calculated Infiltration Period per BMP (hr) =	53

Depth-Storage Data

Depth (ft)	Width (ft)	Length (ft)	Storage Volume per BMP (cf)	Storage Volume in Drainage Area (cf)
0	3	50	0	0
0.5	3	50	15	15
1	3	50	30	30
1.5	5	52	132	132
2	7	54	291	291

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.194	815
Developed Condition	0.088	752
Pre-Developed (Forest) Condition	0.154	735

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.9

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.088	≤ OK	0.189	
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.088	≤ OK	0.194	
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.088	*shall not* be required to be ≤	0.151	

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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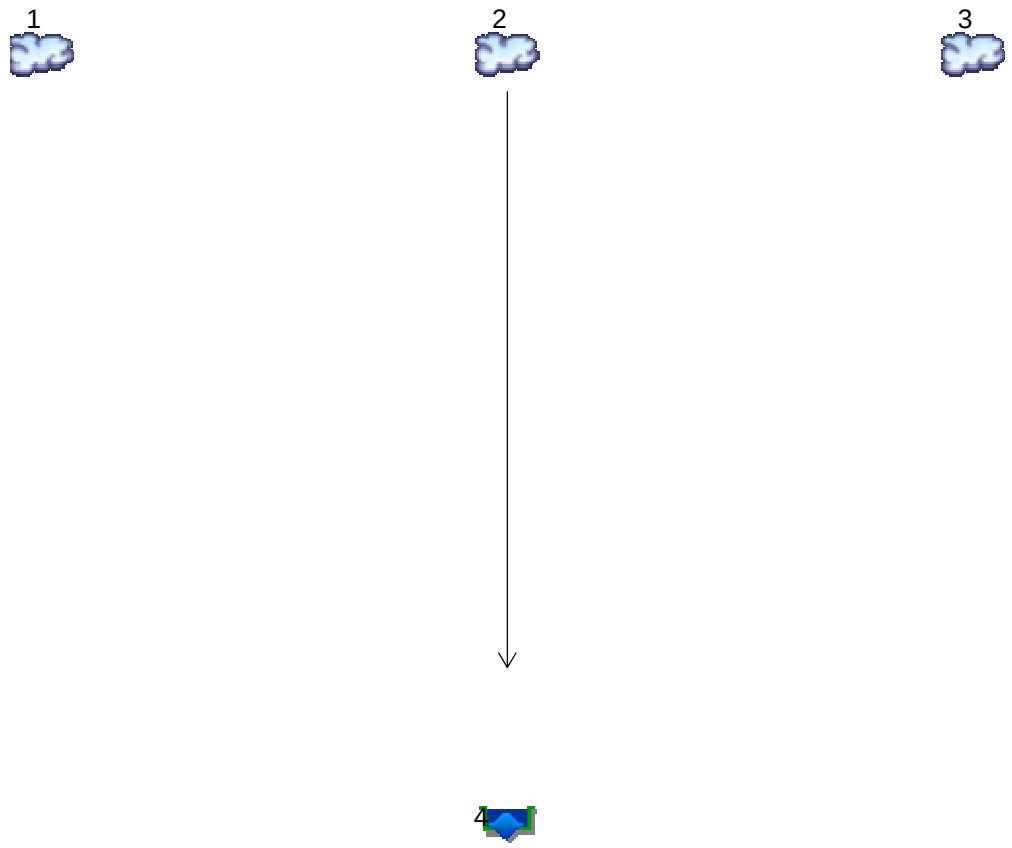
Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-052A Pre
2	SCS Runoff	DA-FR-052A Dev
3	SCS Runoff	DA-FR-052A For
4	Reservoir	WB SOIL AMENDMENTS

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.194	0.358	-------	-------	1.552	-------	-------	-------	DA-FR-052A Pre
2	SCS Runoff	------	0.196	0.346	-------	-------	1.426	-------	-------	-------	DA-FR-052A Dev
3	SCS Runoff	------	0.154	0.306	-------	-------	1.454	-------	-------	-------	DA-FR-052A For
4	Reservoir	2	0.088	0.281	-------	-------	1.409	-------	-------	-------	WB SOIL AMENDMENTS

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.194	1	722	815	------	------	------	DA-FR-052A Pre
2	SCS Runoff	0.196	1	724	884	------	------	------	DA-FR-052A Dev
3	SCS Runoff	0.154	1	723	735	------	------	------	DA-FR-052A For
4	Reservoir	0.088	1	735	752	2	101.56	149	WB SOIL AMENDMENTS

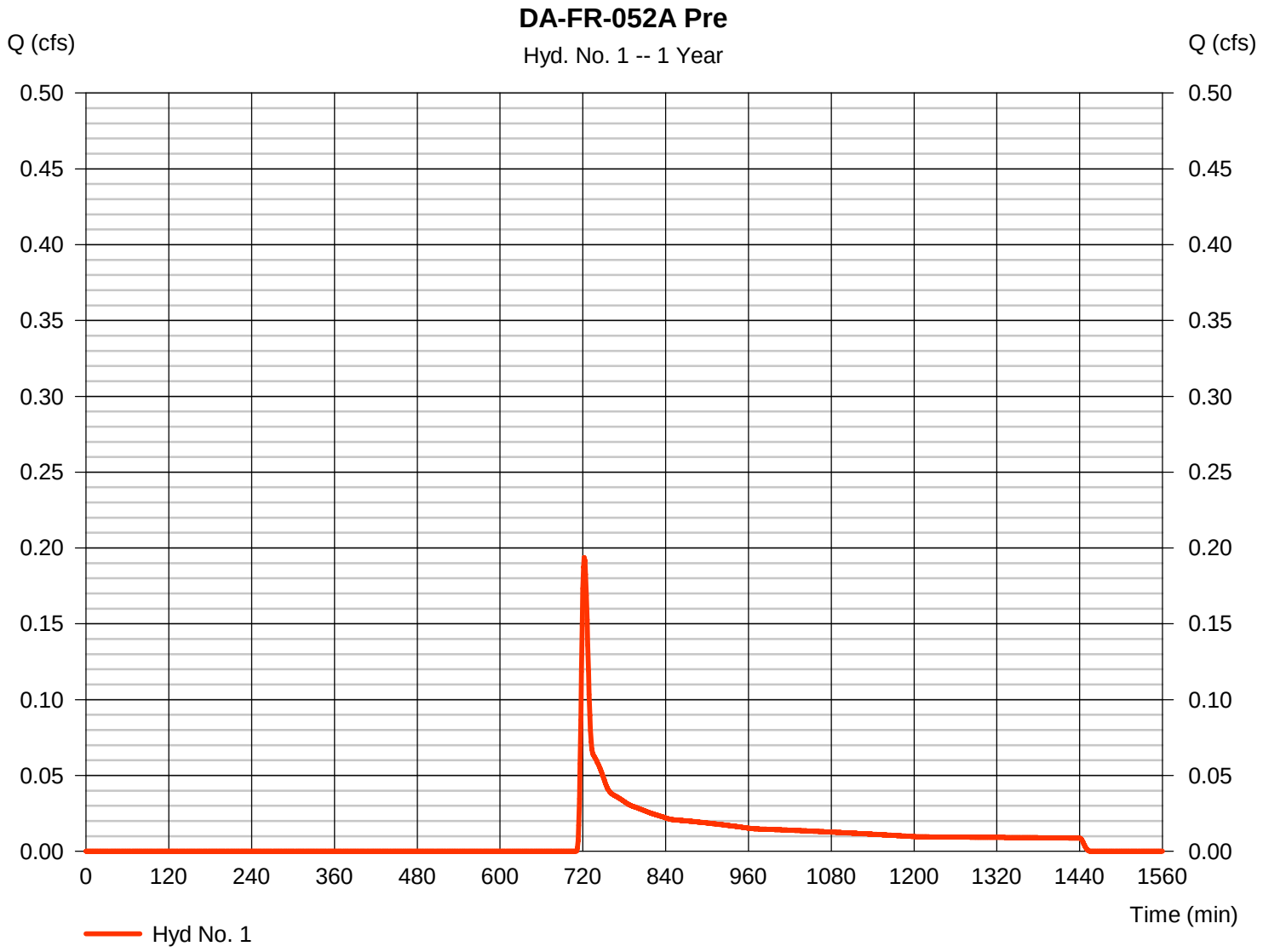
Hydrograph Report

Hyd. No. 1

DA-FR-052A Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.194 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 815 cuft
Drainage area	= 0.720 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.043 x 58) + (0.019 x 100) + (0.660 x 55)] / 0.720



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-052A Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 14.25		0.00		0.00		
Travel Time (min)	**= 9.10**	**+**	**0.00**	**+**	**0.00**	**=**	**9.10**
Shallow Concentrated Flow							
Flow length (ft)	= 147.09		0.00		0.00		
Watercourse slope (%)	= 17.81		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.81		0.00		0.00		
Travel Time (min)	**= 0.36**	**+**	**0.00**	**+**	**0.00**	**=**	**0.36**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.50 min

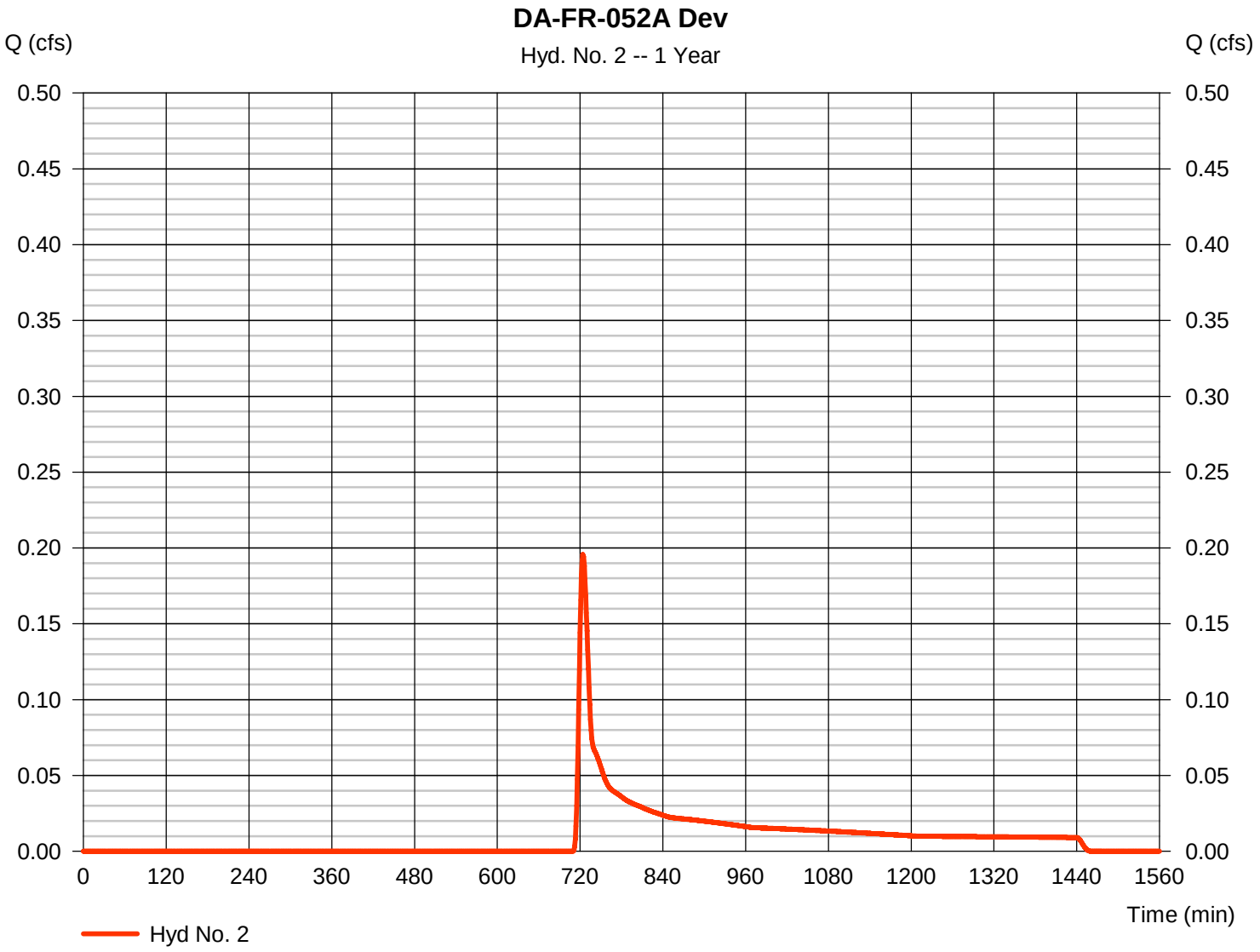
Hydrograph Report

Hyd. No. 2

DA-FR-052A Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.196 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 884 cuft
Drainage area	= 0.720 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.146 x 48) + (0.557 x 58) + (0.019 x 100)] / 0.720



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-052A Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.800		0.400		0.011		
Flow length (ft)	= 17.9		82.1		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 15.33		14.01		0.00		
Travel Time (min)	**= 3.88**	**+**	**7.83**	**+**	**0.00**	**=**	**11.71**
Shallow Concentrated Flow							
Flow length (ft)	= 108.71		39.19		0.00		
Watercourse slope (%)	= 14.49		23.44		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=6.14		7.81		0.00		
Travel Time (min)	**= 0.30**	**+**	**0.08**	**+**	**0.00**	**=**	**0.38**
Channel Flow							
X sectional flow area (sqft)	= 2.00		0.00		0.00		
Wetted perimeter (ft)	= 4.47		0.00		0.00		
Channel slope (%)	= 5.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=4.86						
			0.00				
					0.00		
Flow length (ft)	({0})23.5		0.0		0.0		
Travel Time (min)	**= 0.08**	**+**	**0.00**	**+**	**0.00**	**=**	**0.08**

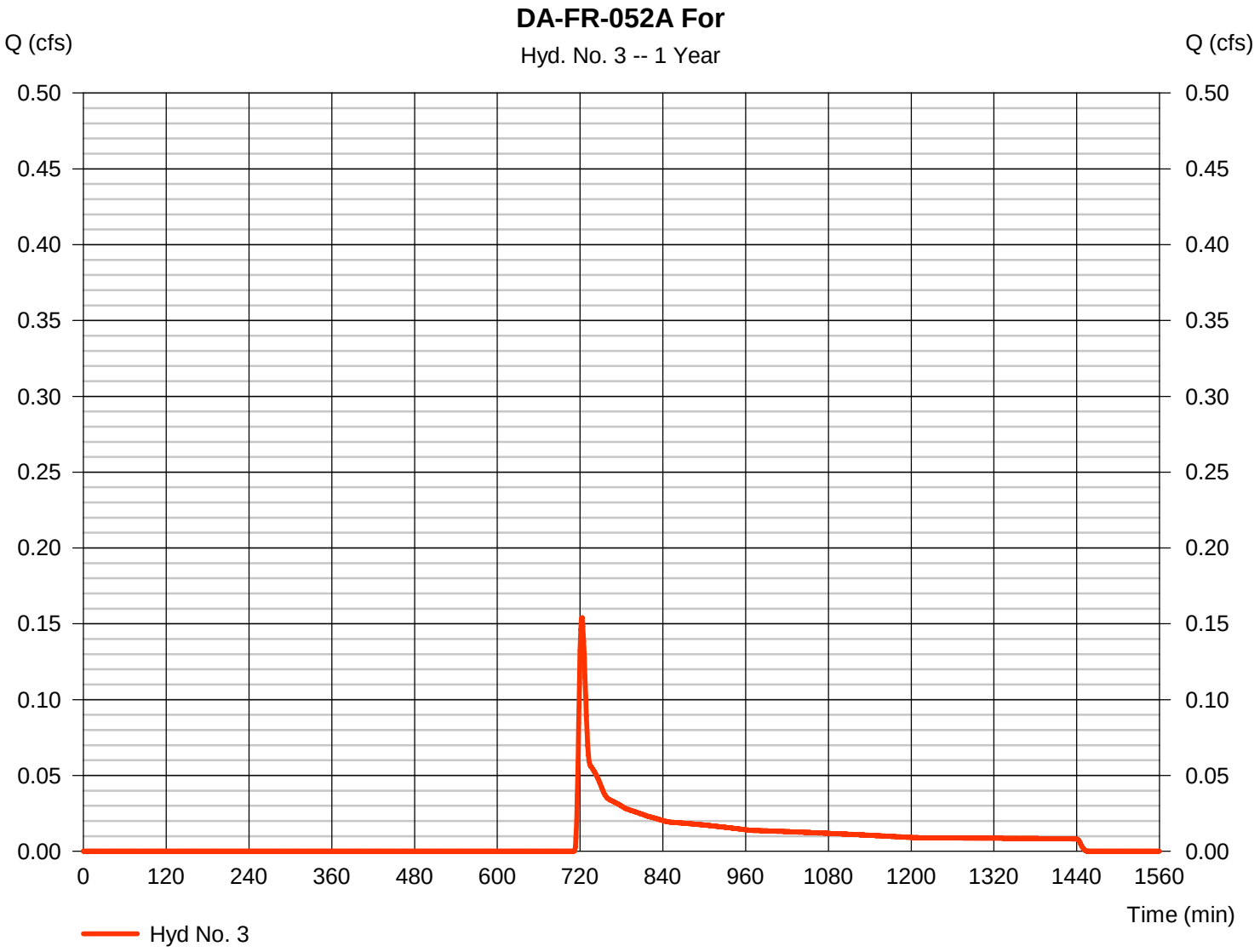
Total Travel Time, Tc ..... 12.20 min

Hydrograph Report

Hyd. No. 3

DA-FR-052A For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.154 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 735 cuft
Drainage area	= 0.720 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-052A For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 14.25		0.00		0.00		
Travel Time (min)	**= 9.10**	**+**	**0.00**	**+**	**0.00**	**=**	**9.10**
Shallow Concentrated Flow							
Flow length (ft)	= 147.09		0.00		0.00		
Watercourse slope (%)	= 17.81		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.81		0.00		0.00		
Travel Time (min)	**= 0.36**	**+**	**0.00**	**+**	**0.00**	**=**	**0.36**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 9.50 min

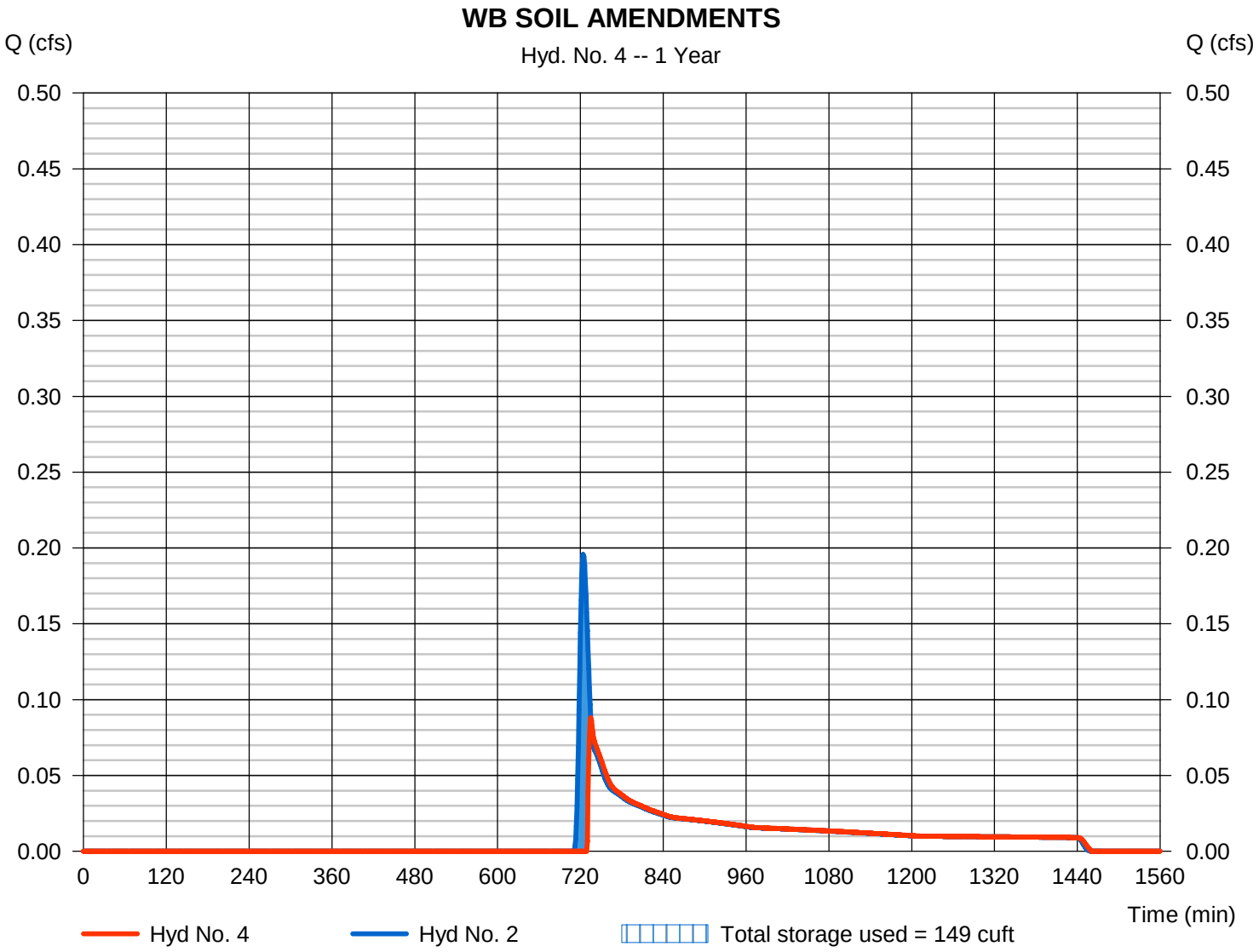
Hydrograph Report

Hyd. No. 4

WB SOIL AMENDMENTS

Hydrograph type	=	Reservoir	Peak discharge	=	0.088 cfs
Storm frequency	=	1 yrs	Time to peak	=	735 min
Time interval	=	1 min	Hyd. volume	=	752 cuft
Inflow hyd. No.	=	2 - DA-FR-052A Dev	Max. Elevation	=	101.56 ft
Reservoir name	=	WATERBAR SOIL AMENDMENTS	Max. Storage	=	149 cuft

Storage Indication method used.



Pond No. 1 - WATERBAR SOIL AMENDMENTS

Pond Data

Pond storage is based on user-defined values.

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	100.00	n/a	0	0
0.50	100.50	n/a	15	15
1.00	101.00	n/a	15	30
1.50	101.50	n/a	102	132
2.00	102.00	n/a	159	291

Culvert / Orifice Structures

	[A]	[B]	[C]	[PrfRsr]
Rise (in)	= 0.00	0.00	0.00	0.00
Span (in)	= 0.00	0.00	0.00	0.00
No. Barrels	= 0	0	0	0
Invert El. (ft)	= 0.00	0.00	0.00	0.00
Length (ft)	= 0.00	0.00	0.00	0.00
Slope (%)	= 0.00	0.00	0.00	n/a
N-Value	= .013	.013	.013	n/a
Orifice Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	No	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 2.00	0.00	0.00	0.00
Crest El. (ft)	= 101.50	0.00	0.00	0.00
Weir Coeff.	= 3.33	3.33	3.33	3.33
Weir Type	= Rect	---	---	---
Multi-Stage	= No	No	No	No

Exfil.(in/hr) = 0.000 (by Wet area)

TW Elev. (ft) = 0.00

Note: Culvert/Orifice outflows are analyzed under inlet (ic) and outlet (oc) control. Weir risers checked for orifice conditions (ic) and submergence (s).

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
0.00	0	100.00	---	---	---	---	0.00	---	---	---	---	---	0.000
0.05	2	100.05	---	---	---	---	0.00	---	---	---	---	---	0.000
0.10	3	100.10	---	---	---	---	0.00	---	---	---	---	---	0.000
0.15	5	100.15	---	---	---	---	0.00	---	---	---	---	---	0.000
0.20	6	100.20	---	---	---	---	0.00	---	---	---	---	---	0.000
0.25	8	100.25	---	---	---	---	0.00	---	---	---	---	---	0.000
0.30	9	100.30	---	---	---	---	0.00	---	---	---	---	---	0.000
0.35	11	100.35	---	---	---	---	0.00	---	---	---	---	---	0.000
0.40	12	100.40	---	---	---	---	0.00	---	---	---	---	---	0.000
0.45	14	100.45	---	---	---	---	0.00	---	---	---	---	---	0.000
0.50	15	100.50	---	---	---	---	0.00	---	---	---	---	---	0.000
0.55	17	100.55	---	---	---	---	0.00	---	---	---	---	---	0.000
0.60	18	100.60	---	---	---	---	0.00	---	---	---	---	---	0.000
0.65	20	100.65	---	---	---	---	0.00	---	---	---	---	---	0.000
0.70	21	100.70	---	---	---	---	0.00	---	---	---	---	---	0.000
0.75	23	100.75	---	---	---	---	0.00	---	---	---	---	---	0.000
0.80	24	100.80	---	---	---	---	0.00	---	---	---	---	---	0.000
0.85	26	100.85	---	---	---	---	0.00	---	---	---	---	---	0.000
0.90	27	100.90	---	---	---	---	0.00	---	---	---	---	---	0.000
0.95	29	100.95	---	---	---	---	0.00	---	---	---	---	---	0.000
1.00	30	101.00	---	---	---	---	0.00	---	---	---	---	---	0.000
1.05	40	101.05	---	---	---	---	0.00	---	---	---	---	---	0.000
1.10	50	101.10	---	---	---	---	0.00	---	---	---	---	---	0.000
1.15	61	101.15	---	---	---	---	0.00	---	---	---	---	---	0.000
1.20	71	101.20	---	---	---	---	0.00	---	---	---	---	---	0.000
1.25	81	101.25	---	---	---	---	0.00	---	---	---	---	---	0.000
1.30	91	101.30	---	---	---	---	0.00	---	---	---	---	---	0.000
1.35	101	101.35	---	---	---	---	0.00	---	---	---	---	---	0.000
1.40	112	101.40	---	---	---	---	0.00	---	---	---	---	---	0.000
1.45	122	101.45	---	---	---	---	0.00	---	---	---	---	---	0.000
1.50	132	101.50	---	---	---	---	0.00	---	---	---	---	---	0.000
1.55	148	101.55	---	---	---	---	0.07	---	---	---	---	---	0.074
1.60	164	101.60	---	---	---	---	0.21	---	---	---	---	---	0.211
1.65	180	101.65	---	---	---	---	0.39	---	---	---	---	---	0.387
1.70	196	101.70	---	---	---	---	0.60	---	---	---	---	---	0.596
1.75	211	101.75	---	---	---	---	0.83	---	---	---	---	---	0.833
1.80	227	101.80	---	---	---	---	1.09	---	---	---	---	---	1.094
1.85	243	101.85	---	---	---	---	1.38	---	---	---	---	---	1.379
1.90	259	101.90	---	---	---	---	1.69	---	---	---	---	---	1.685

Continues on next page...

WATERBAR SOIL AMENDMENTS

Stage / Storage / Discharge Table

Stage ft	Storage cuft	Elevation ft	Clv A cfs	Clv B cfs	Clv C cfs	PrfRsr cfs	Wr A cfs	Wr B cfs	Wr C cfs	Wr D cfs	Exfil cfs	User cfs	Total cfs
1.95	275	101.95	---	---	---	---	2.01	---	---	---	---	---	2.011
2.00	291	102.00	---	---	---	---	2.35	---	---	---	---	---	2.355

...End

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.358	1	721	1,186	------	------	------	DA-FR-052A Pre
2	SCS Runoff	0.346	1	723	1,269	------	------	------	DA-FR-052A Dev
3	SCS Runoff	0.306	1	722	1,086	------	------	------	DA-FR-052A For
4	Reservoir	0.281	1	728	1,137	2	101.62	170	WB SOIL AMENDMENTS

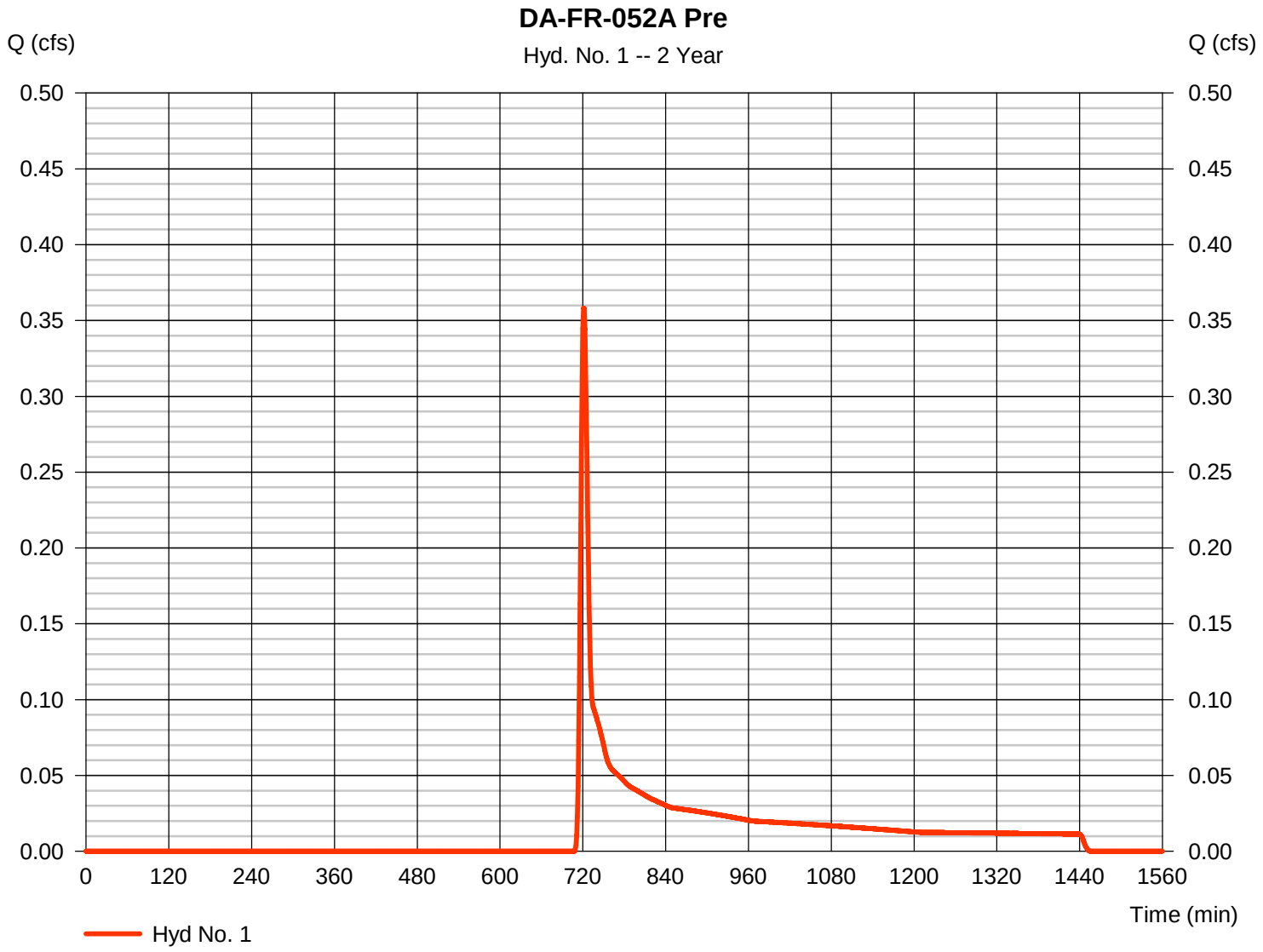
Hydrograph Report

Hyd. No. 1

DA-FR-052A Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.358 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,186 cuft
Drainage area	= 0.720 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.043 x 58) + (0.019 x 100) + (0.660 x 55)] / 0.720



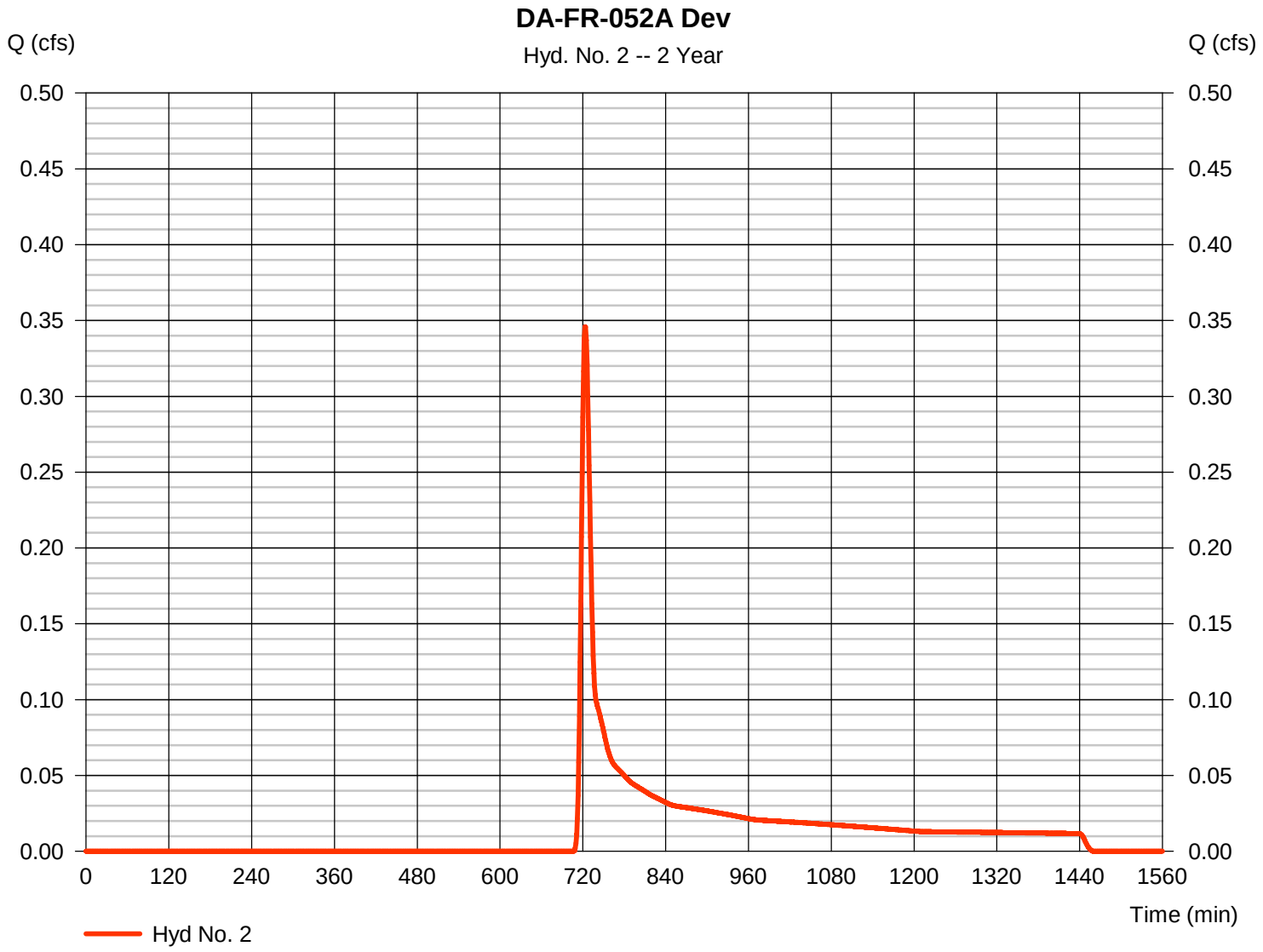
Hydrograph Report

Hyd. No. 2

DA-FR-052A Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.346 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 1,269 cuft
Drainage area	= 0.720 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.146 x 48) + (0.557 x 58) + (0.019 x 100)] / 0.720

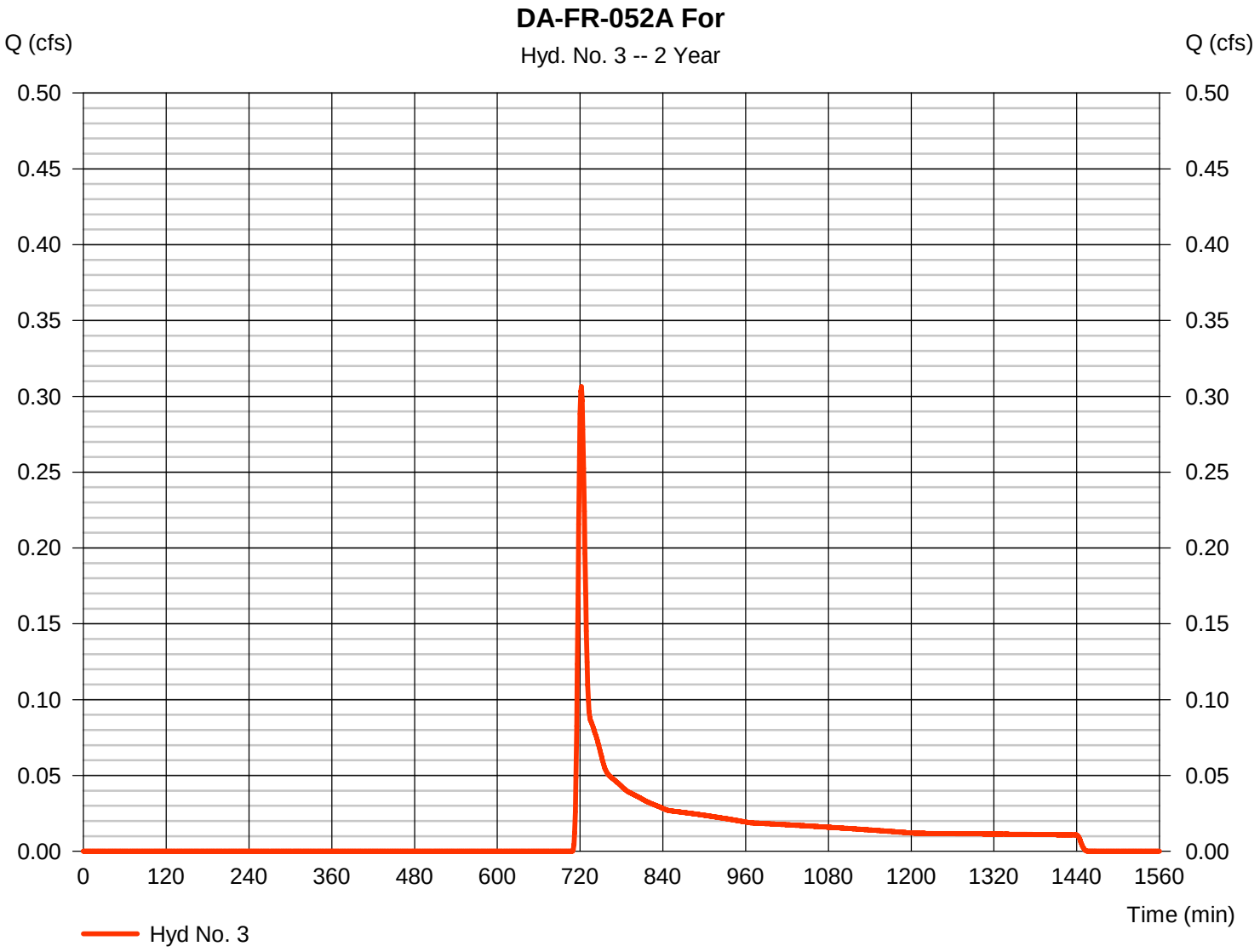


Hydrograph Report

Hyd. No. 3

DA-FR-052A For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.306 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 1,086 cuft
Drainage area	= 0.720 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 9.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



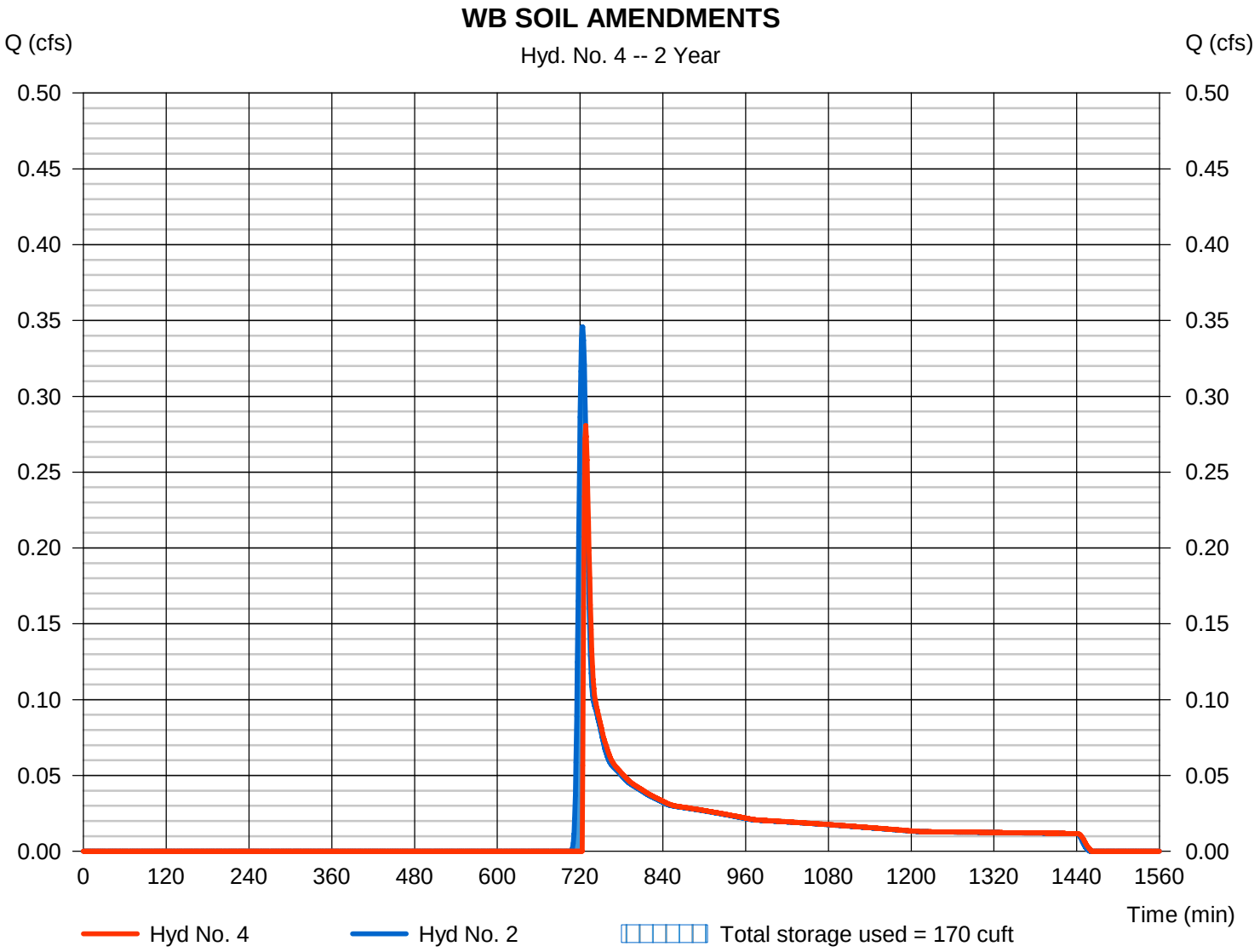
Hydrograph Report

Hyd. No. 4

WB SOIL AMENDMENTS

Hydrograph type	=	Reservoir	Peak discharge	=	0.281 cfs
Storm frequency	=	2 yrs	Time to peak	=	728 min
Time interval	=	1 min	Hyd. volume	=	1,137 cuft
Inflow hyd. No.	=	2 - DA-FR-052A Dev	Max. Elevation	=	101.62 ft
Reservoir name	=	WATERBAR SOIL AMENDMENTS	Max. Storage	=	170 cuft

Storage Indication method used.



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.552	1	720	3,717	------	------	------	DA-FR-052A Pre
2	SCS Runoff	1.426	1	722	3,851	------	------	------	DA-FR-052A Dev
3	SCS Runoff	1.454	1	720	3,524	------	------	------	DA-FR-052A For
4	Reservoir	1.409	1	723	3,719	2	101.86	245	WB SOIL AMENDMENTS

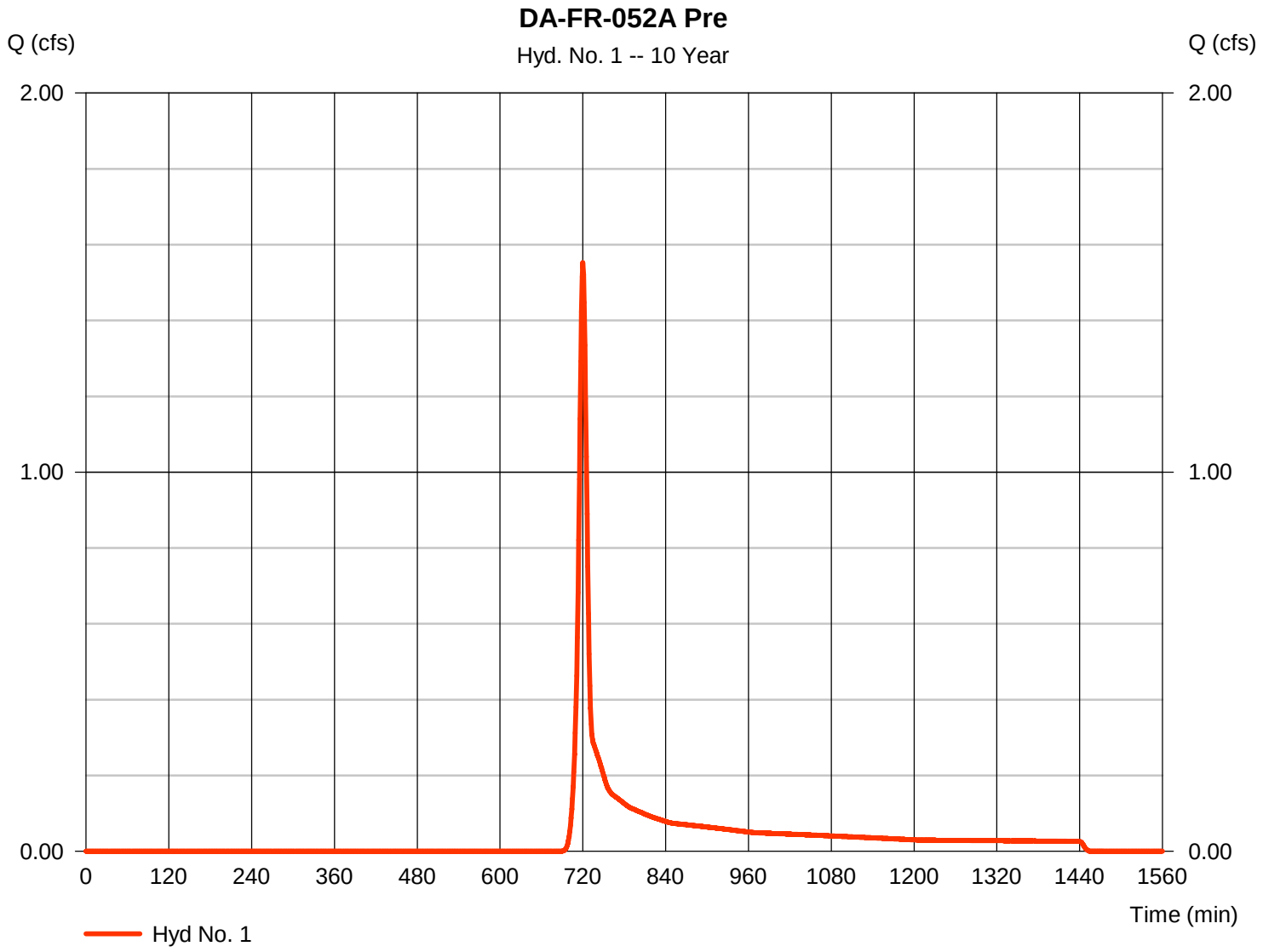
Hydrograph Report

Hyd. No. 1

DA-FR-052A Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.552 cfs
Storm frequency	=	10 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	3,717 cuft
Drainage area	=	0.720 ac	Curve number	=	56*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	9.50 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.043 x 58) + (0.019 x 100) + (0.660 x 55)] / 0.720



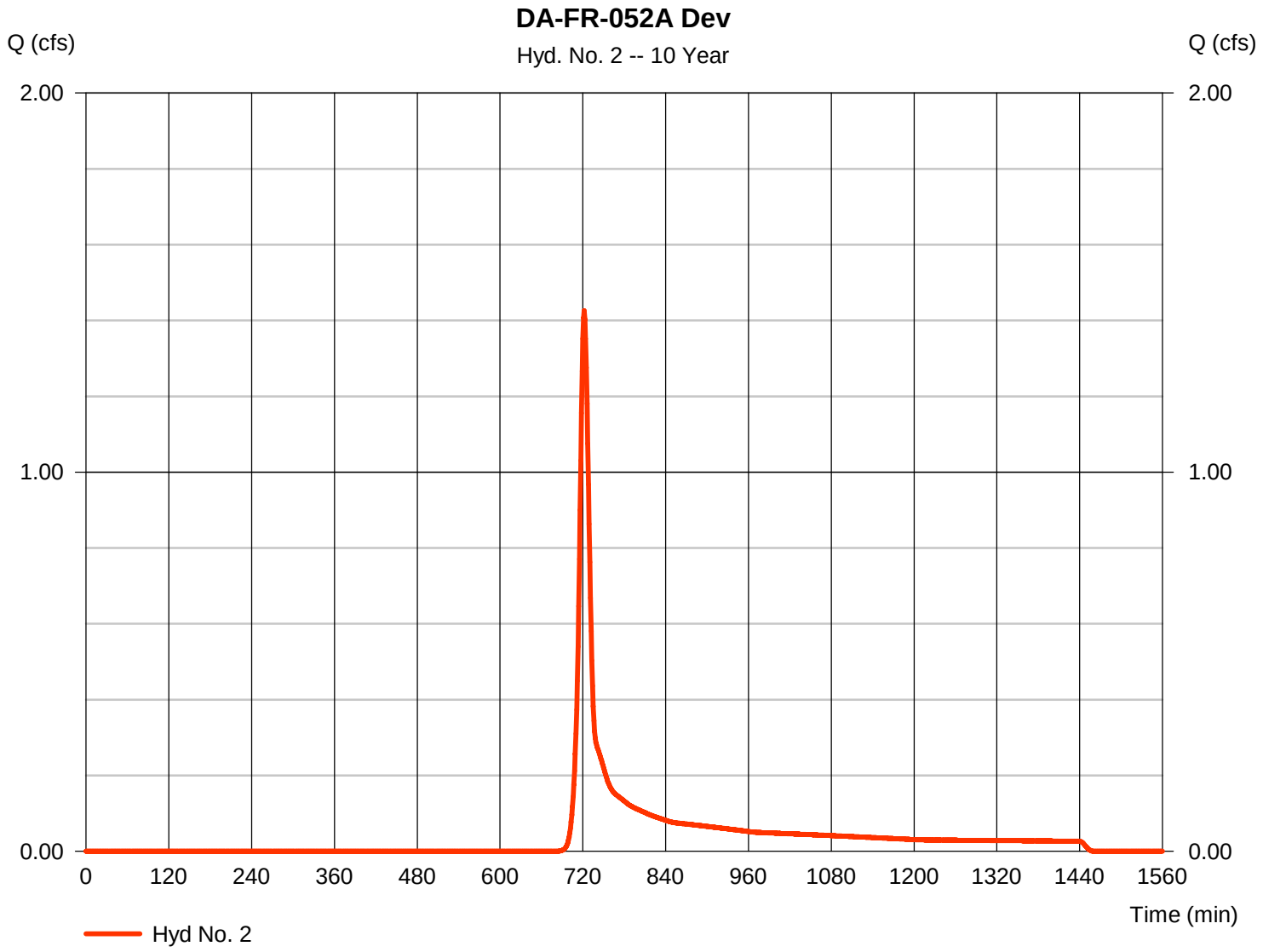
Hydrograph Report

Hyd. No. 2

DA-FR-052A Dev

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.426 cfs
Storm frequency	=	10 yrs	Time to peak	=	722 min
Time interval	=	1 min	Hyd. volume	=	3,851 cuft
Drainage area	=	0.720 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	12.20 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.146 x 48) + (0.557 x 58) + (0.019 x 100)] / 0.720

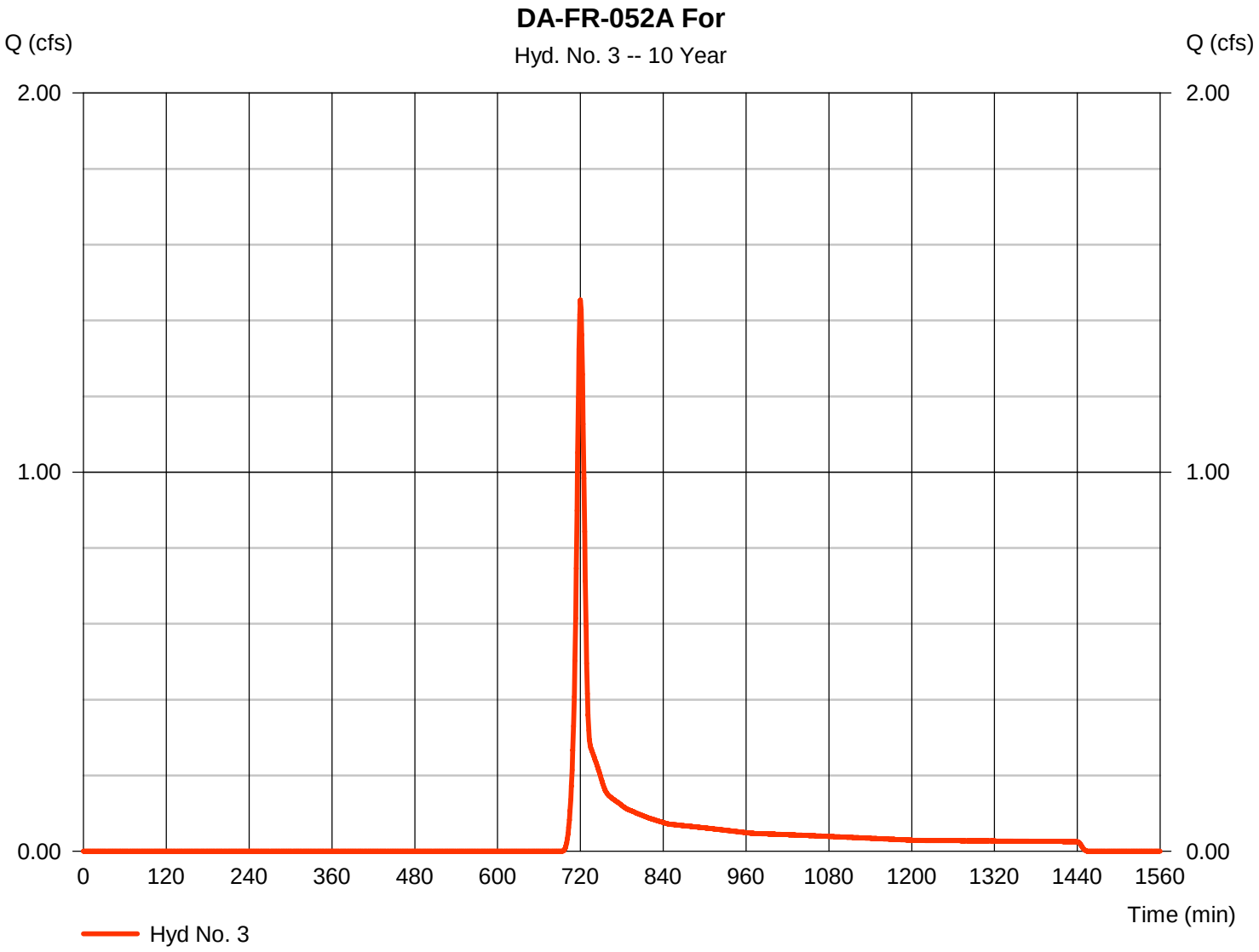


Hydrograph Report

Hyd. No. 3

DA-FR-052A For

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.454 cfs
Storm frequency	=	10 yrs	Time to peak	=	720 min
Time interval	=	1 min	Hyd. volume	=	3,524 cuft
Drainage area	=	0.720 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	9.50 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



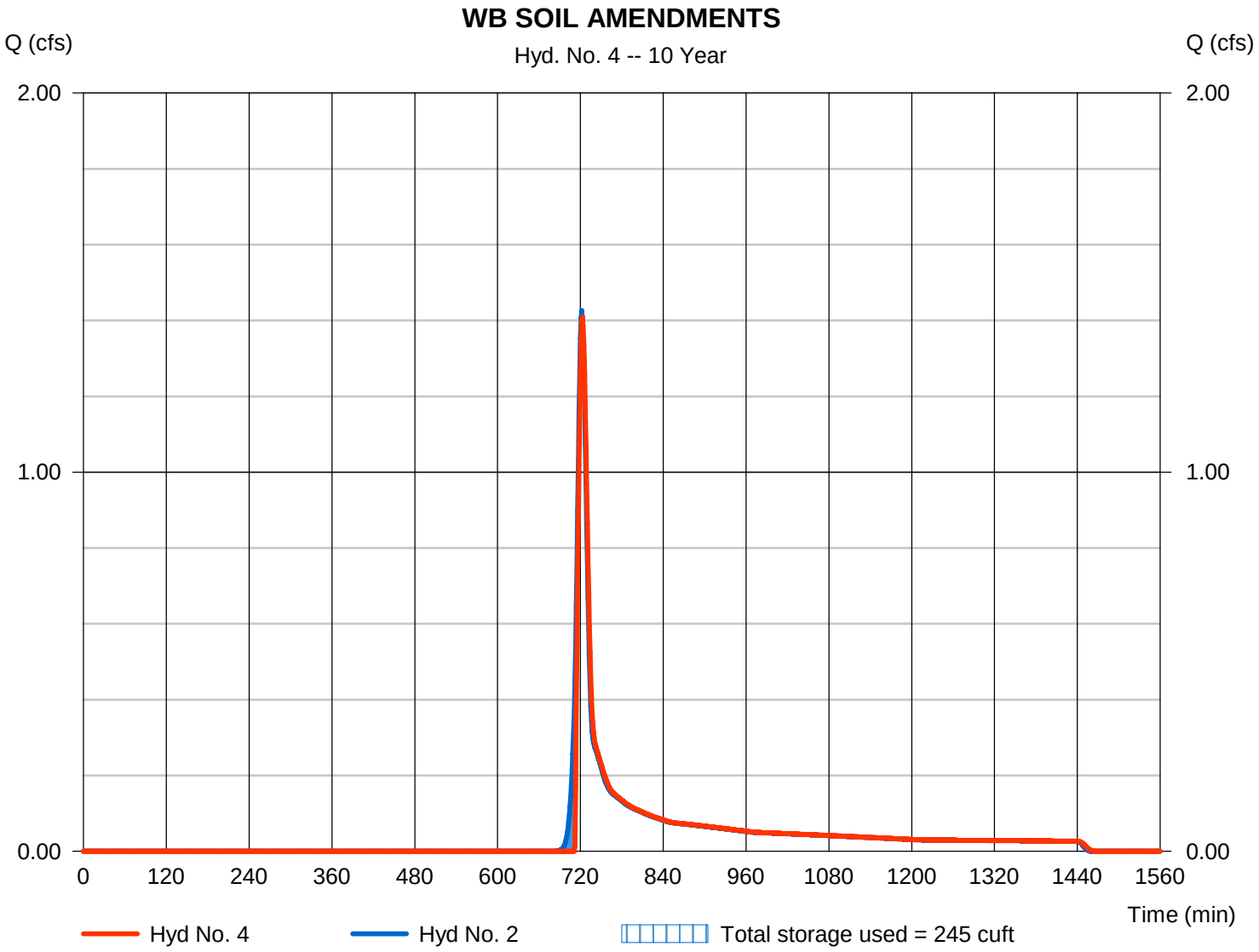
Hydrograph Report

Hyd. No. 4

WB SOIL AMENDMENTS

Hydrograph type	=	Reservoir	Peak discharge	=	1.409 cfs
Storm frequency	=	10 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	3,719 cuft
Inflow hyd. No.	=	2 - DA-FR-052A Dev	Max. Elevation	=	101.86 ft
Reservoir name	=	WATERBAR SOIL AMENDMENTS	Max. Storage	=	245 cuft

Storage Indication method used.



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.p

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-052B

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.181	4547
Developed Condition	0.840	3794
Pre-Developed (Forest) Condition	0.549	3104

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.840	≤ OK	1.132
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.840	≤ OK	1.181
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.840	*shall not* be required to be ≤	0.449

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Oak Grasslands, Open Grasslands	0.60

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-052B Pre
2	SCS Runoff	DA-FR-052B Dev
3	SCS Runoff	DA-FR-052B For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.181	1.926	-------	-------	6.877	-------	-------	-------	DA-FR-052B Pre
2	SCS Runoff	------	0.840	1.484	-------	-------	6.120	-------	-------	-------	DA-FR-052B Dev
3	SCS Runoff	------	0.549	1.092	-------	-------	5.371	-------	-------	-------	DA-FR-052B For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.181	1	724	4,547	------	------	------	DA-FR-052B Pre
2	SCS Runoff	0.840	1	724	3,794	------	------	------	DA-FR-052B Dev
3	SCS Runoff	0.549	1	725	3,104	------	------	------	DA-FR-052B For

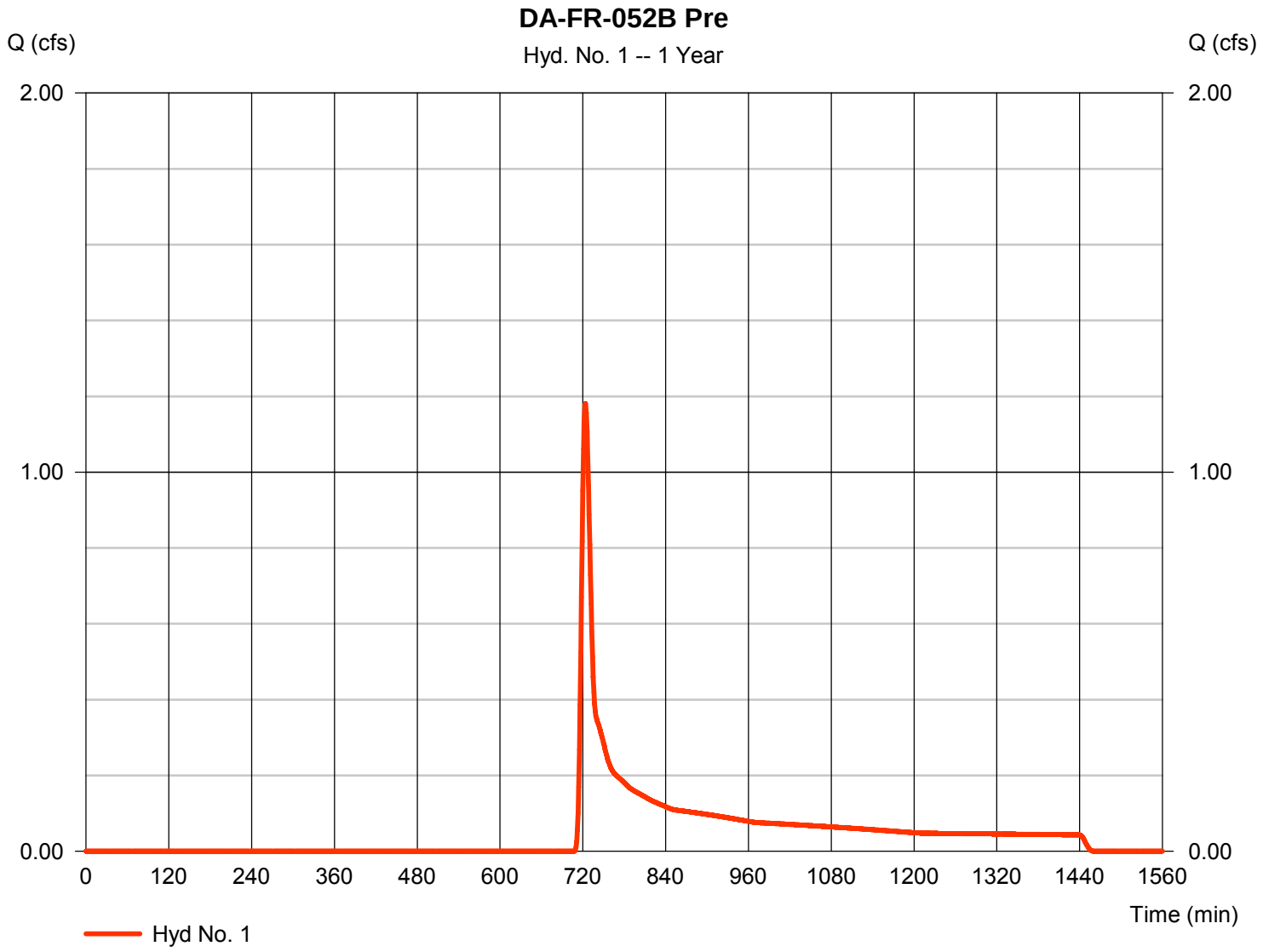
Hydrograph Report

Hyd. No. 1

DA-FR-052B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.181 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 4,547 cuft
Drainage area	= 3.090 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.207 x 98) + (0.315 x 58) + (0.022 x 100) + (2.542 x 55)] / 3.090



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-052B Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.21		0.00		0.00		
Travel Time (min)	**= 11.35**	**+**	**0.00**	**+**	**0.00**	**=**	**11.35**
Shallow Concentrated Flow							
Flow length (ft)	= 326.38		0.00		0.00		
Watercourse slope (%)	= 16.05		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.46		0.00		0.00		
Travel Time (min)	**= 0.84**	**+**	**0.00**	**+**	**0.00**	**=**	**0.84**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 12.20 min

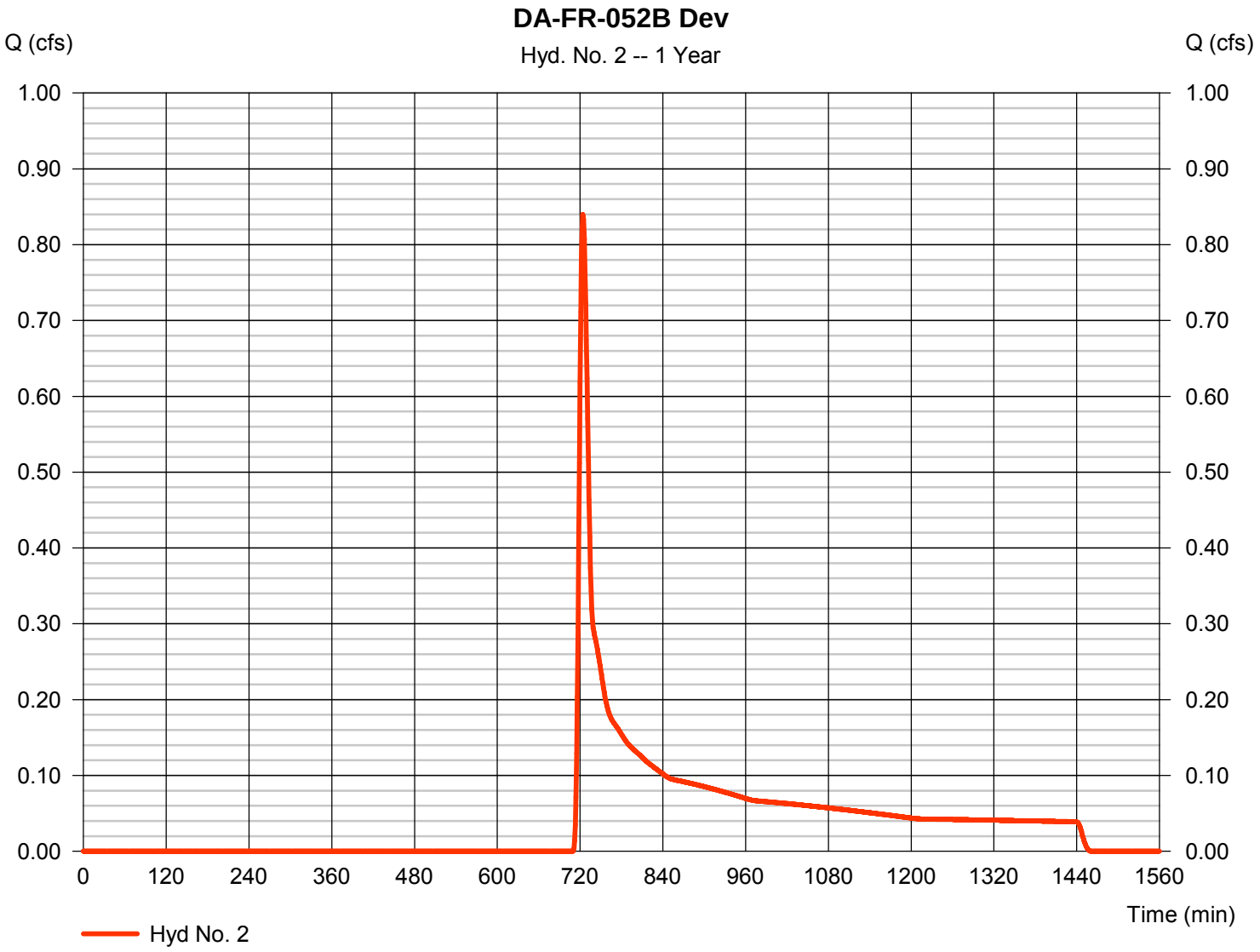
Hydrograph Report

Hyd. No. 2

DA-FR-052B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.840 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 3,794 cuft
Drainage area	= 3.090 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.732 x 48) + (0.207 x 98) + (0.485 x 58) + (0.022 x 100) + (1.640 x 55)] / 3.090



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-052B Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.21		0.00		0.00		
Travel Time (min)	**= 11.35**	**+**	**0.00**	**+**	**0.00**	**=**	**11.35**
Shallow Concentrated Flow							
Flow length (ft)	= 326.38		0.00		0.00		
Watercourse slope (%)	= 16.05		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.46		0.00		0.00		
Travel Time (min)	**= 0.84**	**+**	**0.00**	**+**	**0.00**	**=**	**0.84**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

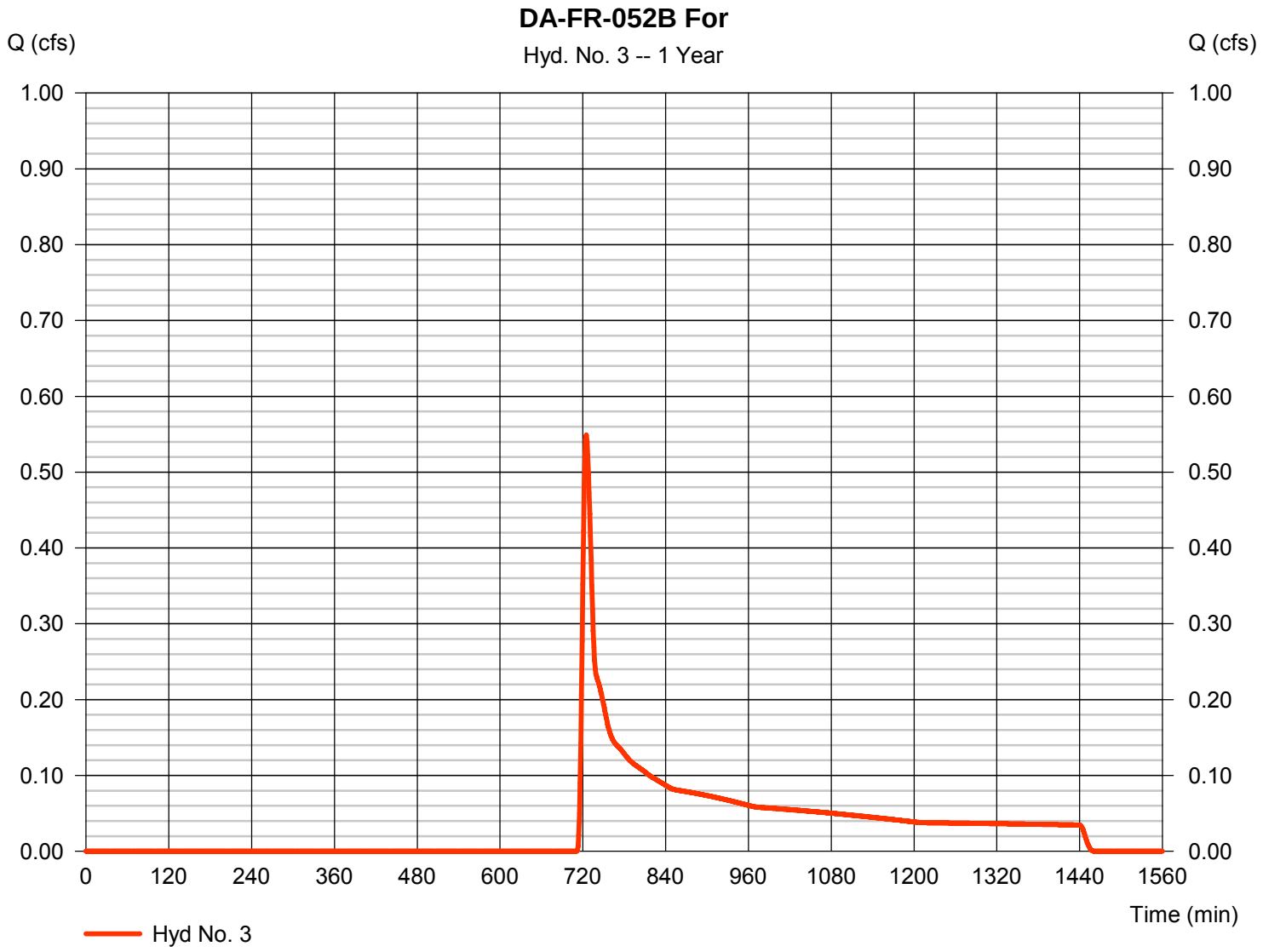
Total Travel Time, Tc ..... 12.20 min

Hydrograph Report

Hyd. No. 3

DA-FR-052B For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.549 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 3,104 cuft
Drainage area	= 3.090 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-052B For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.21		0.00		0.00		
Travel Time (min)	**= 11.35**	**+**	**0.00**	**+**	**0.00**	**=**	**11.35**
Shallow Concentrated Flow							
Flow length (ft)	= 326.38		0.00		0.00		
Watercourse slope (%)	= 16.05		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.46		0.00		0.00		
Travel Time (min)	**= 0.84**	**+**	**0.00**	**+**	**0.00**	**=**	**0.84**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 12.20 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.926	1	723	6,364	------	------	------	DA-FR-052B Pre
2	SCS Runoff	1.484	1	723	5,445	------	------	------	DA-FR-052B Dev
3	SCS Runoff	1.092	1	724	4,589	------	------	------	DA-FR-052B For

Hydrograph Report

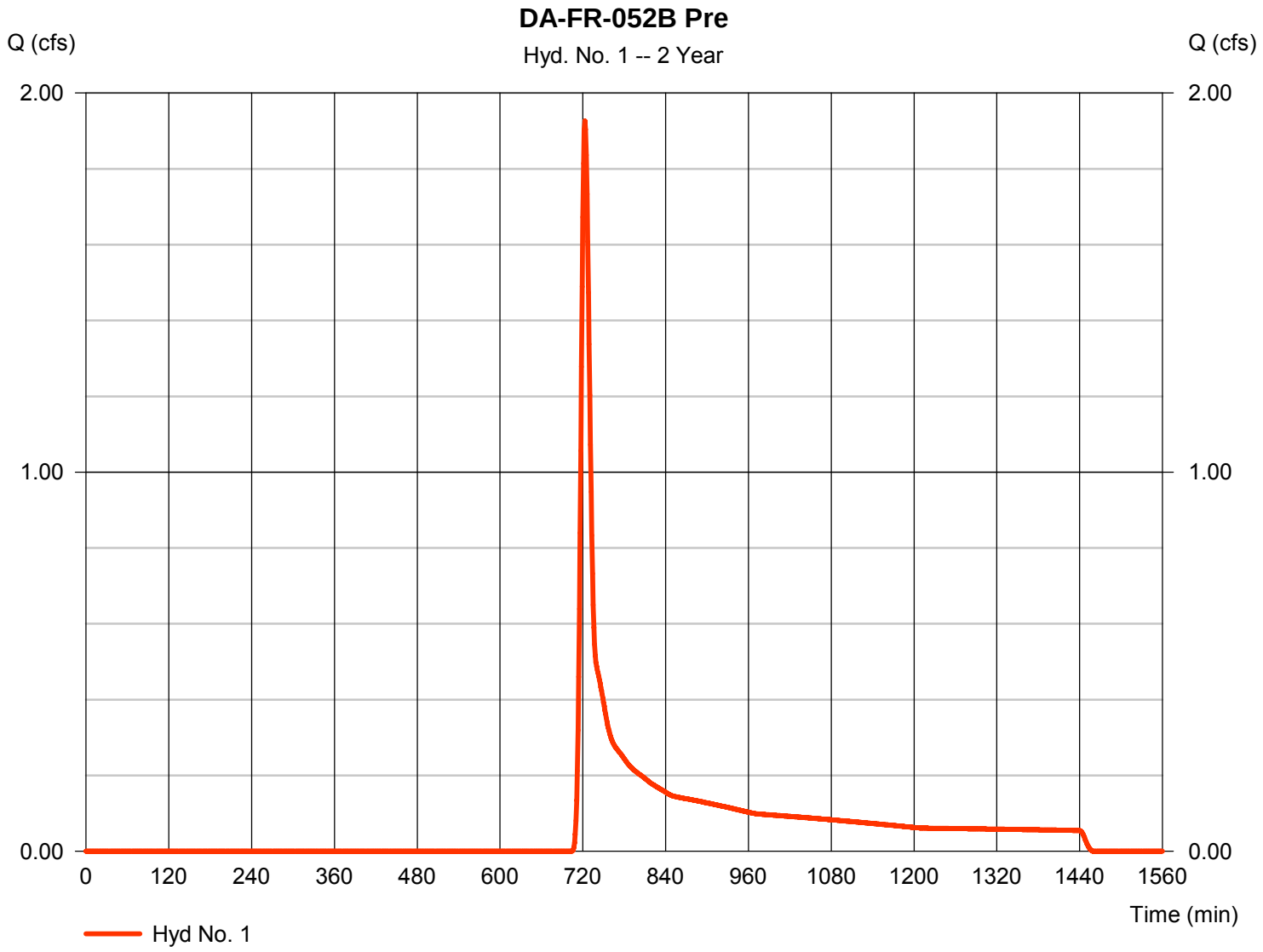
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Wednesday, 09 / 20 / 2017

Hyd. No. 1

DA-FR-052B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.926 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 6,364 cuft
Drainage area	= 3.090 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.207 x 98) + (0.315 x 58) + (0.022 x 100) + (2.542 x 55)] / 3.090



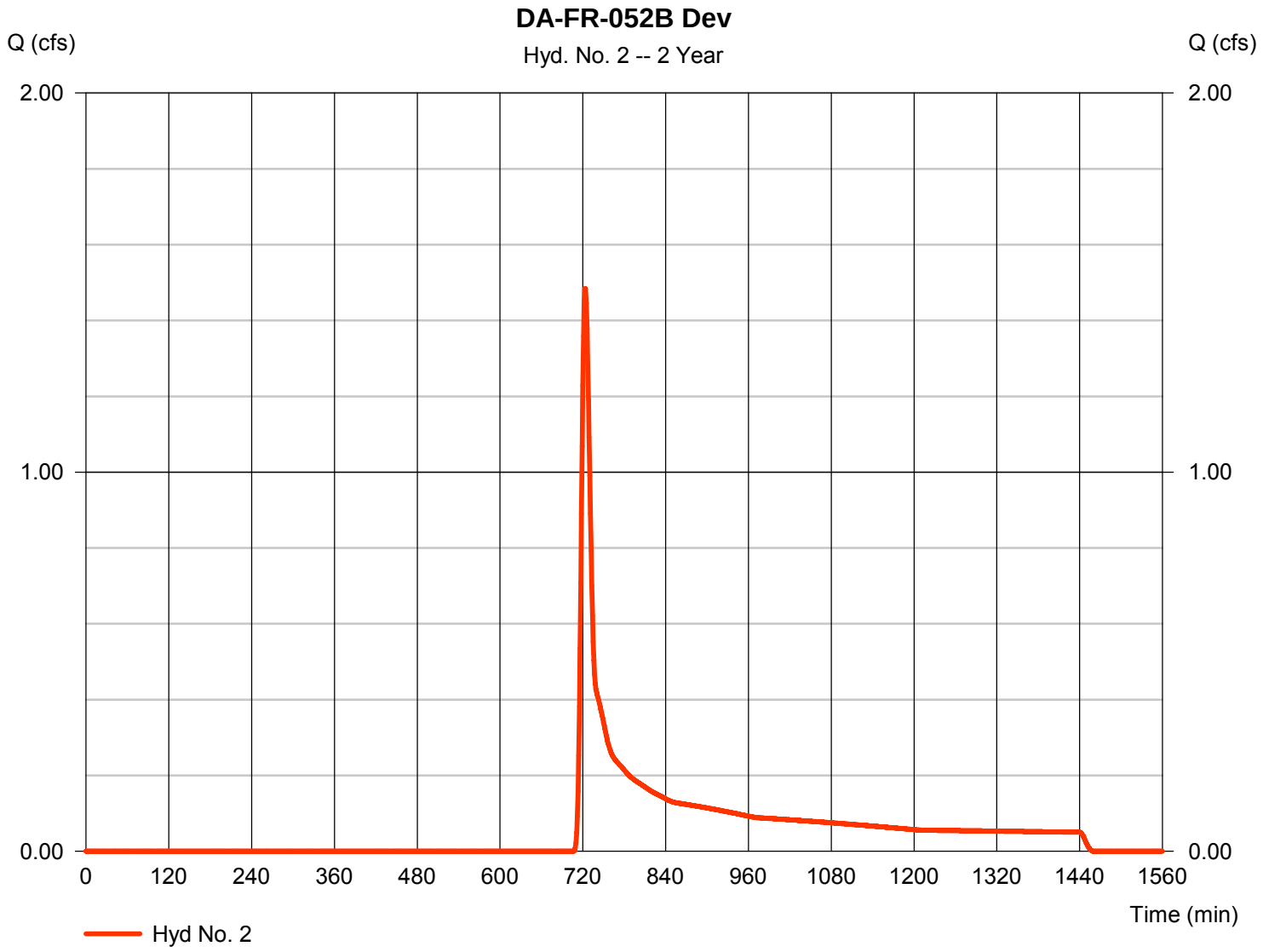
Hydrograph Report

Hyd. No. 2

DA-FR-052B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 1.484 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 5,445 cuft
Drainage area	= 3.090 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.732 x 48) + (0.207 x 98) + (0.485 x 58) + (0.022 x 100) + (1.640 x 55)] / 3.090

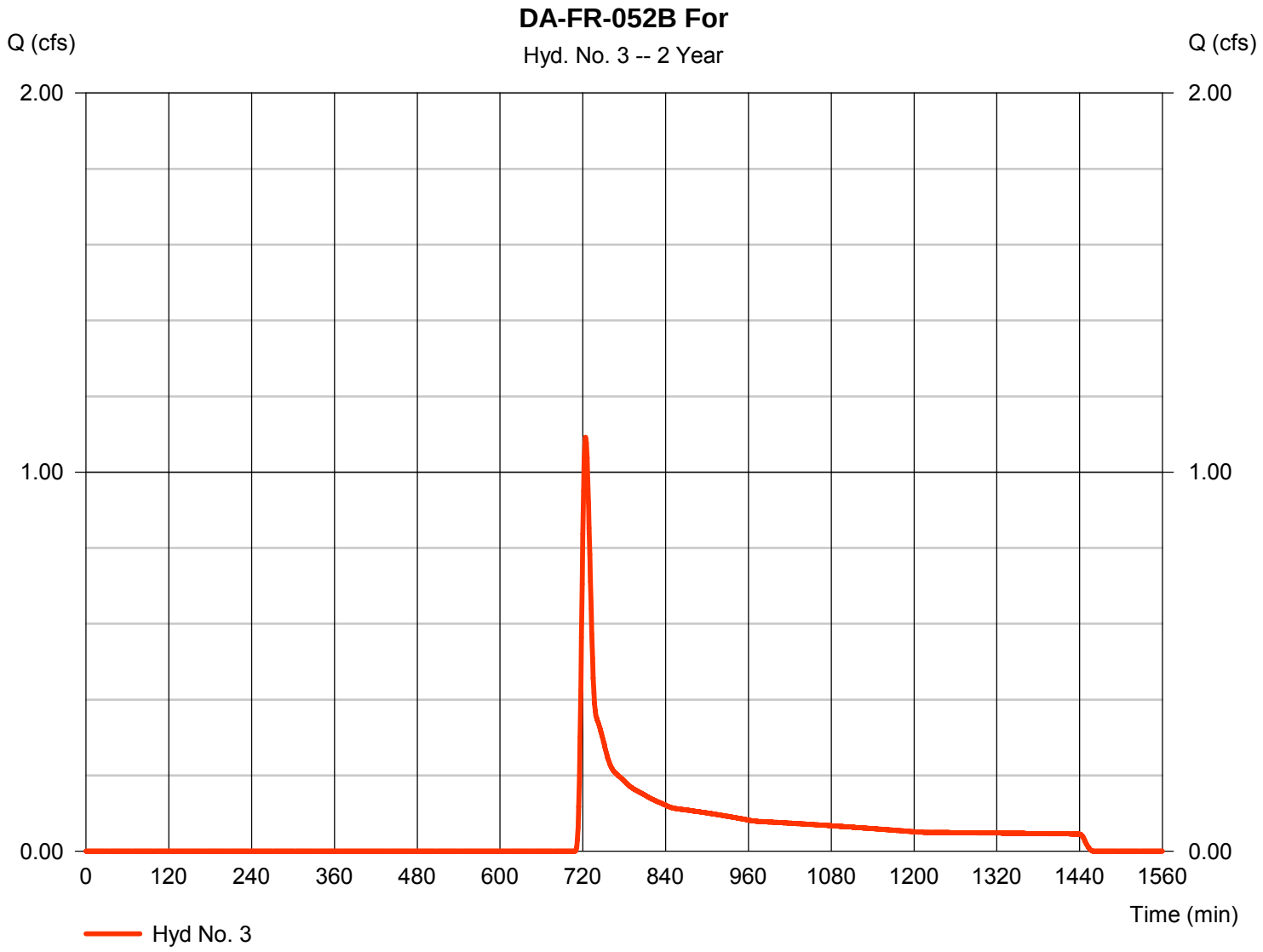


Hydrograph Report

Hyd. No. 3

DA-FR-052B For

Hydrograph type	= SCS Runoff	Peak discharge	= 1.092 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 4,589 cuft
Drainage area	= 3.090 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	6.877	1	722	18,218	------	------	------	DA-FR-052B Pre
2	SCS Runoff	6.120	1	722	16,528	------	------	------	DA-FR-052B Dev
3	SCS Runoff	5.371	1	722	14,889	------	------	------	DA-FR-052B For

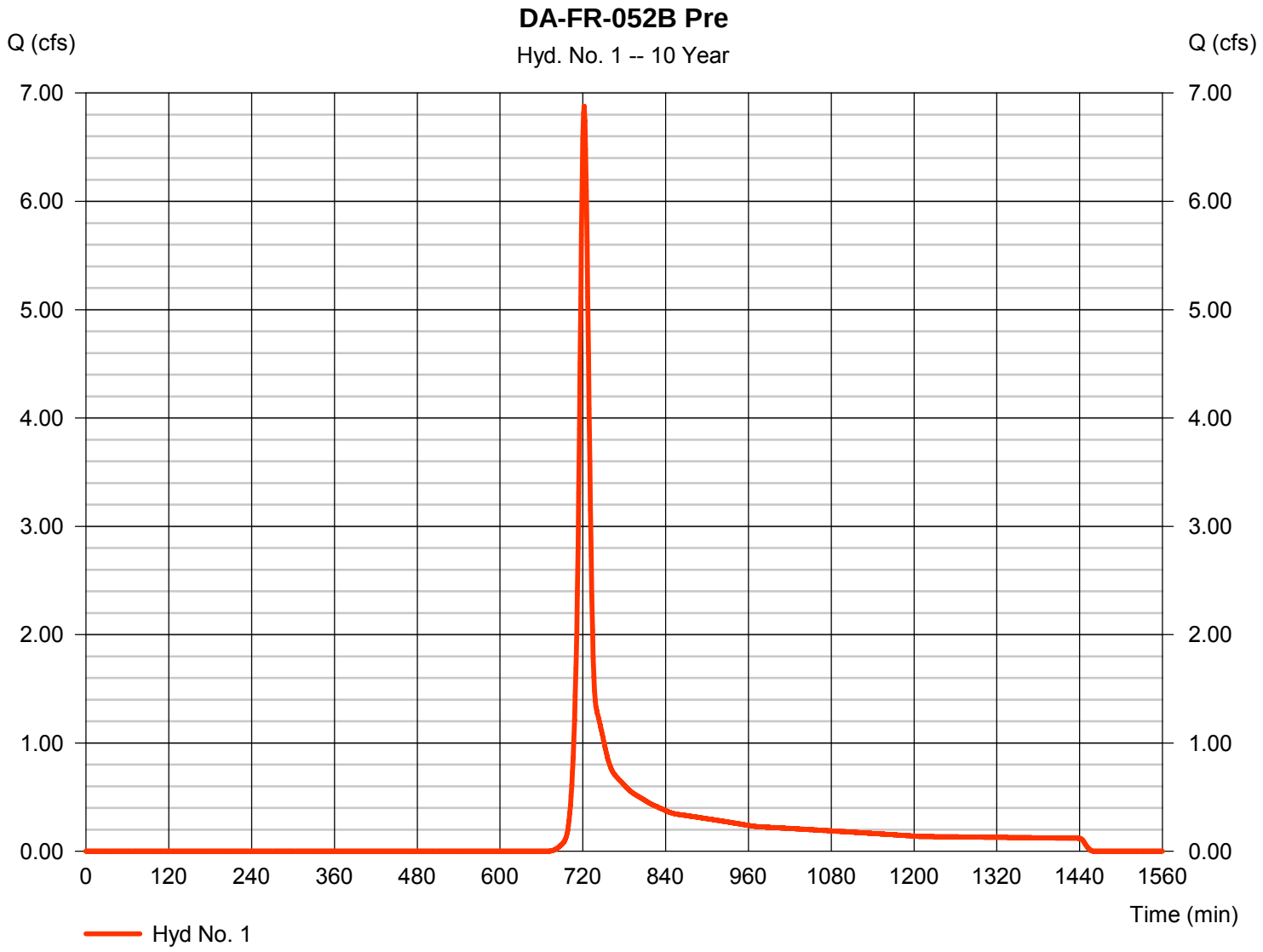
Hydrograph Report

Hyd. No. 1

DA-FR-052B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 6.877 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 18,218 cuft
Drainage area	= 3.090 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.207 x 98) + (0.315 x 58) + (0.022 x 100) + (2.542 x 55)] / 3.090



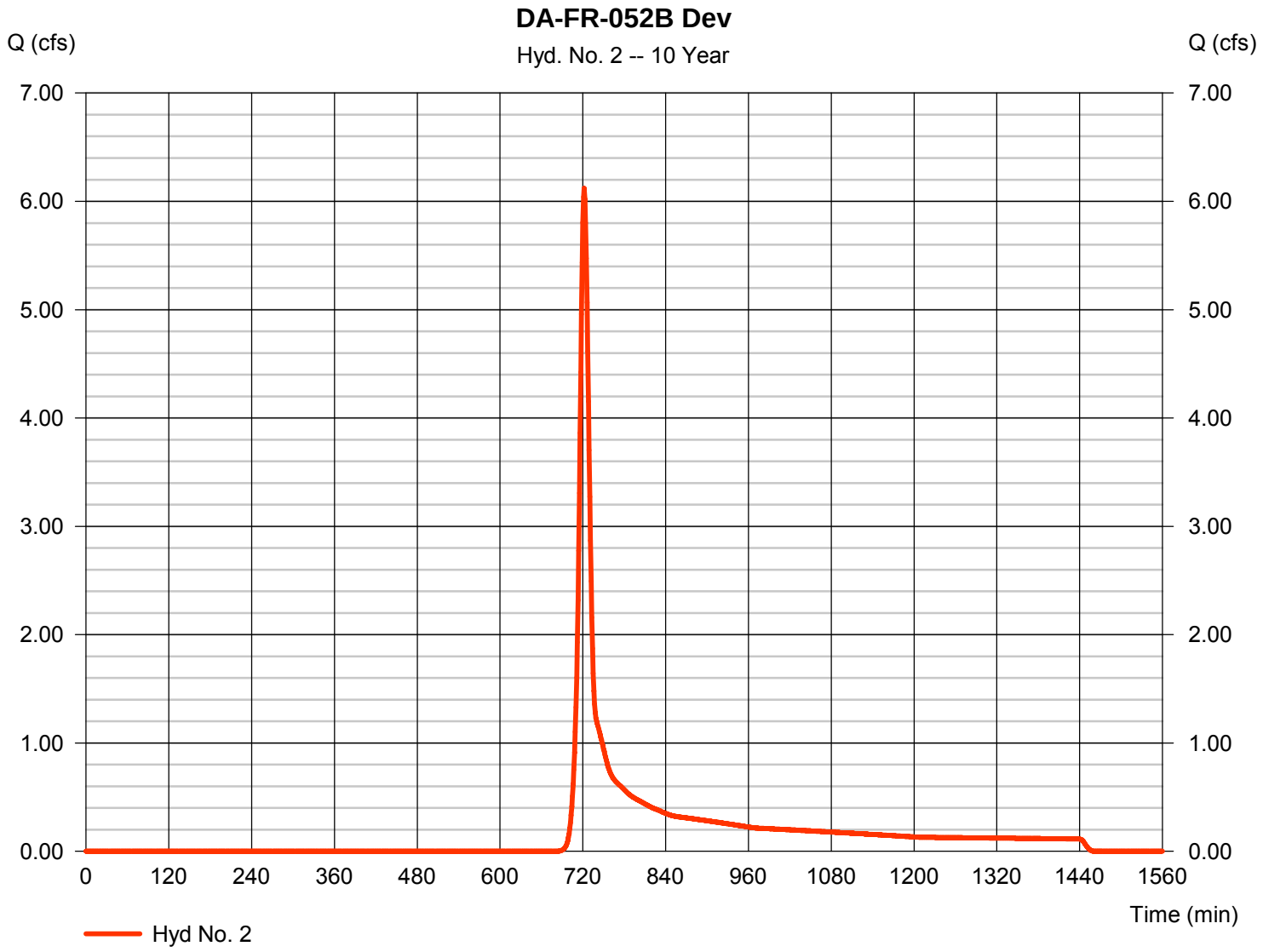
Hydrograph Report

Hyd. No. 2

DA-FR-052B Dev

Hydrograph type	=	SCS Runoff	Peak discharge	=	6.120 cfs
Storm frequency	=	10 yrs	Time to peak	=	722 min
Time interval	=	1 min	Hyd. volume	=	16,528 cuft
Drainage area	=	3.090 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	12.20 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.732 x 48) + (0.207 x 98) + (0.485 x 58) + (0.022 x 100) + (1.640 x 55)] / 3.090

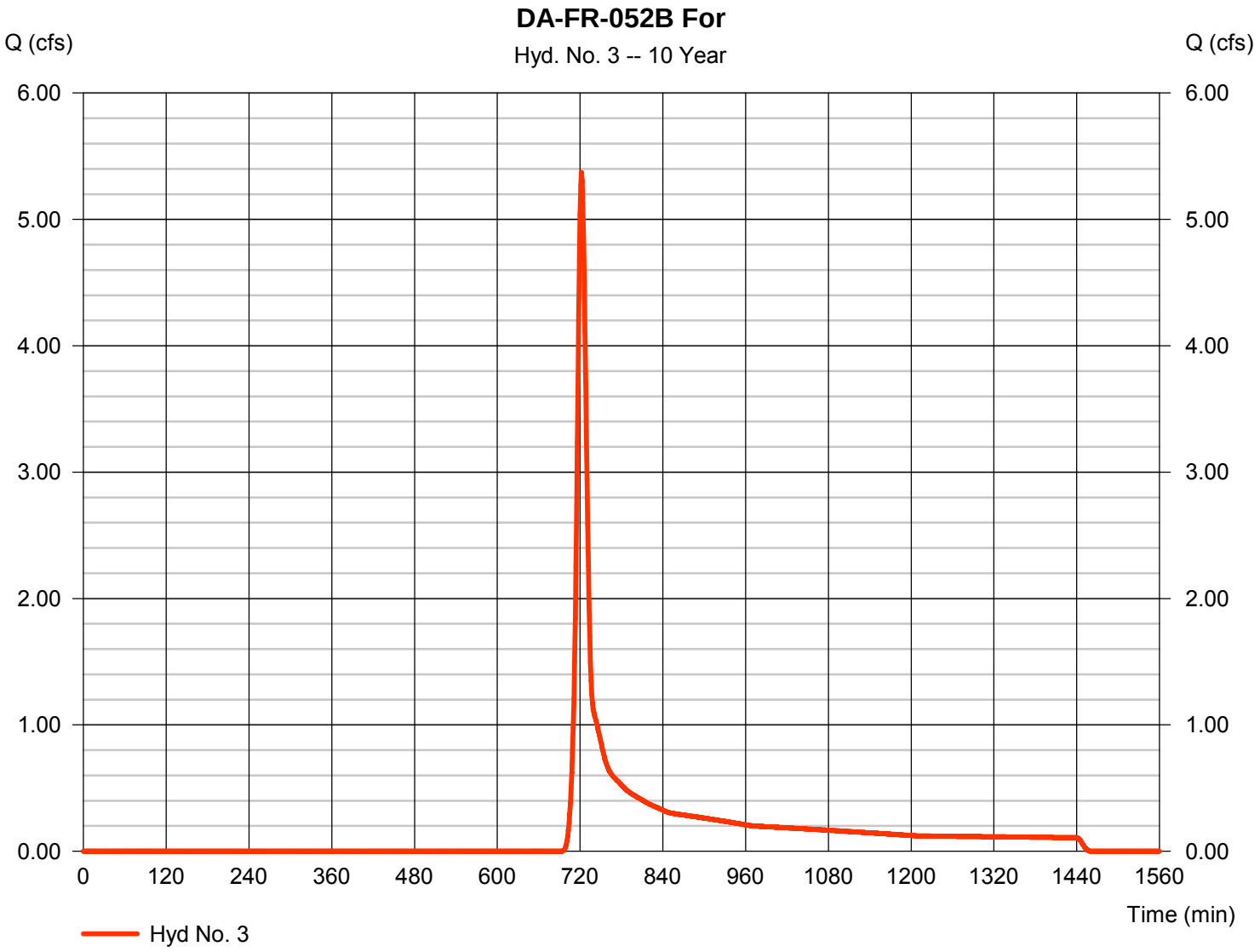


Hydrograph Report

Hyd. No. 3

DA-FR-052B For

Hydrograph type	= SCS Runoff	Peak discharge	= 5.371 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 14,889 cuft
Drainage area	= 3.090 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-053

DA-FR-053 is located in a meadow and forested area with rolling slopes, and also includes gravel and impervious areas (housing areas). The total impervious area is approximately 7.6% of the overall drainage area. No new impervious area is proposed within DA-FR-053. The total phosphorus load reduction required for DA-FR-053 is –0.39 lb/yr.

Stormwater quantity is met via the energy balance method for DA-FR-053. In addition, the Hydraflow Hydrograph's 10-year 24-hour peak discharge results indicate a reduction in flow of 0.89 cfs for the drainage area (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-053A	16.18	15.29	-0.89

Figures and calculations for DA-FR-053 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-053
7.27 acres
Weighted CN =

261.9
262.0
262.1
S-C13
S-C15
S-C14
S-C16
1100
1050
1050
B
Teel Brooke Rd
Parkview Dr

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Gravel
- Impervious
- Meadow
- Woods
- Drainage Area
- Hydrologic Soil Groups
- Agricultural Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,440

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-053
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-053_Pre.mxd

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Gravel
- Impervious
- Meadow
- Woods
- Drainage Area
- Hydrologic Soil Groups
- Agricultural Area

NAD 1983 UTM 17N (feet)

1:1,440

N W E S

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-053
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-053_Post.mxd

Legend

- Milepost
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Delineated Stream
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,440

N W E S

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration
DA-FR-053
Spread 10

Figure 3
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-053_3.mxd

Legend

- Milepost
- Permanent Waterbars
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Delineated Stream
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,440

N W E S

120 60 0 120 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration
DA-FR-053
Spread 10

Figure 4
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-053_4.mxd

Virginia Runoff Reduction Method New Development Worksheet - v2.8 - June 2014

Site Data Summary

Total Rainfall = 46 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	1.15	0.00	0.00	1.15	*100.00*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
					1.15	*100.00*

Site Rv	0.03
Post Development Treatment Volume (ft3)	125
Post Development TP Load (lb/yr)	0.08
Post Development TN Load (lb/yr)	0.60
Total TP Load Reduction Required (lb/yr)	-0.39

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0
Total TN Load Reduction Achieved (lb/yr)	0.00
Adjusted Post Development TP Load (lb/yr)	0.08
Remaining Phosphorous Load Reduction (Lb/yr) Required	0.00

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest (acres)	1.15	0.00	0.00	0.00	0.00	*1.15*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
						1.15

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*
TN Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	2.778	10697
Developed Condition	2.366	9793
Pre-Developed (Forest) Condition	1.291	7302

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	2.366	≤ OK	2.428
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	2.366	≤ OK	2.778
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	2.366	*shall not* be required to be ≤	0.963

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-053 Pre
2	SCS Runoff	DA-FR-053 Dev
3	SCS Runoff	DA-FR-053 For

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	2.778	4.532	-------	-------	16.18	-------	-------	-------	DA-FR-053 Pre
2	SCS Runoff	------	2.366	4.003	-------	-------	15.29	-------	-------	-------	DA-FR-053 Dev
3	SCS Runoff	------	1.291	2.569	-------	-------	12.64	-------	-------	-------	DA-FR-053 For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.778	1	724	10,697	------	------	------	DA-FR-053 Pre
2	SCS Runoff	2.366	1	724	9,793	------	------	------	DA-FR-053 Dev
3	SCS Runoff	1.291	1	725	7,302	------	------	------	DA-FR-053 For

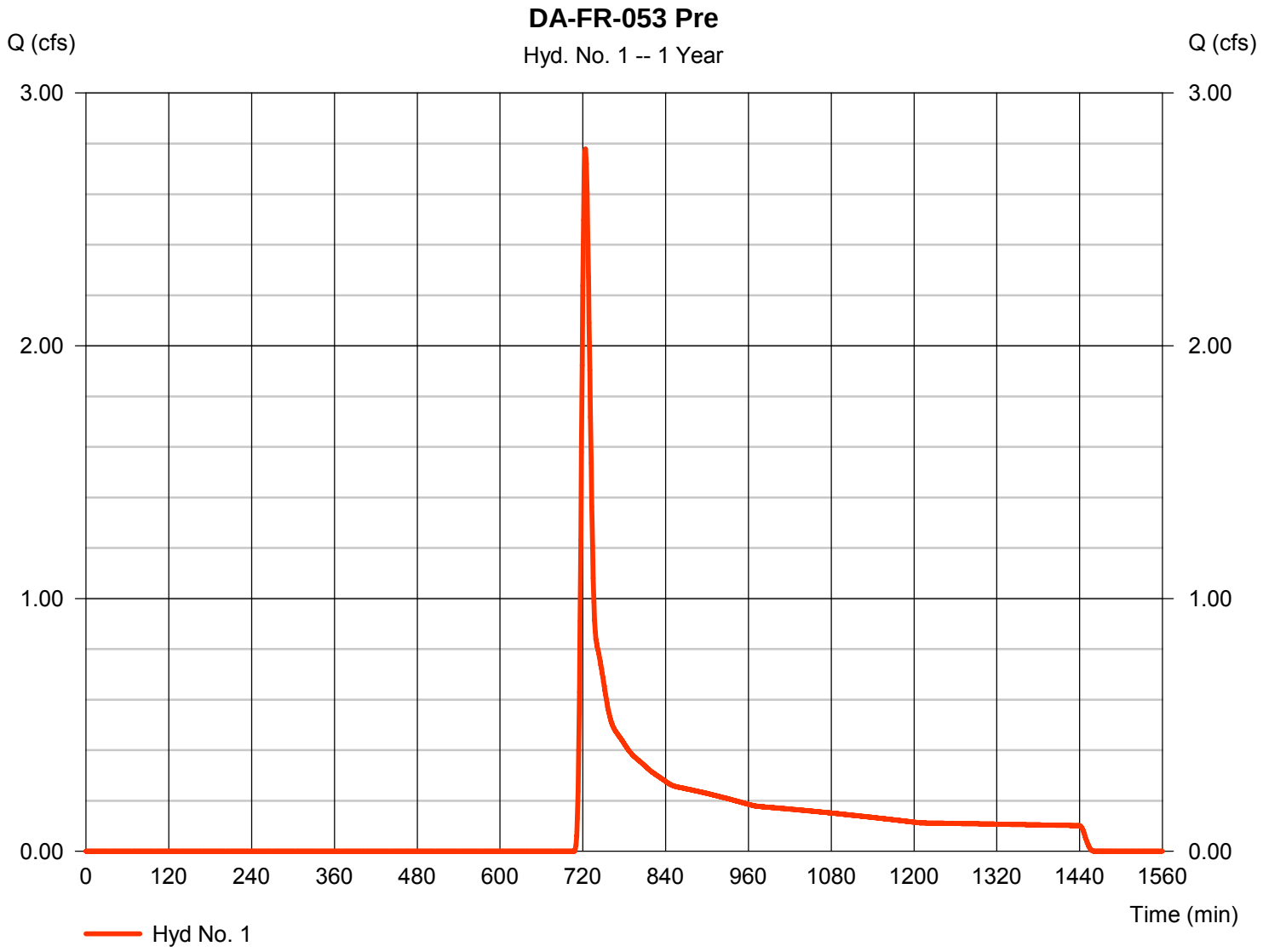
Hydrograph Report

Hyd. No. 1

DA-FR-053 Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.778 cfs
Storm frequency	=	1 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	10,697 cuft
Drainage area	=	7.270 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.10 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.017 x 85) + (0.493 x 98) + (1.961 x 58) + (4.797 x 55)] / 7.270



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-053 Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.110		0.400		
Flow length (ft)	= 15.3		54.7		30.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 2.68		5.27		6.04		
Travel Time (min)	**= 3.96**	**+**	**2.98**	**+**	**4.89**	**=**	**11.83**
Shallow Concentrated Flow							
Flow length (ft)	= 476.47		0.00		0.00		
Watercourse slope (%)	= 16.12		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.48		0.00		0.00		
Travel Time (min)	**= 1.23**	**+**	**0.00**	**+**	**0.00**	**=**	**1.23**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 13.10 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	4.532	1	723	14,973	------	------	------	DA-FR-053 Pre
2	SCS Runoff	4.003	1	723	13,874	------	------	------	DA-FR-053 Dev
3	SCS Runoff	2.569	1	724	10,796	------	------	------	DA-FR-053 For

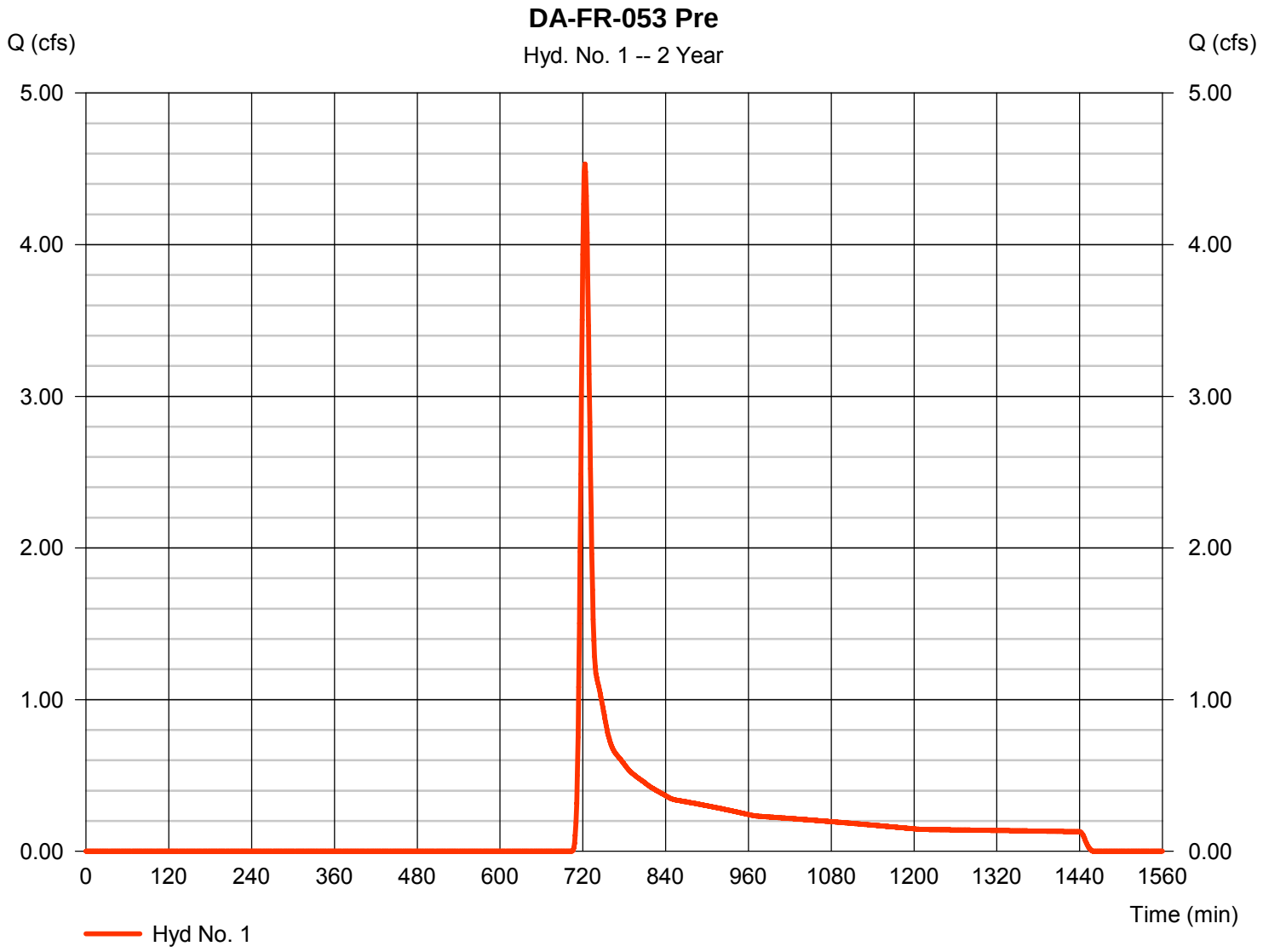
Hydrograph Report

Hyd. No. 1

DA-FR-053 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 4.532 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 14,973 cuft
Drainage area	= 7.270 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.10 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.017 x 85) + (0.493 x 98) + (1.961 x 58) + (4.797 x 55)] / 7.270



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	16.18	1	722	42,863	------	------	------	DA-FR-053 Pre
2	SCS Runoff	15.29	1	722	40,860	------	------	------	DA-FR-053 Dev
3	SCS Runoff	12.64	1	722	35,031	------	------	------	DA-FR-053 For

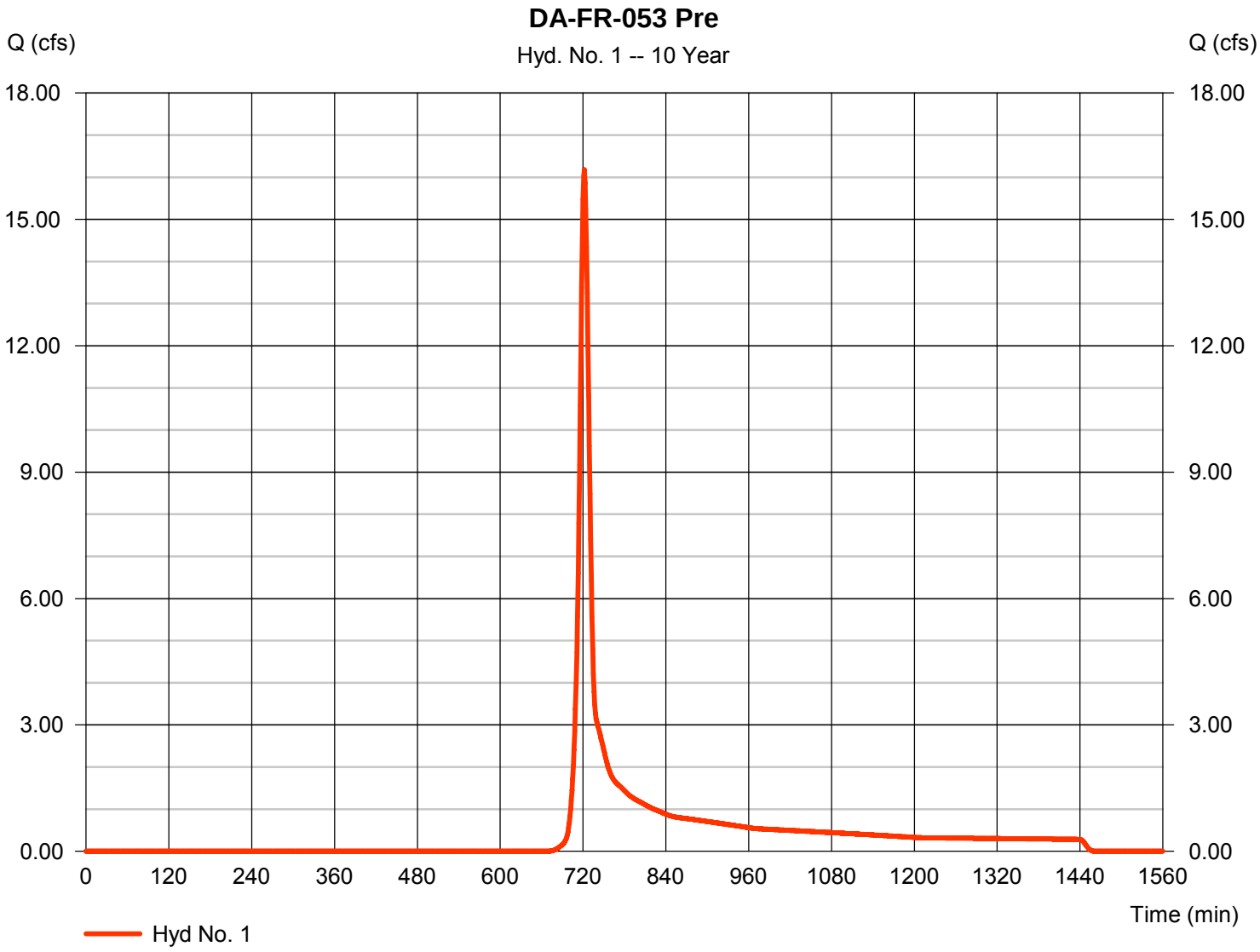
Hydrograph Report

Hyd. No. 1

DA-FR-053 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 16.18 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 42,863 cuft
Drainage area	= 7.270 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.10 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.017 x 85) + (0.493 x 98) + (1.961 x 58) + (4.797 x 55)] / 7.270



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-054

DA-FR-054 is located in a brush, meadow and forested area with rolling slopes. A stream crosses the drainage area. No new impervious area is proposed within DA-FR-054. The total phosphorus load reduction required for DA-FR-054 is –0.12 lb/yr. Multiple points of analysis were evaluated within DA-FR-054 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-054 was sub-divided into two sub-drainage areas (sub areas A and B).

Stormwater quantity is met via the energy balance method for each of the two sub-areas DA-FR-054A and DA-FR-054B. In addition, the Hydraflow Hydrograph's 10-year 24-hour peak discharge results indicate a reduction in flows ranging from 0.09 to 0.25 cfs for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-054A	0.32	0.23	-0.09
DA-FR-054B	1.01	0.76	-0.25

Figures and calculations for each of the sub-areas for DA-FR-054 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Woods
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:600

50 25 0 50 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-054
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-054_Pre.mxd

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Meadow
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:600

N W E S

50 25 0 50 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-054
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-054_Post.mxd

Legend

- Milepost
- Existing 50' Contour
- Existing 10' Contour
- Delineated Stream
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:600

N
W E
S

50 25 0 50 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration
DA-FR-054
Spread 10

Figure 3

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-054_3.mxd

Legend

- Milepost
- Existing 50' Contour
- Existing 10' Contour
- Delineated Stream
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:600

N
W E
S

50 25 0 50 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration DA-FR-054 Spread 10

Figure 4

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-054_4.mxd

Virginia Runoff Reduction Method New Development Worksheet - v2.8 - June 2014

Site Data Summary

Total Rainfall = 46 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	0.36	0.00	0.00	0.36	*100.00*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
					0.36	*100.00*

Site Rv	0.03
Post Development Treatment Volume (ft3)	39
Post Development TP Load (lb/yr)	0.03
Post Development TN Load (lb/yr)	0.19
Total TP Load Reduction Required (lb/yr)	-0.12

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0
Total TN Load Reduction Achieved (lb/yr)	0.00
Adjusted Post Development TP Load (lb/yr)	0.03
Remaining Phosphorous Load Reduction (Lb/yr) Required	0.00

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest (acres)	0.36	0.00	0.00	0.00	0.00	*0.36*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
						0.36

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*
TN Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*

DA-FR-054A

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.036	149
Developed Condition	0.023	155
Pre-Developed (Forest) Condition	0.036	149

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.023	≤ N/A - See Check #3	0.028
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.023	≤ OK	0.036
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.023	*shall not* be required to be ≤	0.035

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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    - TR-55 Tc Worksheet 5

2 - Year
- **Summary Report** 6
- **Hydrograph Reports** 7
  - Hydrograph No. 1, SCS Runoff, DA-FR-054A PRE 7

10 - Year
- **Summary Report** 8
- **Hydrograph Reports** 9
  - Hydrograph No. 1, SCS Runoff, DA-FR-054A PRE 9

IDF Report 10

Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-054A PRE
2	SCS Runoff	DA-FR-054A Dev
3	SCS Runoff	DA-FR-054A For

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.036	0.070	-------	-------	0.321	-------	-------	-------	DA-FR-054A PRE
2	SCS Runoff	------	0.023	0.046	-------	-------	0.232	-------	-------	-------	DA-FR-054A Dev
3	SCS Runoff	------	0.036	0.070	-------	-------	0.321	-------	-------	-------	DA-FR-054A For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

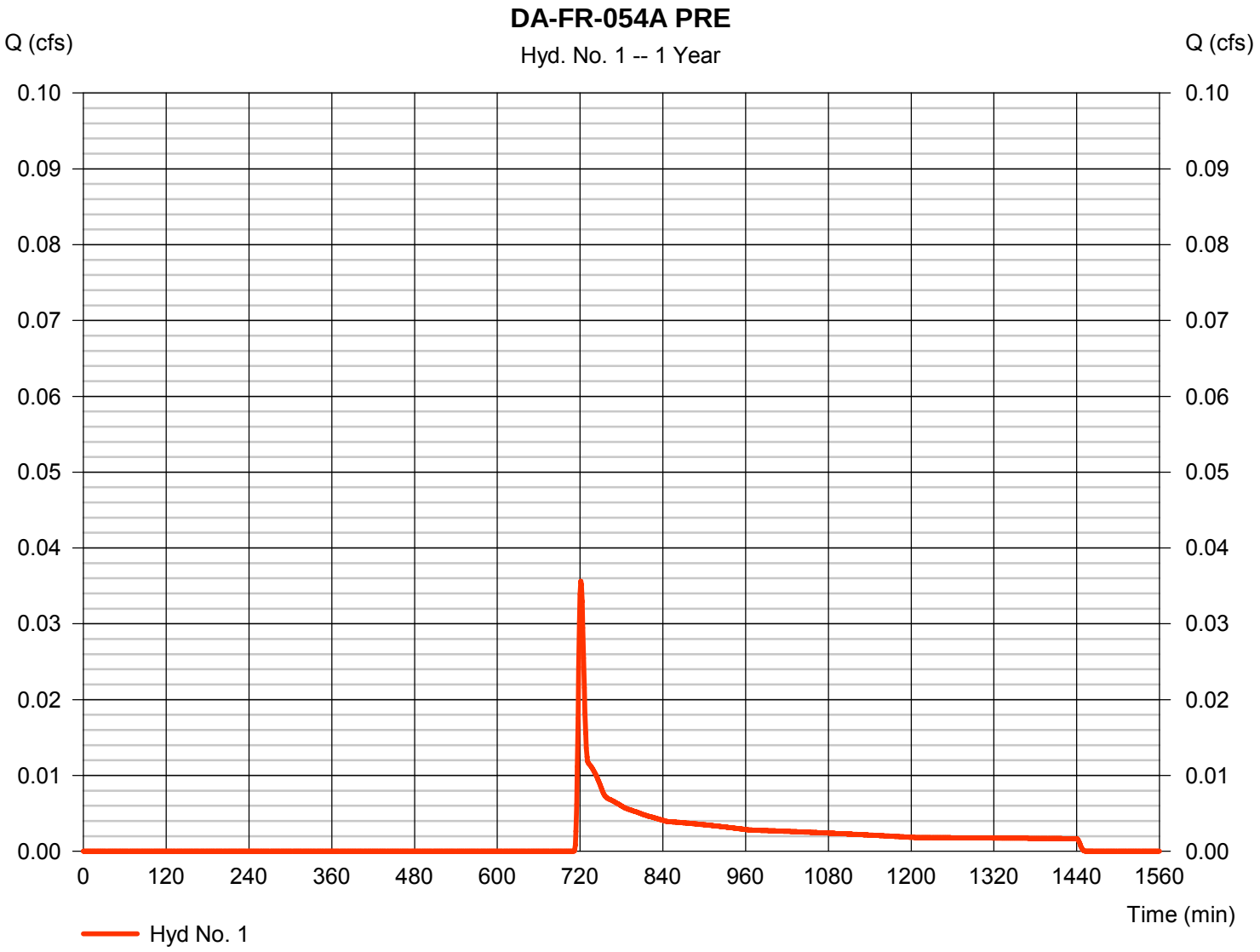
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.036	1	721	149	------	------	------	DA-FR-054A PRE
2	SCS Runoff	0.023	1	727	155	------	------	------	DA-FR-054A Dev
3	SCS Runoff	0.036	1	721	149	------	------	------	DA-FR-054A For

Hydrograph Report

Hyd. No. 1

DA-FR-054A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.036 cfs
Storm frequency	= 1 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 149 cuft
Drainage area	= 0.150 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.30 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-054A PRE

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 18.35		0.00		0.00		
Travel Time (min)	**= 8.23**	**+**	**0.00**	**+**	**0.00**	**=**	**8.23**
Shallow Concentrated Flow							
Flow length (ft)	= 18.43		0.00		0.00		
Watercourse slope (%)	= 6.84		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.22		0.00		0.00		
Travel Time (min)	**= 0.07**	**+**	**0.00**	**+**	**0.00**	**=**	**0.07**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 8.30 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

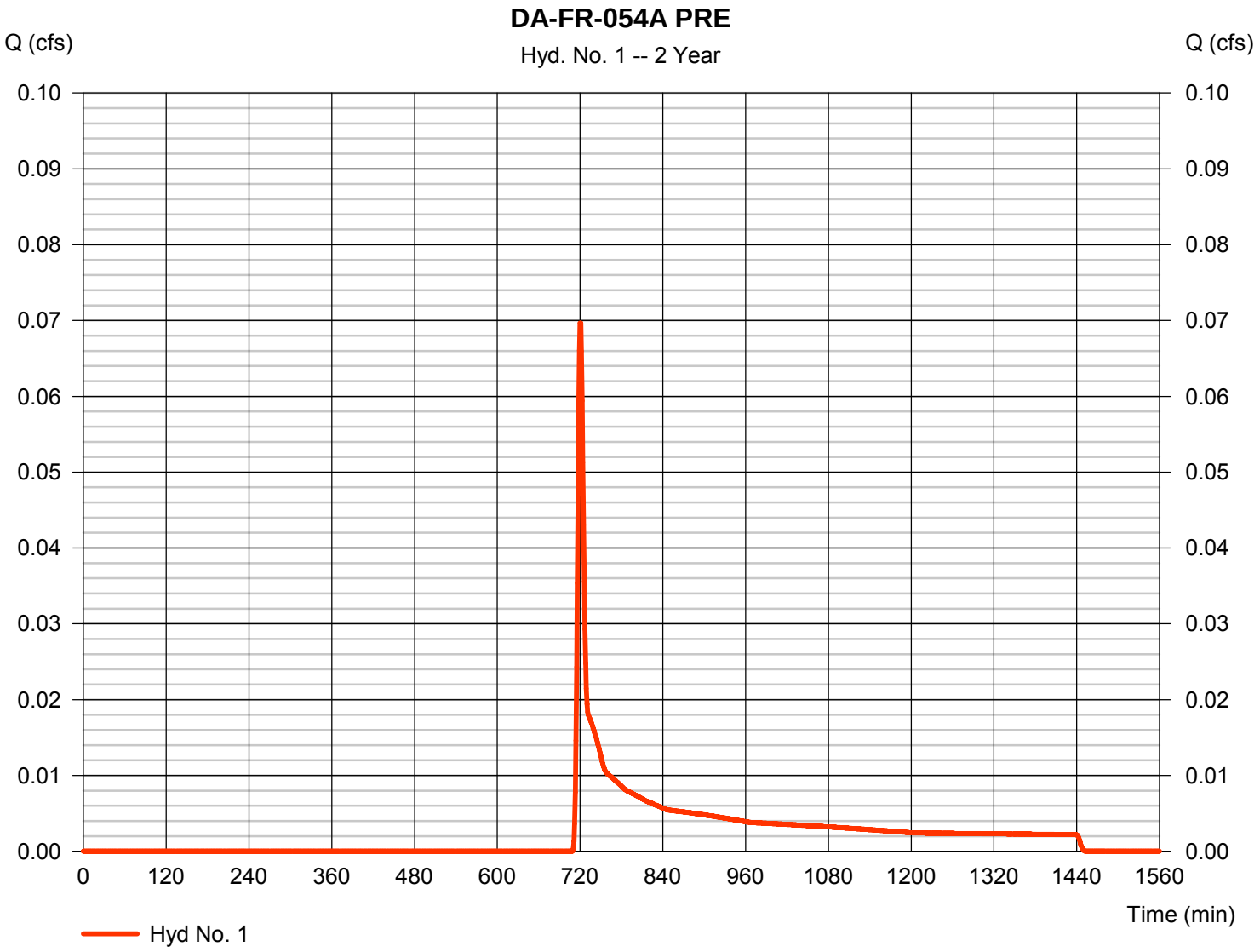
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.070	1	721	221	------	------	------	DA-FR-054A PRE
2	SCS Runoff	0.046	1	726	229	------	------	------	DA-FR-054A Dev
3	SCS Runoff	0.070	1	721	221	------	------	------	DA-FR-054A For

Hydrograph Report

Hyd. No. 1

DA-FR-054A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.070 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 221 cuft
Drainage area	= 0.150 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

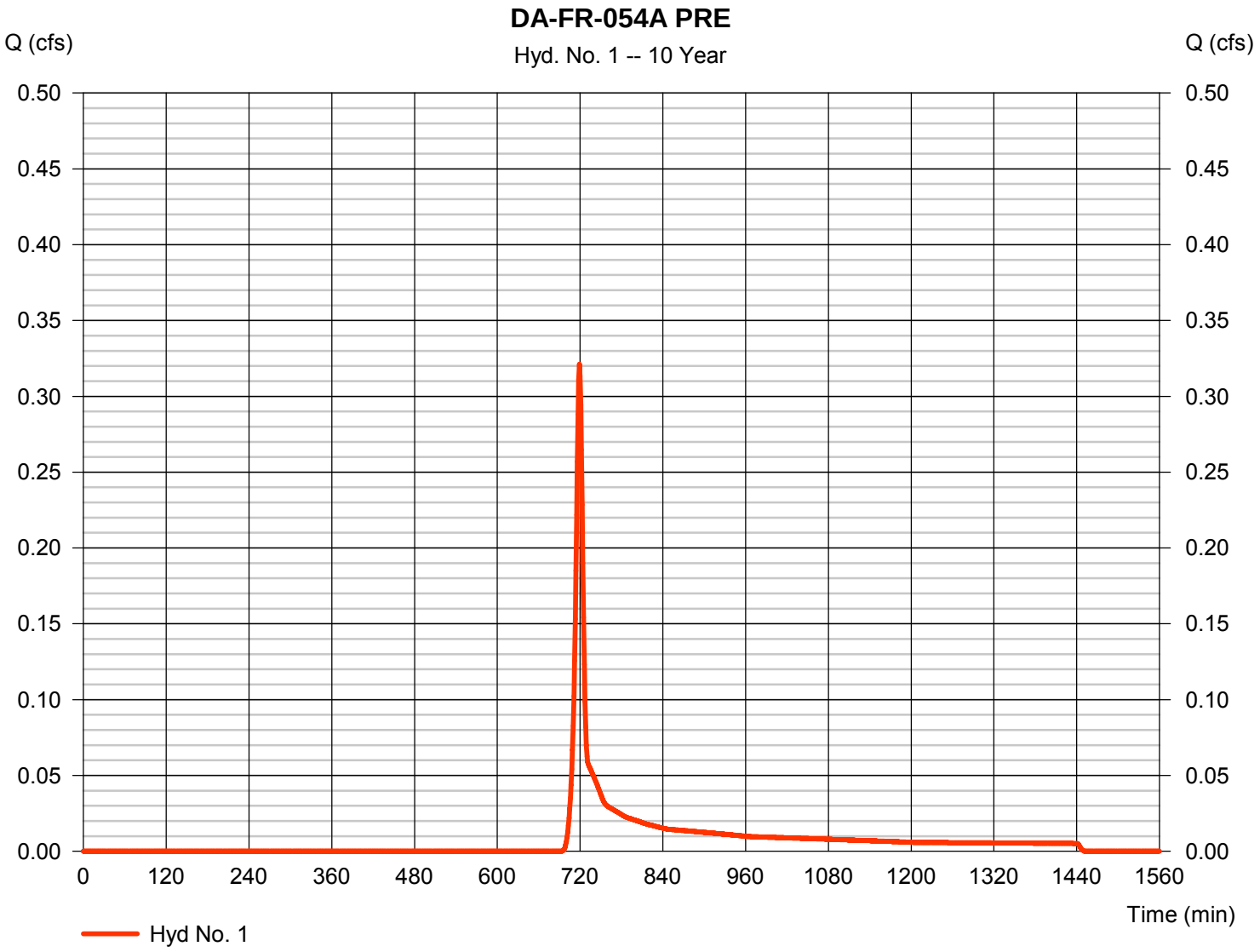
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.321	1	719	716	------	------	------	DA-FR-054A PRE
2	SCS Runoff	0.232	1	724	743	------	------	------	DA-FR-054A Dev
3	SCS Runoff	0.321	1	719	716	------	------	------	DA-FR-054A For

Hydrograph Report

Hyd. No. 1

DA-FR-054A PRE

Hydrograph type	= SCS Runoff	Peak discharge	= 0.321 cfs
Storm frequency	= 10 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 716 cuft
Drainage area	= 0.150 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-054B

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.112	468
Developed Condition	0.064	423
Pre-Developed (Forest) Condition	0.112	468

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.064	≤ N/A - See Check #3	0.099
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.064	≤ N/A - See Check #3	0.112
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.064	*shall not* be required to be ≤	0.124

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-054B Pre
2	SCS Runoff	DA-FR-054B Dev
3	SCS Runoff	DA-FR-054B For

Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)								Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.112	0.218	-------	-------	1.006	-------	-------	-------	DA-FR-054B Pre
2	SCS Runoff	------	0.064	0.138	-------	-------	0.761	-------	-------	-------	DA-FR-054B Dev
3	SCS Runoff	------	0.112	0.218	-------	-------	1.006	-------	-------	-------	DA-FR-054B For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.112	1	721	468	------	------	------	DA-FR-054B Pre
2	SCS Runoff	0.064	1	725	423	------	------	------	DA-FR-054B Dev
3	SCS Runoff	0.112	1	721	468	------	------	------	DA-FR-054B For

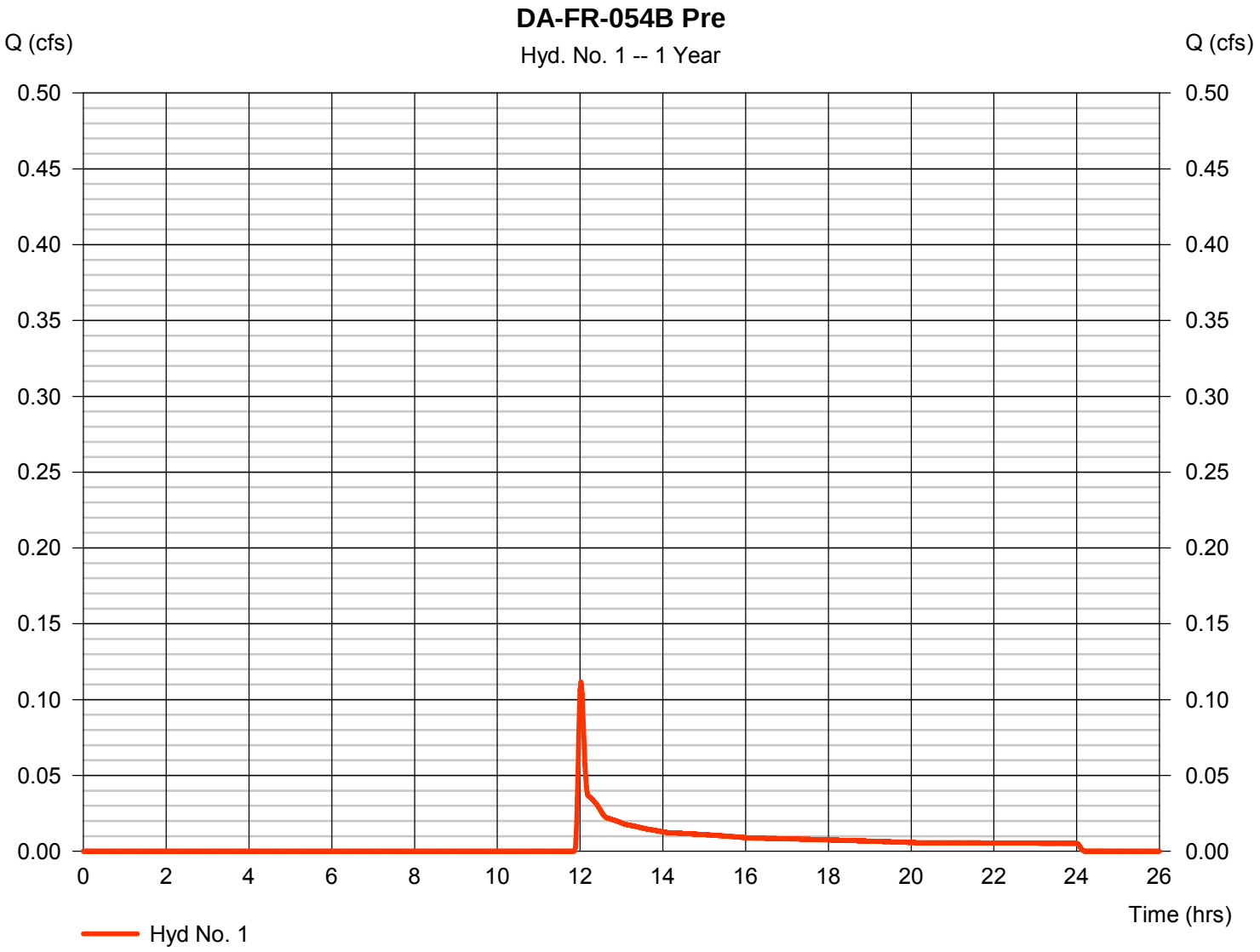
Hydrograph Report

Hyd. No. 1

DA-FR-054B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.112 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.02 hrs
Time interval	= 1 min	Hyd. volume	= 468 cuft
Drainage area	= 0.470 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.470 x 55)] / 0.470



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-054B Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 20.99		0.00		0.00		
Travel Time (min)	**= 7.80**	**+**	**0.00**	**+**	**0.00**	**=**	**7.80**
Shallow Concentrated Flow							
Flow length (ft)	= 132.35		0.00		0.00		
Watercourse slope (%)	= 11.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.39		0.00		0.00		
Travel Time (min)	**= 0.41**	**+**	**0.00**	**+**	**0.00**	**=**	**0.41**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 8.20 min

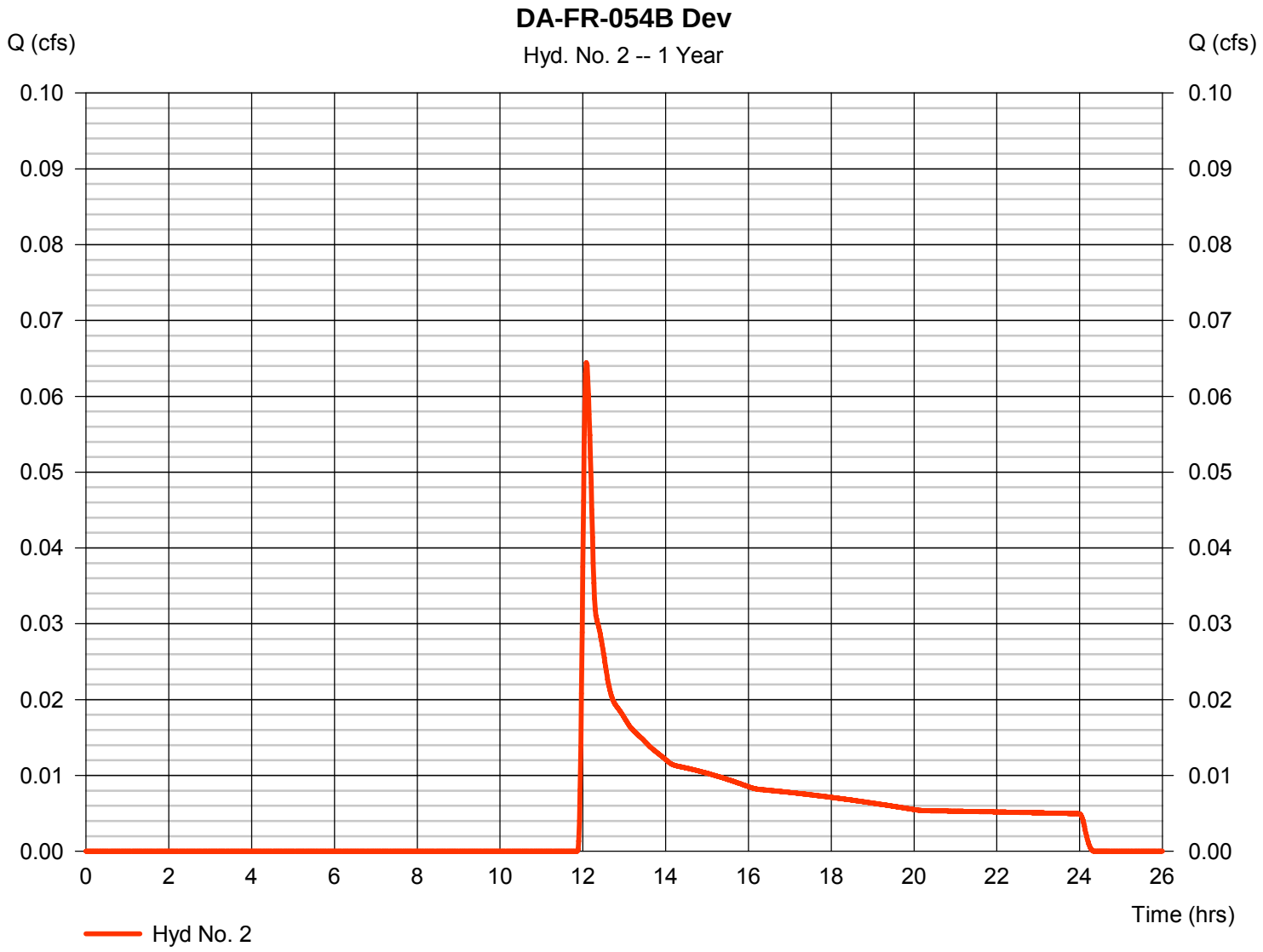
Hydrograph Report

Hyd. No. 2

DA-FR-054B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.064 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.08 hrs
Time interval	= 1 min	Hyd. volume	= 423 cuft
Drainage area	= 0.470 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.210 x 48) + (0.260 x 58)] / 0.470



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-054B Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.800		0.011		
Flow length (ft)	= 47.4		52.6		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 19.21		22.60		0.00		
Travel Time (min)	**= 4.44**	**+**	**7.89**	**+**	**0.00**	**=**	**12.33**
Shallow Concentrated Flow							
Flow length (ft)	= 101.06		29.73		0.00		
Watercourse slope (%)	= 11.83		9.10		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=5.55		4.87		0.00		
Travel Time (min)	**= 0.30**	**+**	**0.10**	**+**	**0.00**	**=**	**0.41**
Channel Flow							
X sectional flow area (sqft)	= 2.00		0.00		0.00		
Wetted perimeter (ft)	= 4.47		0.00		0.00		
Channel slope (%)	= 5.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=4.86						
			0.00				
					0.00		
Flow length (ft)	({0})2.1		0.0		0.0		
Travel Time (min)	**= 0.01**	**+**	**0.00**	**+**	**0.00**	**=**	**0.01**

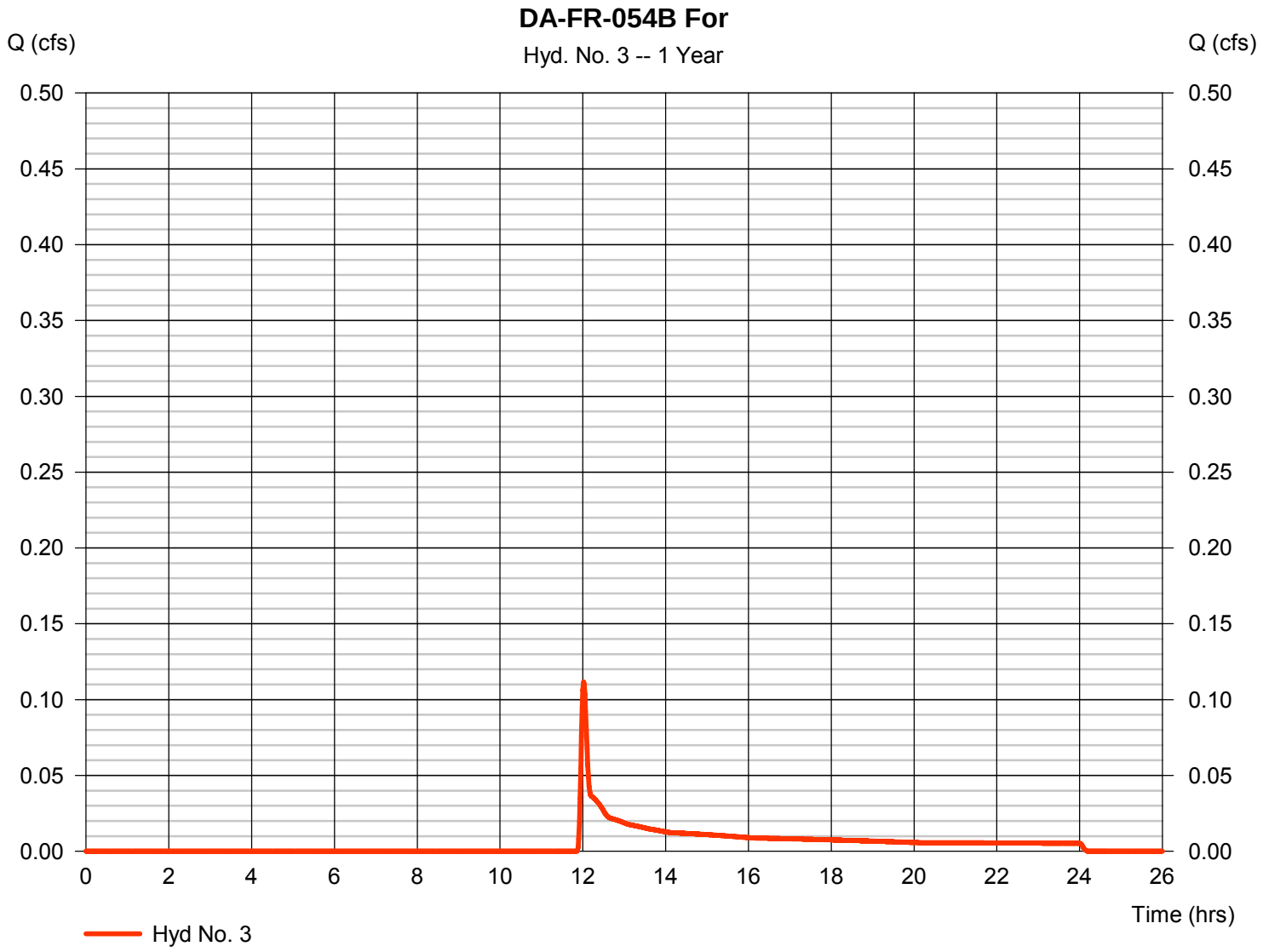
Total Travel Time, Tc ..... 12.70 min

Hydrograph Report

Hyd. No. 3

DA-FR-054B For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.112 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.02 hrs
Time interval	= 1 min	Hyd. volume	= 468 cuft
Drainage area	= 0.470 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-054B For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 20.99		0.00		0.00		
Travel Time (min)	**= 7.80**	**+**	**0.00**	**+**	**0.00**	**=**	**7.80**
Shallow Concentrated Flow							
Flow length (ft)	= 132.35		0.00		0.00		
Watercourse slope (%)	= 11.15		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.39		0.00		0.00		
Travel Time (min)	**= 0.41**	**+**	**0.00**	**+**	**0.00**	**=**	**0.41**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 8.20 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.218	1	721	691	------	------	------	DA-FR-054B Pre
2	SCS Runoff	0.138	1	724	636	------	------	------	DA-FR-054B Dev
3	SCS Runoff	0.218	1	721	691	------	------	------	DA-FR-054B For

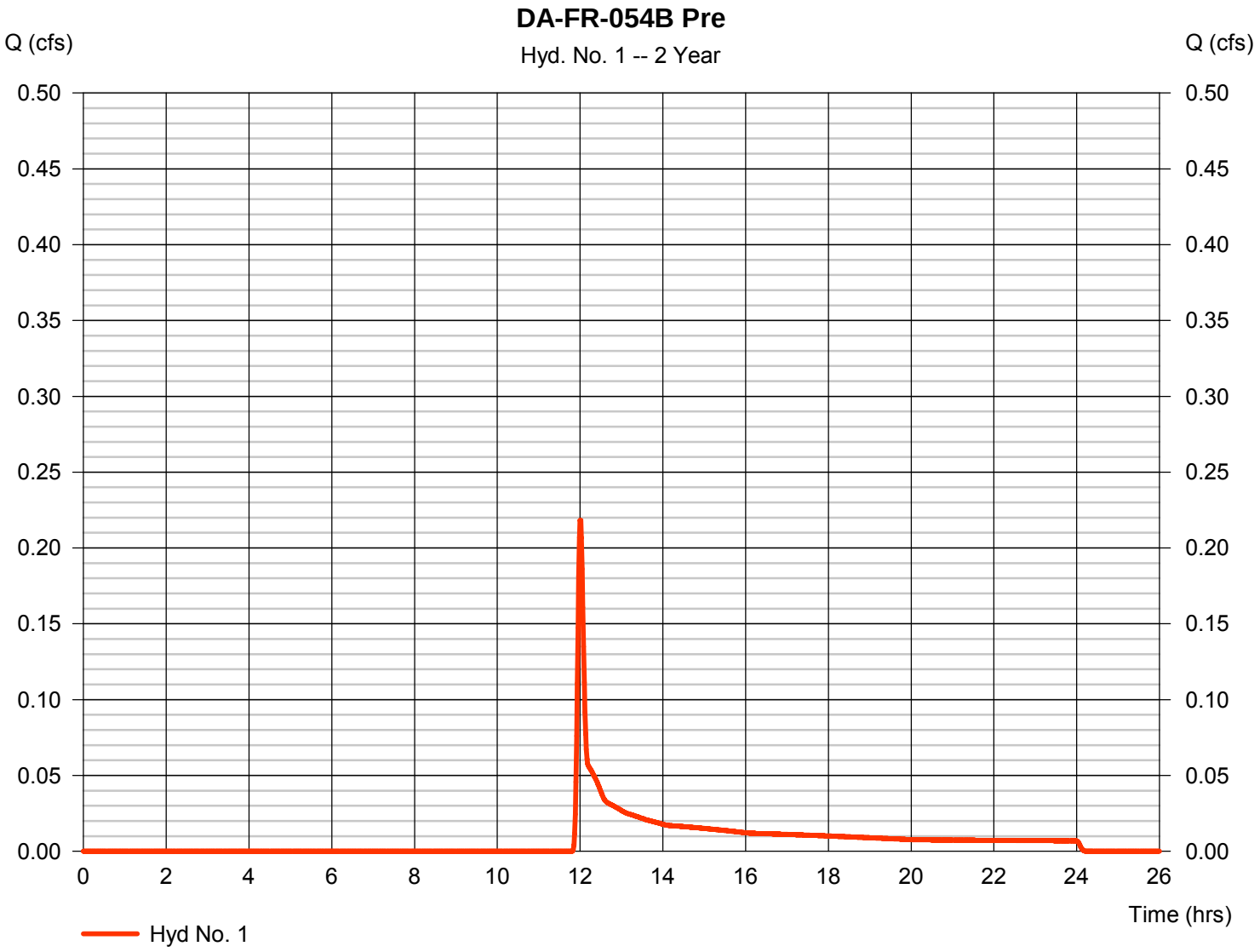
Hydrograph Report

Hyd. No. 1

DA-FR-054B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.218 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.02 hrs
Time interval	= 1 min	Hyd. volume	= 691 cuft
Drainage area	= 0.470 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.470 x 55)] / 0.470



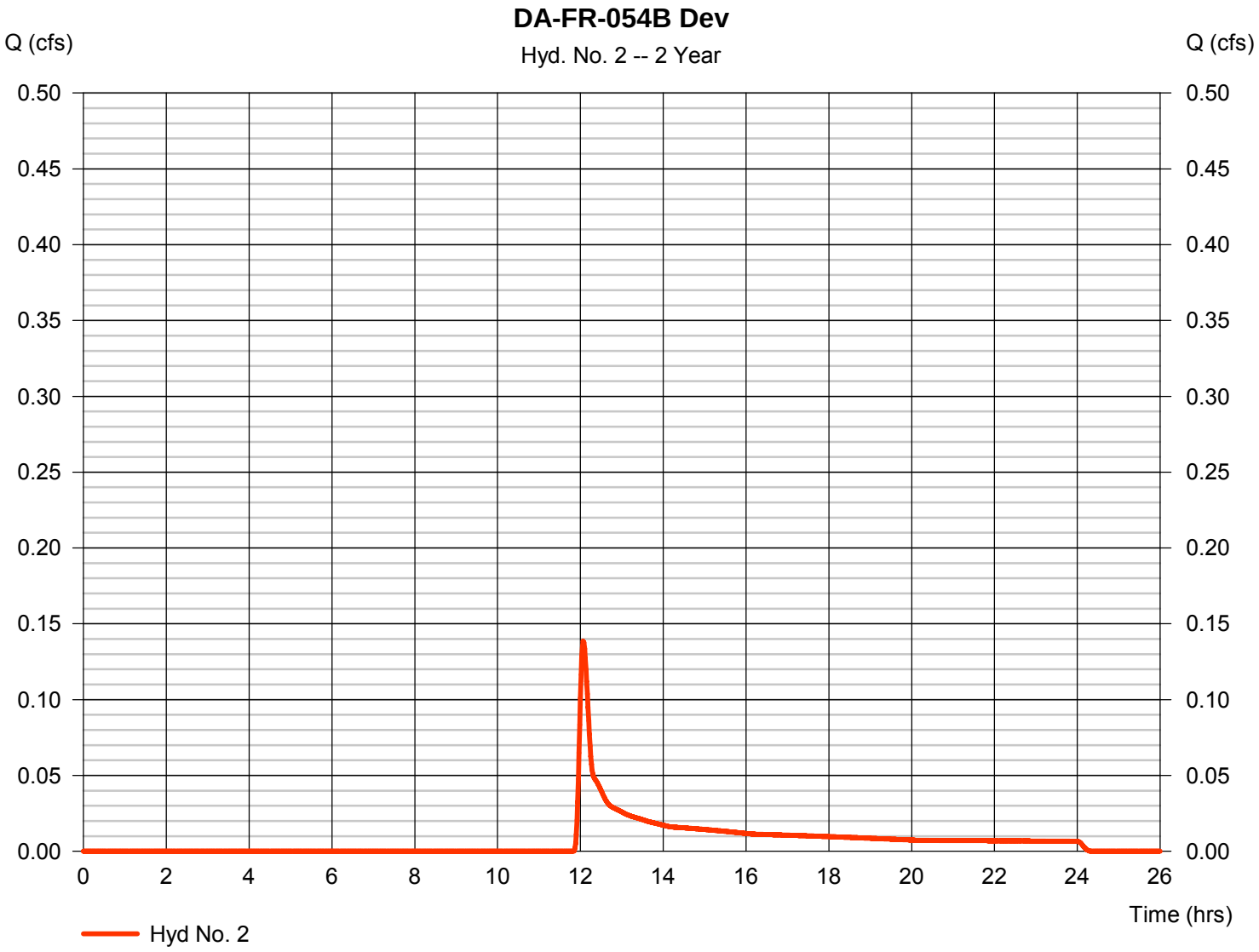
Hydrograph Report

Hyd. No. 2

DA-FR-054B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.138 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.07 hrs
Time interval	= 1 min	Hyd. volume	= 636 cuft
Drainage area	= 0.470 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.70 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.210 x 48) + (0.260 x 58)] / 0.470

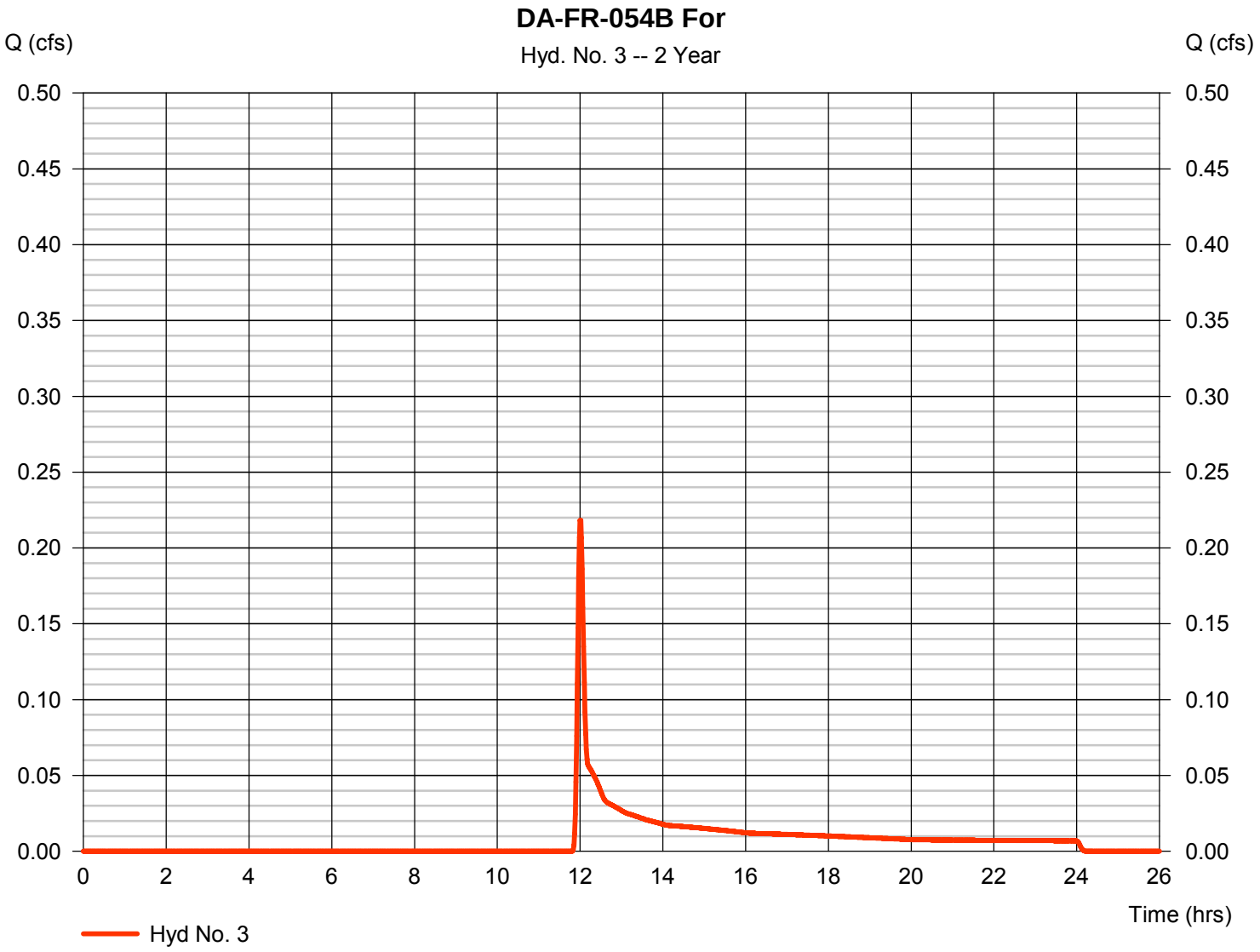


Hydrograph Report

Hyd. No. 3

DA-FR-054B For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.218 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.02 hrs
Time interval	= 1 min	Hyd. volume	= 691 cuft
Drainage area	= 0.470 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.006	1	719	2,243	------	------	------	DA-FR-054B Pre
2	SCS Runoff	0.761	1	722	2,143	------	------	------	DA-FR-054B Dev
3	SCS Runoff	1.006	1	719	2,243	------	------	------	DA-FR-054B For

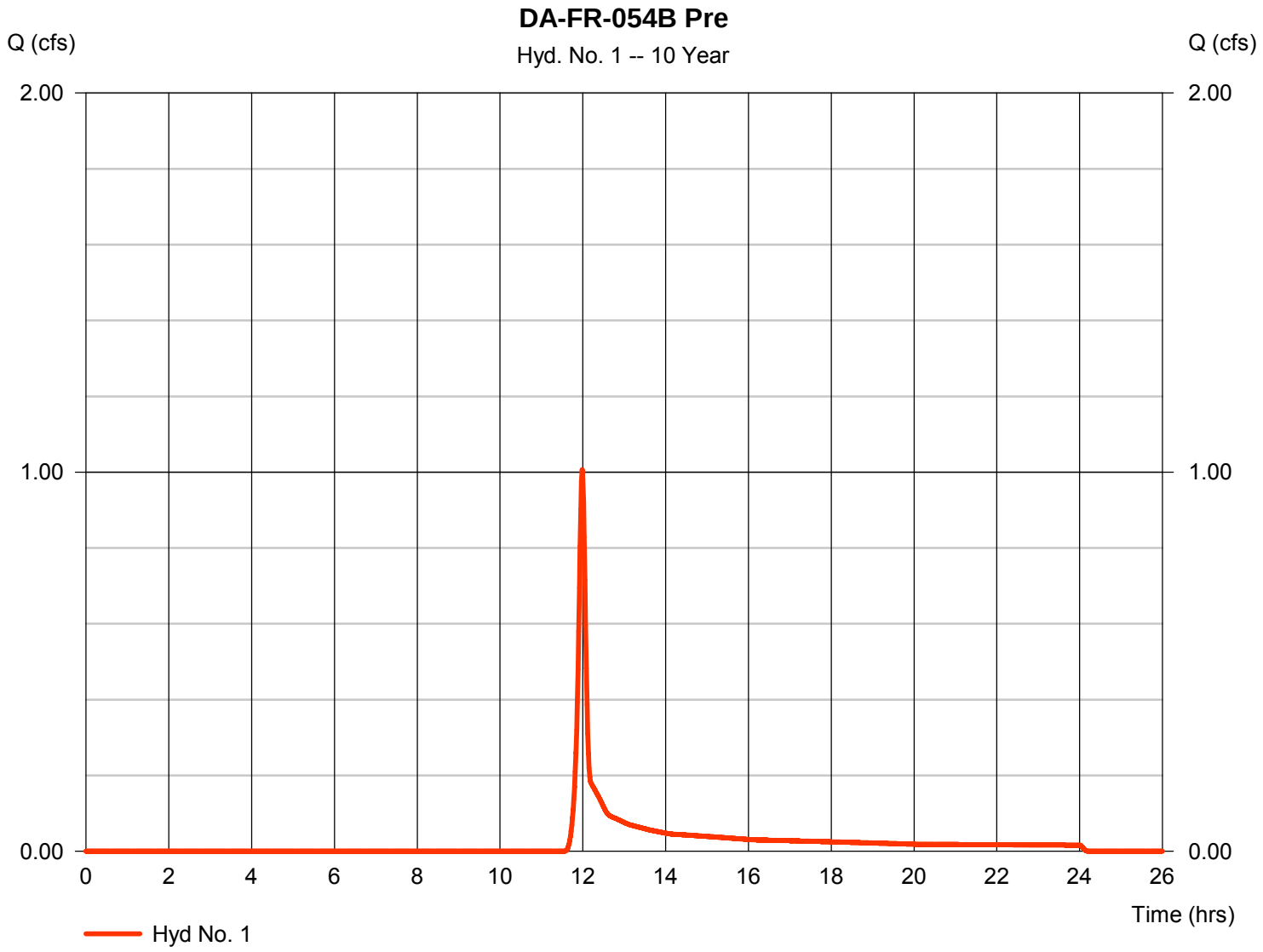
Hydrograph Report

Hyd. No. 1

DA-FR-054B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.006 cfs
Storm frequency	= 10 yrs	Time to peak	= 11.98 hrs
Time interval	= 1 min	Hyd. volume	= 2,243 cuft
Drainage area	= 0.470 ac	Curve number	= 55*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.470 x 55)] / 0.470



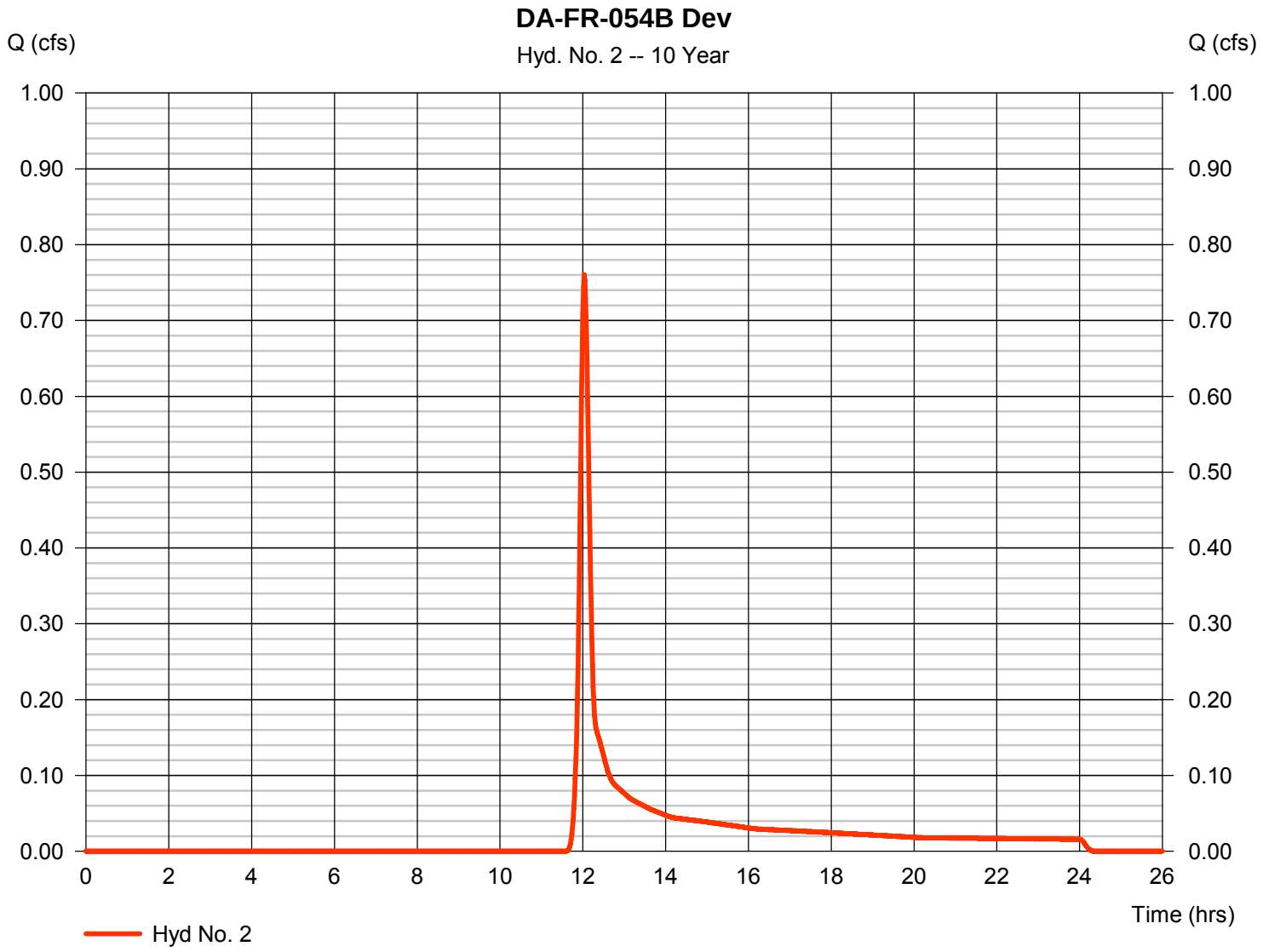
Hydrograph Report

Hyd. No. 2

DA-FR-054B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.761 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.03 hrs
Time interval	= 1 min	Hyd. volume	= 2,143 cuft
Drainage area	= 0.470 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 12.70 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.210 x 48) + (0.260 x 58)] / 0.470

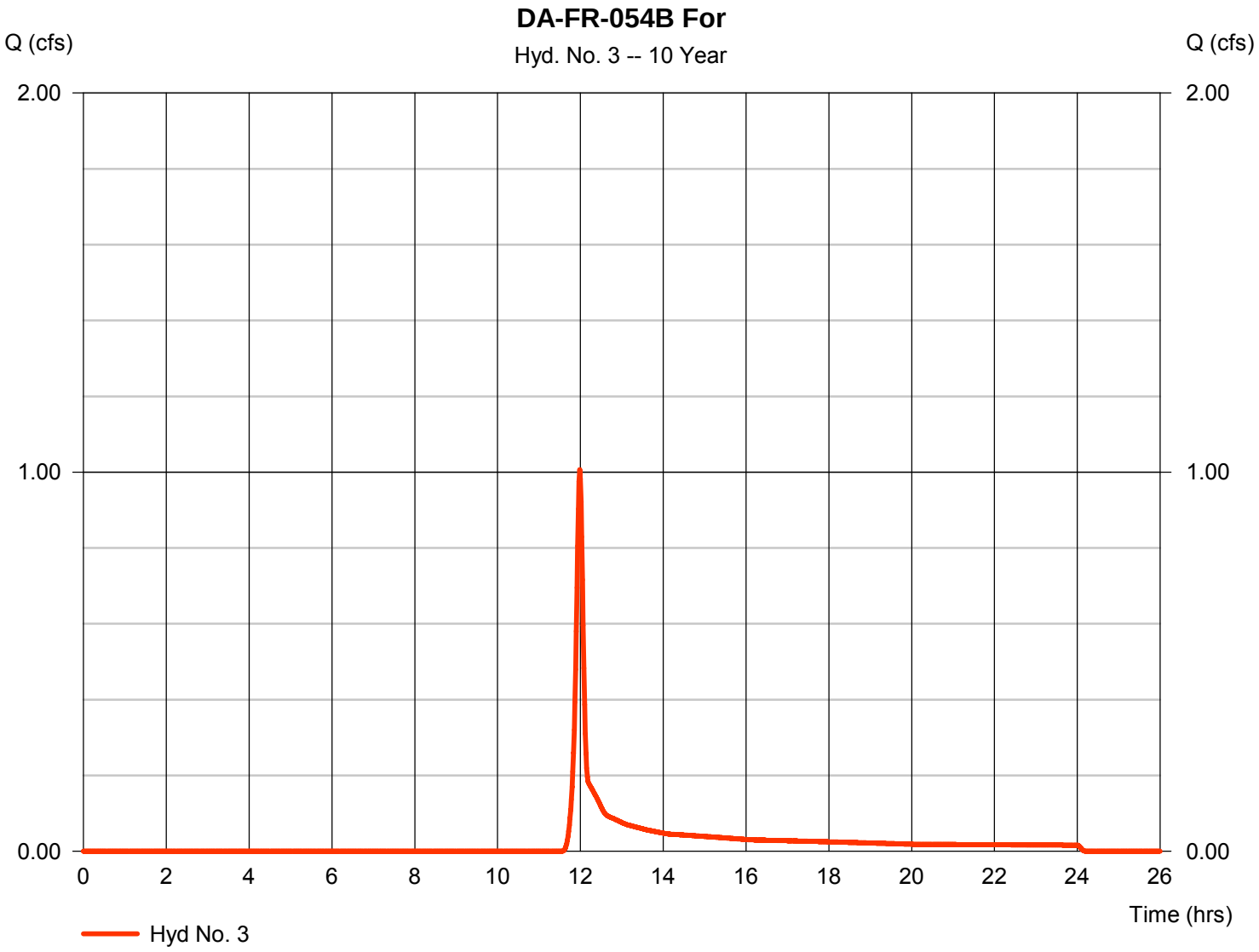


Hydrograph Report

Hyd. No. 3

DA-FR-054B For

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.006 cfs
Storm frequency	=	10 yrs	Time to peak	=	11.98 hrs
Time interval	=	1 min	Hyd. volume	=	2,243 cuft
Drainage area	=	0.470 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	8.20 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-055

DA-FR-055 is located in a meadow and forested areas with steep slopes and contains gravel roads and impervious areas. A stream crosses the drainage area. Total impervious area is less than 1.3% of the overall drainage area. No new impervious area is proposed within DA-FR-055. The total phosphorus load reduction required for DA-FR-055 is –1.26 lb/yr. Multiple points of analysis were evaluated within DA-FR-055 to evaluate the effects on each receiving stream/channel following construction. Specifically, DA-FR-055 was sub-divided into seven sub-drainage areas (sub areas A through G).

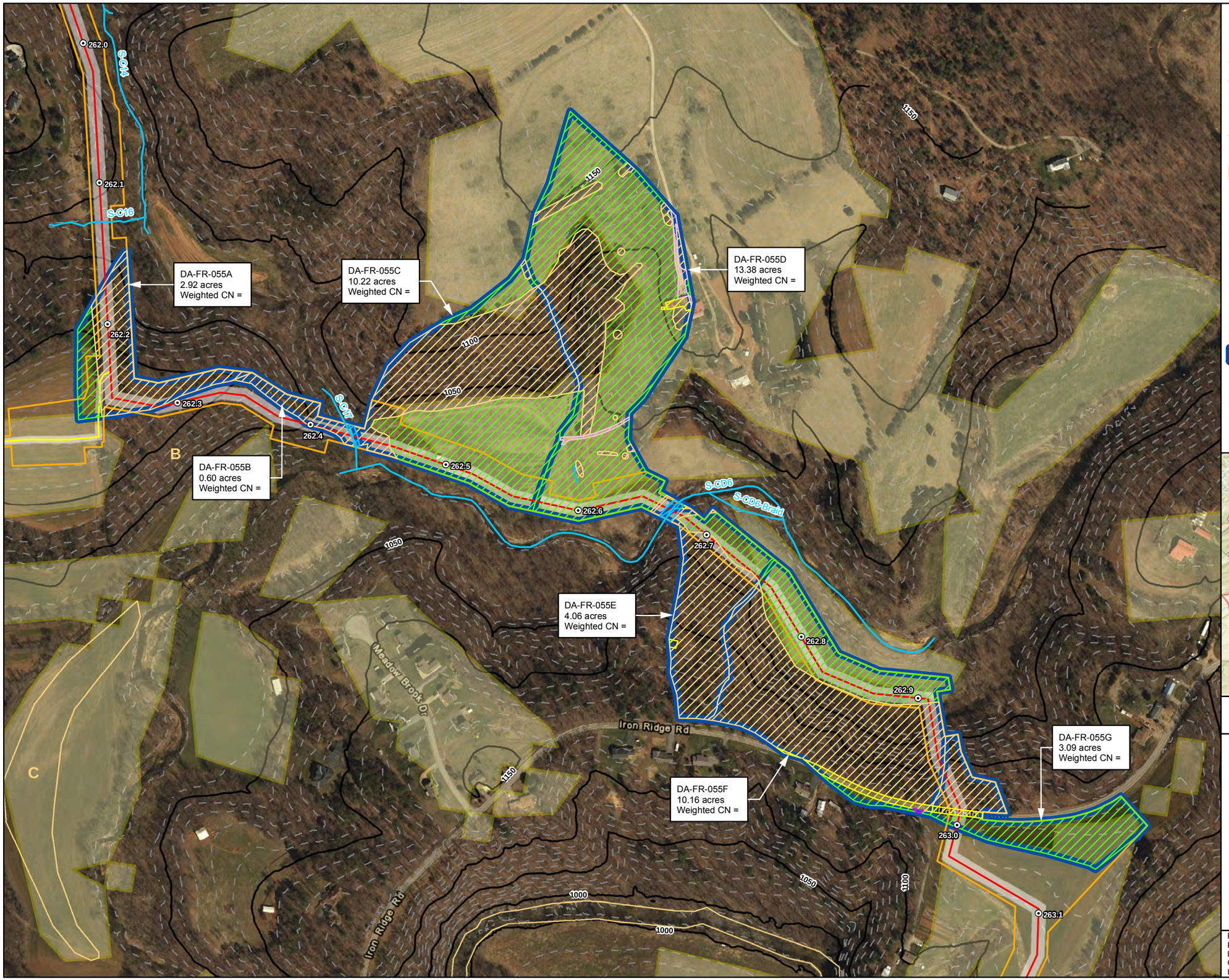
Sub-areas 055C, 055D and 055F contain both agricultural and non-agricultural areas within the limits of disturbance (LOD). Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction. In non-agricultural areas, land use will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. For SWM quality, agricultural areas within the LOD are considered/included and the total permanent ROW is analyzed via VRRM; agricultural areas are considered “Forest/Open Space” in these calculations.

Stormwater quantity is met via the energy balance method for each of the seven sub-areas DA-FR-055A through DA-FR-055G. Agricultural areas within the study area are included in the SWM analysis, but an Improvement Factor (IF) of 1.0 is used when applying the Energy Balance Method. This improvement factor is used to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate a reduction in flows ranging from 0.00 to 3.95 cfs for all drainage areas (as seen in table below).

Sub Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-055A	5.43	4.73	-0.70
DA-FR-055B	1.38	0.83	-0.55
DA-FR-055C	17.93	17.93	0.00
DA-FR-055D	10.80	10.79	-0.01
DA-FR-055E	11.07	7.12	-3.95
DA-FR-055F	21.90	21.90	0.00
DA-FR-055G	6.15	5.78	-0.37

Figures and calculations for each of the sub-areas for DA-FR-055 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.



Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Dirt Road
- Gravel
- Impervious
- Meadow
- Waterbody
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:4,200

N W E S

350 175 0 350 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-055
Spread 10

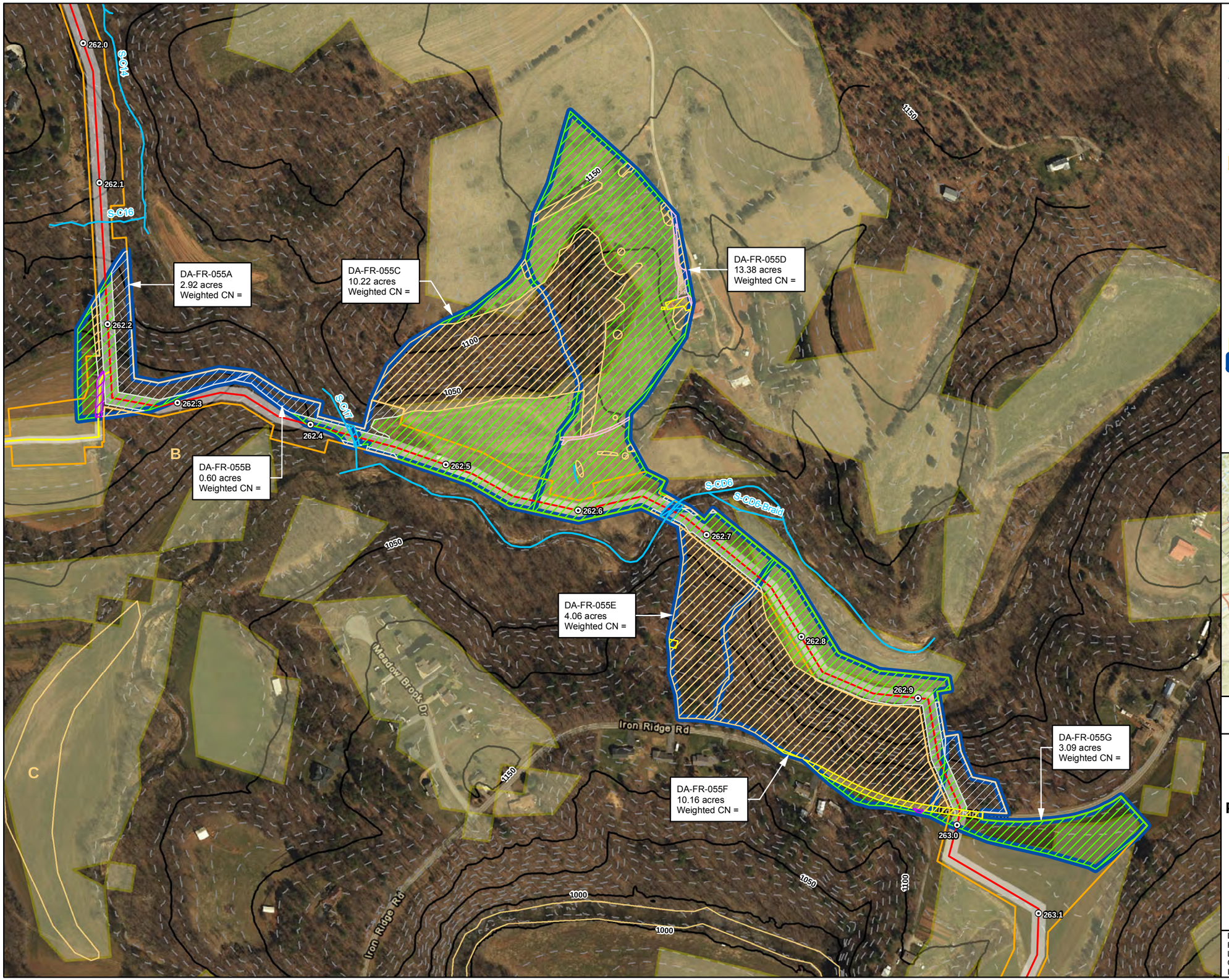
Figure 1

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\FranklinMVP_PCSM_DA-FR-055_Pre.mxd



Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Dirt Road
- Gravel
- Impervious
- Meadow
- Waterbody
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:4,200

N W E S

350 175 0 350 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-055
Spread 10

Figure 2

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\FranklinMVP_PCSM_DA-FR-055_Post.mxd

DA-FR-055A
2.92 acres
Weighted CN =

DA-FR-055B
0.60 acres
Weighted CN =

DA-FR-055C
10.22 acres
Weighted CN =

DA-FR-055D
13.38 acres
Weighted CN =

DA-FR-055E
4.06 acres
Weighted CN =

DA-FR-055F
10.16 acres
Weighted CN =

DA-FR-055G
3.09 acres
Weighted CN =

262.0
262.1
262.2
262.3
262.4
262.5
262.6
262.7
262.8
262.9
263.0
263.1

S-CD4
S-CD5
S-CD6
S-CD6-Braid
S-CD7
S-CD8

1150
1100
1050
1000

Meadow Brook Dr
Iron Ridge Rd

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:4,200

350 175 0 350
Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration DA-FR-055 Spread 10

Figure 3
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-055_3.mxd

DA-FR-055A
2.92 acres
Weighted CN =

DA-FR-055B
0.60 acres
Weighted CN =

DA-FR-055C
10.22 acres
Weighted CN =

DA-FR-055D
13.38 acres
Weighted CN =

DA-FR-055E
4.06 acres
Weighted CN =

DA-FR-055F
10.16 acres
Weighted CN =

DA-FR-055G
3.09 acres
Weighted CN =

262.0
262.1
262.2
262.3
262.4
262.5
262.6
262.7
262.8
262.9
263.0
263.1

S-CD4
S-CD5
S-CD6
S-CD6-Braid
S-CD7
S-CD8

1150
1100
1050
1000

Meadow Brook Dr
Iron Ridge Rd

Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:4,200

350 175 0 350 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration
DA-FR-055
Spread 10

Figure 4
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-055_4.mxd

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary - Linear Development Project***

Total Rainfall (in):	**43**
Total Disturbed Acreage:	**4.43**

Site Land Cover Summary

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	4.40	0.00	0.00	4.40	99
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.03	0.00	0.00	0.03	1
					4.43	100

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total	
Forest/Open (acres)	0.00	4.31	0.00	0.00	4.31	97	*
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0	
Impervious Cover (acres)	0.00	0.12	0.00	0.00	0.12	3	
					4.43	100	

*** Forest/Open Space areas must be protected in accordance with the Virginia Runoff Reduction Method**

Site Tv and Land Cover Nutrient Loads

	Final Post-Development (Post-ReDevelopment & New Impervious)	Post-ReDevelopment	Post-Development (New Impervious)	Adjusted Pre-ReDevelopment
Site Rv	0.05	0.04	0.95	0.04
Treatment Volume (ft^3)	883	573	310	573
TP Load (lb/yr)	0.55	0.36	0.20	0.36

Baseline TP Load (lb/yr): 1.7794* **Reduction below new development load limitation not required*

Pre-ReDevelopment TP Load per acre (lb/acre/yr)	Final Post-Development TP Load per acre (lb/acre/yr)	Post-ReDevelopment TP Load per acre (lb/acre/yr)
0.08	**0.13**	**0.08**

Total TP Load Reduction Required (lb/yr)	**-1.26**	N/A***	N/A***

******This is a linear development project***

	Final Post-Development Load (Post-ReDevelopment & New Impervious)	Pre-ReDevelopment
TN Load (lb/yr)	3.97	2.62

Site Compliance Summary - ***Linear Development Project

Maximum % Reduction Required Below Pre-ReDevelopment Load	20%

** Note: % Reduction will reduce post-development TP load to less than or equal to baseline load of 1.78 lb/yr (0.41 lb/ac/yr)*
[Post-Dev Reduction Requirement = Post-Dev TP load - baseline load of 1.78 lb/yr], baseline load = site area x 0.41 lb/ac/yr

Total Runoff Volume Reduction (ft^3)	0

Total TP Load Reduction Achieved (lb/yr)	0.00
Total TN Load Reduction Achieved (lb/yr)	0.00
Remaining Post Development TP Load (lb/yr)	0.55
Remaining TP Load Reduction (lb/yr) Required	**0.00**

**** TARGET TP REDUCTION EXCEEDED BY 1.26 LB/YEAR ****

**Reduction below new development load limitation not required*

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest/Open (acres)	4.31	0.00	0.00	0.00	0.00	4.31
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.12	0.00	0.00	0.00	0.00	0.12
Total Area (acres)	**4.43**	**0.00**	**0.00**	**0.00**	**0.00**	**4.43**

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00
TN Load Reduced (lb/yr)	0.00	0.00	0.00	0.00	0.00	0.00

Drainage Area A Summary

Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest/Open (acres)	0.00	4.31	0.00	0.00	4.31	97
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.12	0.00	0.00	0.12	3
					4.43	

BMP Selections

Practice	Managed Turf Credit Area (acres)	Impervious Cover Credit Area (acres)	BMP Treatment Volume (ft^3)	TP Load from Upstream Practices (lbs)	Untreated TP Load to Practice (lbs)	TP Removed (lb/yr)	TP Remaining (lb/yr)	Downstream Treatment to be Employed

Total Impervious Cover Treated (acres)	0.00
Total Turf Area Treated (acres)	0.00
Total TP Load Reduction Achieved in D.A. (lb/yr)	0.00
Total TN Load Reduction Achieved in D.A. (lb/yr)	0.00

DA-FR-055A

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.648	3252
Developed Condition	0.400	2629
Pre-Developed (Forest) Condition	0.519	2933

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.400	≤ OK	0.641
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.400	≤ OK	0.648
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.400	*shall not* be required to be ≤	0.579

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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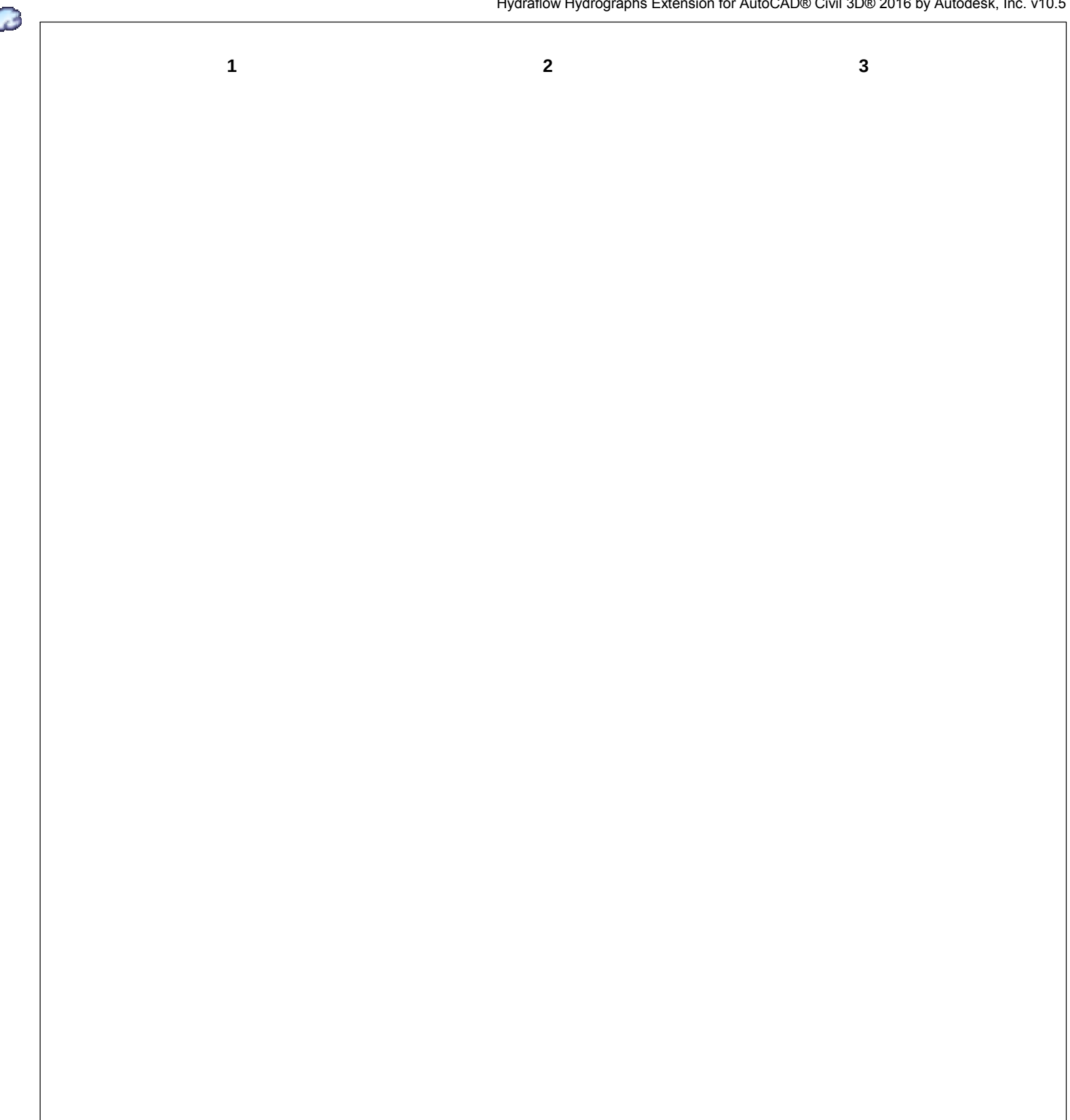
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-055A Pre
2	SCS Runoff	DA-FR-055A Dev
3	SCS Runoff	DA-FR-055A For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.648	1.213	-------	-------	5.428	-------	-------	-------	DA-FR-055A Pre
2	SCS Runoff	------	0.400	0.860	-------	-------	4.725	-------	-------	-------	DA-FR-055A Dev
3	SCS Runoff	------	0.519	1.032	-------	-------	5.076	-------	-------	-------	DA-FR-055A For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.648	1	725	3,252	------	------	------	DA-FR-055A Pre
2	SCS Runoff	0.400	1	725	2,629	------	------	------	DA-FR-055A Dev
3	SCS Runoff	0.519	1	725	2,933	------	------	------	DA-FR-055A For

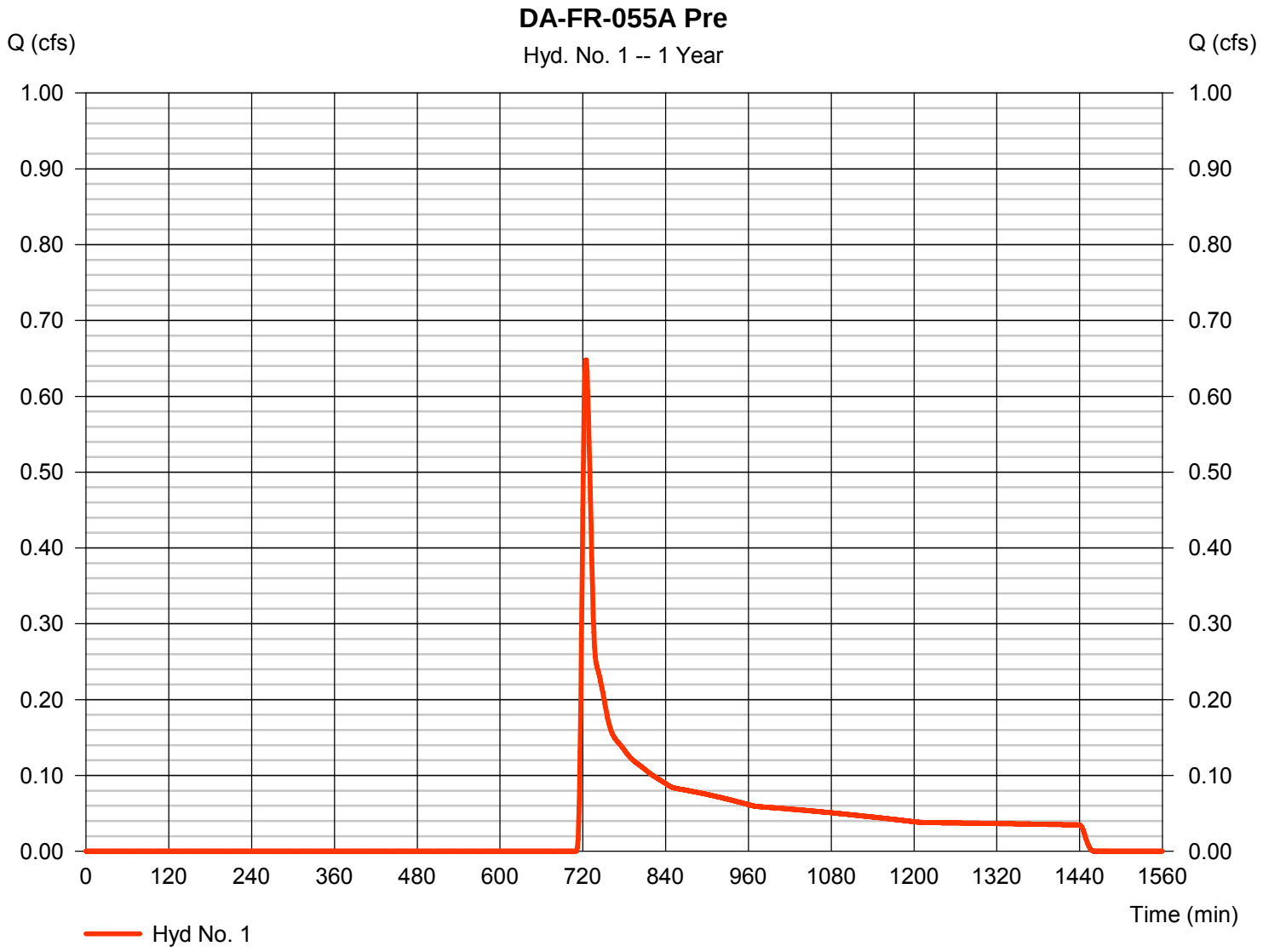
Hydrograph Report

Hyd. No. 1

DA-FR-055A Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.648 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 3,252 cuft
Drainage area	= 2.920 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.638 x 58) + (2.283 x 55)] / 2.920



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-055A Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 7.33		0.00		0.00		
Travel Time (min)	**= 11.88**	**+**	**0.00**	**+**	**0.00**	**=**	**11.88**
Shallow Concentrated Flow							
Flow length (ft)	= 475.32		0.00		0.00		
Watercourse slope (%)	= 17.76		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.80		0.00		0.00		
Travel Time (min)	**= 1.17**	**+**	**0.00**	**+**	**0.00**	**=**	**1.17**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 13.00 min

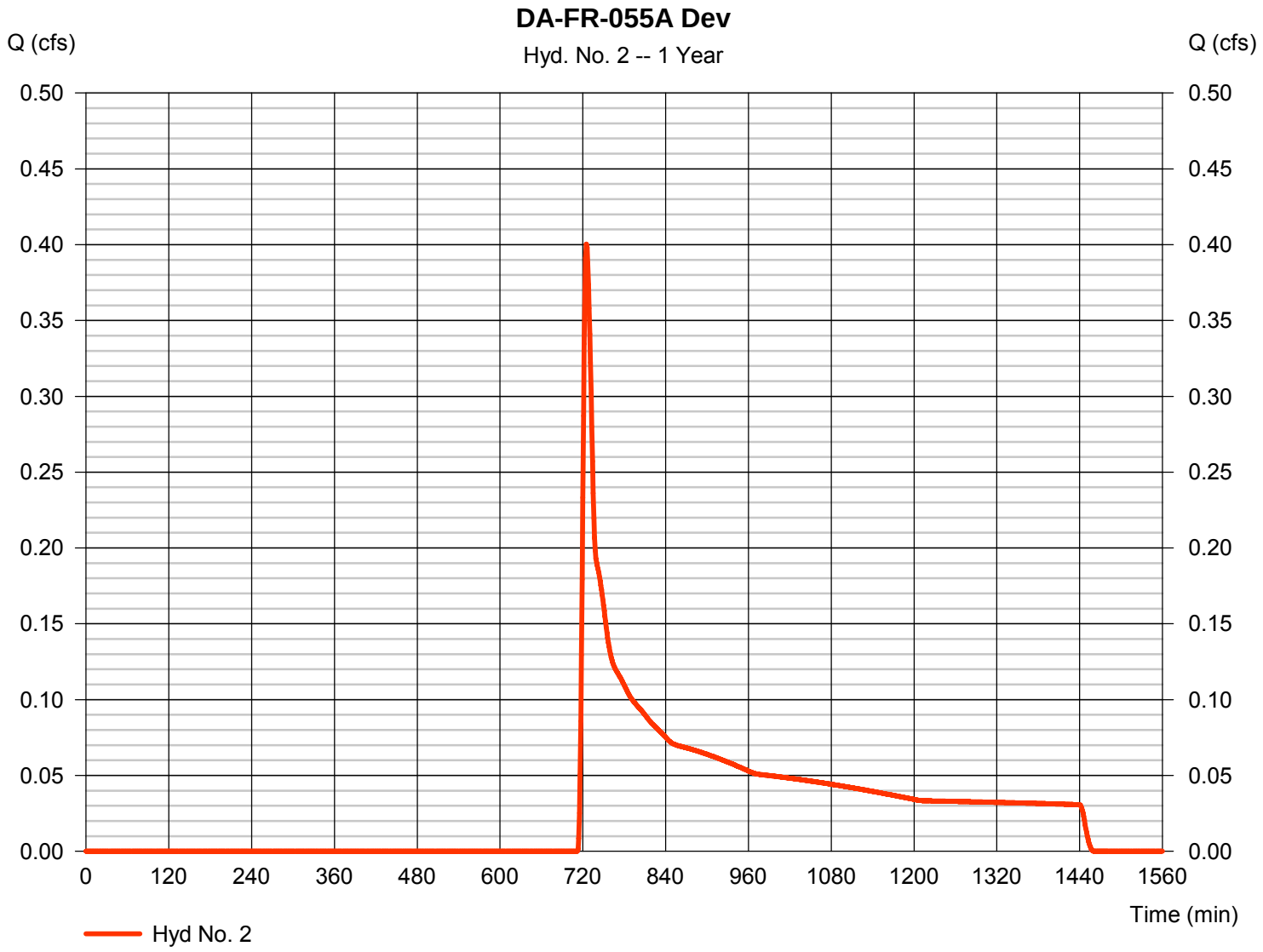
Hydrograph Report

Hyd. No. 2

DA-FR-055A Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.400 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 2,629 cuft
Drainage area	= 2.920 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.410 x 48) + (0.090 x 85) + (1.300 x 58) + (0.120 x 55)] / 2.920



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-055A Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 7.33		0.00		0.00		
Travel Time (min)	**= 11.88**	**+**	**0.00**	**+**	**0.00**	**=**	**11.88**
Shallow Concentrated Flow							
Flow length (ft)	= 475.32		0.00		0.00		
Watercourse slope (%)	= 17.76		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.80		0.00		0.00		
Travel Time (min)	**= 1.17**	**+**	**0.00**	**+**	**0.00**	**=**	**1.17**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

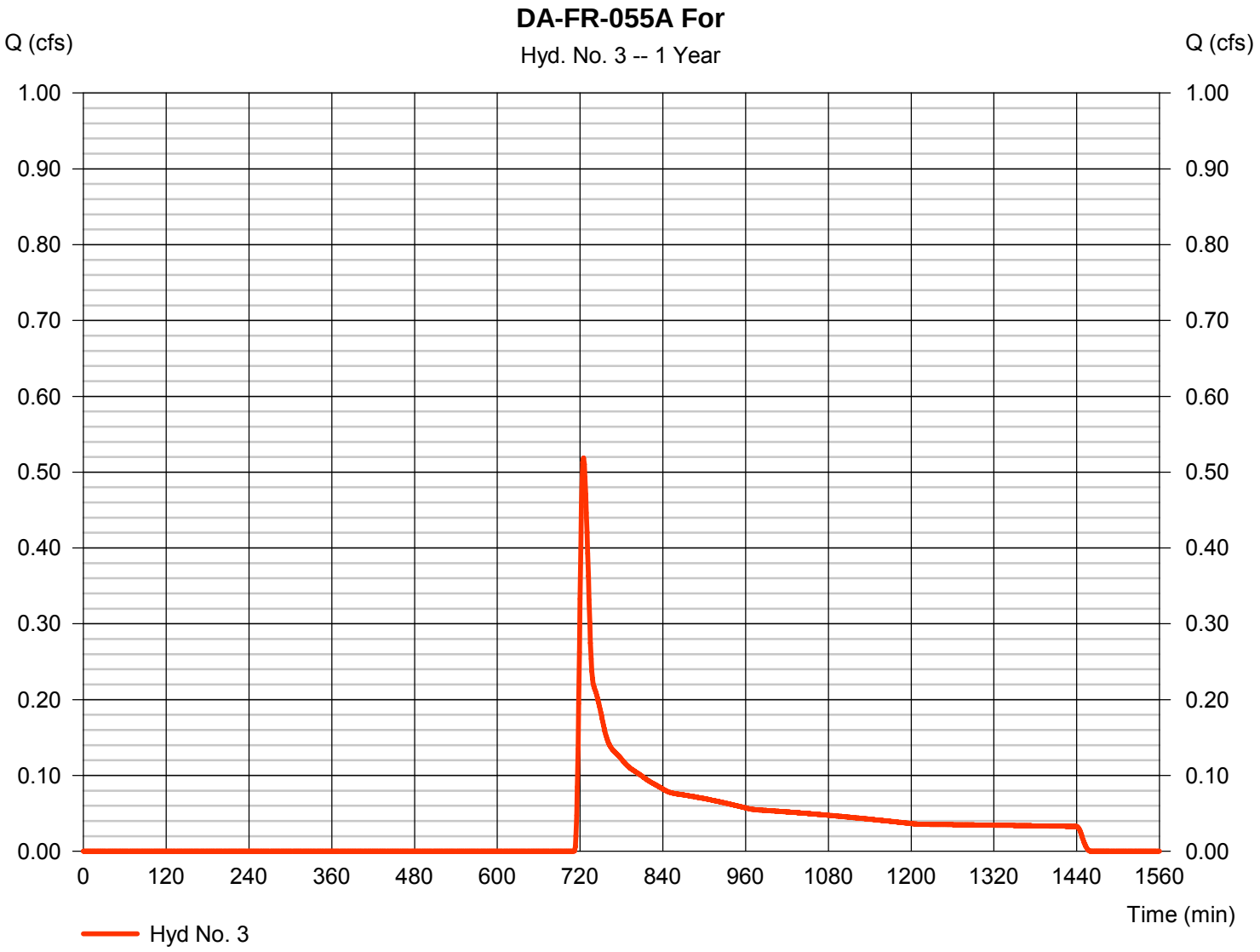
Total Travel Time, Tc ..... 13.00 min

Hydrograph Report

Hyd. No. 3

DA-FR-055A For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.519 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 2,933 cuft
Drainage area	= 2.920 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-055A For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 7.33		0.00		0.00		
Travel Time (min)	**= 11.88**	**+**	**0.00**	**+**	**0.00**	**=**	**11.88**
Shallow Concentrated Flow							
Flow length (ft)	= 475.32		0.00		0.00		
Watercourse slope (%)	= 17.76		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.80		0.00		0.00		
Travel Time (min)	**= 1.17**	**+**	**0.00**	**+**	**0.00**	**=**	**1.17**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 13.00 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.213	1	724	4,734	------	------	------	DA-FR-055A Pre
2	SCS Runoff	0.860	1	724	3,953	------	------	------	DA-FR-055A Dev
3	SCS Runoff	1.032	1	724	4,336	------	------	------	DA-FR-055A For

Hydrograph Report

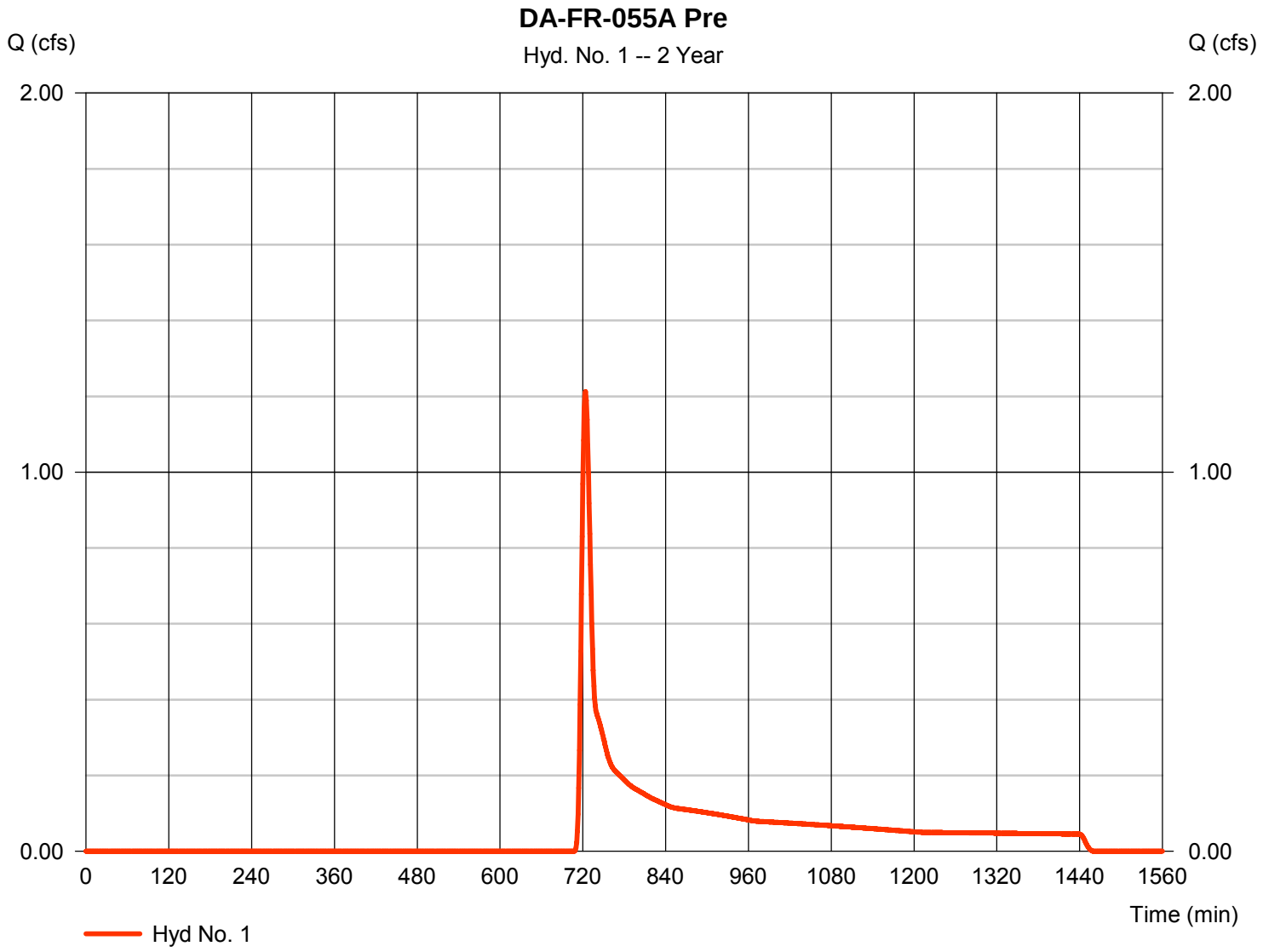
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 1

DA-FR-055A Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.213 cfs
Storm frequency	=	2 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	4,734 cuft
Drainage area	=	2.920 ac	Curve number	=	56*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	13.00 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.638 x 58) + (2.283 x 55)] / 2.920



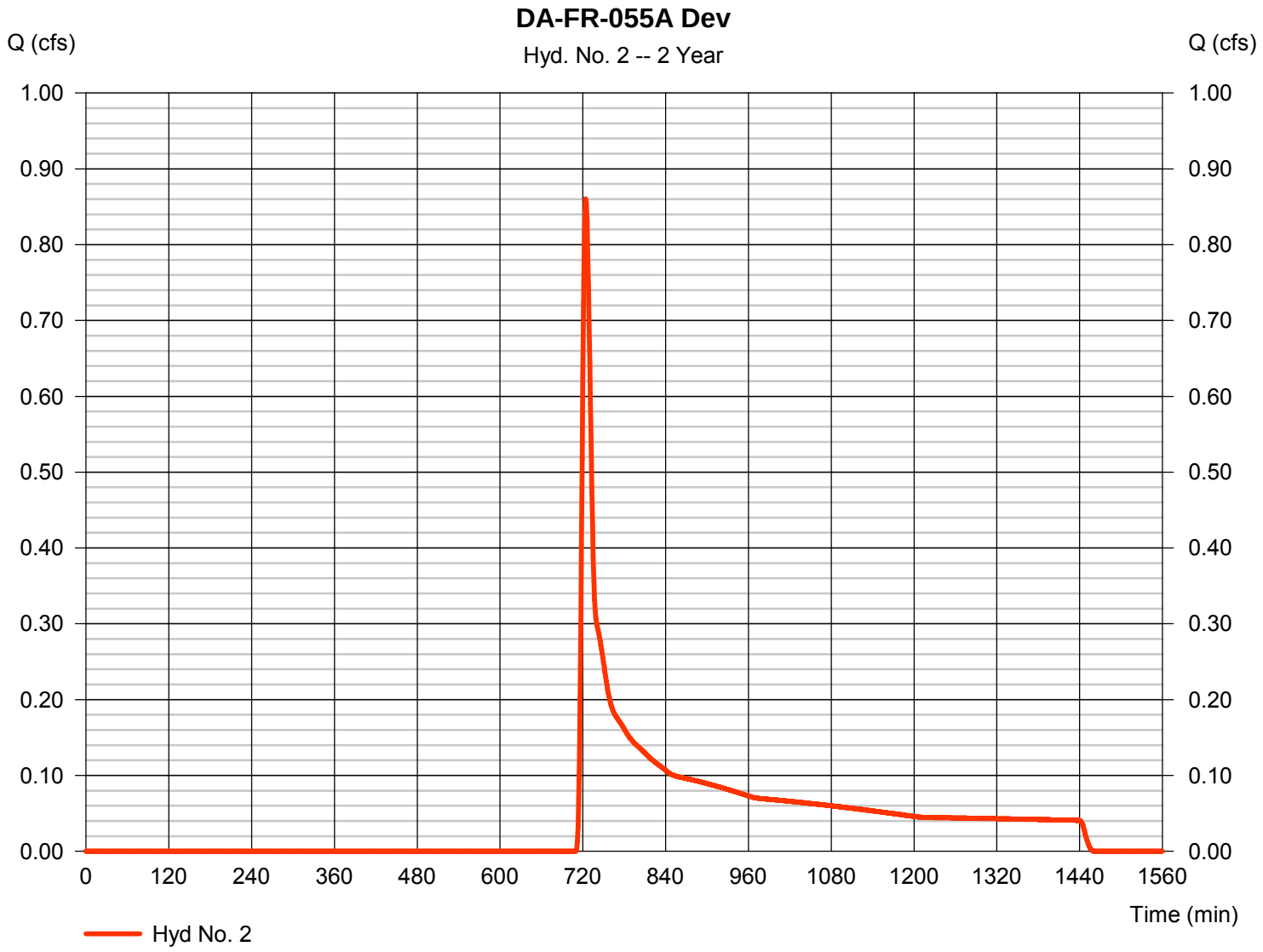
Hydrograph Report

Hyd. No. 2

DA-FR-055A Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.860 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 3,953 cuft
Drainage area	= 2.920 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.410 x 48) + (0.090 x 85) + (1.300 x 58) + (0.120 x 55)] / 2.920

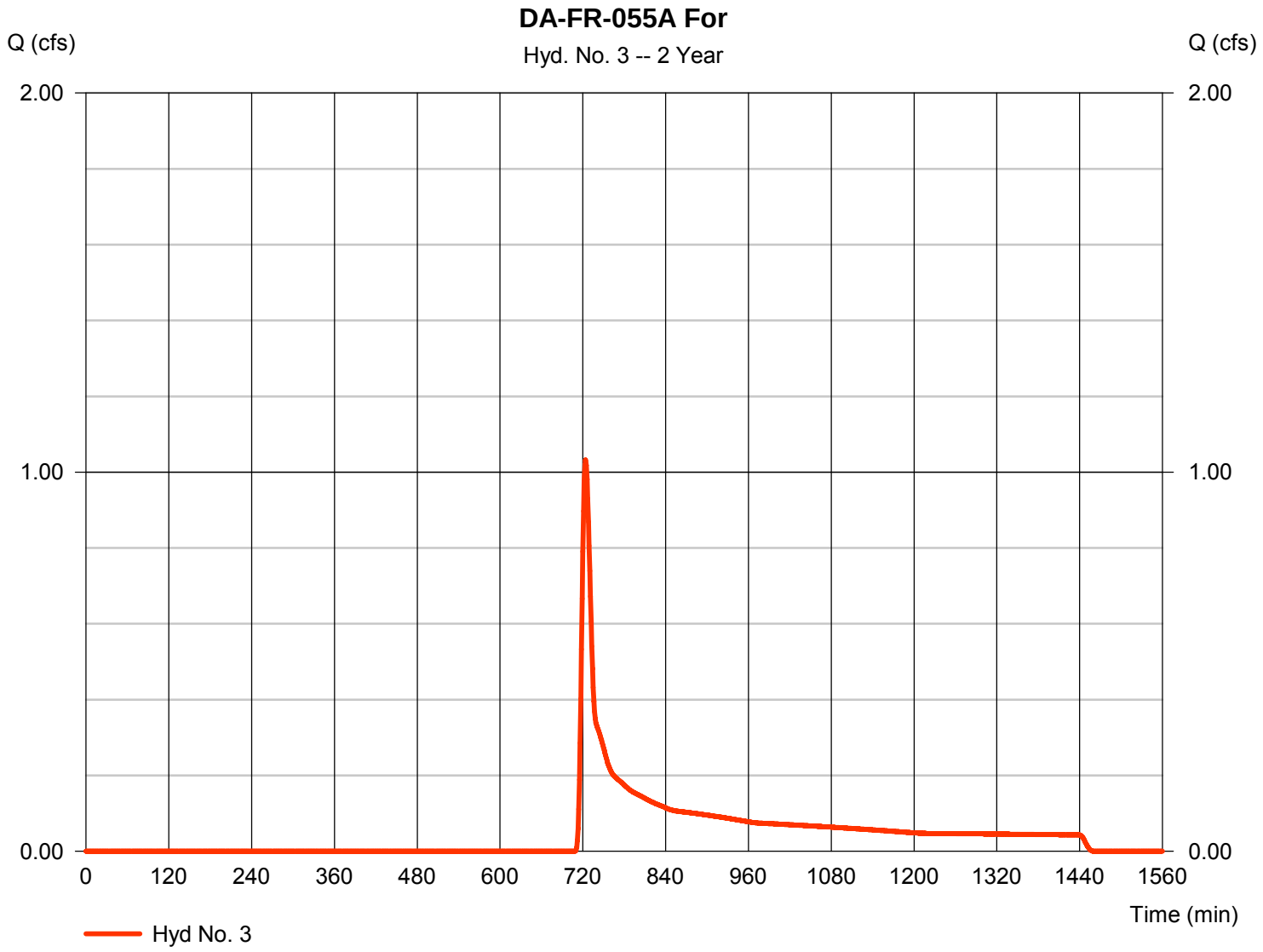


Hydrograph Report

Hyd. No. 3

DA-FR-055A For

Hydrograph type	= SCS Runoff	Peak discharge	= 1.032 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 4,336 cuft
Drainage area	= 2.920 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	5.428	1	722	14,838	------	------	------	DA-FR-055A Pre
2	SCS Runoff	4.725	1	722	13,315	------	------	------	DA-FR-055A Dev
3	SCS Runoff	5.076	1	722	14,070	------	------	------	DA-FR-055A For

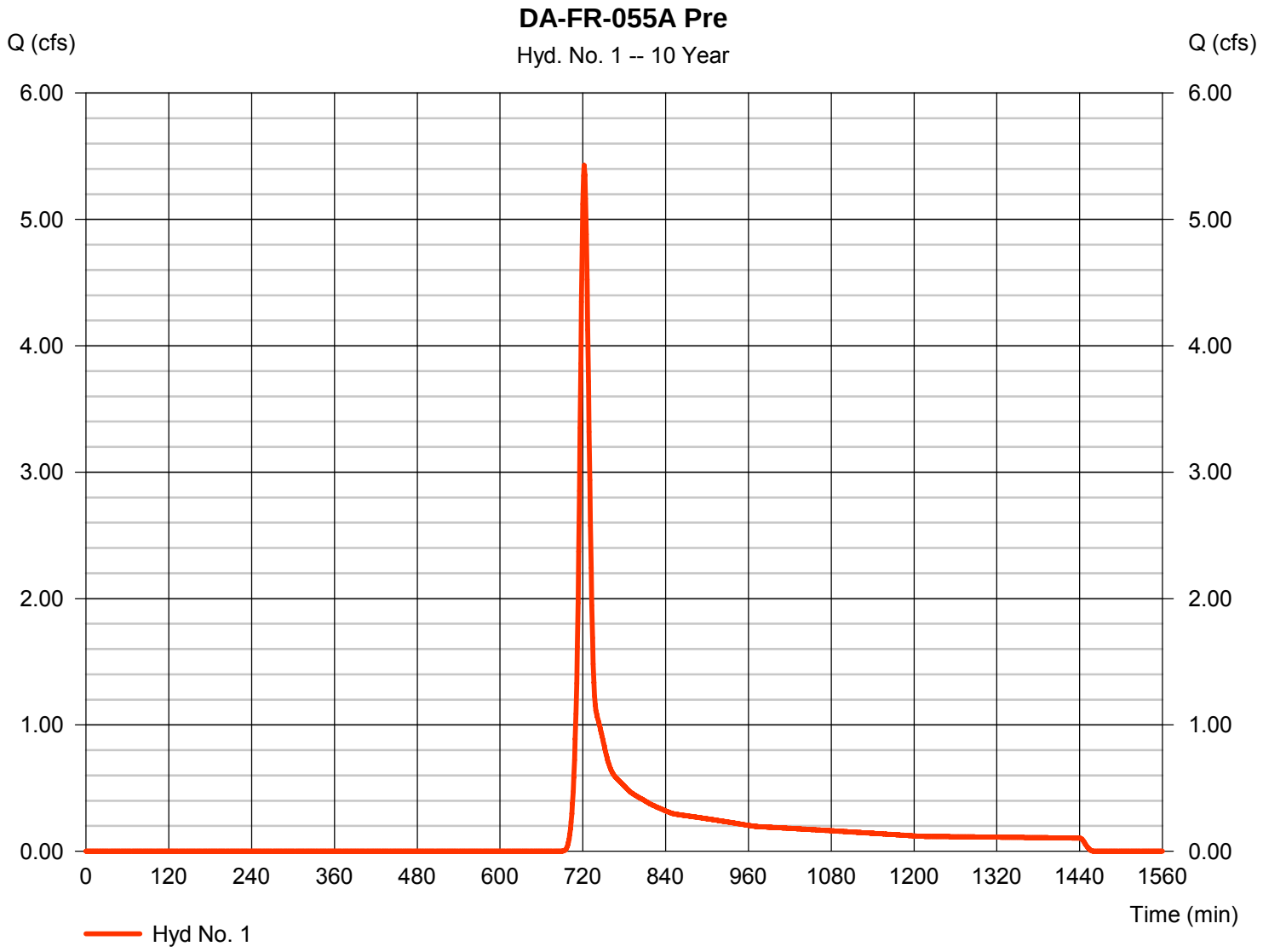
Hydrograph Report

Hyd. No. 1

DA-FR-055A Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 5.428 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 14,838 cuft
Drainage area	= 2.920 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.638 x 58) + (2.283 x 55)] / 2.920



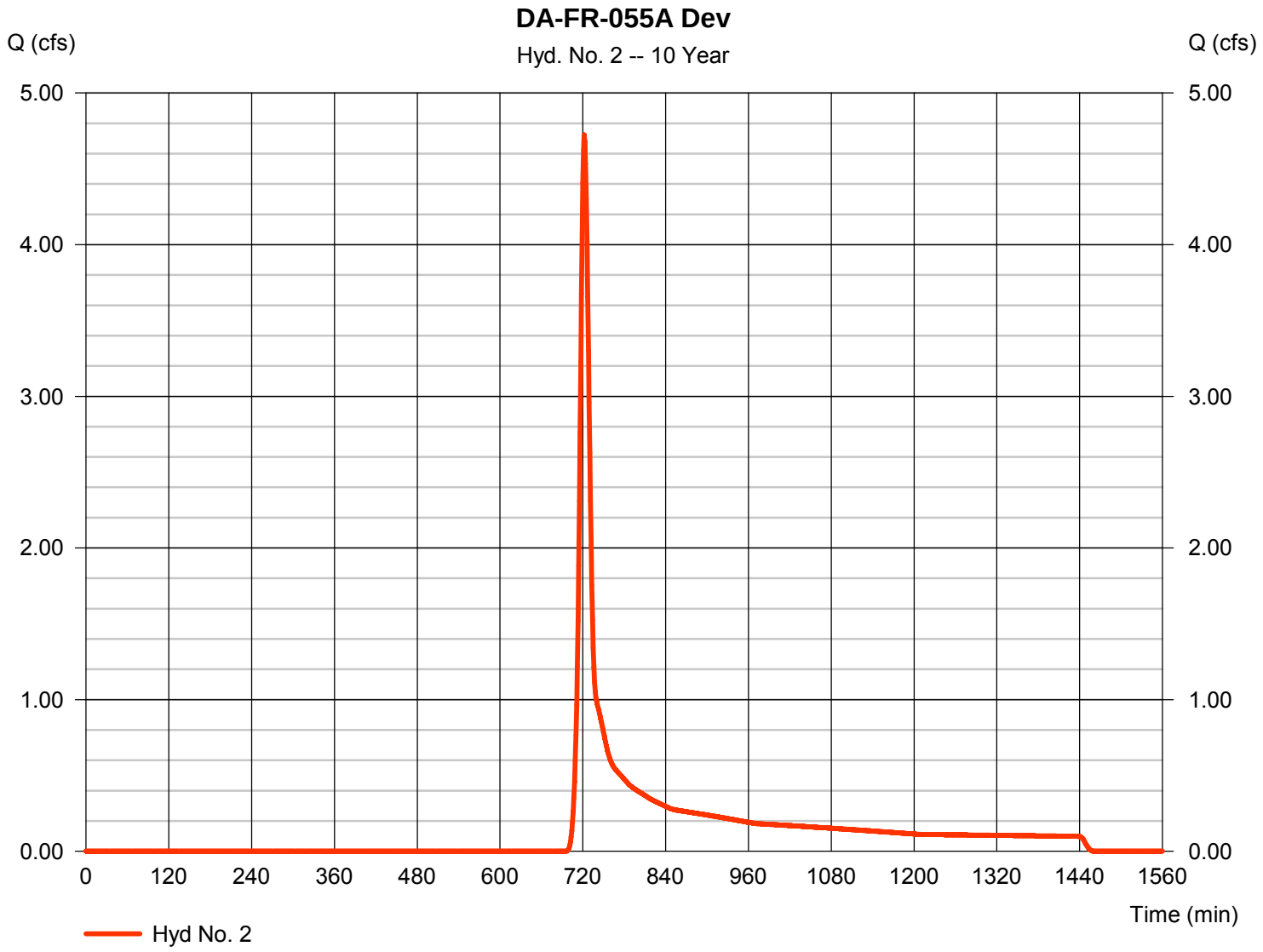
Hydrograph Report

Hyd. No. 2

DA-FR-055A Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 4.725 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 13,315 cuft
Drainage area	= 2.920 ac	Curve number	= 54*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.410 x 48) + (0.090 x 85) + (1.300 x 58) + (0.120 x 55)] / 2.920

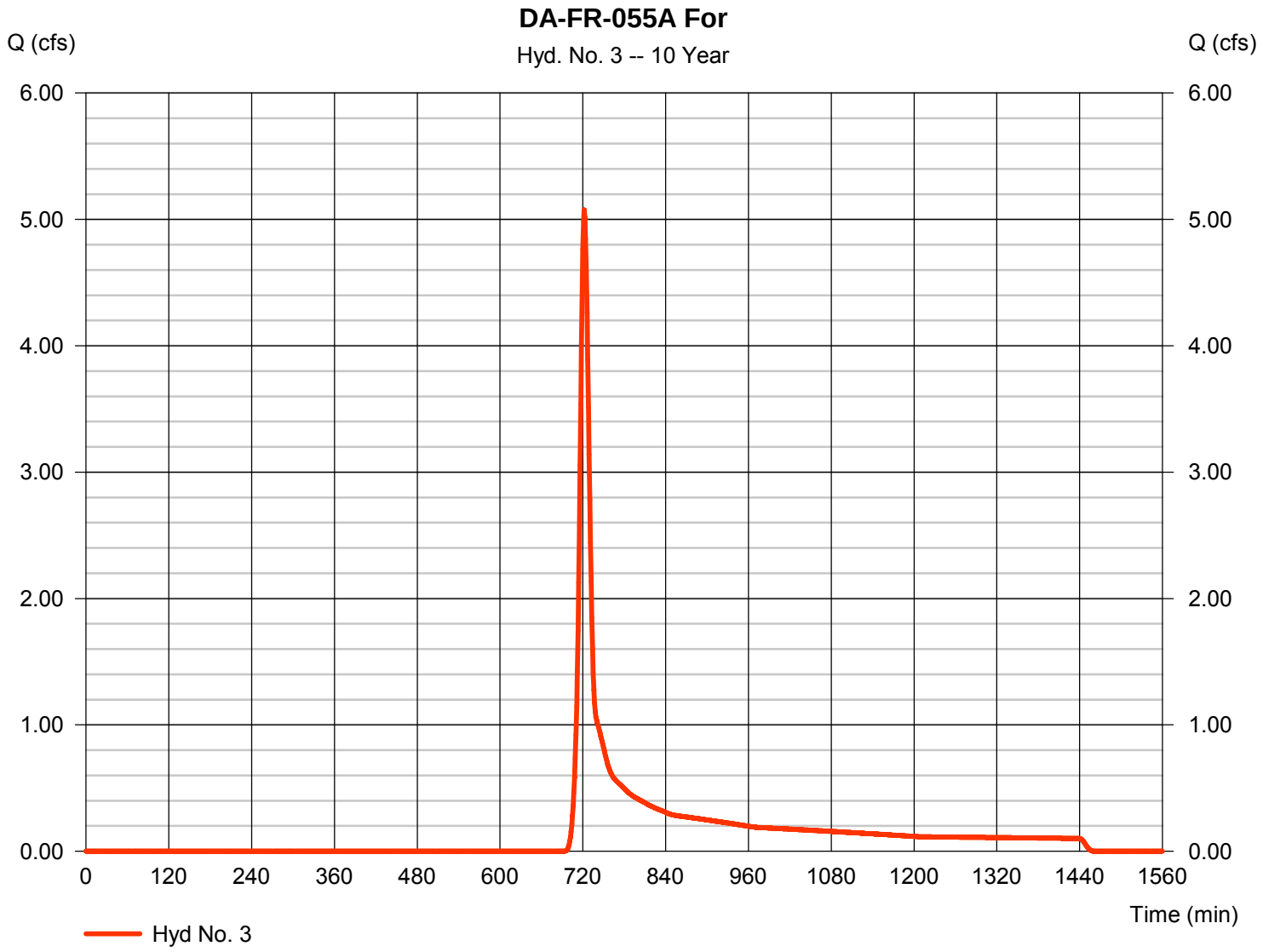


Hydrograph Report

Hyd. No. 3

DA-FR-055A For

Hydrograph type	= SCS Runoff	Peak discharge	= 5.076 cfs
Storm frequency	= 10 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 14,070 cuft
Drainage area	= 2.920 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 13.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-055B

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.197	748
Developed Condition	0.056	480
Pre-Developed (Forest) Condition	0.128	612

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 0.056 ≤ 0.246 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 0.056 ≤ 0.197 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 0.056 *shall not* be required to be ≤ 0.163

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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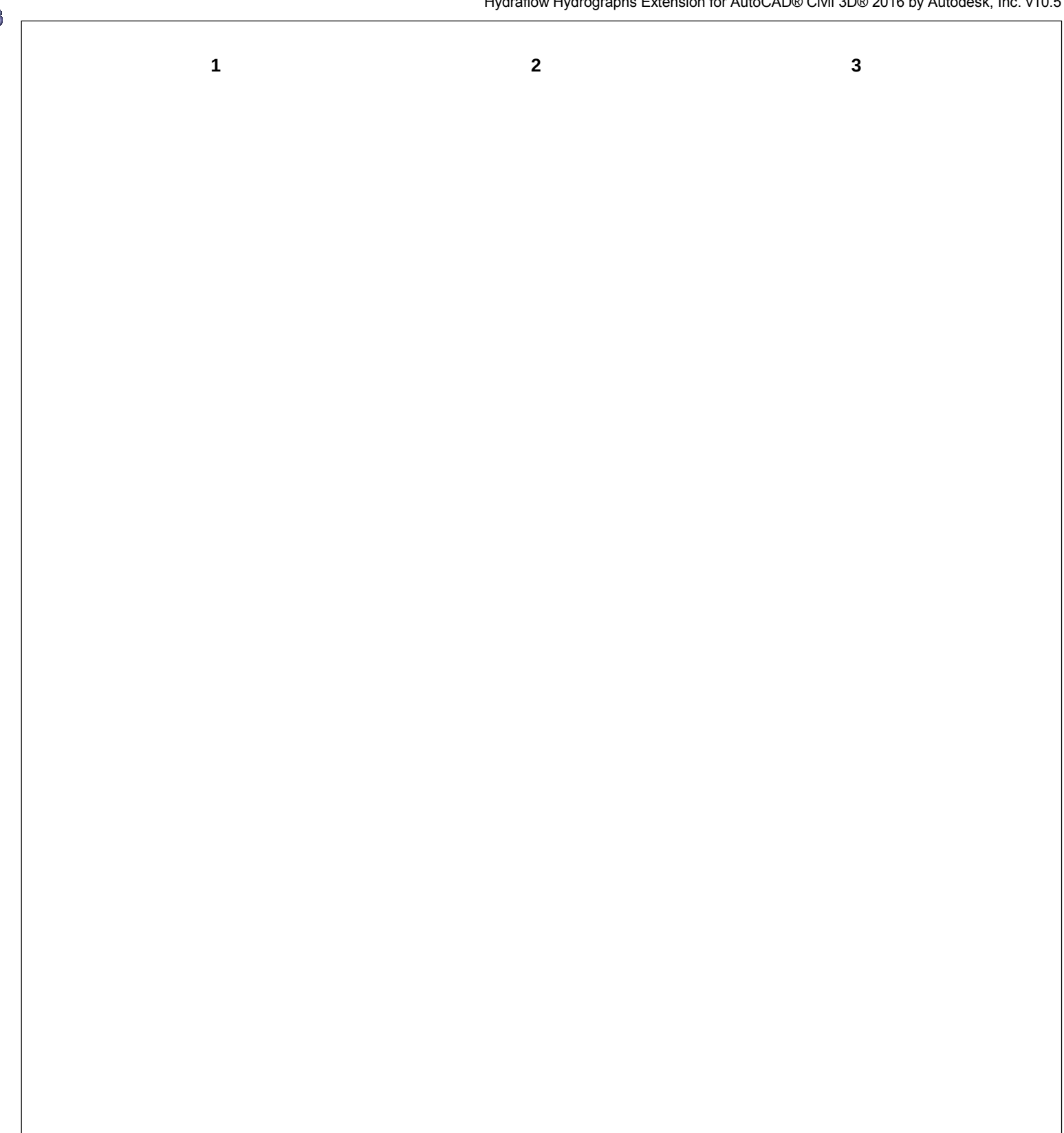
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-055B Pre
2	SCS Runoff	DA-FR-055B Dev
3	SCS Runoff	DA-FR-055B For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.197	0.346	-------	-------	1.376	-------	-------	-------	DA-FR-055B Pre
2	SCS Runoff	------	0.056	0.132	-------	-------	0.831	-------	-------	-------	DA-FR-055B Dev
3	SCS Runoff	------	0.128	0.255	-------	-------	1.212	-------	-------	-------	DA-FR-055B For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.197	1	722	748	------	------	------	DA-FR-055B Pre
2	SCS Runoff	0.056	1	727	480	------	------	------	DA-FR-055B Dev
3	SCS Runoff	0.128	1	723	612	------	------	------	DA-FR-055B For

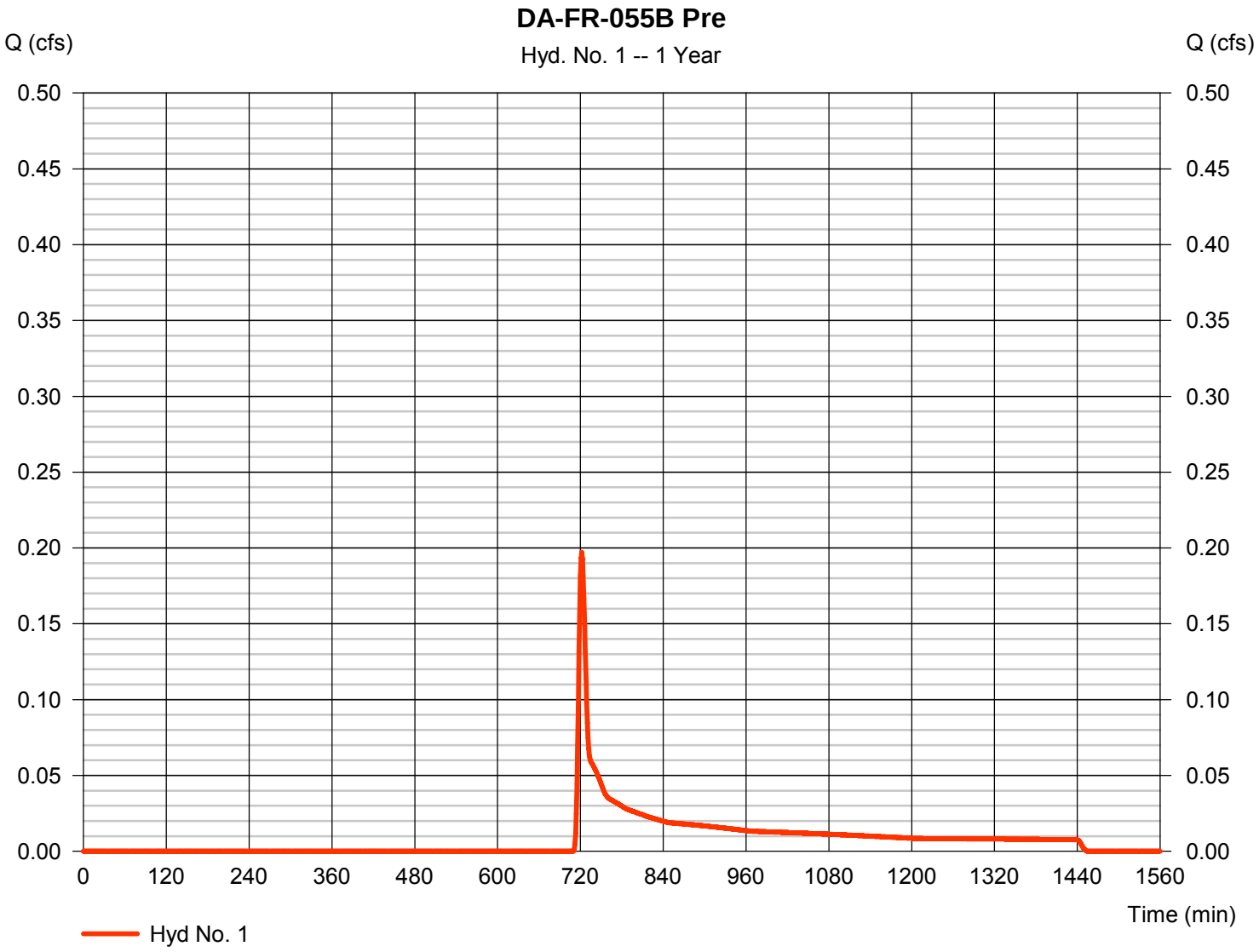
Hydrograph Report

Hyd. No. 1

DA-FR-055B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.197 cfs
Storm frequency	= 1 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 748 cuft
Drainage area	= 0.600 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.032 x 100) + (0.568 x 55)] / 0.600



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-055B Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 17.68		0.00		0.00		
Travel Time (min)	**= 8.35**	**+**	**0.00**	**+**	**0.00**	**=**	**8.35**
Shallow Concentrated Flow							
Flow length (ft)	= 80.73		0.00		0.00		
Watercourse slope (%)	= 29.68		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.79		0.00		0.00		
Travel Time (min)	**= 0.15**	**+**	**0.00**	**+**	**0.00**	**=**	**0.15**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 8.50 min

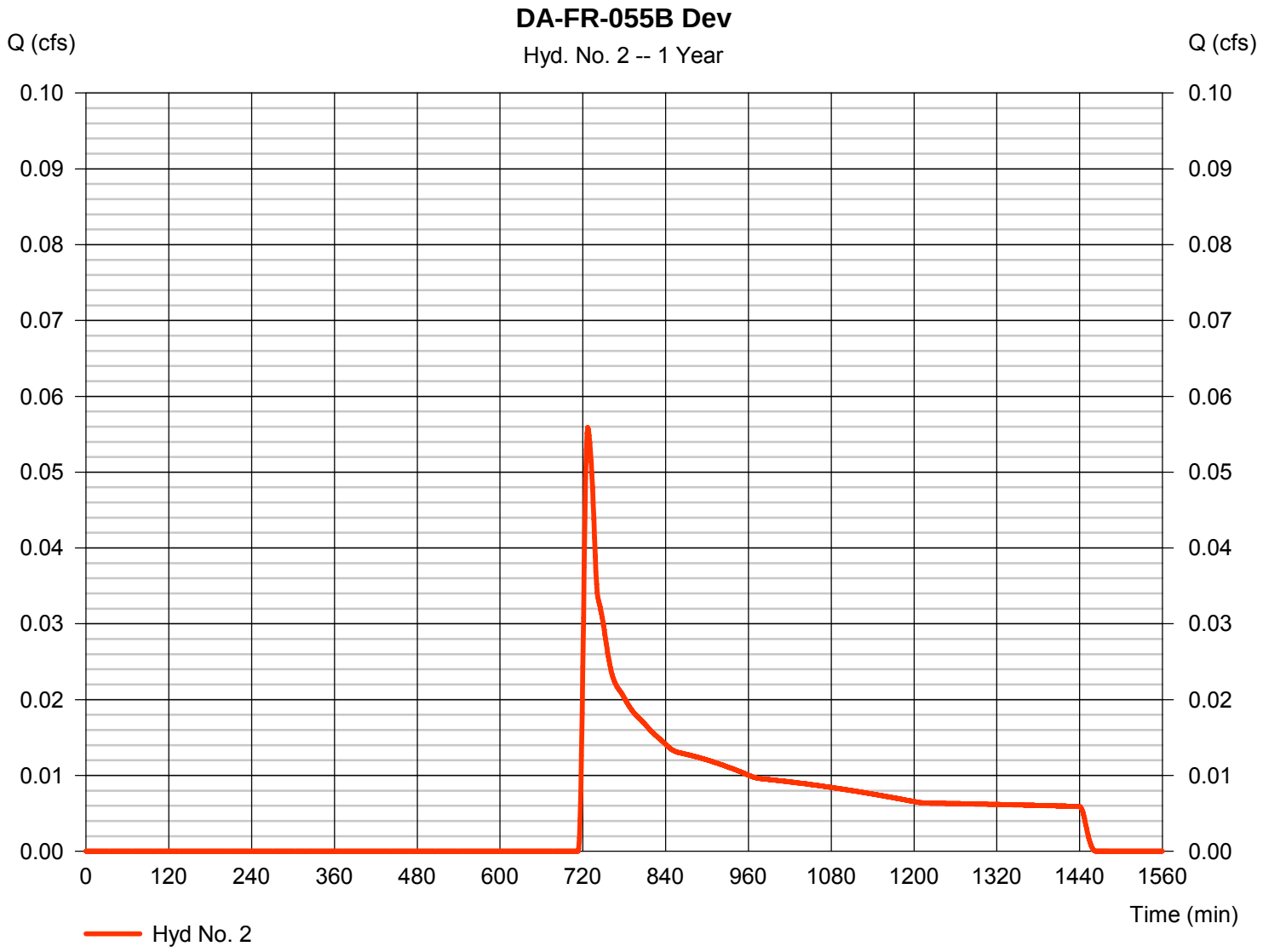
Hydrograph Report

Hyd. No. 2

DA-FR-055B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.056 cfs
Storm frequency	= 1 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 480 cuft
Drainage area	= 0.590 ac	Curve number	= 53*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.410 x 48) + (0.150 x 58) + (0.033 x 100)] / 0.590



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-055B Dev

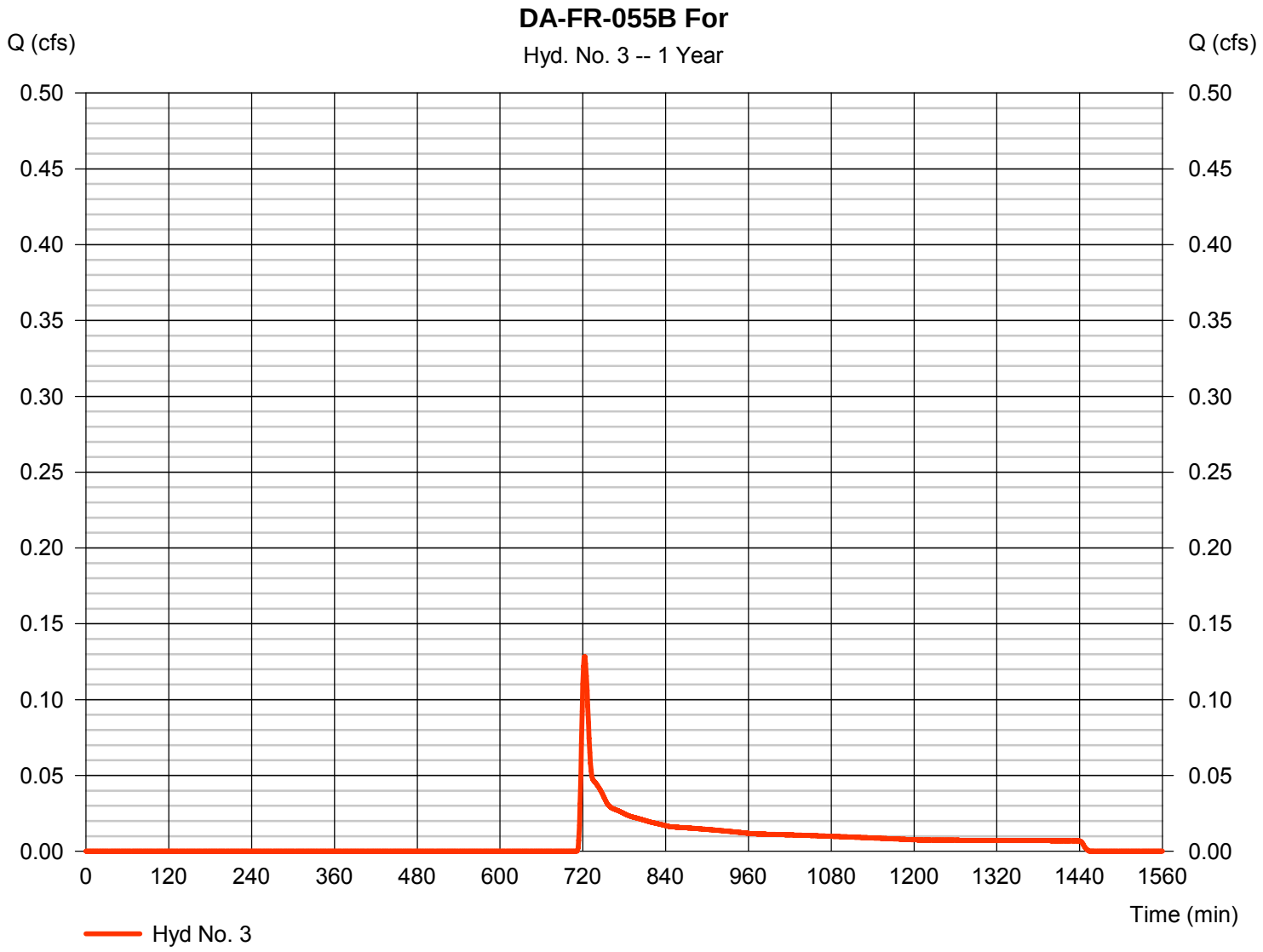
Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.800		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 17.68		0.00		0.00		
Travel Time (min)	**= 14.54**	**+**	**0.00**	**+**	**0.00**	**=**	**14.54**
Shallow Concentrated Flow							
Flow length (ft)	= 80.73		0.00		0.00		
Watercourse slope (%)	= 29.68		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.79		0.00		0.00		
Travel Time (min)	**= 0.15**	**+**	**0.00**	**+**	**0.00**	**=**	**0.15**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Total Travel Time, Tc							**14.70 min**

Hydrograph Report

Hyd. No. 3

DA-FR-055B For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.128 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 612 cuft
Drainage area	= 0.600 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-055B For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 17.68		0.00		0.00		
Travel Time (min)	**= 8.35**	**+**	**0.00**	**+**	**0.00**	**=**	**8.35**
Shallow Concentrated Flow							
Flow length (ft)	= 80.73		0.00		0.00		
Watercourse slope (%)	= 29.68		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.79		0.00		0.00		
Travel Time (min)	**= 0.15**	**+**	**0.00**	**+**	**0.00**	**=**	**0.15**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 8.50 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.346	1	721	1,074	------	------	------	DA-FR-055B Pre
2	SCS Runoff	0.132	1	726	736	------	------	------	DA-FR-055B Dev
3	SCS Runoff	0.255	1	722	905	------	------	------	DA-FR-055B For

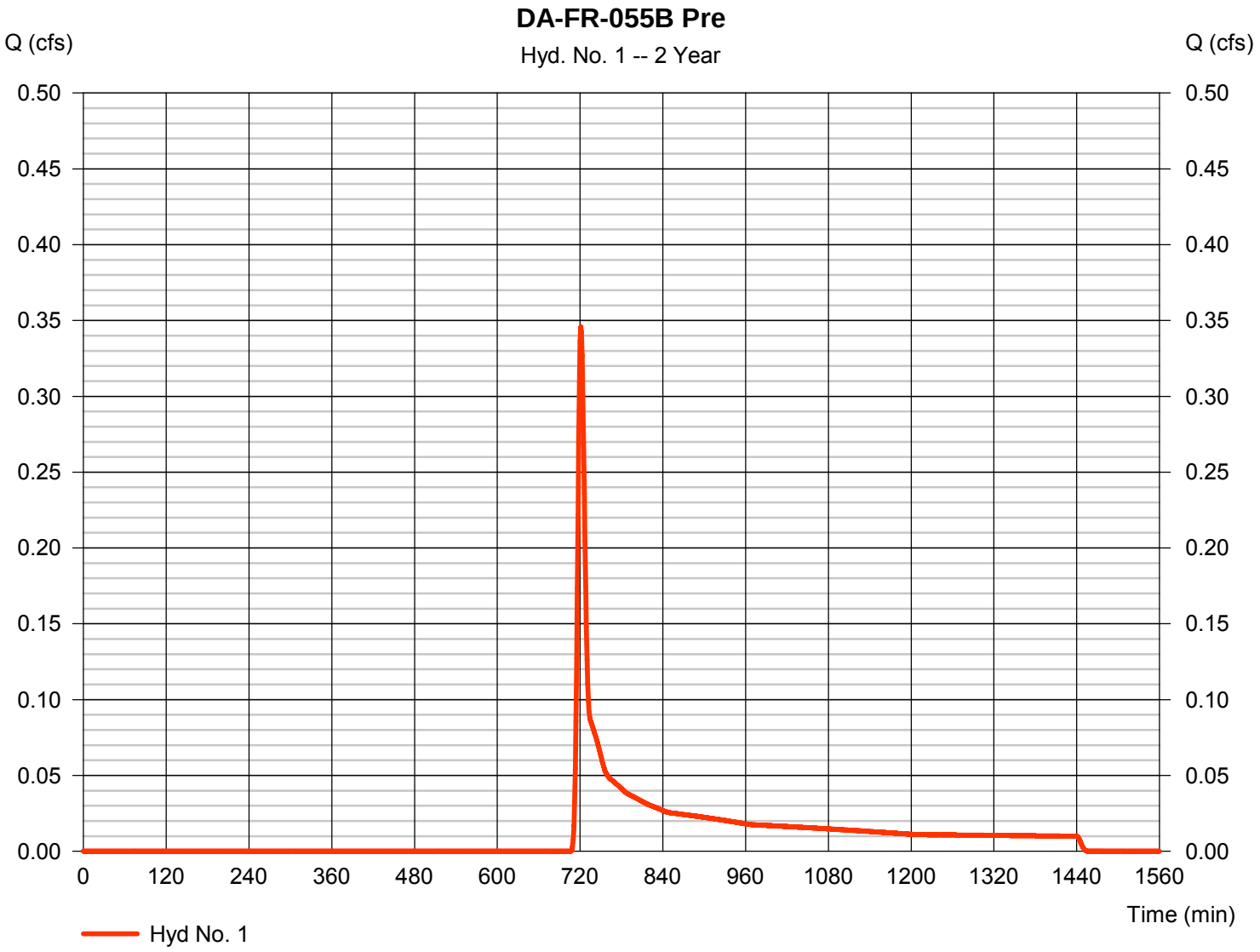
Hydrograph Report

Hyd. No. 1

DA-FR-055B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.346 cfs
Storm frequency	= 2 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 1,074 cuft
Drainage area	= 0.600 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.032 x 100) + (0.568 x 55)] / 0.600



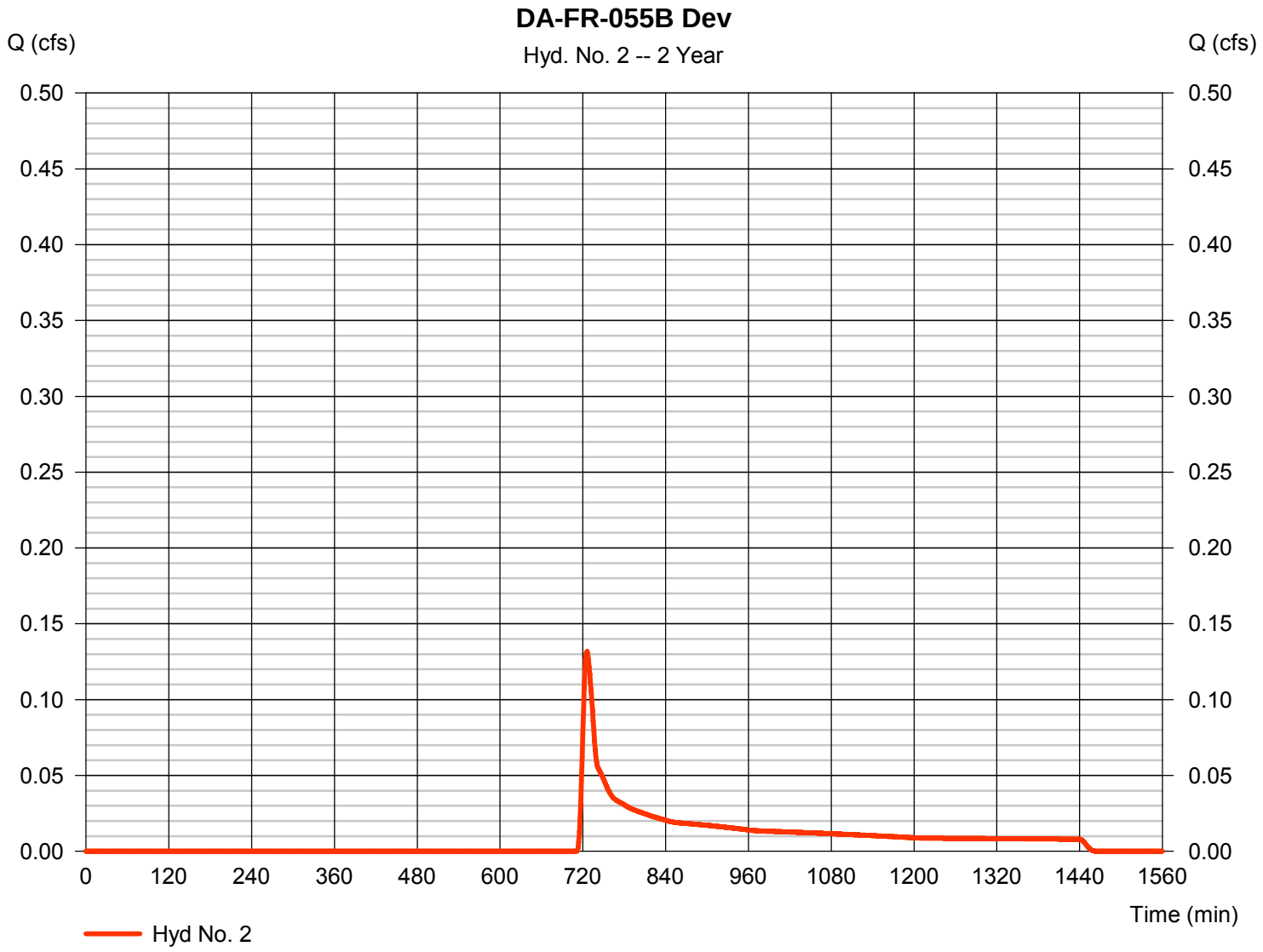
Hydrograph Report

Hyd. No. 2

DA-FR-055B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.132 cfs
Storm frequency	= 2 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 736 cuft
Drainage area	= 0.590 ac	Curve number	= 53*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.70 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.410 x 48) + (0.150 x 58) + (0.033 x 100)] / 0.590

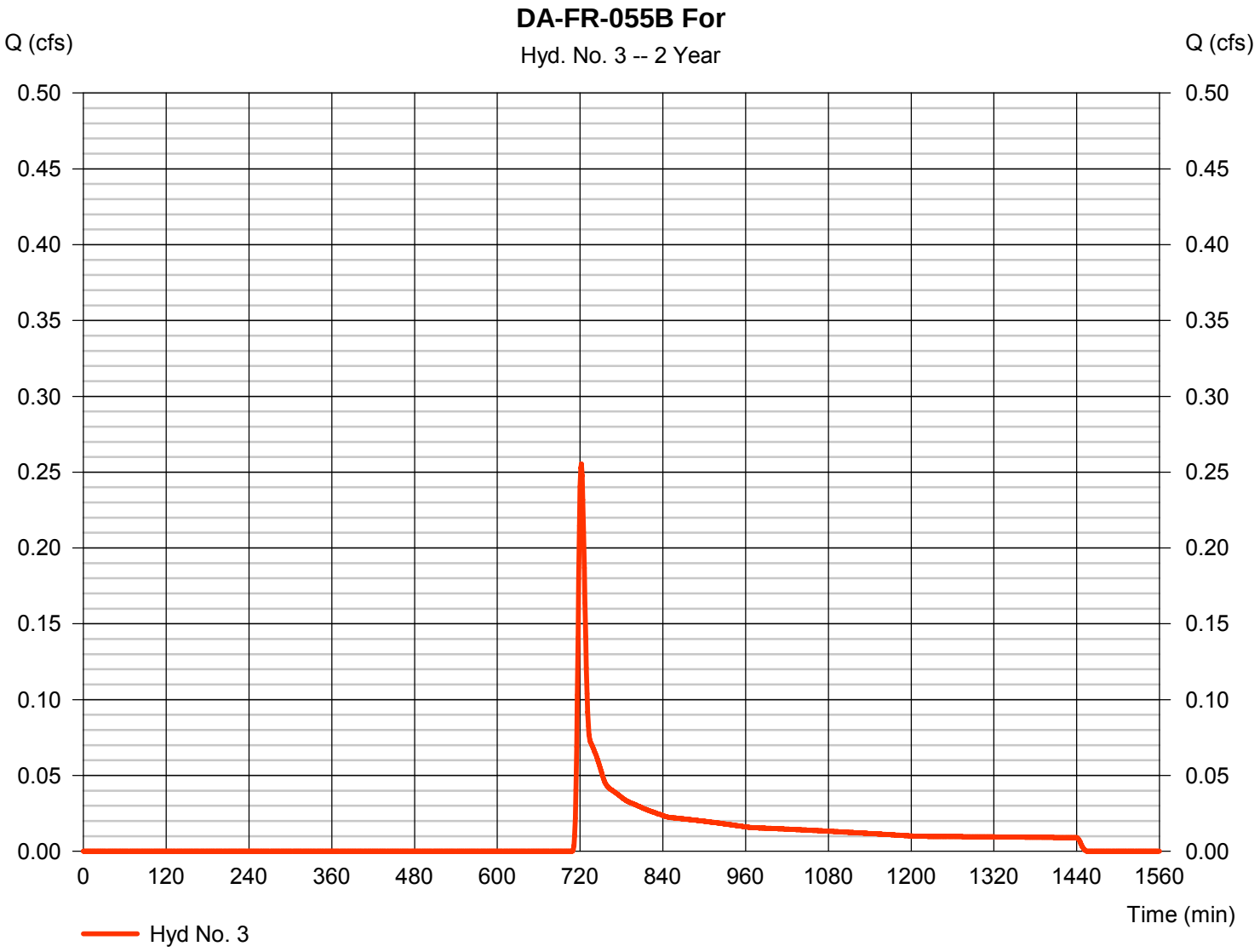


Hydrograph Report

Hyd. No. 3

DA-FR-055B For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.255 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 905 cuft
Drainage area	= 0.600 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.50 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.376	1	720	3,260	------	------	------	DA-FR-055B Pre
2	SCS Runoff	0.831	1	723	2,581	------	------	------	DA-FR-055B Dev
3	SCS Runoff	1.212	1	720	2,937	------	------	------	DA-FR-055B For

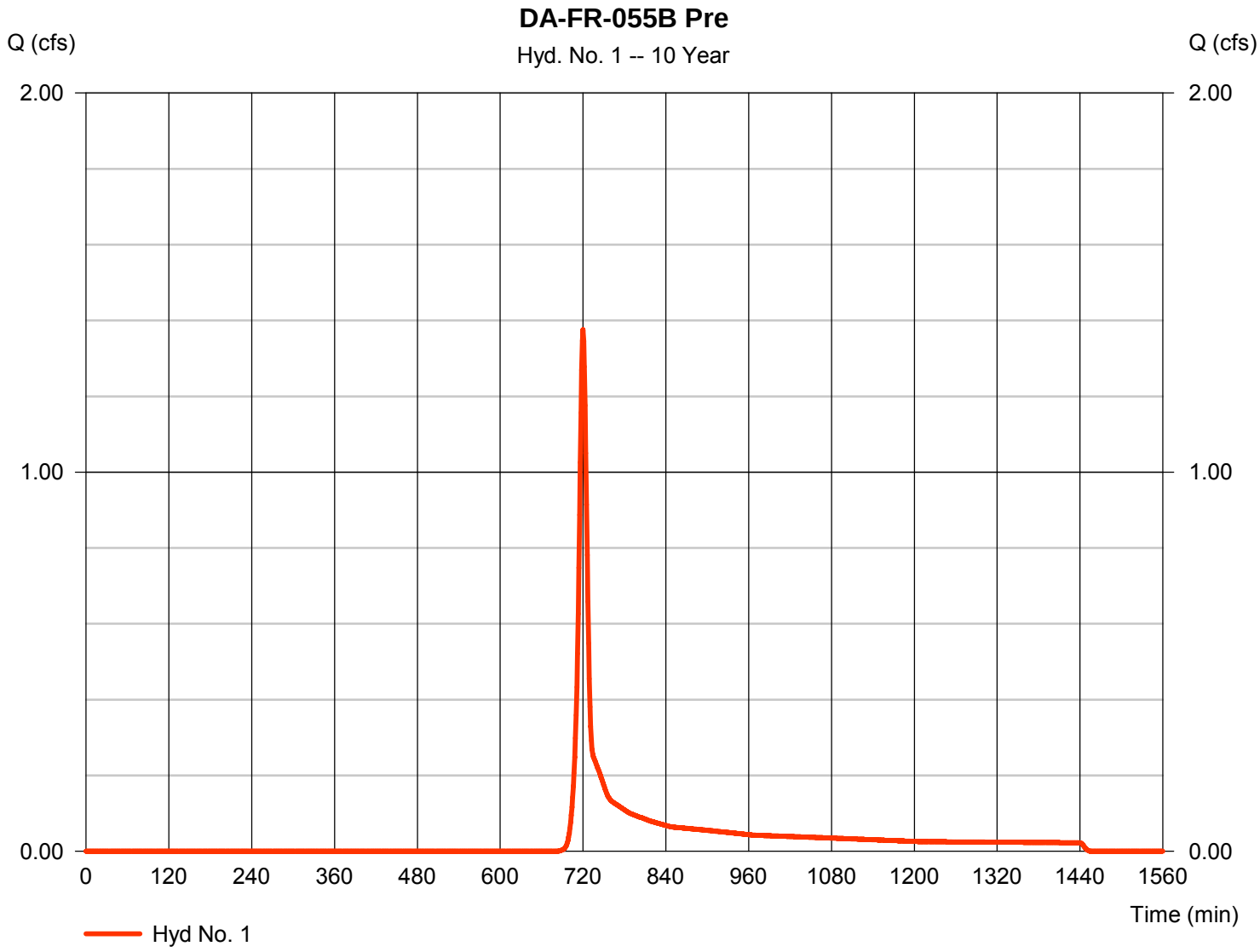
Hydrograph Report

Hyd. No. 1

DA-FR-055B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.376 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 3,260 cuft
Drainage area	= 0.600 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.50 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.032 x 100) + (0.568 x 55)] / 0.600



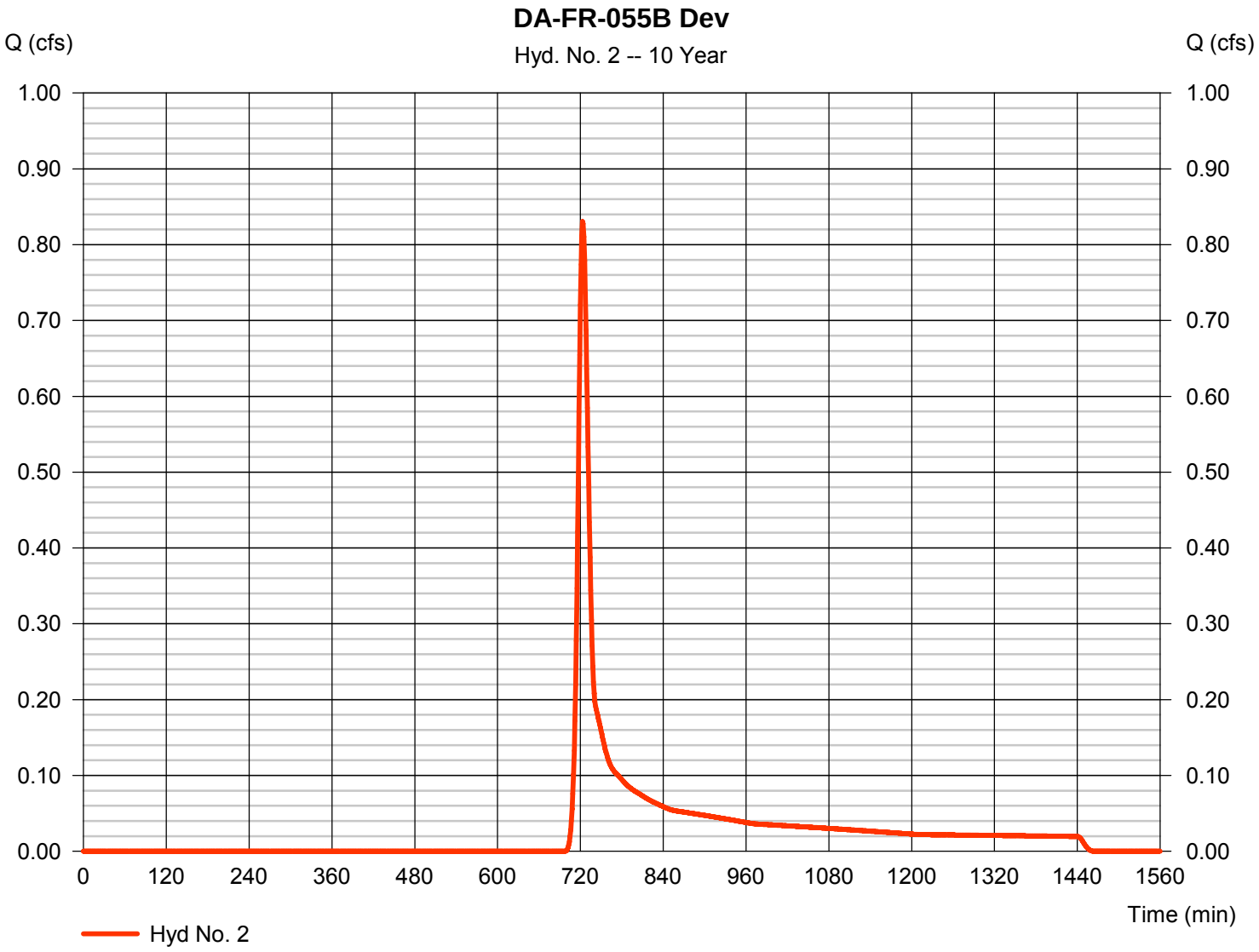
Hydrograph Report

Hyd. No. 2

DA-FR-055B Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.831 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 2,581 cuft
Drainage area	= 0.590 ac	Curve number	= 53*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.70 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.410 x 48) + (0.150 x 58) + (0.033 x 100)] / 0.590

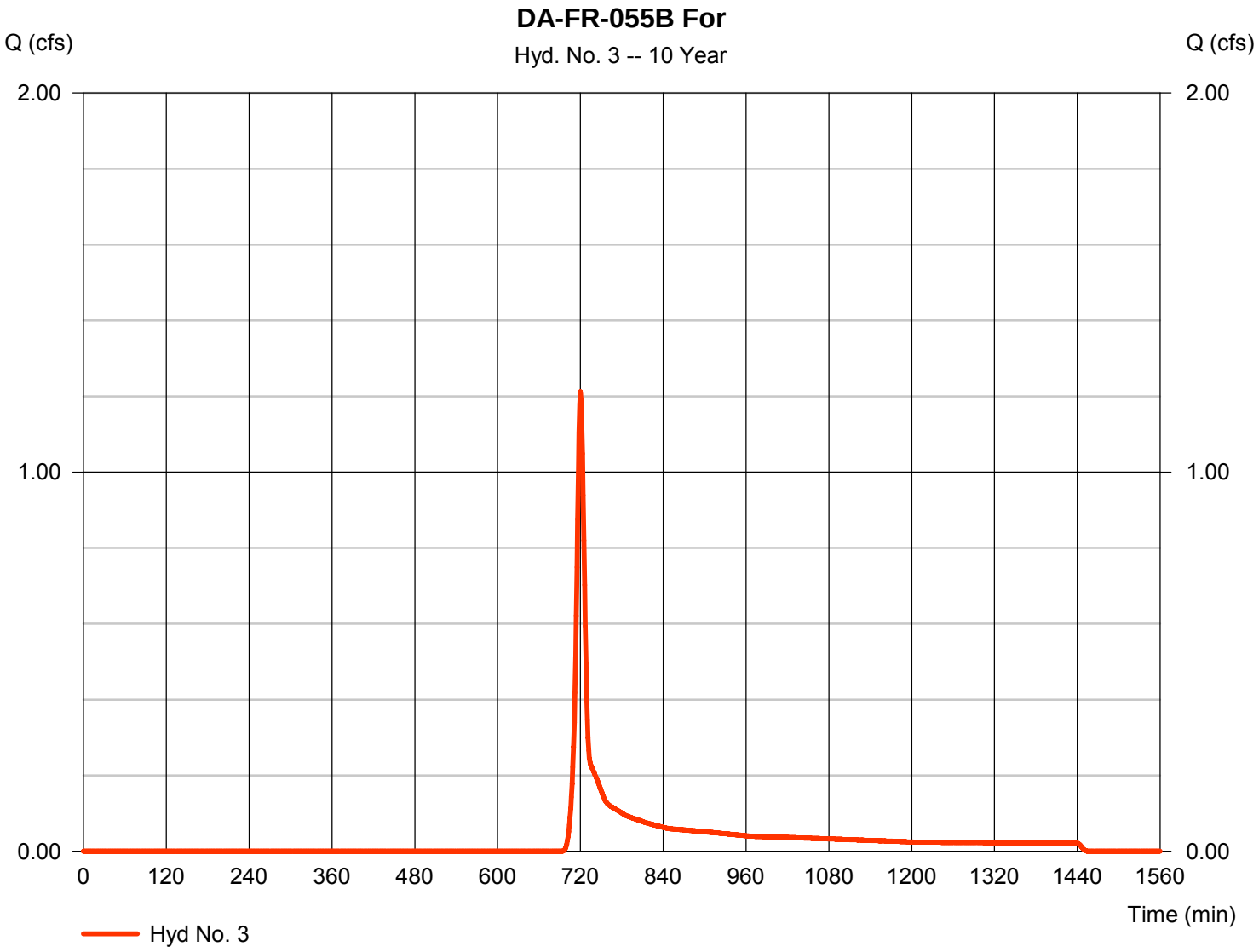


Hydrograph Report

Hyd. No. 3

DA-FR-055B For

Hydrograph type	= SCS Runoff	Peak discharge	= 1.212 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 2,937 cuft
Drainage area	= 0.600 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 8.50 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-055C

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	2.109	11561
Developed Condition	2.109	11561
Pre-Developed (Forest) Condition	3.143	10428

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 2.109 ≤ 2.109

N/A - See Check #3

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 2.109 ≤ 2.109

N/A - See Check #3

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 2.109 *shall not* be required to be ≤ 2.835

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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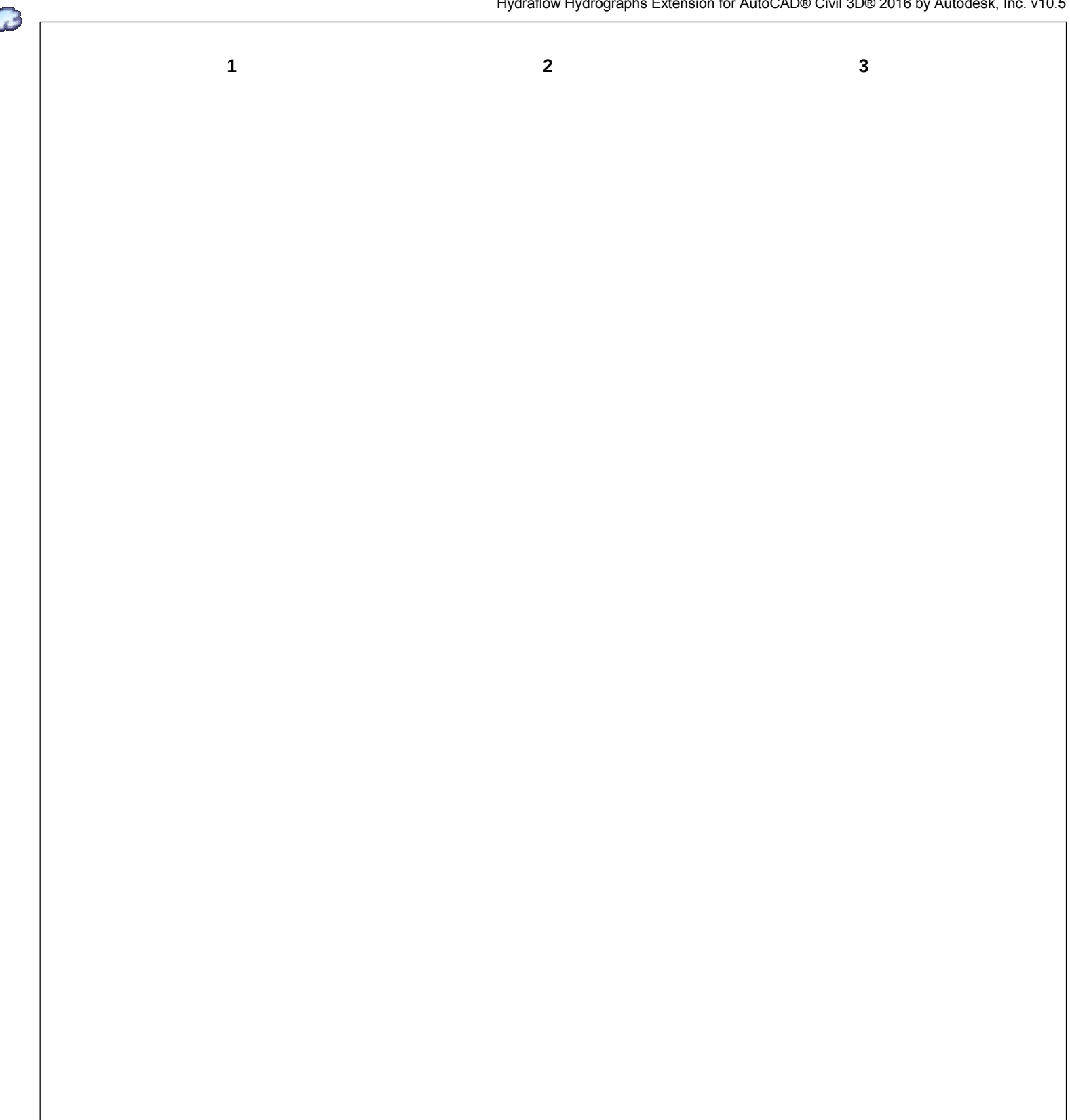
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-055C Pre
2	SCS Runoff	DA-FR-055C Dev
3	SCS Runoff	DA-FR-055C For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	2.109	3.946	-------	-------	17.93	-------	-------	-------	DA-FR-055C Pre
2	SCS Runoff	------	2.109	3.946	-------	-------	17.93	-------	-------	-------	DA-FR-055C Dev
3	SCS Runoff	------	3.143	5.882	-------	-------	25.67	-------	-------	-------	DA-FR-055C For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.109	1	726	11,561	------	------	------	DA-FR-055C Pre
2	SCS Runoff	2.109	1	726	11,561	------	------	------	DA-FR-055C Dev
3	SCS Runoff	3.143	1	719	10,428	------	------	------	DA-FR-055C For

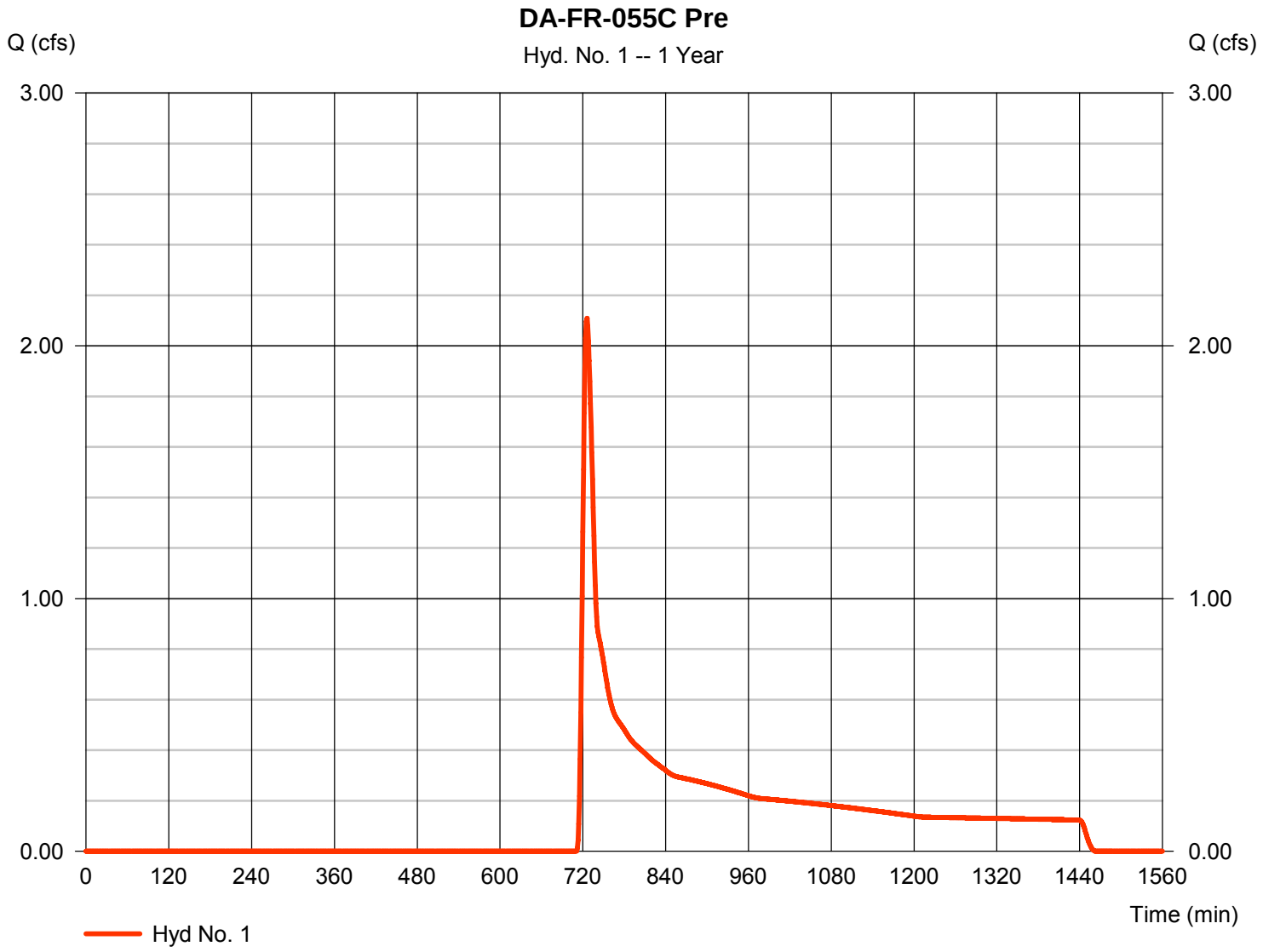
Hydrograph Report

Hyd. No. 1

DA-FR-055C Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 2.109 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 11,561 cuft
Drainage area	= 10.220 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(4.827 x 58) + (5.390 x 55)] / 10.220



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-055C Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.84		0.00		0.00		
Travel Time (min)	**= 11.02**	**+**	**0.00**	**+**	**0.00**	**=**	**11.02**
Shallow Concentrated Flow							
Flow length (ft)	= 999.90		0.00		0.00		
Watercourse slope (%)	= 10.37		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.20		0.00		0.00		
Travel Time (min)	**= 3.21**	**+**	**0.00**	**+**	**0.00**	**=**	**3.21**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.20 min

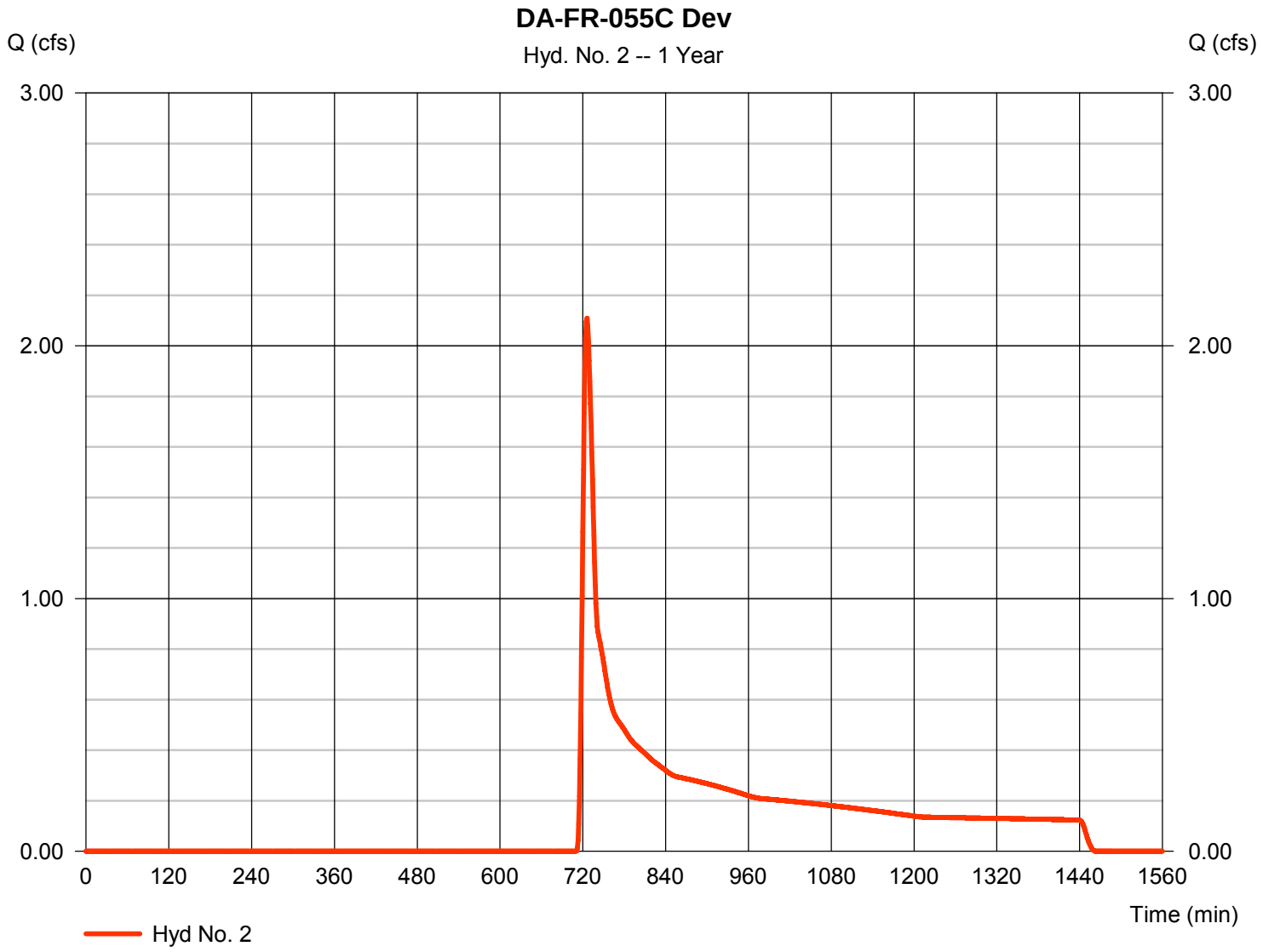
Hydrograph Report

Hyd. No. 2

DA-FR-055C Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 2.109 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 11,561 cuft
Drainage area	= 10.220 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.246 x 48) + (4.970 x 58) + (5.000 x 55)] / 10.220



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-055C Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.84		0.00		0.00		
Travel Time (min)	**= 11.02**	**+**	**0.00**	**+**	**0.00**	**=**	**11.02**
Shallow Concentrated Flow							
Flow length (ft)	= 999.90		0.00		0.00		
Watercourse slope (%)	= 10.37		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.20		0.00		0.00		
Travel Time (min)	**= 3.21**	**+**	**0.00**	**+**	**0.00**	**=**	**3.21**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

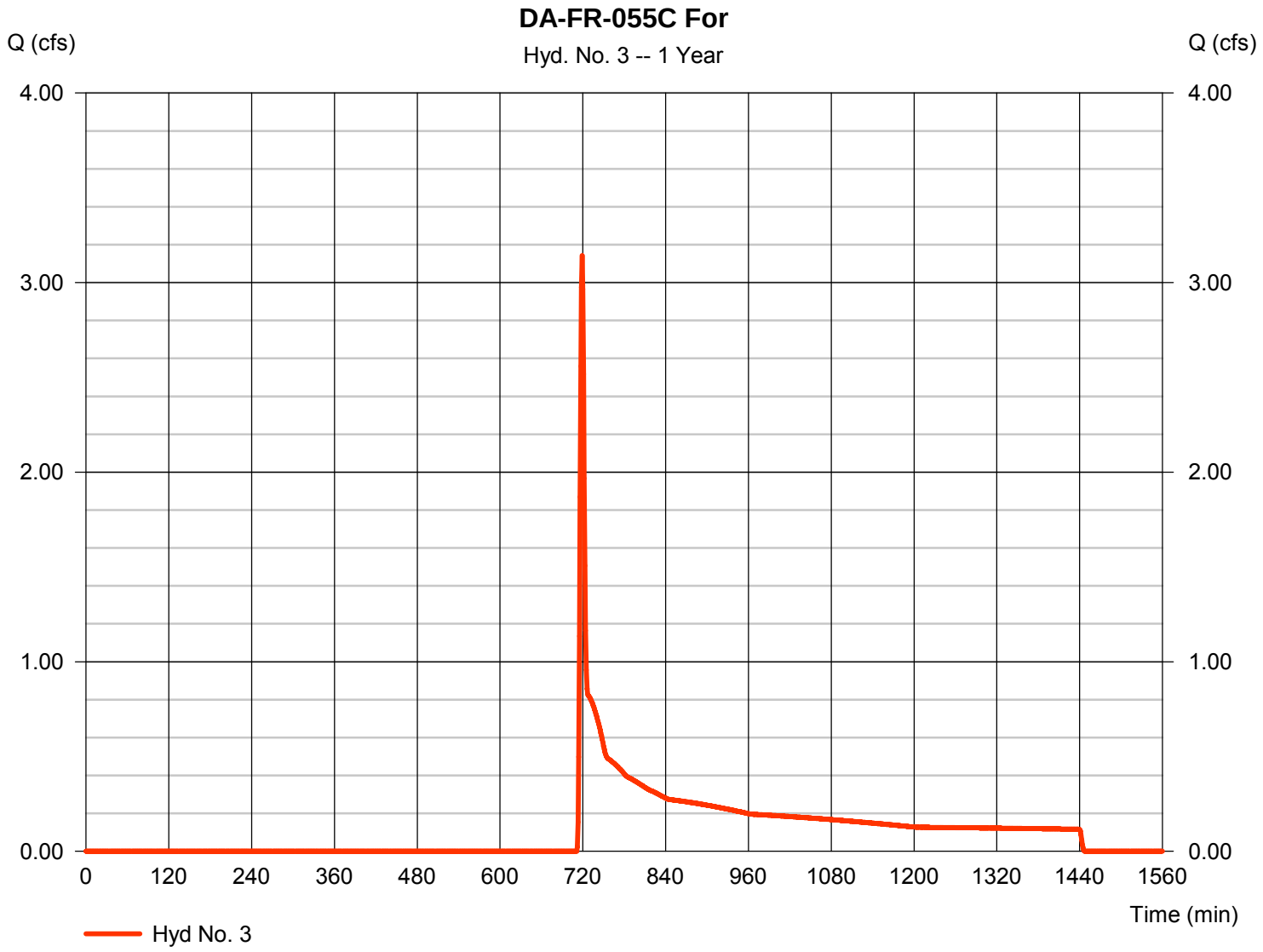
Total Travel Time, Tc ..... 14.20 min

Hydrograph Report

Hyd. No. 3

DA-FR-055C For

Hydrograph type	= SCS Runoff	Peak discharge	= 3.143 cfs
Storm frequency	= 1 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 10,428 cuft
Drainage area	= 10.220 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.80 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-055C For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.011		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 8.84		0.00		0.00		
Travel Time (min)	**= 0.62**	**+**	**0.00**	**+**	**0.00**	**=**	**0.62**
Shallow Concentrated Flow							
Flow length (ft)	= 999.90		0.00		0.00		
Watercourse slope (%)	= 10.37		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.20		0.00		0.00		
Travel Time (min)	**= 3.21**	**+**	**0.00**	**+**	**0.00**	**=**	**3.21**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 3.80 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	3.946	1	725	16,830	------	------	------	DA-FR-055C Pre
2	SCS Runoff	3.946	1	725	16,830	------	------	------	DA-FR-055C Dev
3	SCS Runoff	5.882	1	718	15,417	------	------	------	DA-FR-055C For

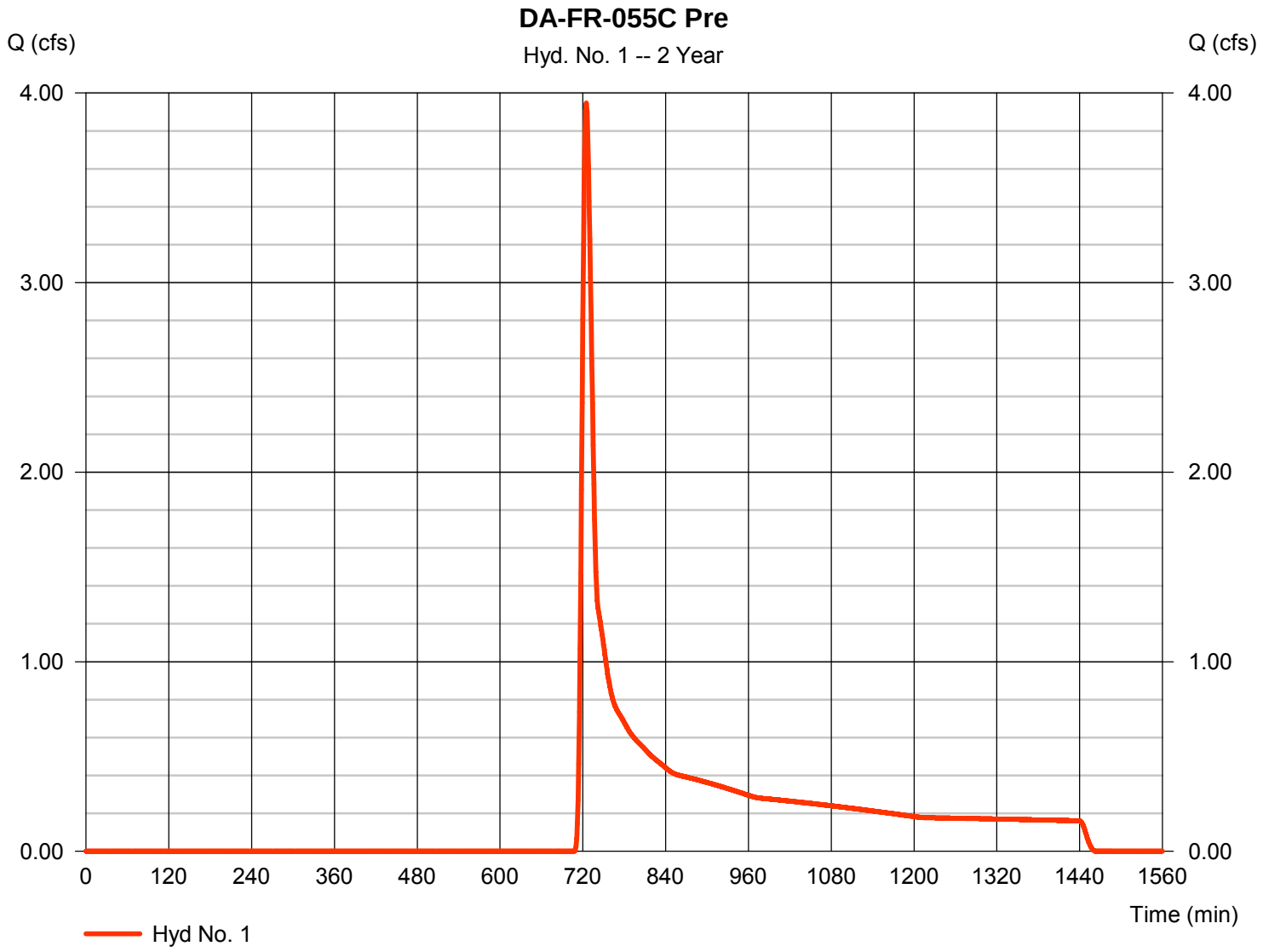
Hydrograph Report

Hyd. No. 1

DA-FR-055C Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 3.946 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 16,830 cuft
Drainage area	= 10.220 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(4.827 x 58) + (5.390 x 55)] / 10.220



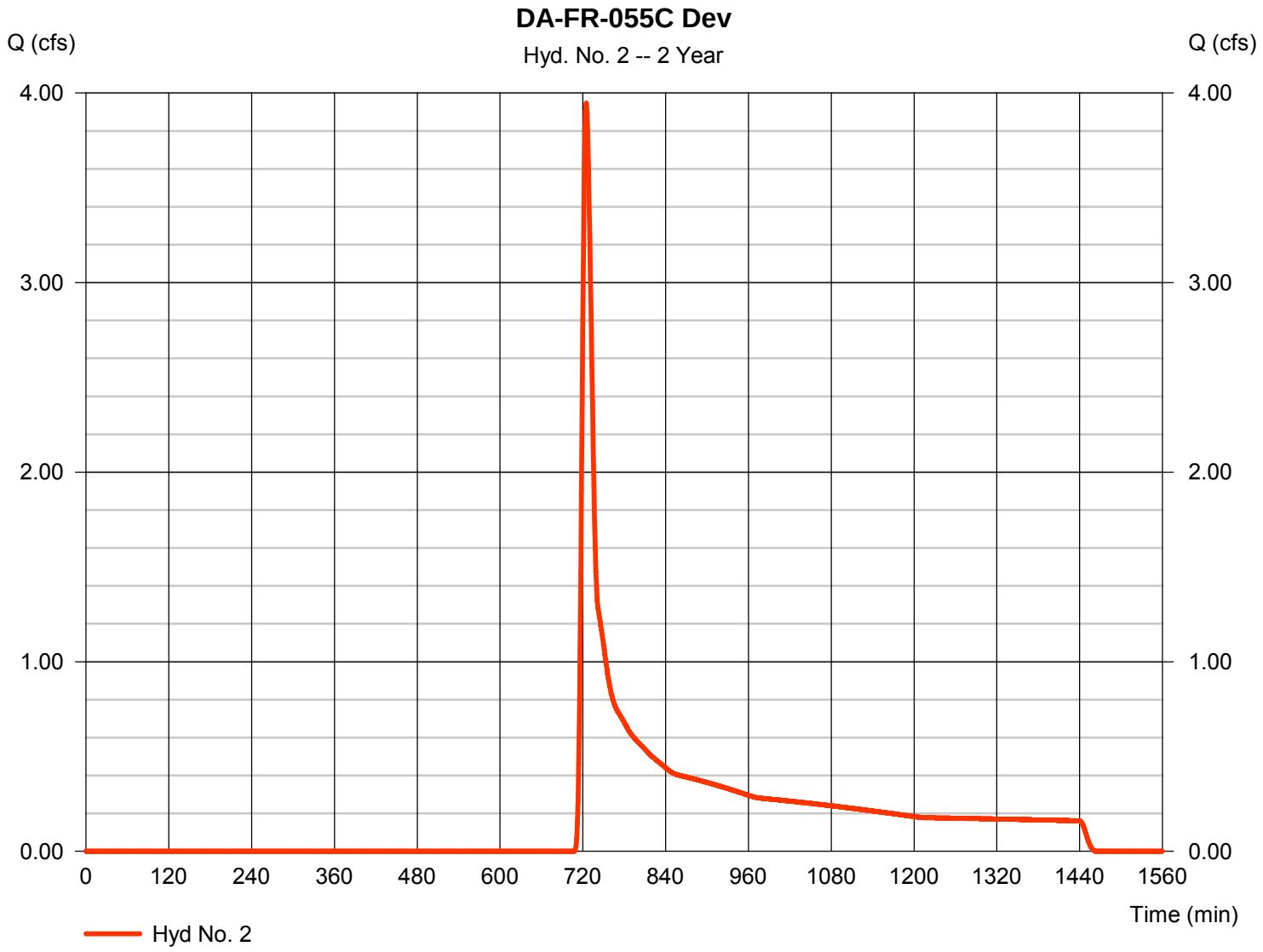
Hydrograph Report

Hyd. No. 2

DA-FR-055C Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 3.946 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 16,830 cuft
Drainage area	= 10.220 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.246 x 48) + (4.970 x 58) + (5.000 x 55)] / 10.220

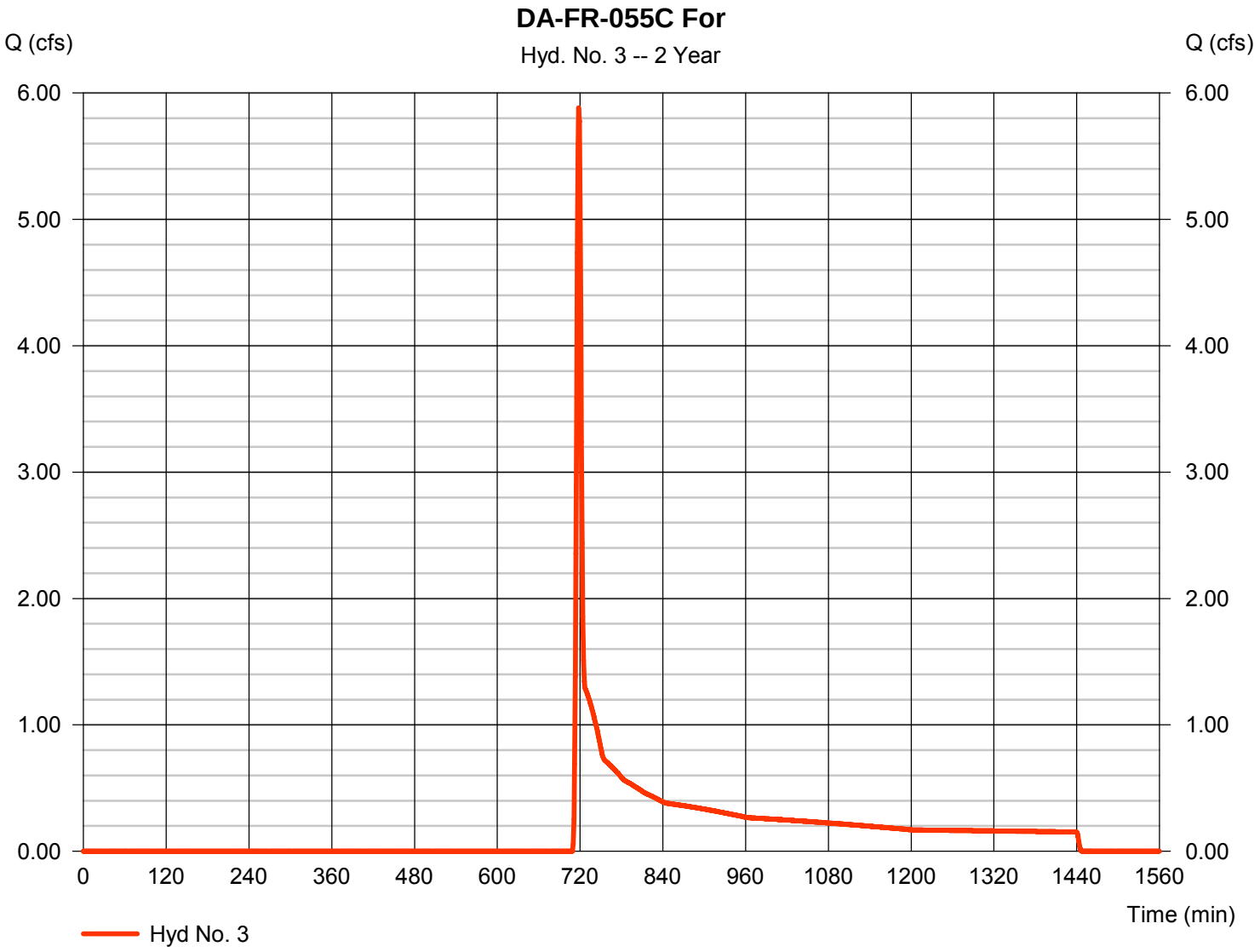


Hydrograph Report

Hyd. No. 3

DA-FR-055C For

Hydrograph type	= SCS Runoff	Peak discharge	= 5.882 cfs
Storm frequency	= 2 yrs	Time to peak	= 718 min
Time interval	= 1 min	Hyd. volume	= 15,417 cuft
Drainage area	= 10.220 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.80 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	17.93	1	723	52,759	------	------	------	DA-FR-055C Pre
2	SCS Runoff	17.93	1	723	52,759	------	------	------	DA-FR-055C Dev
3	SCS Runoff	25.67	1	717	50,028	------	------	------	DA-FR-055C For

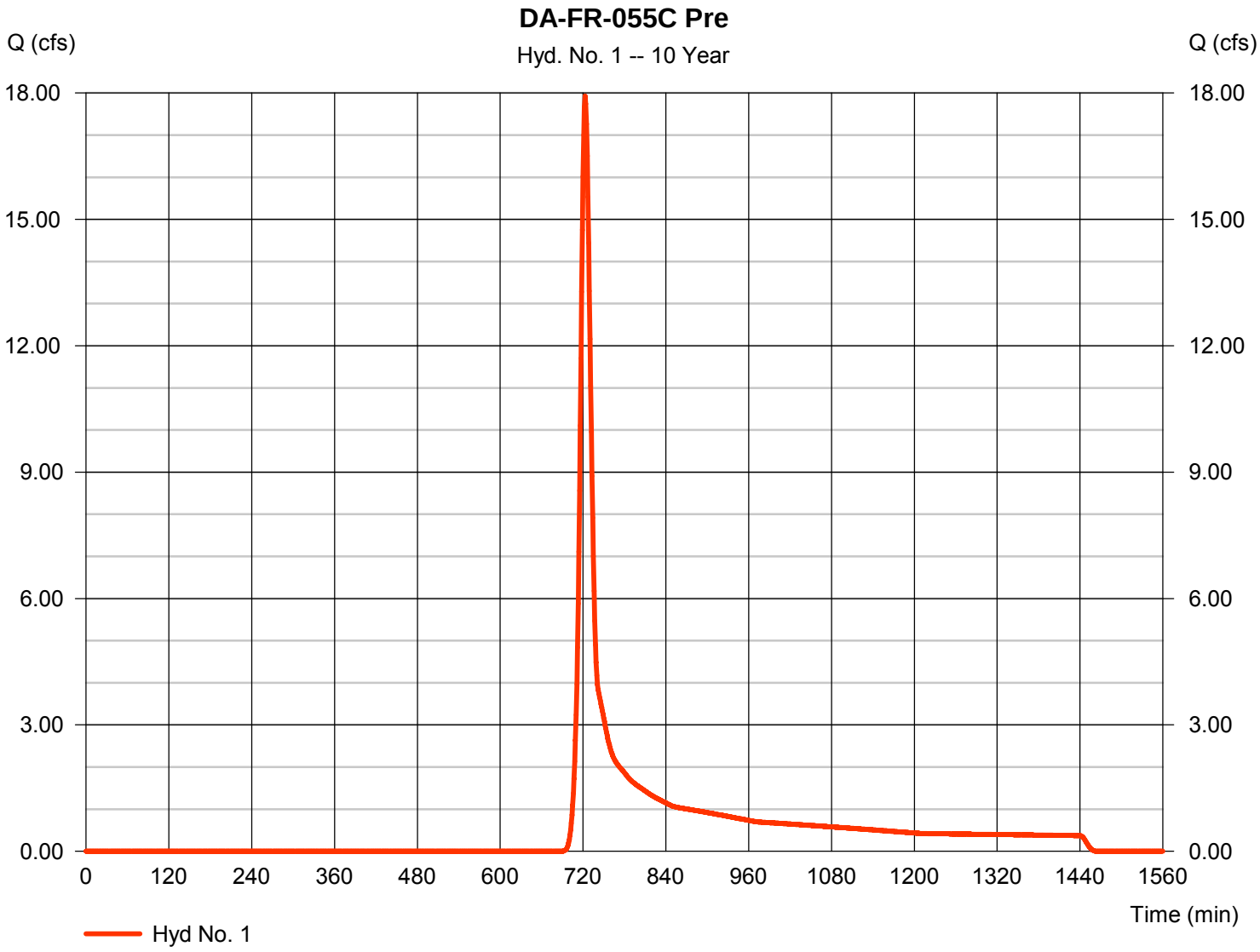
Hydrograph Report

Hyd. No. 1

DA-FR-055C Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 17.93 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 52,759 cuft
Drainage area	= 10.220 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(4.827 x 58) + (5.390 x 55)] / 10.220



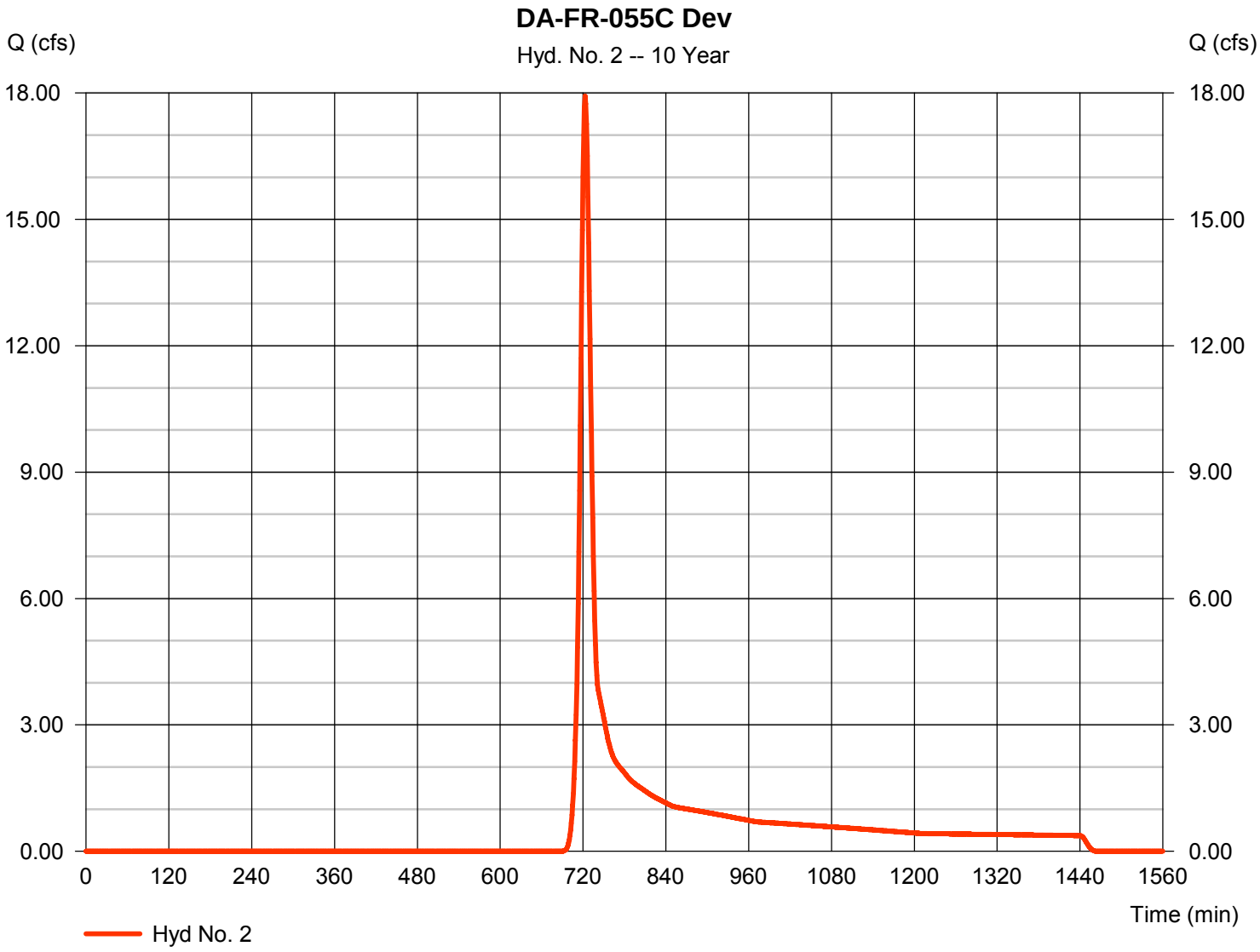
Hydrograph Report

Hyd. No. 2

DA-FR-055C Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 17.93 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 52,759 cuft
Drainage area	= 10.220 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.246 x 48) + (4.970 x 58) + (5.000 x 55)] / 10.220

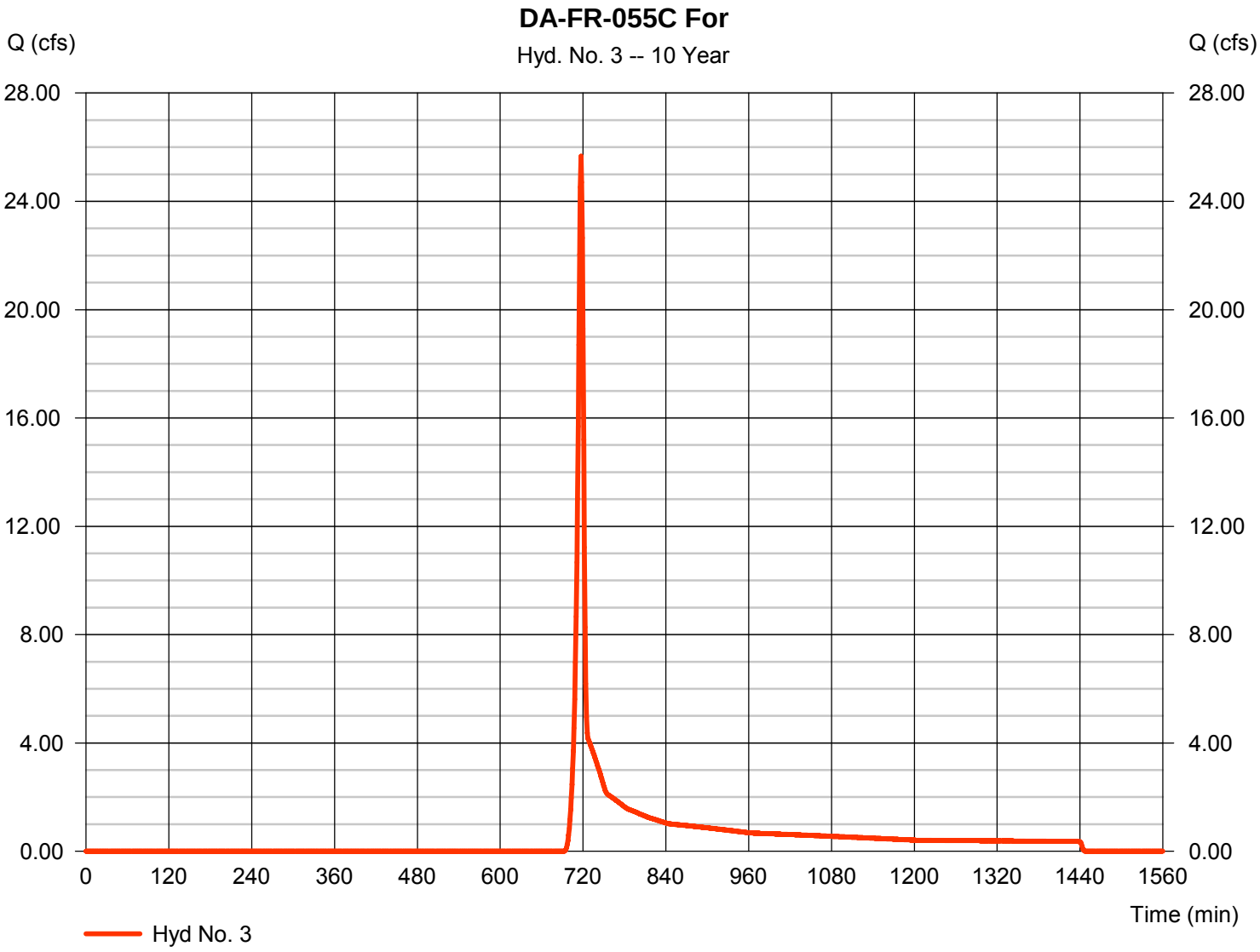


Hydrograph Report

Hyd. No. 3

DA-FR-055C For

Hydrograph type	= SCS Runoff	Peak discharge	= 25.67 cfs
Storm frequency	= 10 yrs	Time to peak	= 717 min
Time interval	= 1 min	Hyd. volume	= 50,028 cuft
Drainage area	= 10.220 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.80 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-055D

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.646	18377
Developed Condition	1.645	18364
Pre-Developed (Forest) Condition	1.003	13702

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 1.645 ≤ 1.647 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 1.645 ≤ 1.646 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 1.645 *shall not* be required to be ≤ 0.748

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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Watershed Model Schematic

1 2 3

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-055D Pre
2	SCS Runoff	DA-FR-055D Dev
3	SCS Runoff	DA-FR-055D

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.646	2.698	-------	-------	10.80	-------	-------	-------	DA-FR-055D Pre
2	SCS Runoff	------	1.645	2.696	-------	-------	10.79	-------	-------	-------	DA-FR-055D Dev
3	SCS Runoff	------	1.003	1.795	-------	-------	8.728	-------	-------	-------	DA-FR-055D

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.646	1	759	18,377	------	------	------	DA-FR-055D Pre
2	SCS Runoff	1.645	1	759	18,364	------	------	------	DA-FR-055D Dev
3	SCS Runoff	1.003	1	766	13,702	------	------	------	DA-FR-055D

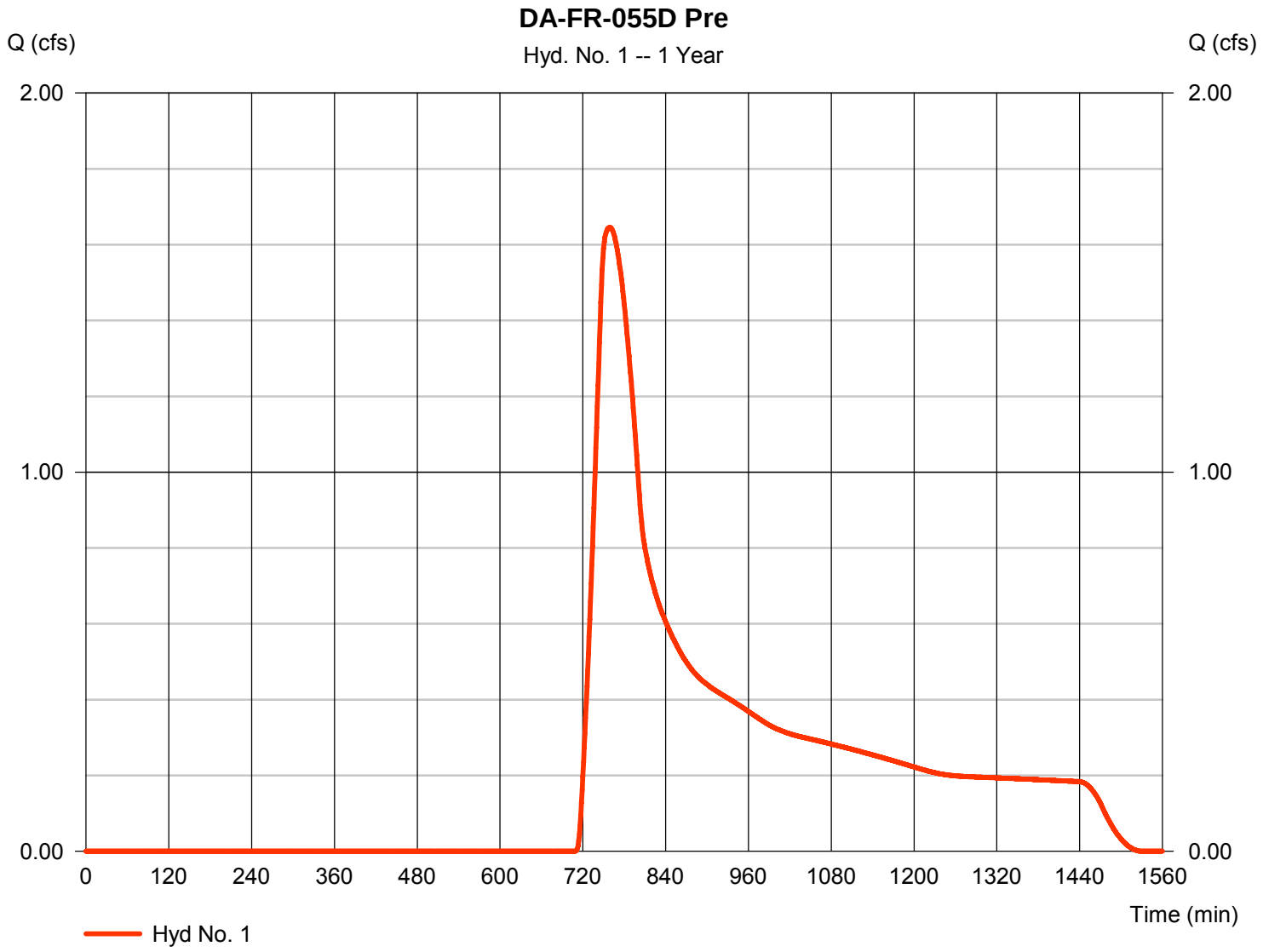
Hydrograph Report

Hyd. No. 1

DA-FR-055D Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.646 cfs
Storm frequency	= 1 yrs	Time to peak	= 759 min
Time interval	= 1 min	Hyd. volume	= 18,377 cuft
Drainage area	= 13.380 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 56.90 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.210 x 82) + (0.080 x 98) + (9.782 x 58) + (0.040 x 100) + (3.270 x 55)] / 13.380



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-055D Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 7.19		0.00		0.00		
Travel Time (min)	**= 11.97**	**+**	**0.00**	**+**	**0.00**	**=**	**11.97**
Shallow Concentrated Flow							
Flow length (ft)	= 787.03		0.00		0.00		
Watercourse slope (%)	= 12.66		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.74		0.00		0.00		
Travel Time (min)	**= 2.28**	**+**	**0.00**	**+**	**0.00**	**=**	**2.28**
Channel Flow							
X sectional flow area (sqft)	= 0.03		0.00		0.00		
Wetted perimeter (ft)	= 3.95		0.00		0.00		
Channel slope (%)	= 4.16		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=0.39						
			0.00				
					0.00		
Flow length (ft)	({0})984.9		0.0		0.0		
Travel Time (min)	**= 42.63**	**+**	**0.00**	**+**	**0.00**	**=**	**42.63**

Total Travel Time, Tc ..... 56.90 min

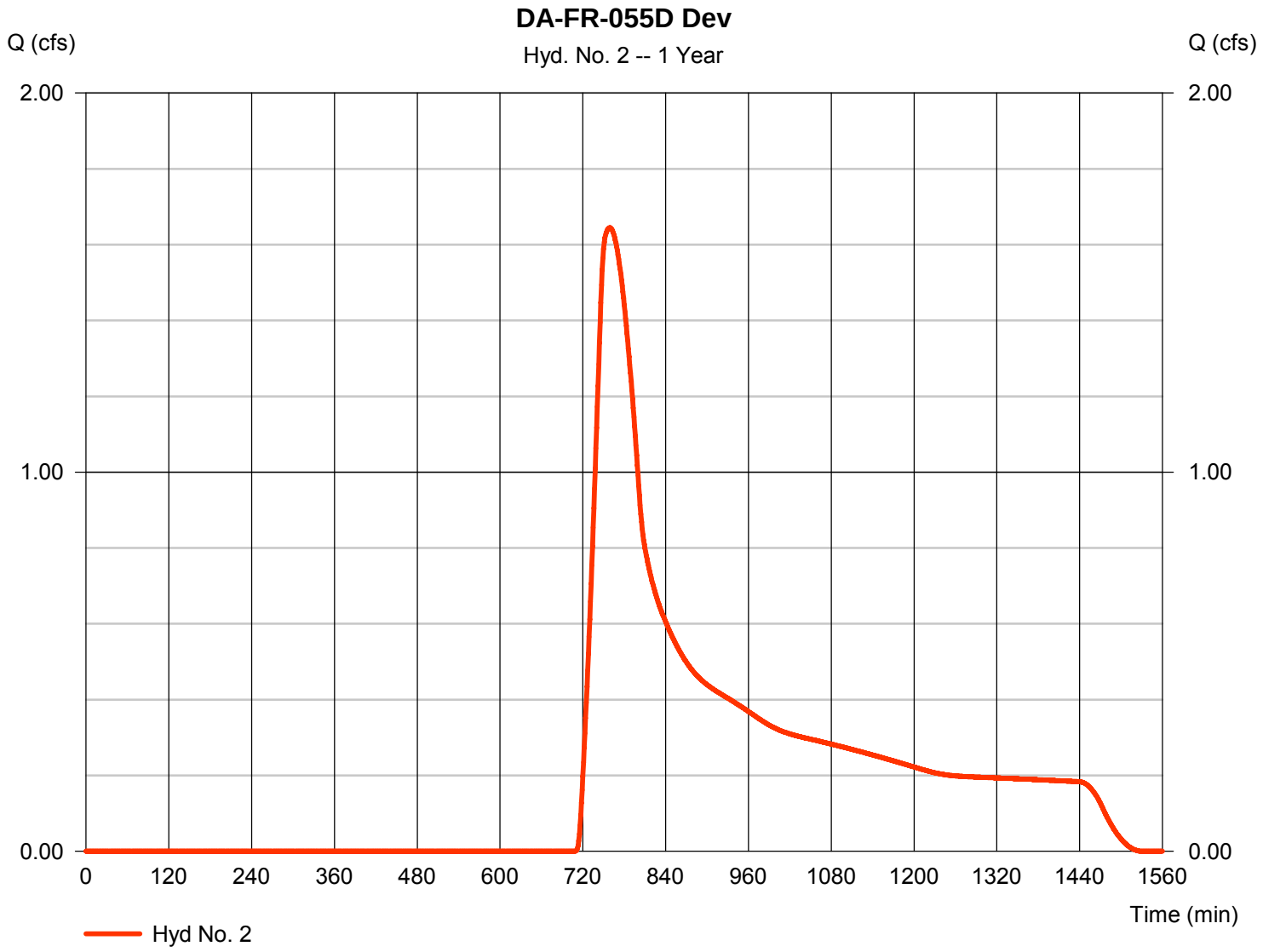
Hydrograph Report

Hyd. No. 2

DA-FR-055D Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 1.645 cfs
Storm frequency	= 1 yrs	Time to peak	= 759 min
Time interval	= 1 min	Hyd. volume	= 18,364 cuft
Drainage area	= 13.370 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 56.90 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.025 x 48) + (0.207 x 82) + (0.075 x 98) + (9.820 x 58) + (0.042 x 100) + (3.204 x 55)] / 13.370



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-055D Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 7.19		0.00		0.00		
Travel Time (min)	**= 11.97**	**+**	**0.00**	**+**	**0.00**	**=**	**11.97**
Shallow Concentrated Flow							
Flow length (ft)	= 787.03		0.00		0.00		
Watercourse slope (%)	= 12.66		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.74		0.00		0.00		
Travel Time (min)	**= 2.28**	**+**	**0.00**	**+**	**0.00**	**=**	**2.28**
Channel Flow							
X sectional flow area (sqft)	= 0.03		0.00		0.00		
Wetted perimeter (ft)	= 3.95		0.00		0.00		
Channel slope (%)	= 4.16		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=0.39						
			0.00				
					0.00		
Flow length (ft)	({0})984.9		0.0		0.0		
Travel Time (min)	**= 42.63**	**+**	**0.00**	**+**	**0.00**	**=**	**42.63**

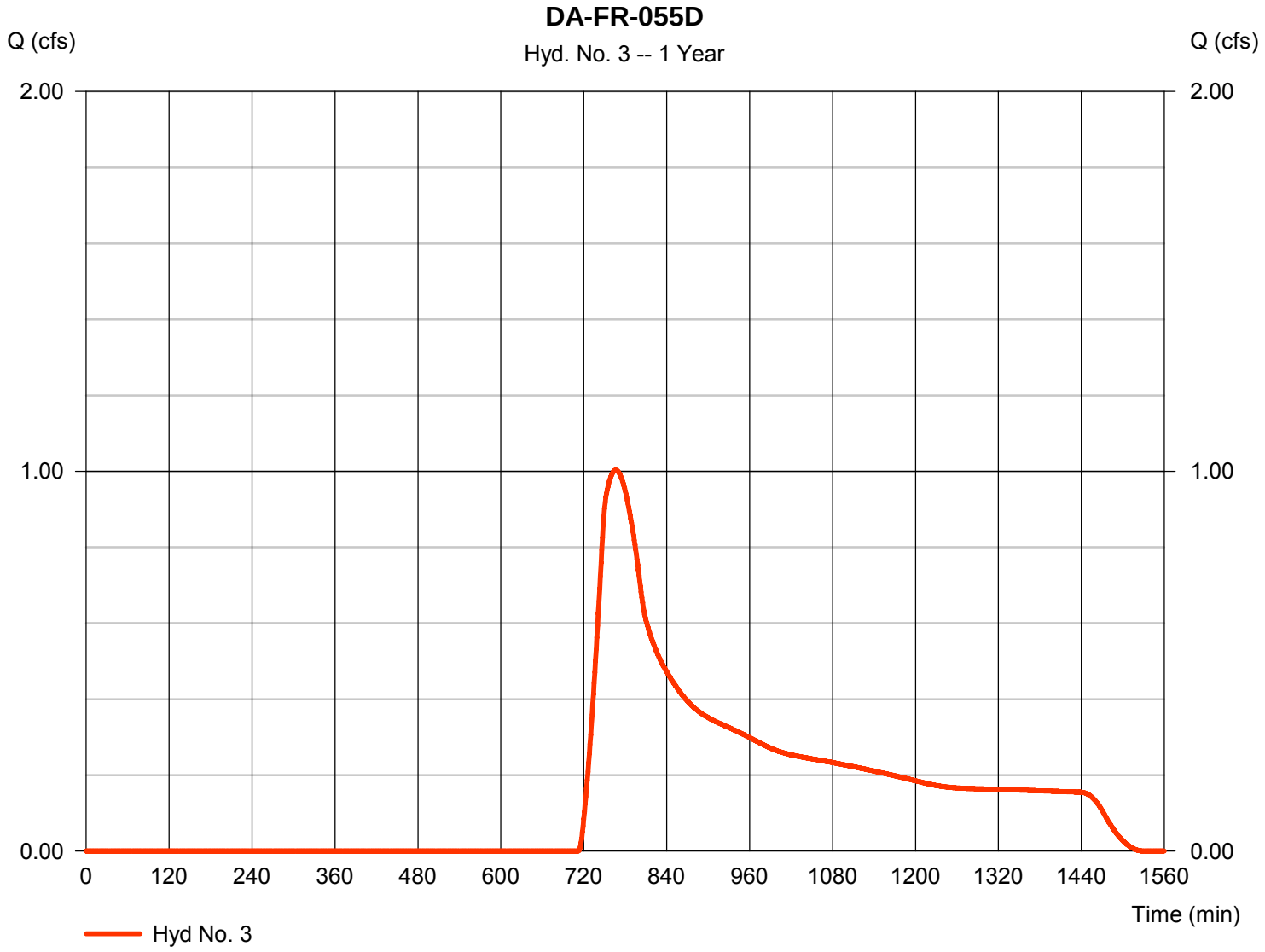
Total Travel Time, Tc ..... 56.90 min

Hydrograph Report

Hyd. No. 3

DA-FR-055D

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.003 cfs
Storm frequency	=	1 yrs	Time to peak	=	766 min
Time interval	=	1 min	Hyd. volume	=	13,702 cuft
Drainage area	=	13.380 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	56.90 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-055D

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 7.19		0.00		0.00		
Travel Time (min)	**= 11.97**	**+**	**0.00**	**+**	**0.00**	**=**	**11.97**
Shallow Concentrated Flow							
Flow length (ft)	= 787.03		0.00		0.00		
Watercourse slope (%)	= 12.66		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=5.74		0.00		0.00		
Travel Time (min)	**= 2.28**	**+**	**0.00**	**+**	**0.00**	**=**	**2.28**
Channel Flow							
X sectional flow area (sqft)	= 0.03		0.00		0.00		
Wetted perimeter (ft)	= 3.95		0.00		0.00		
Channel slope (%)	= 4.16		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=0.39						
			0.00				
					0.00		
Flow length (ft)	({0})984.9		0.0		0.0		
Travel Time (min)	**= 42.63**	**+**	**0.00**	**+**	**0.00**	**=**	**42.63**

Total Travel Time, Tc ..... 56.90 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.698	1	754	26,034	------	------	------	DA-FR-055D Pre
2	SCS Runoff	2.696	1	754	26,015	------	------	------	DA-FR-055D Dev
3	SCS Runoff	1.795	1	759	20,259	------	------	------	DA-FR-055D

Hydrograph Report

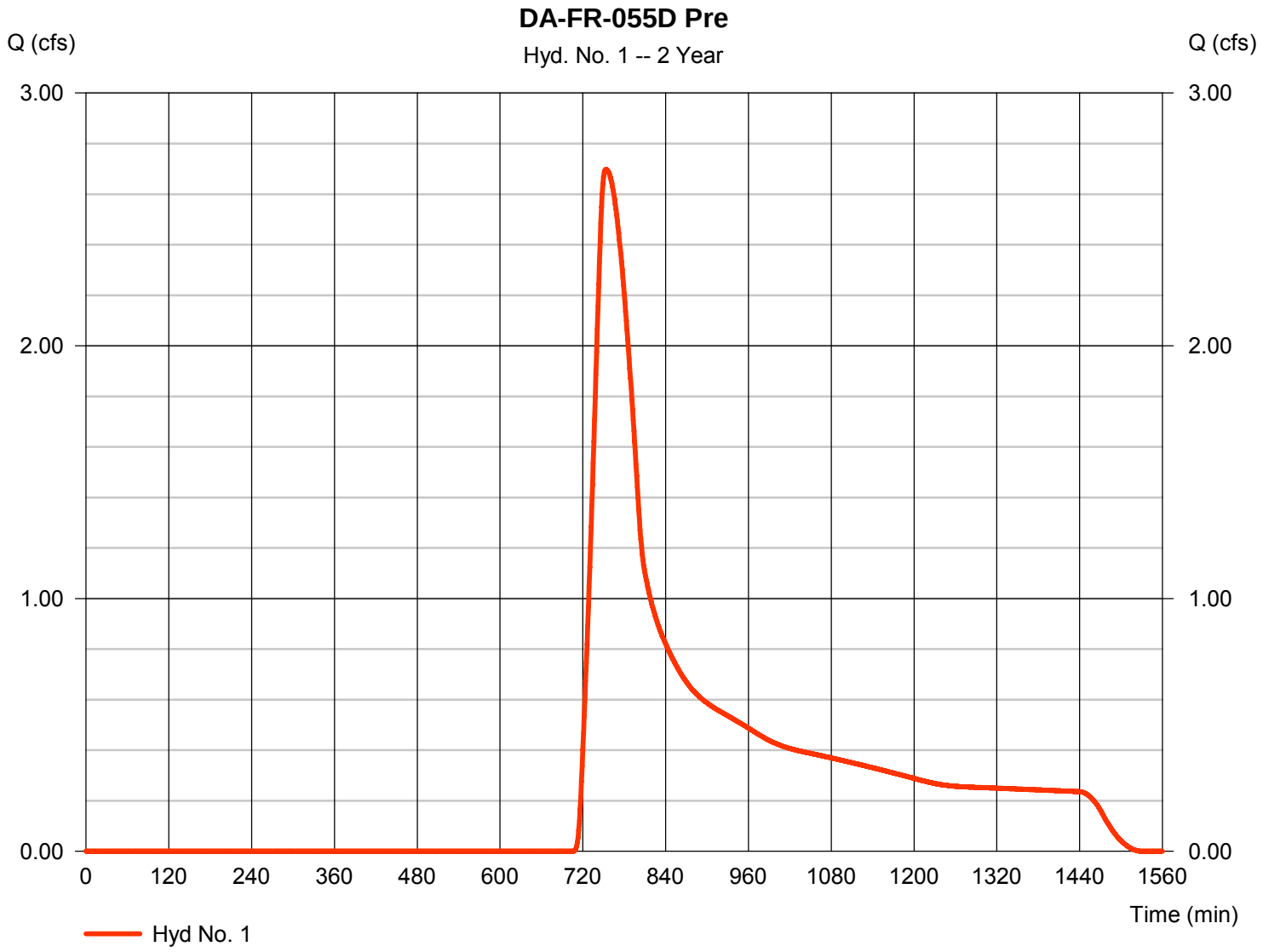
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 1

DA-FR-055D Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.698 cfs
Storm frequency	=	2 yrs	Time to peak	=	754 min
Time interval	=	1 min	Hyd. volume	=	26,034 cuft
Drainage area	=	13.380 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	56.90 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.210 x 82) + (0.080 x 98) + (9.782 x 58) + (0.040 x 100) + (3.270 x 55)] / 13.380



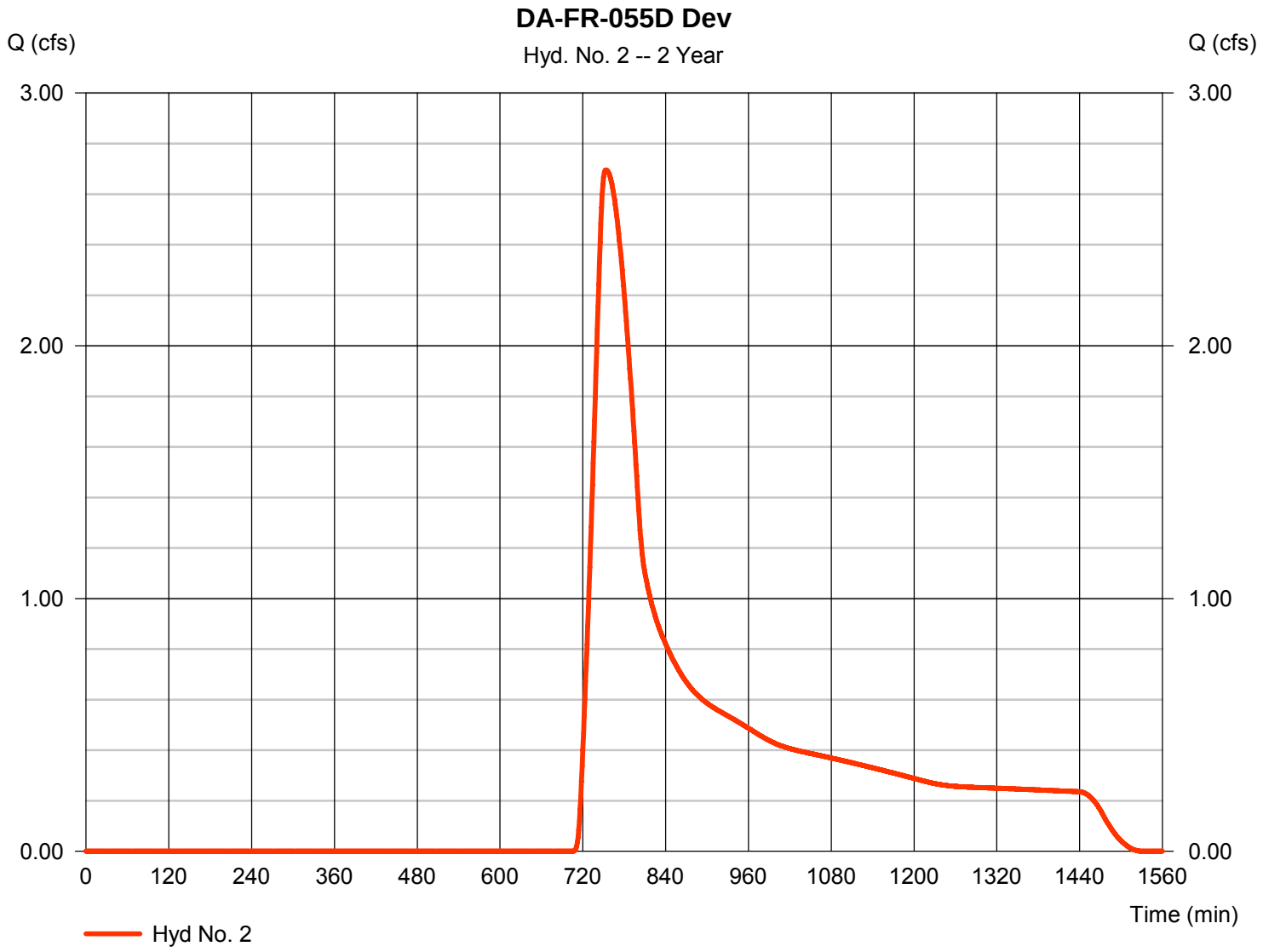
Hydrograph Report

Hyd. No. 2

DA-FR-055D Dev

Hydrograph type	=	SCS Runoff	Peak discharge	=	2.696 cfs
Storm frequency	=	2 yrs	Time to peak	=	754 min
Time interval	=	1 min	Hyd. volume	=	26,015 cuft
Drainage area	=	13.370 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	56.90 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.025 x 48) + (0.207 x 82) + (0.075 x 98) + (9.820 x 58) + (0.042 x 100) + (3.204 x 55)] / 13.370

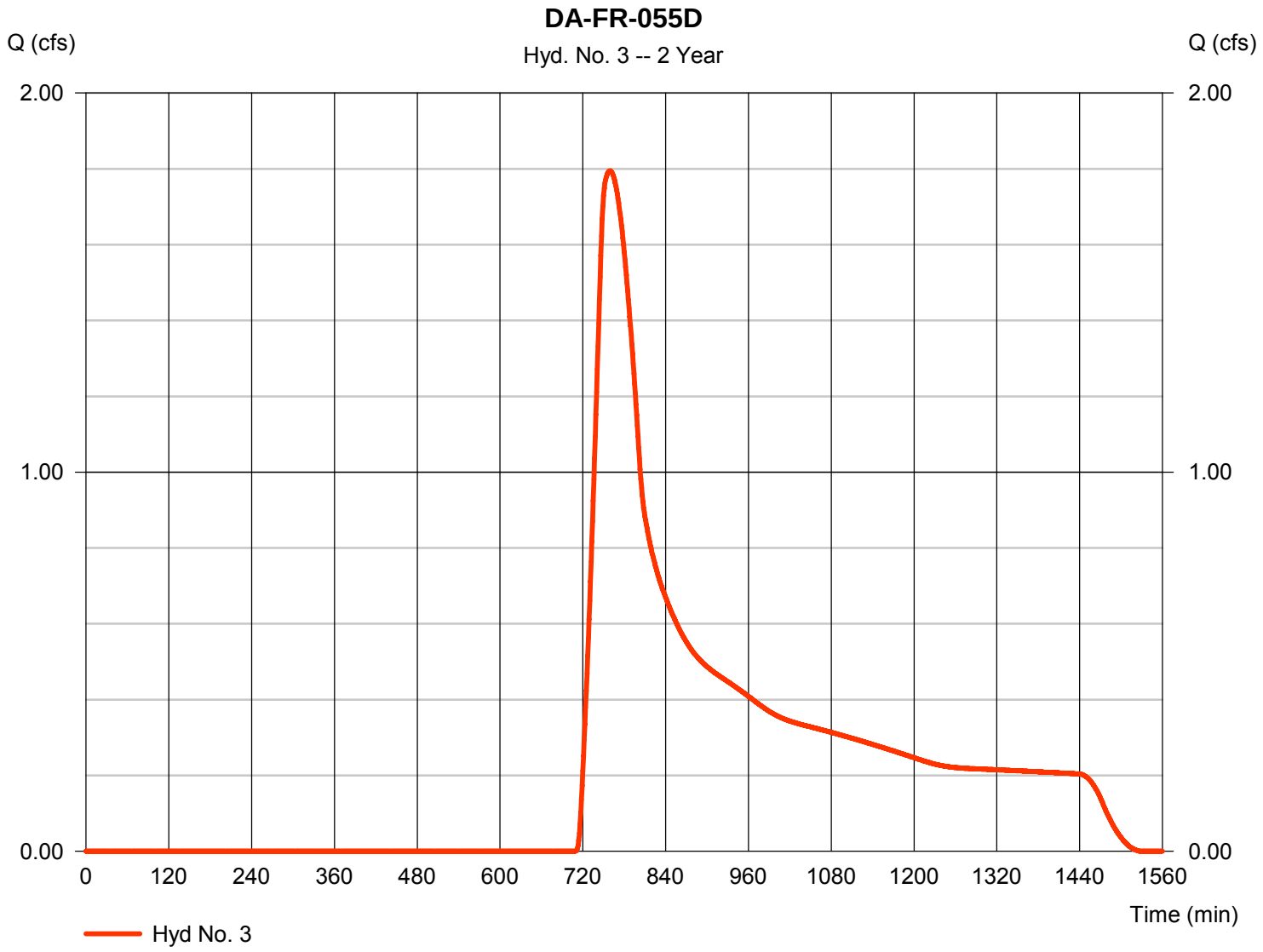


Hydrograph Report

Hyd. No. 3

DA-FR-055D

Hydrograph type	= SCS Runoff	Peak discharge	= 1.795 cfs
Storm frequency	= 2 yrs	Time to peak	= 759 min
Time interval	= 1 min	Hyd. volume	= 20,259 cuft
Drainage area	= 13.380 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 56.90 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	10.80	1	750	76,674	------	------	------	DA-FR-055D Pre
2	SCS Runoff	10.79	1	750	76,617	------	------	------	DA-FR-055D Dev
3	SCS Runoff	8.728	1	750	65,737	------	------	------	DA-FR-055D

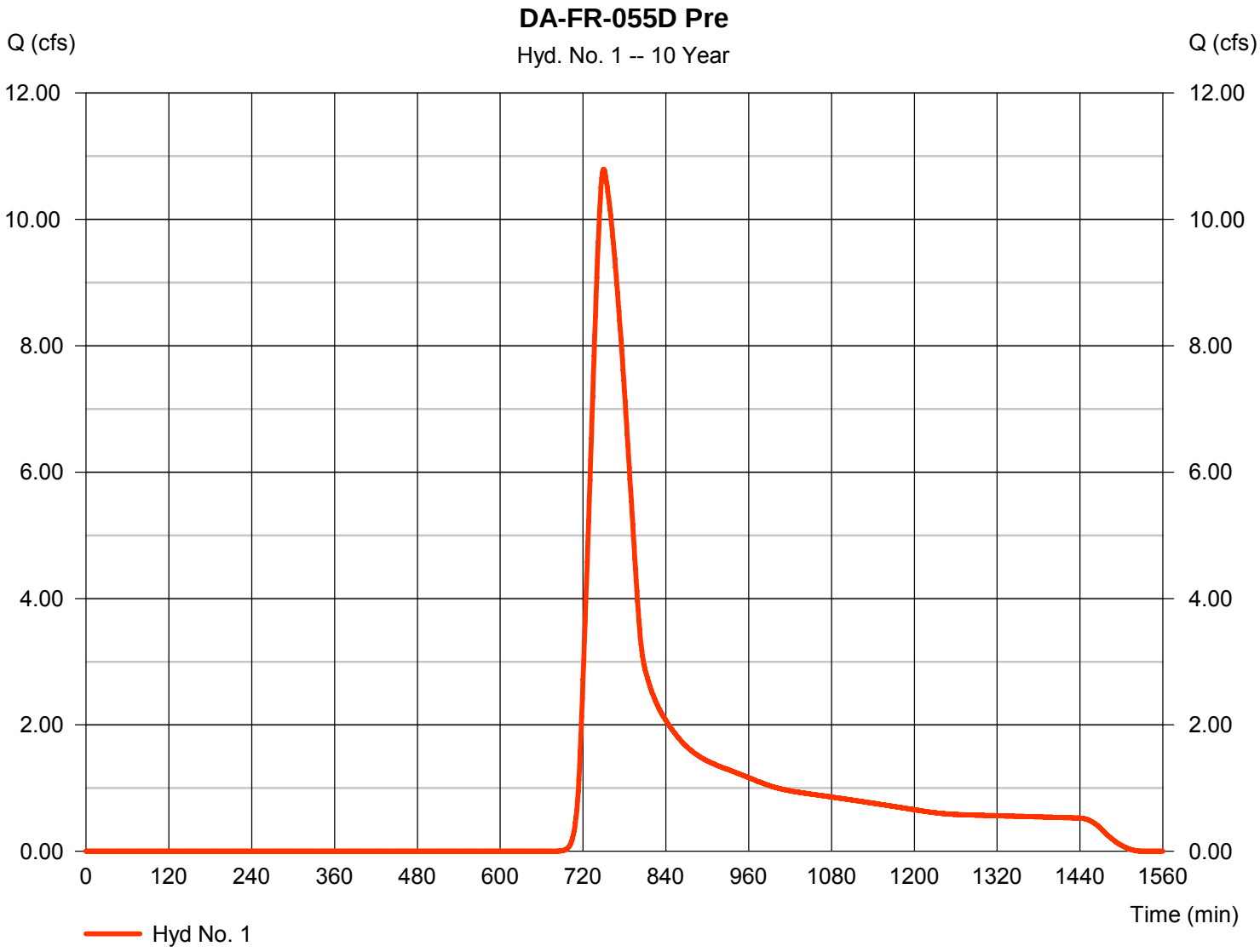
Hydrograph Report

Hyd. No. 1

DA-FR-055D Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	10.80 cfs
Storm frequency	=	10 yrs	Time to peak	=	750 min
Time interval	=	1 min	Hyd. volume	=	76,674 cuft
Drainage area	=	13.380 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	56.90 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.210 x 82) + (0.080 x 98) + (9.782 x 58) + (0.040 x 100) + (3.270 x 55)] / 13.380



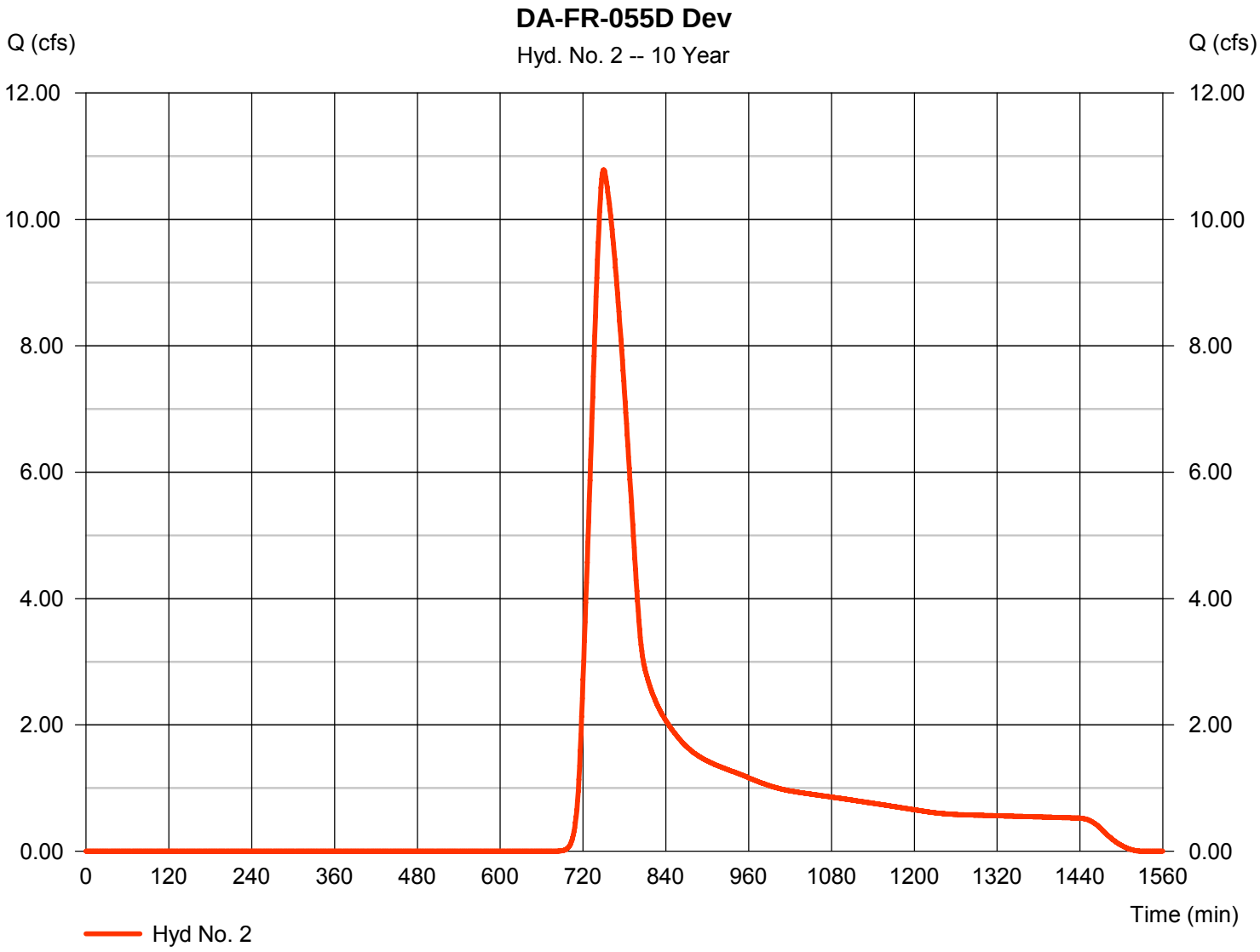
Hydrograph Report

Hyd. No. 2

DA-FR-055D Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 10.79 cfs
Storm frequency	= 10 yrs	Time to peak	= 750 min
Time interval	= 1 min	Hyd. volume	= 76,617 cuft
Drainage area	= 13.370 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 56.90 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.025 x 48) + (0.207 x 82) + (0.075 x 98) + (9.820 x 58) + (0.042 x 100) + (3.204 x 55)] / 13.370

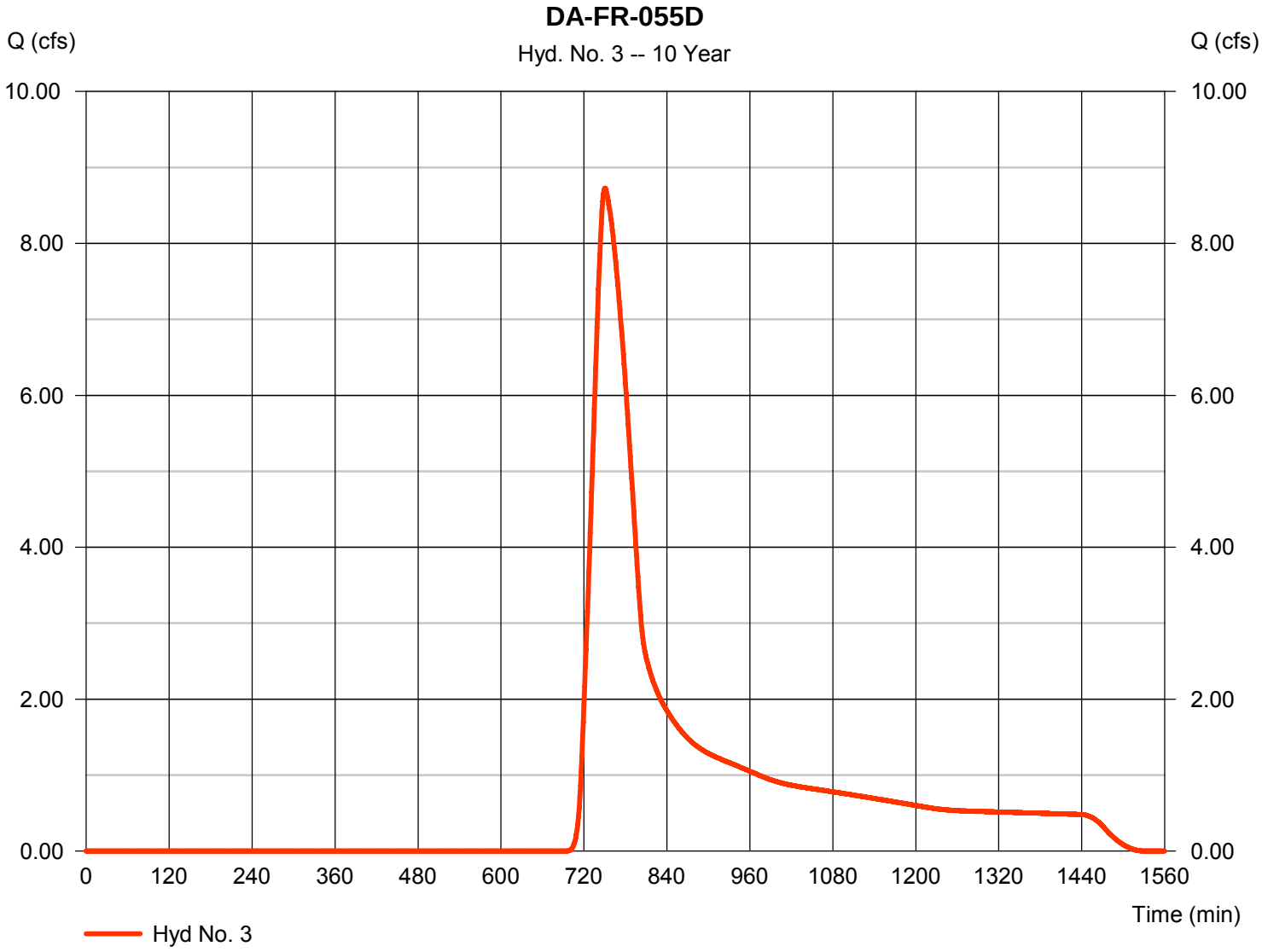


Hydrograph Report

Hyd. No. 3

DA-FR-055D

Hydrograph type	=	SCS Runoff	Peak discharge	=	8.728 cfs
Storm frequency	=	10 yrs	Time to peak	=	750 min
Time interval	=	1 min	Hyd. volume	=	65,737 cuft
Drainage area	=	13.380 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	56.90 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-055E

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.567	4306
Developed Condition	0.838	4593
Pre-Developed (Forest) Condition	0.669	4143

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.838	≤ OK	1.175
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.838	≤ OK	1.567
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.838	*shall not* be required to be ≤	0.603

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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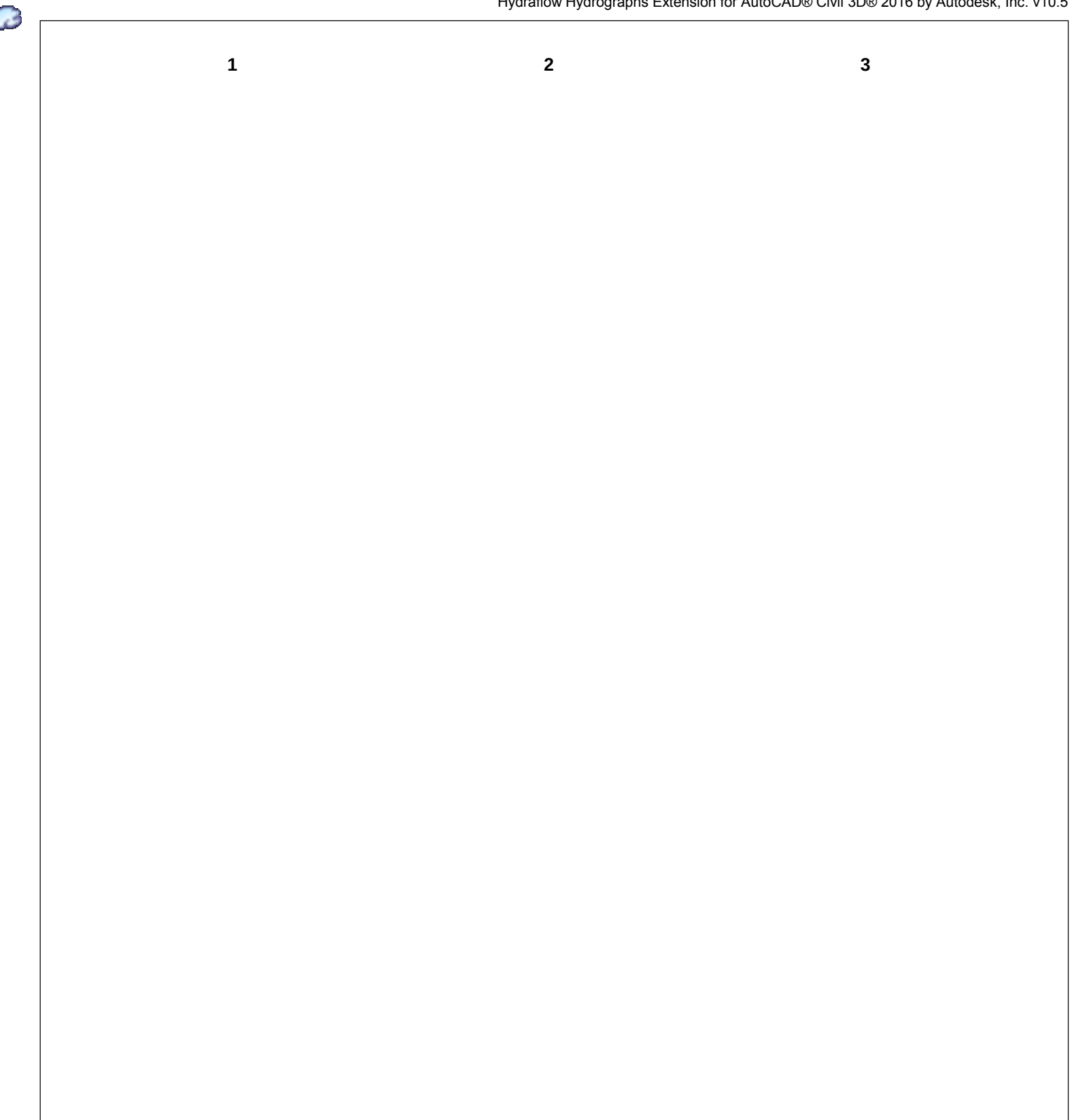
Watershed Model Schematic



Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-055E Pre
2	SCS Runoff	DA-FR-055E Dev
3	SCS Runoff	DA-FR-055E For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.567	2.782	-------	-------	11.07	-------	-------	-------	DA-FR-055E Pre
2	SCS Runoff	------	0.838	1.568	-------	-------	7.122	-------	-------	-------	DA-FR-055E Dev
3	SCS Runoff	------	0.669	1.331	-------	-------	6.650	-------	-------	-------	DA-FR-055E For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.567	1	717	4,306	------	------	------	DA-FR-055E Pre
2	SCS Runoff	0.838	1	726	4,593	------	------	------	DA-FR-055E Dev
3	SCS Runoff	0.669	1	726	4,143	------	------	------	DA-FR-055E For

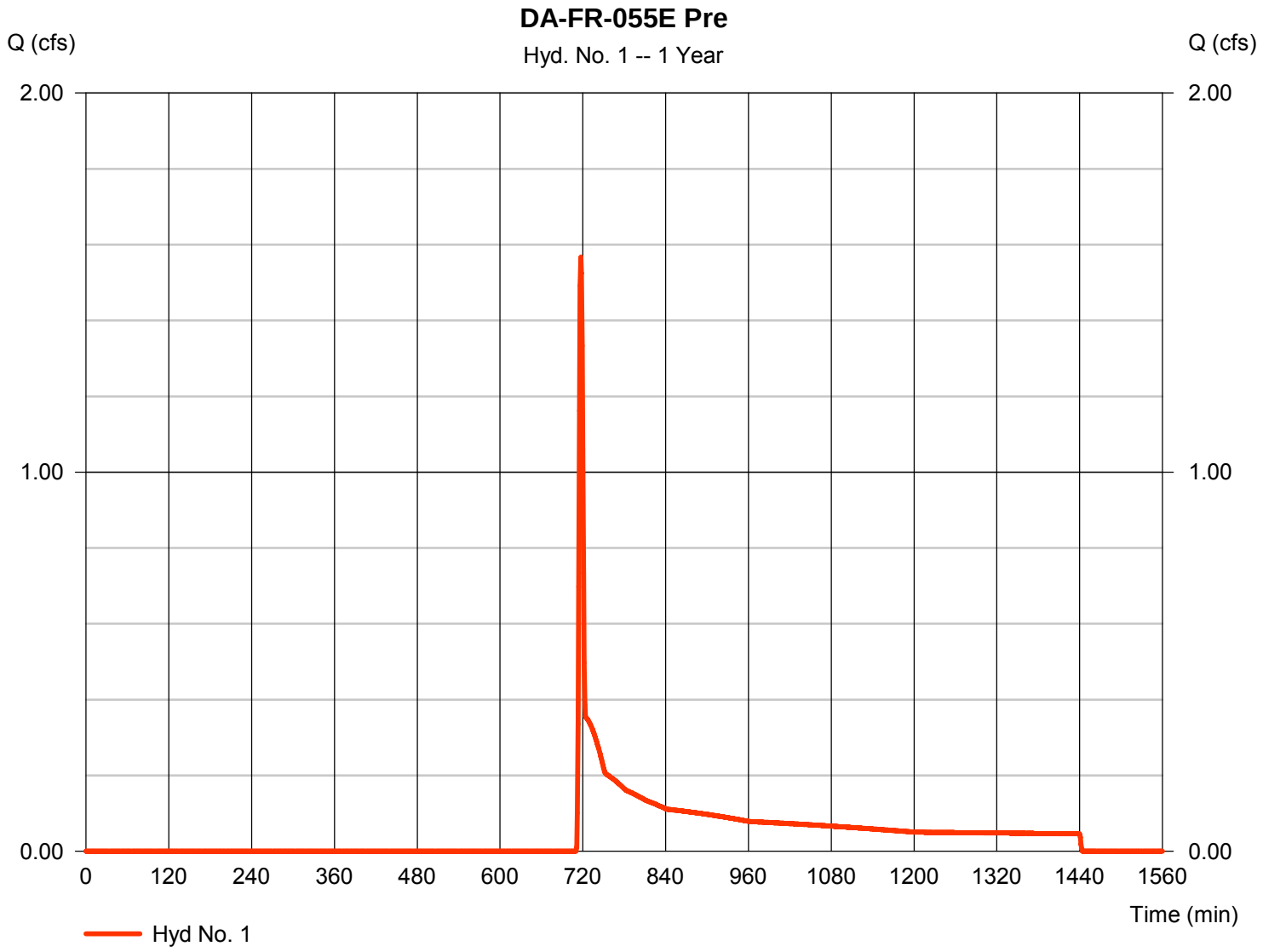
Hydrograph Report

Hyd. No. 1

DA-FR-055E Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.567 cfs
Storm frequency	= 1 yrs	Time to peak	= 717 min
Time interval	= 1 min	Hyd. volume	= 4,306 cuft
Drainage area	= 4.060 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.020 x 98) + (0.720 x 58) + (0.040 x 100) + (3.280 x 55)] / 4.060



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-055E Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.011		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 6.12		0.00		0.00		
Travel Time (min)	**= 0.72**	**+**	**0.00**	**+**	**0.00**	**=**	**0.72**
Shallow Concentrated Flow							
Flow length (ft)	= 818.27		0.00		0.00		
Watercourse slope (%)	= 13.92		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.02		0.00		0.00		
Travel Time (min)	**= 2.27**	**+**	**0.00**	**+**	**0.00**	**=**	**2.27**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 3.00 min

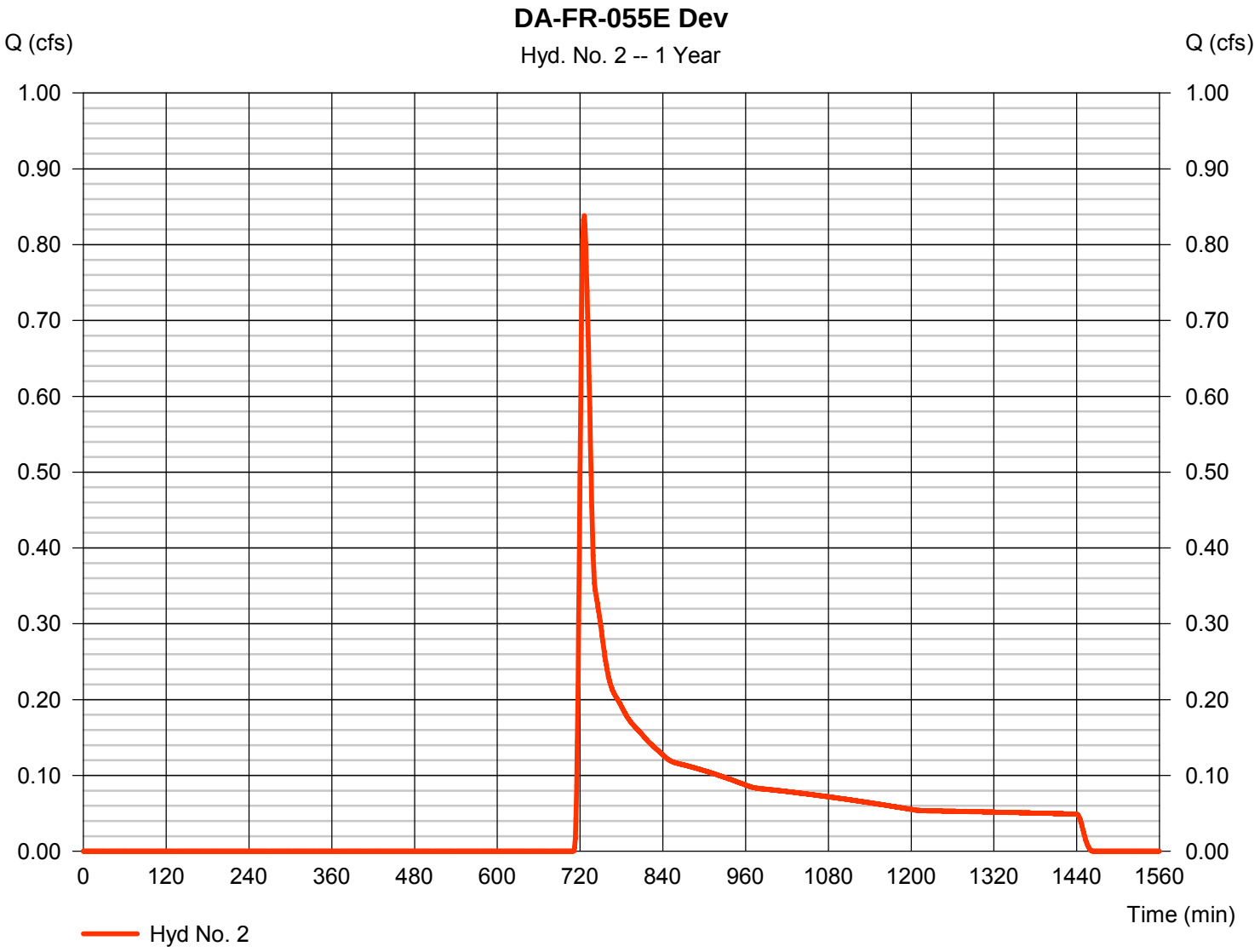
Hydrograph Report

Hyd. No. 2

DA-FR-055E Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.838 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 4,593 cuft
Drainage area	= 4.060 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.130 x 48) + (0.020 x 98) + (0.890 x 58) + (0.040 x 100) + (2.980 x 55)] / 4.060



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-055E Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 6.12		0.00		0.00		
Travel Time (min)	**= 12.77**	**+**	**0.00**	**+**	**0.00**	**=**	**12.77**
Shallow Concentrated Flow							
Flow length (ft)	= 818.27		0.00		0.00		
Watercourse slope (%)	= 13.92		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.02		0.00		0.00		
Travel Time (min)	**= 2.27**	**+**	**0.00**	**+**	**0.00**	**=**	**2.27**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

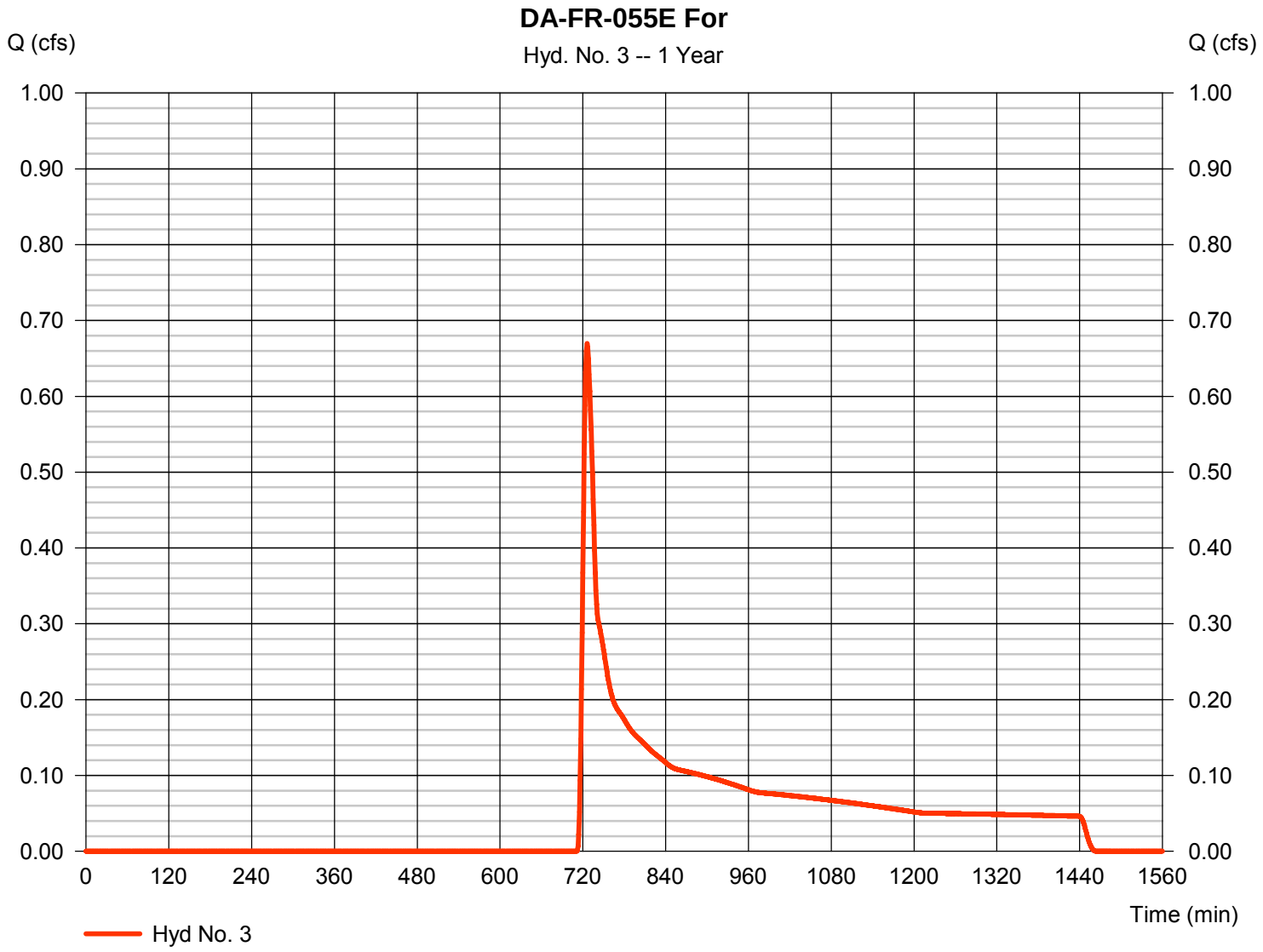
Total Travel Time, Tc ..... 15.00 min

Hydrograph Report

Hyd. No. 3

DA-FR-055E For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.669 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 4,143 cuft
Drainage area	= 4.060 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-055E For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 6.12		0.00		0.00		
Travel Time (min)	**= 12.77**	**+**	**0.00**	**+**	**0.00**	**=**	**12.77**
Shallow Concentrated Flow							
Flow length (ft)	= 818.27		0.00		0.00		
Watercourse slope (%)	= 13.92		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.02		0.00		0.00		
Travel Time (min)	**= 2.27**	**+**	**0.00**	**+**	**0.00**	**=**	**2.27**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 15.00 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	2.782	1	716	6,268	------	------	------	DA-FR-055E Pre
2	SCS Runoff	1.568	1	725	6,686	------	------	------	DA-FR-055E Dev
3	SCS Runoff	1.331	1	725	6,125	------	------	------	DA-FR-055E For

Hydrograph Report

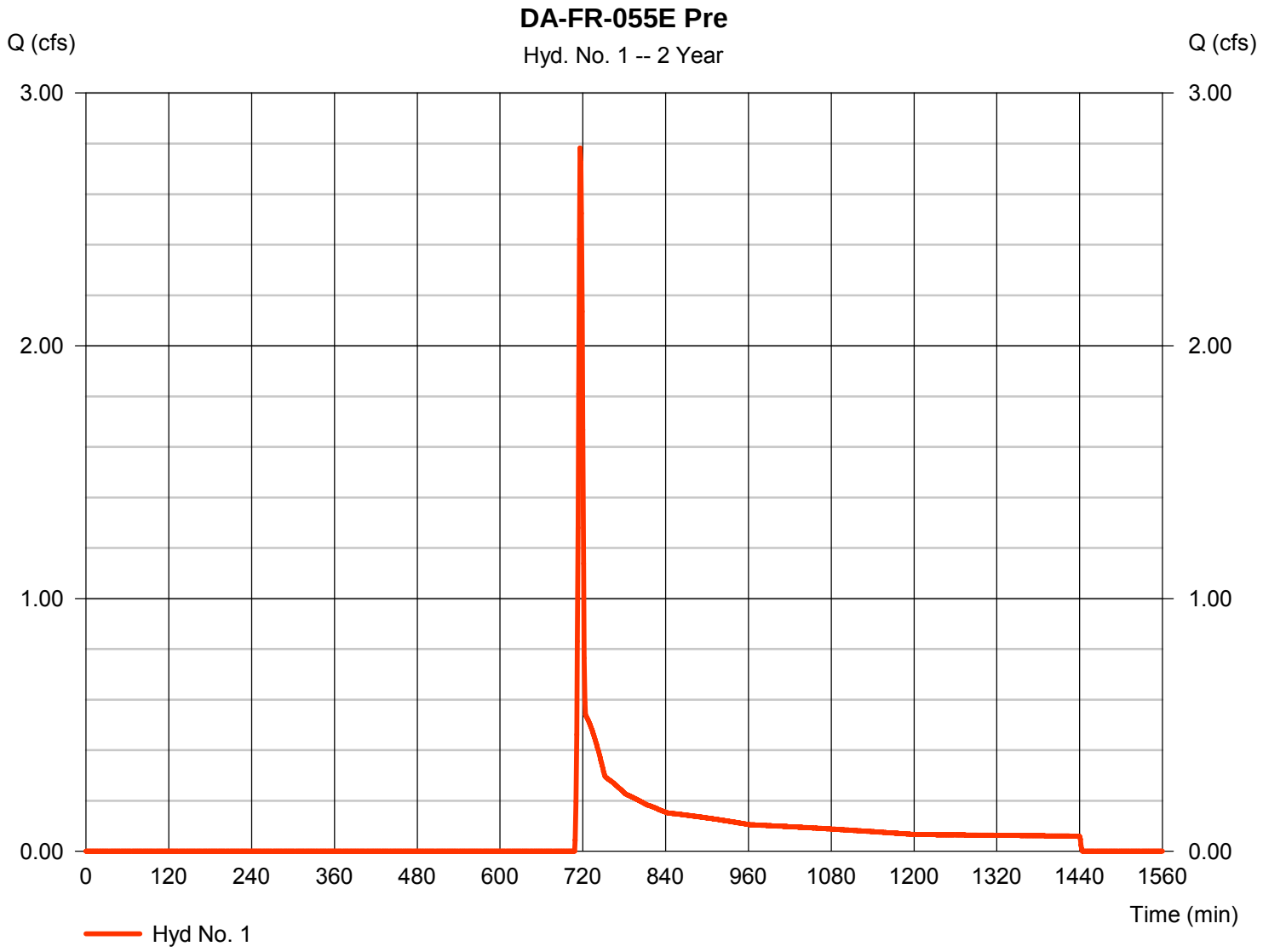
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 1

DA-FR-055E Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 2.782 cfs
Storm frequency	= 2 yrs	Time to peak	= 716 min
Time interval	= 1 min	Hyd. volume	= 6,268 cuft
Drainage area	= 4.060 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.020 x 98) + (0.720 x 58) + (0.040 x 100) + (3.280 x 55)] / 4.060



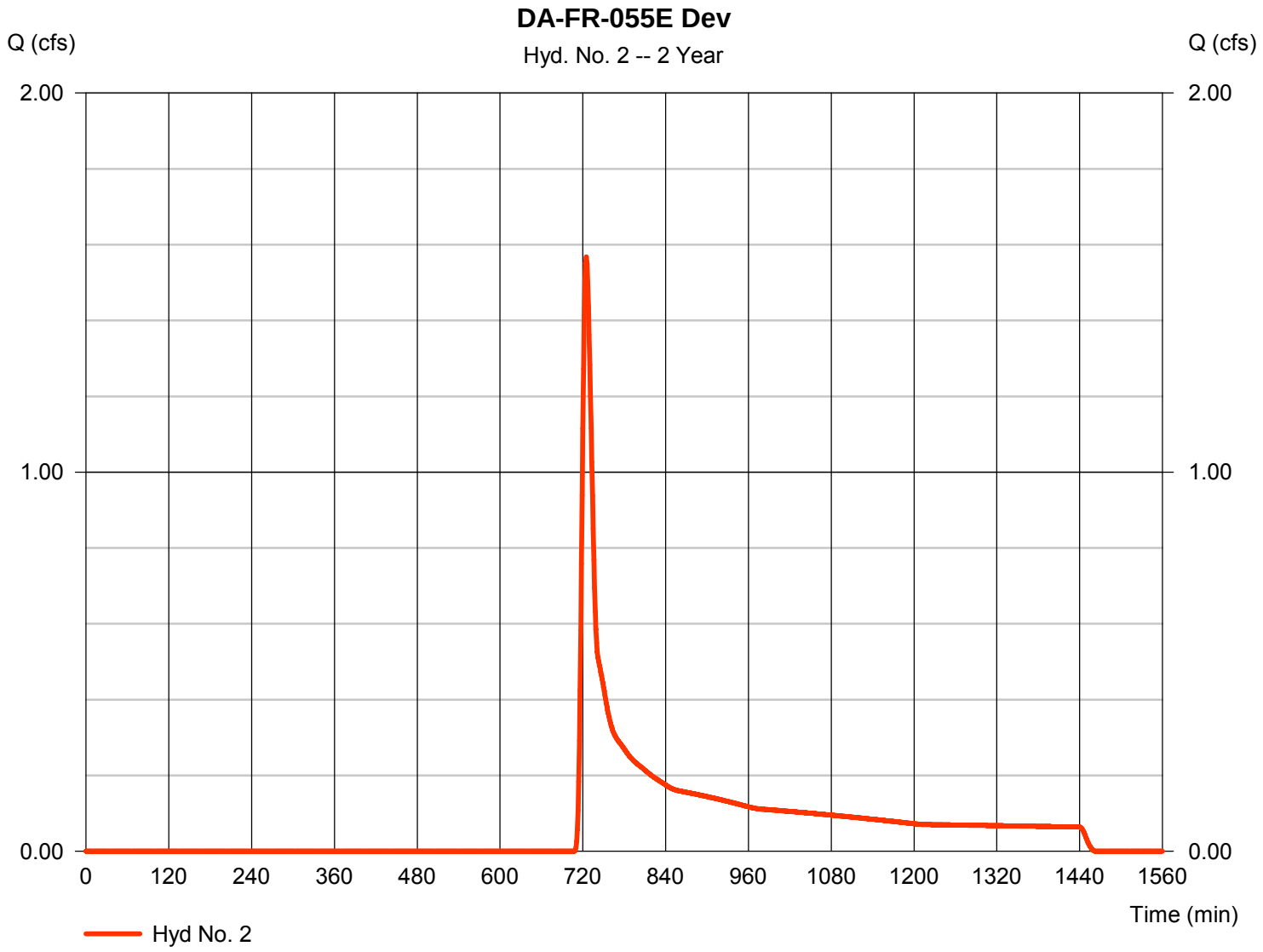
Hydrograph Report

Hyd. No. 2

DA-FR-055E Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 1.568 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 6,686 cuft
Drainage area	= 4.060 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.130 x 48) + (0.020 x 98) + (0.890 x 58) + (0.040 x 100) + (2.980 x 55)] / 4.060

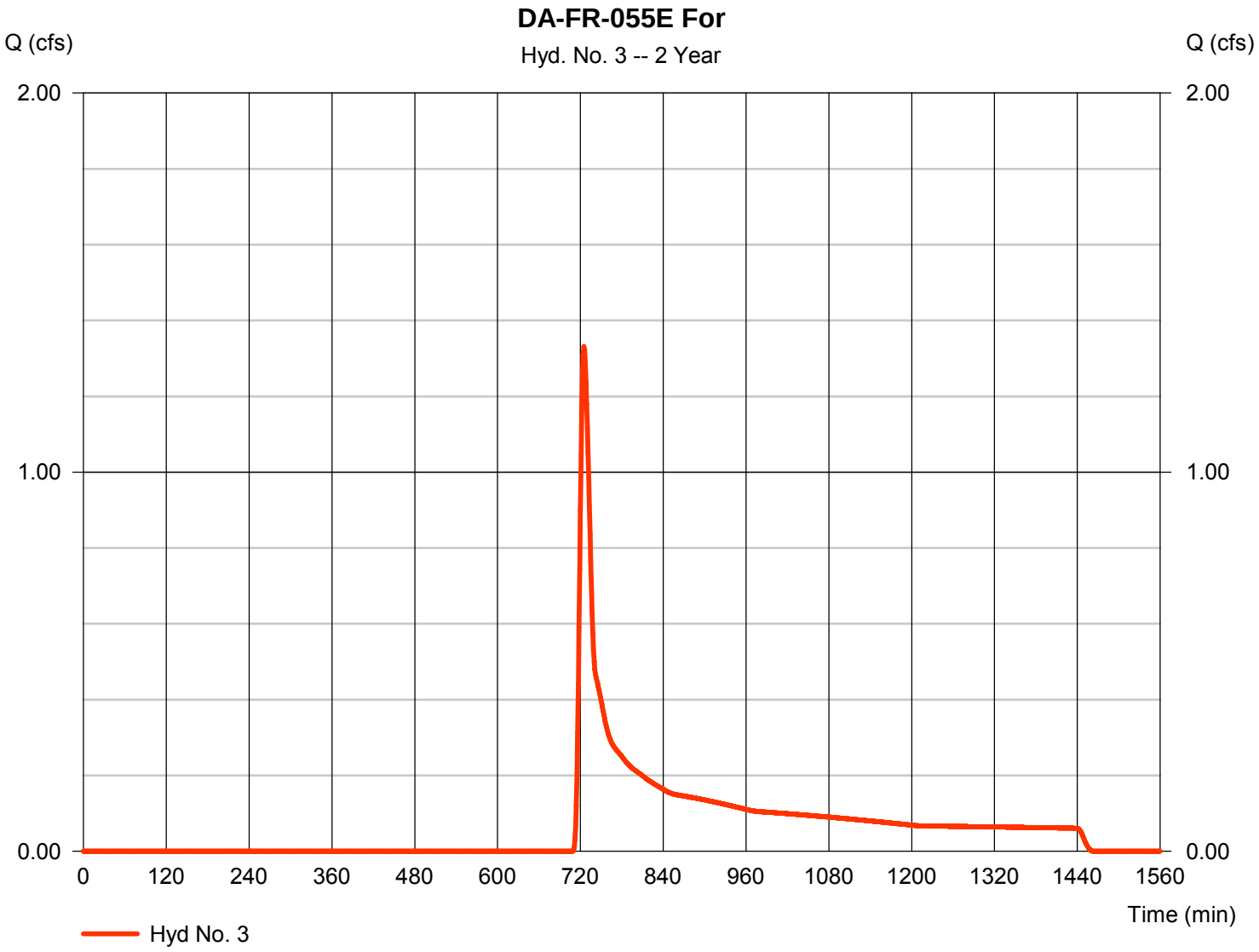


Hydrograph Report

Hyd. No. 3

DA-FR-055E For

Hydrograph type	= SCS Runoff	Peak discharge	= 1.331 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 6,125 cuft
Drainage area	= 4.060 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	11.07	1	716	19,649	------	------	------	DA-FR-055E Pre
2	SCS Runoff	7.122	1	723	20,959	------	------	------	DA-FR-055E Dev
3	SCS Runoff	6.650	1	723	19,874	------	------	------	DA-FR-055E For

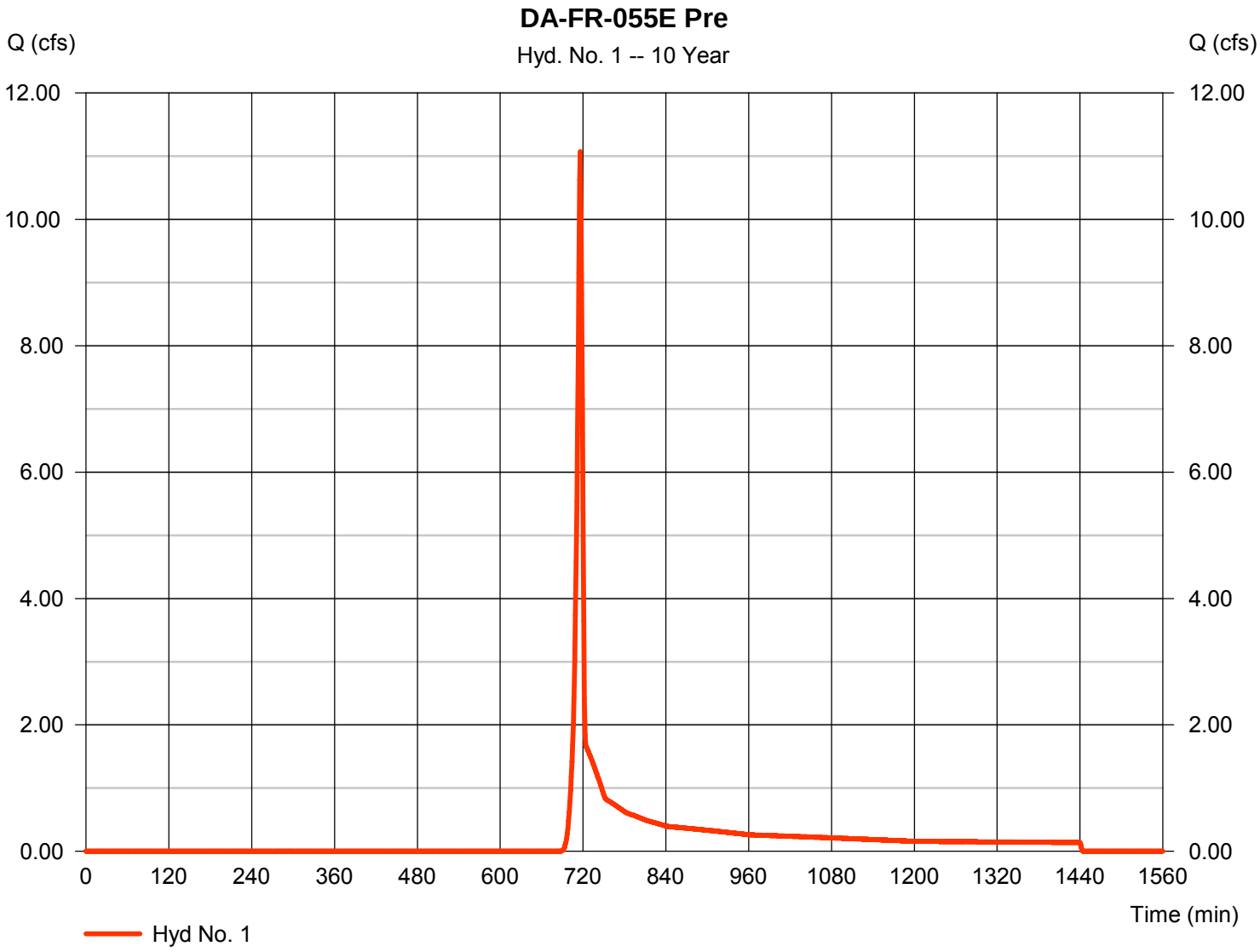
Hydrograph Report

Hyd. No. 1

DA-FR-055E Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 11.07 cfs
Storm frequency	= 10 yrs	Time to peak	= 716 min
Time interval	= 1 min	Hyd. volume	= 19,649 cuft
Drainage area	= 4.060 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 3.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.020 x 98) + (0.720 x 58) + (0.040 x 100) + (3.280 x 55)] / 4.060



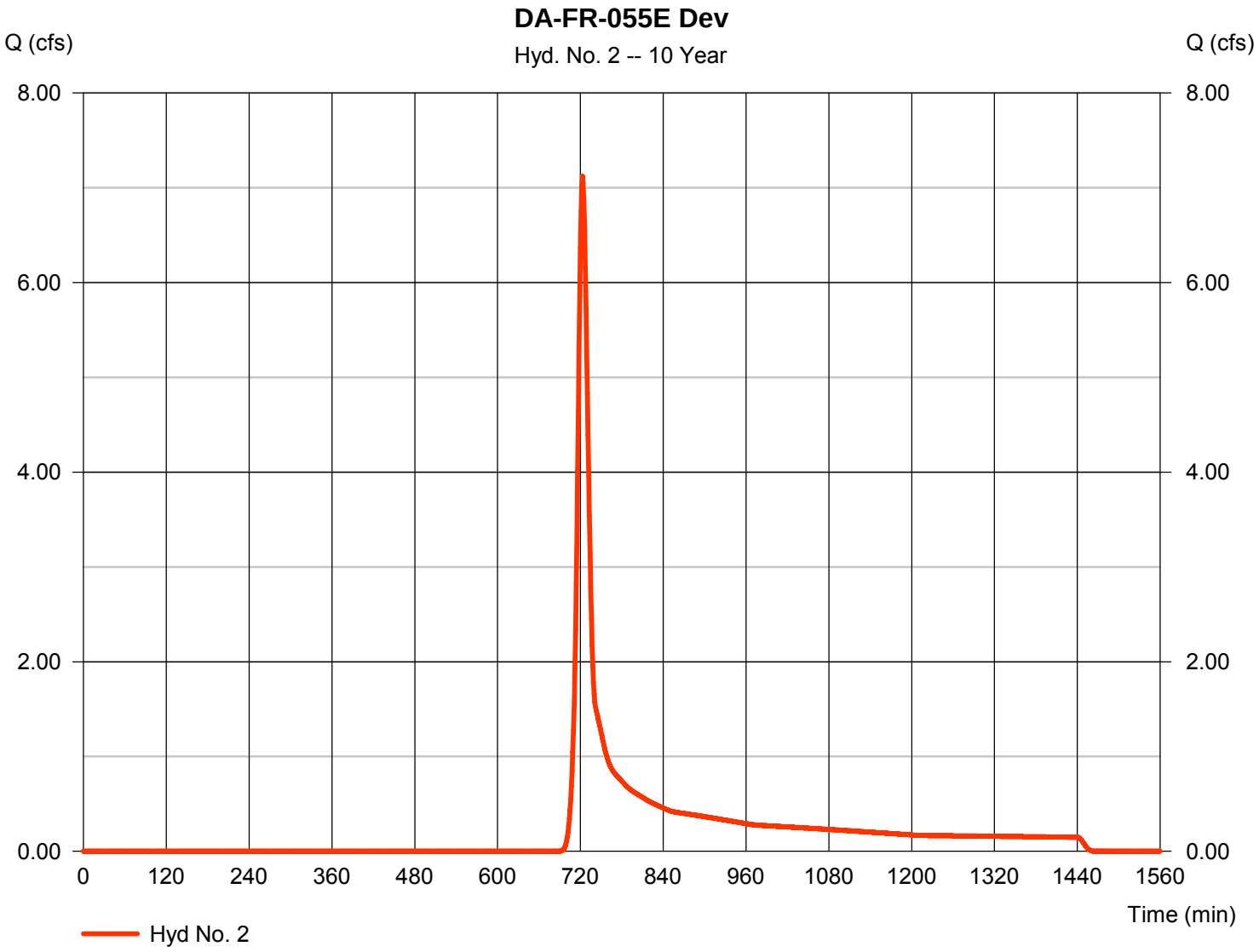
Hydrograph Report

Hyd. No. 2

DA-FR-055E Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 7.122 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 20,959 cuft
Drainage area	= 4.060 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.130 x 48) + (0.020 x 98) + (0.890 x 58) + (0.040 x 100) + (2.980 x 55)] / 4.060

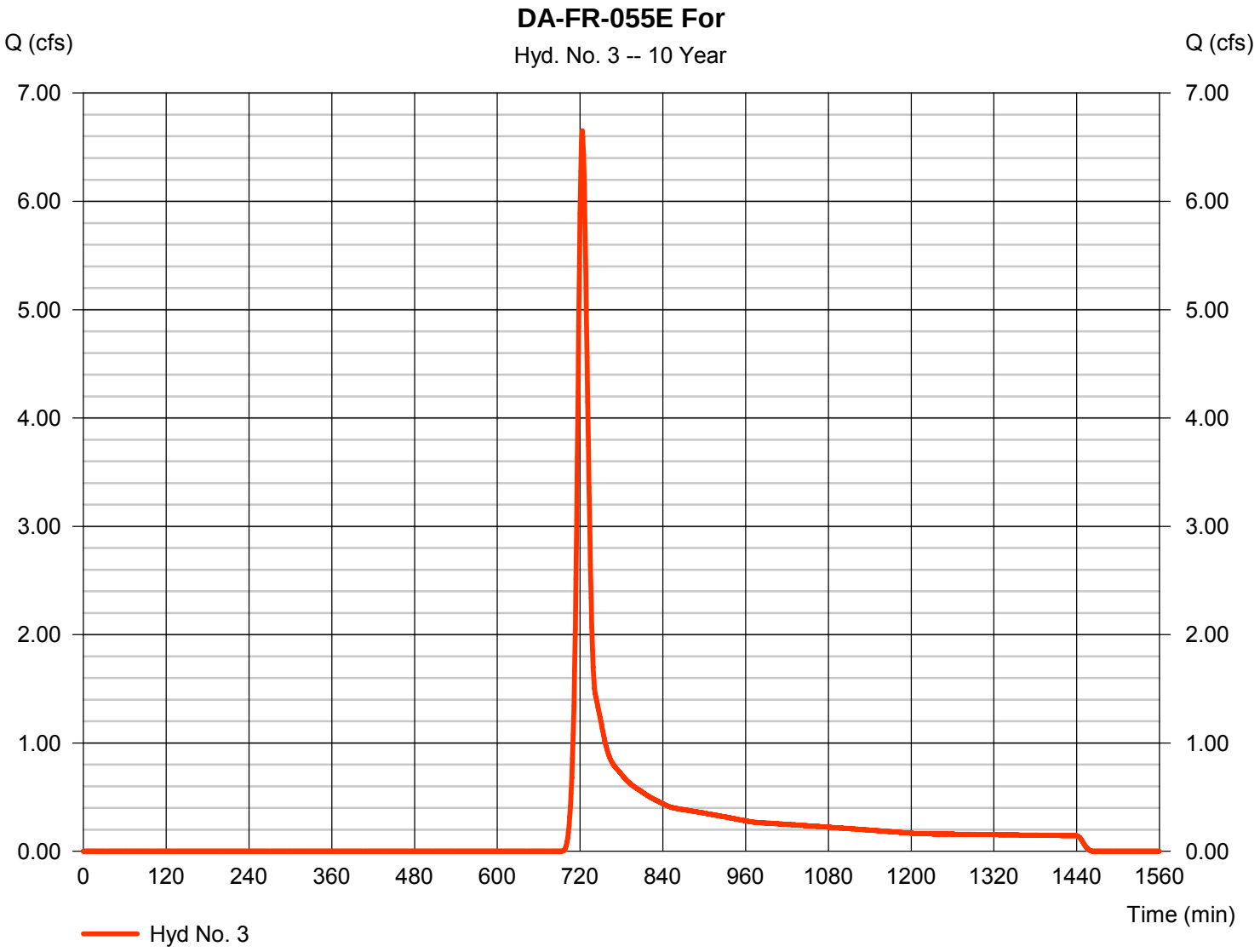


Hydrograph Report

Hyd. No. 3

DA-FR-055E For

Hydrograph type	= SCS Runoff	Peak discharge	= 6.650 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 19,874 cuft
Drainage area	= 4.060 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

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Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-055F

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	3.043	12899
Developed Condition	3.043	12899
Pre-Developed (Forest) Condition	1.986	10552

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1: $Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ----------> 3.043 ≤ 3.043 OK

Check #2: $Q_{developed} \leq Q_{pre\text{-}developed}$ ----------> 3.043 ≤ 3.043 OK

Check #3: $Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ ---> 3.043 *shall not* be required to be ≤ 1.625

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

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Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-055F Pre
2	SCS Runoff	DA-FR-055F Dev
3	SCS Runoff	DA-FR-055F For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	3.043	5.365	-------	-------	21.90	-------	-------	-------	DA-FR-055F Pre
2	SCS Runoff	------	3.043	5.365	-------	-------	21.90	-------	-------	-------	DA-FR-055F Dev
3	SCS Runoff	------	1.986	3.955	-------	-------	19.24	-------	-------	-------	DA-FR-055F For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	3.043	1	723	12,899	------	------	------	DA-FR-055F Pre
2	SCS Runoff	3.043	1	723	12,899	------	------	------	DA-FR-055F Dev
3	SCS Runoff	1.986	1	724	10,552	------	------	------	DA-FR-055F For

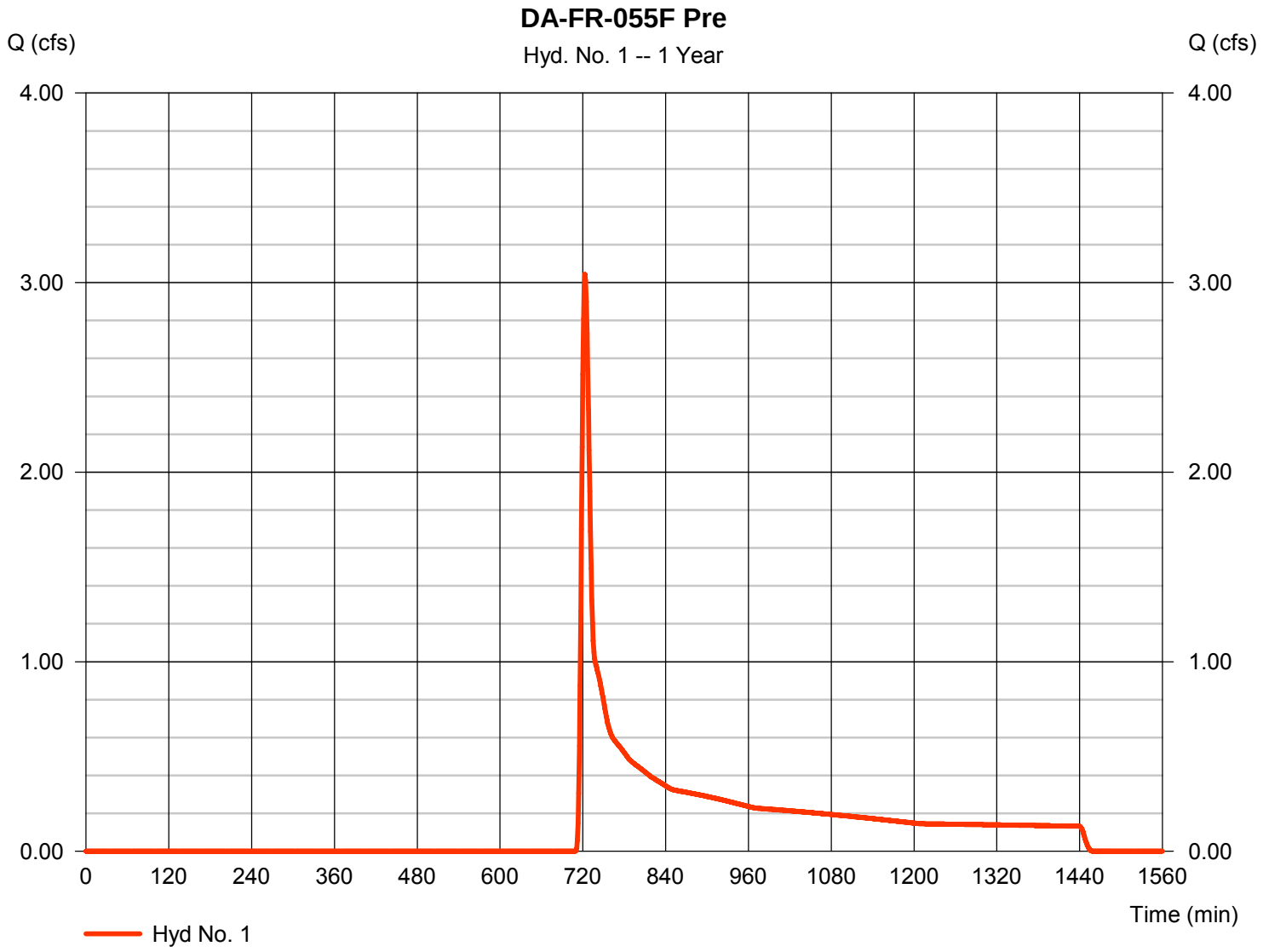
Hydrograph Report

Hyd. No. 1

DA-FR-055F Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 3.043 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 12,899 cuft
Drainage area	= 10.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.007 x 85) + (0.259 x 98) + (2.835 x 58) + (7.060 x 55)] / 10.160



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-055F Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.110		0.400		0.011		
Flow length (ft)	= 22.0		78.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 3.74		14.48		0.00		
Travel Time (min)	**= 1.65**	**+**	**7.41**	**+**	**0.00**	**=**	**9.06**
Shallow Concentrated Flow							
Flow length (ft)	= 623.17		0.00		0.00		
Watercourse slope (%)	= 15.99		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.45		0.00		0.00		
Travel Time (min)	**= 1.61**	**+**	**0.00**	**+**	**0.00**	**=**	**1.61**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 10.70 min

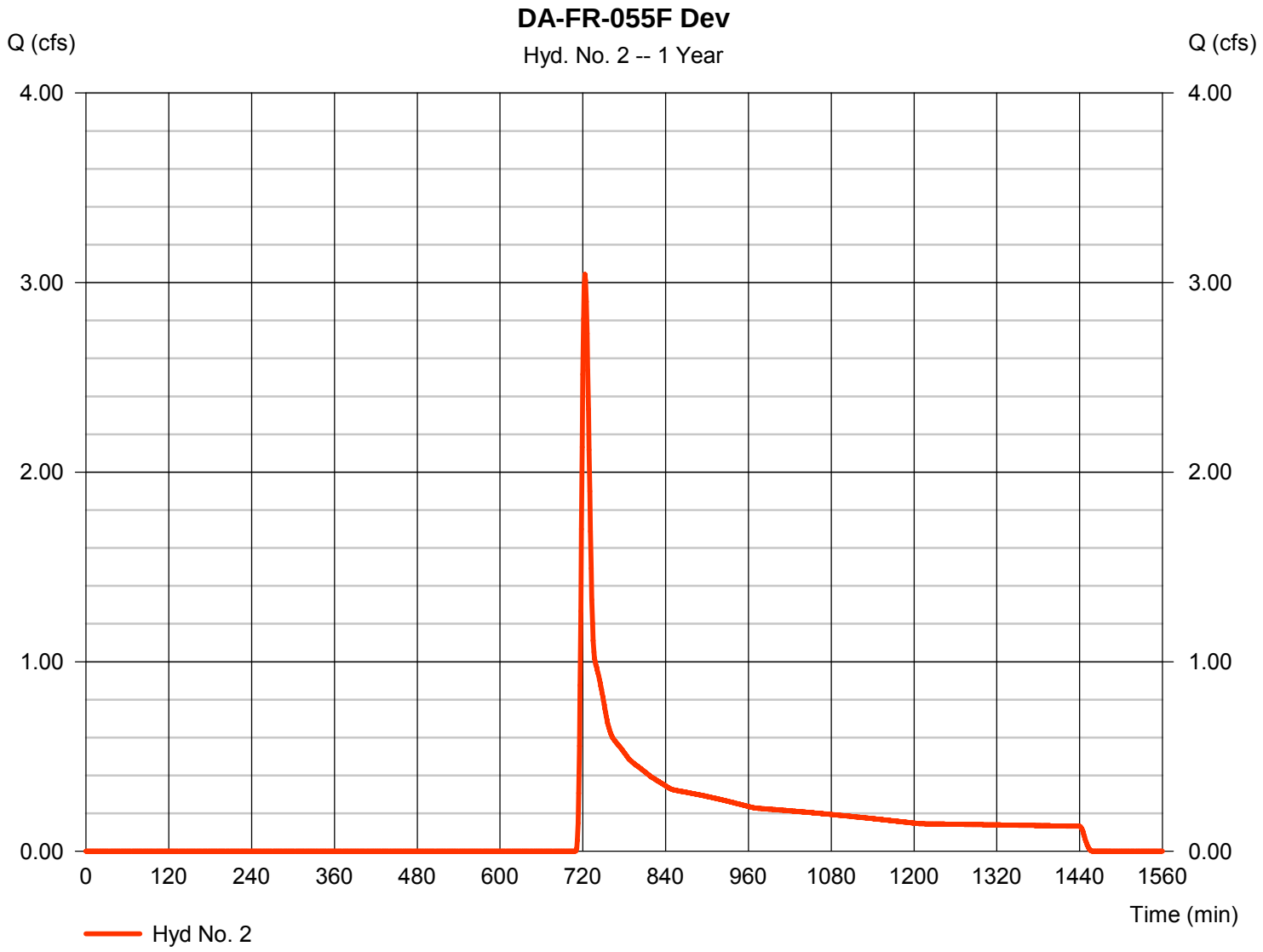
Hydrograph Report

Hyd. No. 2

DA-FR-055F Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 3.043 cfs
Storm frequency	= 1 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 12,899 cuft
Drainage area	= 10.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.195 x 48) + (0.007 x 85) + (0.259 x 98) + (3.135 x 58) + (6.566 x 55)] / 10.160



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-055F Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.110		0.400		0.011		
Flow length (ft)	= 22.0		78.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 3.74		14.48		0.00		
Travel Time (min)	**= 1.65**	**+**	**7.41**	**+**	**0.00**	**=**	**9.06**
Shallow Concentrated Flow							
Flow length (ft)	= 623.17		0.00		0.00		
Watercourse slope (%)	= 15.99		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.45		0.00		0.00		
Travel Time (min)	**= 1.61**	**+**	**0.00**	**+**	**0.00**	**=**	**1.61**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

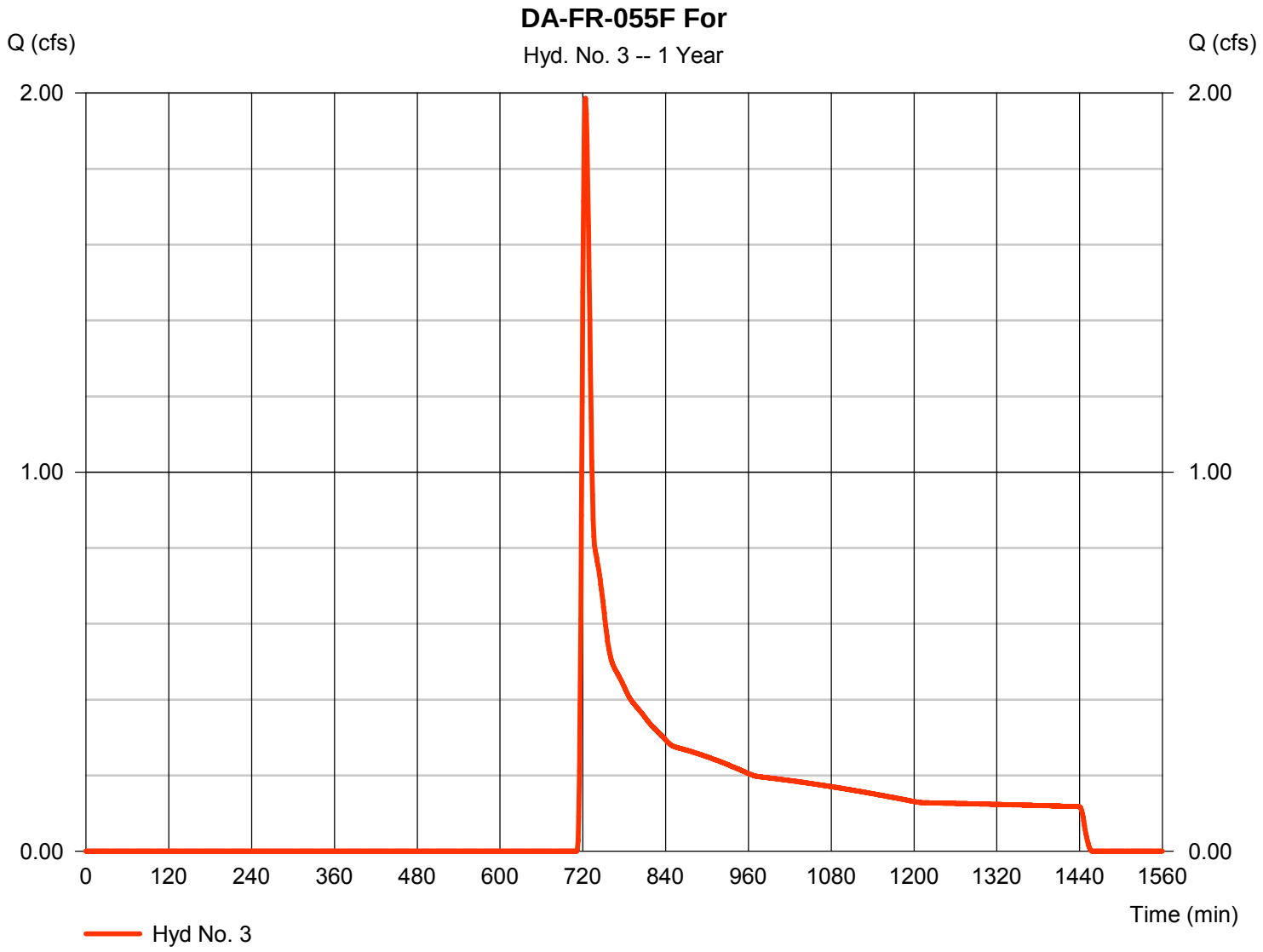
Total Travel Time, Tc ..... 10.70 min

Hydrograph Report

Hyd. No. 3

DA-FR-055F For

Hydrograph type	= SCS Runoff	Peak discharge	= 1.986 cfs
Storm frequency	= 1 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 10,552 cuft
Drainage area	= 10.160 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-055F For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.110		0.400		0.011		
Flow length (ft)	= 22.0		78.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 3.74		14.48		0.00		
Travel Time (min)	**= 1.65**	**+**	**7.41**	**+**	**0.00**	**=**	**9.06**
Shallow Concentrated Flow							
Flow length (ft)	= 623.17		0.00		0.00		
Watercourse slope (%)	= 15.99		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=6.45		0.00		0.00		
Travel Time (min)	**= 1.61**	**+**	**0.00**	**+**	**0.00**	**=**	**1.61**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 10.70 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	5.365	1	722	18,512	------	------	------	DA-FR-055F Pre
2	SCS Runoff	5.365	1	722	18,512	------	------	------	DA-FR-055F Dev
3	SCS Runoff	3.955	1	723	15,601	------	------	------	DA-FR-055F For

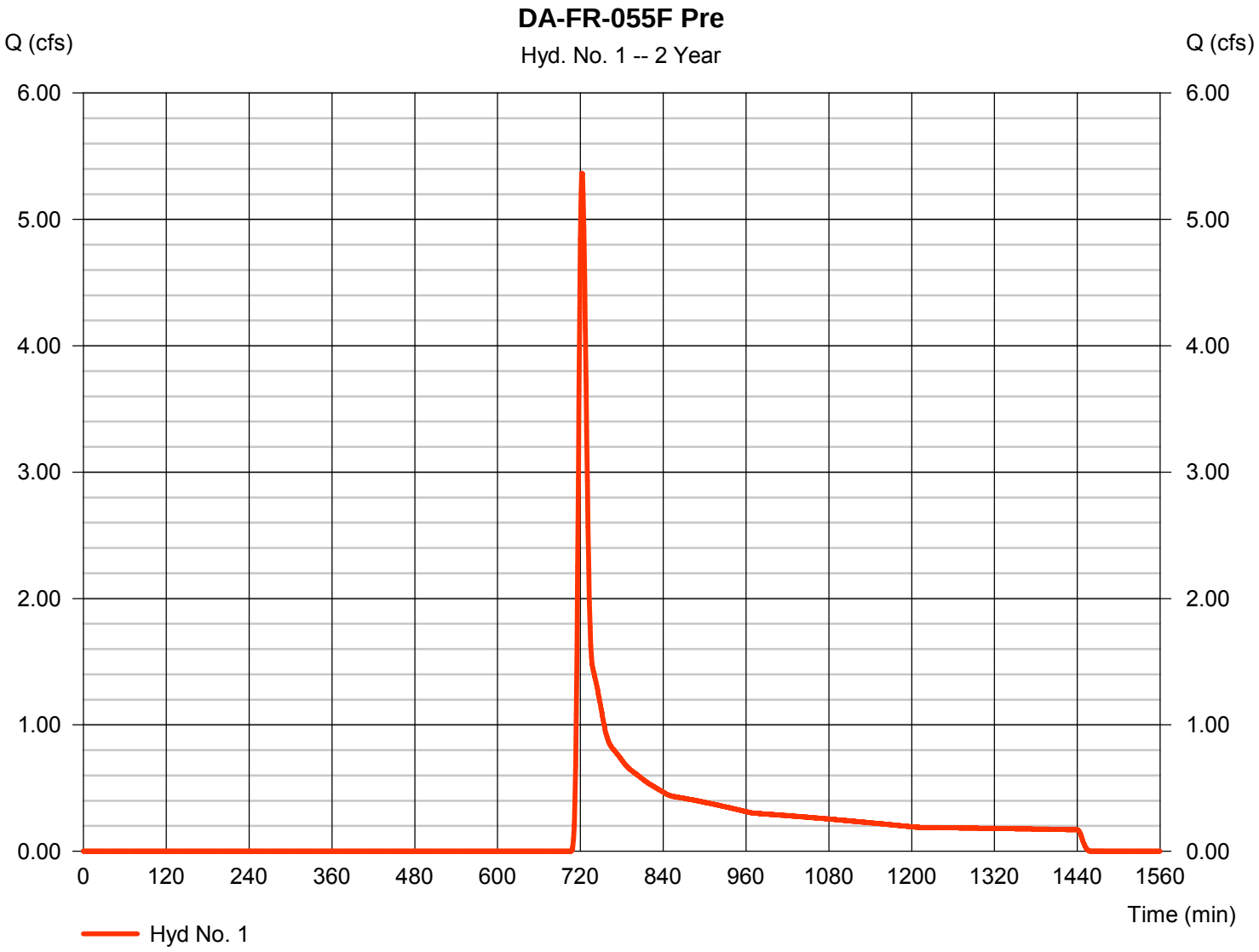
Hydrograph Report

Hyd. No. 1

DA-FR-055F Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 5.365 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 18,512 cuft
Drainage area	= 10.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.007 x 85) + (0.259 x 98) + (2.835 x 58) + (7.060 x 55)] / 10.160



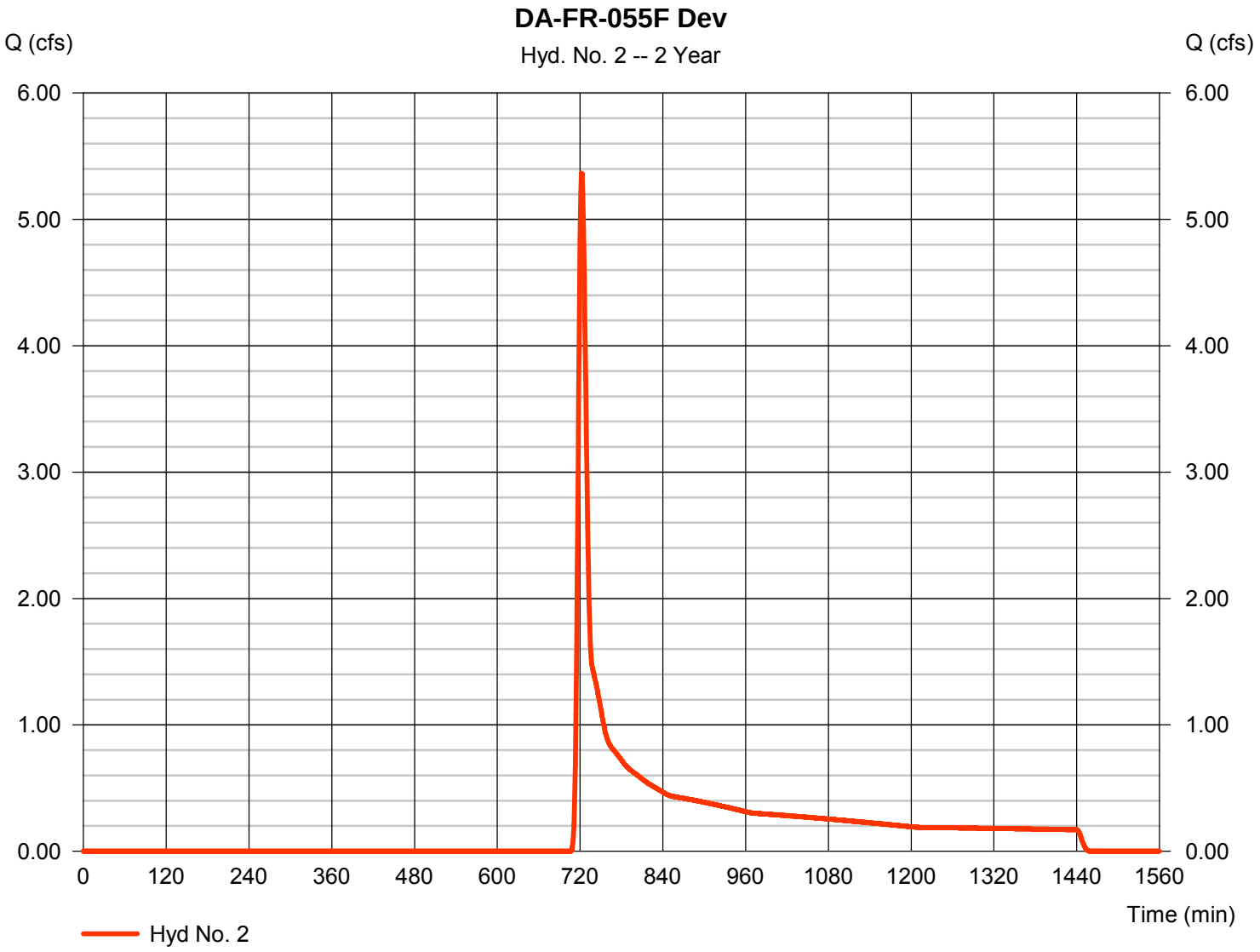
Hydrograph Report

Hyd. No. 2

DA-FR-055F Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 5.365 cfs
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 18,512 cuft
Drainage area	= 10.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.195 x 48) + (0.007 x 85) + (0.259 x 98) + (3.135 x 58) + (6.566 x 55)] / 10.160

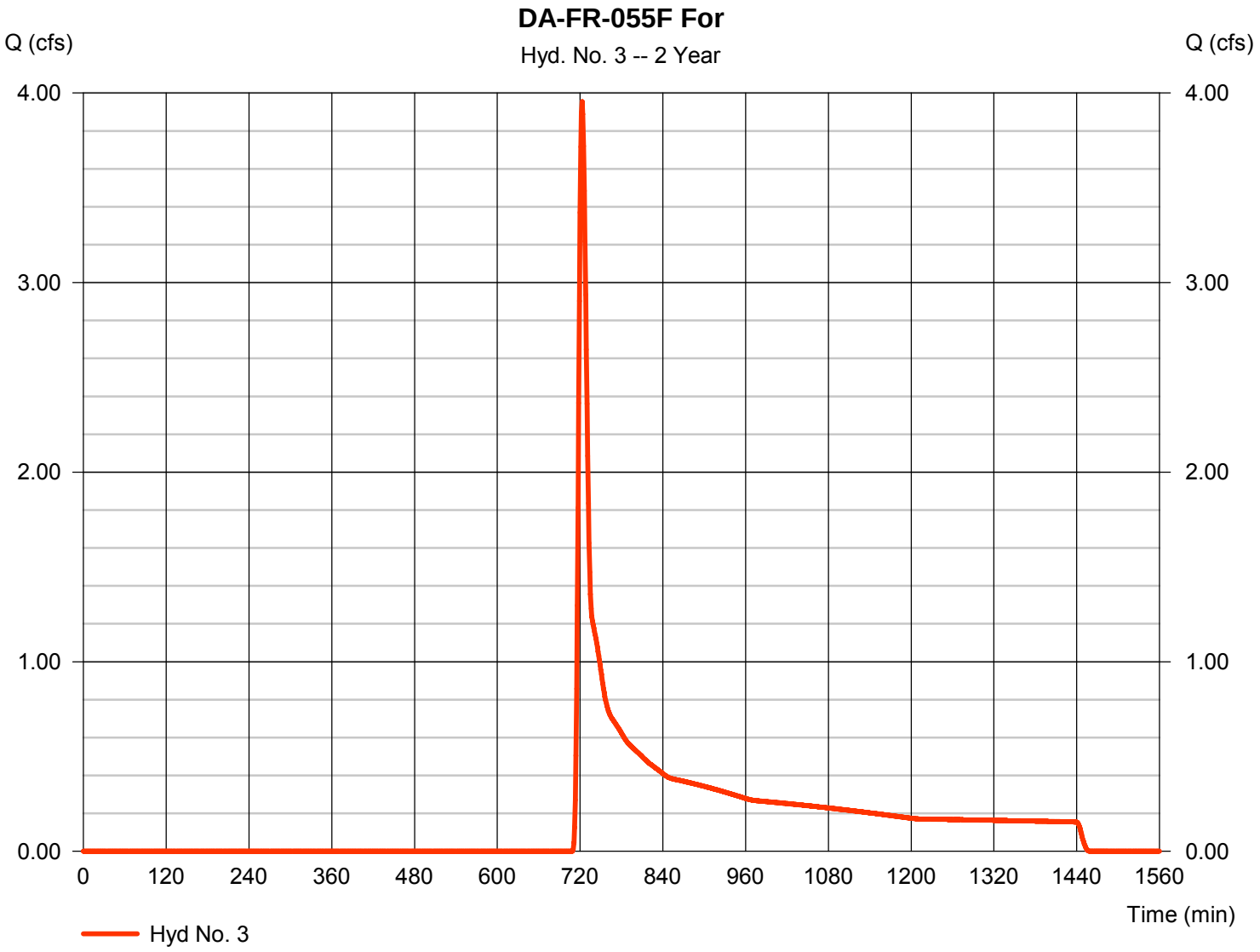


Hydrograph Report

Hyd. No. 3

DA-FR-055F For

Hydrograph type	= SCS Runoff	Peak discharge	= 3.955 cfs
Storm frequency	= 2 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 15,601 cuft
Drainage area	= 10.160 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	21.90	1	721	56,193	------	------	------	DA-FR-055F Pre
2	SCS Runoff	21.90	1	721	56,193	------	------	------	DA-FR-055F Dev
3	SCS Runoff	19.24	1	721	50,622	------	------	------	DA-FR-055F For

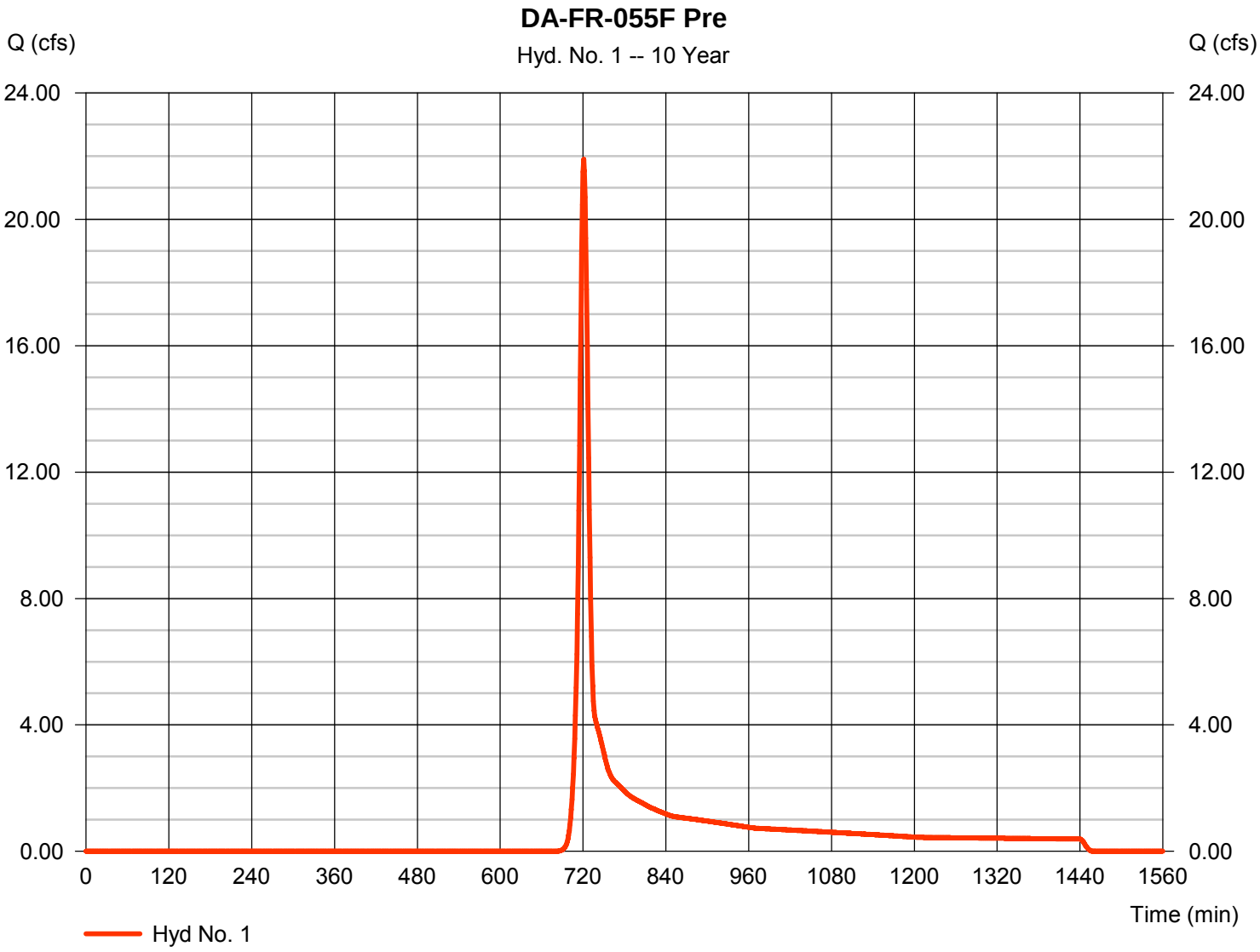
Hydrograph Report

Hyd. No. 1

DA-FR-055F Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 21.90 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 56,193 cuft
Drainage area	= 10.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.007 x 85) + (0.259 x 98) + (2.835 x 58) + (7.060 x 55)] / 10.160



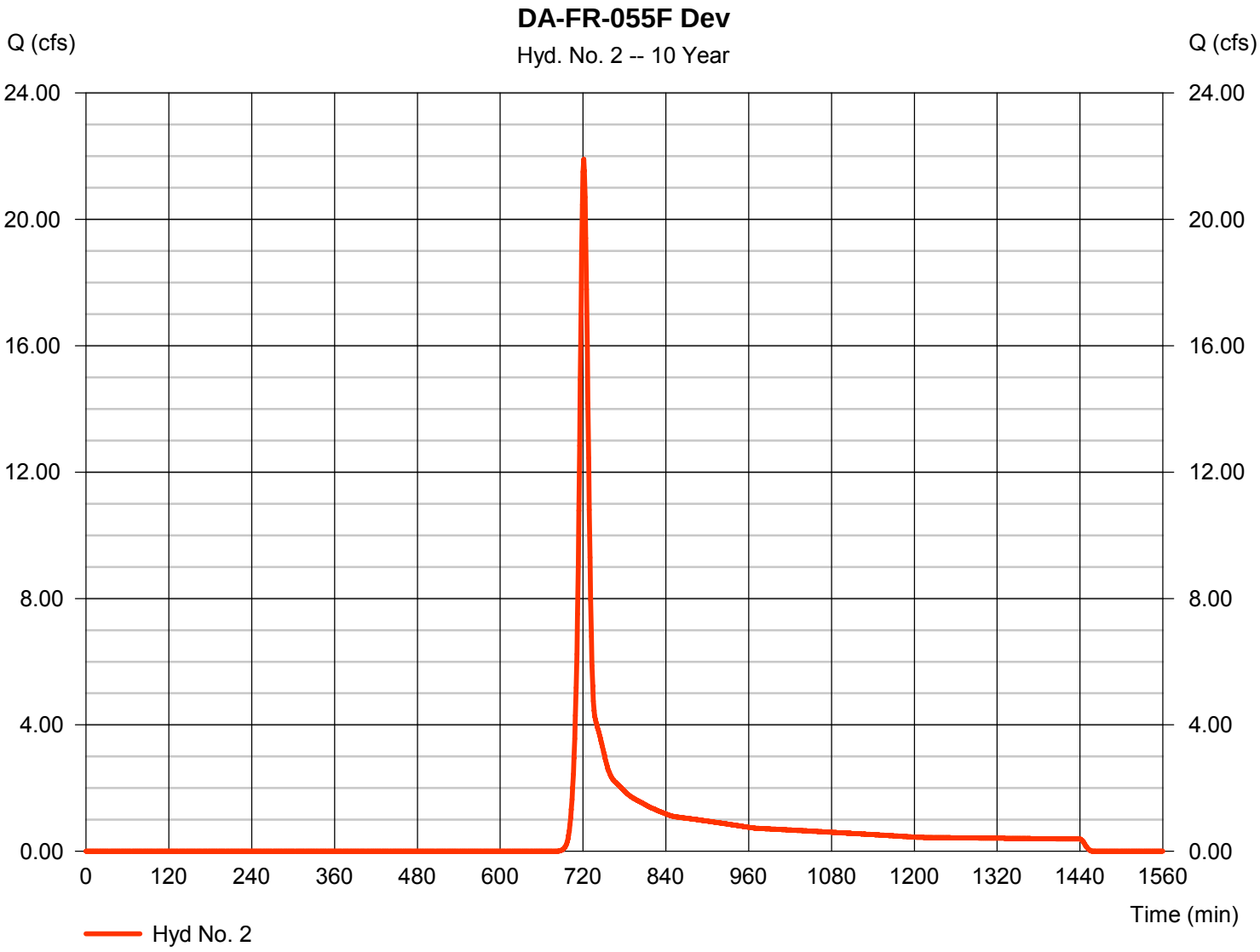
Hydrograph Report

Hyd. No. 2

DA-FR-055F Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 21.90 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 56,193 cuft
Drainage area	= 10.160 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.195 x 48) + (0.007 x 85) + (0.259 x 98) + (3.135 x 58) + (6.566 x 55)] / 10.160

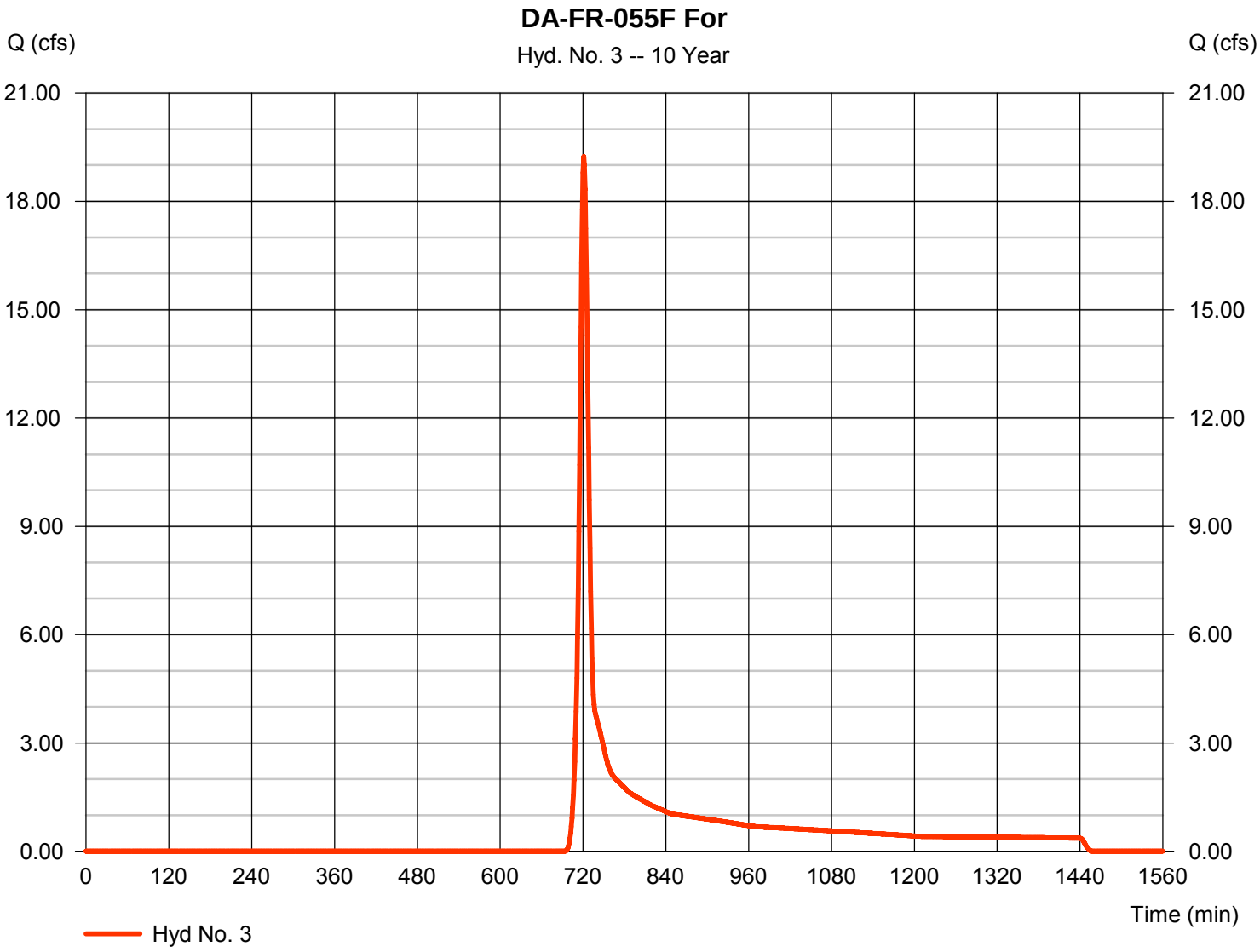


Hydrograph Report

Hyd. No. 3

DA-FR-055F For

Hydrograph type	= SCS Runoff	Peak discharge	= 19.24 cfs
Storm frequency	= 10 yrs	Time to peak	= 721 min
Time interval	= 1 min	Hyd. volume	= 50,622 cuft
Drainage area	= 10.160 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 10.70 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-055G

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.933	4229
Developed Condition	0.778	3854
Pre-Developed (Forest) Condition	0.509	3153

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 0.8

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.778	≤ OK	0.819
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.778	≤ OK	0.933
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.778	*shall not* be required to be ≤	0.416

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-055G Pre
2	SCS Runoff	DA-FR-055G Dev
3	SCS Runoff	DA-FR-055G For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.933	1.582	-------	-------	6.146	-------	-------	-------	DA-FR-055G Pre
2	SCS Runoff	------	0.778	1.382	-------	-------	5.782	-------	-------	-------	DA-FR-055G Dev
3	SCS Runoff	------	0.509	1.013	-------	-------	5.062	-------	-------	-------	DA-FR-055G For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	0.933	1	725	4,229	------	------	------	DA-FR-055G Pre
2	SCS Runoff	0.778	1	725	3,854	------	------	------	DA-FR-055G Dev
3	SCS Runoff	0.509	1	726	3,153	------	------	------	DA-FR-055G For

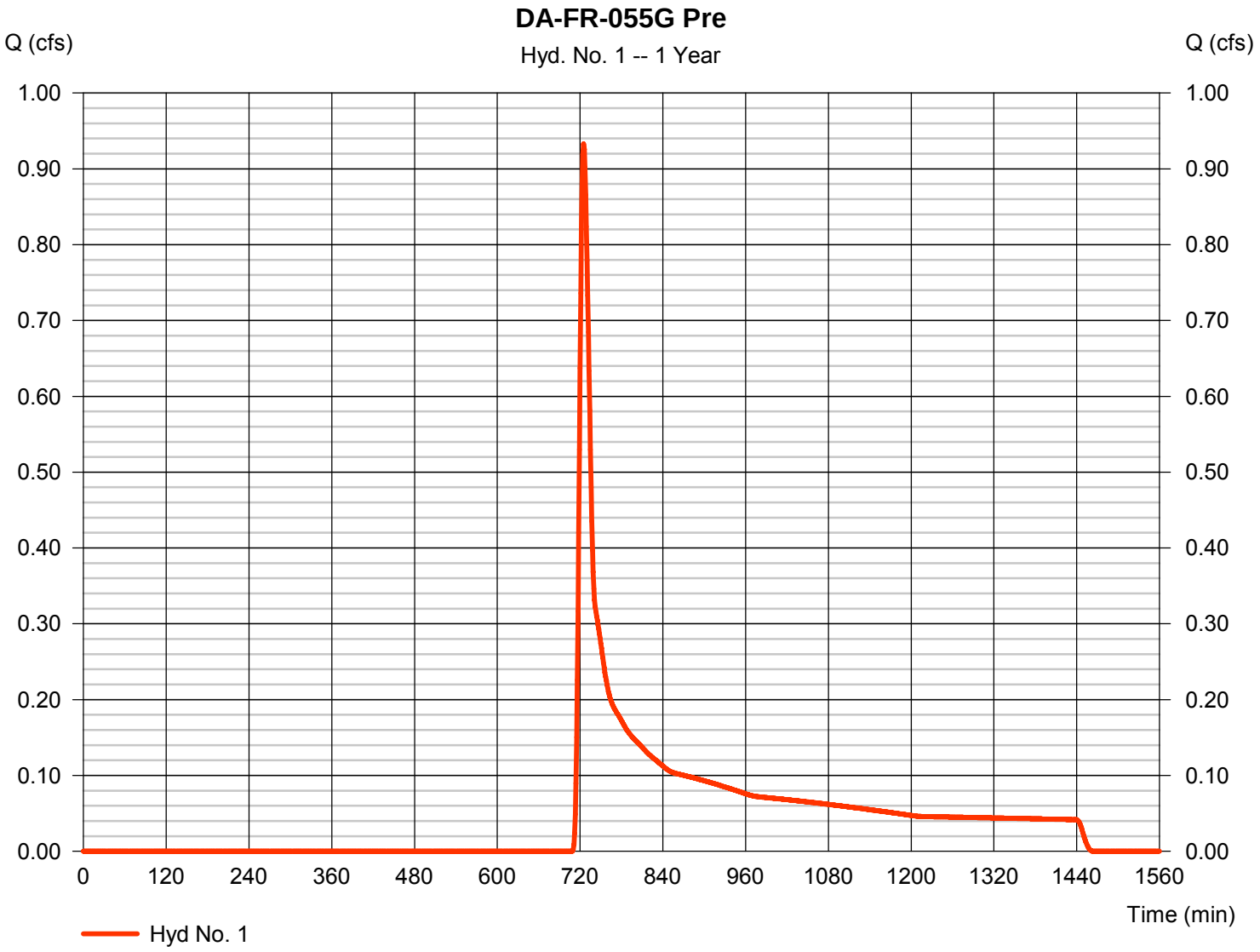
Hydrograph Report

Hyd. No. 1

DA-FR-055G Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.933 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 4,229 cuft
Drainage area	= 3.090 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.100 x 98) + (2.090 x 58) + (0.900 x 55)] / 3.090



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-055G Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.110		0.400		
Flow length (ft)	= 61.2		22.7		16.2		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.90		3.77		9.82		
Travel Time (min)	**= 9.42**	**+**	**1.68**	**+**	**2.46**	**=**	**13.56**
Shallow Concentrated Flow							
Flow length (ft)	= 218.18		0.00		0.00		
Watercourse slope (%)	= 25.71		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.18		0.00		0.00		
Travel Time (min)	**= 0.44**	**+**	**0.00**	**+**	**0.00**	**=**	**0.44**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.00 min

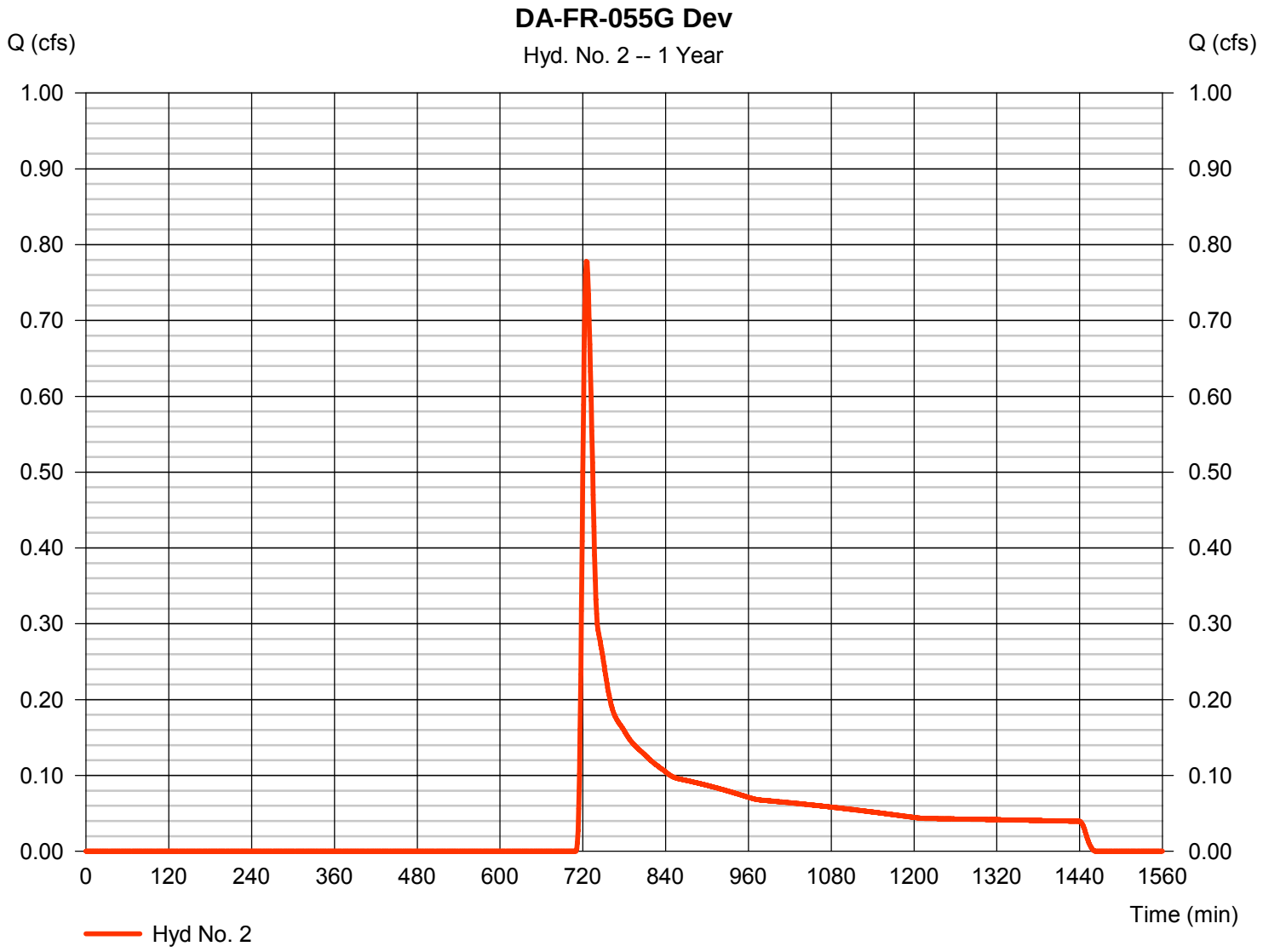
Hydrograph Report

Hyd. No. 2

DA-FR-055G Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.778 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 3,854 cuft
Drainage area	= 3.090 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.665 x 48) + (0.097 x 98) + (2.276 x 58) + (0.049 x 55)] / 3.090



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-055G Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.110		0.400		
Flow length (ft)	= 61.2		22.7		16.2		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.90		3.77		9.82		
Travel Time (min)	**= 9.42**	**+**	**1.68**	**+**	**2.46**	**=**	**13.56**
Shallow Concentrated Flow							
Flow length (ft)	= 218.18		0.00		0.00		
Watercourse slope (%)	= 25.71		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.18		0.00		0.00		
Travel Time (min)	**= 0.44**	**+**	**0.00**	**+**	**0.00**	**=**	**0.44**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

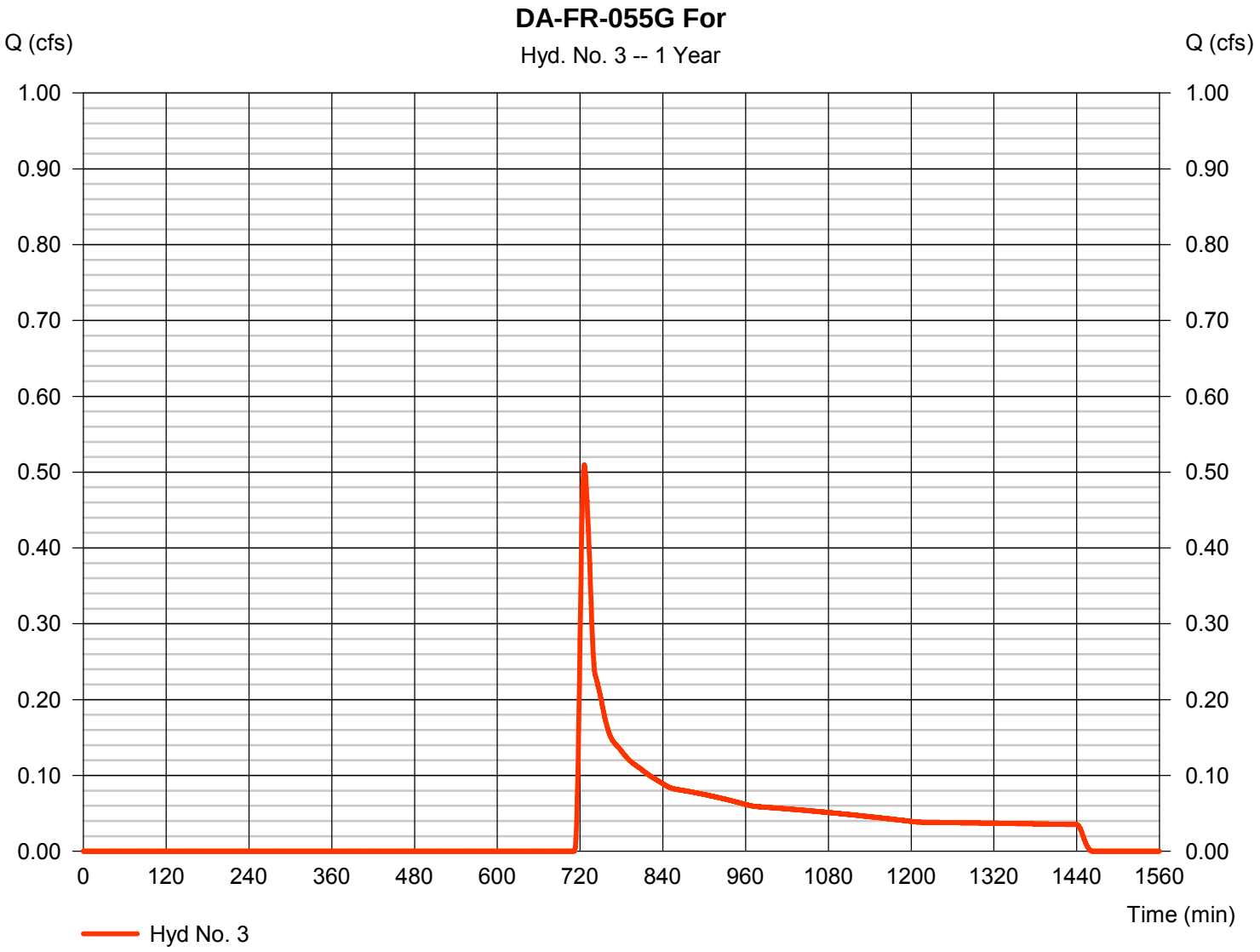
Total Travel Time, Tc ..... 14.00 min

Hydrograph Report

Hyd. No. 3

DA-FR-055G For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.509 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 3,153 cuft
Drainage area	= 3.090 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-055G For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.110		0.400		
Flow length (ft)	= 61.2		22.7		16.2		
Two-year 24-hr precip. (in)	= 3.70		3.70		3.70		
Land slope (%)	= 4.90		3.77		9.82		
Travel Time (min)	**= 9.42**	**+**	**1.68**	**+**	**2.46**	**=**	**13.56**
Shallow Concentrated Flow							
Flow length (ft)	= 218.18		0.00		0.00		
Watercourse slope (%)	= 25.71		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=8.18		0.00		0.00		
Travel Time (min)	**= 0.44**	**+**	**0.00**	**+**	**0.00**	**=**	**0.44**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.00 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.582	1	724	5,990	------	------	------	DA-FR-055G Pre
2	SCS Runoff	1.382	1	725	5,531	------	------	------	DA-FR-055G Dev
3	SCS Runoff	1.013	1	725	4,661	------	------	------	DA-FR-055G For

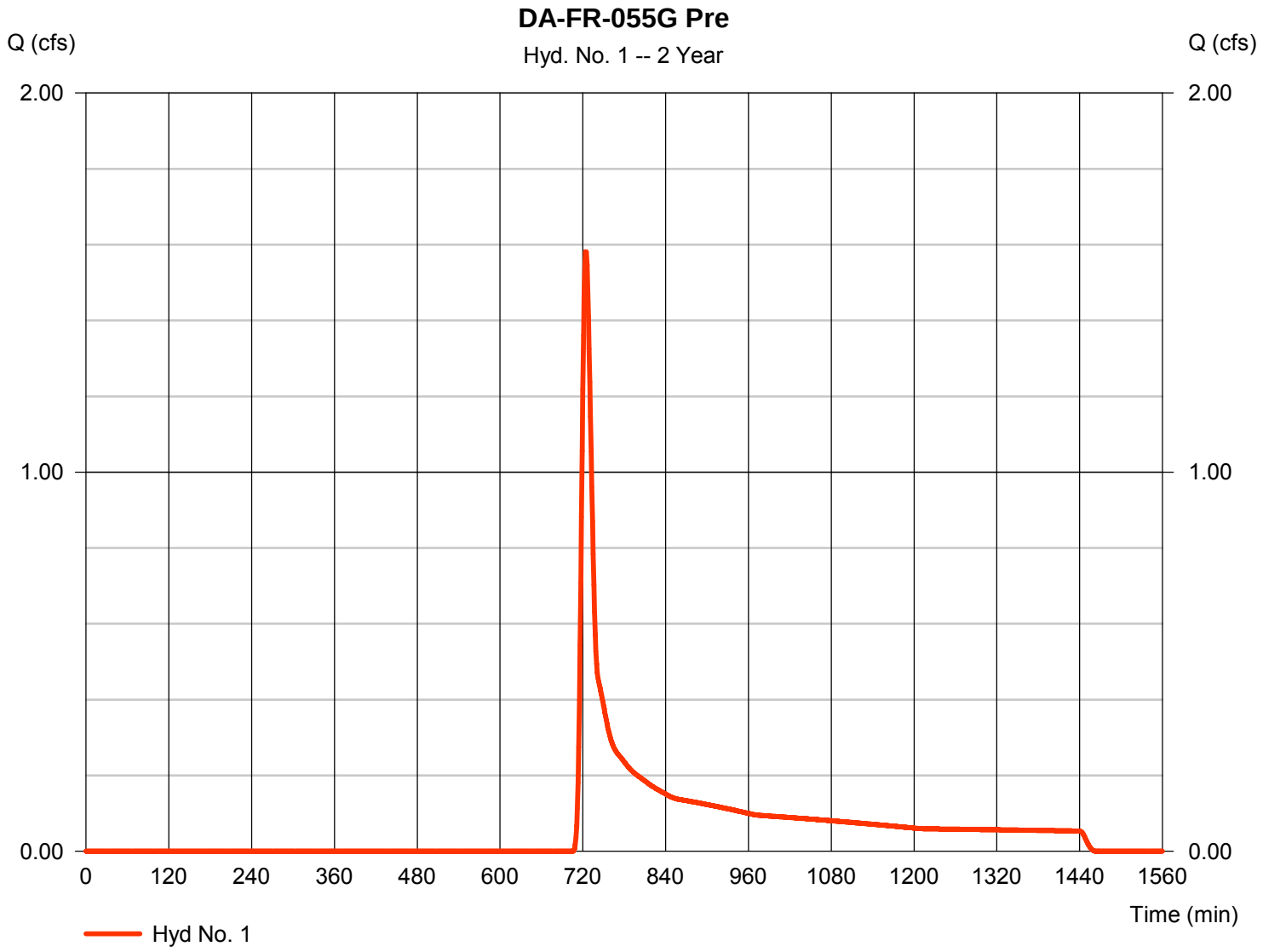
Hydrograph Report

Hyd. No. 1

DA-FR-055G Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.582 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 5,990 cuft
Drainage area	= 3.090 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.100 x 98) + (2.090 x 58) + (0.900 x 55)] / 3.090



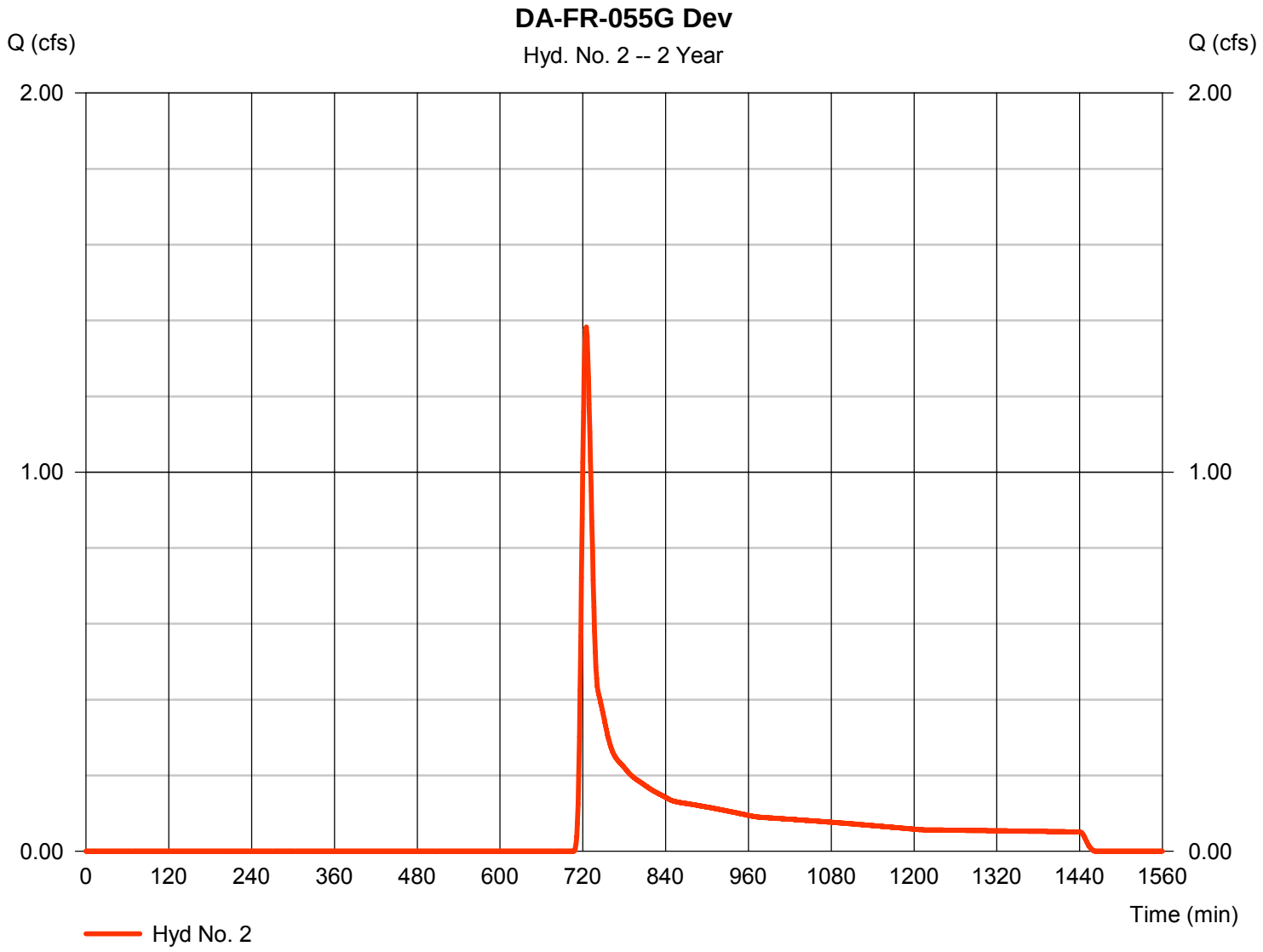
Hydrograph Report

Hyd. No. 2

DA-FR-055G Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 1.382 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 5,531 cuft
Drainage area	= 3.090 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.665 x 48) + (0.097 x 98) + (2.276 x 58) + (0.049 x 55)] / 3.090

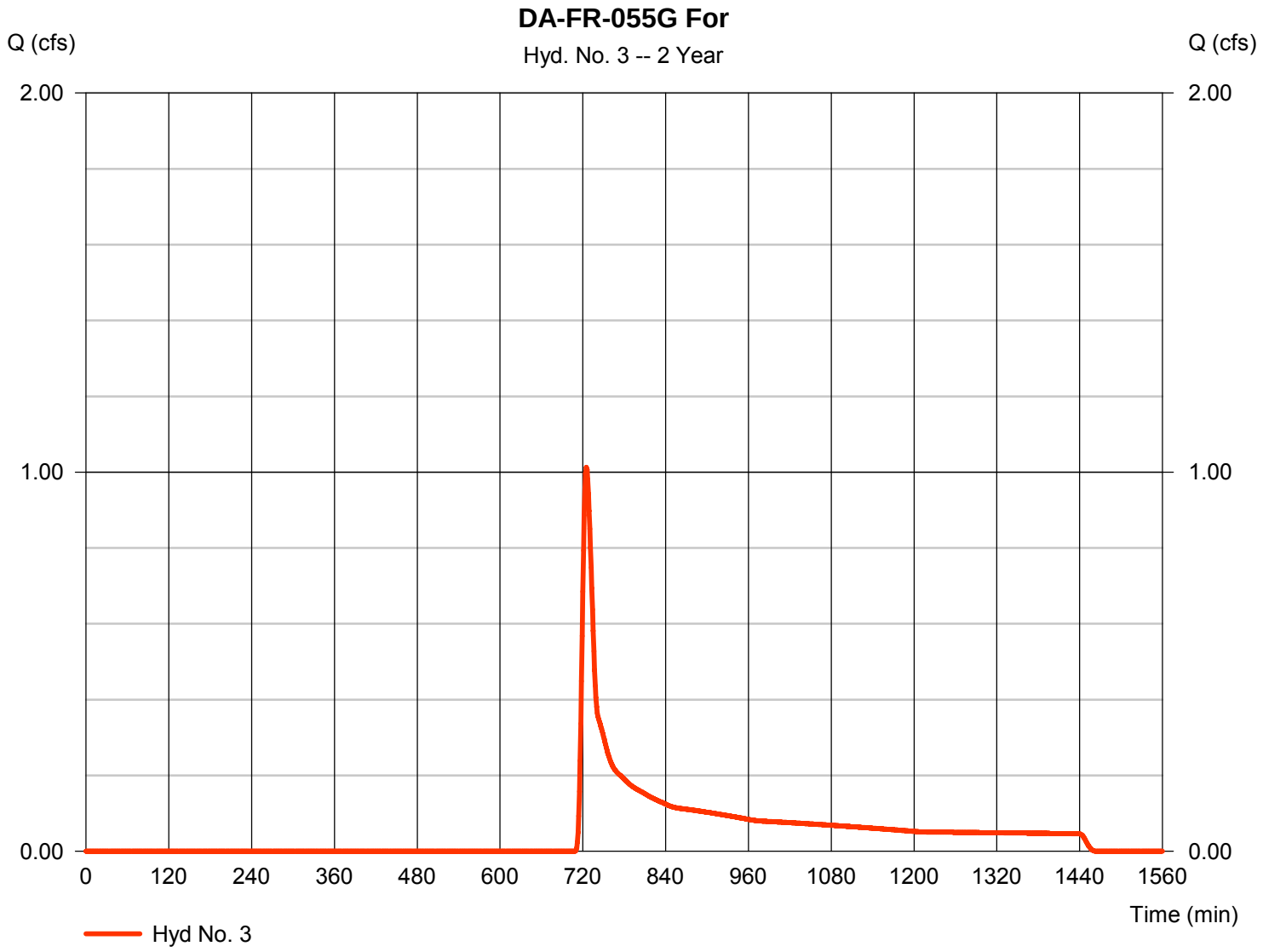


Hydrograph Report

Hyd. No. 3

DA-FR-055G For

Hydrograph type	= SCS Runoff	Peak discharge	= 1.013 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 4,661 cuft
Drainage area	= 3.090 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	6.146	1	723	17,642	------	------	------	DA-FR-055G Pre
2	SCS Runoff	5.782	1	723	16,790	------	------	------	DA-FR-055G Dev
3	SCS Runoff	5.062	1	723	15,126	------	------	------	DA-FR-055G For

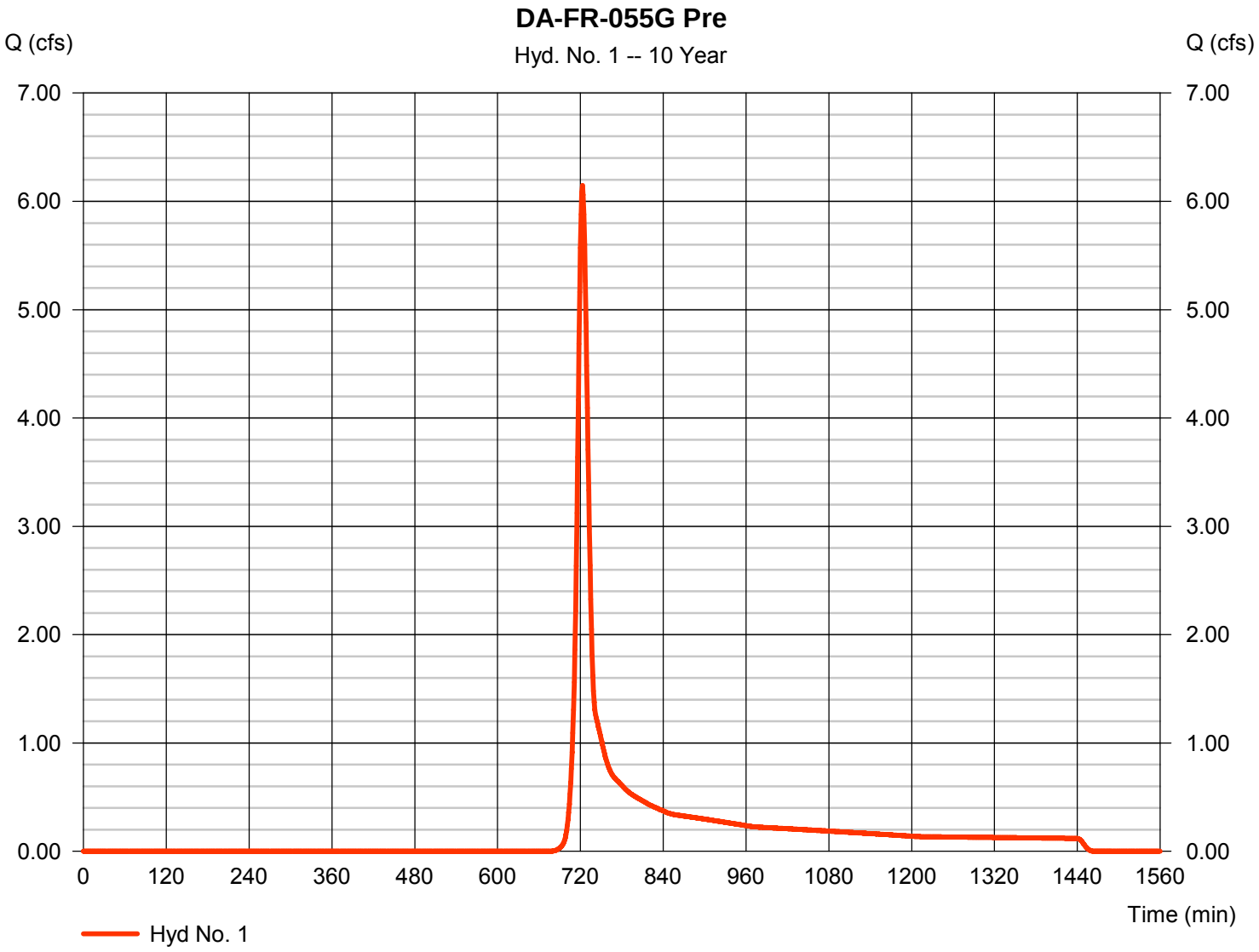
Hydrograph Report

Hyd. No. 1

DA-FR-055G Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 6.146 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 17,642 cuft
Drainage area	= 3.090 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.100 x 98) + (2.090 x 58) + (0.900 x 55)] / 3.090



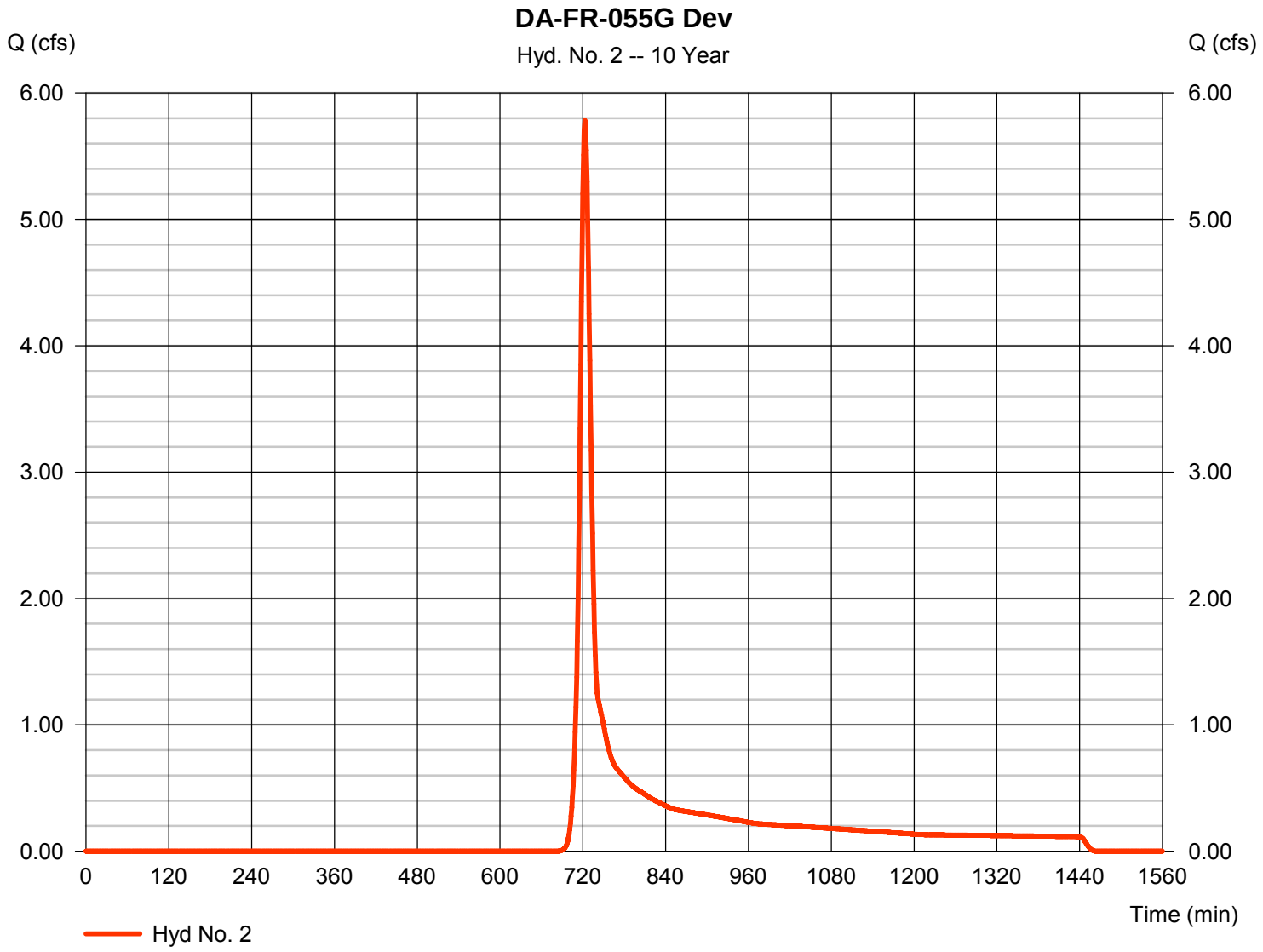
Hydrograph Report

Hyd. No. 2

DA-FR-055G Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 5.782 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 16,790 cuft
Drainage area	= 3.090 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.665 x 48) + (0.097 x 98) + (2.276 x 58) + (0.049 x 55)] / 3.090

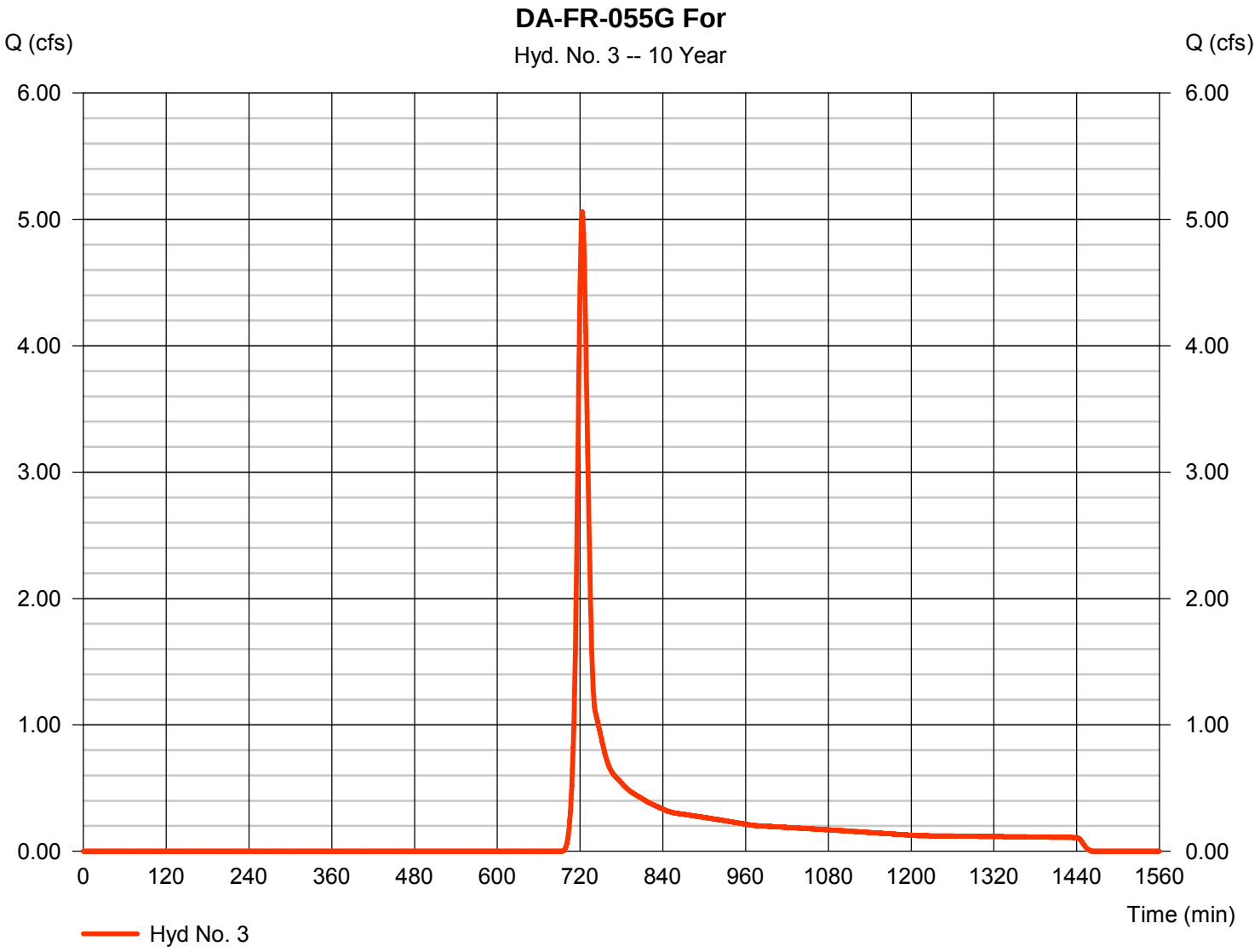


Hydrograph Report

Hyd. No. 3

DA-FR-055G For

Hydrograph type	= SCS Runoff	Peak discharge	= 5.062 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 15,126 cuft
Drainage area	= 3.090 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.00 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-057

DA-FR-057 is located in a meadow area with rolling slopes. This area is primarily agricultural, but not entirely. No new impervious area is proposed within DA-FR-057. The total phosphorus load reduction required for DA-FR-057 is –0.03 lb/yr. There will be no permanent impacts to DA-FR-057 from construction of the gas pipeline.

DA-FR-057 contains both agricultural and non-agricultural areas within the limits of disturbance (LOD). Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction. In non-agricultural areas land use will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. Agricultural areas within the LOD are included in the SWM quality analysis and the total permanent Right of Way (ROW) is analyzed via VRRM; in these calculations agricultural areas are considered “Forest/Open Space”.

Storm water quantity requirements based on energy balance method are satisfied. Agricultural areas within the study area are included in the SWM analysis, but an Improvement Factor (IF) of 1.0 is used when applying the Energy Balance Method. This improvement factor is used to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate a reduction in flow of 0.00 cfs for this drainage area (as seen in table below).

Drainage Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-057	0.11	0.11	0.00

Figures and calculations for DA-FR-057 are presented in following pages. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-057
0.10 acres
Weighted CN =

B

1050
1100
1000

Legend

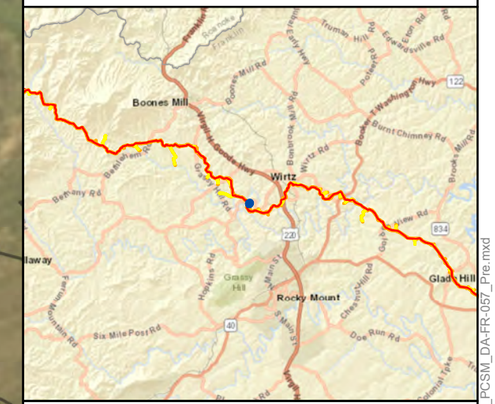
- Existing 50' Contour
- Existing 10' Contour
- Limit of Disturbance
- Meadow
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:720

60 30 0 60 Feet



Mountain Valley Pipeline Project

Mountain Valley PIPELINE

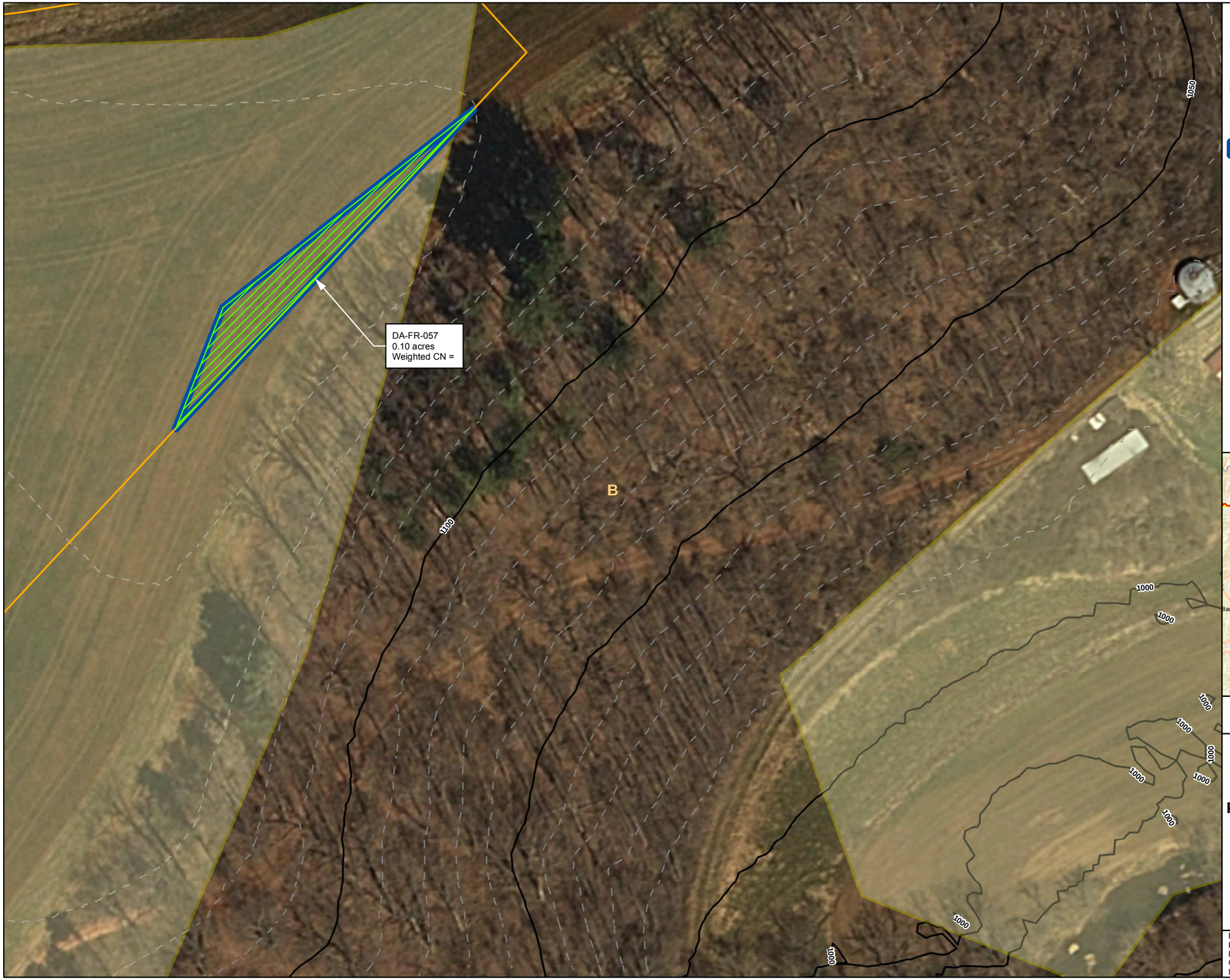
Pre-Construction Drainage Area Map
DA-FR-057
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-057_Pre.mxd



Legend

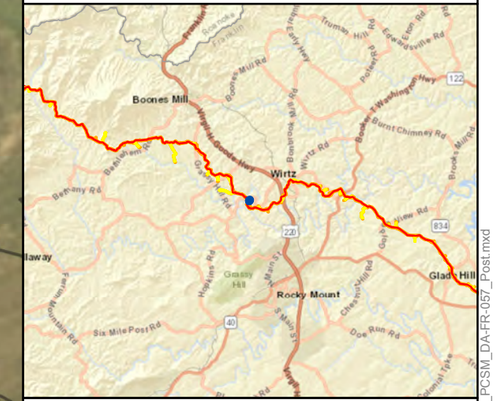
- Existing 50' Contour
- Existing 10' Contour
- Limit of Disturbance
- Meadow
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:720

60 30 0 60 Feet



Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-057
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-057_Post.mxd

Legend

- Existing 50' Contour
- Existing 10' Contour
- Limit of Disturbance
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:720

60 30 0 60 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration
DA-FR-057
Spread 10

Figure 3
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-057_3.mxd

Legend

- Existing 50' Contour
- Existing 10' Contour
- Limit of Disturbance
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:720

60 30 0 60 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration
DA-FR-057
Spread 10

Figure 4

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-057_4.mxd

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.000	0
Developed Condition	0.000	0
Pre-Developed (Forest) Condition	0.000	0

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.000	≤ OK	#DIV/0!
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.000	≤ OK	0.000
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.000	*shall not* be required to be ≤	#DIV/0!

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-057 Pre
2	SCS Runoff	DA-FR-057 Dev
3	SCS Runoff	DA-FR-057 For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.000	0.001	-------	-------	0.114	-------	-------	-------	DA-FR-057 Pre
2	SCS Runoff	------	0.000	0.001	-------	-------	0.114	-------	-------	-------	DA-FR-057 Dev
3	SCS Runoff	------	0.000	0.000	-------	-------	0.084	-------	-------	-------	DA-FR-057 For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

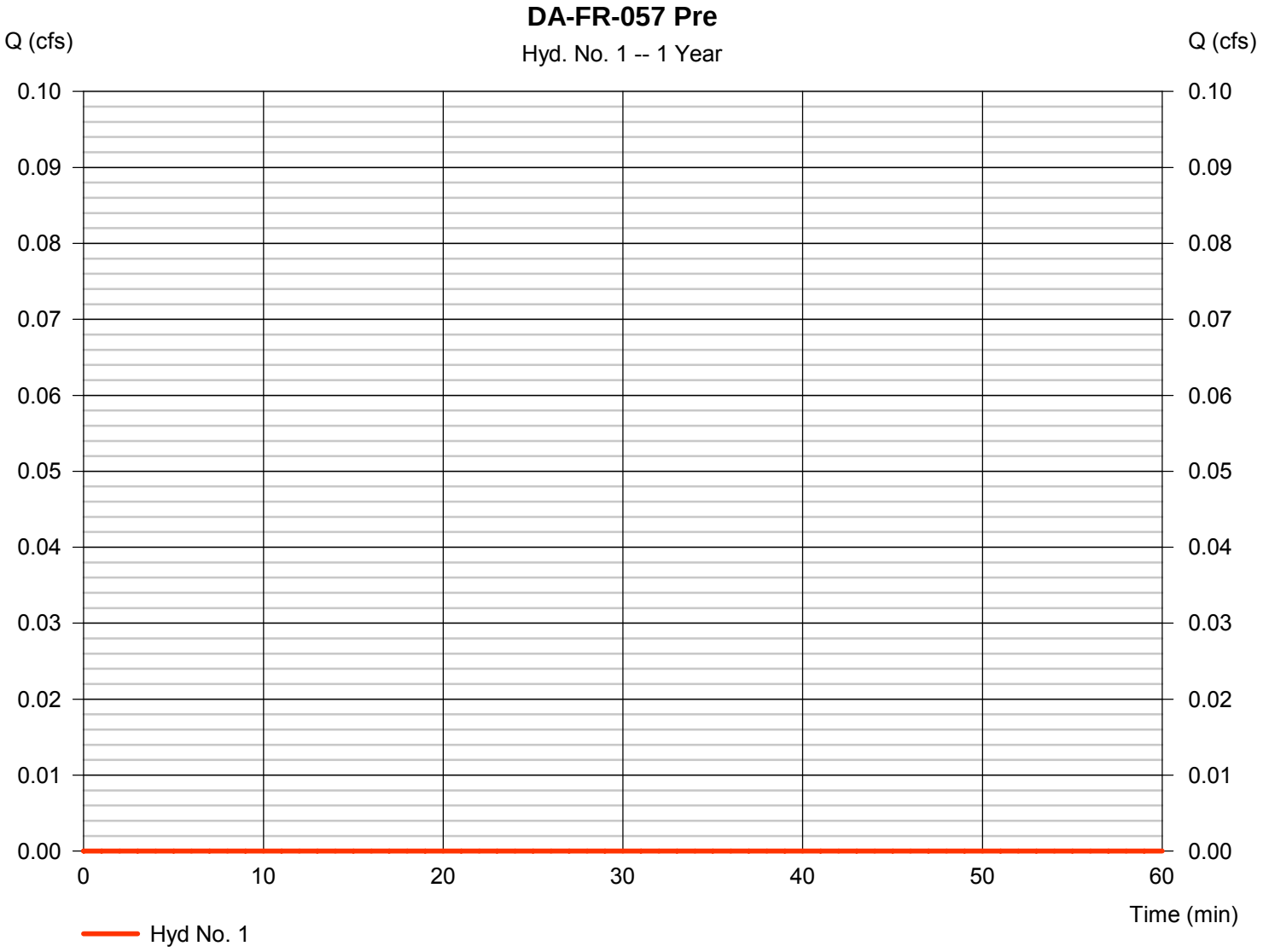
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.000	1	n/a	0	------	------	------	DA-FR-057 Pre
2	SCS Runoff	0.000	1	n/a	0	------	------	------	DA-FR-057 Dev
3	SCS Runoff	0.000	1	n/a	0	------	------	------	DA-FR-057 For

Hydrograph Report

Hyd. No. 1

DA-FR-057 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.000 cfs
Storm frequency	= 1 yrs	Time to peak	= n/a
Time interval	= 1 min	Hyd. volume	= 0 cuft
Drainage area	= 0.098 ac	Curve number	= 58
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-057 Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 28.7		0.0		0.0		
Two-year 24-hr precip. (in)	= 2.20		0.00		0.00		
Land slope (%)	= 4.00		0.00		0.00		
Travel Time (min)	**= 7.23**	**+**	**0.00**	**+**	**0.00**	**=**	**7.23**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

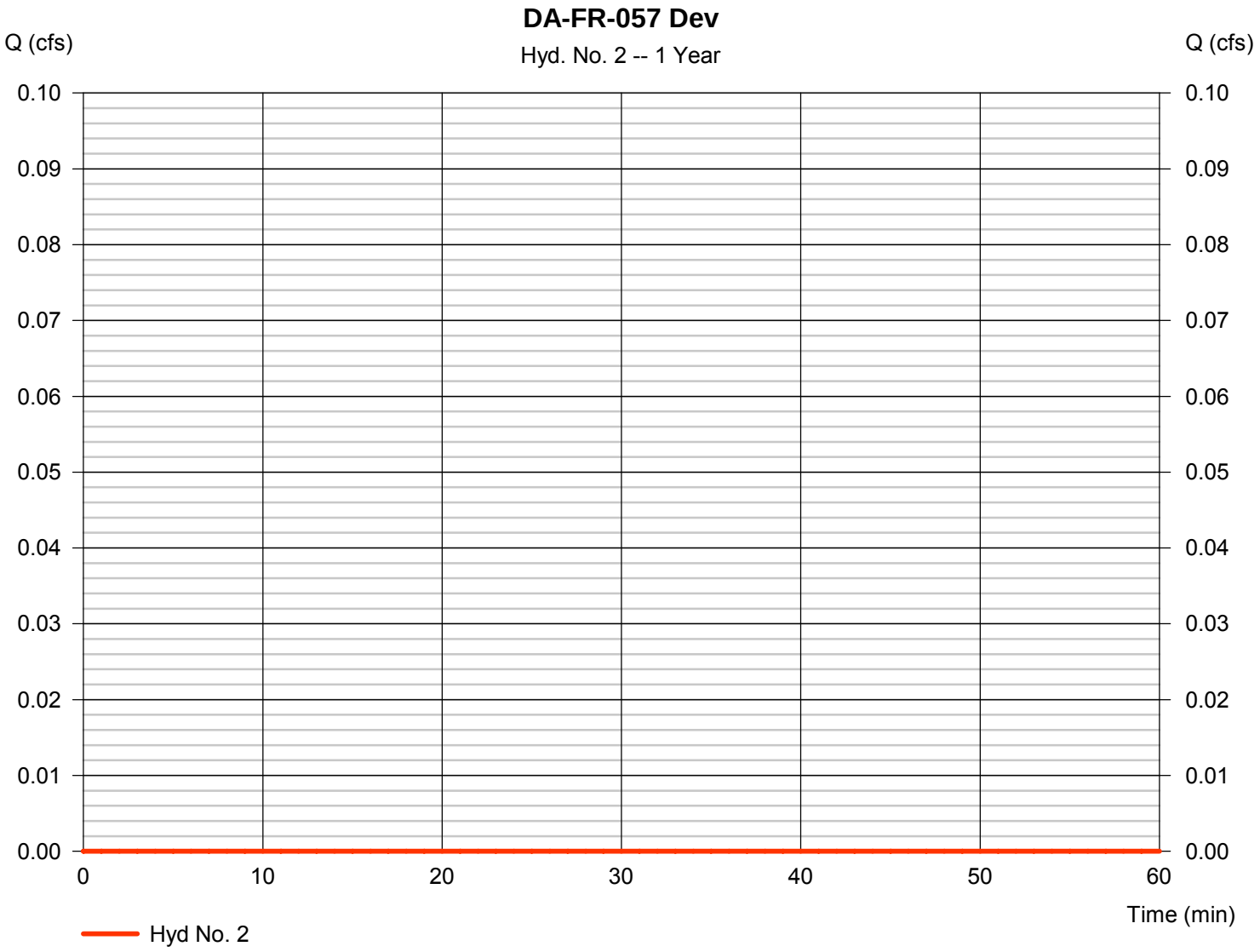
Total Travel Time, Tc ..... 7.20 min

Hydrograph Report

Hyd. No. 2

DA-FR-057 Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.000 cfs
Storm frequency	= 1 yrs	Time to peak	= n/a
Time interval	= 1 min	Hyd. volume	= 0 cuft
Drainage area	= 0.098 ac	Curve number	= 58
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-057 Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 28.7		0.0		0.0		
Two-year 24-hr precip. (in)	= 2.20		0.00		0.00		
Land slope (%)	= 4.00		0.00		0.00		
Travel Time (min)	**= 7.23**	**+**	**0.00**	**+**	**0.00**	**=**	**7.23**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

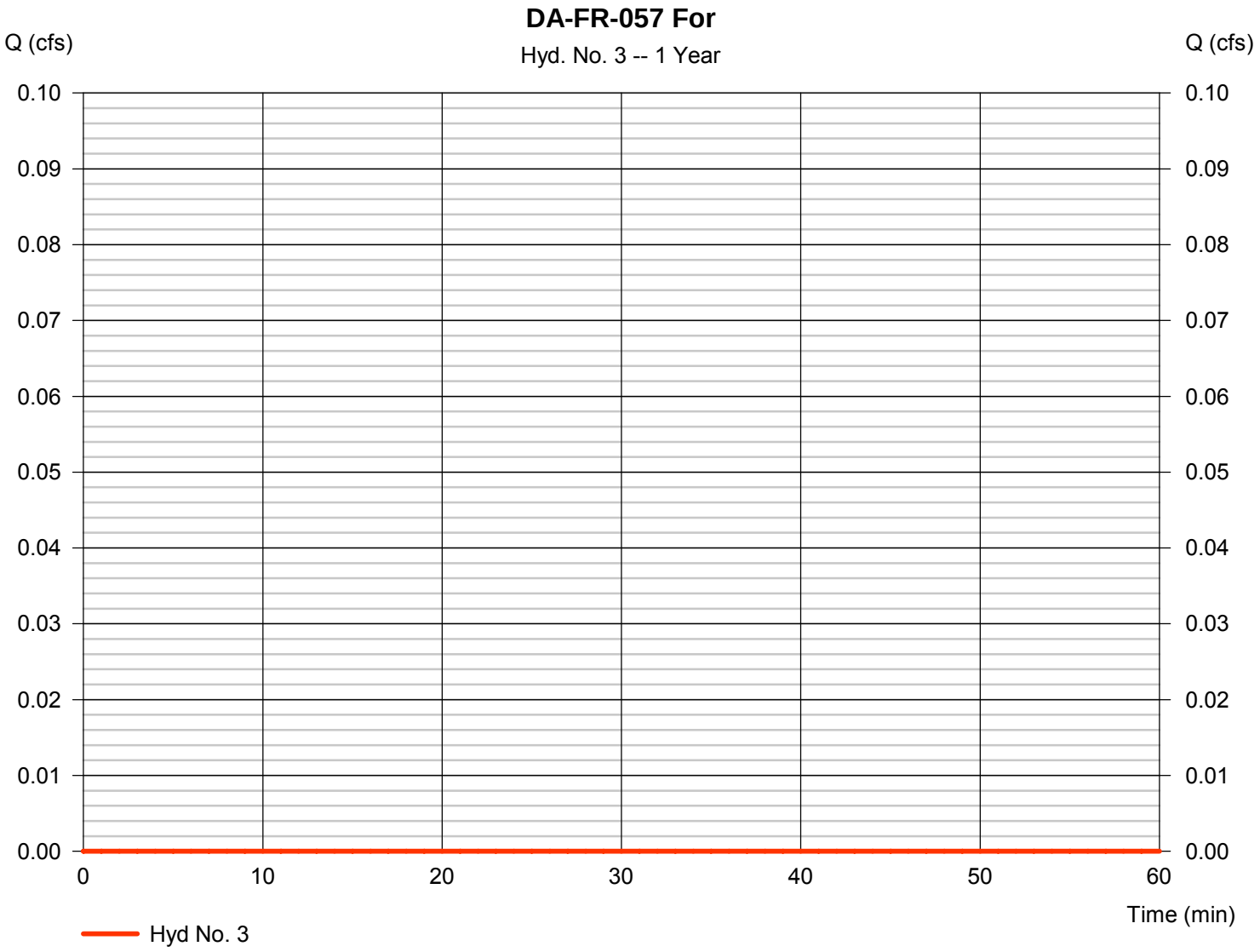
Total Travel Time, Tc ..... 7.20 min

Hydrograph Report

Hyd. No. 3

DA-FR-057 For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.000 cfs
Storm frequency	= 1 yrs	Time to peak	= n/a
Time interval	= 1 min	Hyd. volume	= 0 cuft
Drainage area	= 0.098 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-057 For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 28.7		0.0		0.0		
Two-year 24-hr precip. (in)	= 2.20		0.00		0.00		
Land slope (%)	= 4.00		0.00		0.00		
Travel Time (min)	**= 7.23**	**+**	**0.00**	**+**	**0.00**	**=**	**7.23**
Shallow Concentrated Flow							
Flow length (ft)	= 0.00		0.00		0.00		
Watercourse slope (%)	= 0.00		0.00		0.00		
Surface description	= Paved		Paved		Paved		
Average velocity (ft/s)	=0.00		0.00		0.00		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 7.20 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

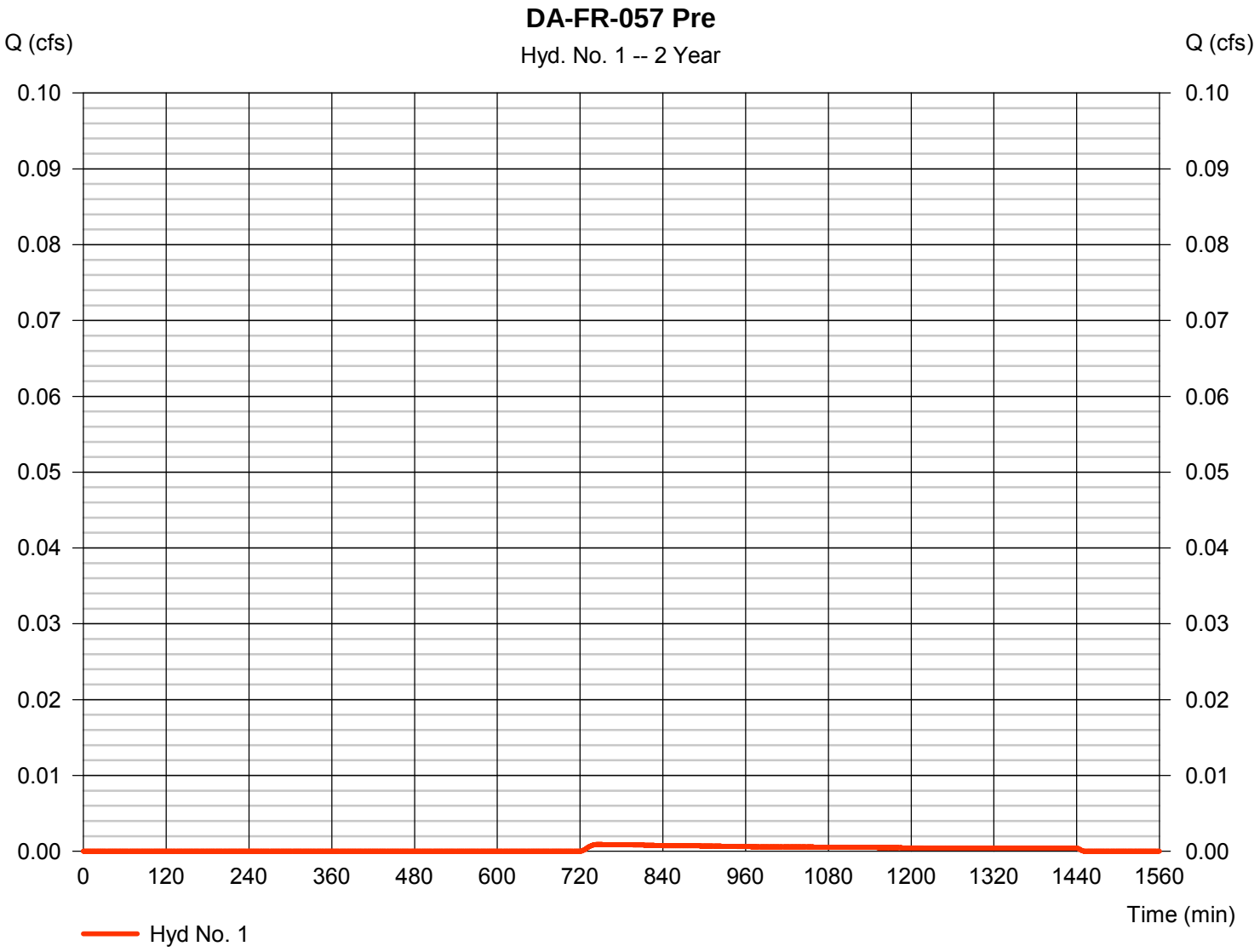
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.001	1	747	25	------	------	------	DA-FR-057 Pre
2	SCS Runoff	0.001	1	747	25	------	------	------	DA-FR-057 Dev
3	SCS Runoff	0.000	1	915	13	------	------	------	DA-FR-057 For

Hydrograph Report

Hyd. No. 1

DA-FR-057 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.001 cfs
Storm frequency	= 2 yrs	Time to peak	= 747 min
Time interval	= 1 min	Hyd. volume	= 25 cuft
Drainage area	= 0.098 ac	Curve number	= 58
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

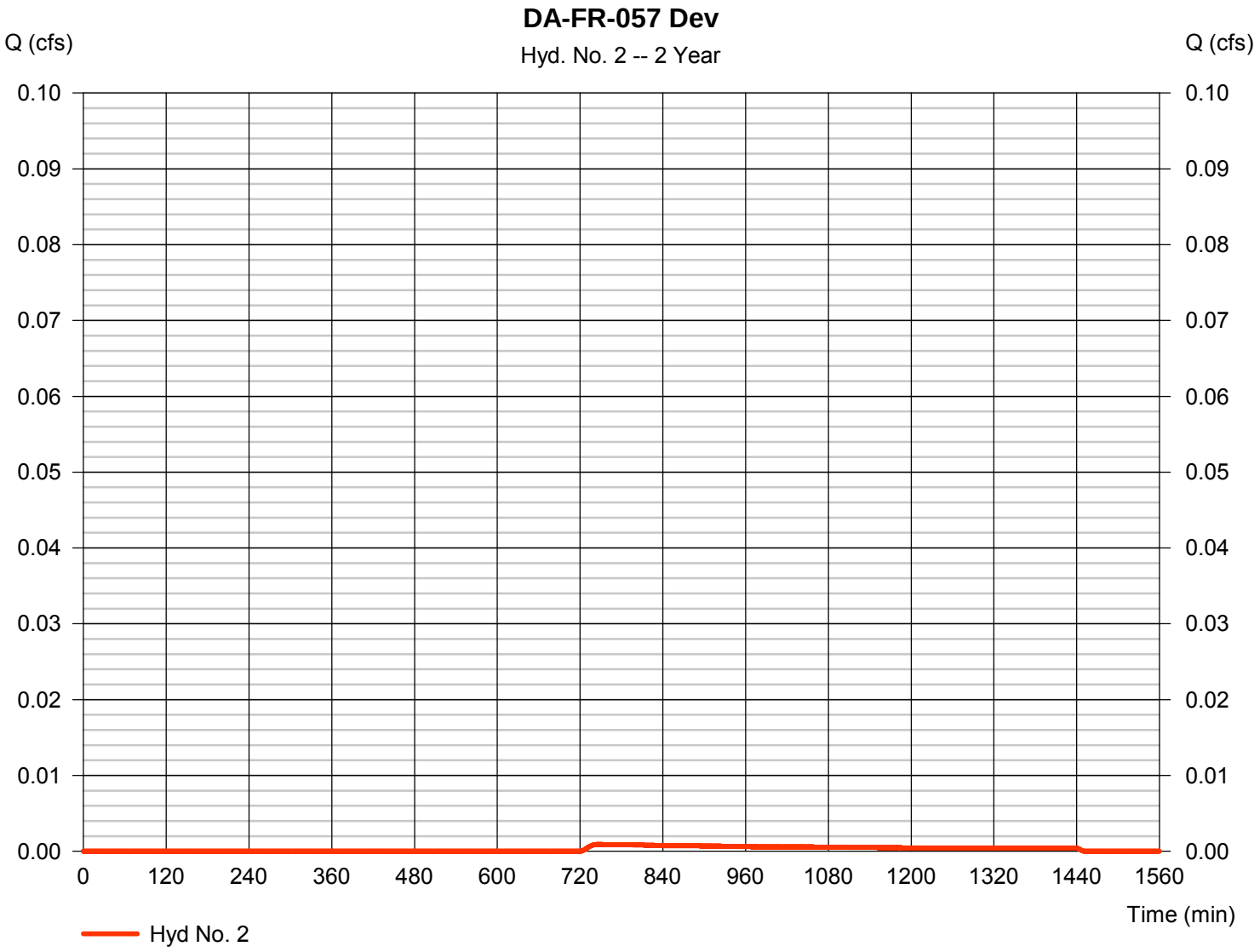


Hydrograph Report

Hyd. No. 2

DA-FR-057 Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.001 cfs
Storm frequency	= 2 yrs	Time to peak	= 747 min
Time interval	= 1 min	Hyd. volume	= 25 cuft
Drainage area	= 0.098 ac	Curve number	= 58
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

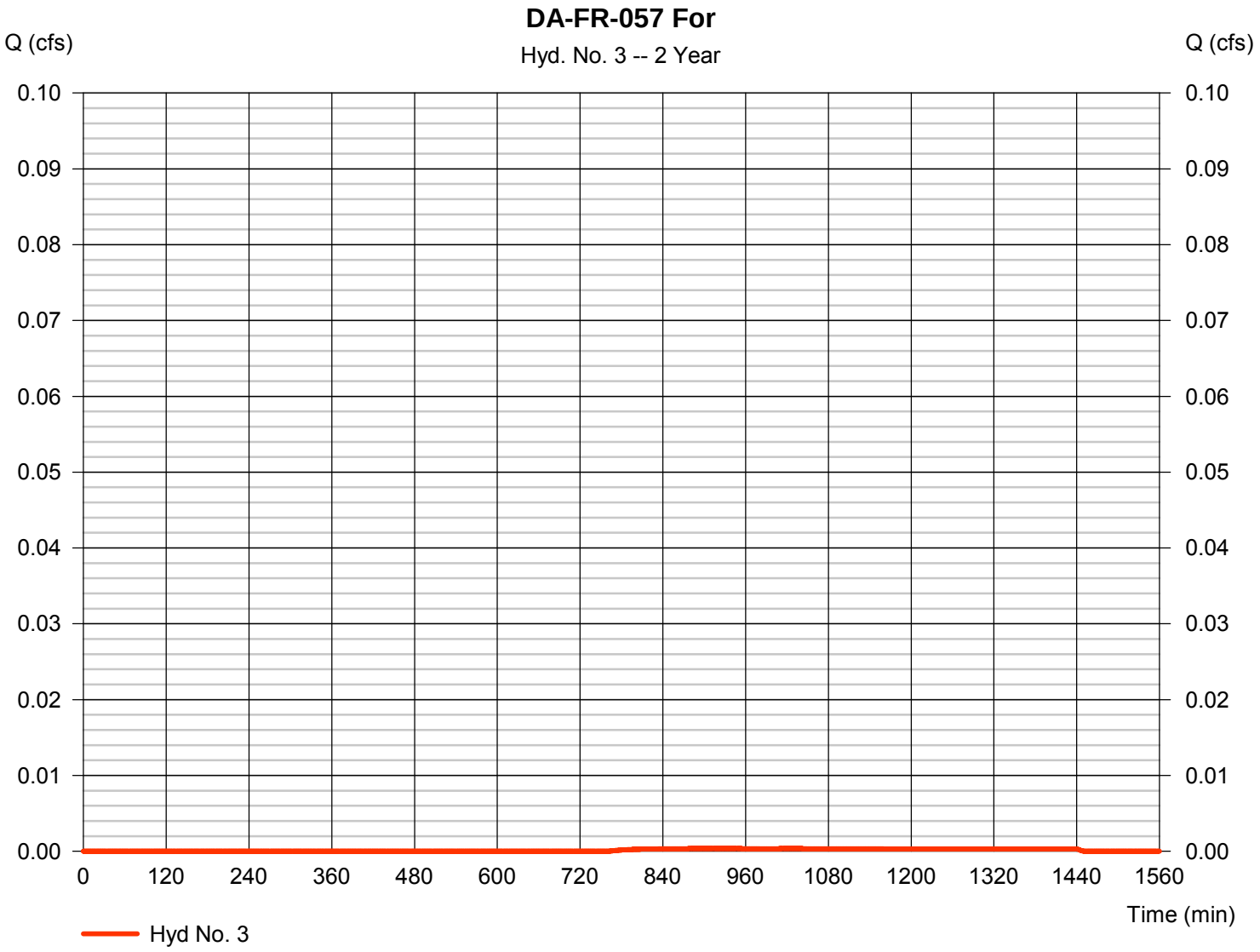


Hydrograph Report

Hyd. No. 3

DA-FR-057 For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.000 cfs
Storm frequency	= 2 yrs	Time to peak	= 915 min
Time interval	= 1 min	Hyd. volume	= 13 cuft
Drainage area	= 0.098 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

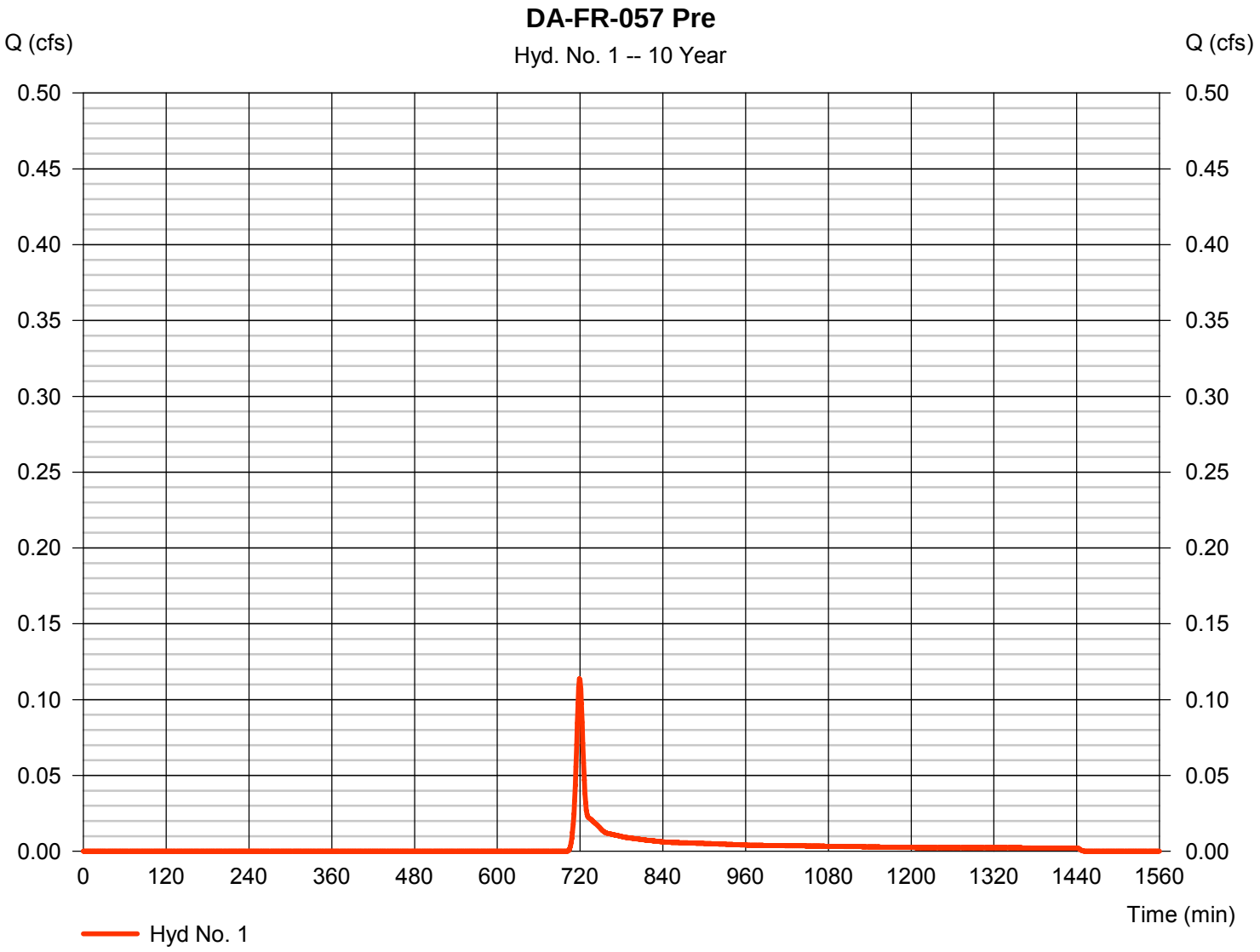
Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.114	1	719	272	------	------	------	DA-FR-057 Pre
2	SCS Runoff	0.114	1	719	272	------	------	------	DA-FR-057 Dev
3	SCS Runoff	0.084	1	720	221	------	------	------	DA-FR-057 For

Hydrograph Report

Hyd. No. 1

DA-FR-057 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.114 cfs
Storm frequency	= 10 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 272 cuft
Drainage area	= 0.098 ac	Curve number	= 58
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

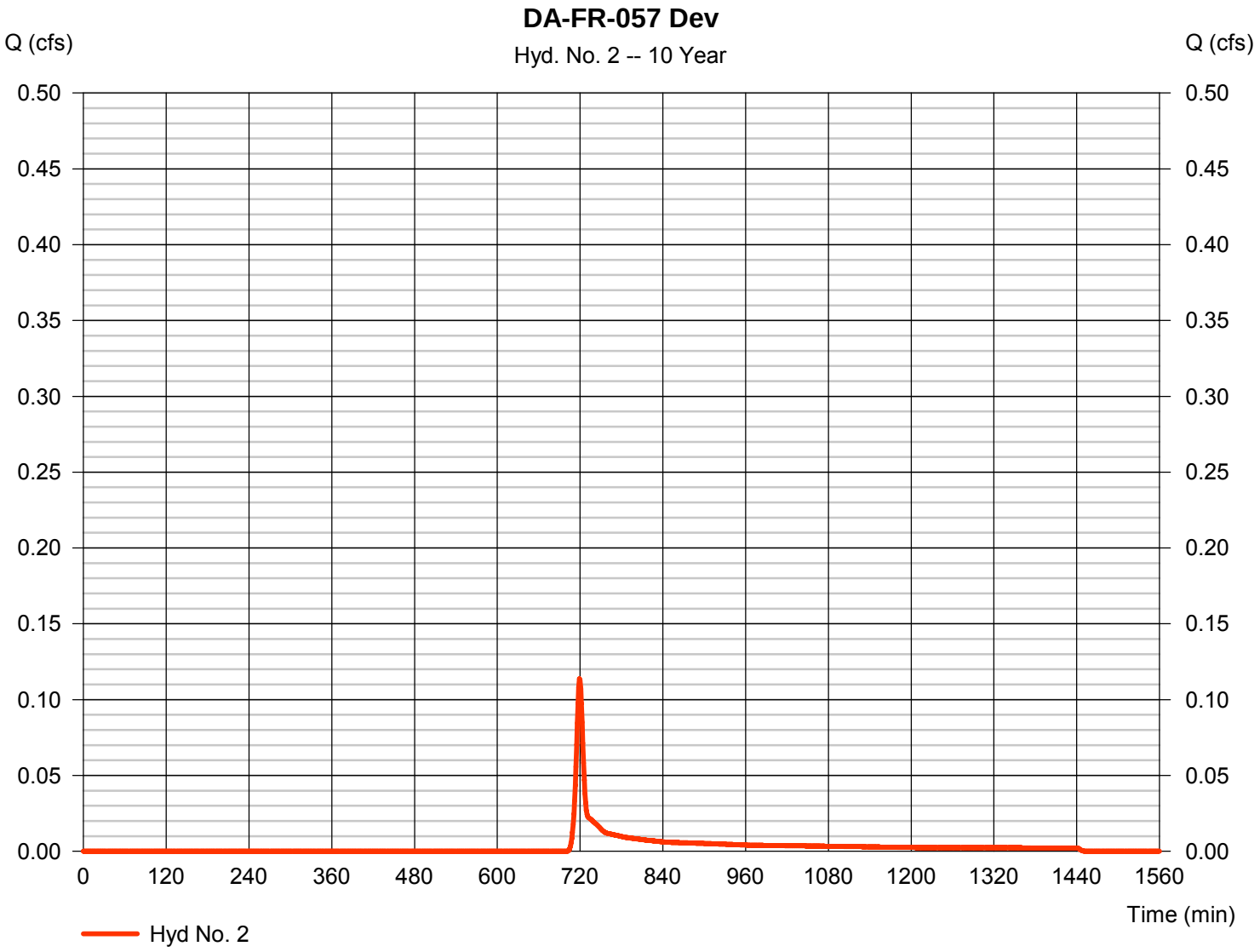


Hydrograph Report

Hyd. No. 2

DA-FR-057 Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 0.114 cfs
Storm frequency	= 10 yrs	Time to peak	= 719 min
Time interval	= 1 min	Hyd. volume	= 272 cuft
Drainage area	= 0.098 ac	Curve number	= 58
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

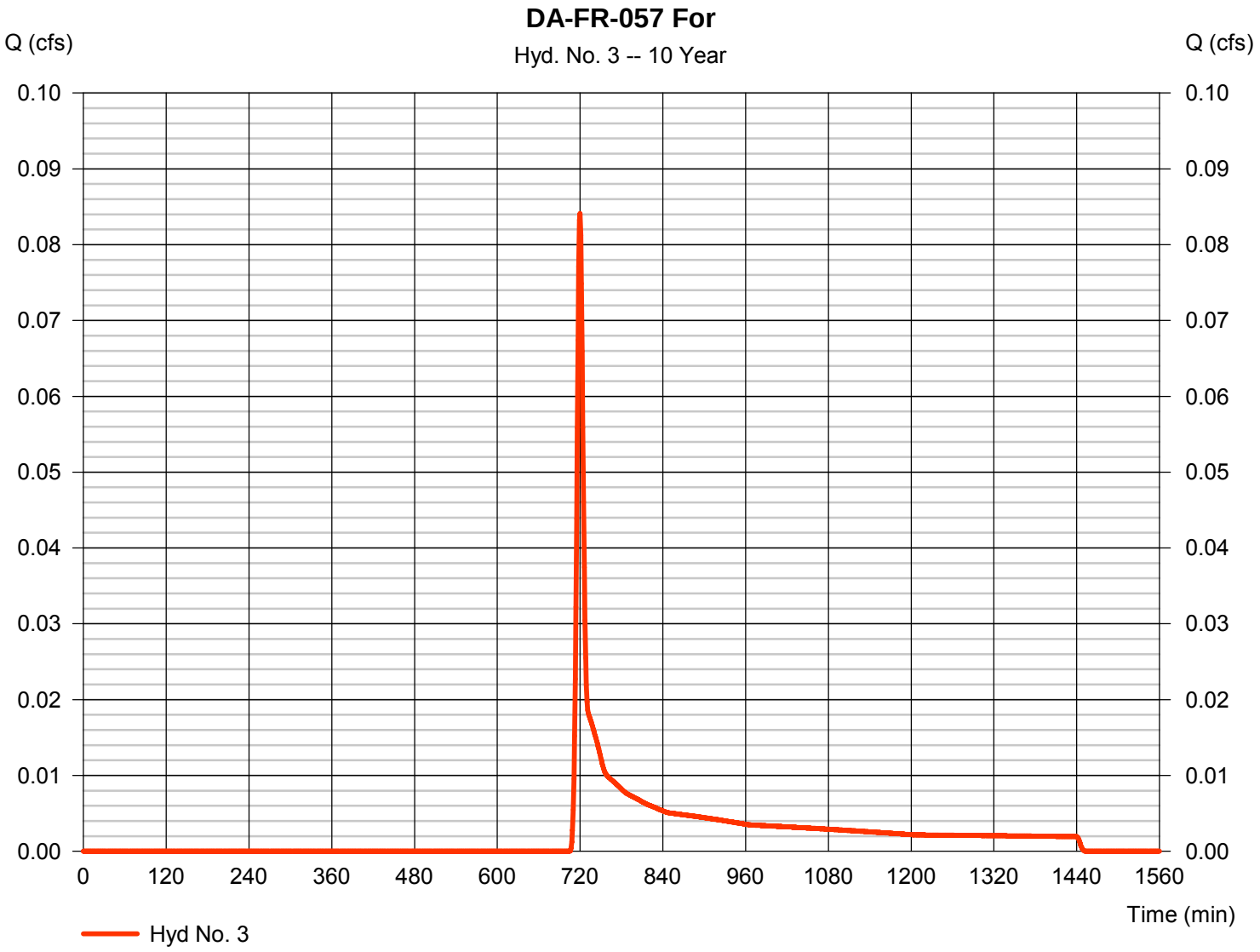


Hydrograph Report

Hyd. No. 3

DA-FR-057 For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.084 cfs
Storm frequency	= 10 yrs	Time to peak	= 720 min
Time interval	= 1 min	Hyd. volume	= 221 cuft
Drainage area	= 0.098 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 7.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-058

DA-FR-058 is located in a meadow area with rolling slopes. No new impervious area is proposed within DA-FR-058. The total phosphorus load reduction required for DA-FR-058 is –0.38 lb/yr.

DA-FR-058 contains both agricultural and non-agricultural areas within the limits of disturbance (LOD). Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction. In non-agricultural areas, land use will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. For SWM quality, agricultural areas within the LOD are considered/ included and the total permanent ROW is analyzed via VRRM; agricultural areas are considered “Forest/Open Space” in these calculations.

Stormwater quantity is met via the energy balance method for the DA-FR-058. In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate no reduction in flow for this drainage area (as seen in table below).

Drainage Area	Pre Peak Flow, 10-yr Q (cfs)	Post Peak Flow, Q 10-yr (cfs)	Flow differential
DA-FR-058	7.06	7.06	0.00

Figures and calculations for DA-FR-058 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

Iron Ridge Rd

263.0

263.1

263.2

1100

1050

1000

B

DA-FR-058
4.66 acres
Weighted CN =

Legend

- Milepost
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Meadow
- Woods
- Agricultural Area
- Permanent Right-of-Way
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:1,200

100 50 0 100 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-058
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-058_Pre.mxd

Iron Ridge Rd

263.0

263.1

263.2

1100

1050

1000

B

DA-FR-058
4.66 acres
Weighted CN =

Legend

- Milepost
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Brush
- Meadow
- Agricultural Area
- Permanent Right-of-Way
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,200

100 50 0 100 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-058
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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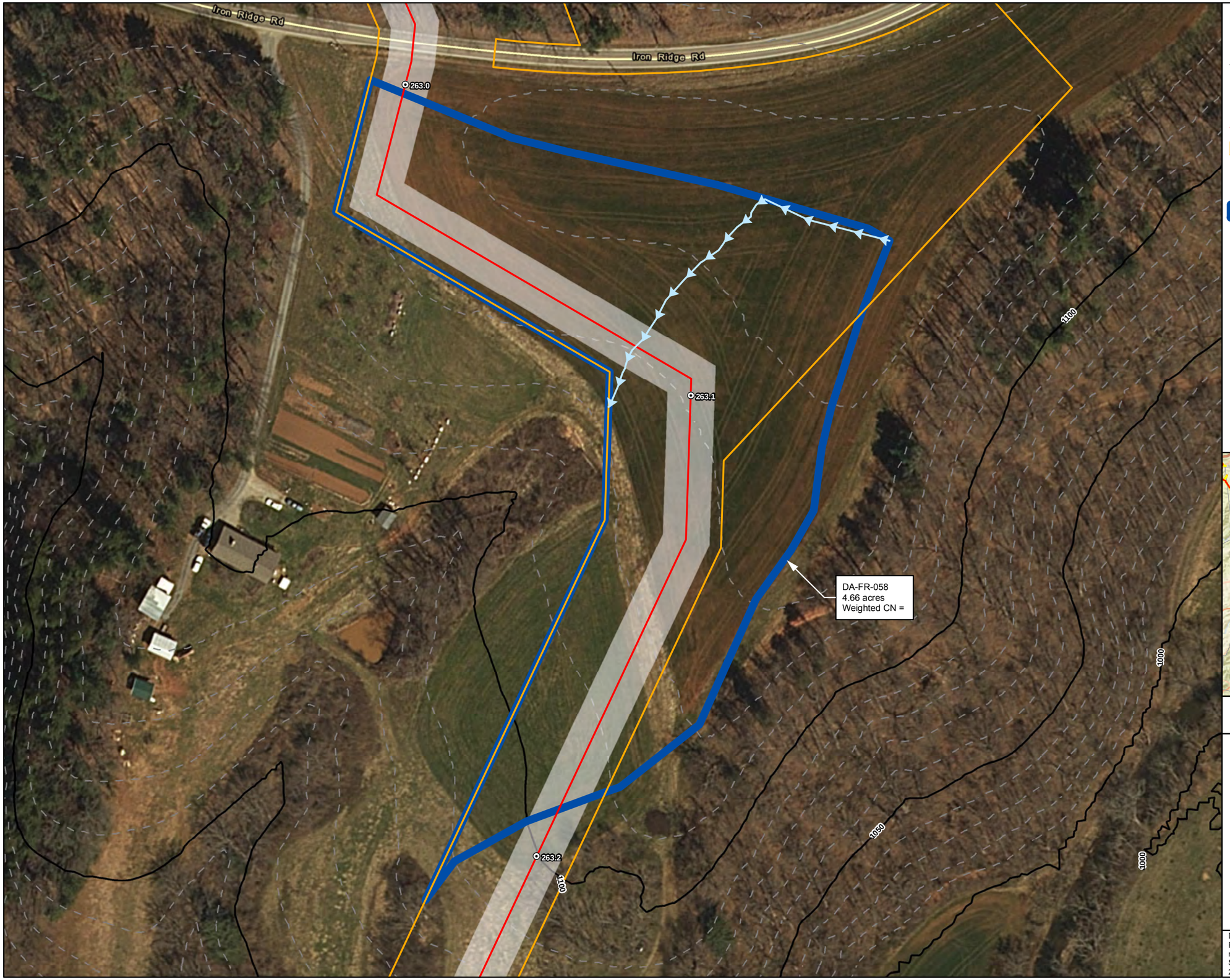


Legend

- Milepost
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,200

100 50 0 100 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration DA-FR-058 Spread 10

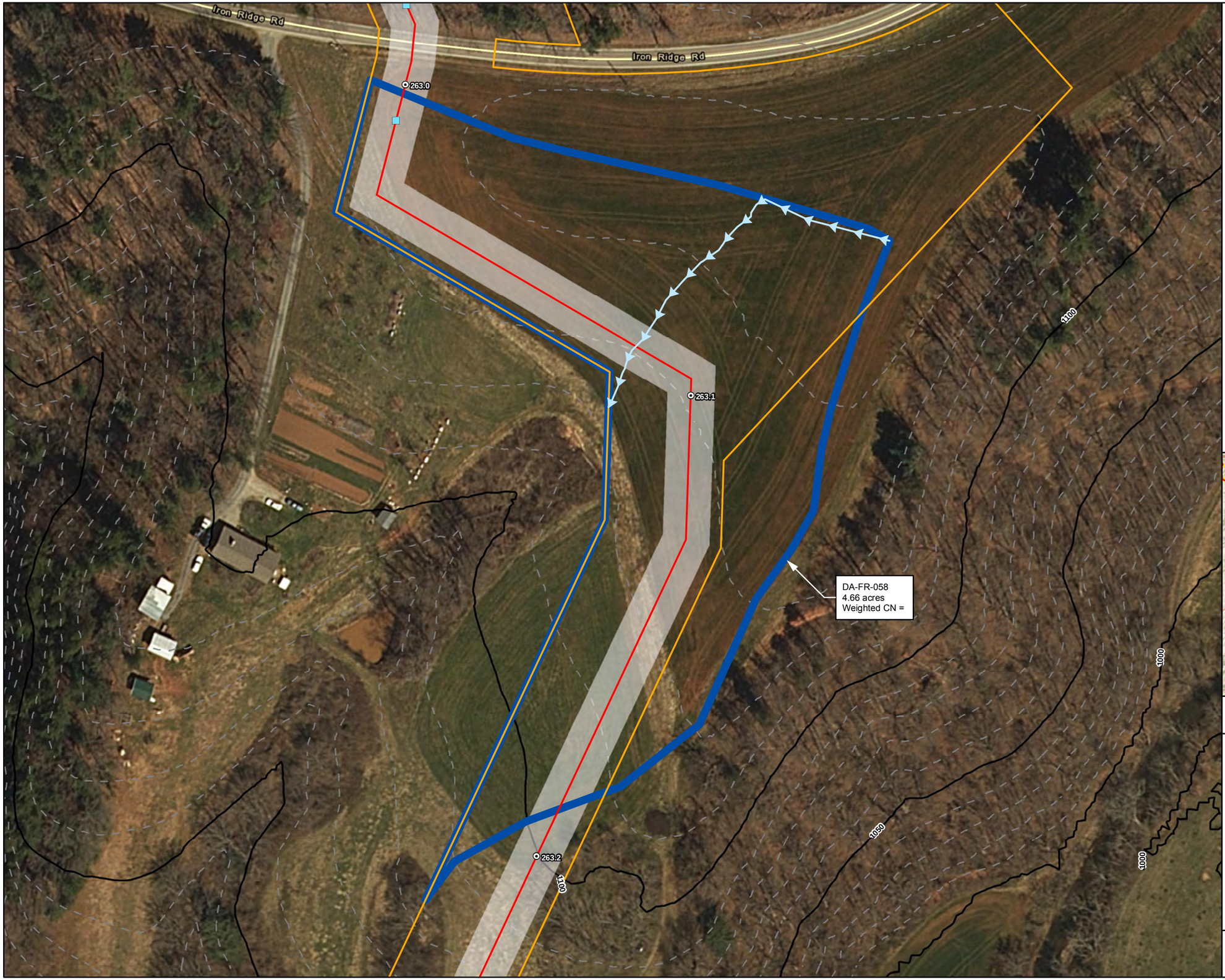
Figure 3

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-058_3.mxd



Legend

- Milepost
- Permanent Waterbars
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,200

100 50 0 100 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration DA-FR-058 Spread 10

Figure 4

Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Integrated WQ Report Rivers from the VEGIS datasets 2014, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-058_4.mxd

Virginia Runoff Reduction Method New Development Worksheet - v2.8 - June 2014

Site Data Summary

Total Rainfall = 46 inches

Site Land Cover Summary

	A Soils	B Soils	C Soils	D Soils	Total	% of Total
Forest (acres)	0.00	1.14	0.00	0.00	1.14	*100.00*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
					1.14	*100.00*

Site Rv	0.03
Post Development Treatment Volume (ft3)	124
Post Development TP Load (lb/yr)	0.08
Post Development TN Load (lb/yr)	0.60
Total TP Load Reduction Required (lb/yr)	-0.38

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0
Total TN Load Reduction Achieved (lb/yr)	0.00
Adjusted Post Development TP Load (lb/yr)	0.08
Remaining Phosphorous Load Reduction (Lb/yr) Required	0.00

Drainage Area Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
Forest (acres)	1.14	0.00	0.00	0.00	0.00	*1.14*
Turf (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
Impervious (acres)	0.00	0.00	0.00	0.00	0.00	*0.00*
						1.14

Drainage Area Compliance Summary

	D.A. A	D.A. B	D.A. C	D.A. D	D.A. E	Total
TP Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*
TN Load Red. (lb/yr)	0.00	0.00	0.00	0.00	0.00	*0.00*

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.036	6320
Developed Condition	1.036	6320
Pre-Developed (Forest) Condition	0.573	4712

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	1.036	≤ OK	1.036
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	1.036	≤ OK	1.036
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	1.036	*shall not* be required to be ≤	0.427

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-058 Pre
2	SCS Runoff	DA-FR-058 Dev
3	SCS Runoff	DA-FR-058 For

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.036	1.759	-------	-------	7.061	-------	-------	-------	DA-FR-058 Pre
2	SCS Runoff	------	1.036	1.759	-------	-------	7.061	-------	-------	-------	DA-FR-058 Dev
3	SCS Runoff	------	0.573	1.125	-------	-------	5.751	-------	-------	-------	DA-FR-058 For

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.036	1	731	6,320	------	------	------	DA-FR-058 Pre
2	SCS Runoff	1.036	1	731	6,320	------	------	------	DA-FR-058 Dev
3	SCS Runoff	0.573	1	732	4,712	------	------	------	DA-FR-058 For

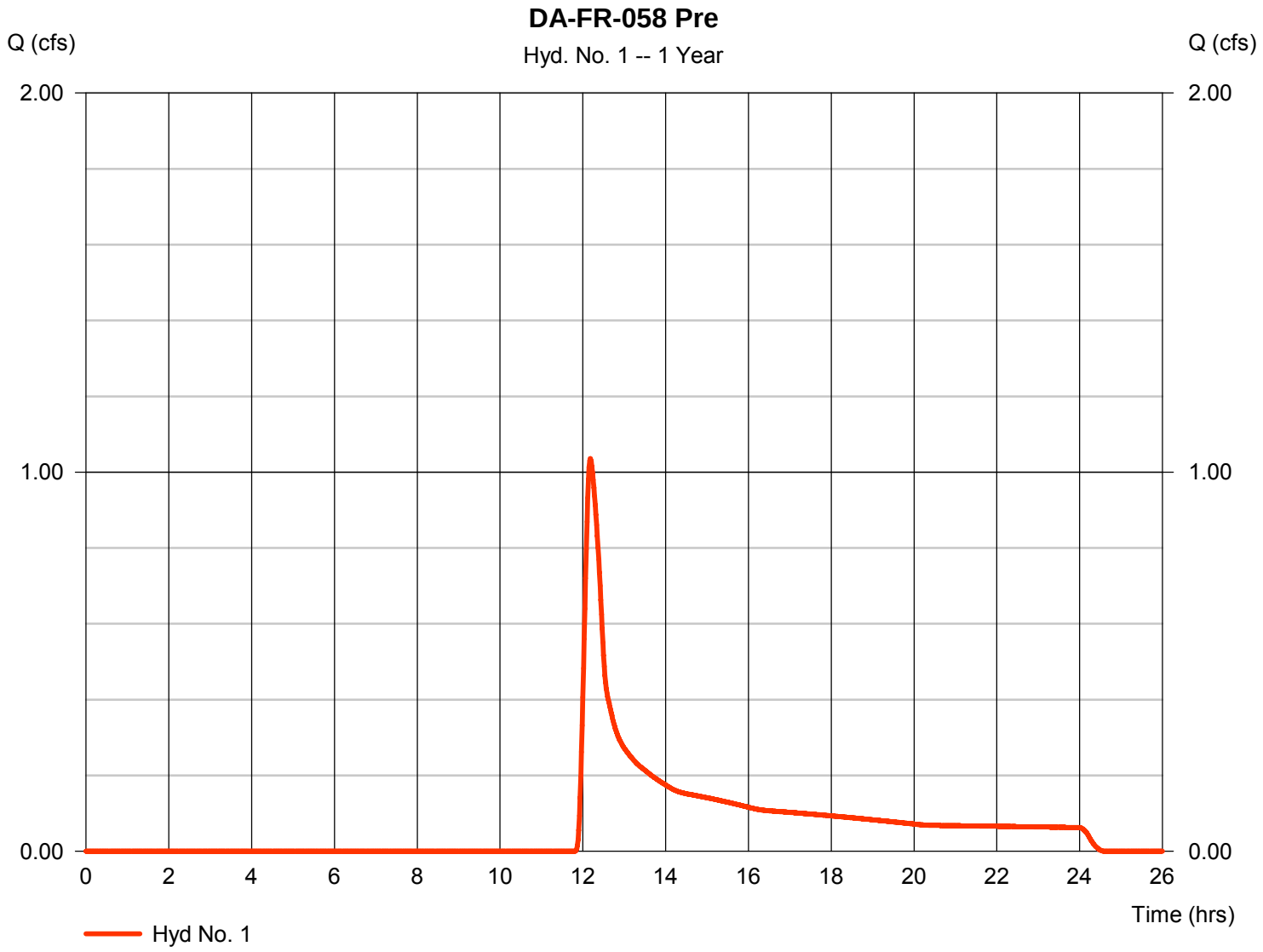
Hydrograph Report

Hyd. No. 1

DA-FR-058 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.036 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.18 hrs
Time interval	= 1 min	Hyd. volume	= 6,320 cuft
Drainage area	= 4.660 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.001 x 55) + (4.656 x 58)] / 4.660



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-058 Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 1.81		0.00		0.00		
Travel Time (min)	**= 20.78**	**+**	**0.00**	**+**	**0.00**	**=**	**20.78**
Shallow Concentrated Flow							
Flow length (ft)	= 326.32		0.00		0.00		
Watercourse slope (%)	= 6.84		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.22		0.00		0.00		
Travel Time (min)	**= 1.29**	**+**	**0.00**	**+**	**0.00**	**=**	**1.29**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 22.10 min

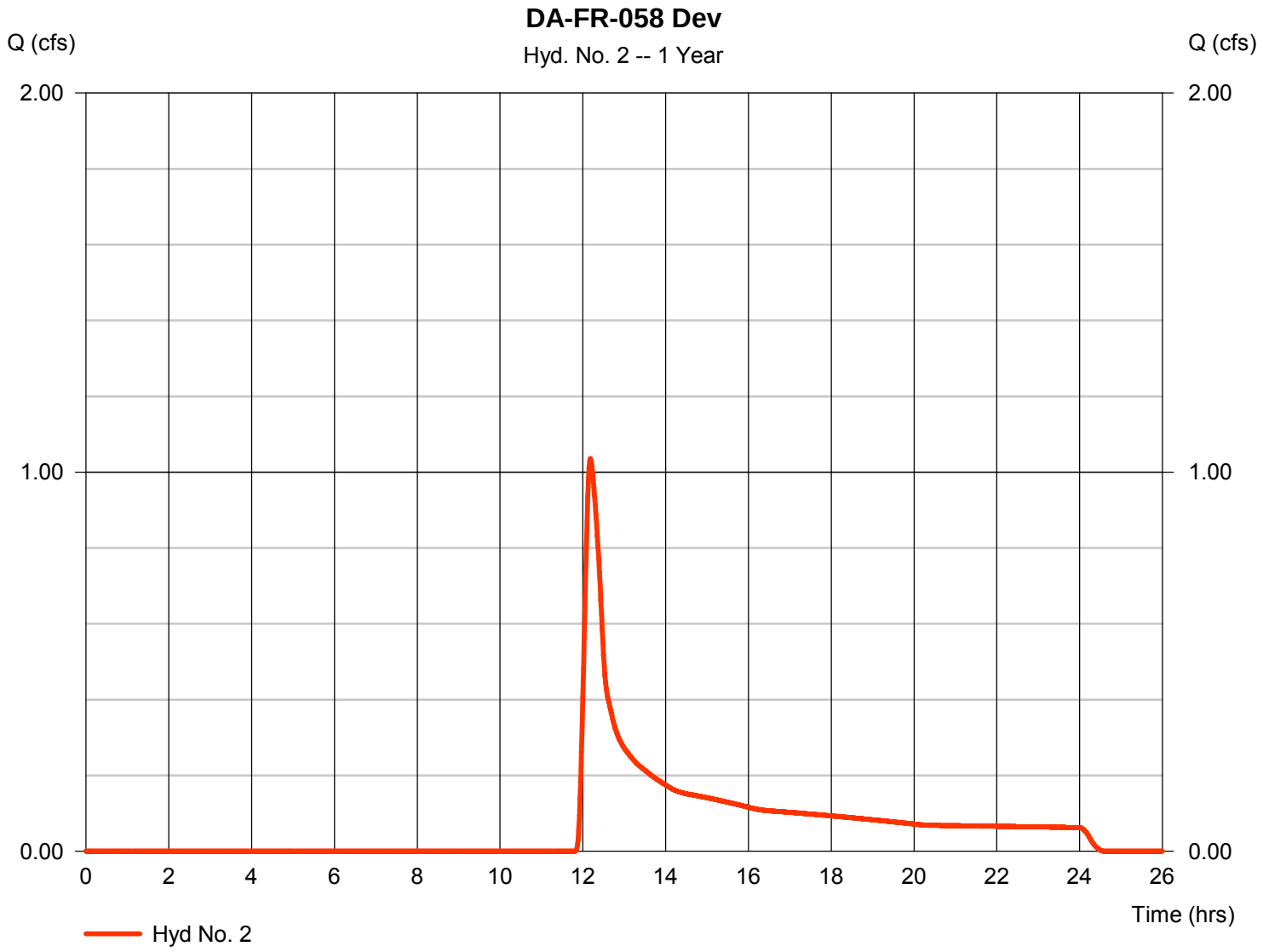
Hydrograph Report

Hyd. No. 2

DA-FR-058 Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 1.036 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.18 hrs
Time interval	= 1 min	Hyd. volume	= 6,320 cuft
Drainage area	= 4.660 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = + (4.660 x 58)] / 4.660



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-058 Dev

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 1.81		0.00		0.00		
Travel Time (min)	**= 20.78**	**+**	**0.00**	**+**	**0.00**	**=**	**20.78**
Shallow Concentrated Flow							
Flow length (ft)	= 326.32		0.00		0.00		
Watercourse slope (%)	= 6.84		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.22		0.00		0.00		
Travel Time (min)	**= 1.29**	**+**	**0.00**	**+**	**0.00**	**=**	**1.29**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

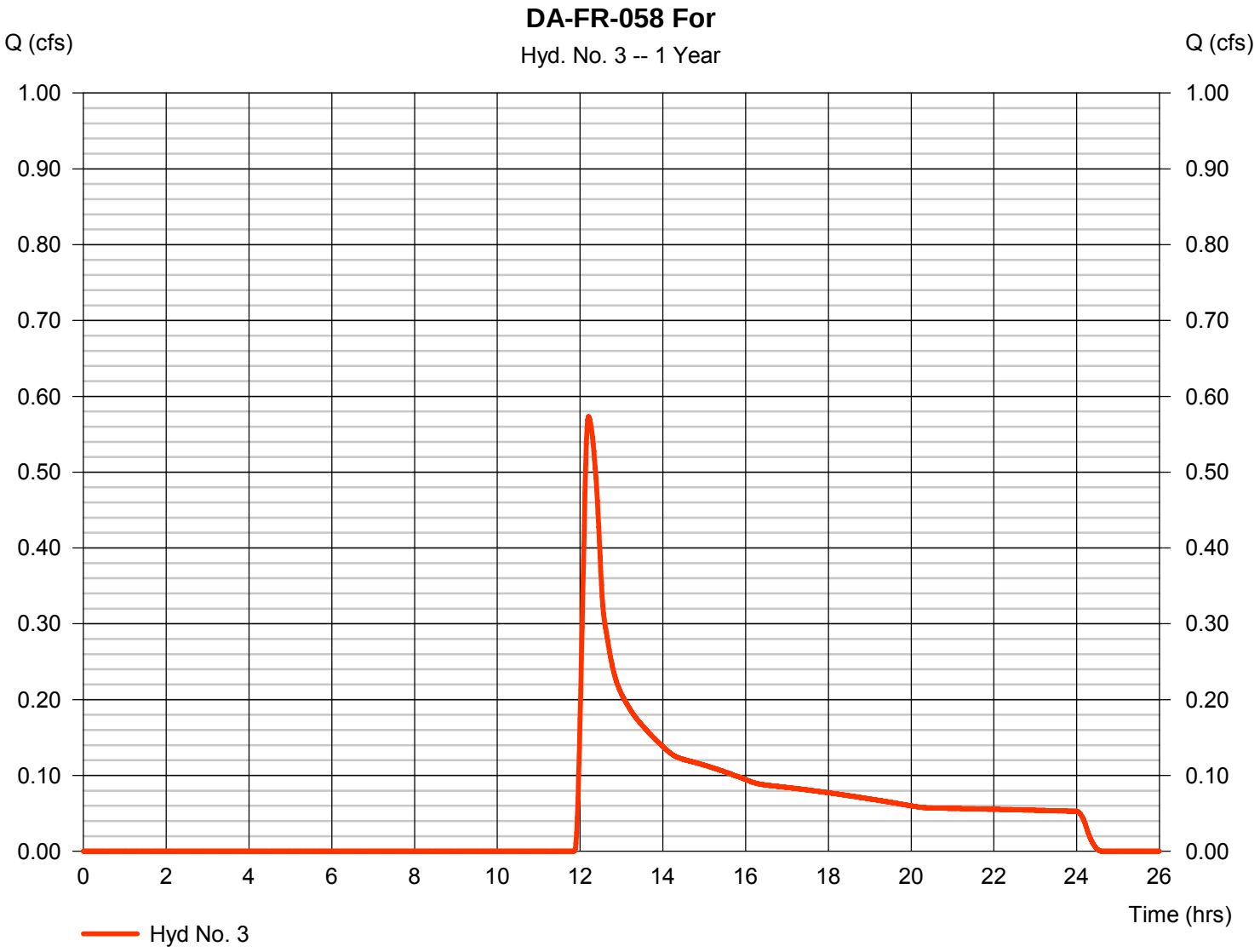
Total Travel Time, Tc ..... 22.10 min

Hydrograph Report

Hyd. No. 3

DA-FR-058 For

Hydrograph type	= SCS Runoff	Peak discharge	= 0.573 cfs
Storm frequency	= 1 yrs	Time to peak	= 12.20 hrs
Time interval	= 1 min	Hyd. volume	= 4,712 cuft
Drainage area	= 4.660 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-058 For

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 1.81		0.00		0.00		
Travel Time (min)	**= 20.78**	**+**	**0.00**	**+**	**0.00**	**=**	**20.78**
Shallow Concentrated Flow							
Flow length (ft)	= 326.32		0.00		0.00		
Watercourse slope (%)	= 6.84		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.22		0.00		0.00		
Travel Time (min)	**= 1.29**	**+**	**0.00**	**+**	**0.00**	**=**	**1.29**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 22.10 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	1.759	1	730	8,953	------	------	------	DA-FR-058 Pre
2	SCS Runoff	1.759	1	730	8,953	------	------	------	DA-FR-058 Dev
3	SCS Runoff	1.125	1	731	6,967	------	------	------	DA-FR-058 For

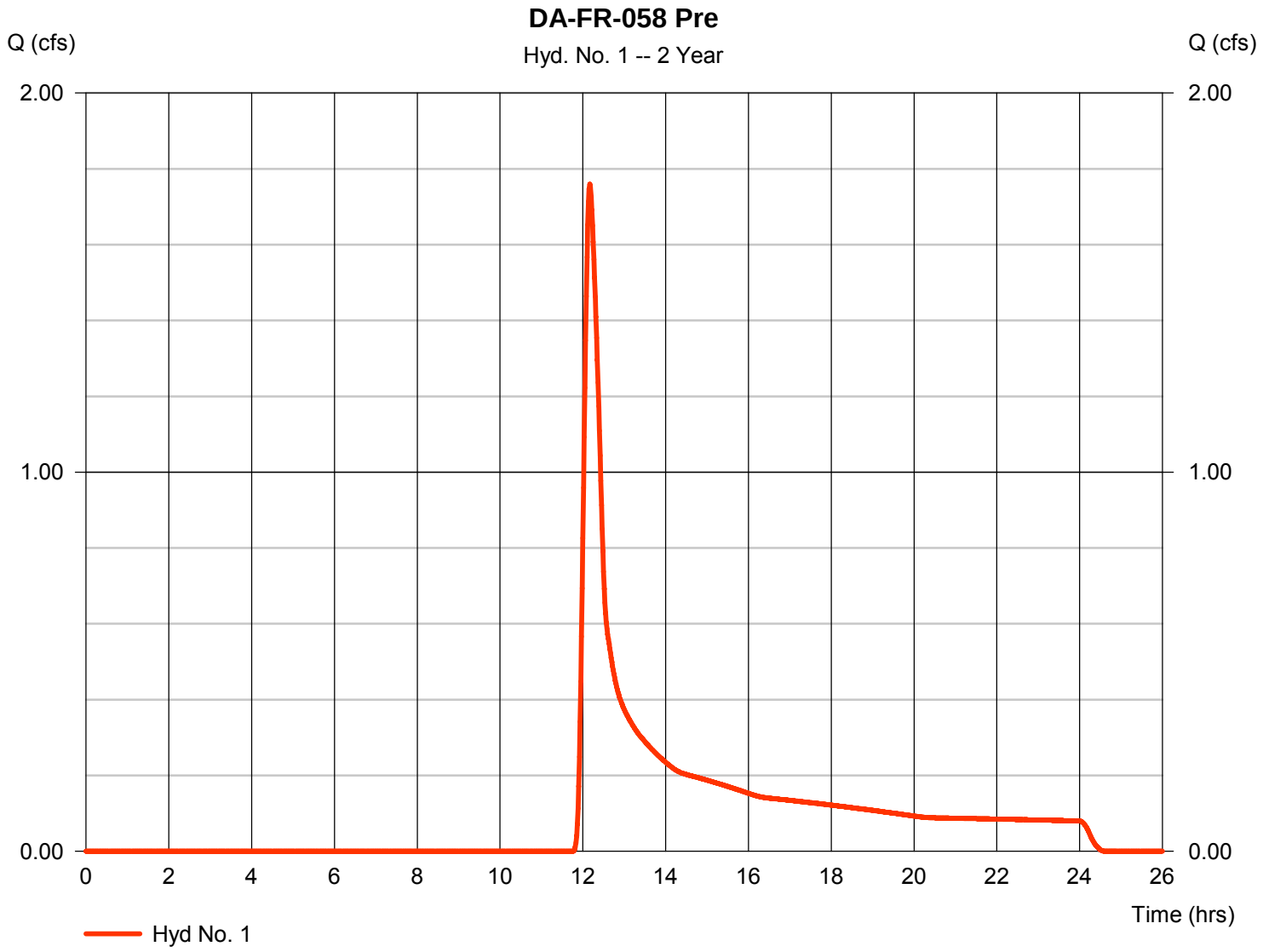
Hydrograph Report

Hyd. No. 1

DA-FR-058 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 1.759 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.17 hrs
Time interval	= 1 min	Hyd. volume	= 8,953 cuft
Drainage area	= 4.660 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.001 x 55) + (4.656 x 58)] / 4.660



Hydrograph Report

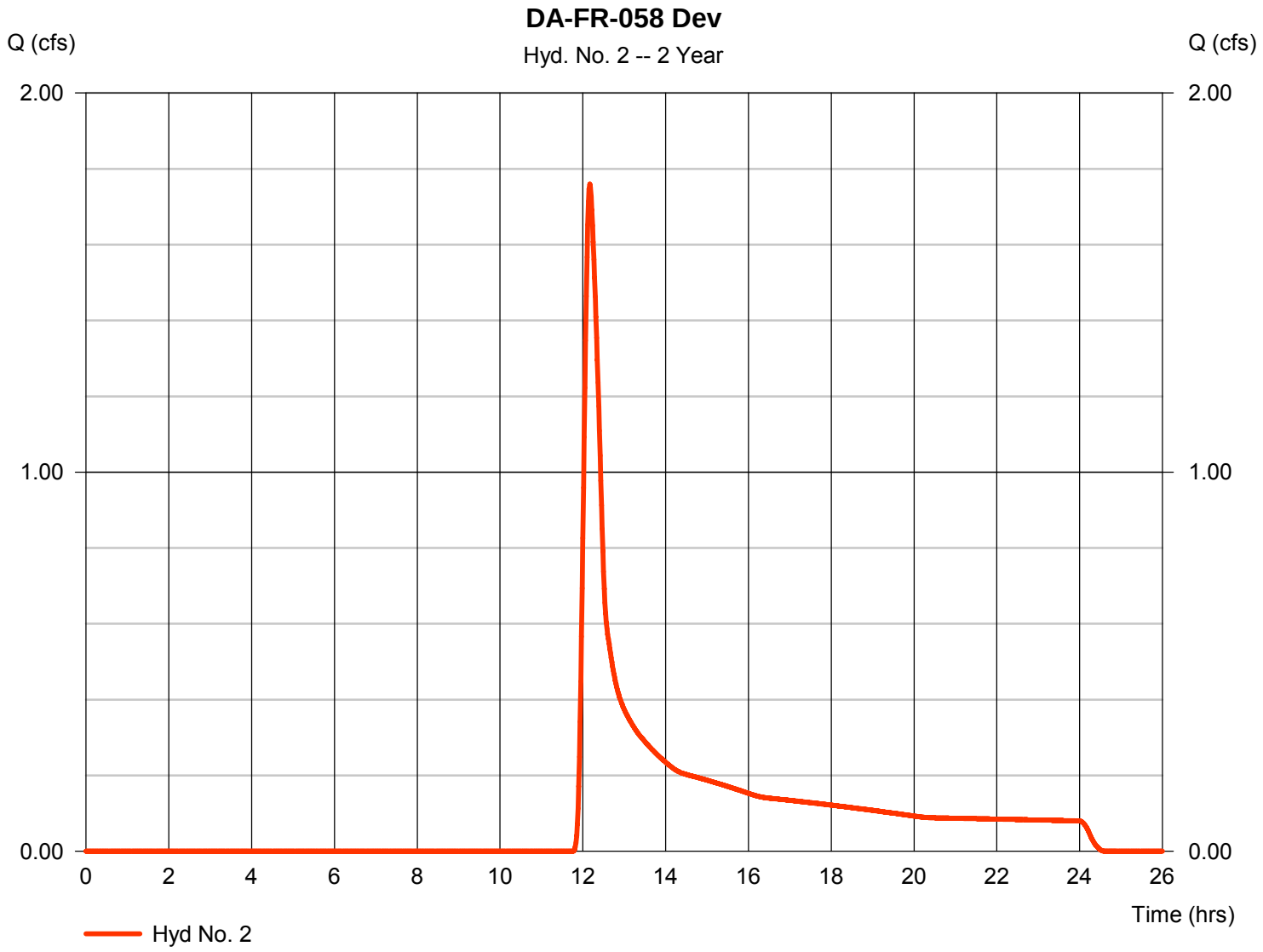
Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5 Tuesday, 09 / 19 / 2017

Hyd. No. 2

DA-FR-058 Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 1.759 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.17 hrs
Time interval	= 1 min	Hyd. volume	= 8,953 cuft
Drainage area	= 4.660 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = + (4.660 x 58)] / 4.660

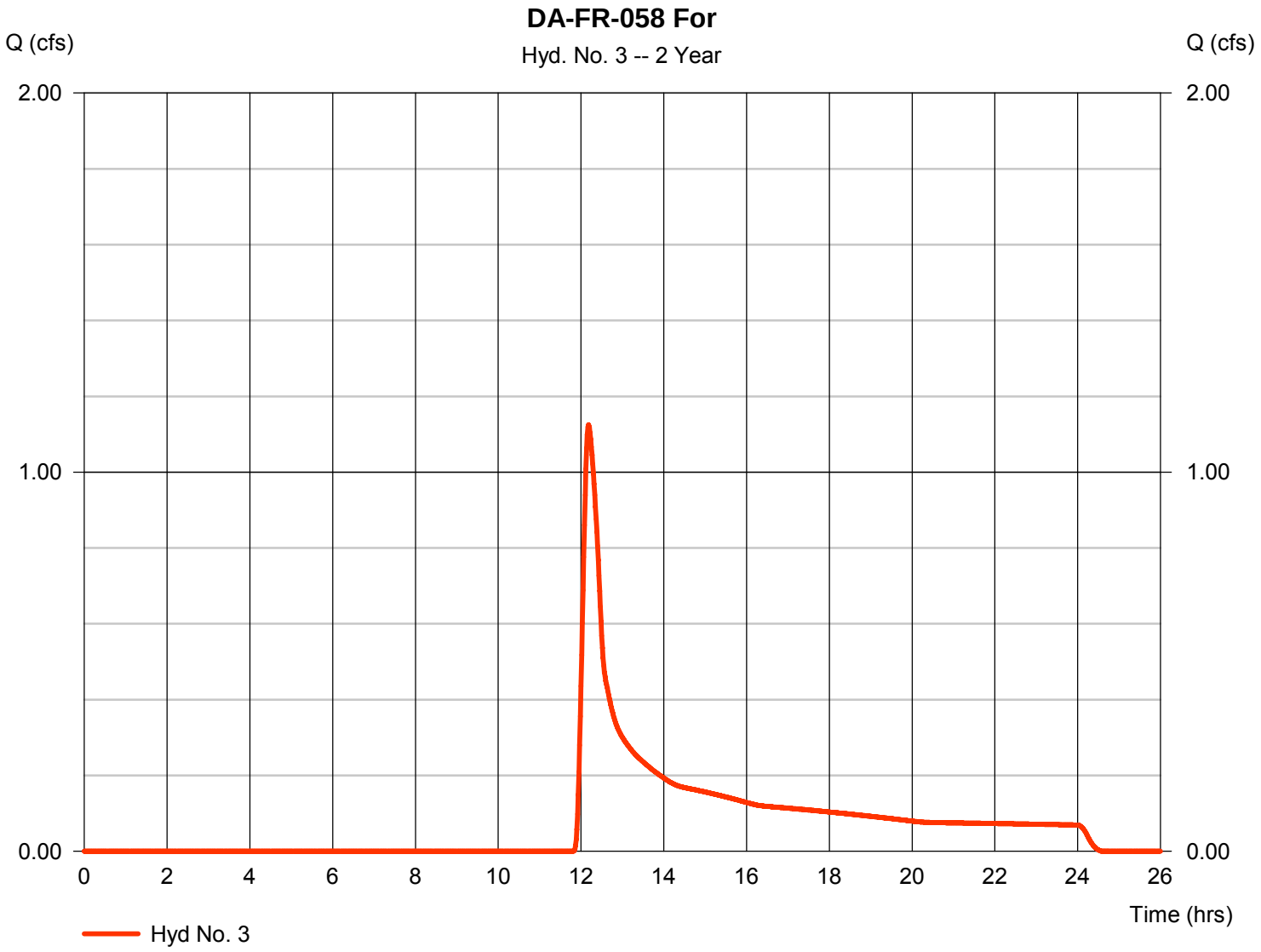


Hydrograph Report

Hyd. No. 3

DA-FR-058 For

Hydrograph type	= SCS Runoff	Peak discharge	= 1.125 cfs
Storm frequency	= 2 yrs	Time to peak	= 12.18 hrs
Time interval	= 1 min	Hyd. volume	= 6,967 cuft
Drainage area	= 4.660 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v10.5

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	7.061	1	728	26,369	------	------	------	DA-FR-058 Pre
2	SCS Runoff	7.061	1	728	26,369	------	------	------	DA-FR-058 Dev
3	SCS Runoff	5.751	1	728	22,607	------	------	------	DA-FR-058 For

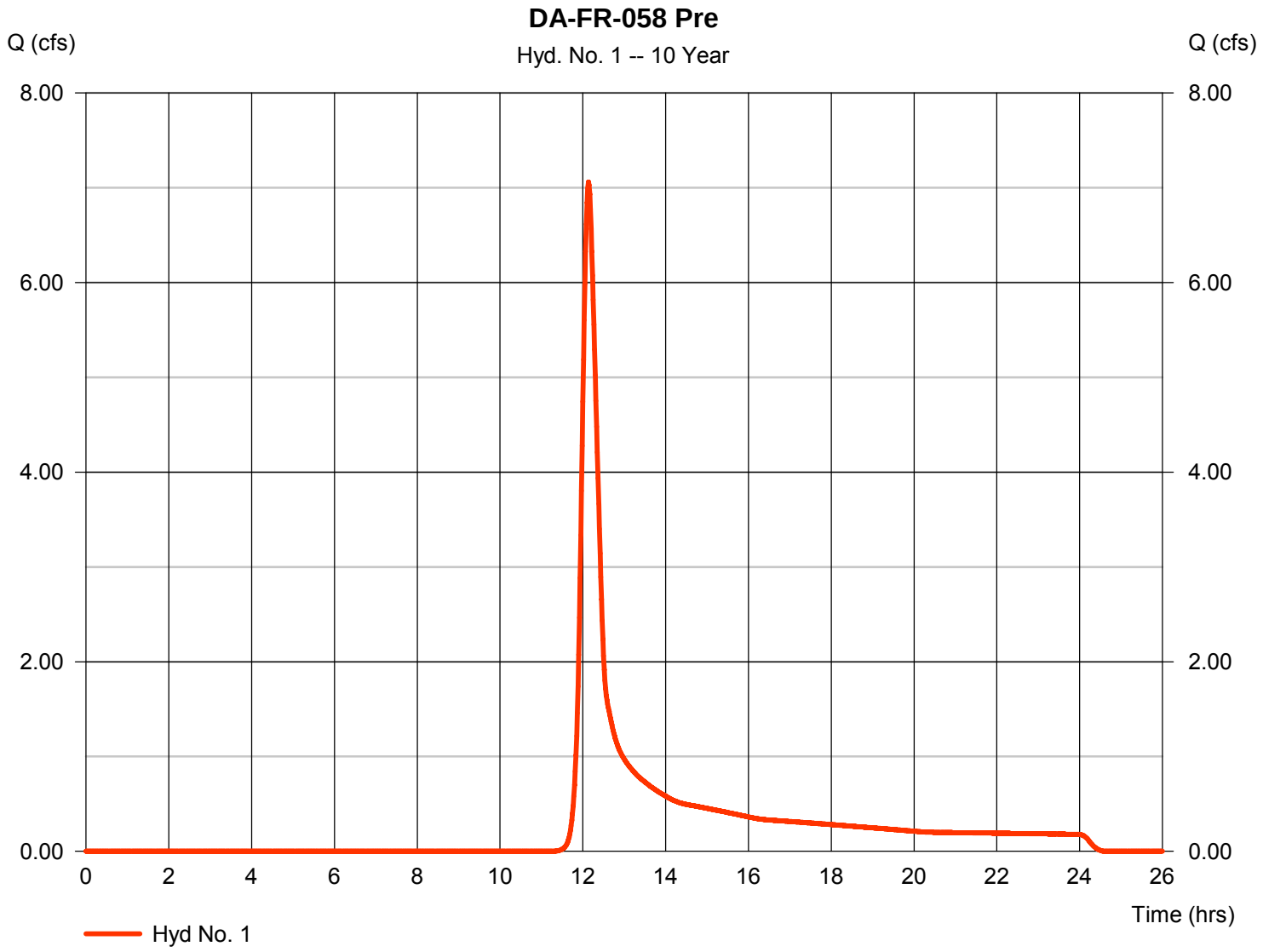
Hydrograph Report

Hyd. No. 1

DA-FR-058 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 7.061 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.13 hrs
Time interval	= 1 min	Hyd. volume	= 26,369 cuft
Drainage area	= 4.660 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.001 x 55) + (4.656 x 58)] / 4.660



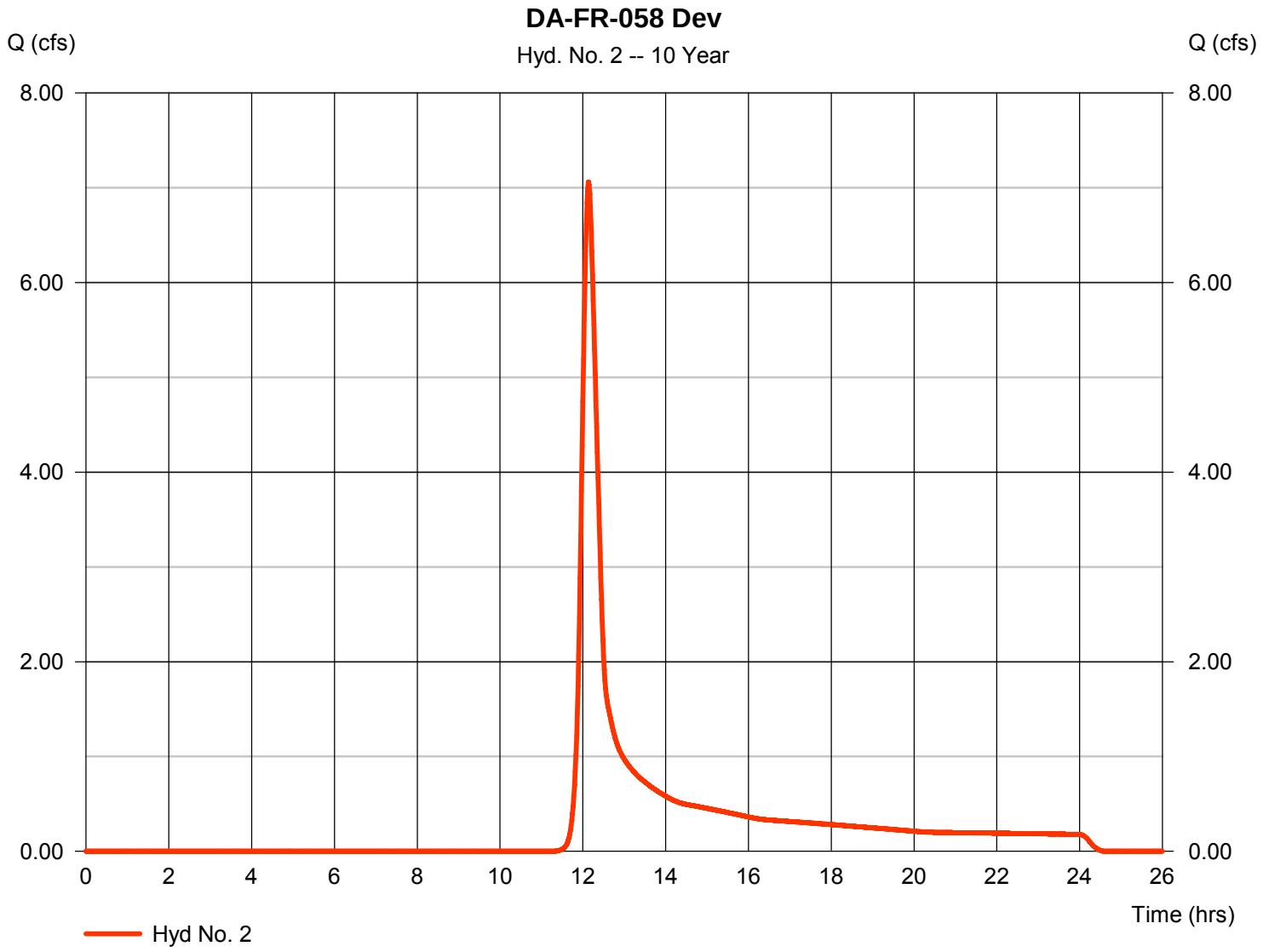
Hydrograph Report

Hyd. No. 2

DA-FR-058 Dev

Hydrograph type	= SCS Runoff	Peak discharge	= 7.061 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.13 hrs
Time interval	= 1 min	Hyd. volume	= 26,369 cuft
Drainage area	= 4.660 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = + (4.660 x 58)] / 4.660

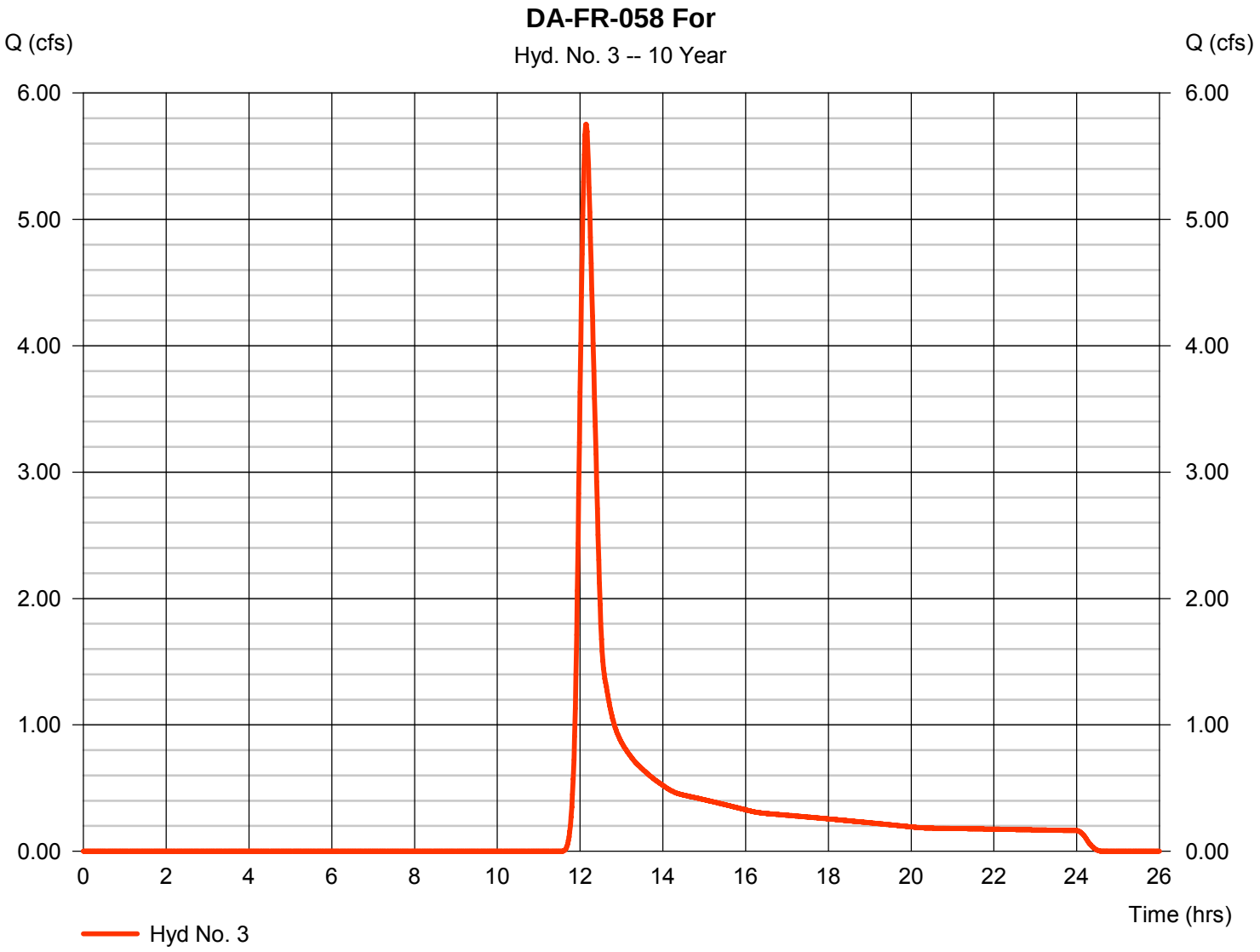


Hydrograph Report

Hyd. No. 3

DA-FR-058 For

Hydrograph type	= SCS Runoff	Peak discharge	= 5.751 cfs
Storm frequency	= 10 yrs	Time to peak	= 12.13 hrs
Time interval	= 1 min	Hyd. volume	= 22,607 cuft
Drainage area	= 4.660 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 22.10 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

ling\Franklin County\Downloaded Files\Franklin County DA Batch 4 - 046 - 058\Precipitation\Hydraflow\FranklinCo.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-060

DA-FR-060 is located in a meadow and forested area with undulating slopes and contains existing houses. No new impervious area is proposed within DA-FR-060. Total phosphorus load reduction is not required for DA-FR-060. Agricultural areas/fields that will be returned to crop production, in identical condition, upon completion of pipeline construction are exempt from meeting the VA water quality (9VAC25-870-63) and the VA water quantity (9VAC25-870-66) requirements per § 62.1-44.15:34 and 9VAC25-870-300. Therefore, the provisions of water quality design criteria requirements and permanent stormwater management controls for DA-FR-060 are exempt and no stormwater BMPs are required. Figures for DA-FR-060 are presented in following pages. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

DA-FR-060
7.16 acres
Weighted CN = 58

263.6
263.7
263.8
263.9
264.0
264.1

S-GD2
S-GD3
S-GD1

1050
1100

B

LAND USE	HSG	CN	AREA (AC)
Impervious	B	98	0.03
Meadow	B	58	7.07
Woods - Good	B	55	0.06

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:2,400

200 100 0 200 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-060
Spread 11

Figure 1
Franklin County, Virginia

August, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\MapDocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-060_Pre.mxd

DA-FR-060
7.16 acres
Weighted CN = 58

DA-FR-060 Permanent ROW
1.22 acres

263.6
263.7
263.8
263.9
264.0
264.1

S-001
S-002
S-003
S-004

1050
1100

B

LAND USE	HSG	CN	AREA (AC)
Impervious	B	98	0.03
Meadow	B	58	7.07
Woods - Good	B	55	0.06

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:2,400

200 100 0 200
Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-060
Spread 11

Figure 2
Franklin County, Virginia

August, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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DA-FR-061

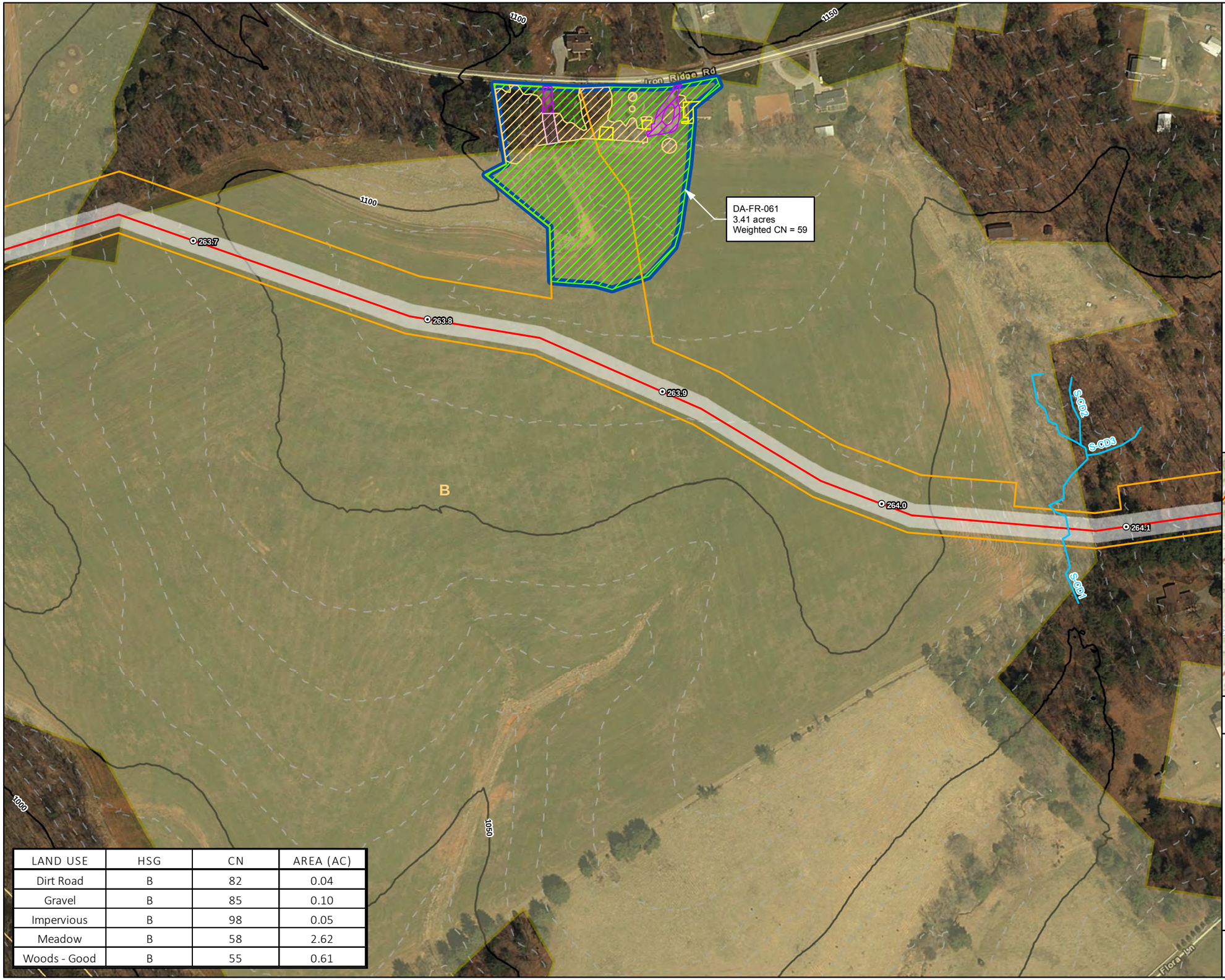
DA-FR-061 is located in a meadow and forested area with undulating slopes and contains both agricultural and non-agricultural areas within the limits of disturbance (LOD). No new impervious area is proposed within DA-FR-061. The drainage area extent encompasses a temporary work space and does not include any part of the permanent right-of-way (ROW). Water quality analysis is not required for DA-FR-061 since the drainage area does not encompass the permanent ROW.

Stormwater quantity is met via the energy balance method. For SWM quantity, agricultural areas within the study area are considered/included but an Improvement Factor of 1.00 is used when applying the Energy Balance Method to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph's 10-year 24-hour peak discharge results indicate a decrease in flow of 0.41 cfs for DA-FR-061 (as seen in table below).

Sub-area	Pre-peak Flow, 10-yr Q (cfs)	Post-peak Flow, 10-yr Q (cfs)	Flow differential
DA-FR-061	7.19	6.78	-0.41

Figures and calculations for DA-FR-061 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.



LAND USE	HSG	CN	AREA (AC)
Dirt Road	B	82	0.04
Gravel	B	85	0.10
Impervious	B	98	0.05
Meadow	B	58	2.62
Woods - Good	B	55	0.61

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Dirt Road
- Gravel
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:2,400

200 100 0 200 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

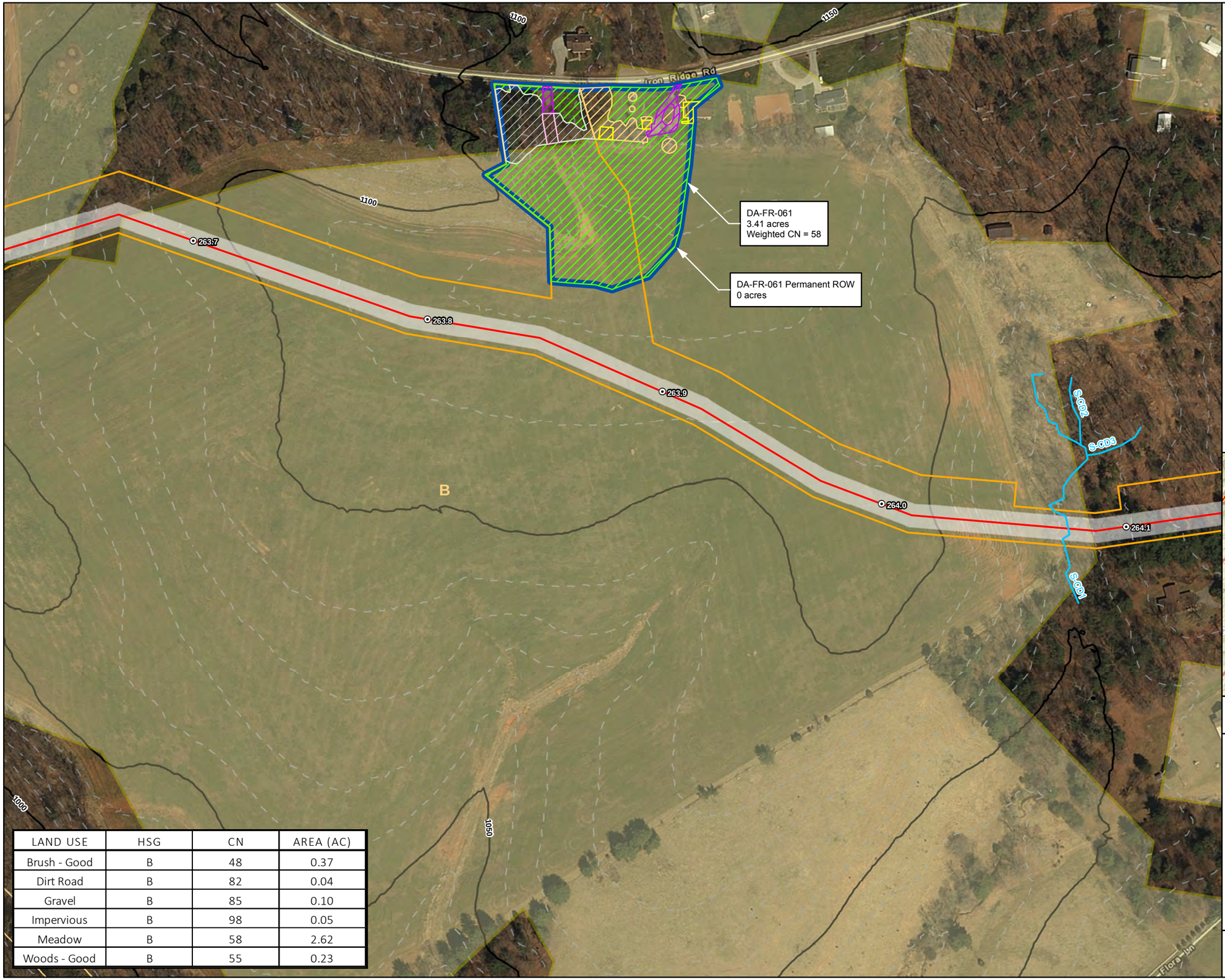
Pre-Construction Drainage Area Map
DA-FR-061
Spread 11

Figure 1
Franklin County, Virginia

August, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-061_Pre.mxd



LAND USE	HSG	CN	AREA (AC)
Brush - Good	B	48	0.37
Dirt Road	B	82	0.04
Gravel	B	85	0.10
Impervious	B	98	0.05
Meadow	B	58	2.62
Woods - Good	B	55	0.23

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Dirt Road
- Gravel
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:2,400

200 100 0 200 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-061
Spread 11

Figure 2

Franklin County, Virginia

August, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

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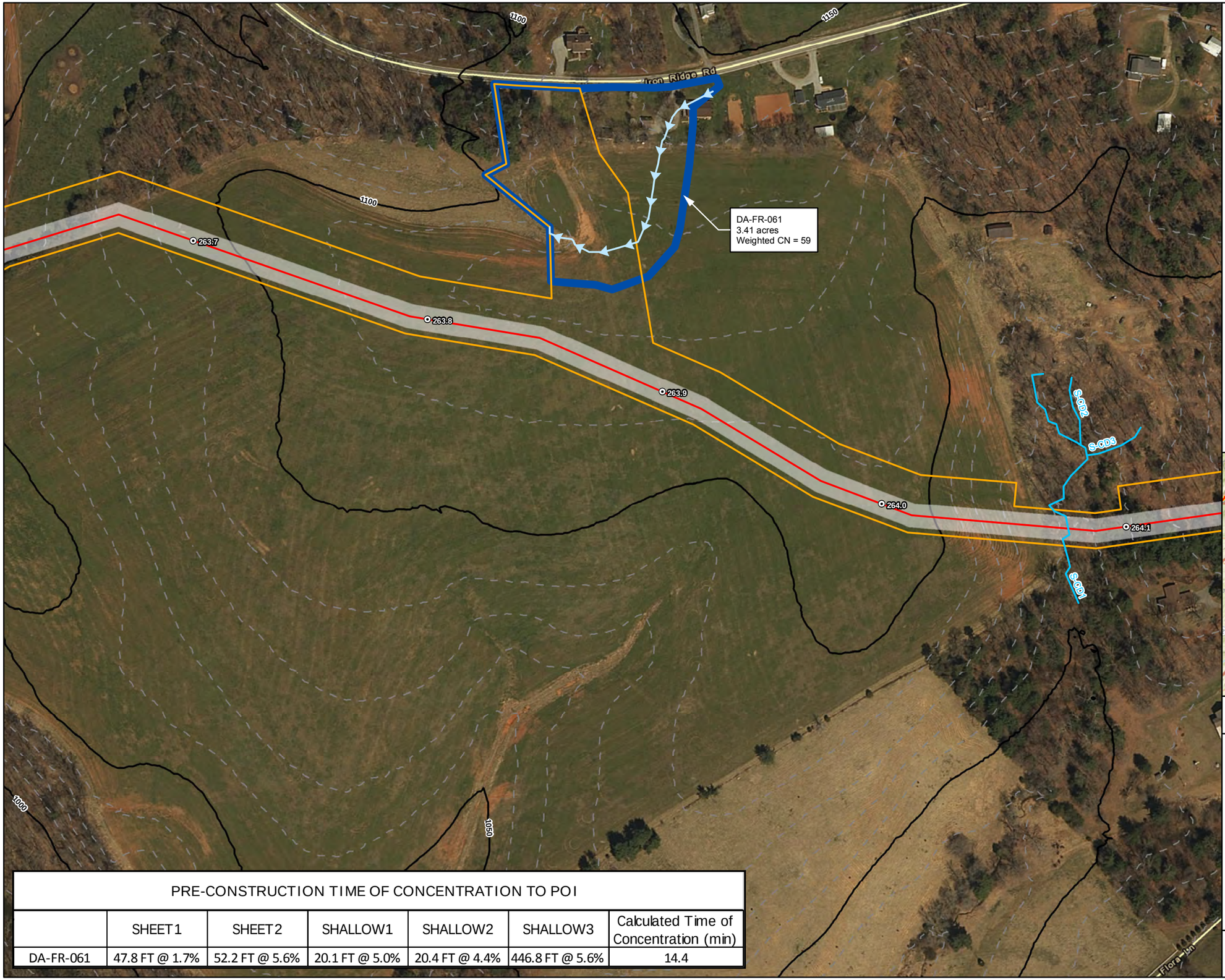


PRE-CONSTRUCTION TIME OF CONCENTRATION TO POI						
	SHEET 1	SHEET 2	SHALLOW1	SHALLOW2	SHALLOW3	Calculated Time of Concentration (min)
DA-FR-061	47.8 FT @ 1.7%	52.2 FT @ 5.6%	20.1 FT @ 5.0%	20.4 FT @ 4.4%	446.8 FT @ 5.6%	14.4

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:2,400

200 100 0 200 Feet

N W E S

Mountain Valley Pipeline Project

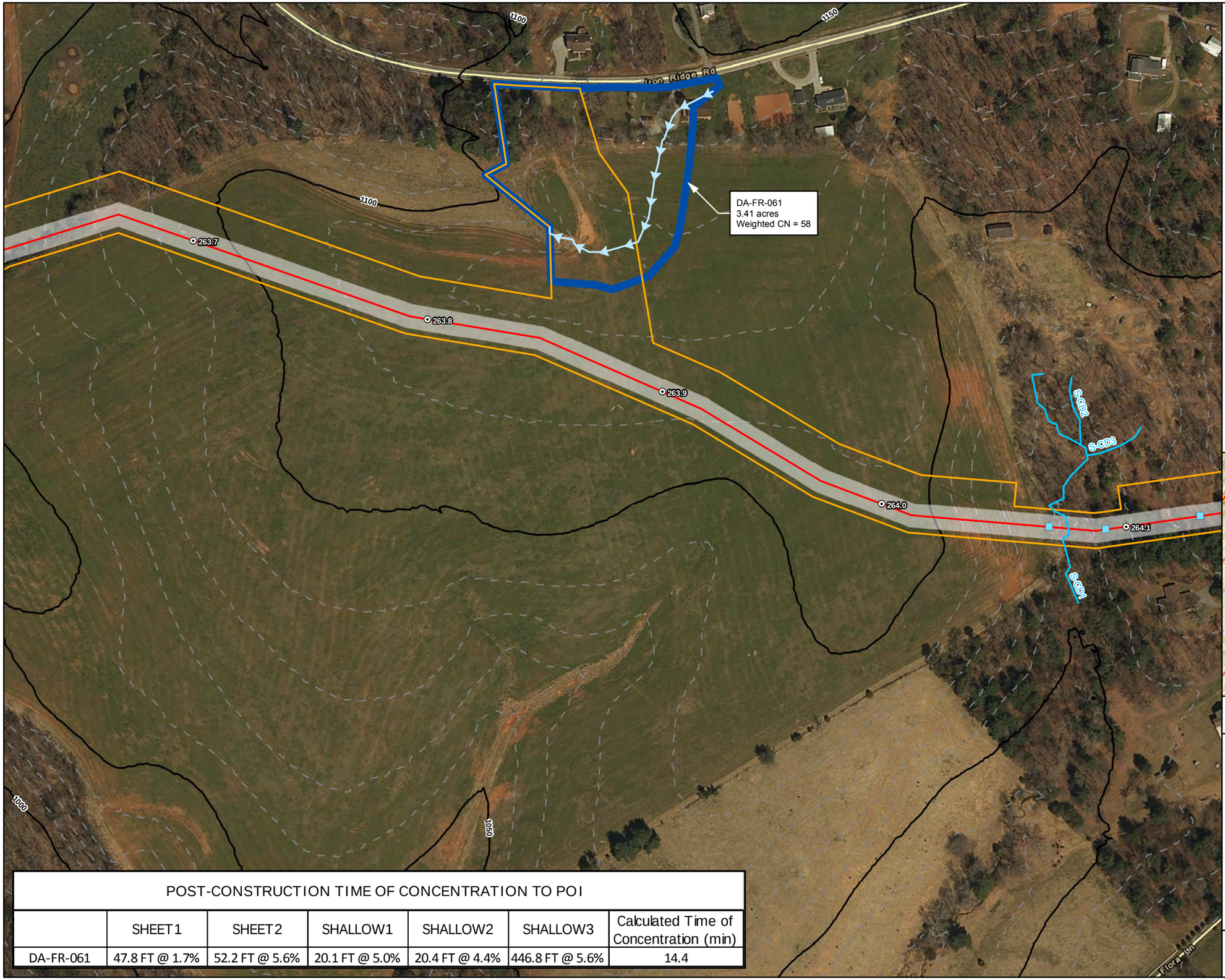
Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration
DA-FR-061
Spread 11

Figure 3
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-061_3.mxd



POST-CONSTRUCTION TIME OF CONCENTRATION TO POI						
	SHEET 1	SHEET 2	SHALLOW1	SHALLOW2	SHALLOW3	Calculated Time of Concentration (min)
DA-FR-061	47.8 FT @ 1.7%	52.2 FT @ 5.6%	20.1 FT @ 5.0%	20.4 FT @ 4.4%	446.8 FT @ 5.6%	14.4

Legend

- Milepost
- Permanent Waterbars
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:2,400

200 100 0 200 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration
DA-FR-061
Spread 11

Figure 4
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016.

Document Path: P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-061_4.mxd

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.212	5,097
Developed Condition	1.030	4,666
Pre-Developed (Forest) Condition	0.442	3,513

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

			Q (cfs)		Q (cfs)
Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->		1.03	≤ OK	1.324
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->		1.03	≤ OK	1.212
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->		1.03	*shall not* be required to be ≤	0.333

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

[1]For Paved Road land surface types a Manning's n value of 0.011 was used.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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DA-FR-061.gpw

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Watershed Model Schematic

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-061 Pre
2	SCS Runoff	DA-FR-061 Post
3	SCS Runoff	DA-FR-061 Pre-Forested

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.212	1.981	-------	-------	7.185	-------	-------	-------	DA-FR-061 Pre
2	SCS Runoff	------	1.030	1.745	-------	-------	6.782	-------	-------	-------	DA-FR-061 Post
3	SCS Runoff	------	0.442	0.870	-------	-------	4.446	-------	-------	-------	DA-FR-061 Pre-Forested

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	1.212	1	725	5,097	------	------	------	DA-FR-061 Pre
2	SCS Runoff	1.030	1	725	4,666	------	------	------	DA-FR-061 Post
3	SCS Runoff	0.442	1	731	3,513	------	------	------	DA-FR-061 Pre-Forested

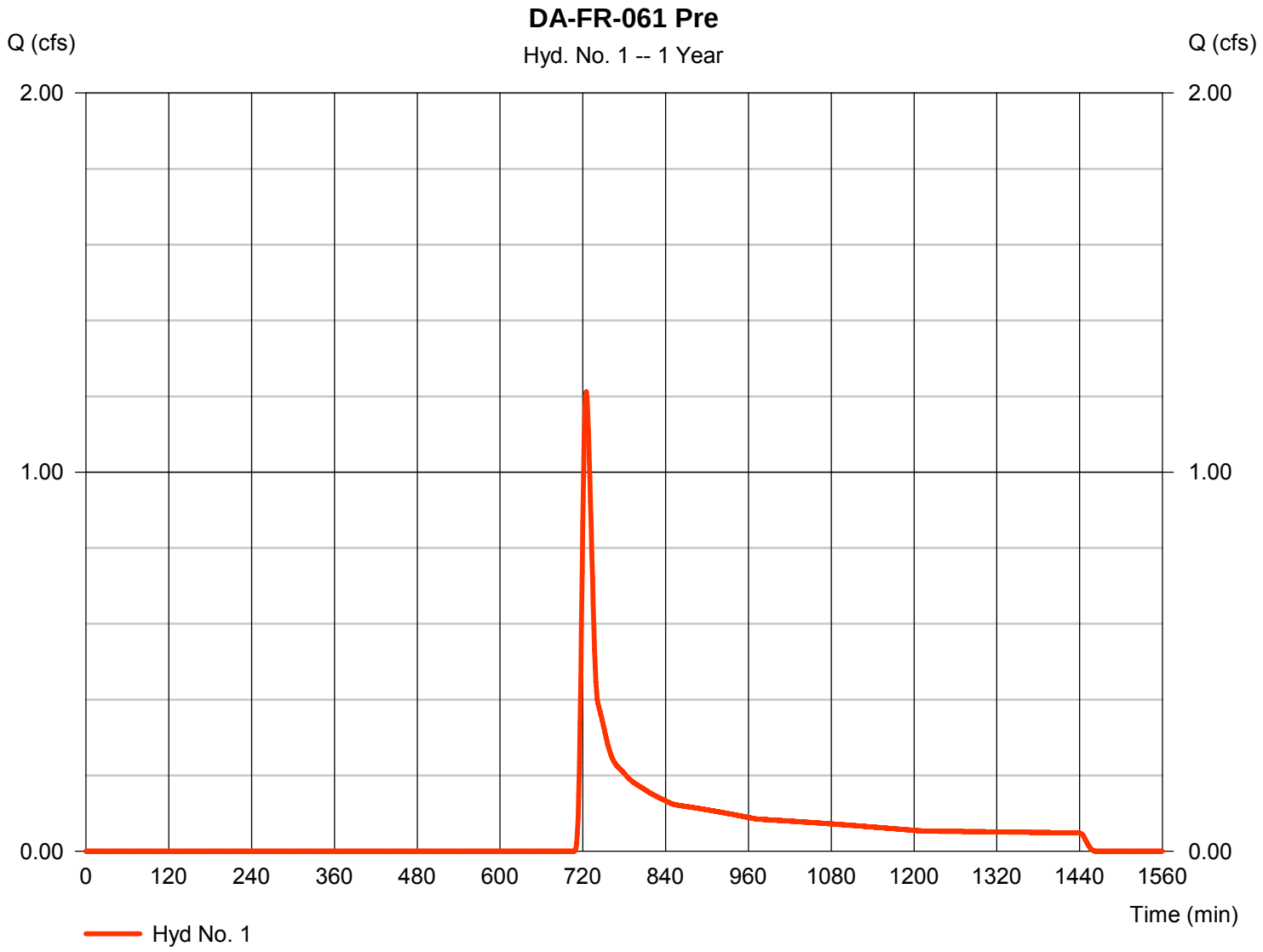
Hydrograph Report

Hyd. No. 1

DA-FR-061 Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.212 cfs
Storm frequency	=	1 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	5,097 cuft
Drainage area	=	3.410 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.40 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.036 x 82) + (0.098 x 85) + (0.048 x 98) + (2.620 x 58) + (0.605 x 55)] / 3.410



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-061 Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 47.8		52.2		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 1.70		5.60		0.00		
Travel Time (min)	**= 11.81**	**+**	**0.44**	**+**	**0.00**	**=**	**12.25**
Shallow Concentrated Flow							
Flow length (ft)	= 20.10		20.40		446.80		
Watercourse slope (%)	= 5.00		4.40		5.60		
Surface description	= Unpaved		Paved		Unpaved		
Average velocity (ft/s)	=3.61		4.26		3.82		
Travel Time (min)	**= 0.09**	**+**	**0.08**	**+**	**1.95**	**=**	**2.12**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.40 min

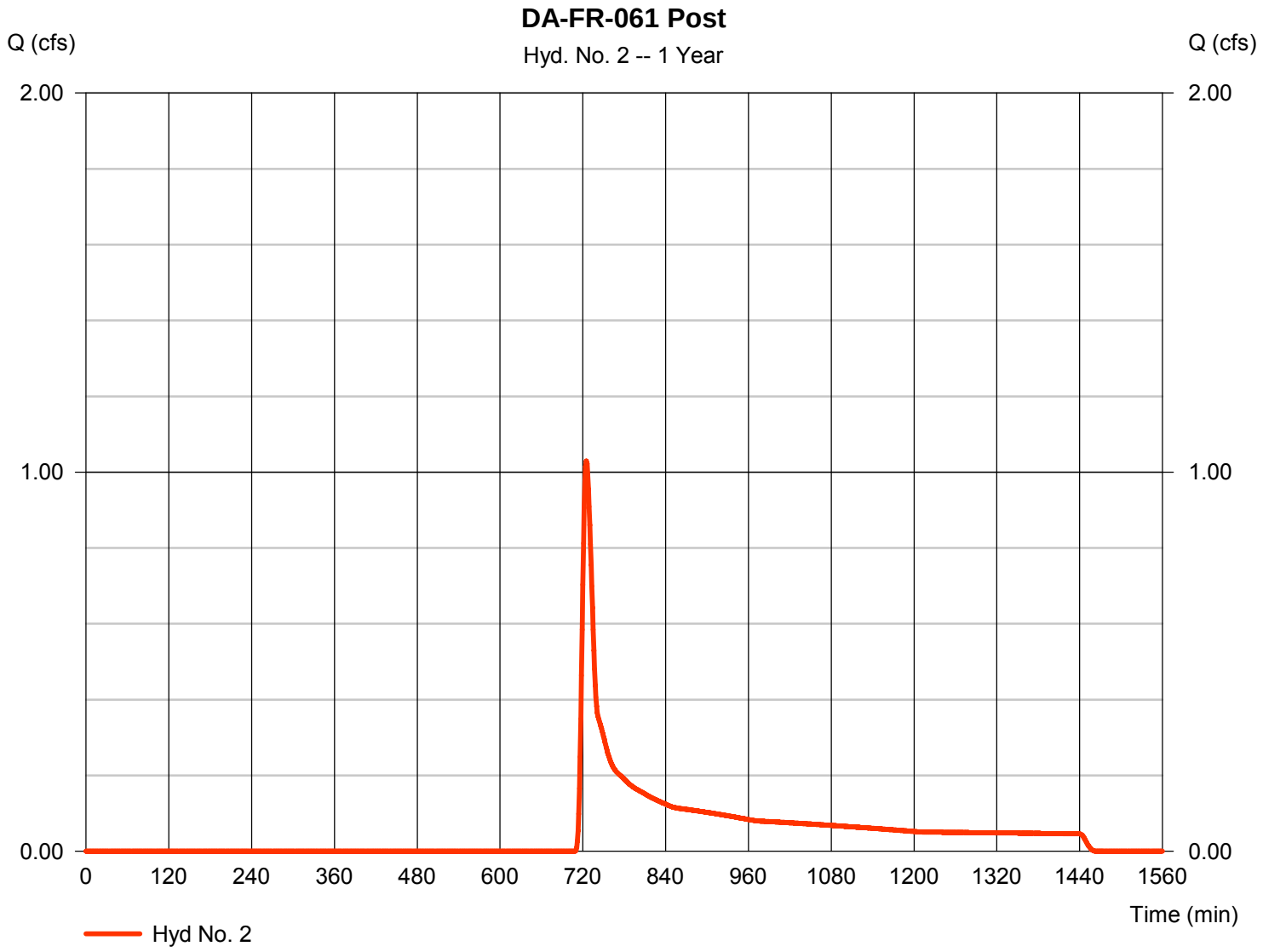
Hydrograph Report

Hyd. No. 2

DA-FR-061 Post

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.030 cfs
Storm frequency	=	1 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	4,666 cuft
Drainage area	=	3.410 ac	Curve number	=	58*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.40 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.370 x 48) + (0.040 x 82) + (0.100 x 85) + (0.050 x 98) + (2.620 x 58) + (0.230 x 55)] / 3.410



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-061 Post

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 47.8		52.2		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 1.70		5.60		0.00		
Travel Time (min)	**= 11.81**	**+**	**0.44**	**+**	**0.00**	**=**	**12.25**
Shallow Concentrated Flow							
Flow length (ft)	= 20.10		20.40		446.80		
Watercourse slope (%)	= 5.00		4.40		5.60		
Surface description	= Unpaved		Paved		Unpaved		
Average velocity (ft/s)	=3.61		4.26		3.82		
Travel Time (min)	**= 0.09**	**+**	**0.08**	**+**	**1.95**	**=**	**2.12**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

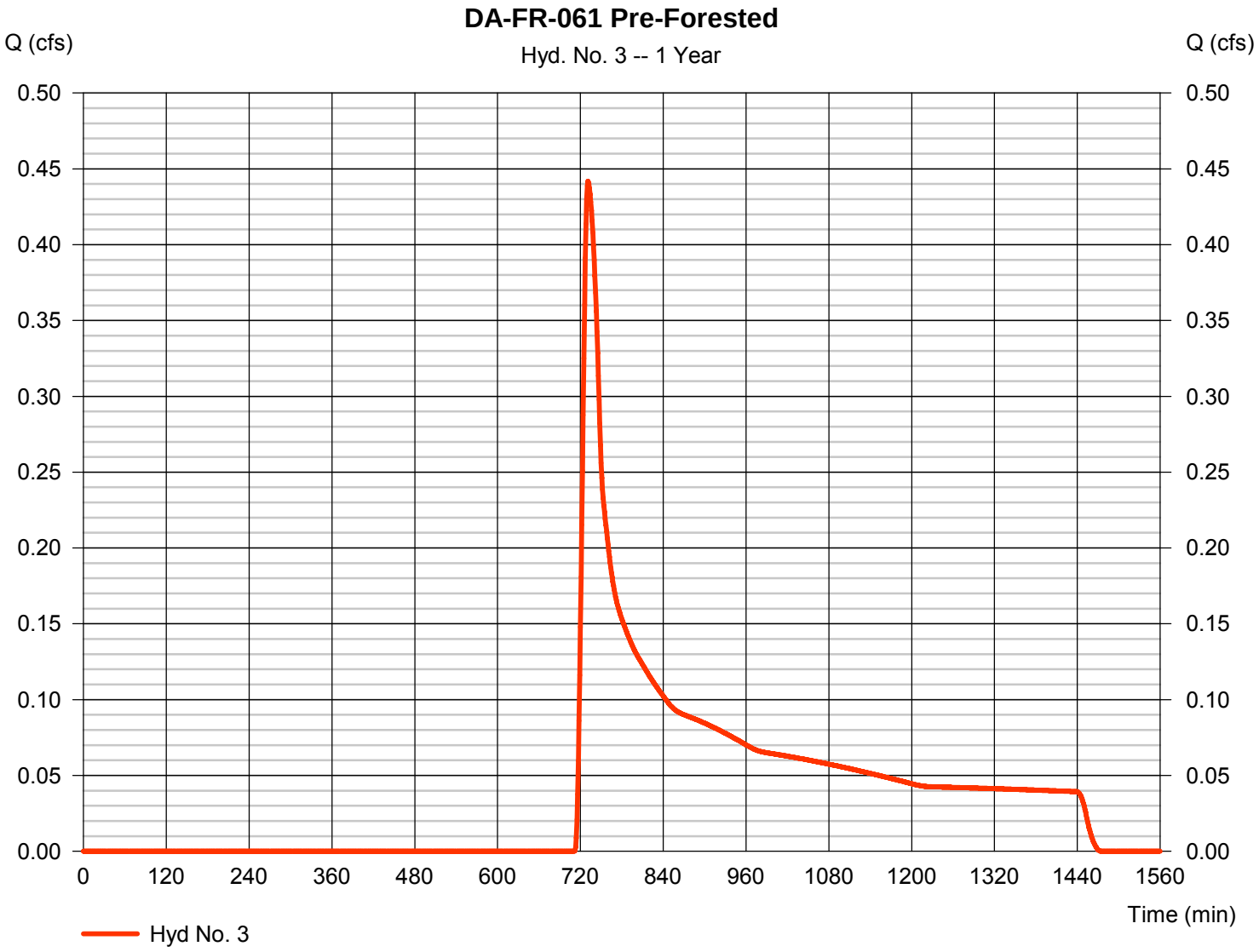
Total Travel Time, Tc ..... 14.40 min

Hydrograph Report

Hyd. No. 3

DA-FR-061 Pre-Forested

Hydrograph type	= SCS Runoff	Peak discharge	= 0.442 cfs
Storm frequency	= 1 yrs	Time to peak	= 731 min
Time interval	= 1 min	Hyd. volume	= 3,513 cuft
Drainage area	= 3.410 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 21.80 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-061 Pre-Forested

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.400		0.011		
Flow length (ft)	= 47.8		52.2		0.0		
Two-year 24-hr precip. (in)	= 3.70		3.70		0.00		
Land slope (%)	= 1.70		5.60		0.00		
Travel Time (min)	**= 11.81**	**+**	**7.86**	**+**	**0.00**	**=**	**19.67**
Shallow Concentrated Flow							
Flow length (ft)	= 20.10		20.40		446.80		
Watercourse slope (%)	= 5.00		4.40		5.60		
Surface description	= Unpaved		Unpaved		Unpaved		
Average velocity (ft/s)	=3.61		3.38		3.82		
Travel Time (min)	**= 0.09**	**+**	**0.10**	**+**	**1.95**	**=**	**2.14**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 21.80 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	1.981	1	724	7,135	------	------	------	DA-FR-061 Pre
2	SCS Runoff	1.745	1	724	6,611	------	------	------	DA-FR-061 Post
3	SCS Runoff	0.870	1	730	5,194	------	------	------	DA-FR-061 Pre-Forested

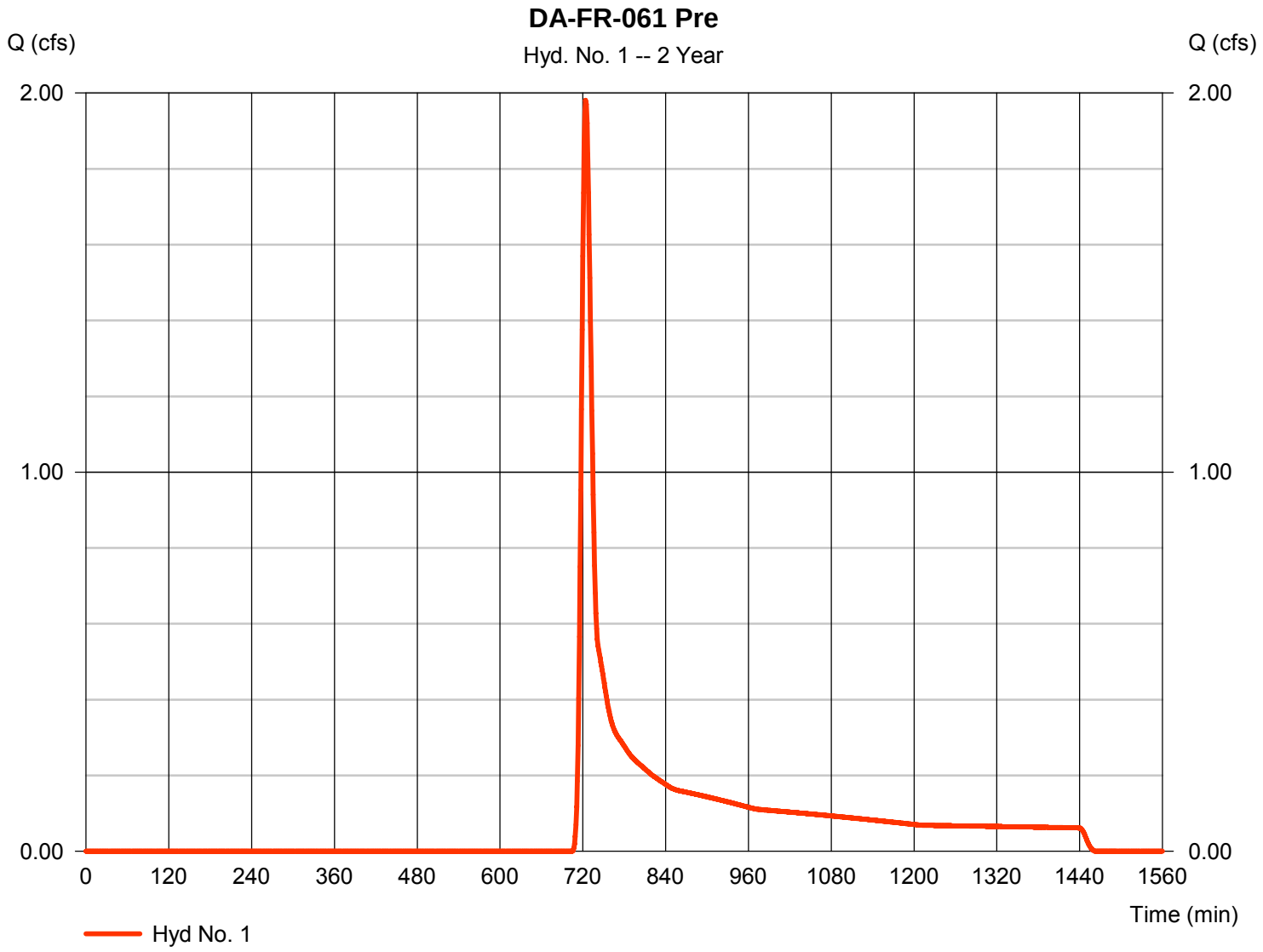
Hydrograph Report

Hyd. No. 1

DA-FR-061 Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.981 cfs
Storm frequency	=	2 yrs	Time to peak	=	724 min
Time interval	=	1 min	Hyd. volume	=	7,135 cuft
Drainage area	=	3.410 ac	Curve number	=	59*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.40 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.036 x 82) + (0.098 x 85) + (0.048 x 98) + (2.620 x 58) + (0.605 x 55)] / 3.410



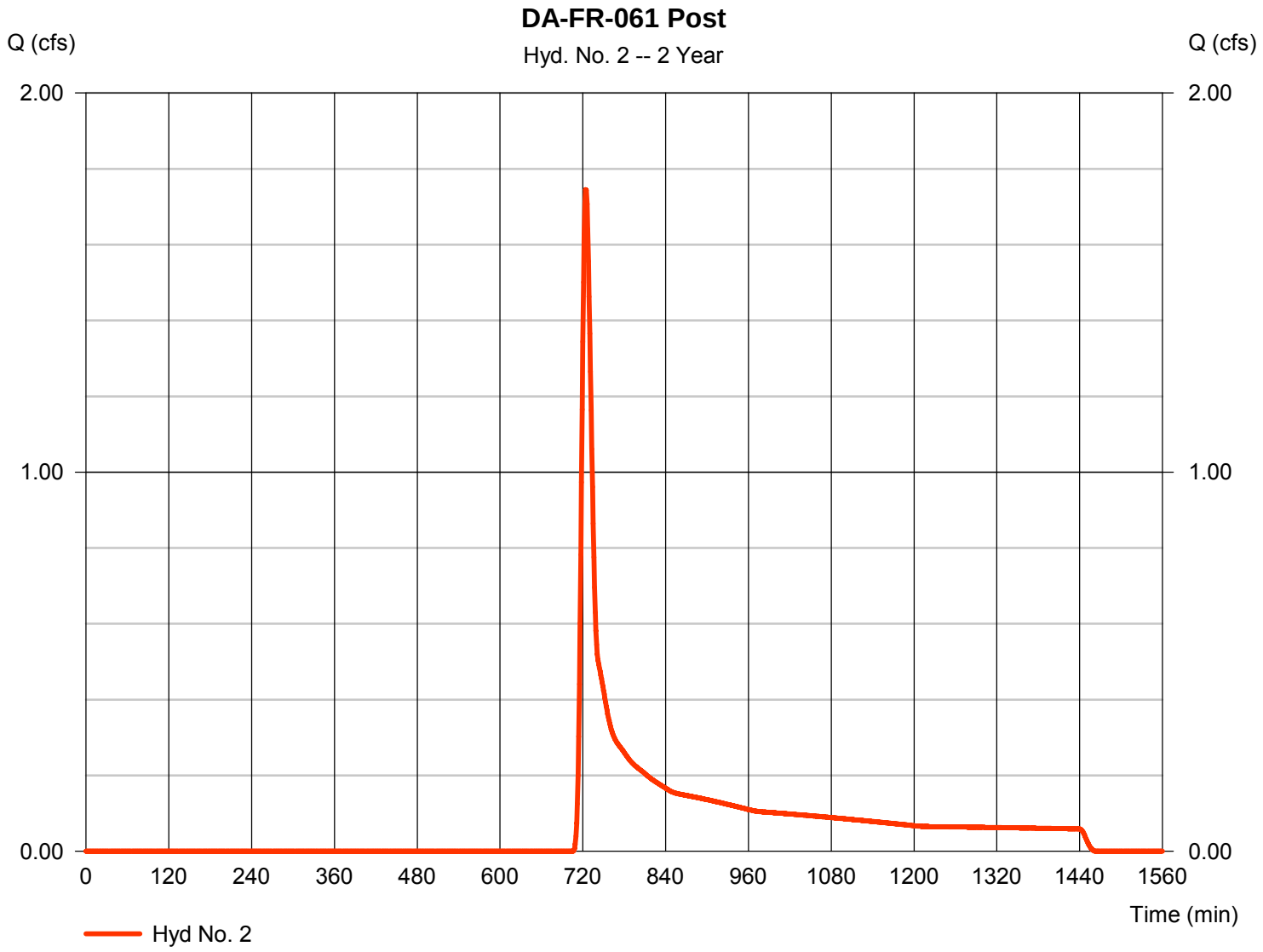
Hydrograph Report

Hyd. No. 2

DA-FR-061 Post

Hydrograph type	= SCS Runoff	Peak discharge	= 1.745 cfs
Storm frequency	= 2 yrs	Time to peak	= 724 min
Time interval	= 1 min	Hyd. volume	= 6,611 cuft
Drainage area	= 3.410 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.370 x 48) + (0.040 x 82) + (0.100 x 85) + (0.050 x 98) + (2.620 x 58) + (0.230 x 55)] / 3.410

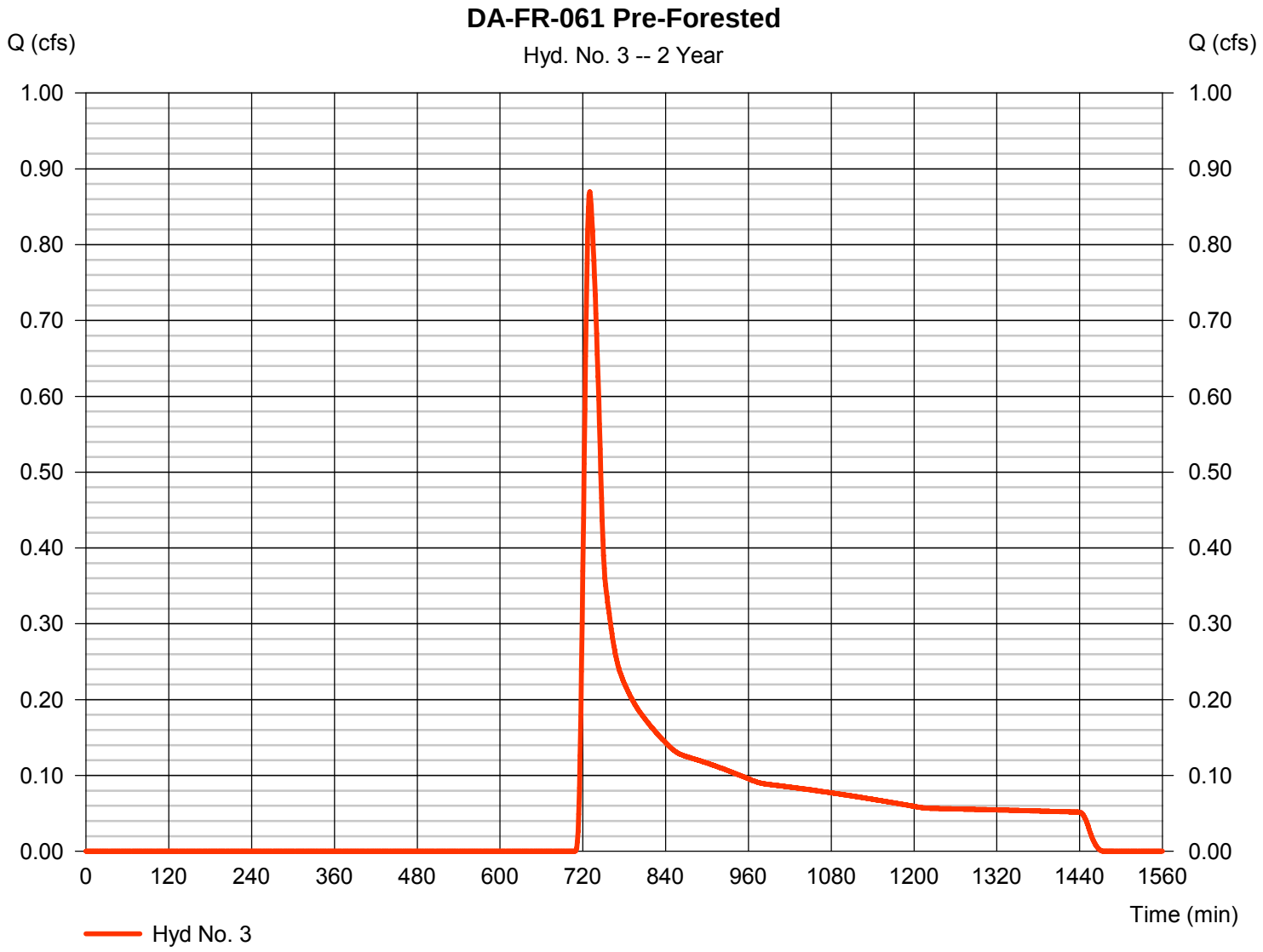


Hydrograph Report

Hyd. No. 3

DA-FR-061 Pre-Forested

Hydrograph type	= SCS Runoff	Peak discharge	= 0.870 cfs
Storm frequency	= 2 yrs	Time to peak	= 730 min
Time interval	= 1 min	Hyd. volume	= 5,194 cuft
Drainage area	= 3.410 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 21.80 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	7.185	1	723	20,424	------	------	------	DA-FR-061 Pre
2	SCS Runoff	6.782	1	723	19,469	------	------	------	DA-FR-061 Post
3	SCS Runoff	4.446	1	727	16,853	------	------	------	DA-FR-061 Pre-Forested

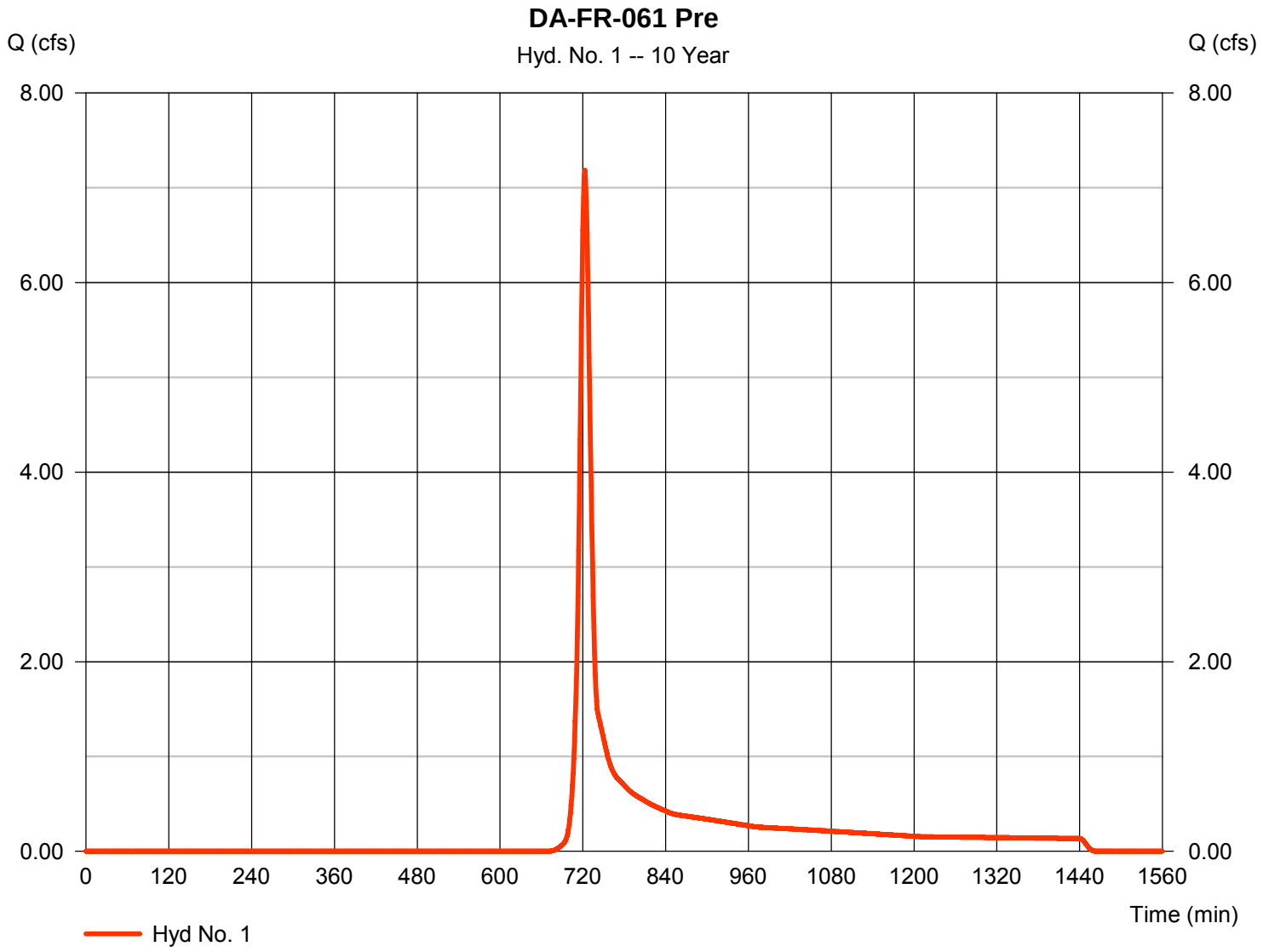
Hydrograph Report

Hyd. No. 1

DA-FR-061 Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 7.185 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 20,424 cuft
Drainage area	= 3.410 ac	Curve number	= 59*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.036 x 82) + (0.098 x 85) + (0.048 x 98) + (2.620 x 58) + (0.605 x 55)] / 3.410



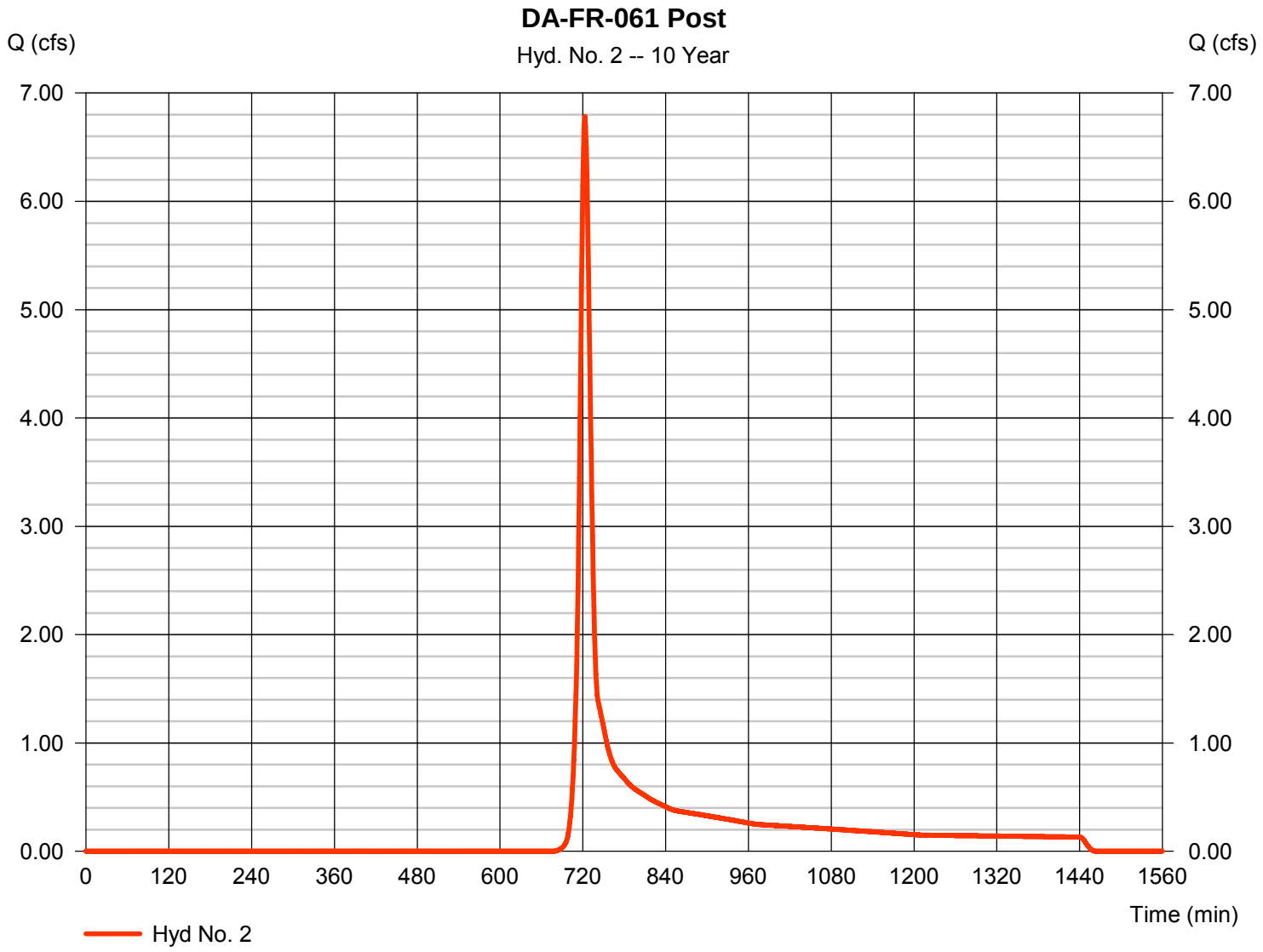
Hydrograph Report

Hyd. No. 2

DA-FR-061 Post

Hydrograph type	= SCS Runoff	Peak discharge	= 6.782 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 19,469 cuft
Drainage area	= 3.410 ac	Curve number	= 58*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.40 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.370 x 48) + (0.040 x 82) + (0.100 x 85) + (0.050 x 98) + (2.620 x 58) + (0.230 x 55)] / 3.410

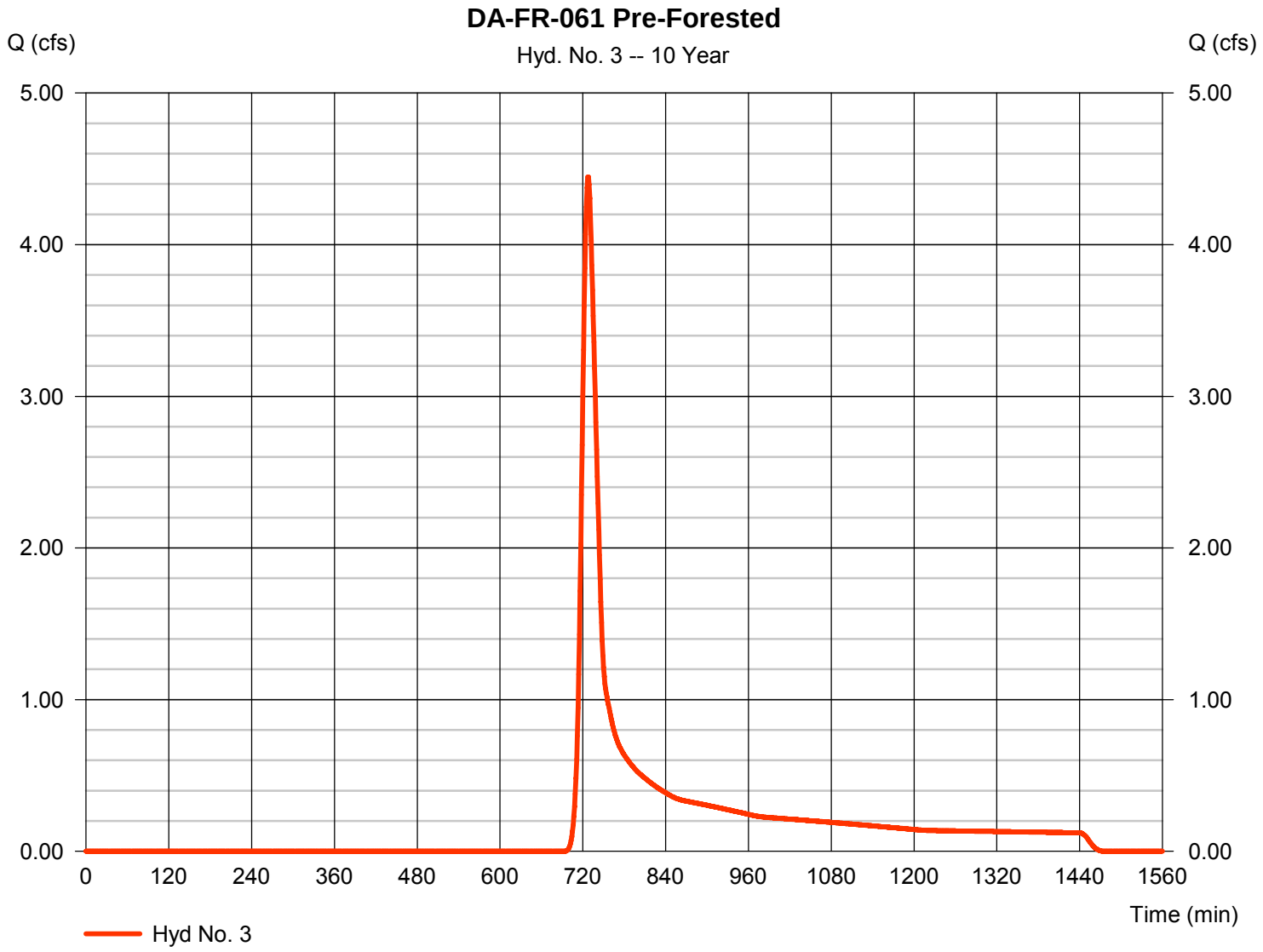


Hydrograph Report

Hyd. No. 3

DA-FR-061 Pre-Forested

Hydrograph type	= SCS Runoff	Peak discharge	= 4.446 cfs
Storm frequency	= 10 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 16,853 cuft
Drainage area	= 3.410 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 21.80 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

Precip. file name: P:\67639\143-67639-17006\SupportDocs\Calcs\Franklin-County-Rainfall.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-062

DA-FR-062 is located in a meadow and forested area with a slope ranging from undulating to hilly and contains both non-agricultural and agricultural areas within the limits of disturbance (LOD). The drainage area contains an existing paved roadway, which is less than 4% of the overall drainage area. No new impervious area is proposed within DA-FR-062. Multiple points of analysis were evaluated within DA-FR-062 to determine the effects on each receiving stream/channel following construction. Specifically, DA-FR-062 was sub-divided into three sub-drainage areas (sub-areas A, B and C).

Sub-area DA-FR-062A is an agricultural area/field that will be returned to crop production, in identical condition, upon completion of pipeline construction and is exempt from meeting the VA water quality (9VAC25-870-63) and the VA water quantity (9VAC25-870-66) requirements per § 62.1-44.15:34 and 9VAC25-870-300. Therefore, the provisions of water quality design criteria requirements and permanent stormwater management controls for DA-FR-062A are exempt and no stormwater BMPs are required.

Pre-construction agricultural areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction, but land use in non-agricultural areas will be restored following construction as noted in the Stormwater Management (SWM) Narrative and the Annual Standards and Specifications. Agricultural areas within the LOD are included in the SWM quality analysis and the total permanent right-of-way (ROW) is analyzed via VRRM; in these calculations agricultural areas are considered “Forest/Open Space”. The total phosphorous load reduction required for DA-FR-062 is -0.47 lb/yr.

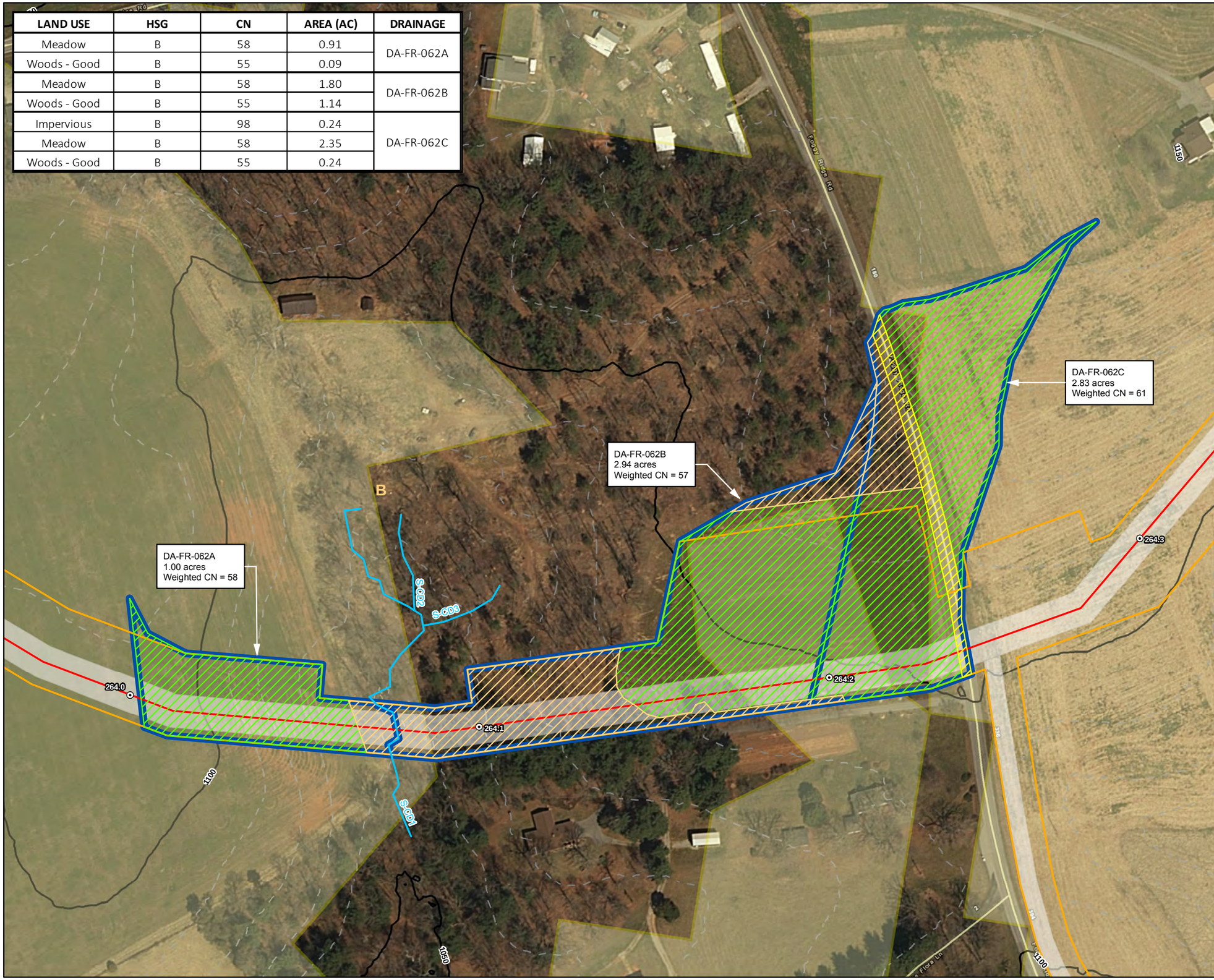
Stormwater quantity is met via the energy balance method for each of the sub-areas DA-FR-062B and DA-FR-062C. Agricultural areas within the study area are included in the SWM analysis, but an Improvement Factor of 1.00 is used when applying the energy balance method. This improvement factor is used to account for the exemption of agricultural areas (§ 62.1-44.15:34 and 9VAC25-870-300) since such areas will be returned to agricultural land use (i.e., returned to crop production, in identical condition) following construction.

In addition, the Hydraflow Hydrograph’s 10-year 24-hour peak discharge results indicate a decrease in flows ranging from 0.00 cfs to 0.34 cfs for each drainage area (as seen in table below).

Sub-area	Pre-peak Flow, 10-yr Q (cfs)	Post-peak Flow, 10-yr Q (cfs)	Flow differential
DA-FR-062B	5.50	5.16	-0.34
DA-FR-062C	5.90	5.90	0.00

Figures and calculations for each of the sub-areas for DA-FR-062 follow. See Appendix D of the Annual Standards and Specifications for further detail on stormwater methodology.

LAND USE	HSG	CN	AREA (AC)	DRAINAGE
Meadow	B	58	0.91	DA-FR-062A
Woods - Good	B	55	0.09	
Meadow	B	58	1.80	DA-FR-062B
Woods - Good	B	55	1.14	
Impervious	B	98	0.24	DA-FR-062C
Meadow	B	58	2.35	
Woods - Good	B	55	0.24	



Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:1,680

140 70 0 140 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-062
Spread 11

Figure 1
Franklin County, Virginia

August, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-062_Pre.mxd

LAND USE	HSG	CN	AREA (AC)	DRAINAGE
Brush - Good	B	48	0.02	DA-FR-062A
Meadow	B	58	0.972	
Brush - Good	B	48	0.53	DA-FR-062B
Meadow	B	58	2.229	
Woods - Good	B	55	0.18	
Brush - Good	B	48	0.01	DA-FR-062C
Impervious	B	98	0.241	
Meadow	B	58	2.353	
Woods - Good	B	55	0.23	

DA-FR-062A
1.00 acres
Weighted CN = 58

DA-FR-062B
2.94 acres
Weighted CN = 56

DA-FR-062C
2.83 acres
Weighted CN = 61

DA-FR-062 Permanent ROW
1.43 acres

Foxy Ridge Rd

S-OD2

S-OD3

S-OD1

264.0

264.1

264.2

264.3

1100

1050

1150

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Impervious
- Meadow
- Woods
- Agricultural Area
- Drainage Area

NAD 1983 UTM 17N (feet)

N
W E
S

1:1,680

140 70 0 140 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-062
Spread 11

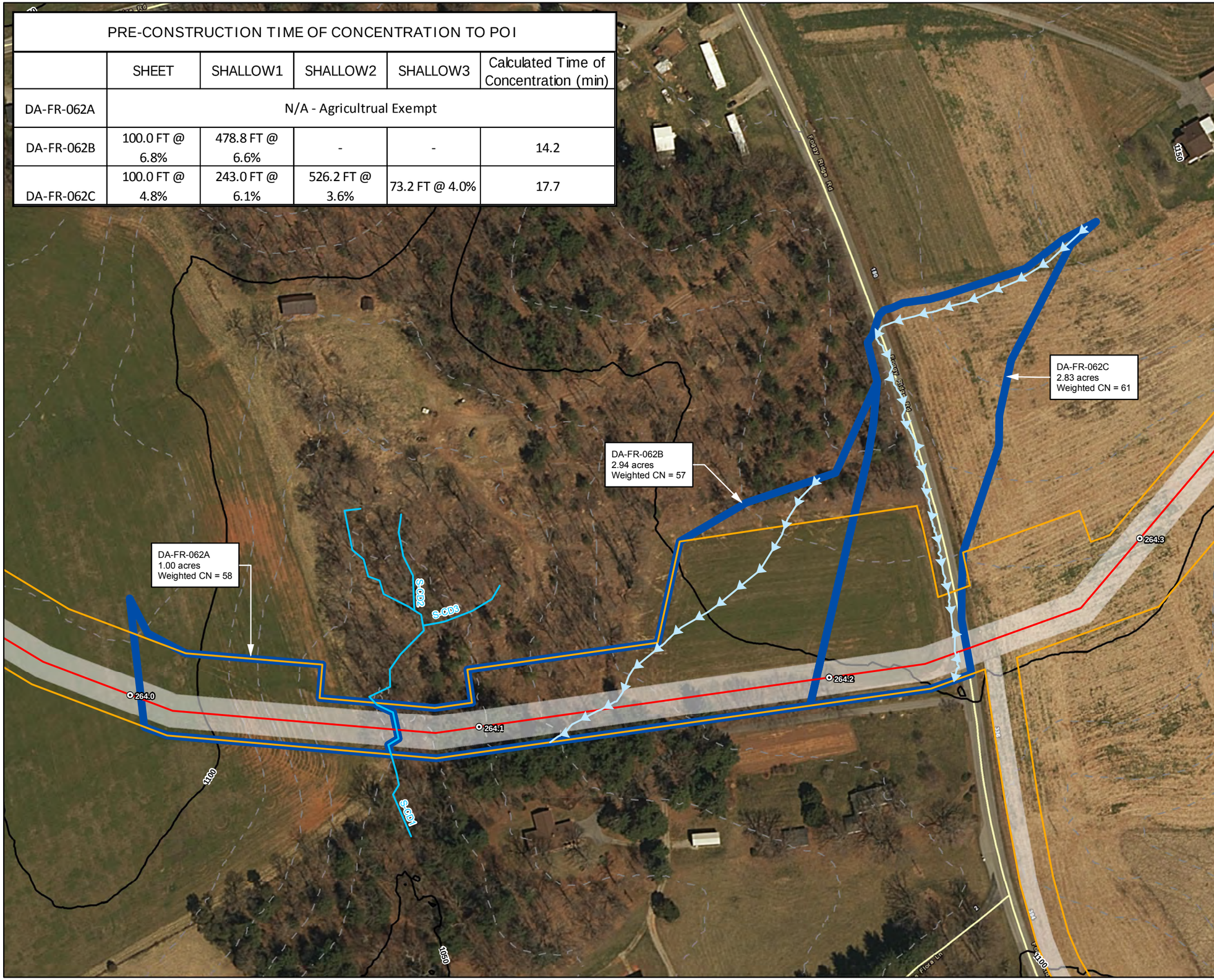
Figure 2
Franklin County, Virginia

August, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EOT_MVP\Mapdocs\Drainage\MXD\FranklinMVP_PCSM_DA-FR-062_Post.mxd

PRE-CONSTRUCTION TIME OF CONCENTRATION TO POI					
	SHEET	SHALLOW1	SHALLOW2	SHALLOW3	Calculated Time of Concentration (min)
DA-FR-062A	N/A - Agricultrual Exempt				
DA-FR-062B	100.0 FT @ 6.8%	478.8 FT @ 6.6%	-	-	14.2
DA-FR-062C	100.0 FT @ 4.8%	243.0 FT @ 6.1%	526.2 FT @ 3.6%	73.2 FT @ 4.0%	17.7



Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,680

140 70 0 140 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

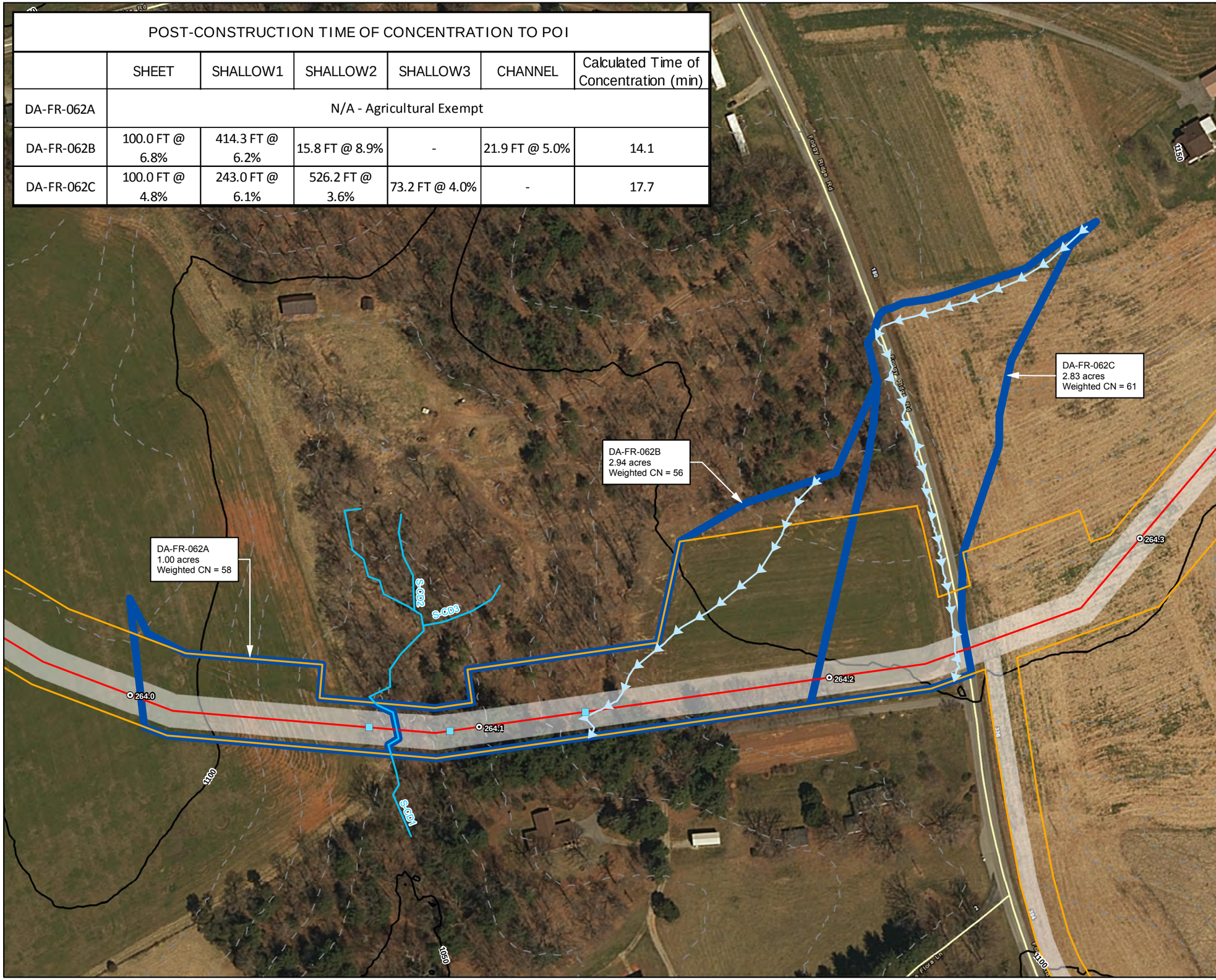
Pre-Construction Drainage Area and Time of Concentration
DA-FR-062
Spread 11

Figure 3
Franklin County, Virginia
August, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\Figures 3-4\MVP_PCSM_DA-FR-062_3.mxd

POST-CONSTRUCTION TIME OF CONCENTRATION TO POI						
	SHEET	SHALLOW1	SHALLOW2	SHALLOW3	CHANNEL	Calculated Time of Concentration (min)
DA-FR-062A	N/A - Agricultural Exempt					
DA-FR-062B	100.0 FT @ 6.8%	414.3 FT @ 6.2%	15.8 FT @ 8.9%	-	21.9 FT @ 5.0%	14.1
DA-FR-062C	100.0 FT @ 4.8%	243.0 FT @ 6.1%	526.2 FT @ 3.6%	73.2 FT @ 4.0%	-	17.7



Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Road Centerline
- Alignment Centerline
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:1,680

140 70 0 140 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration
DA-FR-062
Spread 11

Figure 4
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016.

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DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 3.0

BMP Design Specifications List: **2013 Draft Stds & Specs**

Site Summary - Linear Development Project***

Total Rainfall (in):	**43**
Total Disturbed Acreage:	**1.43**

Site Land Cover Summary

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total
Forest/Open (acres)	0.00	1.42	0.00	0.00	1.42	99
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0
Impervious Cover (acres)	0.00	0.01	0.00	0.00	0.01	1
					1.43	100

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals	% of Total	
Forest/Open (acres)	0.00	1.42	0.00	0.00	1.42	99	*
Managed Turf (acres)	0.00	0.00	0.00	0.00	0.00	0	
Impervious Cover (acres)	0.00	0.01	0.00	0.00	0.01	1	
					1.43	100	

*** Forest/Open Space areas must be protected in accordance with the Virginia Runoff Reduction Method**

Site Tv and Land Cover Nutrient Loads

	Final Post-Development (Post-ReDevelopment & New Impervious)	Post-ReDevelopment	Post-Development (New Impervious)	Adjusted Pre-ReDevelopment
Site Rv	0.04	0.04	--	0.04
Treatment Volume (ft^3)	189	189	--	189
TP Load (lb/yr)	0.12	0.12	--	0.12

Baseline TP Load (lb/yr): 0.5863* **Reduction below new development load limitation not required*

Pre-ReDevelopment TP Load per acre (lb/acre/yr)	Final Post-Development TP Load per acre (lb/acre/yr)	Post-ReDevelopment TP Load per acre (lb/acre/yr)
0.08	**0.08**	**0.08**

Total TP Load Reduction Required (lb/yr)	**-0.47**	N/A***	N/A***

******This is a linear development project***

	Final Post-Development Load (Post-ReDevelopment & New Impervious)	Pre-ReDevelopment
TN Load (lb/yr)	0.85	0.85

Site Compliance Summary - ***Linear Development Project

Maximum % Reduction Required Below Pre-ReDevelopment Load	20%

** Note: % Reduction will reduce post-development TP load to less than or equal to baseline load of 0.59 lb/yr (0.41 lb/ac/yr)*
[Post-Dev Reduction Requirement = Post-Dev TP load - baseline load of 0.59 lb/yr], baseline load = site area x 0.41 lb/ac/yr

Total Runoff Volume Reduction (ft^3)	0
Total TP Load Reduction Achieved (lb/yr)	0.00
Total TN Load Reduction Achieved (lb/yr)	0.00
Remaining Post Development TP Load (lb/yr)	0.12
Remaining TP Load Reduction (lb/yr) Required	**0.00**

**** TARGET TP REDUCTION EXCEEDED BY 0.47 LB/YEAR ****

**Reduction below new development load limitation not required*

DA-FR-062B

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.740	3,667
Developed Condition	0.607	3,326
Pre-Developed (Forest) Condition	0.485	3,000

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

			Q (cfs)		Q (cfs)
Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->		0.607	≤ OK	0.816
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->		0.607	≤ OK	0.740
Check #3:	$Q_{developed}$ *shall not* be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->		0.607	*shall not* be required to be ≤	0.437

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]For the developed condition, a conservative Manning's n value of 0.040 was used in Hydraflow Hydrographs for open channel flow through the permanent waterbar or grass channel.

[2]For the pre-developed condition (if applicable), a Manning's n value of 0.030 was used in Hydraflow Hydrographs.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

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Watershed Model Schematic

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-062B Pre
2	SCS Runoff	DA-FR-062B Post
3	SCS Runoff	DA-FR-062B Pre-Forested

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.740	1.315	-------	-------	5.501	-------	-------	-------	DA-FR-062B Pre
2	SCS Runoff	------	0.607	1.135	-------	-------	5.158	-------	-------	-------	DA-FR-062B Post
3	SCS Runoff	------	0.485	0.964	-------	-------	4.816	-------	-------	-------	DA-FR-062B Pre-Forested

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	0.740	1	725	3,667	------	------	------	DA-FR-062B Pre
2	SCS Runoff	0.607	1	726	3,326	------	------	------	DA-FR-062B Post
3	SCS Runoff	0.485	1	726	3,000	------	------	------	DA-FR-062B Pre-Forested

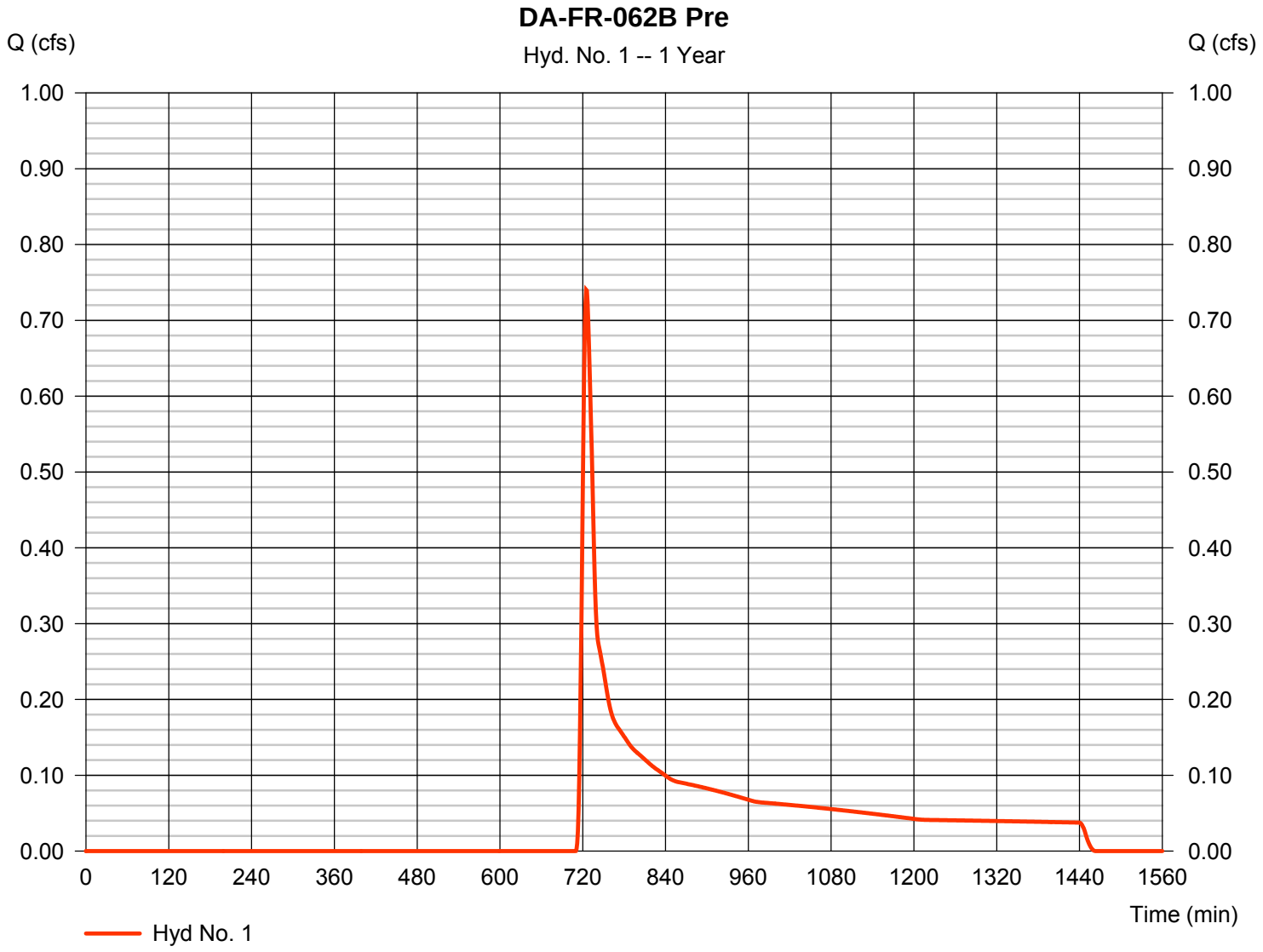
Hydrograph Report

Hyd. No. 1

DA-FR-062B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 0.740 cfs
Storm frequency	= 1 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 3,667 cuft
Drainage area	= 2.940 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.800 x 58) + (1.140 x 55)] / 2.940



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-062B Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 6.80		0.00		0.00		
Travel Time (min)	**= 12.24**	**+**	**0.00**	**+**	**0.00**	**=**	**12.24**
Shallow Concentrated Flow							
Flow length (ft)	= 478.80		0.00		0.00		
Watercourse slope (%)	= 6.60		0.00		0.00		
Surface description	= Unpaved		Paved		Paved		
Average velocity (ft/s)	=4.15		0.00		0.00		
Travel Time (min)	**= 1.93**	**+**	**0.00**	**+**	**0.00**	**=**	**1.93**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.20 min

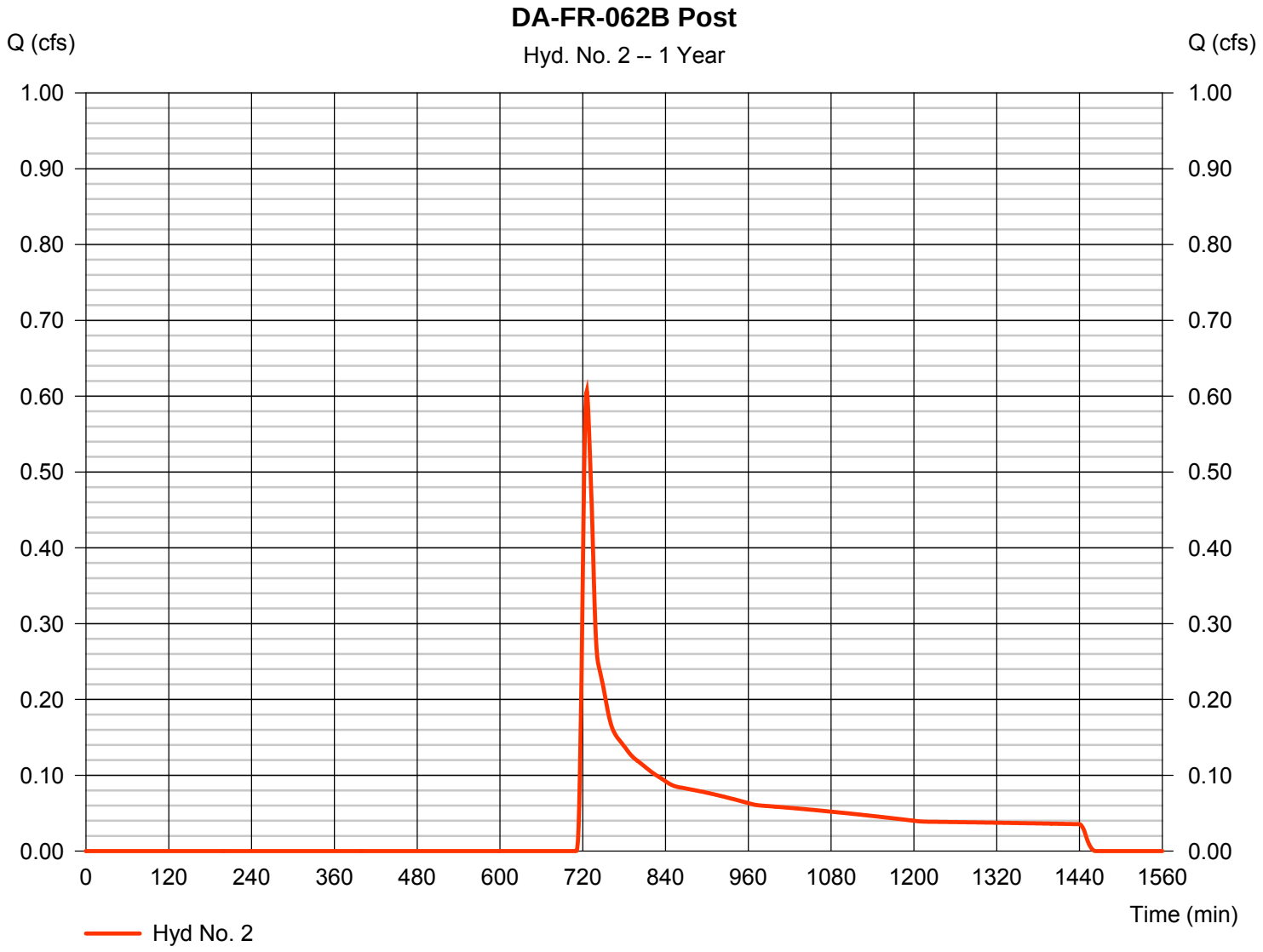
Hydrograph Report

Hyd. No. 2

DA-FR-062B Post

Hydrograph type	= SCS Runoff	Peak discharge	= 0.607 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 3,326 cuft
Drainage area	= 2.940 ac	Curve number	= 56*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.10 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.530 x 48) + (2.230 x 58) + (0.180 x 55)] / 2.940



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-062B Post

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 6.80		0.00		0.00		
Travel Time (min)	**= 12.24**	**+**	**0.00**	**+**	**0.00**	**=**	**12.24**
Shallow Concentrated Flow							
Flow length (ft)	= 414.30		15.80		0.00		
Watercourse slope (%)	= 6.20		8.90		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=4.02		4.81		0.00		
Travel Time (min)	**= 1.72**	**+**	**0.05**	**+**	**0.00**	**=**	**1.77**
Channel Flow							
X sectional flow area (sqft)	= 2.00		0.00		0.00		
Wetted perimeter (ft)	= 4.47		0.00		0.00		
Channel slope (%)	= 5.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=4.86						
			0.00				
					0.00		
Flow length (ft)	({0})21.9		0.0		0.0		
Travel Time (min)	**= 0.08**	**+**	**0.00**	**+**	**0.00**	**=**	**0.08**

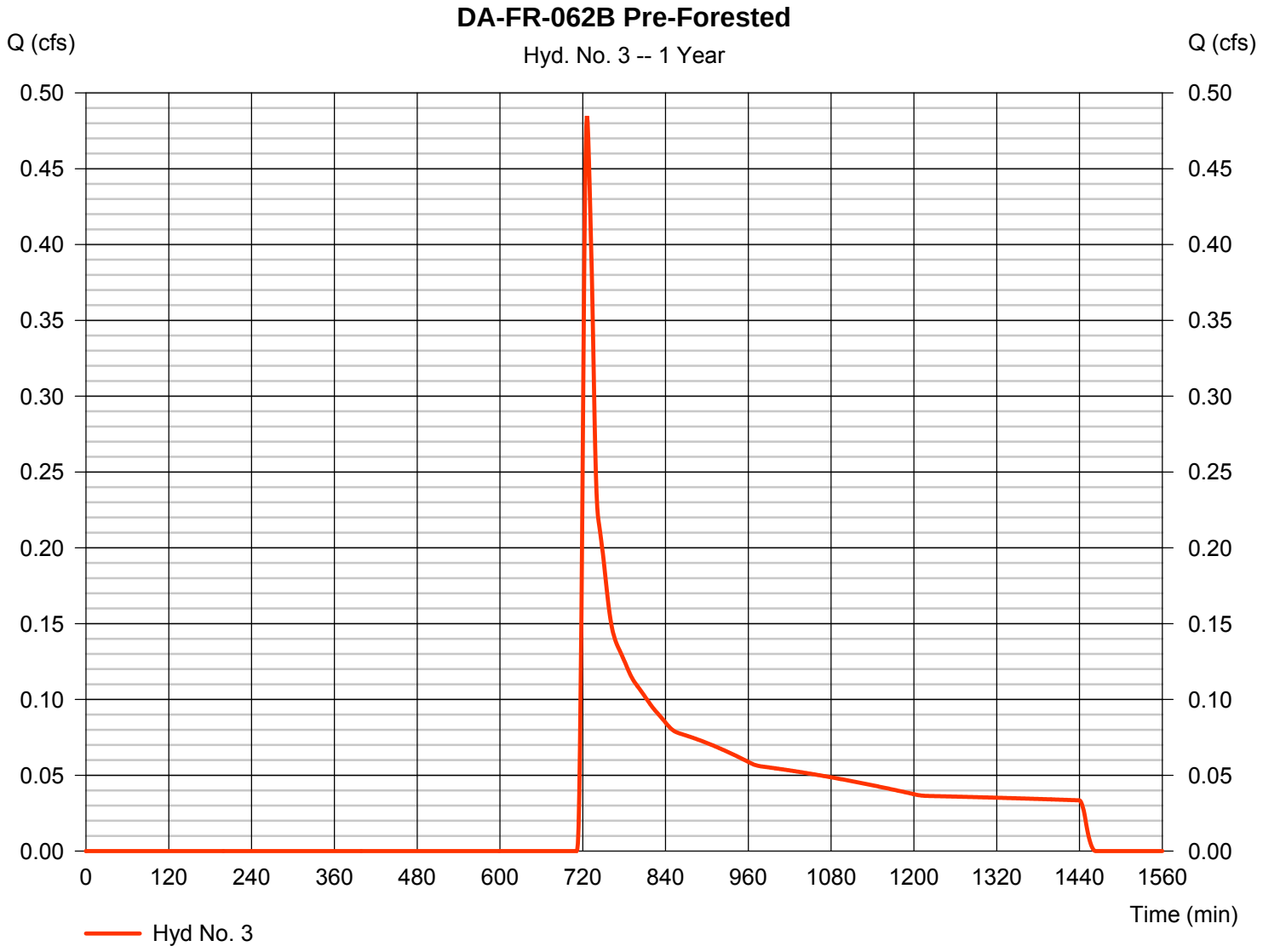
Total Travel Time, Tc ..... 14.10 min

Hydrograph Report

Hyd. No. 3

DA-FR-062B Pre-Forested

Hydrograph type	= SCS Runoff	Peak discharge	= 0.485 cfs
Storm frequency	= 1 yrs	Time to peak	= 726 min
Time interval	= 1 min	Hyd. volume	= 3,000 cuft
Drainage area	= 2.940 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-062B Pre-Forested

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 6.80		0.00		0.00		
Travel Time (min)	**= 12.24**	**+**	**0.00**	**+**	**0.00**	**=**	**12.24**
Shallow Concentrated Flow							
Flow length (ft)	= 478.80		0.00		0.00		
Watercourse slope (%)	= 6.60		0.00		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=4.15		0.00		0.00		
Travel Time (min)	**= 1.93**	**+**	**0.00**	**+**	**0.00**	**=**	**1.93**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 14.20 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	1.315	1	725	5,263	------	------	------	DA-FR-062B Pre
2	SCS Runoff	1.135	1	725	4,842	------	------	------	DA-FR-062B Post
3	SCS Runoff	0.964	1	725	4,435	------	------	------	DA-FR-062B Pre-Forested

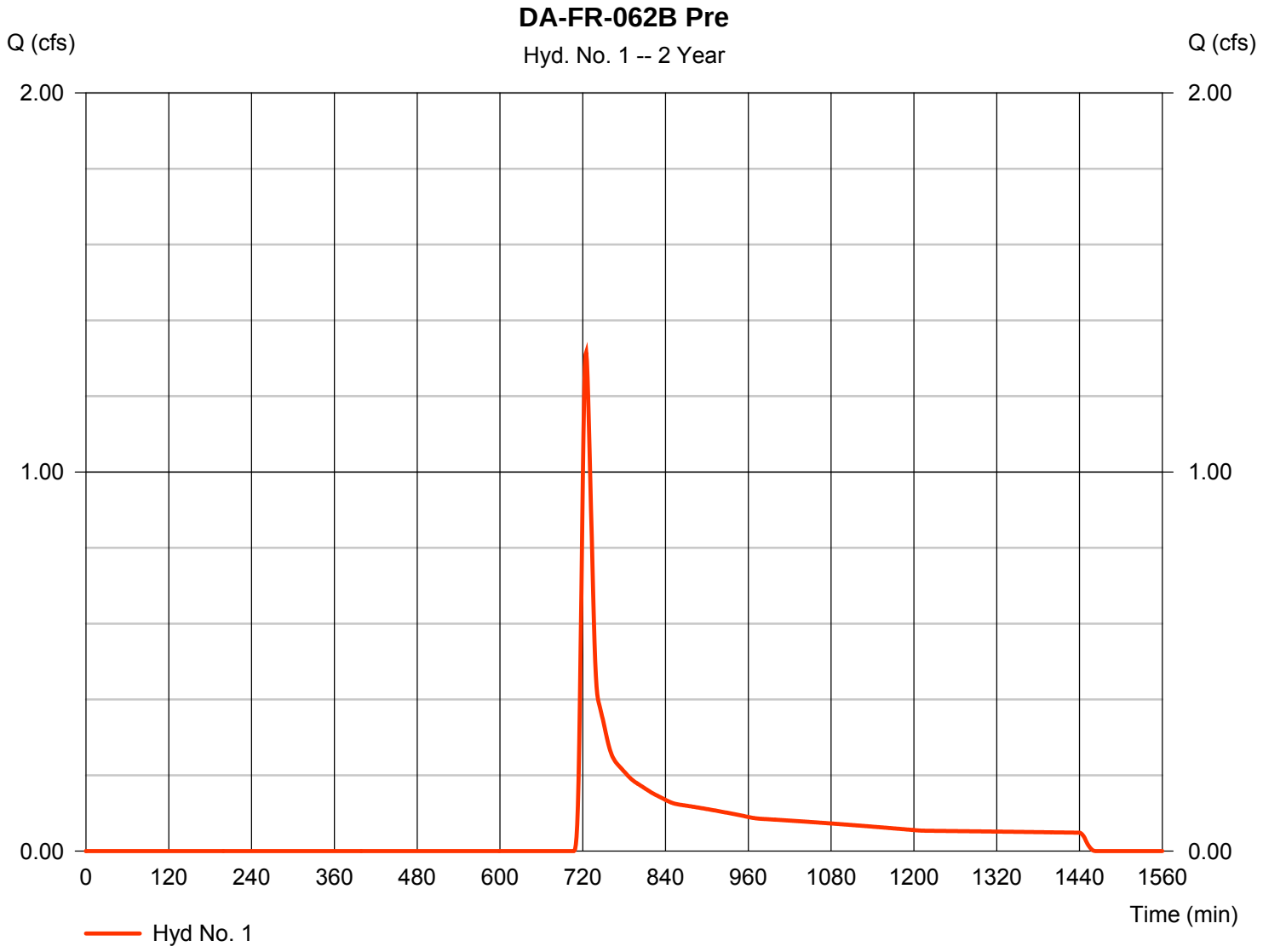
Hydrograph Report

Hyd. No. 1

DA-FR-062B Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.315 cfs
Storm frequency	=	2 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	5,263 cuft
Drainage area	=	2.940 ac	Curve number	=	57*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.20 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(1.800 x 58) + (1.140 x 55)] / 2.940



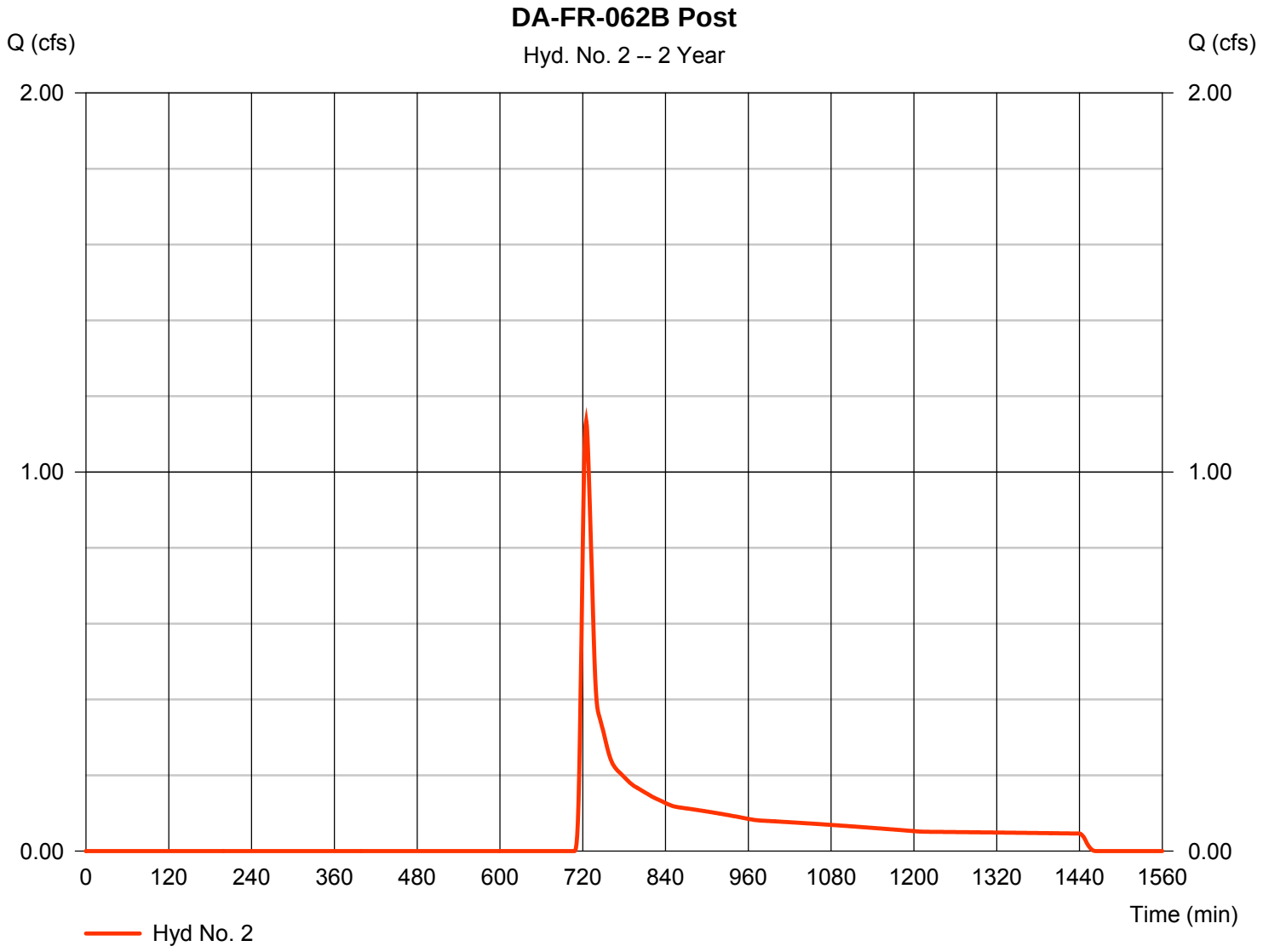
Hydrograph Report

Hyd. No. 2

DA-FR-062B Post

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.135 cfs
Storm frequency	=	2 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	4,842 cuft
Drainage area	=	2.940 ac	Curve number	=	56*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.10 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.530 x 48) + (2.230 x 58) + (0.180 x 55)] / 2.940

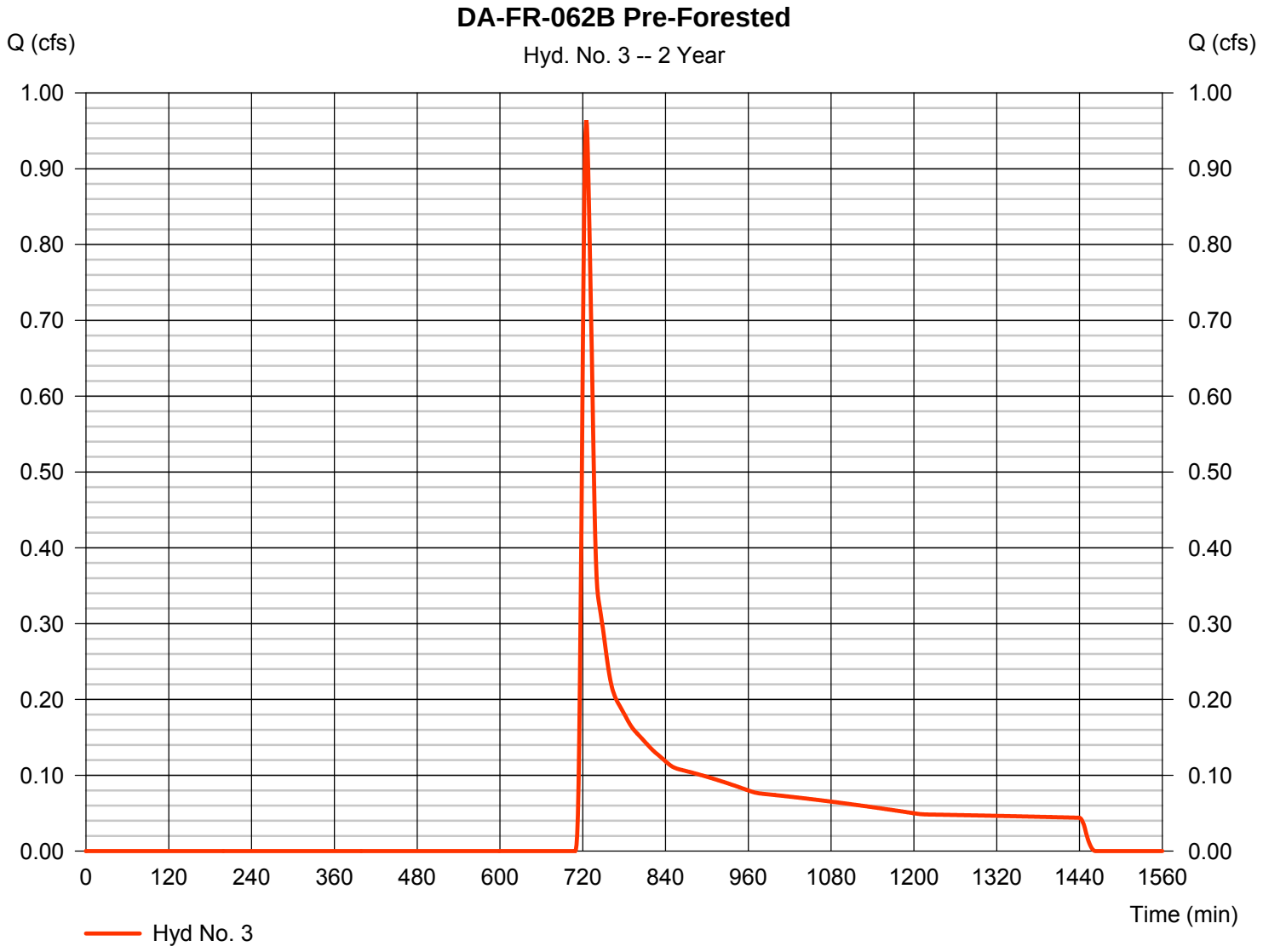


Hydrograph Report

Hyd. No. 3

DA-FR-062B Pre-Forested

Hydrograph type	= SCS Runoff	Peak discharge	= 0.964 cfs
Storm frequency	= 2 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 4,435 cuft
Drainage area	= 2.940 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	5.501	1	723	15,975	------	------	------	DA-FR-062B Pre
2	SCS Runoff	5.158	1	723	15,177	------	------	------	DA-FR-062B Post
3	SCS Runoff	4.816	1	723	14,392	------	------	------	DA-FR-062B Pre-Forested

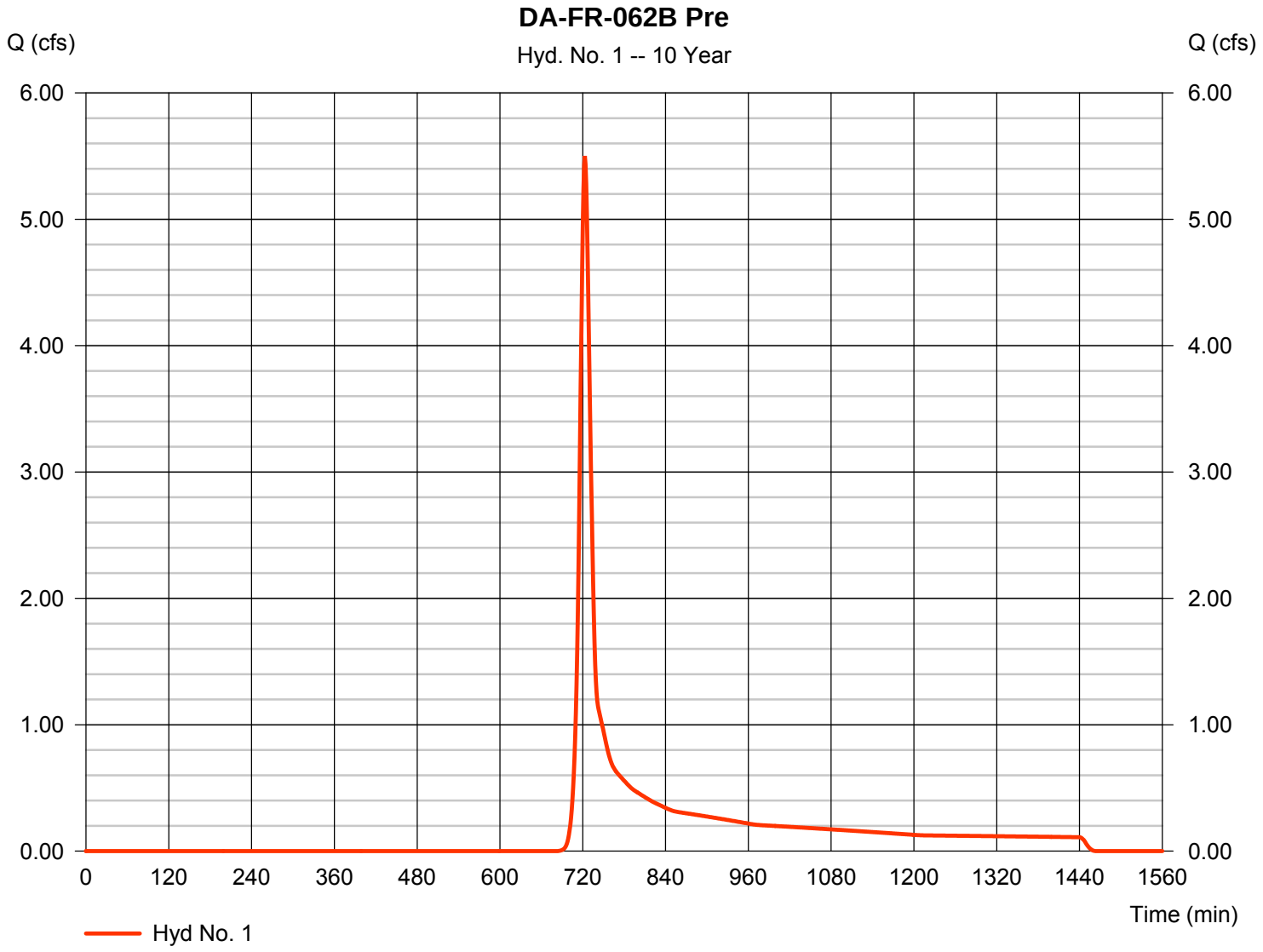
Hydrograph Report

Hyd. No. 1

DA-FR-062B Pre

Hydrograph type	= SCS Runoff	Peak discharge	= 5.501 cfs
Storm frequency	= 10 yrs	Time to peak	= 723 min
Time interval	= 1 min	Hyd. volume	= 15,975 cuft
Drainage area	= 2.940 ac	Curve number	= 57*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 14.20 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(1.800 x 58) + (1.140 x 55)] / 2.940



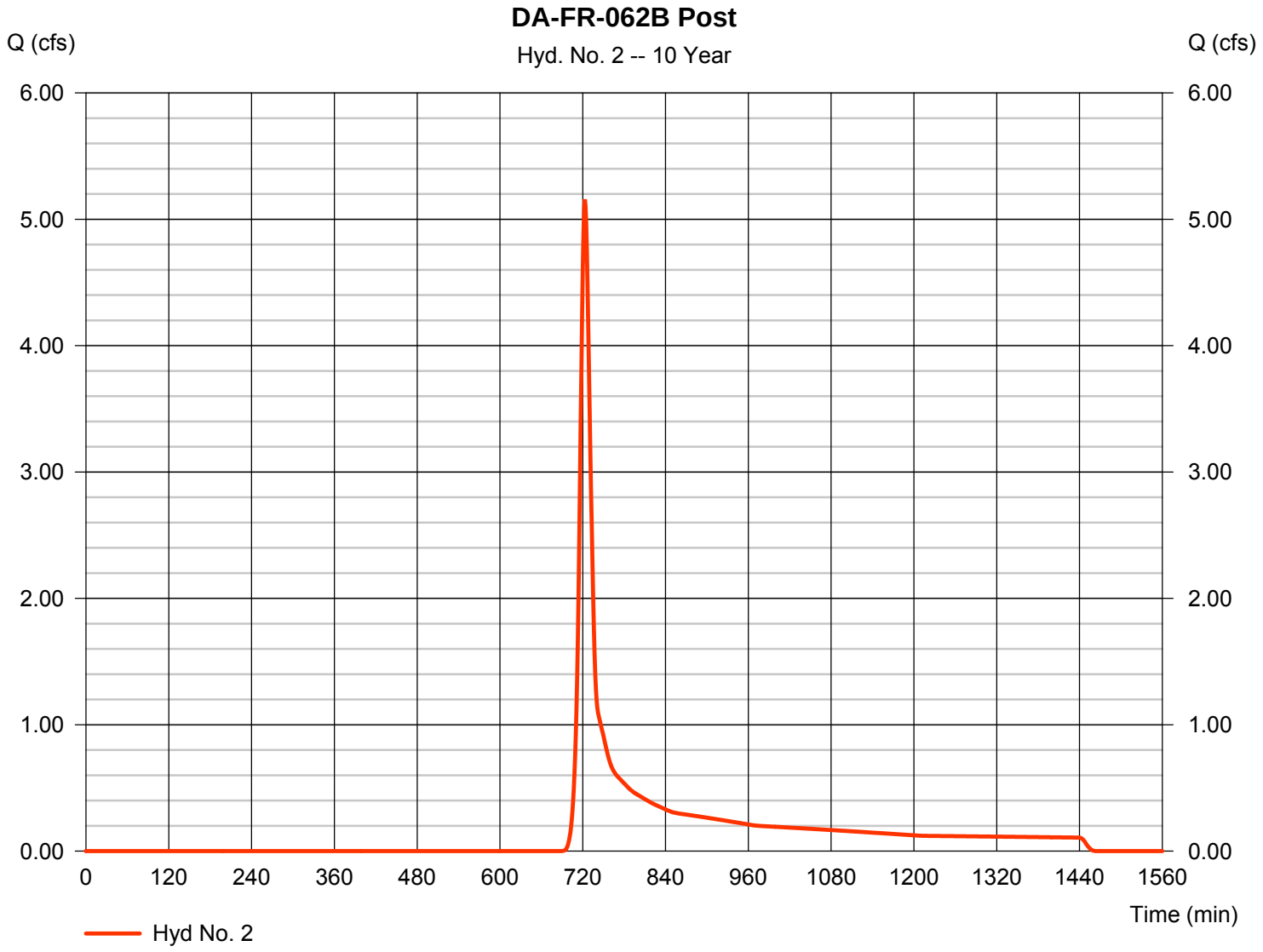
Hydrograph Report

Hyd. No. 2

DA-FR-062B Post

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.158 cfs
Storm frequency	=	10 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	15,177 cuft
Drainage area	=	2.940 ac	Curve number	=	56*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.10 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.530 x 48) + (2.230 x 58) + (0.180 x 55)] / 2.940

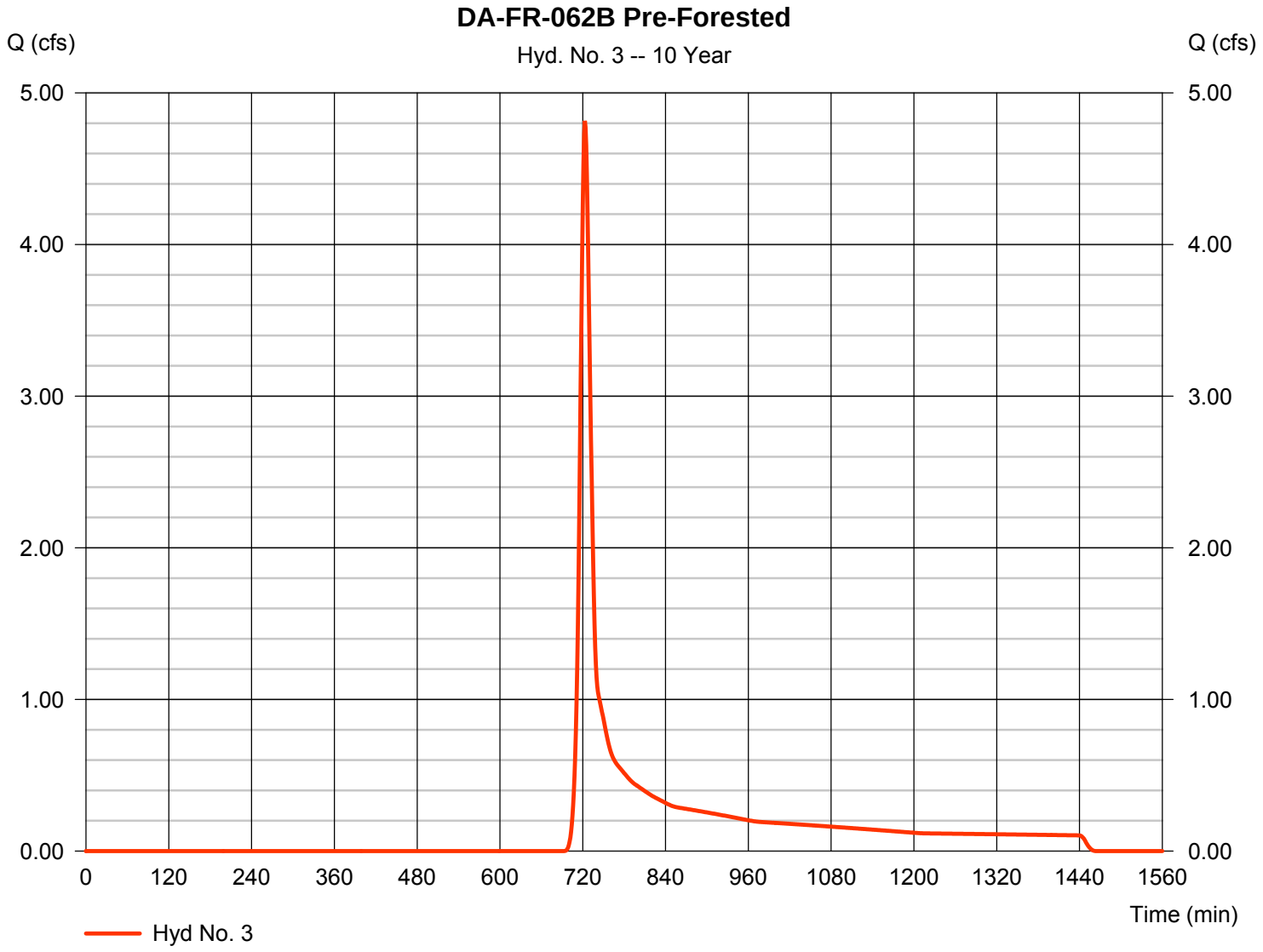


Hydrograph Report

Hyd. No. 3

DA-FR-062B Pre-Forested

Hydrograph type	=	SCS Runoff	Peak discharge	=	4.816 cfs
Storm frequency	=	10 yrs	Time to peak	=	723 min
Time interval	=	1 min	Hyd. volume	=	14,392 cuft
Drainage area	=	2.940 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	14.20 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

Precip. file name: Sample.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	0.00	5.70	0.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DA-FR-062C

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	1.163	4,931
Developed Condition	1.163	4,931
Pre-Developed (Forest) Condition	0.407	2,855

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Improvement Factor, IF = 1

Calculations:

			Q (cfs)		Q (cfs)
Check #1:	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->		1.163	≤ OK	1.163
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->		1.163	≤ OK	1.163
Check #3:	$Q_{developed}$ ***shall not*** be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->		1.163	***shall not*** be required to be ≤	0.236

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

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Watershed Model Schematic

Legend

Hyd.	Origin	Description
1	SCS Runoff	DA-FR-062C Pre
2	SCS Runoff	DA-FR-062C Post
3	SCS Runoff	DA-FR-062C Pre-Forested

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	1.163	1.795	-------	-------	5.902	-------	-------	-------	DA-FR-062C Pre
2	SCS Runoff	------	1.163	1.795	-------	-------	5.902	-------	-------	-------	DA-FR-062C Post
3	SCS Runoff	------	0.407	0.805	-------	-------	4.089	-------	-------	-------	DA-FR-062C Pre-Forested

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	1.163	1	727	4,931	------	------	------	DA-FR-062C Pre
2	SCS Runoff	1.163	1	727	4,931	------	------	------	DA-FR-062C Post
3	SCS Runoff	0.407	1	729	2,855	------	------	------	DA-FR-062C Pre-Forested

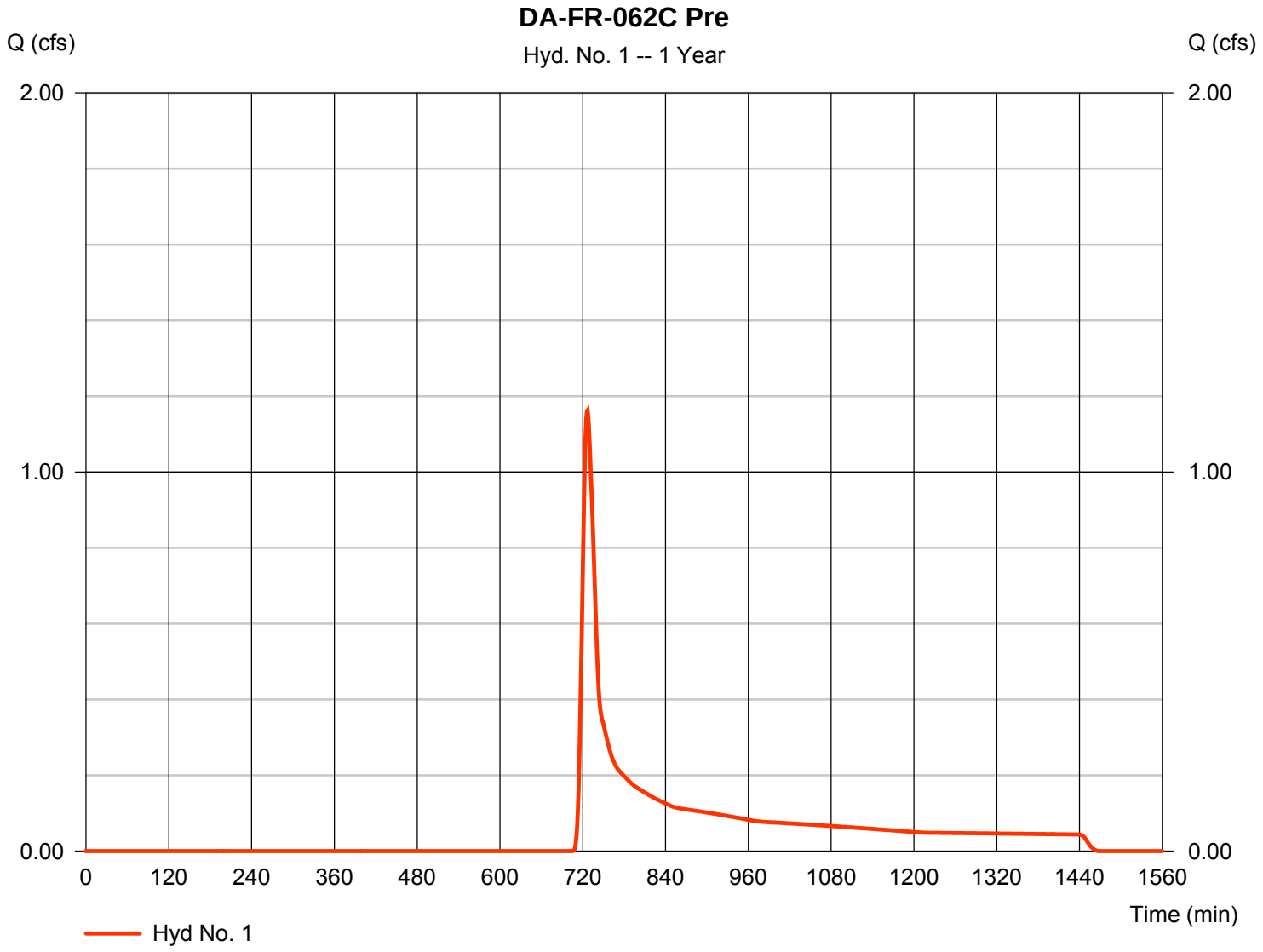
Hydrograph Report

Hyd. No. 1

DA-FR-062C Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.163 cfs
Storm frequency	=	1 yrs	Time to peak	=	727 min
Time interval	=	1 min	Hyd. volume	=	4,931 cuft
Drainage area	=	2.830 ac	Curve number	=	61*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	17.70 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.240 x 98) + (2.350 x 58) + (0.240 x 55)] / 2.830



TR55 Tc Worksheet

Hyd. No. 1

DA-FR-062C Pre

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 4.80		0.00		0.00		
Travel Time (min)	**= 14.07**	**+**	**0.00**	**+**	**0.00**	**=**	**14.07**
Shallow Concentrated Flow							
Flow length (ft)	= 243.00		526.20		73.20		
Watercourse slope (%)	= 6.10		3.60		4.00		
Surface description	= Unpaved		Paved		Unpaved		
Average velocity (ft/s)	=3.98		3.86		3.23		
Travel Time (min)	**= 1.02**	**+**	**2.27**	**+**	**0.38**	**=**	**3.67**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 17.70 min

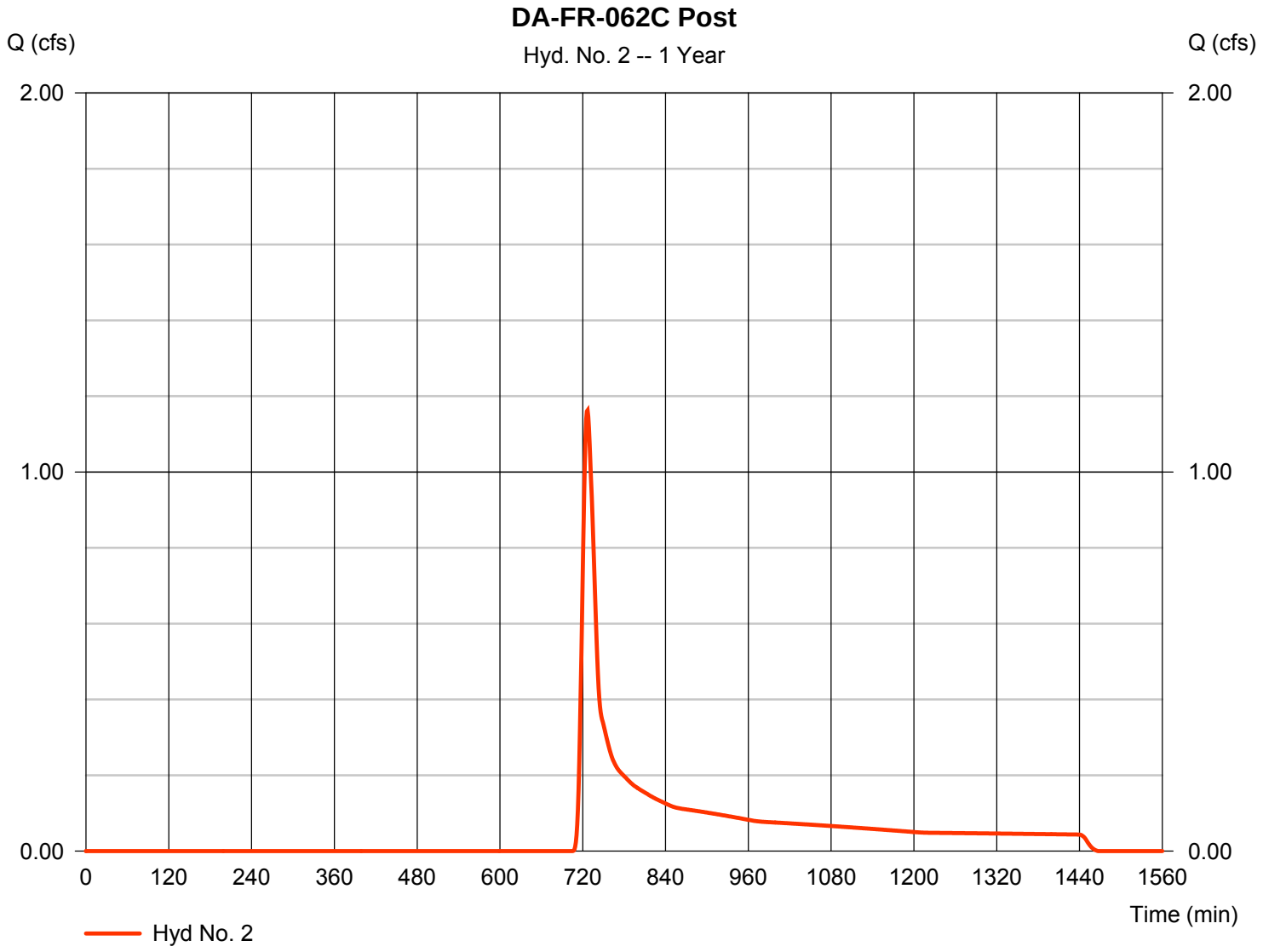
Hydrograph Report

Hyd. No. 2

DA-FR-062C Post

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.163 cfs
Storm frequency	=	1 yrs	Time to peak	=	727 min
Time interval	=	1 min	Hyd. volume	=	4,931 cuft
Drainage area	=	2.830 ac	Curve number	=	61*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	17.70 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.010 x 48) + (0.240 x 98) + (2.350 x 58) + (0.230 x 55)] / 2.830



TR55 Tc Worksheet

Hyd. No. 2

DA-FR-062C Post

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 4.80		0.00		0.00		
Travel Time (min)	**= 14.07**	**+**	**0.00**	**+**	**0.00**	**=**	**14.07**
Shallow Concentrated Flow							
Flow length (ft)	= 243.00		526.20		73.20		
Watercourse slope (%)	= 6.10		3.60		4.00		
Surface description	= Unpaved		Paved		Unpaved		
Average velocity (ft/s)	=3.98		3.86		3.23		
Travel Time (min)	**= 1.02**	**+**	**2.27**	**+**	**0.38**	**=**	**3.67**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

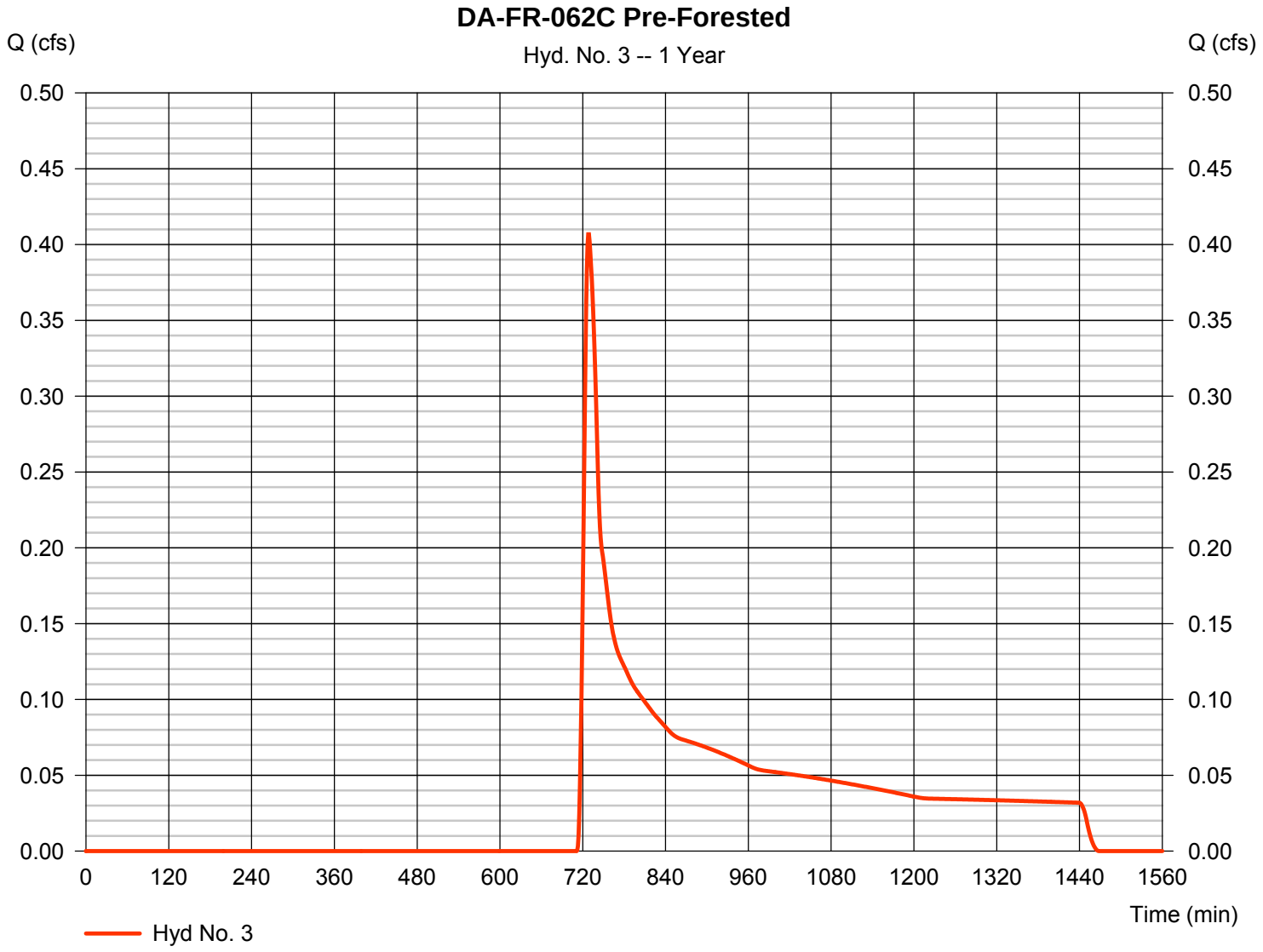
Total Travel Time, Tc ..... 17.70 min

Hydrograph Report

Hyd. No. 3

DA-FR-062C Pre-Forested

Hydrograph type	=	SCS Runoff	Peak discharge	=	0.407 cfs
Storm frequency	=	1 yrs	Time to peak	=	729 min
Time interval	=	1 min	Hyd. volume	=	2,855 cuft
Drainage area	=	2.830 ac	Curve number	=	55
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	18.30 min
Total precip.	=	3.30 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484



TR55 Tc Worksheet

Hyd. No. 3

DA-FR-062C Pre-Forested

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.400		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 4.80		0.00		0.00		
Travel Time (min)	**= 14.07**	**+**	**0.00**	**+**	**0.00**	**=**	**14.07**
Shallow Concentrated Flow							
Flow length (ft)	= 243.00		526.20		73.20		
Watercourse slope (%)	= 6.10		3.60		4.00		
Surface description	= Unpaved		Unpaved		Unpaved		
Average velocity (ft/s)	=3.98		3.06		3.23		
Travel Time (min)	**= 1.02**	**+**	**2.86**	**+**	**0.38**	**=**	**4.26**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.040		0.015		0.015		
Velocity (ft/s)	=0.00						
			0.00				
					0.00		
Flow length (ft)	({0})0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 18.30 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	1.795	1	726	6,755	------	------	------	DA-FR-062C Pre
2	SCS Runoff	1.795	1	726	6,755	------	------	------	DA-FR-062C Post
3	SCS Runoff	0.805	1	727	4,221	------	------	------	DA-FR-062C Pre-Forested

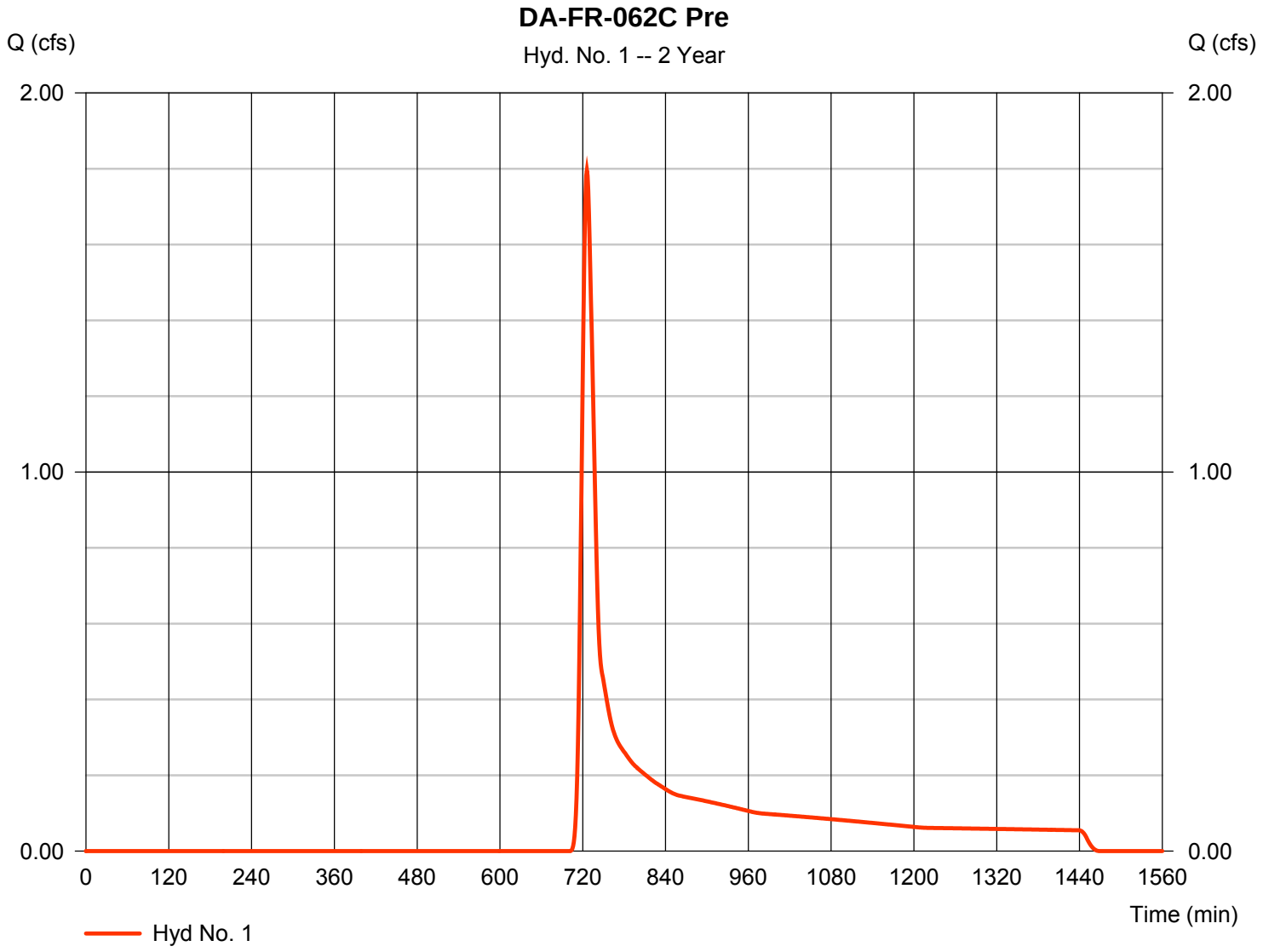
Hydrograph Report

Hyd. No. 1

DA-FR-062C Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.795 cfs
Storm frequency	=	2 yrs	Time to peak	=	726 min
Time interval	=	1 min	Hyd. volume	=	6,755 cuft
Drainage area	=	2.830 ac	Curve number	=	61*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	17.70 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.240 x 98) + (2.350 x 58) + (0.240 x 55)] / 2.830



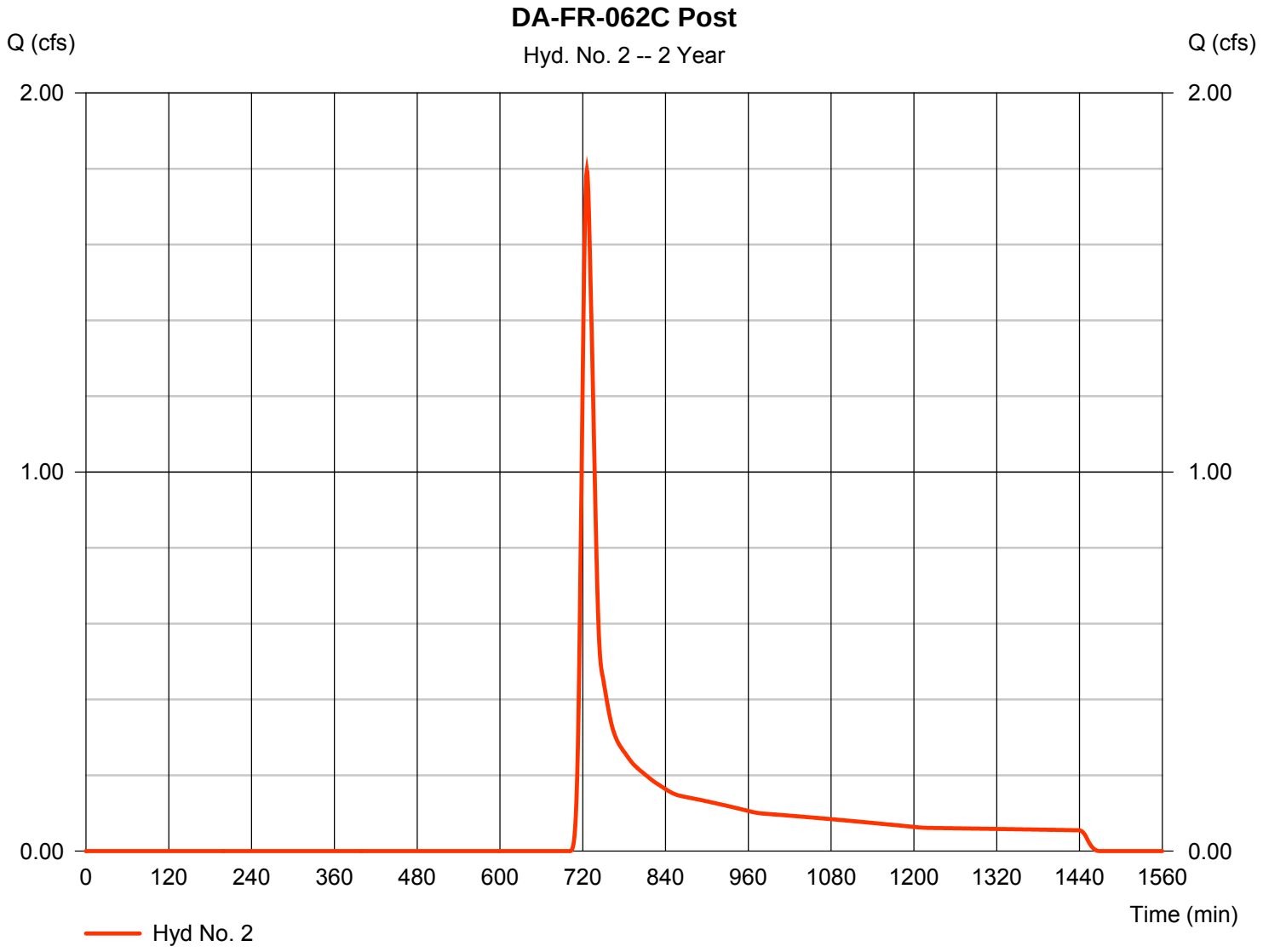
Hydrograph Report

Hyd. No. 2

DA-FR-062C Post

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.795 cfs
Storm frequency	=	2 yrs	Time to peak	=	726 min
Time interval	=	1 min	Hyd. volume	=	6,755 cuft
Drainage area	=	2.830 ac	Curve number	=	61*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	17.70 min
Total precip.	=	3.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.010 x 48) + (0.240 x 98) + (2.350 x 58) + (0.230 x 55)] / 2.830

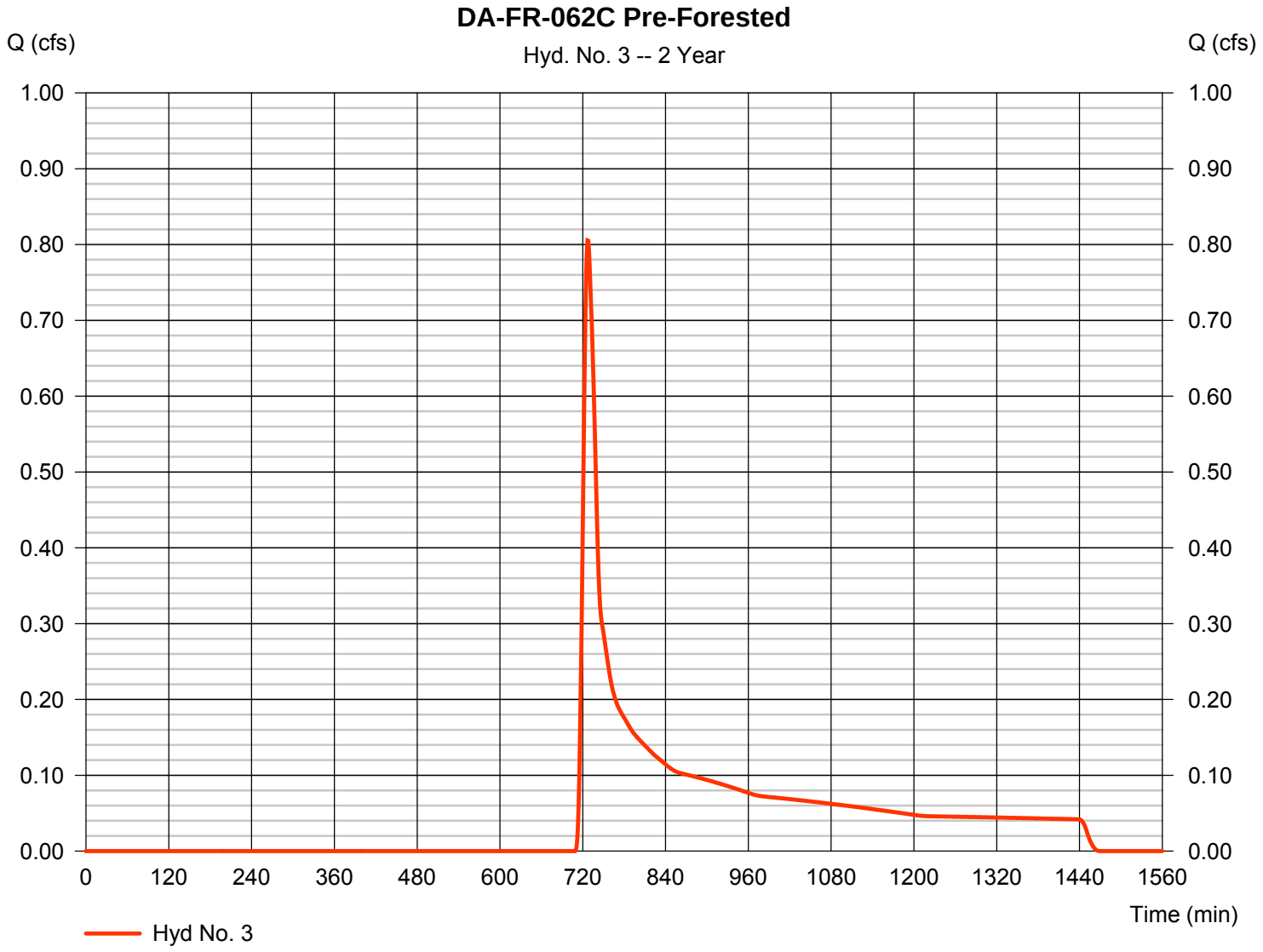


Hydrograph Report

Hyd. No. 3

DA-FR-062C Pre-Forested

Hydrograph type	= SCS Runoff	Peak discharge	= 0.805 cfs
Storm frequency	= 2 yrs	Time to peak	= 727 min
Time interval	= 1 min	Hyd. volume	= 4,221 cuft
Drainage area	= 2.830 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 18.30 min
Total precip.	= 3.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4

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	5.902	1	725	18,358	------	------	------	DA-FR-062C Pre
2	SCS Runoff	5.902	1	725	18,358	------	------	------	DA-FR-062C Post
3	SCS Runoff	4.089	1	725	13,696	------	------	------	DA-FR-062C Pre-Forested

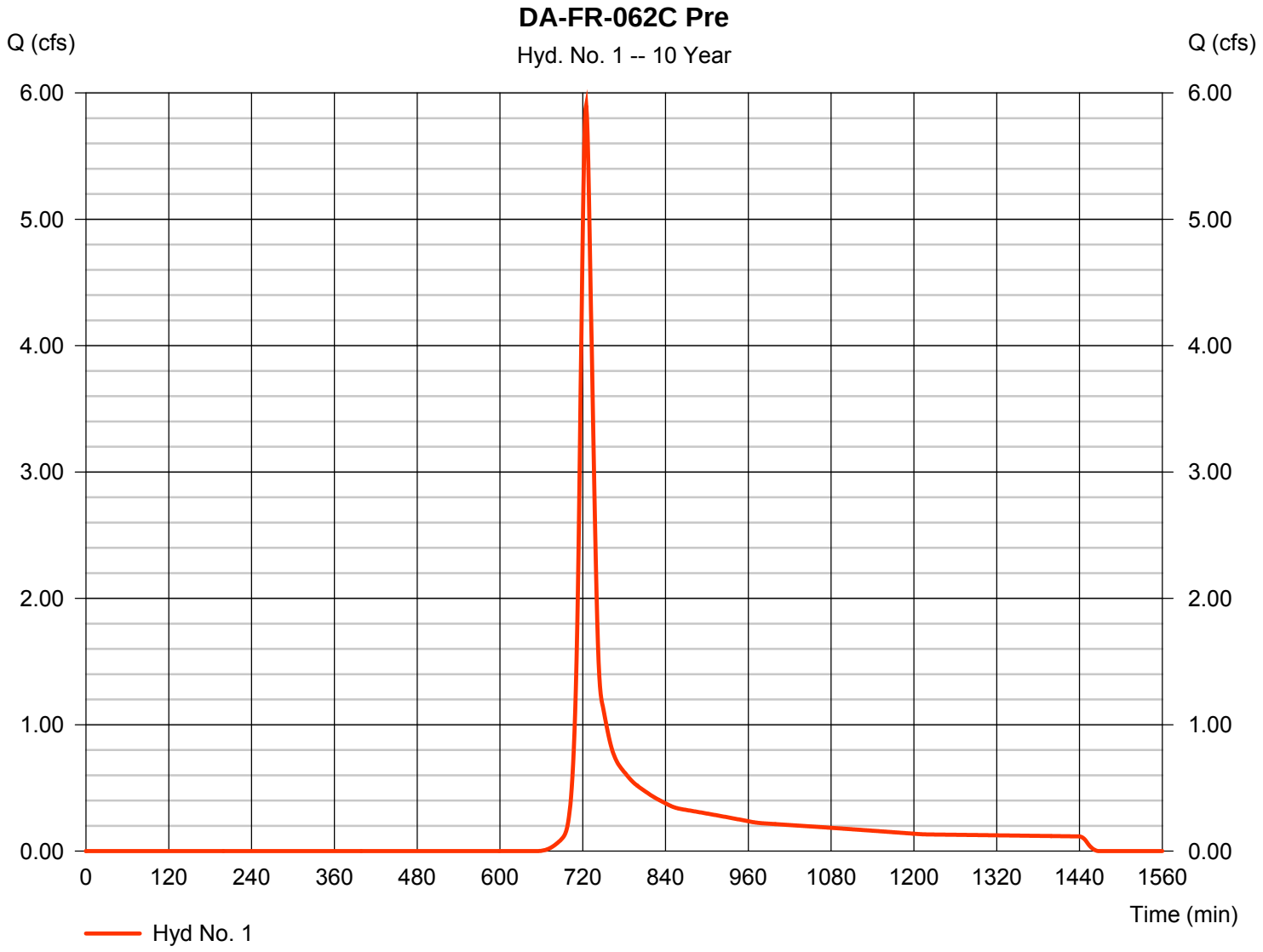
Hydrograph Report

Hyd. No. 1

DA-FR-062C Pre

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.902 cfs
Storm frequency	=	10 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	18,358 cuft
Drainage area	=	2.830 ac	Curve number	=	61*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	17.70 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.240 x 98) + (2.350 x 58) + (0.240 x 55)] / 2.830



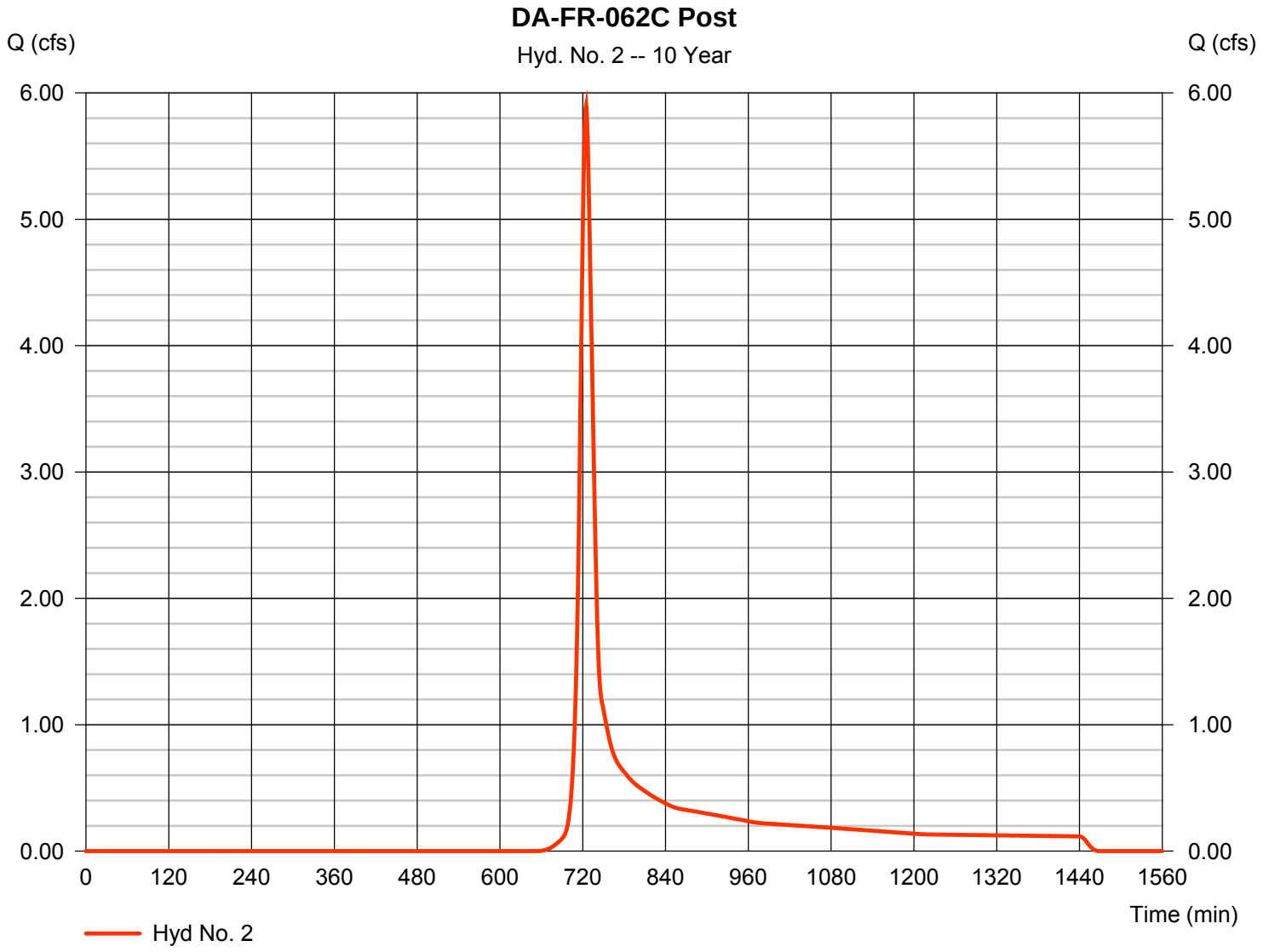
Hydrograph Report

Hyd. No. 2

DA-FR-062C Post

Hydrograph type	=	SCS Runoff	Peak discharge	=	5.902 cfs
Storm frequency	=	10 yrs	Time to peak	=	725 min
Time interval	=	1 min	Hyd. volume	=	18,358 cuft
Drainage area	=	2.830 ac	Curve number	=	61*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	17.70 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.010 x 48) + (0.240 x 98) + (2.350 x 58) + (0.230 x 55)] / 2.830

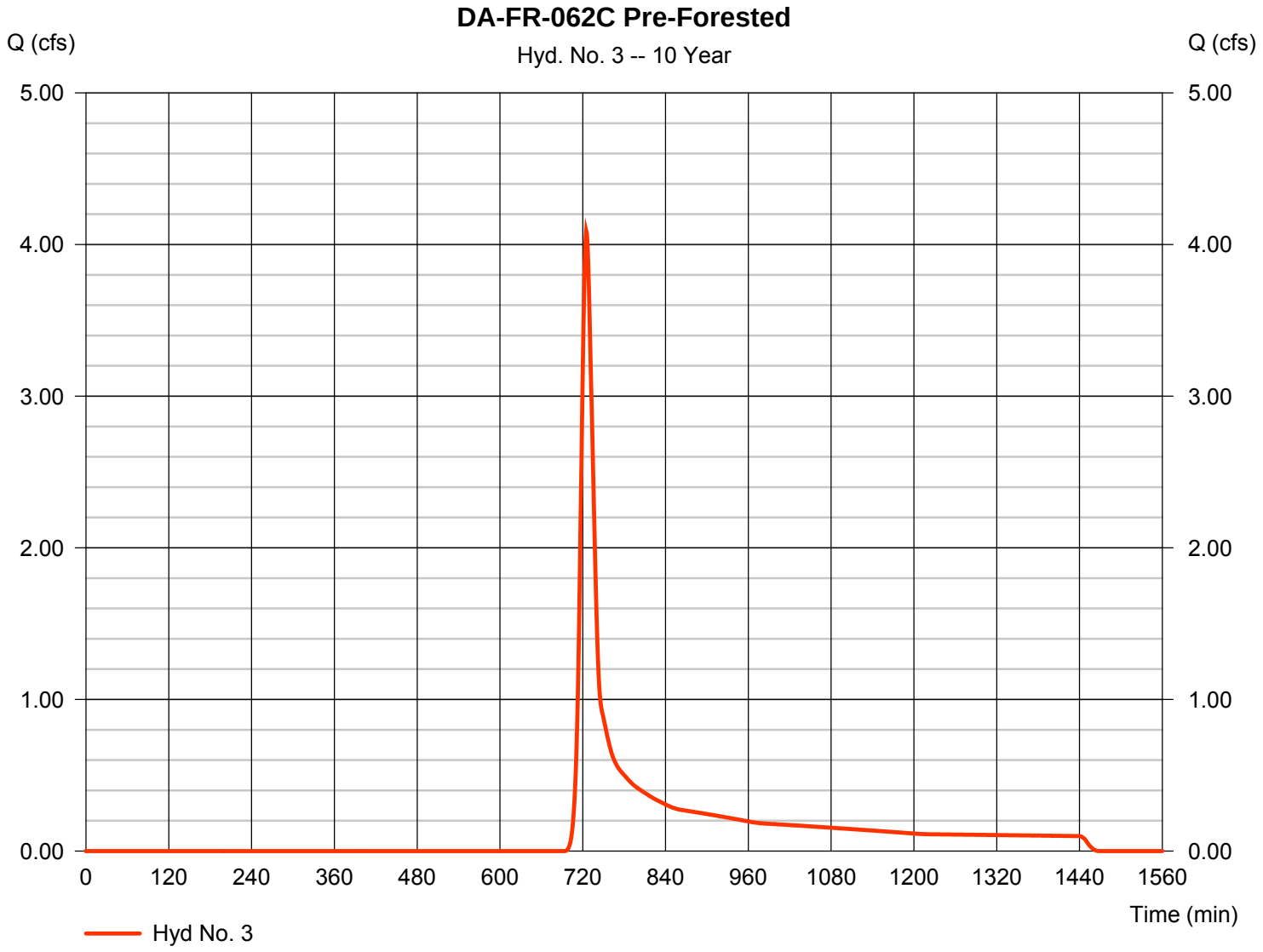


Hydrograph Report

Hyd. No. 3

DA-FR-062C Pre-Forested

Hydrograph type	= SCS Runoff	Peak discharge	= 4.089 cfs
Storm frequency	= 10 yrs	Time to peak	= 725 min
Time interval	= 1 min	Hyd. volume	= 13,696 cuft
Drainage area	= 2.830 ac	Curve number	= 55
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 18.30 min
Total precip.	= 5.70 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

Precip. file name: Sample.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	3.70	0.00	3.30	5.70	5.77	6.80	7.95
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Huff-1st	0.00	0.00	0.00	2.75	0.00	5.38	6.50	8.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	2.80	0.00	5.25	6.00	7.10