October 1, 2020

**City of Lee's Summit**
**Development Services**
220 SW Green Street
Lee's Summit, MO, 64063

**RE: Osage 2nd Plat**
**Olsson Project #019-2339C**

**To Whom It May Concern:**

Osage 2nd plat is a proposed 10.42-acre residential development in Lee's Summit, Jackson County, Missouri. The residential development will include a mix of 6 four-plex townhome lots, 12 two-plex townhome lots, and 16 single family homes. The property is located within the Osage Development and bounded by Pryor Road to the east, Highway 150 to the north, and undeveloped private property to the west and south.

The impacts from the development of Osage 2nd plat has been previously analyzed with the Osage Development Preliminary Stormwater Drainage Study along with Osage Development Final/First Micro Stormwater Drainage Study. No changes to the overall development have been made since the Osage Development Final/First Micro Stormwater Drainage Study was prepared and approved. The approved Osage Development Final/First Micro Stormwater Drainage Study has been included with this memo, for reference. Since the overall plan has not changed from the previously approved memo, we are requesting approval of this memo to satisfy stormwater drainage requirements for Osage 2nd Plat development.

Should you have any questions regarding this submittal, or the plan moving forward, please do not hesitate to reach out to me for discussion at (816) 422-6044, or jsellers@olsson.com.

Sincerely,

STATE OF MISSOURI
JULIE ELAINE SELLERS
NUMBER PE-2017000367
10/1/20
PROFESSIONAL ENGINEER

Julie E. Sellers, P.E.
*Olsson Project Engineer*

1301 Burlington Street / Suite 100 / North Kansas City, MO 64116
**O** 816.361.1177 / **olsson.com**

# OSAGE DEVELOPMENT FINAL/FIRST PLAT MICRO STORMWATER DRAINAGE STUDY

**Prepared for:**

Clayton Properties Group Inc.
DBA Summit Homes
Lee's Summit, Missouri

Olsson Project No. A19-2339
June 2020

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# 1. GENERAL INFORMATION

Osage is a proposed single-family residential development on approximately 36 acres, including a pool, amenity tract reserved for open space, and stormwater detention basin. This project is in the southwest of the intersection of Northwest Pryor Road and Highway 150 in Lee's Summit, Missouri. The Osage development first plat is approximately 21 acres and consists of 41 single family residential lots, the detention facility, and the amenity tract. Figure 1 shows the Osage development and first plat boundaries.

This drainage study is an update to the previously approved preliminary drainage study and will evaluate the hydrologic impact generated by construction of the Osage development first plat (proposed conditions). This study will also evaluate future conditions, which include the full build-out of the Osage development. For the future condition's analysis, there are no major hydrologic changes from the previously approved preliminary drainage study; however, the City of Lee's Summit's criteria for final stormwater management studies requires more detail, so these details have been included in Appendix E.

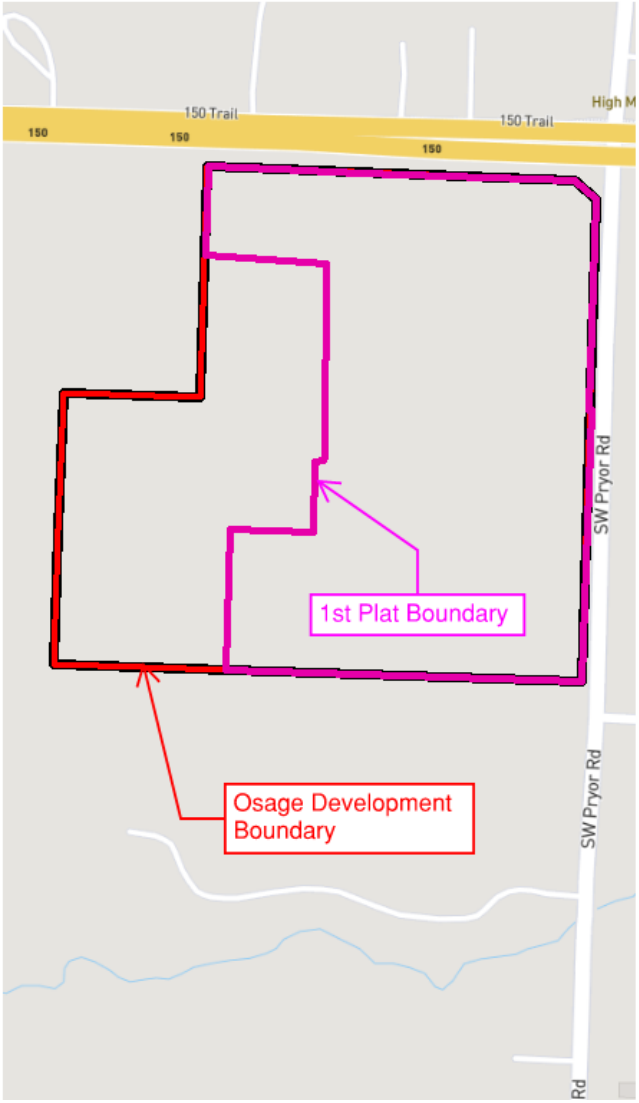



**Figure 1. Location Map.**

## 1.1 Federal Emergency Management Agency (FEMA) Floodplain Classification

FEMA Flood Boundary and Floodway Map Community Panel Number 29095C0531G classifies the Osage property as an unshaded "Zone X" area, which FEMA defines as an area of minimal flood hazard, usually above the 500-year flood level. See Exhibit 1 – Floodplain Map in Appendix A for the location of the site in relation to FEMA flood boundaries.

## 1.2 Soil Classifications

Soil maps published on the Natural Resources Conservation Service's (NRCS) Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) categorize soils on the Osage property as shown in Table 1. See Exhibit 2 in Appendix A for a map of soils on the property.

**Table 1. Soil Classifications.**

| Symbol | Name | Slopes | Hydrologic Soil Groups |
|---|---|---|---|
| 10082 | Arisburg-Urban Land Complex | 1-5% | C |
| 10116 | Sampsel Silty Clay Loam | 2-5% | C/D |
| 10117 | Sampsel Silty Clay Loam | 5-9% | C/D |
| 10122 | Sharpsburg Silt Loam | 5-9% | C |

# 2. METHODOLOGY

The base data for the models prepared for this report has been obtained from available online maps and aerial imagery. Stormwater management is based upon methods and objectives defined in the Kansas City Metropolitan Chapter of the American Public Works Association's (KC-APWA) 2011 design guidance document called "Section 5600 Storm Drainage Systems & Facilities" (2011).

The following methods were used in this study to model existing and proposed conditions for stormwater runoff:

Hydraflow Hydrographs Extension Version 12

- Soil Conservation Survey (SCS) Unit Hydrograph Method
  - Two-year, 10-year, and 100-year Return Frequency Storms
  - Antecedent Moisture Conditions (AMC) II Soil Moisture Conditions
  - 24-Hour SCS Type II Rainfall Distribution
  - SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a – 2-2c)
  - SCS TR-55 methods for determination of time of concentration and travel time. Where specific data pertaining to channel geometry is not available, length and velocity estimates for channel flow travel time is used per Section 5600, KC-APWA Standard Specifications and Design Criteria.

Stormwater runoff models were created for the two-, 10-, and 100-year design storm events. The precipitation depths used in the analysis have been interpolated from the "Technical Paper No. 40 Rainfall Frequency Atlas of the United States" (TP-40) isopluvial maps (May 1961). Table 2 below summarizes the rainfall depths used in this analysis:

**Table 2. Precipitation Depths.**

| Return Period | 24-Hour Precipitation Depth (inches) |
|---|---|
| 2-Year (50% Storm) | 3.60 |
| 10-year (10% Storm) | 5.34 |
| 100-Year (1% Storm) | 7.90 |

# 3. EXISTING CONDITIONS

To quantify the effects of developing this project, the following areas and points of interest have been used for existing and proposed conditions analysis. See Exhibit 3 – Existing Conditions Drainage Map in Appendix A.

**Drainage Area A** represents the area in the southwestern corner of the site, which bypasses the proposed detention location. In existing conditions, drainage area A has an area of 5.16 acres.

**Drainage Area B** represents the majority of the site in both the existing and the proposed conditions models and drains to the southeastern corner of the site. In existing conditions, drainage area B has an area of 28.57 acres.

**Drainage Area C** is located in the northwestern corner of the site and drains north to Highway 150. In existing conditions, drainage area C has an area of 11.27 acres.

Three points of interest were chosen for comparison between existing and proposed conditions based on the three points of discharge from the site. These points can be found in both exhibits 3 and 4 in Appendix A.

**Point of Interest A1** represents the southwestern corner of the site and compares drainage area A for both models. For the first plat, no area draining to this point of interest will be developed.

**Point of Interest B1** represents a point near the southeastern corner of the site, just upstream of the triple, 30-inch corrugated metal pipe culverts crossing Northwest Pryor Road. Discharge to this point was compared between drainage area B in the existing conditions model and drainage areas B1 and B2 in the proposed conditions model at the outlet of the detention basin. Drainage area B2 bypasses the basin; flows from drainage areas B1 and B2 were combined before comparing with the existing conditions. See Exhibit 4 – Proposed Conditions Drainage Map in Appendix A and also Section 4 of this report for a more detailed discussion of the proposed conditions drainage areas.

**Point of Interest C1** represents the northwestern corner of the site and compares drainage area C for existing and proposed conditions.

**Bypass Area A** was included in the model to account for area that does not pass through the site but drains to the culvert under Northwest Pryor Road near the southeastern corner of the development. This area was included in the model to calculate tailwater elevations for the proposed detention basin.

Tables 3, 4, and 5 below summarize the results of the existing conditions analysis. The proposed conditions data is compared to these results in Sections 4 of this report. Refer to Appendix B for output and a schematic for the existing conditions model and detailed calculations for the time of concentration.

Curve numbers were determined for existing and proposed conditions as shown in Table 3.

**Table 3. Curve Numbers.**

| Land Use | Hydrologic Soil Group | Curve Number |
|---|---|---|
| Straight Row Crop | C | 85 |
| Straight Row Crop | D | 89 |
| Multifamily Residential | C | 90 |
| Multifamily Residential | D | 92 |
| Pasture | C | 79 |
| Pasture | D | 84 |
| Paved Open Ditches with Right-of-Way | C | 92 |
| Paved Open Ditched with Right-of-Way | D | 93 |

**Table 4. Existing Conditions Area Data.**

| Area Name | On-site Area (acres) | Off-site Area (acres) | Total Area (acres) | $T_C$ (hours) | Weighted Curve Number |
|---|---|---|---|---|---|
| A | 2.10 | 3.06 | 5.16 | 0.33 | 82 |
| B | 25.26 | 3.31 | 28.57 | 0.36 | 84 |
| C | 4.02 | 7.25 | 11.27 | 0.33 | 83 |
| Bypass A | 0 | 2.86 | 2.86 | 0.18 | 87 |

**Table 5. Existing Conditions Point of Interest Peak Flow Rates.**

| Point of Interest | $Q_2$ (cfs)* | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| A1 | 11.1 | 20.2 | 33.9 |
| B1 | 61.8 | 109 | 179 |
| C1 | 25.4 | 45.3 | 75.2 |

* cfs = cubic feet per second

Per APWA Section 5608.4 and the City of Lee's Summit criteria, the performance criteria for comprehensive control is to provide detention to limit peak flow rates at downstream points of interest to maximum release rates:

- 50 percent storm peak rate less than or equal to 0.5 cubic feet per second (cfs) per site acre
- 10 percent storm peak rate less than or equal to 2.0 cfs per site acre
- 1 percent storm peak rate less than or equal to 3.0 cfs per site acre

Extended detention of the 90 percent mean annual event is also required for comprehensive control per APWA Section 5608.4.

Allowable release rates were calculated for the points of interest, allowing that off-site peak discharges would be permitted to bypass the detention. Off-site bypass peak flow rates were calculated as the first plat's percentage of the existing conditions, relating to the percentage of off-site area flowing to each point. The release rates for the proposed development on the development site were calculated based on the detention criteria. The development release rates were added to the bypass peak flow rates to calculate an allowable peak flow rate for each point of interest as follows. These allowable release rates represent the first plat development only. Note that point of interest A1 will remain unaffected by first plat development; hence, the percent on-site is 0 percent, and no allowable release rate was calculated, as it is not applicable. Tables 6 and 7 below summarize the amount of area on-site and the allowable discharges for each storm event.

**Table 6. Point of Interest On-site Area.**

| Point of Interest | Total Area (acres) | On-site Area (acres) | Percent (%) On-site |
|---|---|---|---|
| A1 | 5.16 | 0 | 0 |
| B1 | 28.57 | 18.88 | 66.1 |
| C1 | 11.27 | 2.28 | 20.2 |

**Table 7. Allowable Peak Flow Rates.**

| Point of Interest | Allowable 2-Year (cfs) | Allowable 10-Year Q (cfs) | Allowable 100-Year Q (cfs) |
|---|---|---|---|
| B1 | 30.4 | 74.7 | 117.3 |
| C1 | 21.4 | 40.7 | 66.8 |

# 4. PROPOSED CONDITIONS

The proposed conditions sections of this analysis assume completion of only the Osage development's first plat, including the construction of the detention facility. The difference between the existing conditions model and the proposed conditions model is a direct result of the Osage development first plat. Refer to Appendix A for the proposed conditions drainage area map.

## 4.1 Effects of Development

The proposed conditions analysis assumes completion of the first plat of the Osage development. The modeled subareas and points of interest are similar to the existing conditions model. However, throughout the site, some shifting of ridgelines will occur, accommodating proposed detention facilities and anticipated grading activities, which will change the relative areas draining to each point of interest. The following is a summary of the proposed conditions drainage areas. See Exhibit 4 – Proposed Conditions Drainage Map in Appendix A. Table 8 summarizes the proposed conditions area data.

**Drainage Area A** in proposed conditions is unaffected from existing conditions since it will not be developed with the first plat; hence, no further analysis is provided for proposed conditions.

**Drainage Area B1** in proposed conditions is 28.87 acres and will drain to the proposed detention basin. For the first plat, 16.6 acres of this drainage area will be developed. Drainage area from existing conditions is shifted from drainage areas A and C to area B1.

**Drainage Area B2** was previously part of drainage area B in existing conditions. This area was separated in the proposed conditions model, because it bypasses the detention basin. For consistency, the sum of drainage areas B1 and B2 were compared at the same point of interest as drainage area B in existing conditions. Drainage area B2 is 2.73 acres, which will be entirely developed with the first plat.

**Drainage Area C** in proposed conditions is 8.30 acres. Proposed grading shifts area from drainage area C to drainage area B1. Of this drainage area, 1.81 acres of this drainage area will be developed with the first plat.

The analysis provided in Section 3 established existing conditions of the development's drainage areas. The analysis in this section will provide guidance for configuring the detention basin to meet the objectives established in Section 3.

The following tables summarize the results of the proposed conditions analysis. Tables 9 and 10 assume no detention is provided, to demonstrate the effects of development for each drainage area. Refer to Appendix C for output from and a schematic of the proposed conditions Hydraflow Hydrographs model.

**Table 8. Proposed Conditions Area Data.**

| Area Name | Area (ac.) | $T_C$ (hr.) | Weighted CN |
|---|---|---|---|
| A1 | 5.16 | 0.33 | 82 |
| B1 | 28.82 | 0.35 | 87 |
| B2 | 2.73 | 0.10 | 90 |
| C | 8.30 | 0.32 | 85 |
| Bypass A | 2.86 | 0.18 | 87 |

**Table 9. Proposed (No Detention) Conditions Point of Interest Peak Flow Rates.**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| B1 | 77.3 | 129.8 | 206.9 |
| C1 | 20.3 | 35.1 | 57.1 |

Table 9 shows post-development peak discharge values points of interest assuming no detention is provided. Table 10 compares these to the existing conditions from Section 3 at the points of interest. Negative values indicate a reduction in peak flow rate, while positive values indicate an increase. Without detention, flow rates will increase at point B1, but decrease for C1. The decrease in flow rates at C1 is due to the proposed changes in grading, which shifts parts of the area areas to drainage area B1.

**Table 10. Proposed (No Detention) vs. Existing Conditions.**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| B1 | 15.5 | 20.8 | 27.9 |
| C1 | -5.1 | -10.2 | -18.1 |

## 4.2 Proposed Detention Facilities

To mitigate the increases in peak flows (shown in the previous table) and, where possible, to decrease further to the allowable release rates established in Section 3, detention will be provided for drainage area B1. This detention facility will be constructed as part of the first plat development.

Since the facility discharges directly to Pryor Road, the tailwater of the primary outlet pipe was set at the upstream elevation of the triple 30-inch corrugated metal pipe culverts during the appropriate storm event. Model results for the Pryor Road culverts can be found in Appendix D. These results assume that the culverts are clear with no sediment build up. Currently, the culverts have a heavy amount of silt deposition, which will need to be cleaned during the construction of the first plat.

The detention facility is designed to capture most of the site runoff and to mitigate increases in peak discharge from the site. The detention facility will be located near the southeastern corner of the site and will meet of the requirements outlined in Section 3. It will contain a multistage outlet structure and an independent 160-foot-long broad-crested weir graded into the eastern side of the berm. The following points summarize the multistage outlet structure and the emergency spillway:

- The structure itself will be a 6-foot-by-6-foot open-top concrete box with a top elevation of 1,017.1 feet, which generally controls the 100-year discharge.
- A 36-inch opening is present in the box at an elevation of 1,012.6 feet, which generally controls the 10-year and 100-year discharge.
- A 4.5-inch orifice is present in the box at the bottom elevation of the pond of 1010.0 feet. This helps control the 90 percent mean annual storm event. The two-year discharge is controlled by a combination of the 4.5-inch orifice and the 36-inch opening.
- The entire structure outlets to a 48-inch reinforced concrete pipe, which carries the water to Pryor Road.
- The emergency spillway will consist of a 160-foot-long broad-crested weir set at an elevation of 1,018.4 feet.

A 4.5-inch orifice will be set at the bottom of the multistage outlet structure. This orifice is sized to comply with the KC-AWPA requirement for 40-hour release of the 90 percent mean annual event for future conditions, which represents the entirety of the Osage development. To comply with the KC-APWA requirement for 40-hour release of the 90 percent mean annual event for the first plat development, this orifice could be partially covered with a steel plate to a 3.5-inch (+/-) diameter. The total inflow volume from the first plat 90 percent mean annual event is 1.40 acre-feet. This would then be released over 40 hours at a rate of 0.42 cfs given the 3.5-inch diameter. Upon completion of the entire development, the steel plate cover should be removed. Another option is not to cover the 4.5-inch opening, which will release the water quality volume faster than the 40-hour limit until the entirety of Osage is complete.

Table 11 includes a hydrologic summary of the proposed detention facility.

**Table 11. Proposed Conditions Detention Flow and Volume Data.**

| | Peak Q In (cfs) | TP In (hr) | Peak Q Out (cfs) | TP Out (hr) | Peak W.S.E. (ft) | Stored Volume (ac-ft) |
|---|---|---|---|---|---|---|
| 2-Year | 70.0 | 12.10 | 4.2 | 13.83 | 1013.51 | 3.5 |
| 10-Year | 118.1 | 12.10 | 27.4 | 12.50 | 1015.00 | 5.2 |
| 100-Year | 188.8 | 12.10 | 56.3 | 12.43 | 1017.16 | 8.0 |

## 4.3 Effects of Proposed Detention

The following tables compare the results of the proposed conditions analysis with the detention described above to the existing conditions from Section 3 at the points of interest. Table 12 shows peak discharge values at peaks of interest for the completion of the first plat and detention facility. Tables 13 and 14 compare these discharge values to existing and allowable discharge values. In Tables 13 and 14, negative values indicate a reduction in peak flows, while positive values indicate an increase.

As shown in Table 14, with the addition of the detention facility, peak discharge at all three points of interest will be at or below the allowable release rates. As previously mentioned, no analysis is provided for point of interest A1, because no development will occur in this area for the first plat addition; therefore, discharge at point of interest A1 will be the same in proposed conditions and existing conditions.

Point of interest C1 shows a lower peak discharge for all storm events than the allowable release rate for two reasons. The first is that changes in the ridgeline move area from point of interest C1 to point of interest B1. The second is that the first plat addition does not develop the entire drainage area draining to C1. When the entirety of the Osage development is complete, a waiver will be required for point of interest C1 in the two-year event, which was documented in the preliminary stormwater drainage study. This study can be found in Appendix F.

**Table 12. Proposed (with Detention) Point of Interest Peak Flow Rates.**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| B1 | 10.2 | 29.2 | 59.3 |
| C1 | 20.2 | 34.9 | 56.7 |

**Table 13. Proposed (with Detention) vs. Allowable Release Rates.**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| B1 | -20.2 | -45.5 | -58.0 |
| C1 | -1.2 | -5.8 | -10.1 |

**Table 14. Proposed (with Detention) vs. Existing Conditions.**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| B1 | -51.6 | -79.8 | -120 |
| C1 | -5.2 | -10.4 | -18.5 |

# 5. FUTURE CONDITIONS

Future conditions represent the built-out state of the Osage development. No changes that would affect hydrology have occurred since the preliminary stormwater drainage study was accepted in October 2018. Therefore, the final stormwater drainage study for the future conditions of the Osage development is the same as the proposed conditions analysis in the preliminary stormwater drainage study. The preliminary stormwater drainage study is included in Appendix F. While the basin outlet configuration, flow rates, etc. have not changed from the preliminary stormwater drainage study, the City requires additional hydrologic calculations to be included with the final stormwater drainage study. These calculations are present in Appendix E.

# 6. SUMMARY

This stormwater drainage study was prepared to evaluate the hydrologic impact generated by the first plat development of Osage and to provide recommendations for a comprehensive stormwater management plan for the future development. The first plat consists of 41 single-family residential lots, one detention facility, and the amenity called Tract E. The future built-out project is a single-family residential development on approximately 36 acres.

Increases in peak flow rates caused by the first plat development will be mitigated for all points of discharge through the site through a combination of dry detention and drainage area changes. The future conditions for the built-out Osage development remains hydrologically unchanged from the preliminary stormwater drainage study.

# 7. CONCLUSIONS AND RECOMMENDATIONS

This proposed first plat micro stormwater management plan and final stormwater management plan was designed to achieve compliance with current design criteria in effect for the City of Lee's Summit, Missouri; however, a waiver for point of interest C1 is still requested per the reasoning outlined in the preliminary stormwater drainage study for the future development of the second and third plats. That is, no waiver pertaining to the first plat alone is required, because the allowable discharge is met for all points of interest, but the originally requested waiver for the entire future development is still applicable. This waiver is submitted alongside this study for approval.

The results of the analysis demonstrate that the proposed first plat micro stormwater management plan for the project achieves compliance with design criteria, including extended detention of the 90 percent mean annual event, and that the final stormwater management plan likewise achieves compliance along with the requested waiver for drainage area C. We therefore request approval of this Final / First Plat Micro Osage Stormwater Drainage Study. This approval is conditional and should be substantiated with each future plat of Osage.

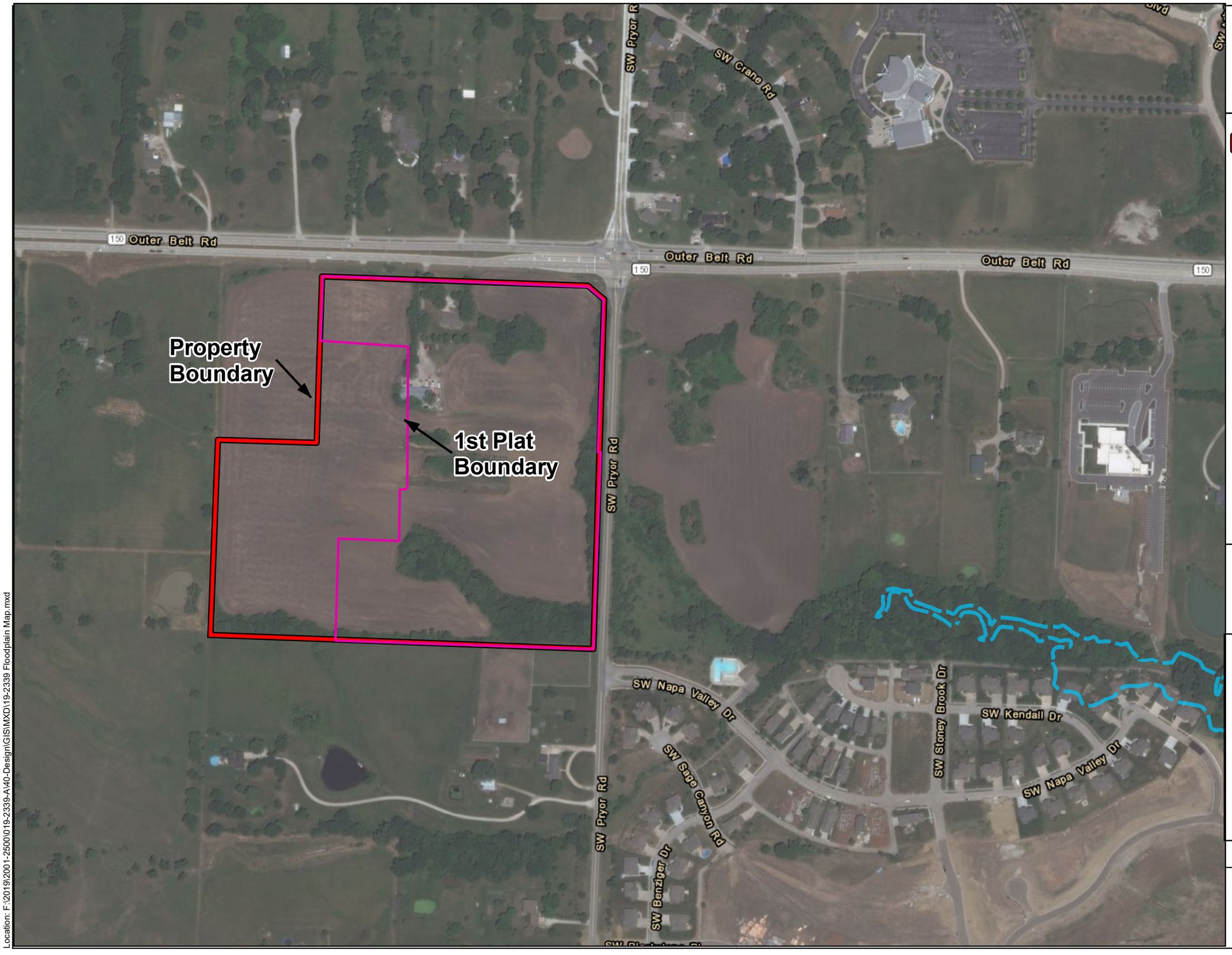
# 8. REFERENCES

KC-APWA (Kansas City Metropolitan Chapter of the American Public Works Association). (2011). “Section 5600 Storm Drainage & Facilities.”

United States Weather Bureau. “Technical Paper No. 40 Rainfall Frequency Atlas of the United States” (1961). Department of Commerce, Washington, D.C.

# APPENDIX A

Site Maps




# OSAGE

FLOODPLAIN MAP

EXHIBIT 1

LEGEND

- SITE BOUNDARY
- CURRENT EFFECTIVE ZONE X FLOODPLAIN
- 1ST PLAT BOUNDARY

Source:
FEMA Flood Boundary & Floodway Map
29095C0531G

Effective Date: 01/20/2017

N

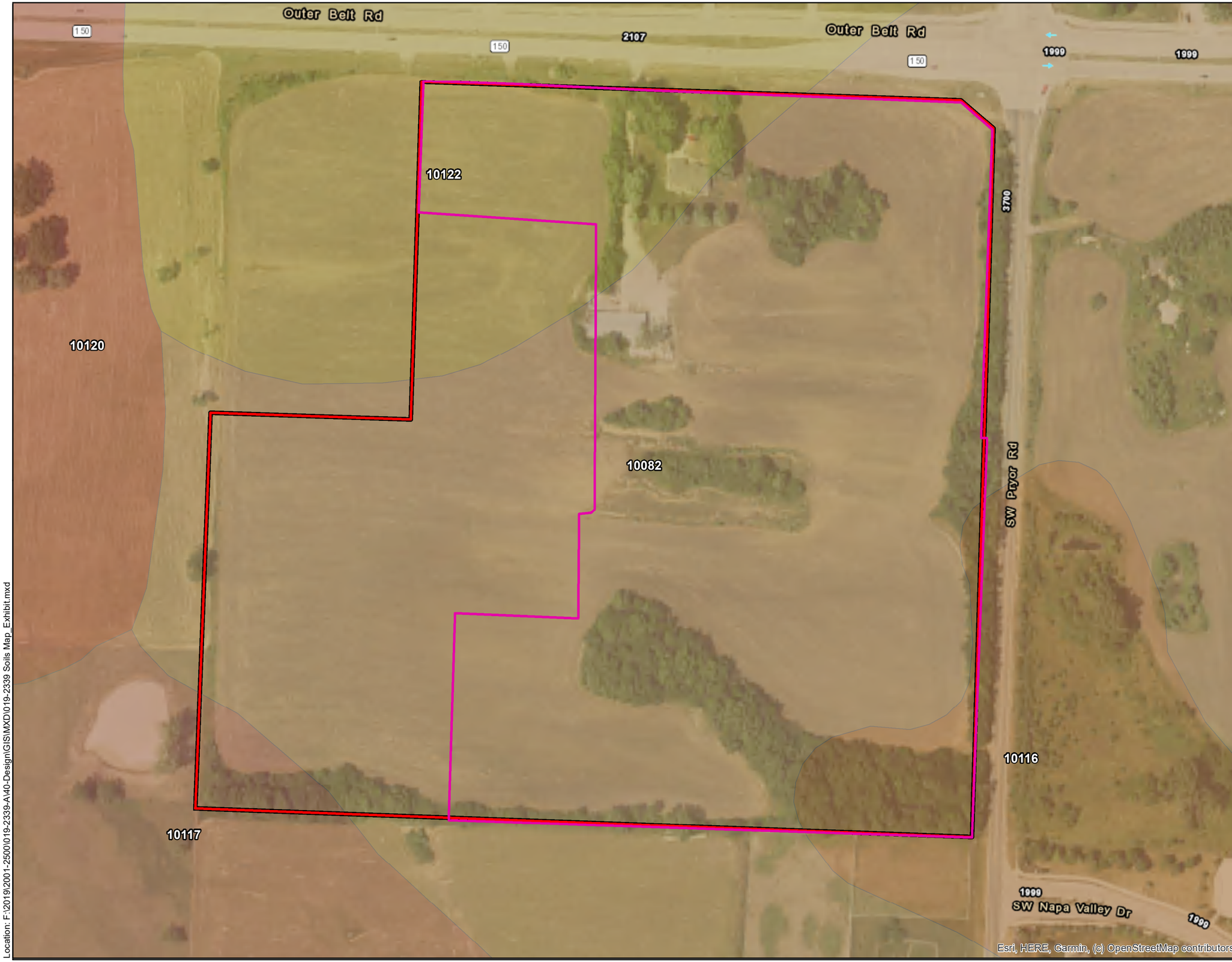
0 300 600 Feet

1 ' = 300 "

Drawn: B. Fairchild 3/4/2020

olsson

Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\19-2339 Floodplain Map.mxd




# OSAGE

SOIL MAP

EXHIBIT 2

LEGEND

- 1ST PLAT BOUNDARY
- PROPERTY BOUNDARY
- *10000* *ARISBURG SILT LOAM* *1 to 5% SLOPES*
- *10082* *ARISBURG LAND COMPLEX* *1 to 5% SLOPES*
- *10016* *SAMPSEL SILTY CLAY LOAM* *2 to 5% SLOPES*
- *10017* *SAMPSEL SILTY CLAY LOAM* *5 to 9% SLOPES*
- *10120* *SHARPSBURG SILT LOAM* *2 to 5% SLOPES*
- *10122* *SHARPSBURG SILT LOAM* *5 to 9% SLOPES*

Source:
Soil Survey of Jackson County, Missouri

N

0 150 300 Feet

1 ' = 150 "

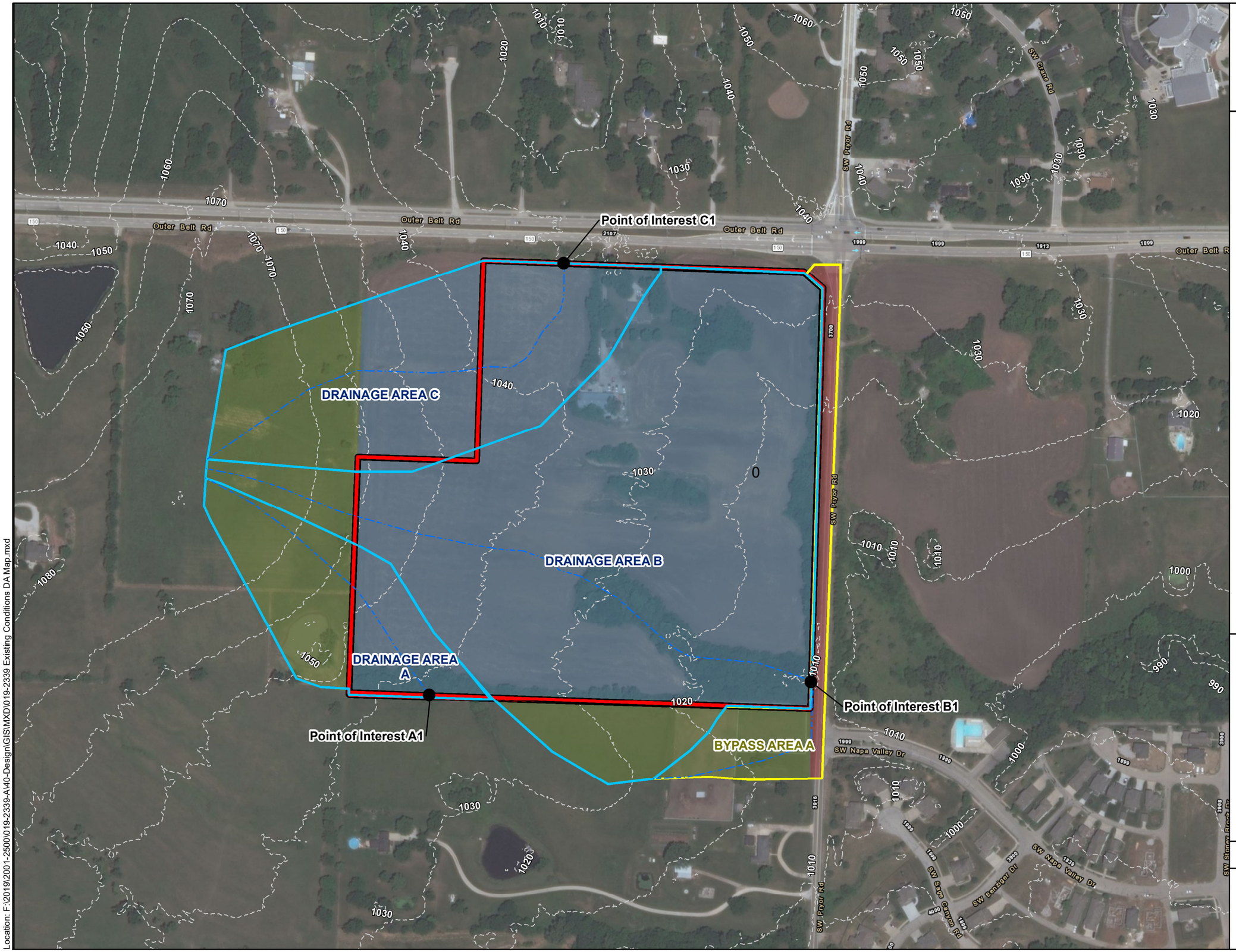
Drawn: B. Fairchild 3/4/2020

olsson

Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\019-2339 Soils Map_Exhibit.mxd

# OSAGE

EXISTING CONDITIONS
DRAINAGE MAP
EXHIBIT 3




LEGEND

- SITE BOUNDARY
- EXISTING DRAINAGE AREA BOUNDARIES
- BYPASS AREA BOUNDARIES
- EXISTING 10-FT CONTOURS
- EXISTING FLOW PATH

**LAND USE**

- Multifamily Residential
- Pasture
- Paved Open Ditches w/ ROW
- Straight Row Crop

N

0 250 500 Feet

1 ' = 250 "

Drawn: B. Fairchild 3/4/2020

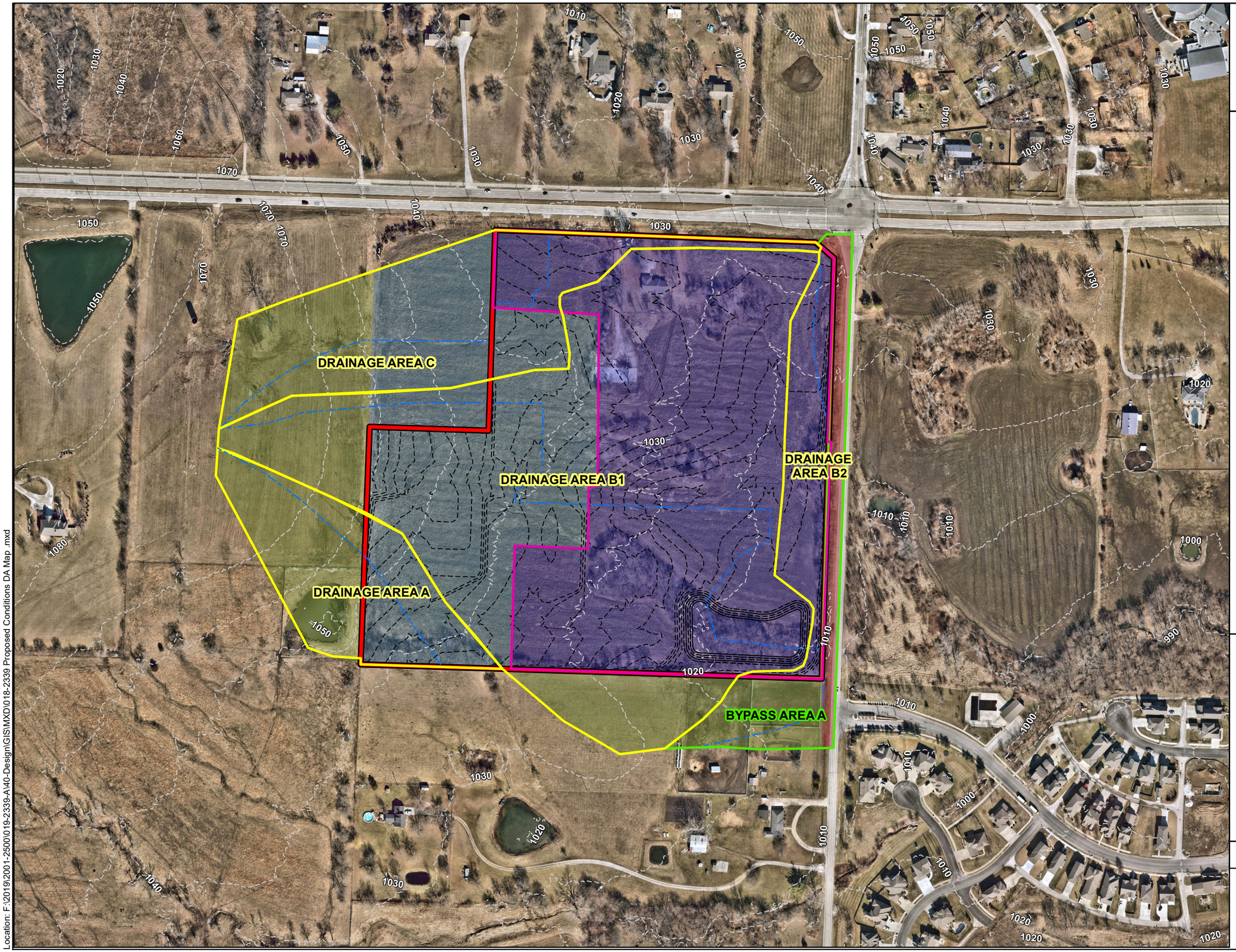
olsson

Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\019-2339 Existing Conditions DA Map.mxd

# OSAGE

## PROPOSED CONDITIONS DRAINAGE MAP

## EXHIBIT 4




LEGEND

- 1ST PLAT BOUNDARY
- SITE BOUNDARY
- BYPASS AREA BOUNDARIES
- PROPOSED FLOW PATHS
- 1ST PLAT DRAINAGE BOUNDARIES
- PROPOSED 2-FT CONTOURS
- EXISTING 10-FT CONTOURS

**1ST PLAT LAND USE**

- Multifamily Residential
- Pasture
- Paved Open Ditches w/ ROW
- Straight Row Crop

N

0 250 500 Feet

1 ' = 250 "

Drawn: B. Fairchild 3/4/2020

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Location: F:\2019\2001-2500\019-2339-A\40-Design\GIS\MXD\018-2339 Proposed Conditions DA Map .mxd

# APPENDIX B

Existing Conditions Hydraflow Hydrographs Model Input and Results

**Subarea A**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.005 | Grass-Range, Short (0.15) | | 0.272 |
| Shallow Concentrated | 778 | 0.052 | Unpaved | | 0.059 |
| Channel | | | | | |
| Total | 878 | | | | 0.331 |

**Subarea B**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.005 | Grass-Range, Short (0.15) | | 0.272 |
| Shallow Concentrated | 646 | 0.052 | Unpaved | | 0.049 |
| Channel | 1,065 | | | 7 | 0.042 |
| Total | 1,811 | | | | 0.363 |

**Subarea C**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.005 | Grass-Range, Short (0.15) | | 0.272 |
| Shallow Concentrated | 451 | 0.057 | Unpaved | | 0.033 |
| Channel | 709 | | | 7 | 0.028 |
| Total | 1,260 | | | | 0.333 |

**Bypass Area A**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.030 | Grass-Range, Short (0.15) | | 0.133 |
| Shallow Concentrated | 472 | 0.035 | Unpaved | | 0.044 |
| Channel | | | | | |
| Total | 572 | | | | 0.177 |

# Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

| 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 | ------ | ------- | 11.16 | ------- | ------- | 20.21 | ------- | ------- | 33.87 | Existing Conditions Area A |
| 2 | SCS Runoff | ------ | ------- | 61.82 | ------- | ------- | 108.92 | ------- | ------- | 179.23 | Existing Conditions Area B |
| 3 | SCS Runoff | ------ | ------- | 25.41 | ------- | ------- | 45.33 | ------- | ------- | 75.19 | Existing Conditions Area C |
| 4 | SCS Runoff | ------ | ------- | 9.322 | ------- | ------- | 15.64 | ------- | ------- | 24.90 | Bypass Area A |
| 5 | Combine | 2, 4 | ------- | 68.77 | ------- | ------- | 120.39 | ------- | ------- | 197.29 | Pryor Culvert |

# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

| 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 | 11.16 | 2 | 724 | 34,942 | ------ | ------ | ------ | Existing Conditions Area A |
| 2 | SCS Runoff | 61.82 | 2 | 726 | 213,484 | ------ | ------ | ------ | Existing Conditions Area B |
| 3 | SCS Runoff | 25.41 | 2 | 724 | 79,488 | ------ | ------ | ------ | Existing Conditions Area C |
| 4 | SCS Runoff | 9.322 | 2 | 720 | 24,330 | ------ | ------ | ------ | Bypass Area A |
| 5 | Combine | 68.77 | 2 | 726 | 237,814 | 2, 4 | ------ | ------ | Pryor Culvert |

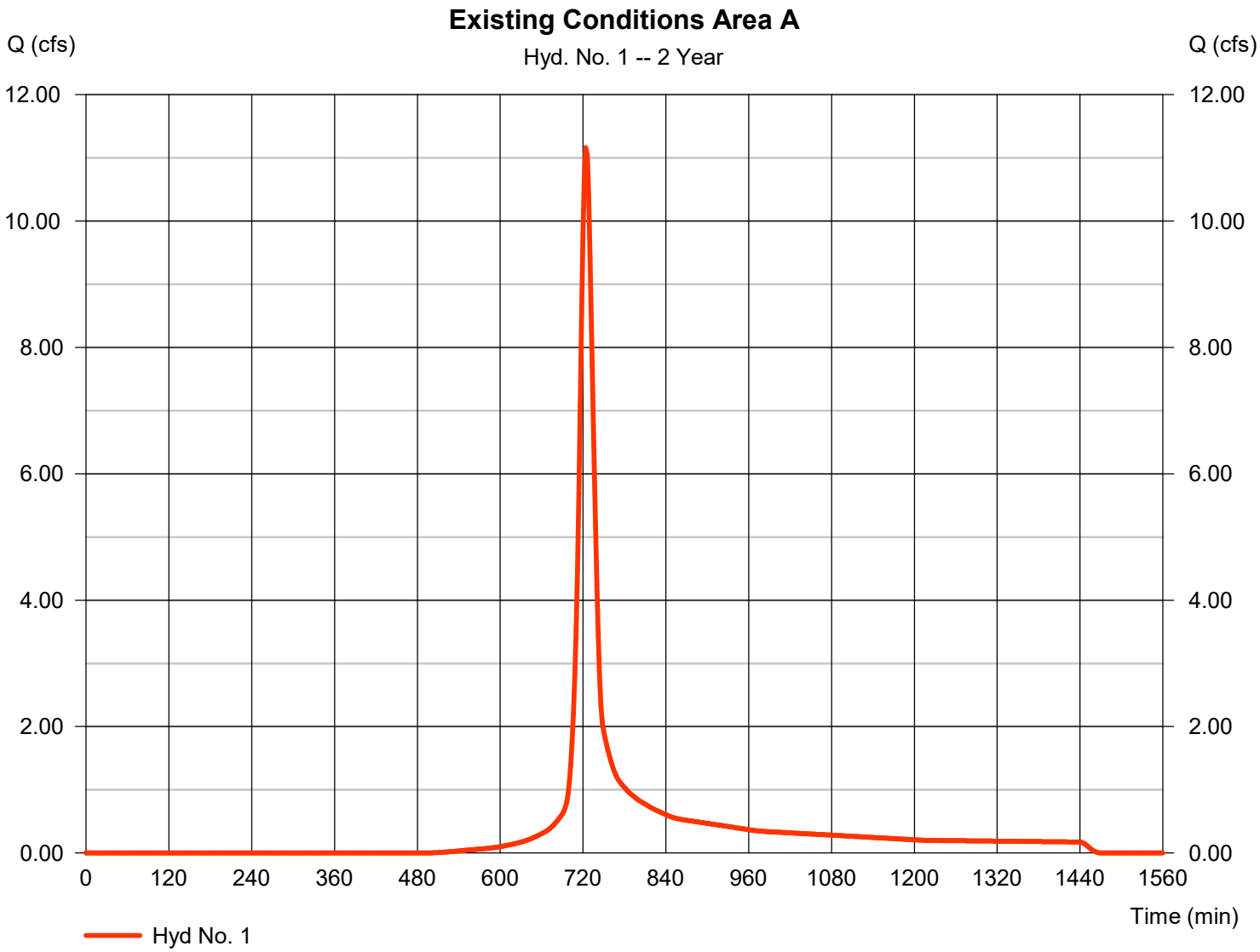
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 1

Existing Conditions Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 11.16 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 34,942 cuft |
| Drainage area | = 5.160 ac | Curve number | = 82 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



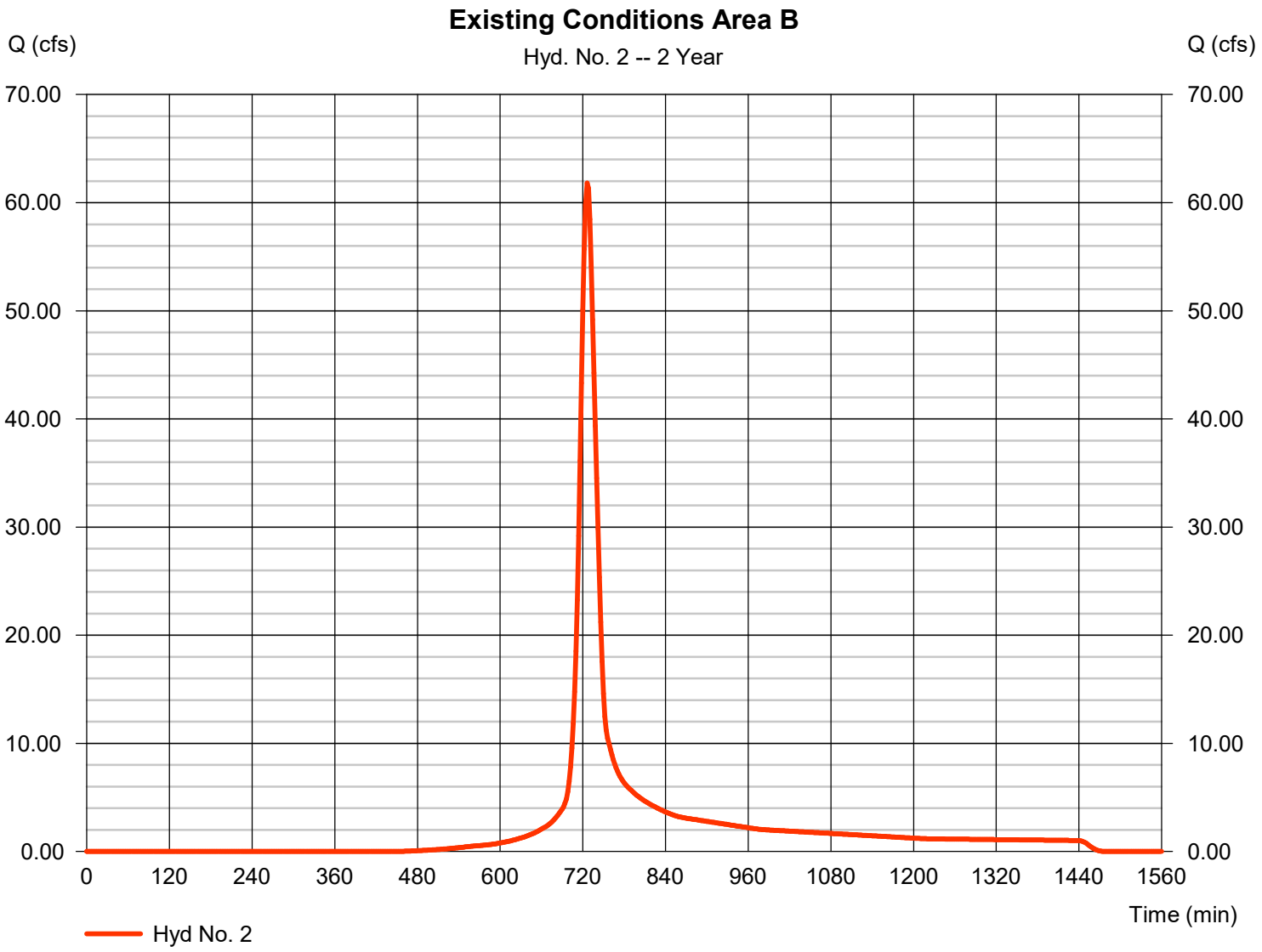
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 2

Existing Conditions Area B

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 61.82 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 213,484 cuft |
| Drainage area | = 28.570 ac | Curve number | = 84 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 22.00 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



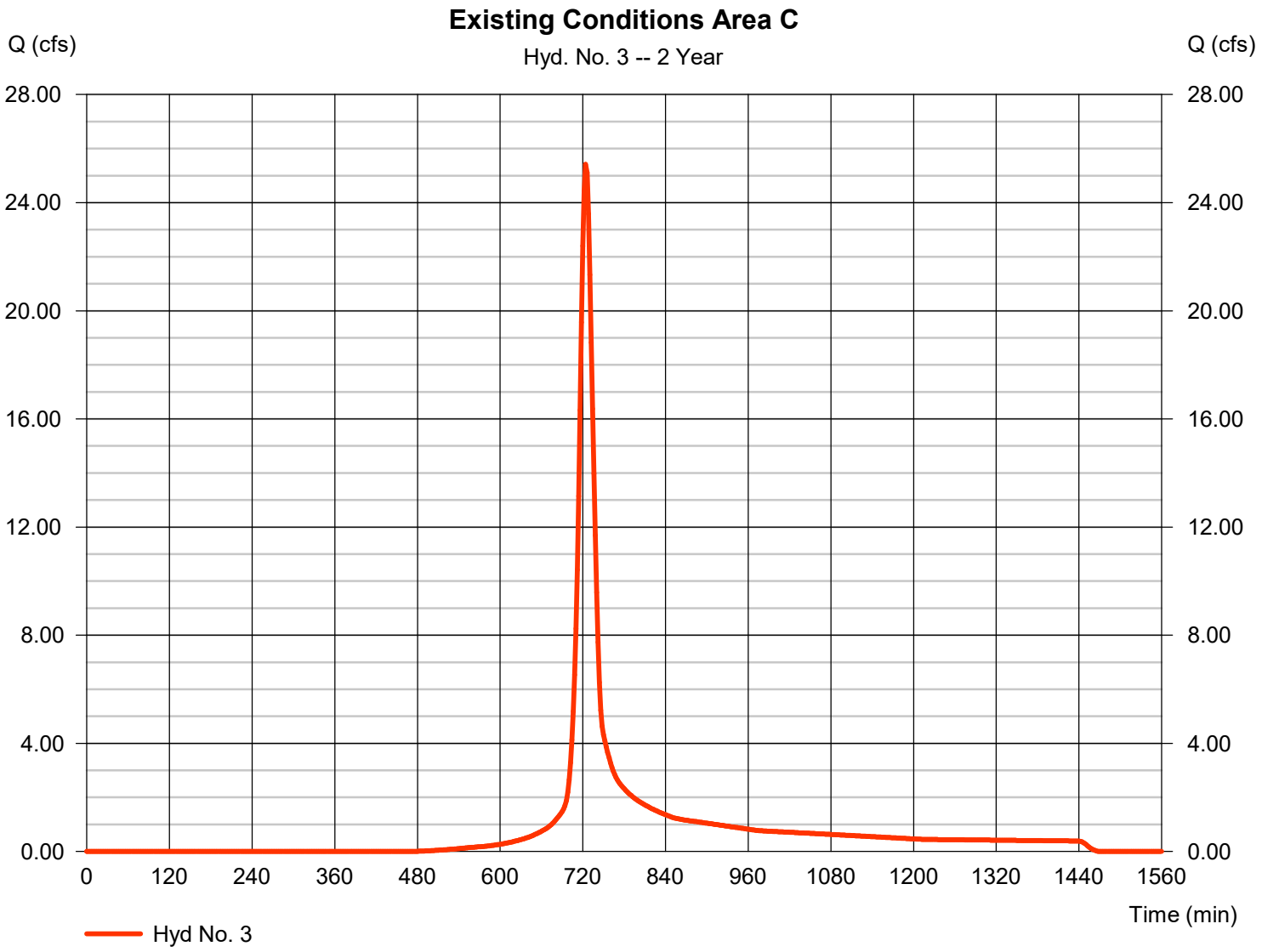
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 3

Existing Conditions Area C

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 25.41 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 79,488 cuft |
| Drainage area | = 11.270 ac | Curve number | = 83 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



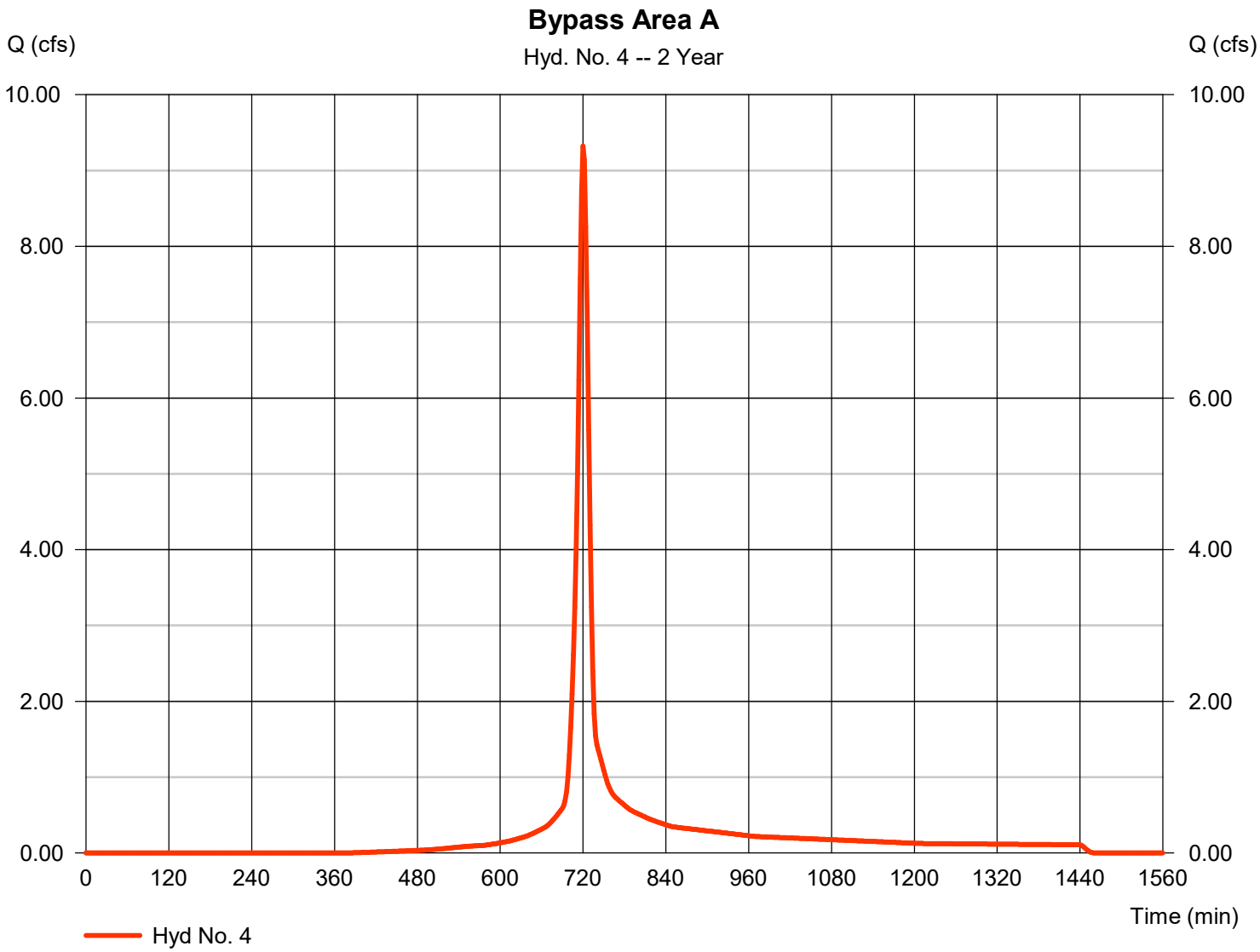
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 4

Bypass Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 9.322 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 24,330 cuft |
| Drainage area | = 2.860 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.60 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



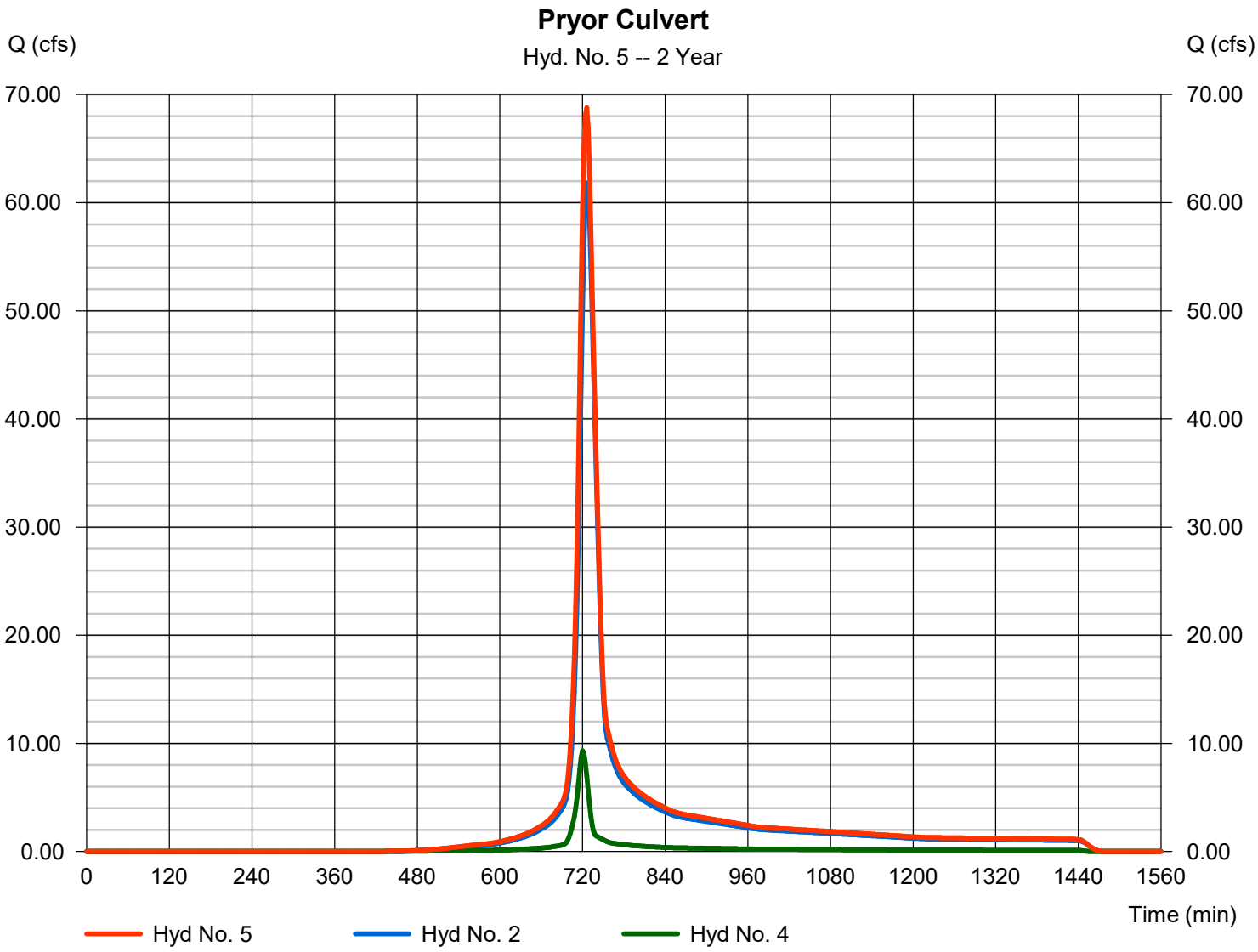
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 5

Pryor Culvert

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 68.77 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 237,814 cuft |
| Inflow hyds. | = 2, 4 | Contrib. drain. area | = 31.430 ac |



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

| 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 | 20.21 | 2 | 724 | 63,402 | ------ | ------ | ------ | Existing Conditions Area A |
| 2 | SCS Runoff | 108.92 | 2 | 726 | 378,212 | ------ | ------ | ------ | Existing Conditions Area B |
| 3 | SCS Runoff | 45.33 | 2 | 724 | 142,503 | ------ | ------ | ------ | Existing Conditions Area C |
| 4 | SCS Runoff | 15.64 | 2 | 720 | 41,632 | ------ | ------ | ------ | Bypass Area A |
| 5 | Combine | 120.39 | 2 | 726 | 419,844 | 2, 4 | ------ | ------ | Pryor Culvert |

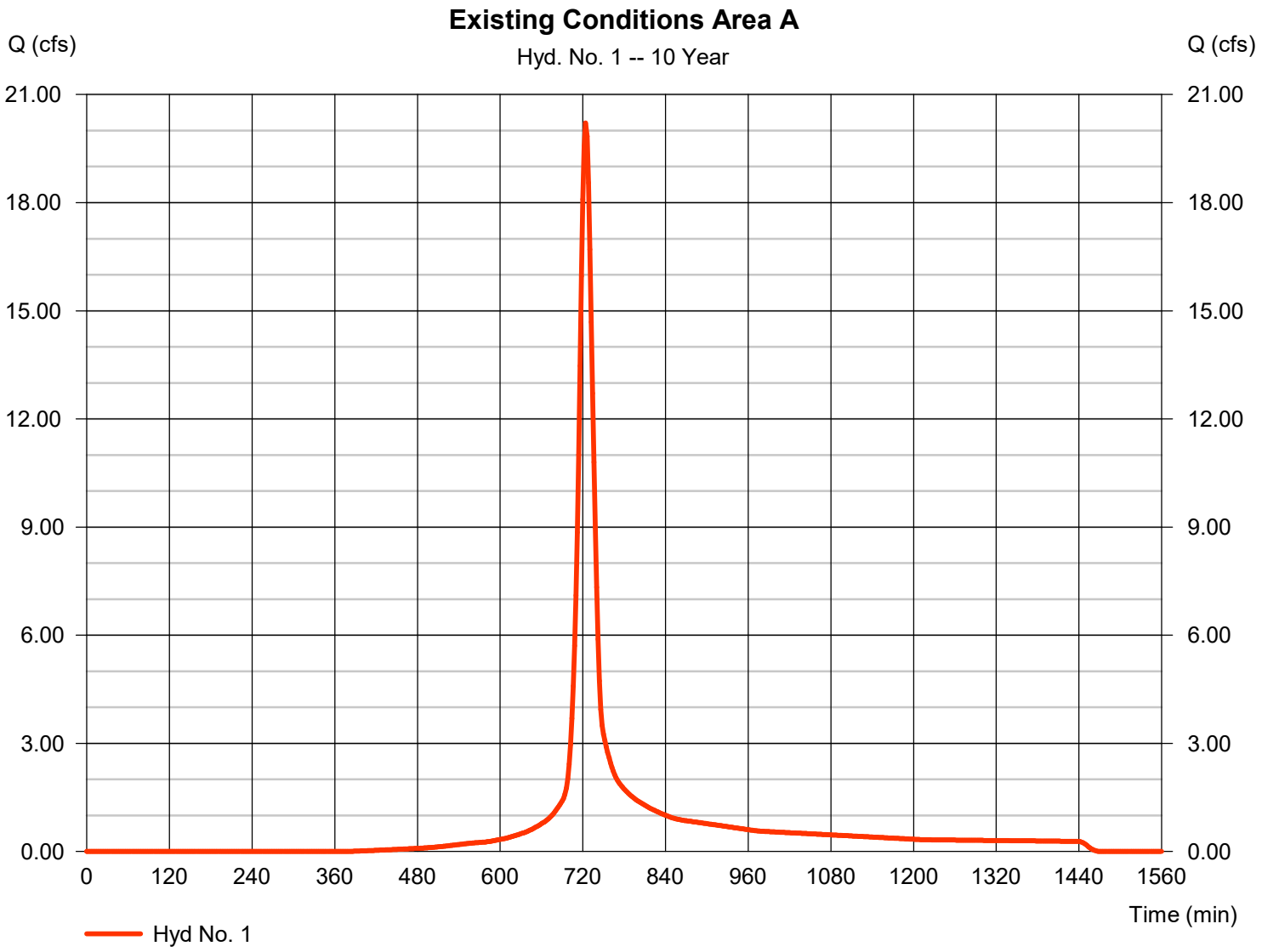
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 1

Existing Conditions Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 20.21 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 63,402 cuft |
| Drainage area | = 5.160 ac | Curve number | = 82 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



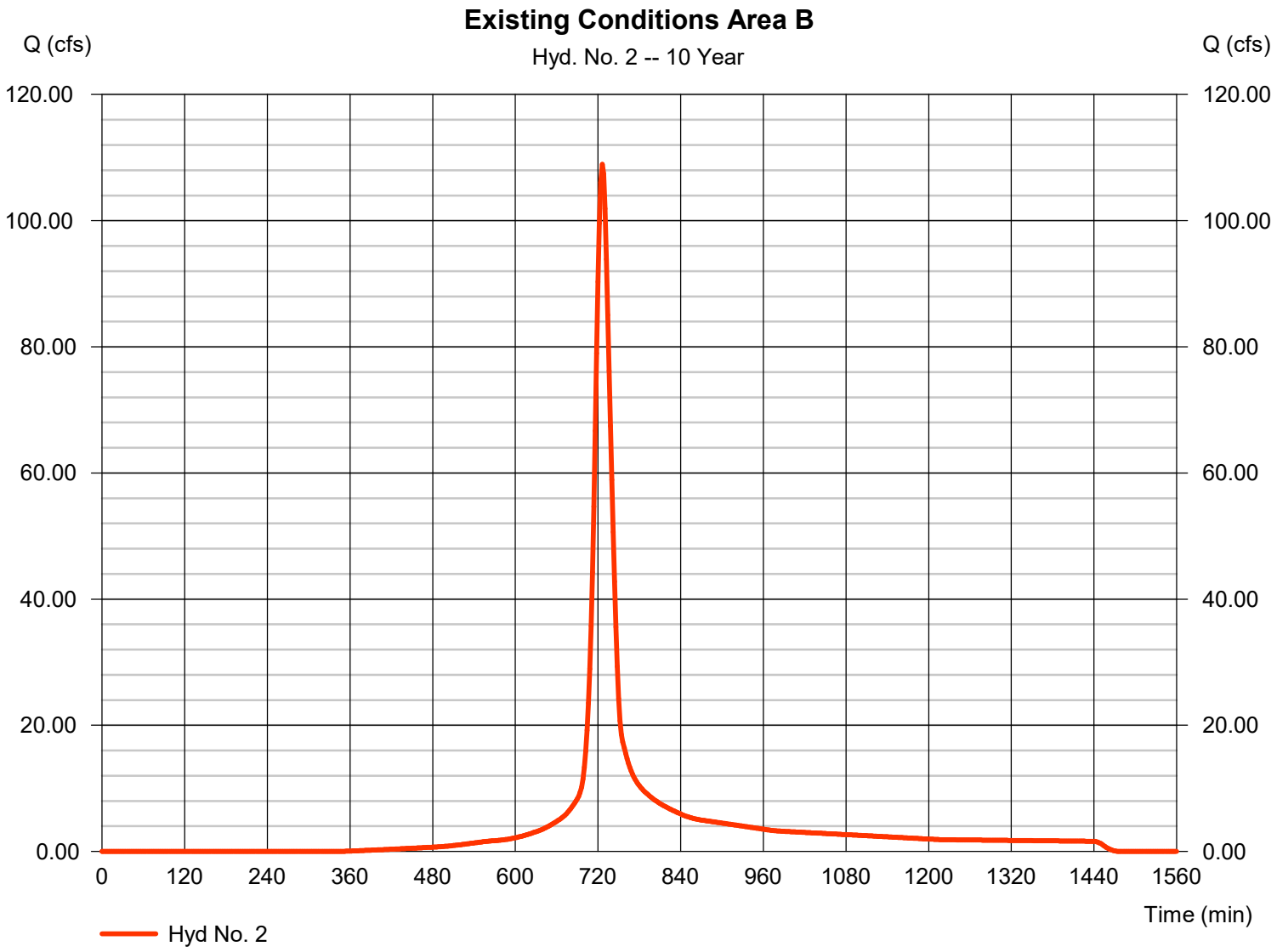
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 2

Existing Conditions Area B

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 108.92 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 378,212 cuft |
| Drainage area | = 28.570 ac | Curve number | = 84 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 22.00 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



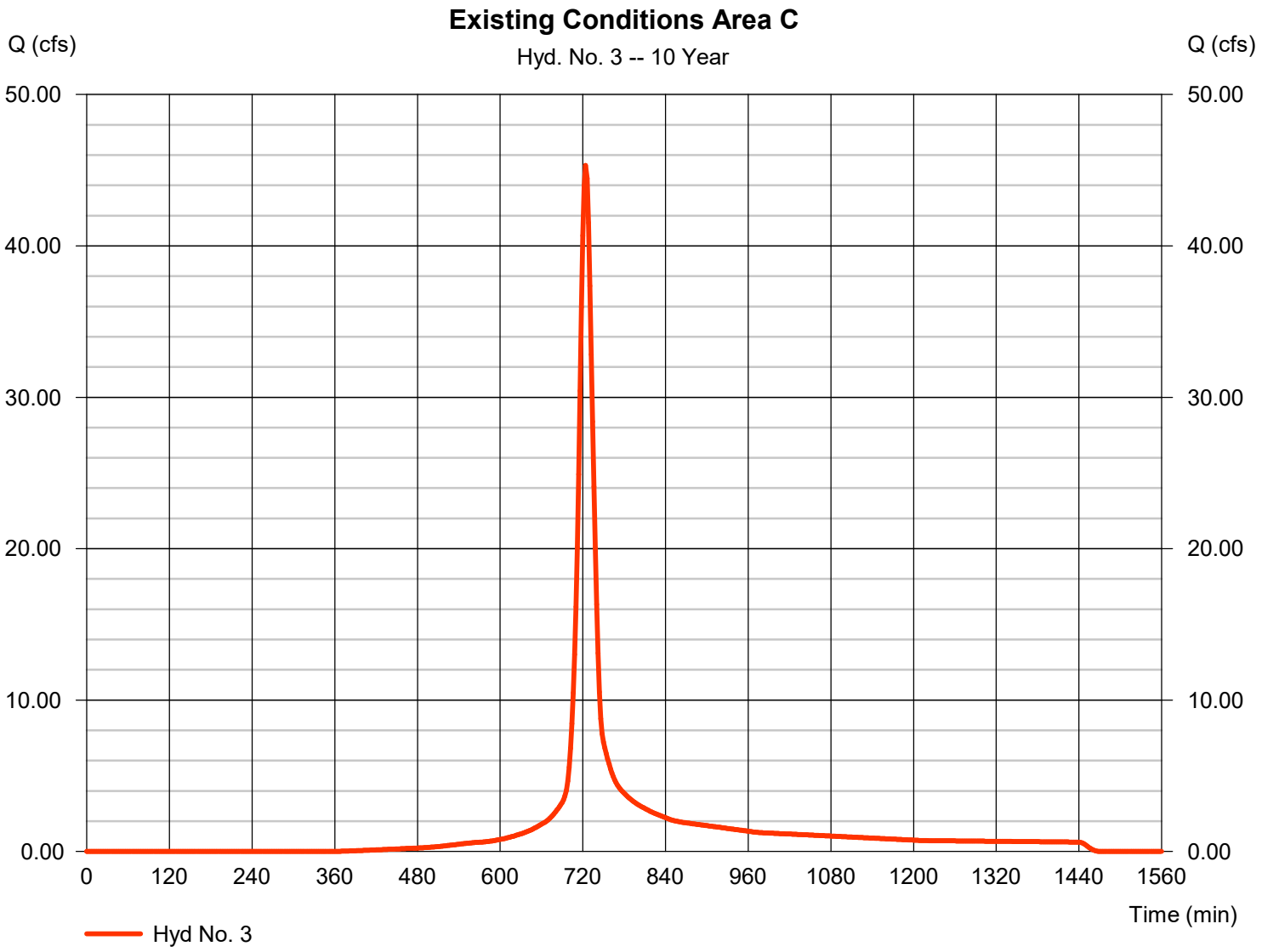
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 3

Existing Conditions Area C

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 45.33 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 142,503 cuft |
| Drainage area | = 11.270 ac | Curve number | = 83 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



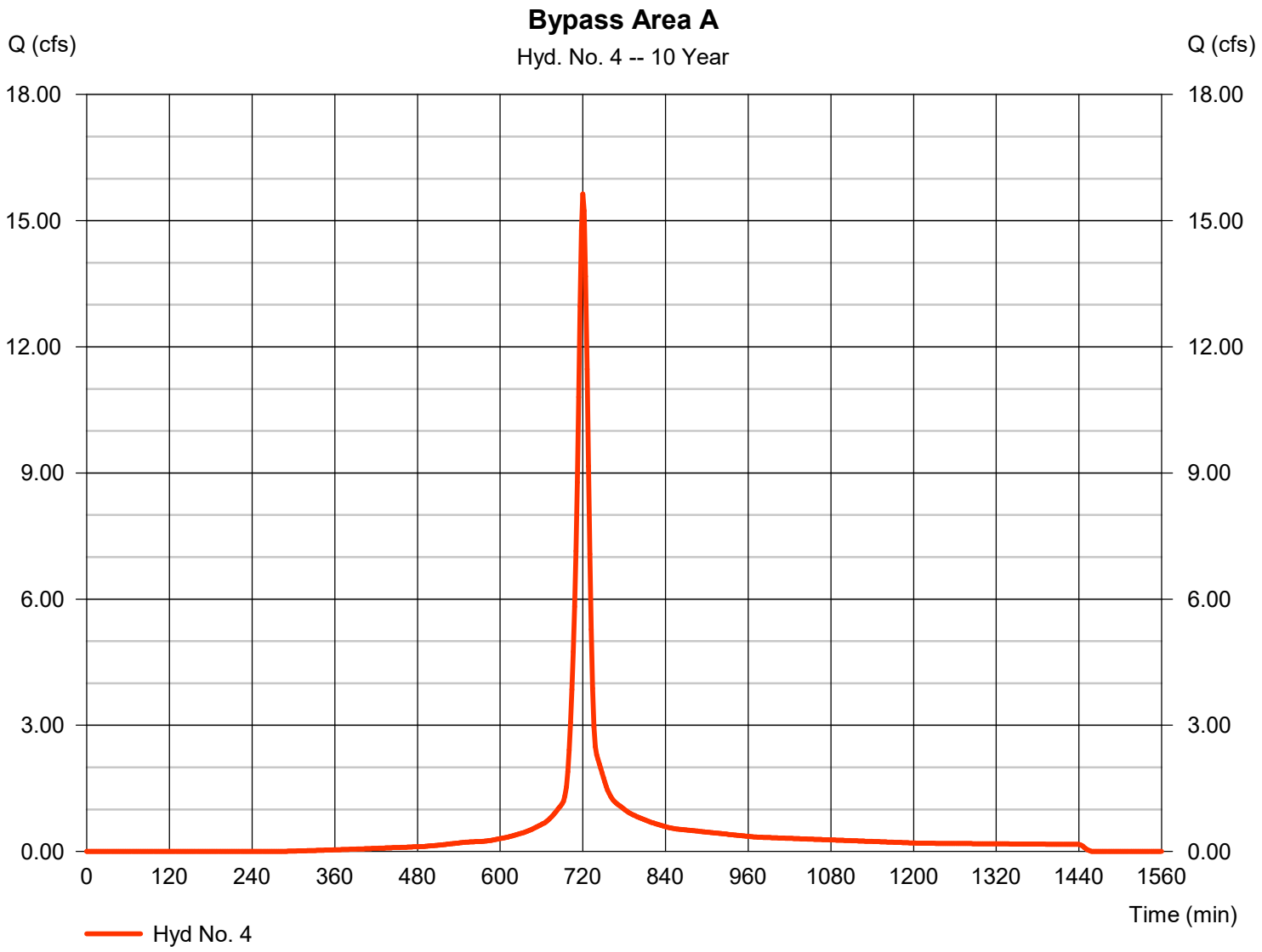
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 4

Bypass Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 15.64 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 41,632 cuft |
| Drainage area | = 2.860 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.60 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



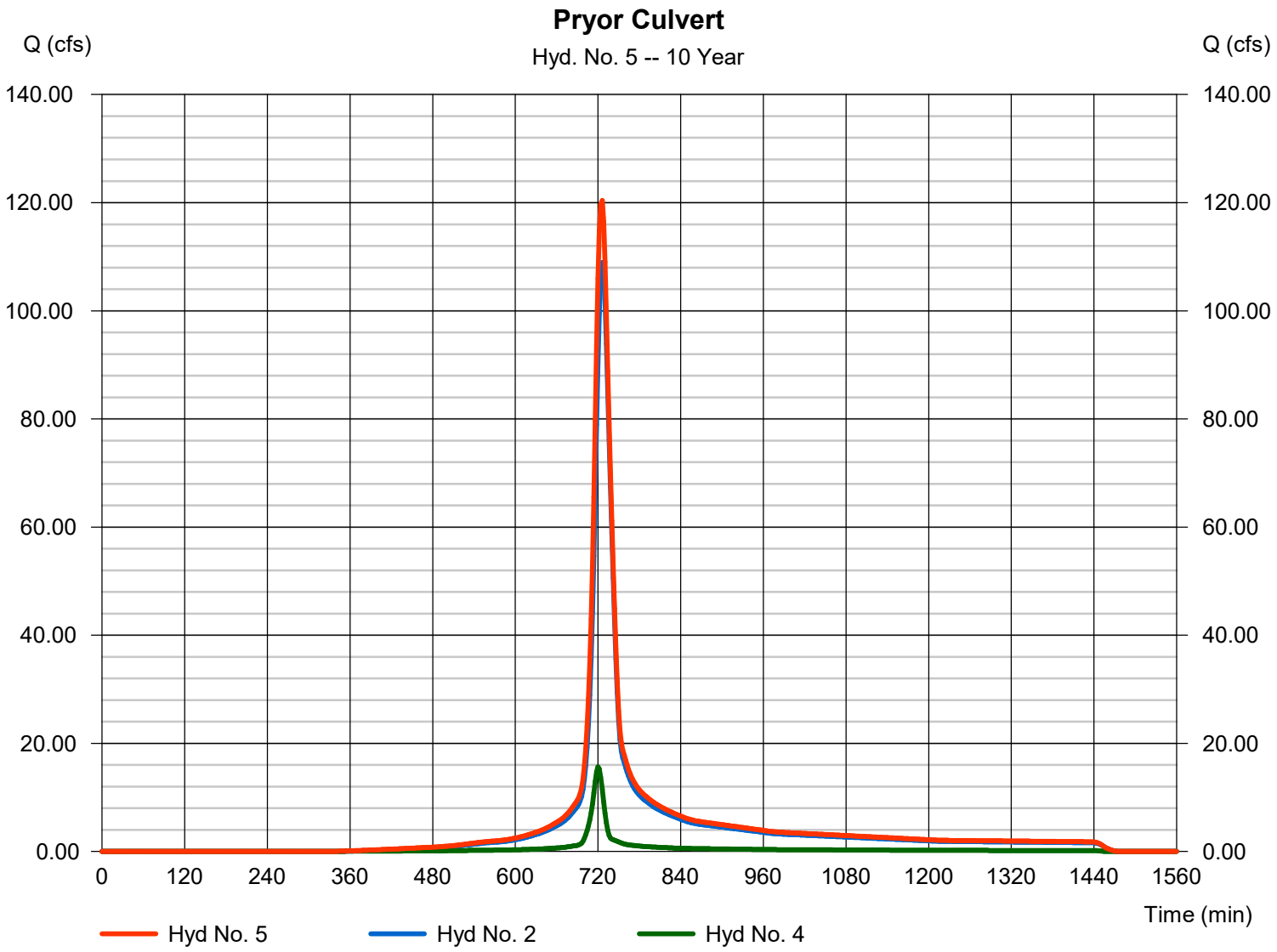
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 5

Pryor Culvert

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 120.39 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 419,844 cuft |
| Inflow hyds. | = 2, 4 | Contrib. drain. area | = 31.430 ac |



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

| 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 | 33.87 | 2 | 724 | 107,981 | ------ | ------ | ------ | Existing Conditions Area A |
| 2 | SCS Runoff | 179.23 | 2 | 726 | 633,290 | ------ | ------ | ------ | Existing Conditions Area B |
| 3 | SCS Runoff | 75.19 | 2 | 724 | 240,632 | ------ | ------ | ------ | Existing Conditions Area C |
| 4 | SCS Runoff | 24.90 | 2 | 720 | 68,010 | ------ | ------ | ------ | Bypass Area A |
| 5 | Combine | 197.29 | 2 | 726 | 701,300 | 2, 4 | ------ | ------ | Pryor Culvert |

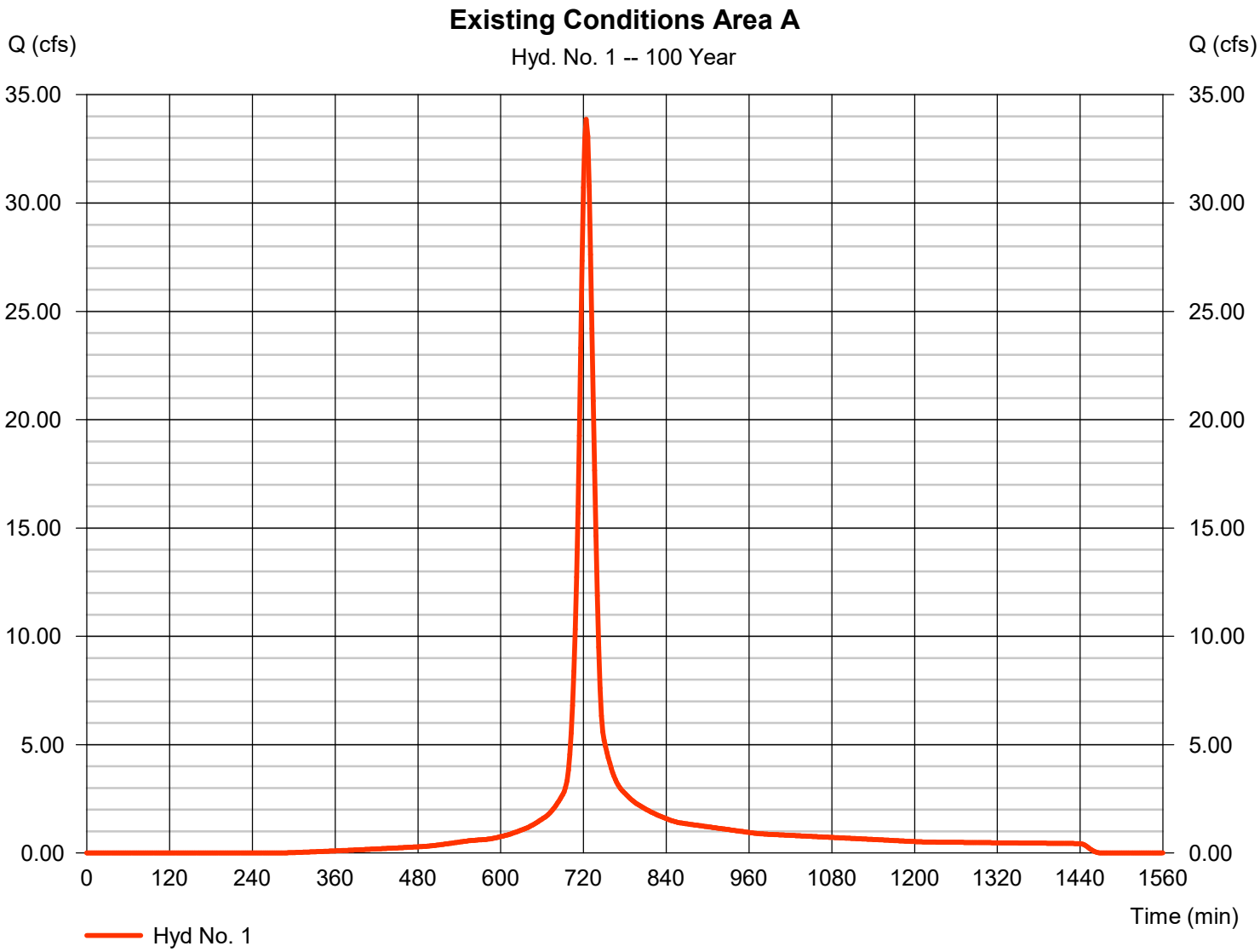
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 1

Existing Conditions Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 33.87 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 107,981 cuft |
| Drainage area | = 5.160 ac | Curve number | = 82 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



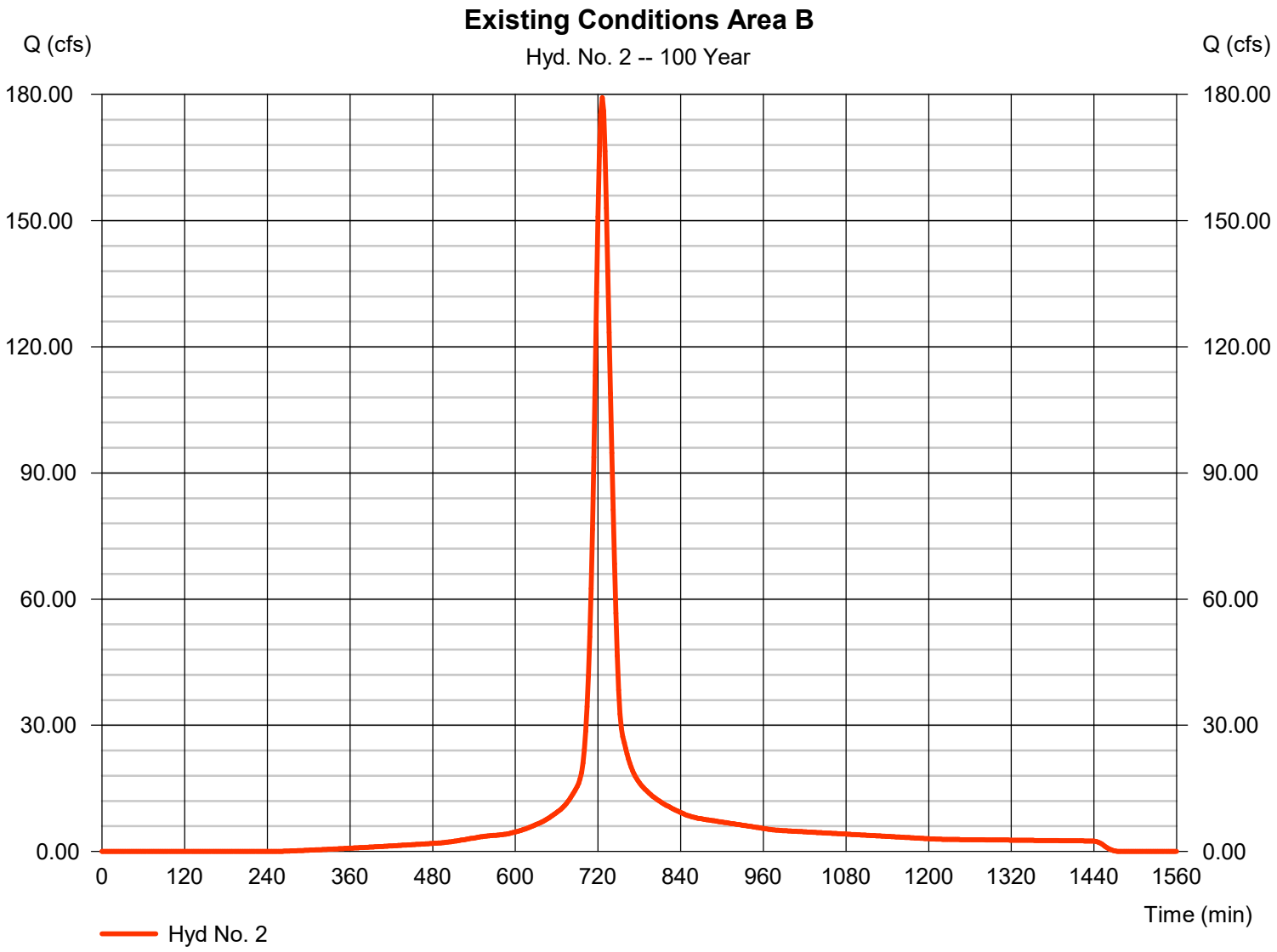
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 2

Existing Conditions Area B

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 179.23 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 633,290 cuft |
| Drainage area | = 28.570 ac | Curve number | = 84 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 22.00 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



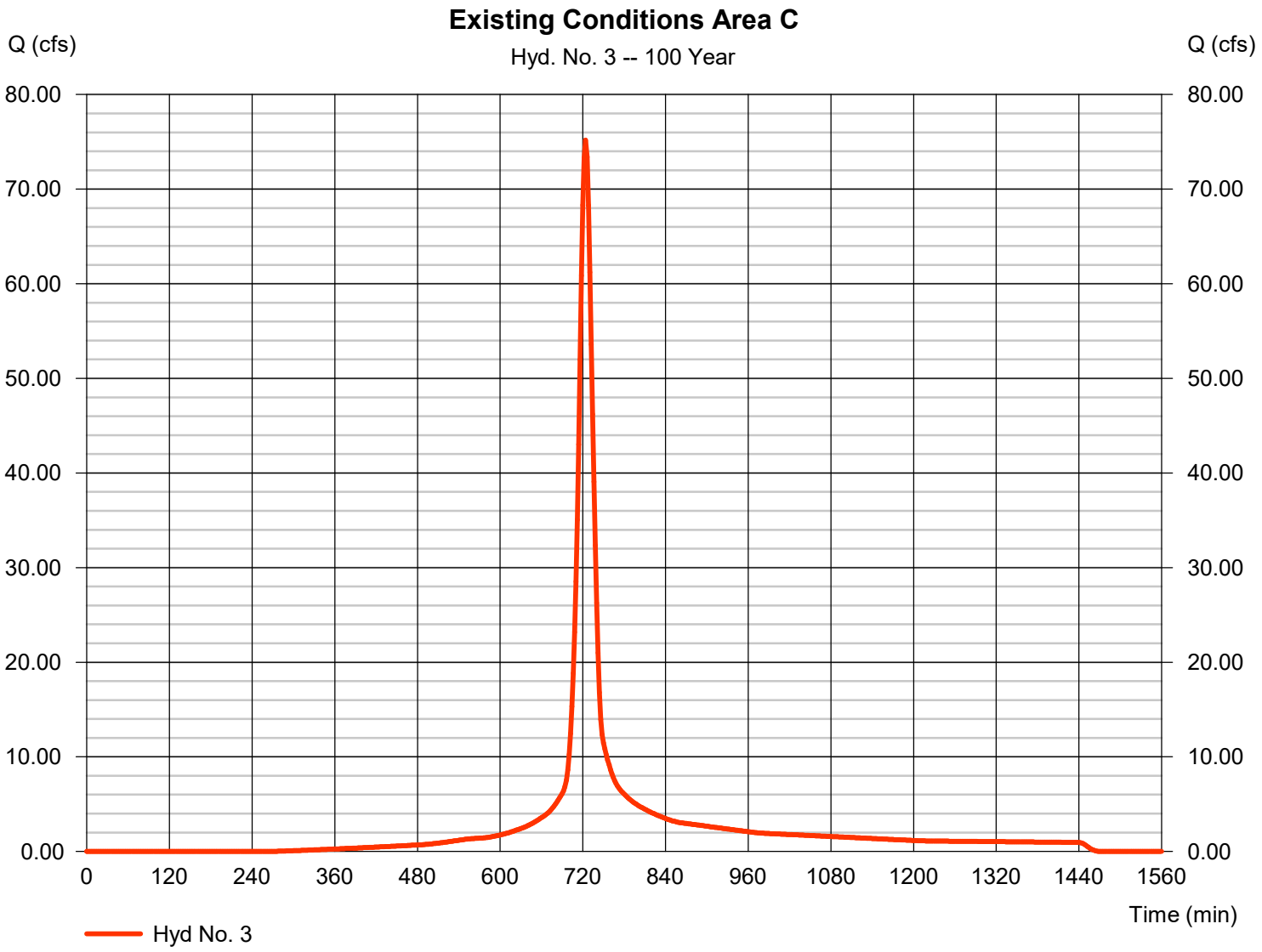
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 3

Existing Conditions Area C

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 75.19 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 240,632 cuft |
| Drainage area | = 11.270 ac | Curve number | = 83 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



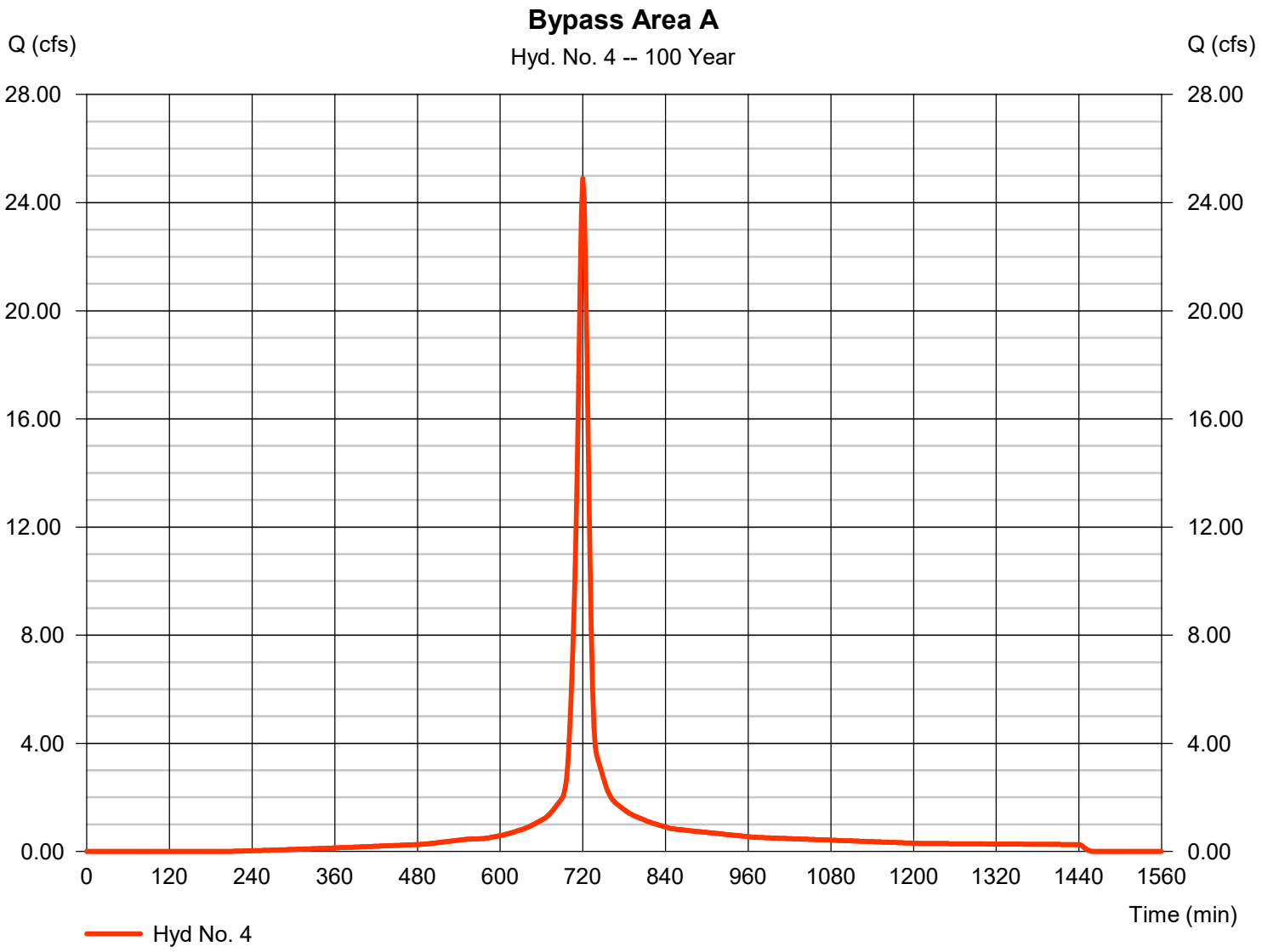
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 4

Bypass Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 24.90 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 68,010 cuft |
| Drainage area | = 2.860 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.60 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



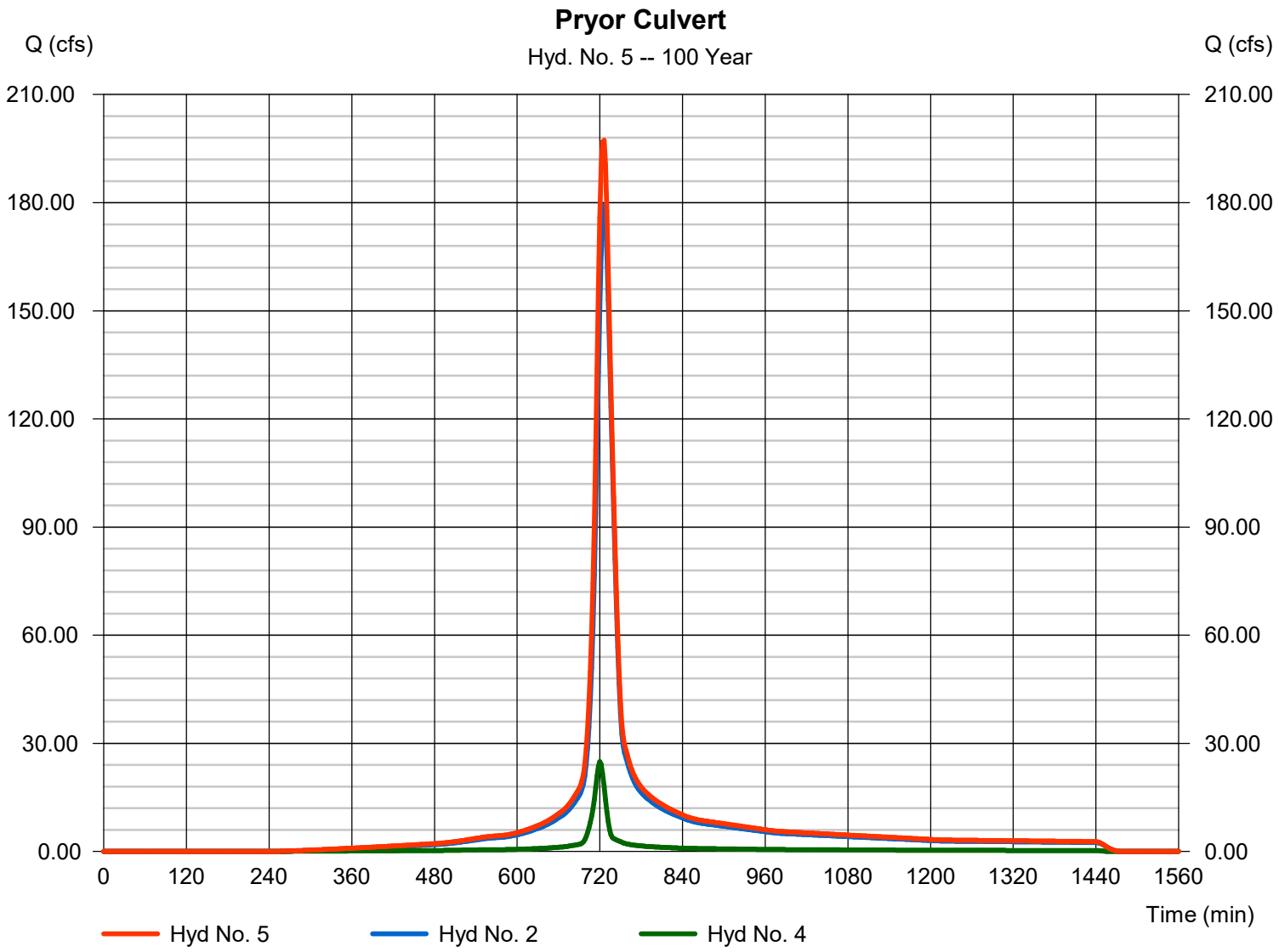
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 Thursday, 09 / 12 / 2019

## Hyd. No. 5

Pryor Culvert

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 197.29 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 701,300 cuft |
| Inflow hyds. | = 2, 4 | Contrib. drain. area | = 31.430 ac |



# APPENDIX C

Proposed Conditions Hydraflow Hydrographs Model Input and Results

**Subarea A**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.005 | Grass-Range, Short (0.15) | | 0.272 |
| Shallow Concentrated | 778 | 0.052 | Unpaved | | 0.059 |
| Channel | | | | | |
| Total | 878 | | | | 0.331 |

**Subarea B1**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.005 | Grass-Range, Short (0.15) | | 0.272 |
| Shallow Concentrated | 646 | 0.0503 | Unpaved | | 0.05 |
| Channel | 1,771 | | | 15 | 0.033 |
| Total | 2,517 | | | | 0.355 |

**Subarea B2**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.0420 | Grass-Range, Short (0.15) | | 0.116 |
| Shallow Concentrated | 469 | .0336 | Unpaved | | 0.044 |
| Channel | 539 | | | 7 | 0.021 |
| Total | 1,108 | | | | 0.181 |

**Subarea C**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.005 | Grass-Range, Short (0.15) | | 0.272 |
| Shallow Concentrated | 451 | 0.057 | Unpaved | | 0.033 |
| Channel | 746 | | | 10 | 0.021 |
| Total | 1,297 | | | | 0.326 |

**Bypass Area A**

| | Length (ft) | Slope (ft/ft) | Surface (Manning's n) | Velocity (ft/s) | Time (hr) |
|---|---|---|---|---|---|
| Sheet | 100 | 0.030 | Grass-Range, Short (0.15) | | 0.133 |
| Shallow Concentrated | 472 | 0.035 | Unpaved | | 0.044 |
| Channel | | | | | |
| Total | 572 | | | | 0.177 |

# Hydrograph Return Period Recap

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| 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 | 11.16 | ------- | ------- | 20.21 | ------- | 27.99 | 33.87 | Proposed Area A |
| 2 | SCS Runoff | ------ | 0.000 | 69.97 | ------- | ------- | 118.08 | ------- | 158.49 | 188.79 | Proposed Area B1 |
| 3 | SCS Runoff | ------ | 0.000 | 20.15 | ------- | ------- | 34.89 | ------- | 47.36 | 56.74 | Proposed Area C |
| 4 | SCS Runoff | ------ | 0.000 | 9.813 | ------- | ------- | 15.83 | ------- | 20.84 | 24.59 | Proposed Area B2 |
| 5 | SCS Runoff | ------ | 0.000 | 9.322 | ------- | ------- | 15.64 | ------- | 20.93 | 24.90 | Bypass Area A |
| 6 | Reservoir | 2 | 0.000 | 4.275 | ------- | ------- | 28.05 | ------- | 46.49 | 56.31 | Detention Pond |
| 7 | Combine | 4, 6 | 0.000 | 9.813 | ------- | ------- | 29.88 | ------- | 49.02 | 59.28 | Point of Interest |
| 8 | Combine | 5, 7 | 0.000 | 19.14 | ------- | ------- | 43.85 | ------- | 66.58 | 99.07 | Point of Interest w/ Bypass Area |

# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| 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 | 11.16 | 2 | 724 | 34,942 | ------ | ------ | ------ | Proposed Area A |
| 2 | SCS Runoff | 69.97 | 2 | 726 | 241,987 | ------ | ------ | ------ | Proposed Area B1 |
| 3 | SCS Runoff | 20.15 | 2 | 724 | 63,001 | ------ | ------ | ------ | Proposed Area C |
| 4 | SCS Runoff | 9.813 | 2 | 720 | 25,975 | ------ | ------ | ------ | Proposed Area B2 |
| 5 | SCS Runoff | 9.322 | 2 | 720 | 24,330 | ------ | ------ | ------ | Bypass Area A |
| 6 | Reservoir | 4.275 | 2 | 830 | 155,233 | 2 | 1013.53 | 152,744 | Detention Pond |
| 7 | Combine | 9.813 | 2 | 720 | 181,208 | 4, 6 | ------ | ------ | Point of Interest |
| 8 | Combine | 19.14 | 2 | 720 | 256,012 | 5, 7 | ------ | ------ | Point of Interest w/ Bypass Area |

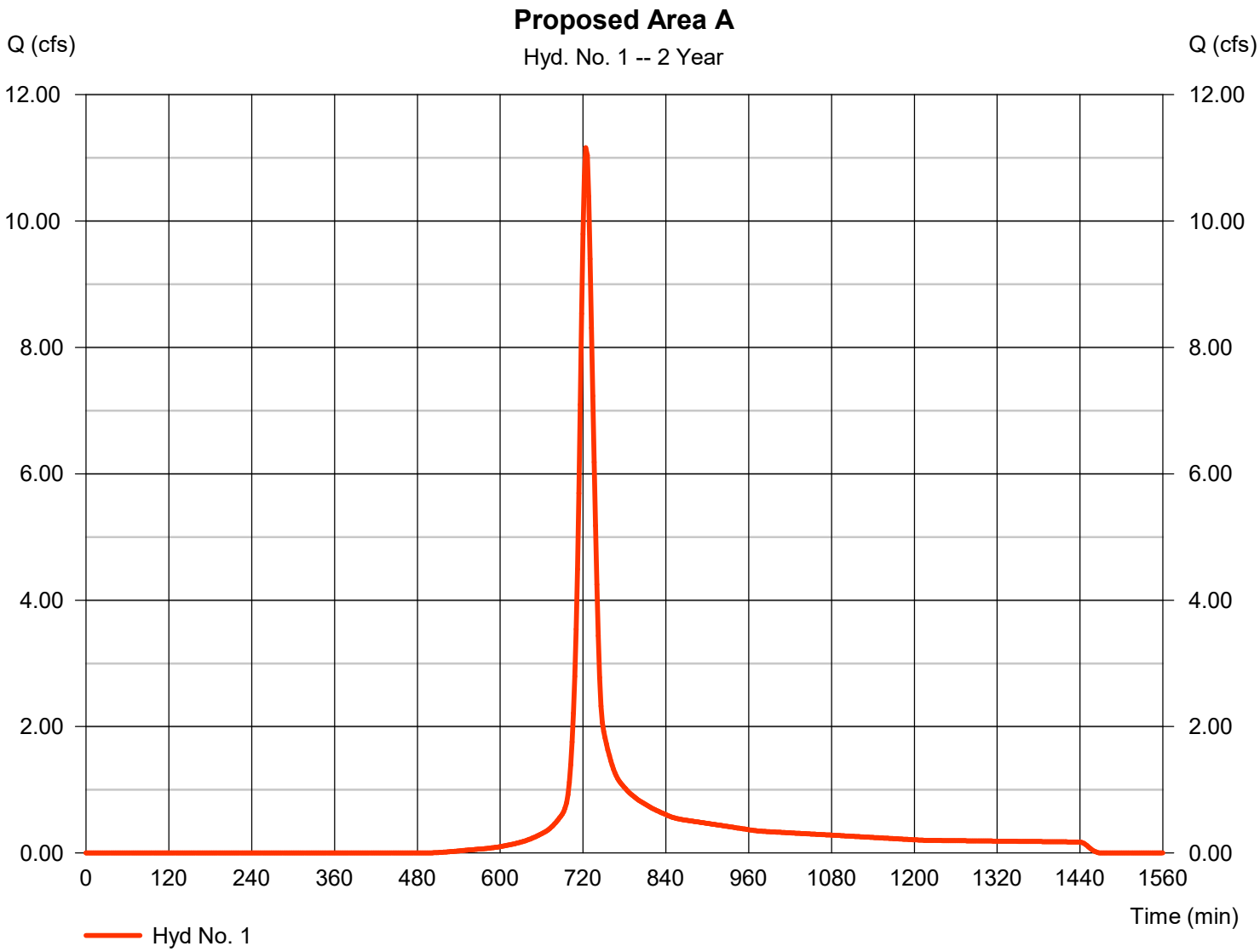
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 1

Proposed Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 11.16 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 34,942 cuft |
| Drainage area | = 5.160 ac | Curve number | = 82 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



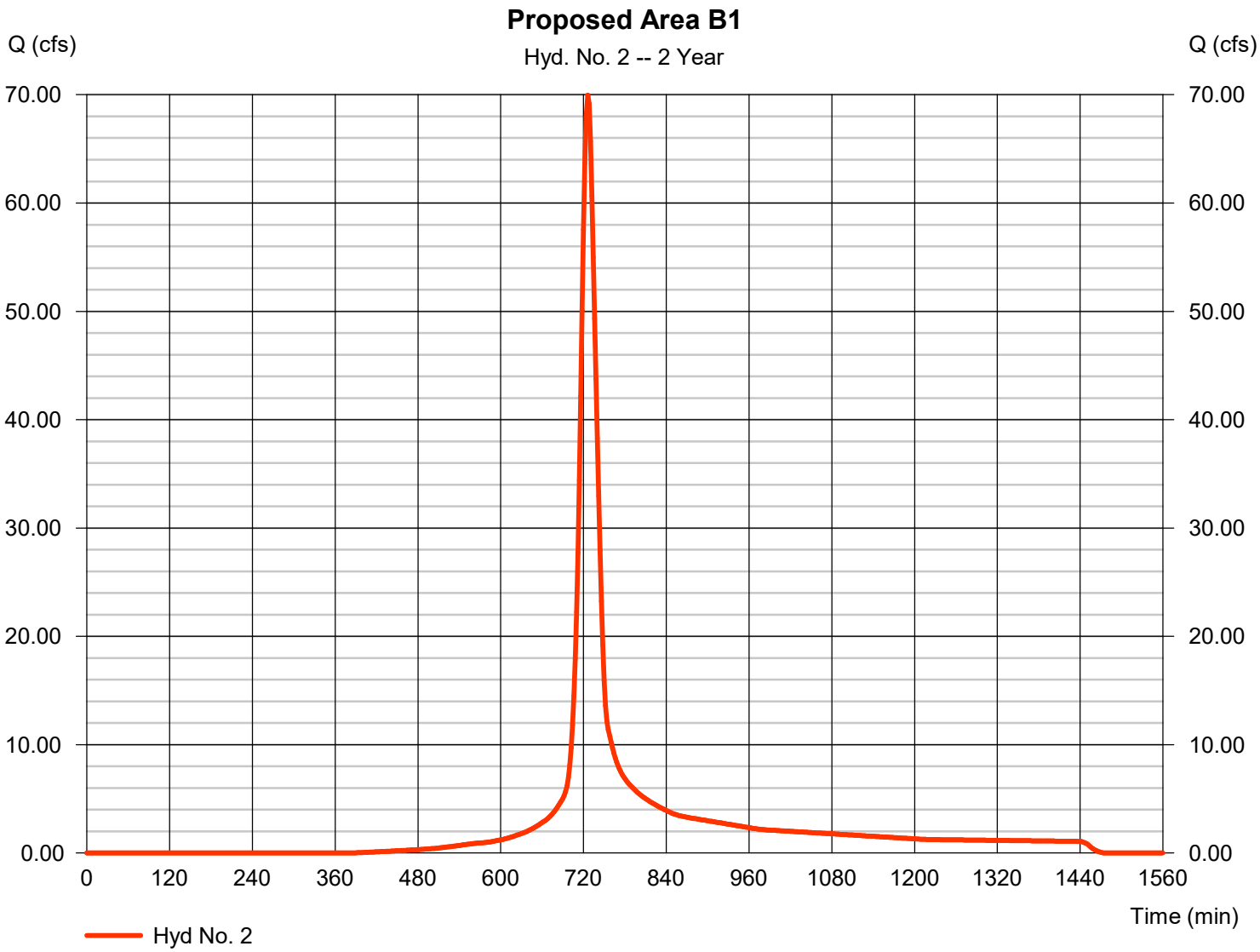
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 2

Proposed Area B1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 69.97 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 241,987 cuft |
| Drainage area | = 28.820 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 21.30 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



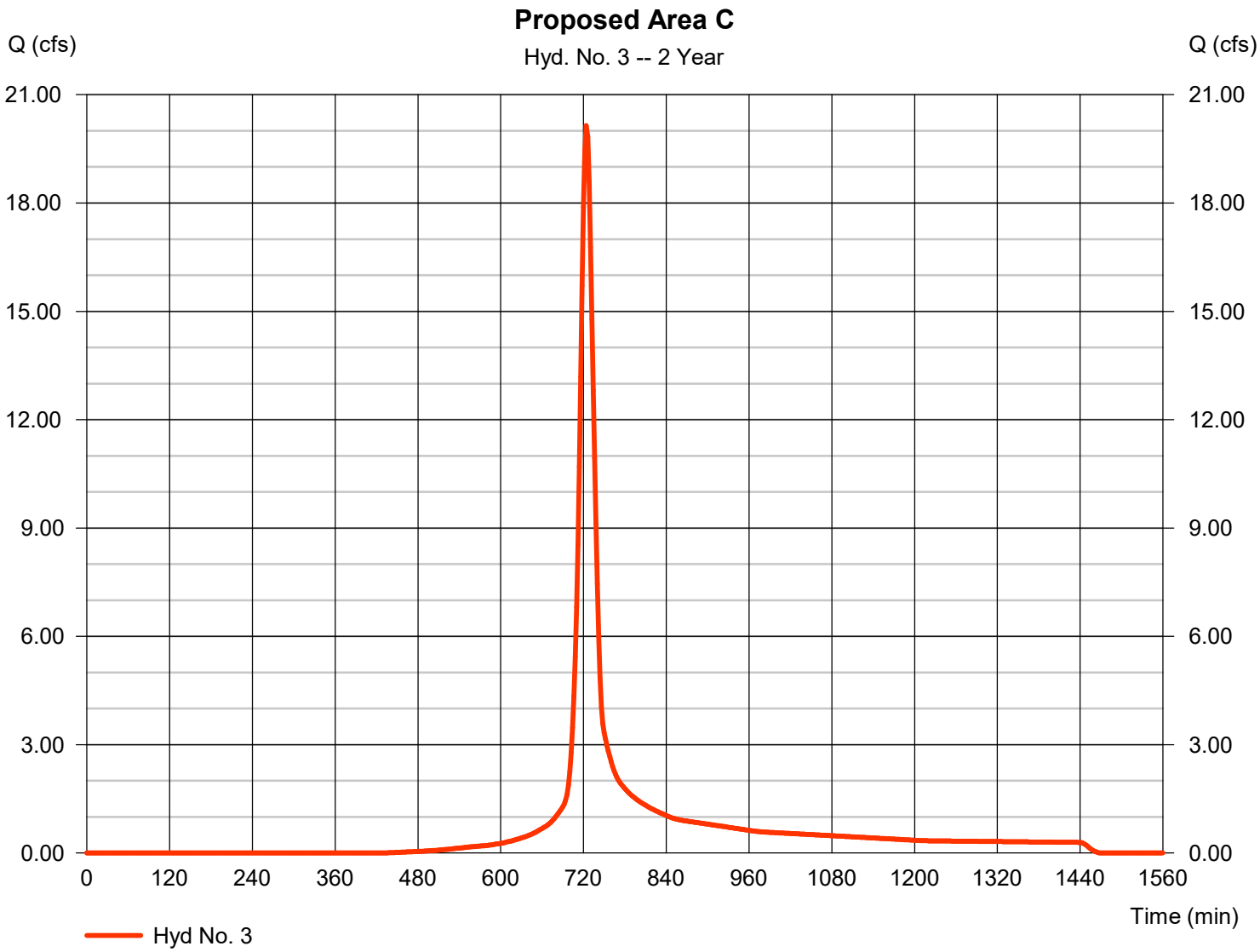
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 3

Proposed Area C

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 20.15 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 63,001 cuft |
| Drainage area | = 8.250 ac | Curve number | = 85 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 19.60 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



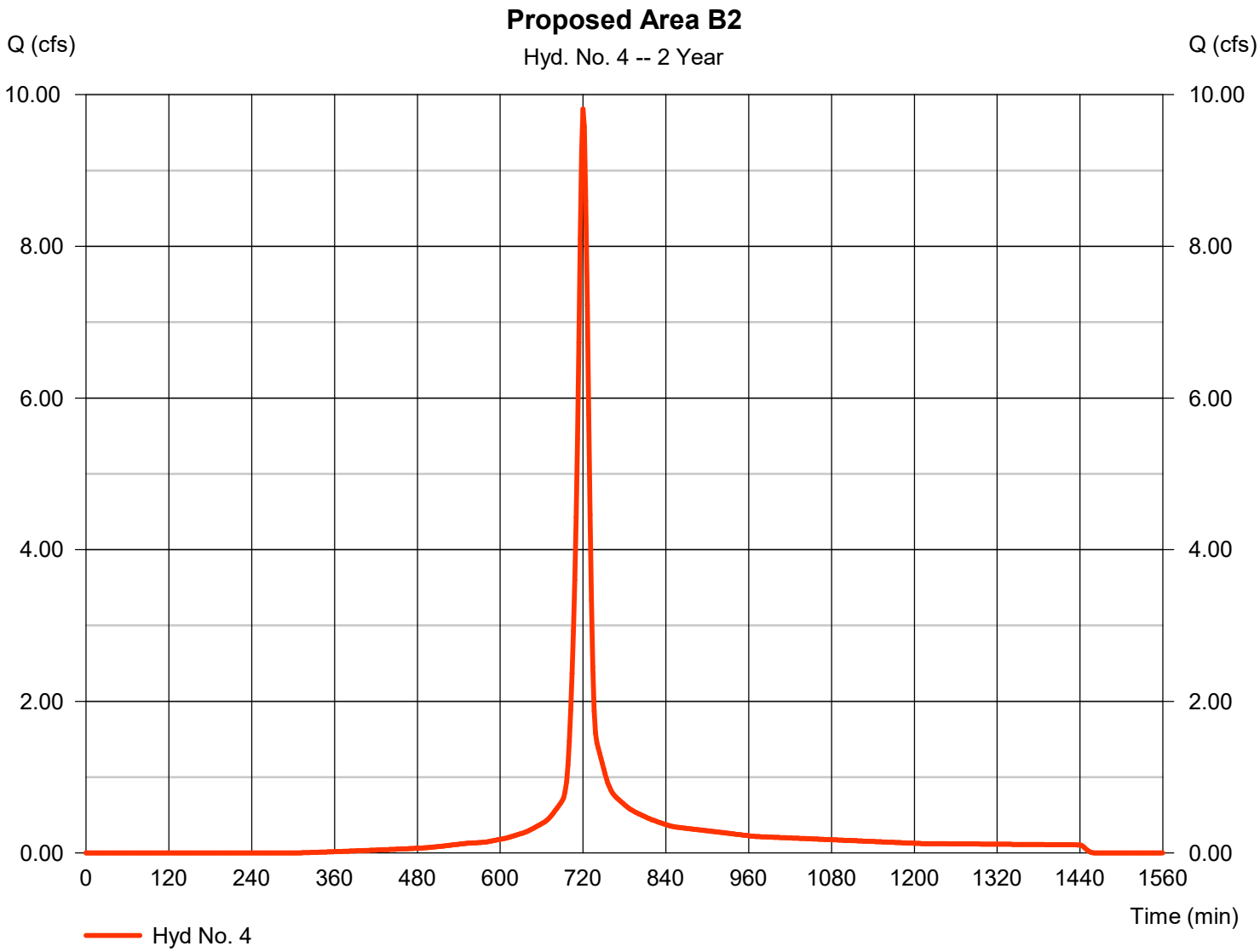
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 4

Proposed Area B2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 9.813 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 25,975 cuft |
| Drainage area | = 2.730 ac | Curve number | = 90 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.90 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



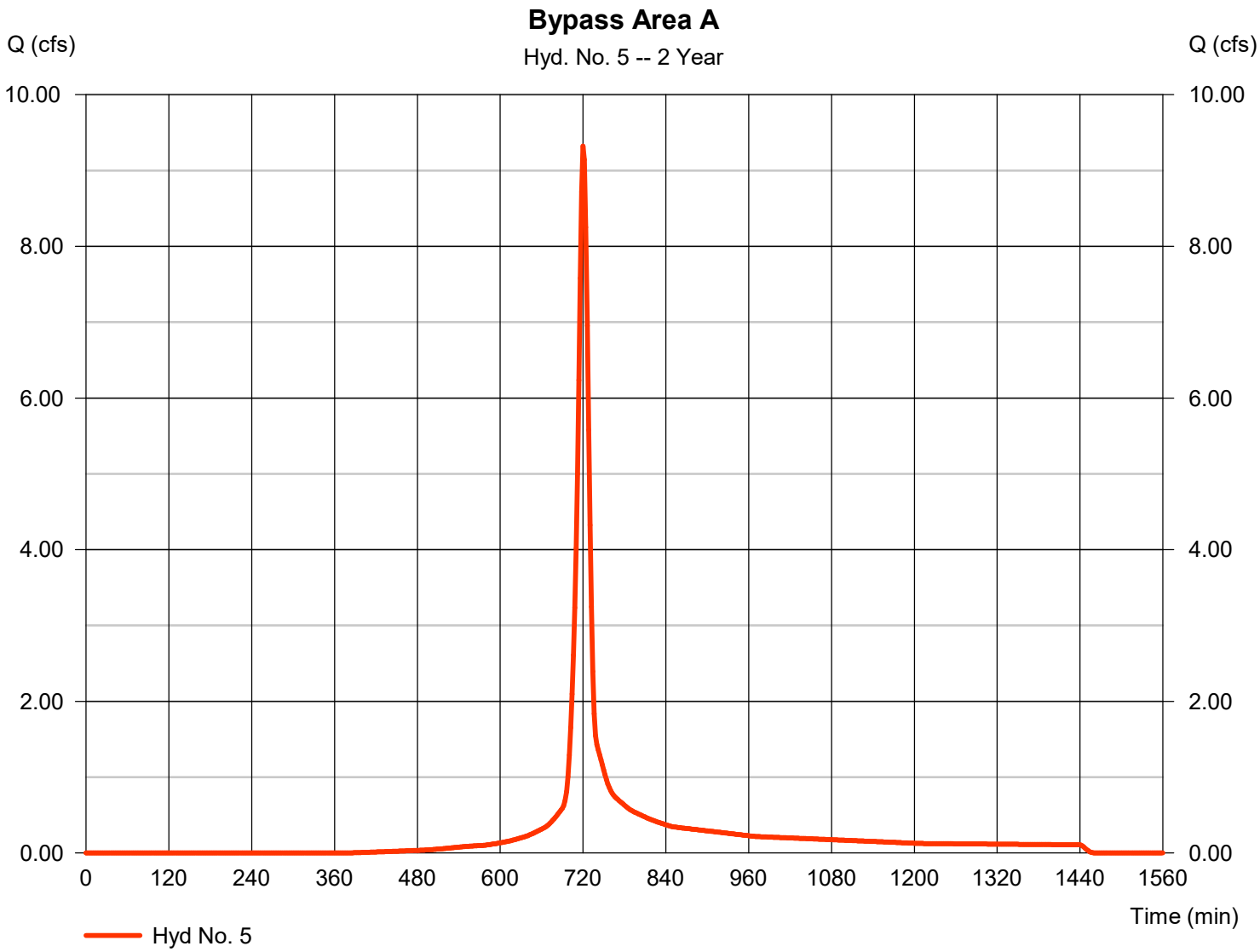
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 5

Bypass Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 9.322 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 24,330 cuft |
| Drainage area | = 2.860 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.60 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# Hydrograph Report

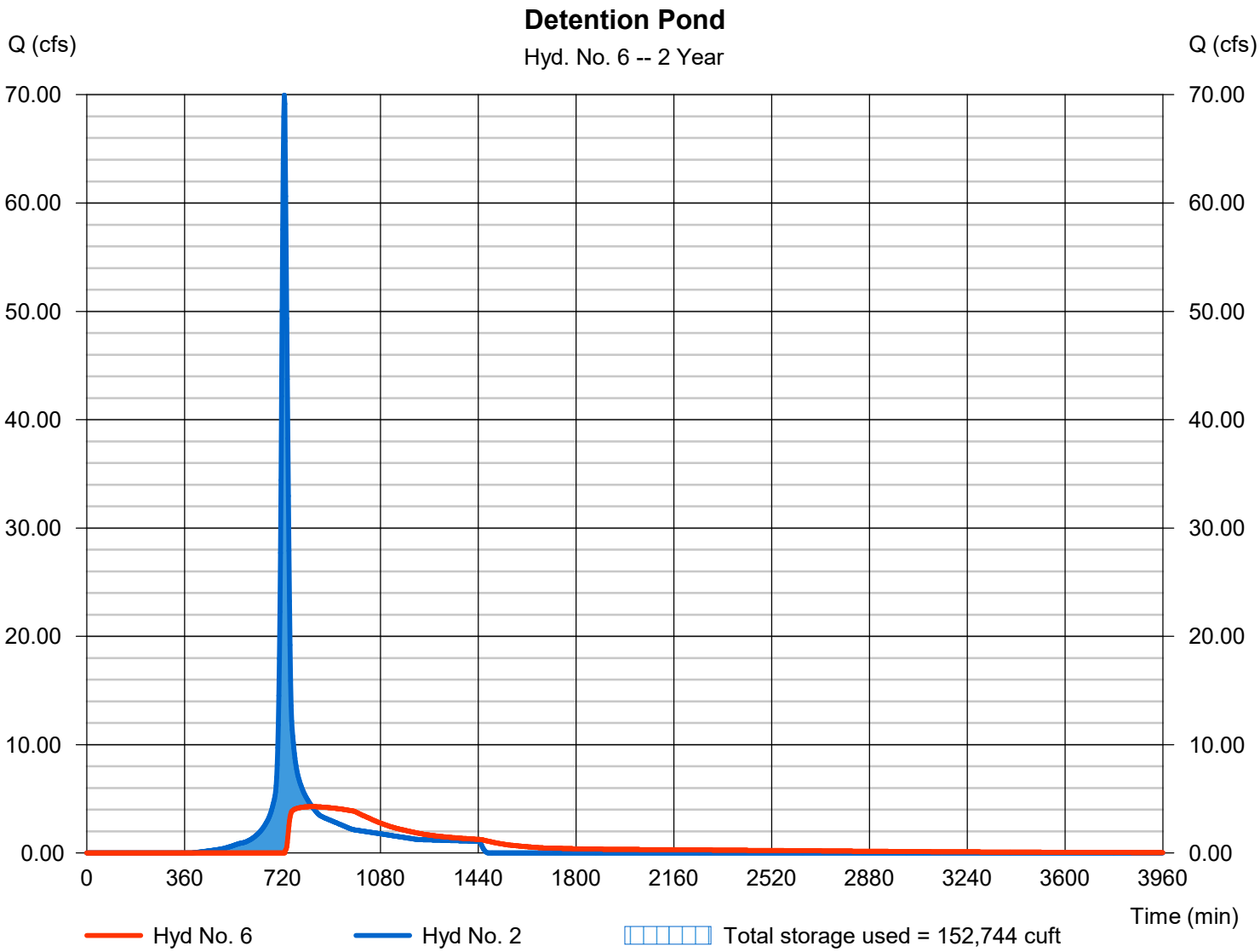
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 4.275 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 830 min |
| Time interval | = 2 min | Hyd. volume | = 155,233 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1013.53 ft |
| Reservoir name | = Detention | Max. Storage | = 152,744 cuft |

Storage Indication method used.



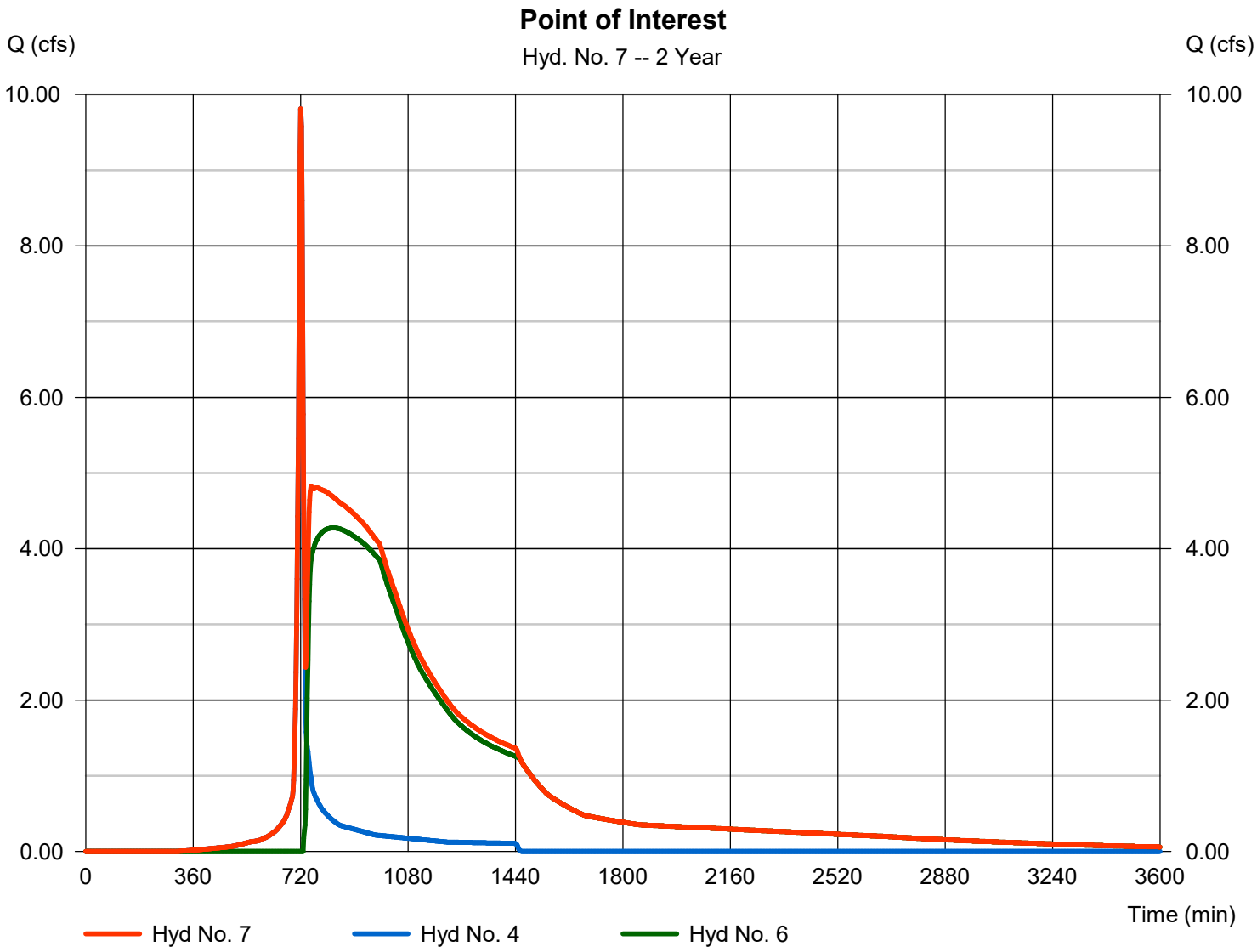
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 7

Point of Interest

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 9.813 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 181,208 cuft |
| Inflow hyds. | = 4, 6 | Contrib. drain. area | = 2.730 ac |



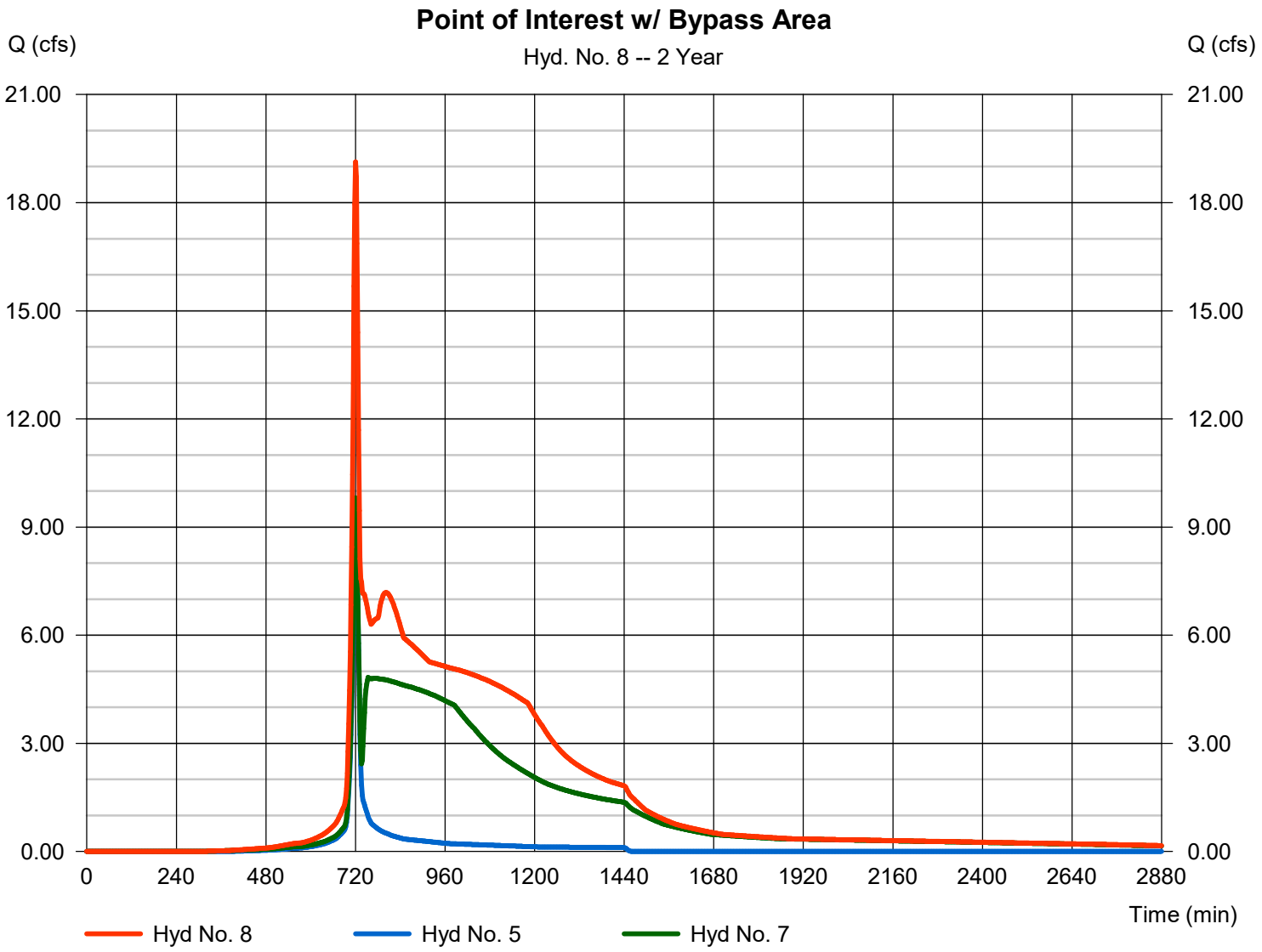
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 8

Point of Interest w/ Bypass Area

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 19.14 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 256,012 cuft |
| Inflow hyds. | = 5, 7 | Contrib. drain. area | = 2.860 ac |



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| 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 | 20.21 | 2 | 724 | 63,402 | ------ | ------ | ------ | Proposed Area A |
| 2 | SCS Runoff | 118.08 | 2 | 726 | 414,070 | ------ | ------ | ------ | Proposed Area B1 |
| 3 | SCS Runoff | 34.89 | 2 | 724 | 110,315 | ------ | ------ | ------ | Proposed Area C |
| 4 | SCS Runoff | 15.83 | 2 | 720 | 42,972 | ------ | ------ | ------ | Proposed Area B2 |
| 5 | SCS Runoff | 15.64 | 2 | 720 | 41,632 | ------ | ------ | ------ | Bypass Area A |
| 6 | Reservoir | 28.05 | 2 | 750 | 327,304 | 2 | 1015.03 | 228,021 | Detention Pond |
| 7 | Combine | 29.88 | 2 | 748 | 370,276 | 4, 6 | ------ | ------ | Point of Interest |
| 8 | Combine | 43.85 | 2 | 746 | 492,636 | 5, 7 | ------ | ------ | Point of Interest w/ Bypass Area |

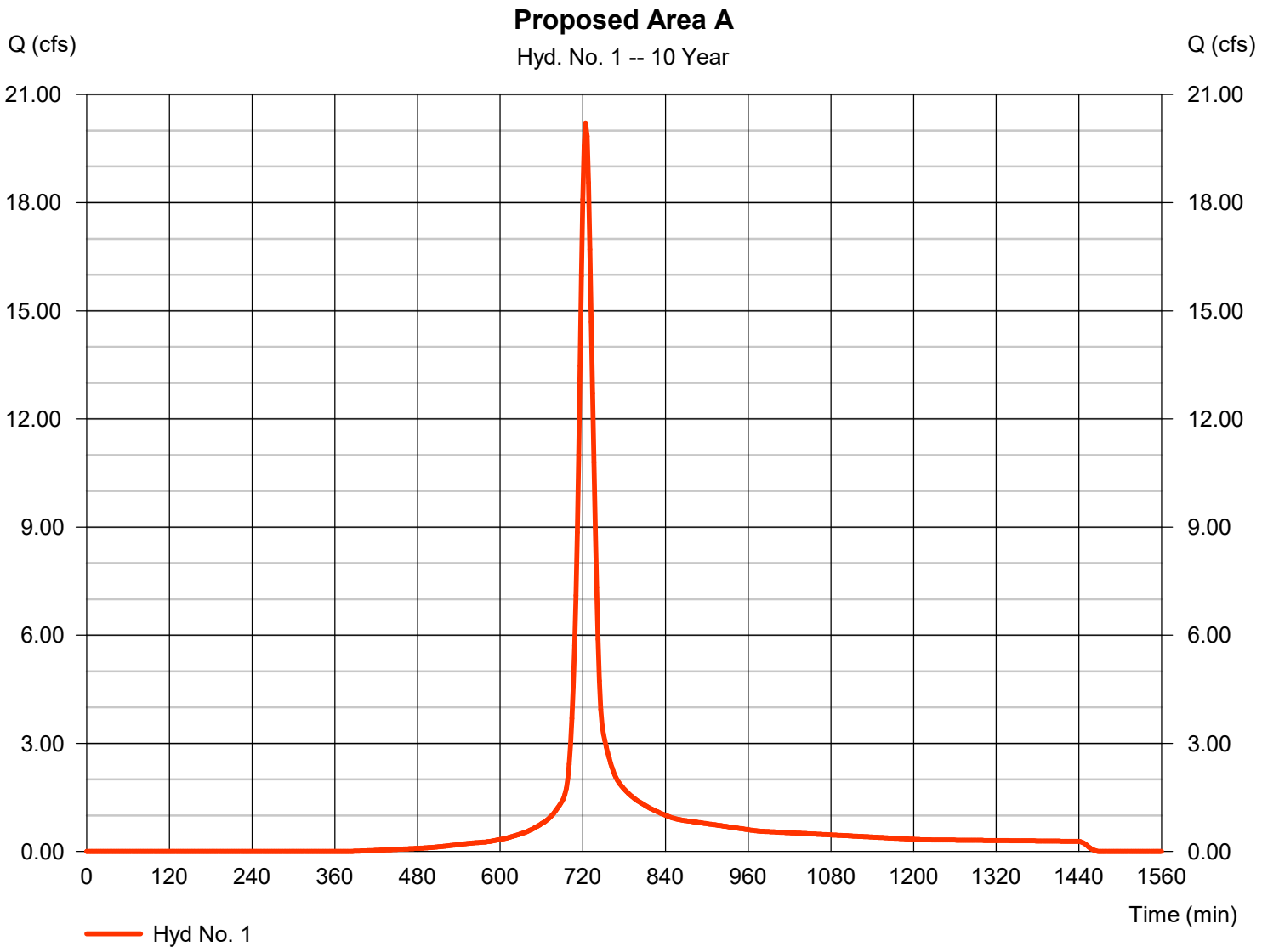
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 1

Proposed Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 20.21 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 63,402 cuft |
| Drainage area | = 5.160 ac | Curve number | = 82 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



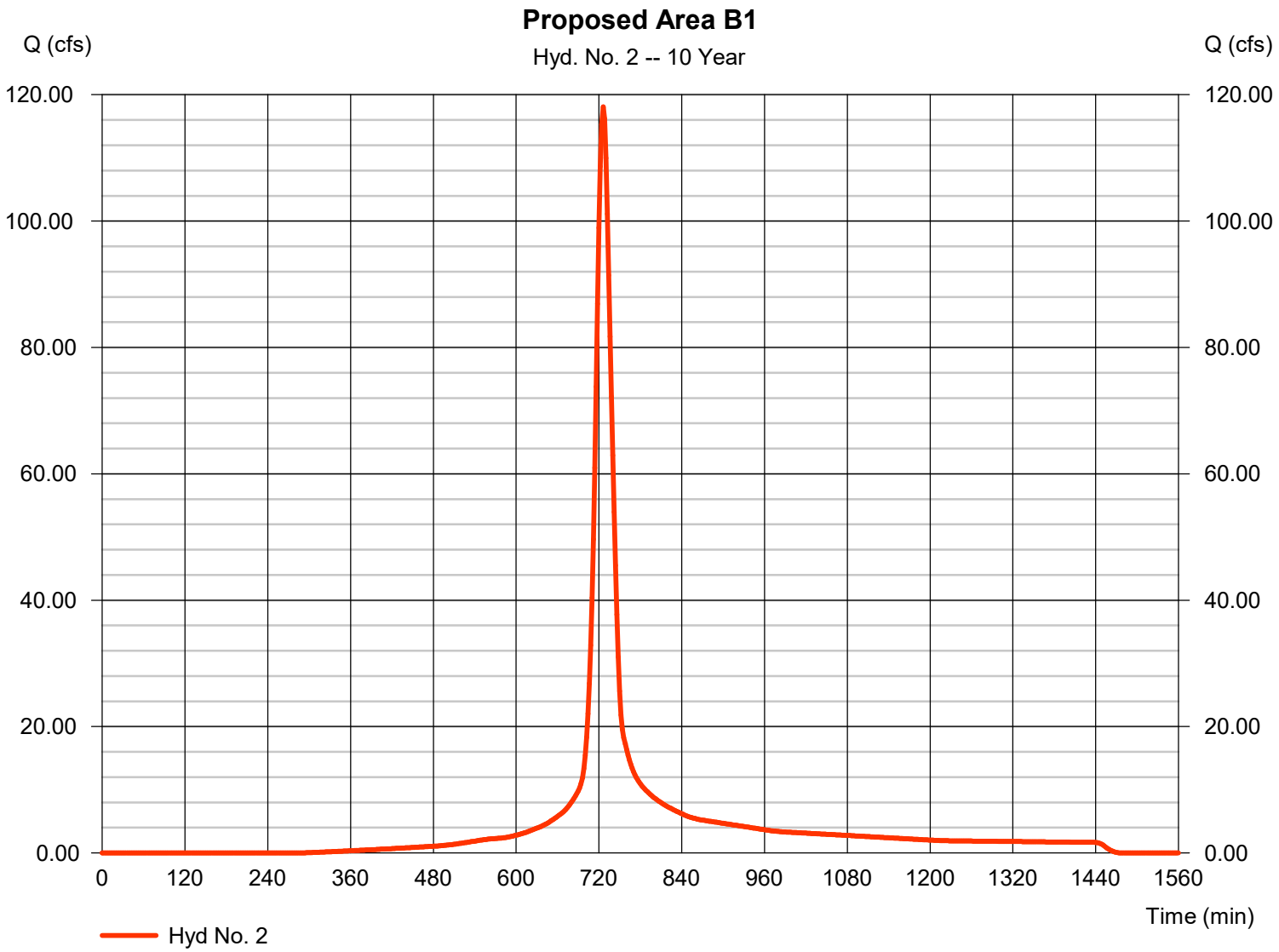
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 2

Proposed Area B1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 118.08 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 414,070 cuft |
| Drainage area | = 28.820 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 21.30 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



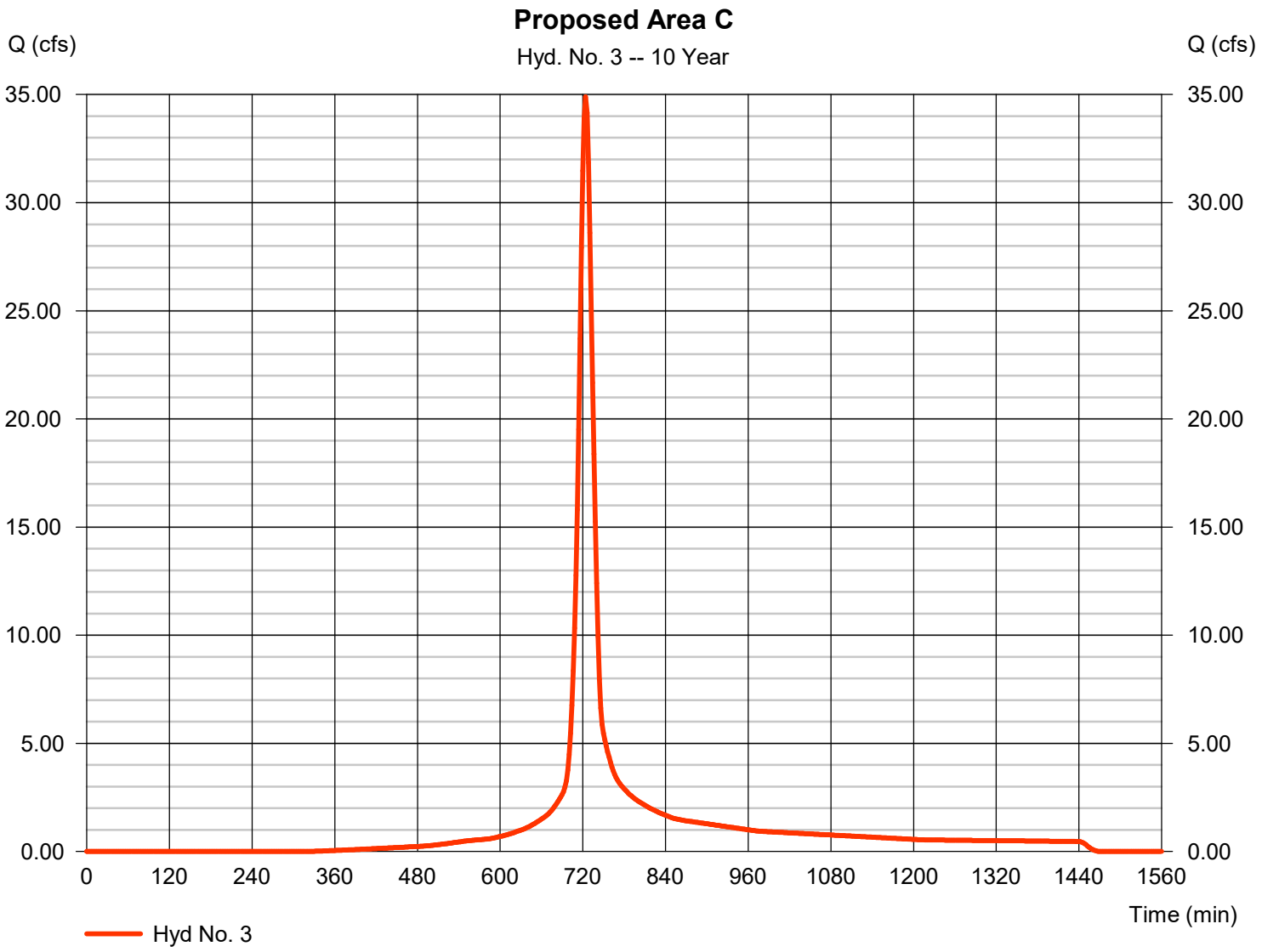
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 3

Proposed Area C

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 34.89 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 110,315 cuft |
| Drainage area | = 8.250 ac | Curve number | = 85 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 19.60 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



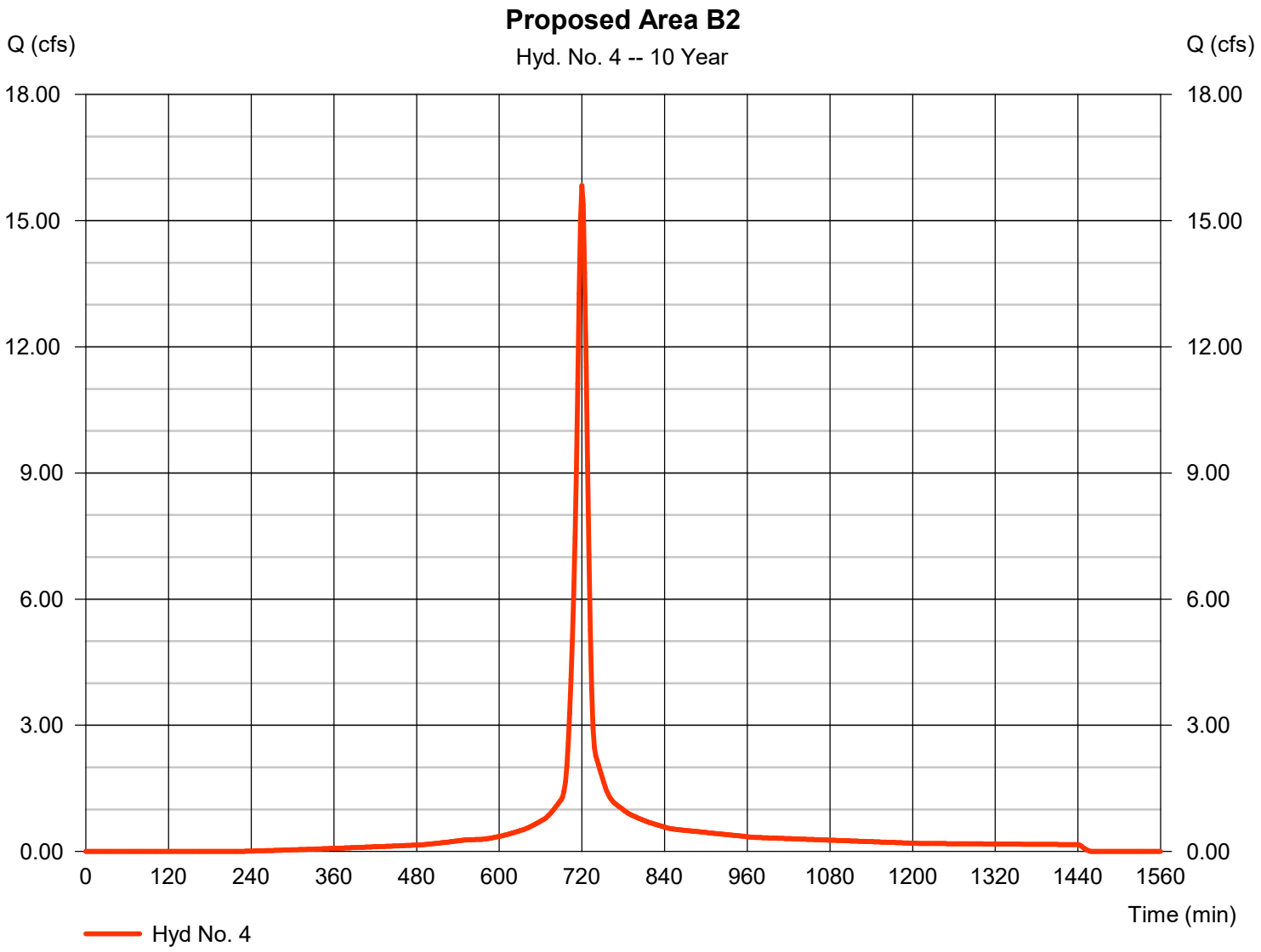
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 4

Proposed Area B2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 15.83 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 42,972 cuft |
| Drainage area | = 2.730 ac | Curve number | = 90 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.90 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



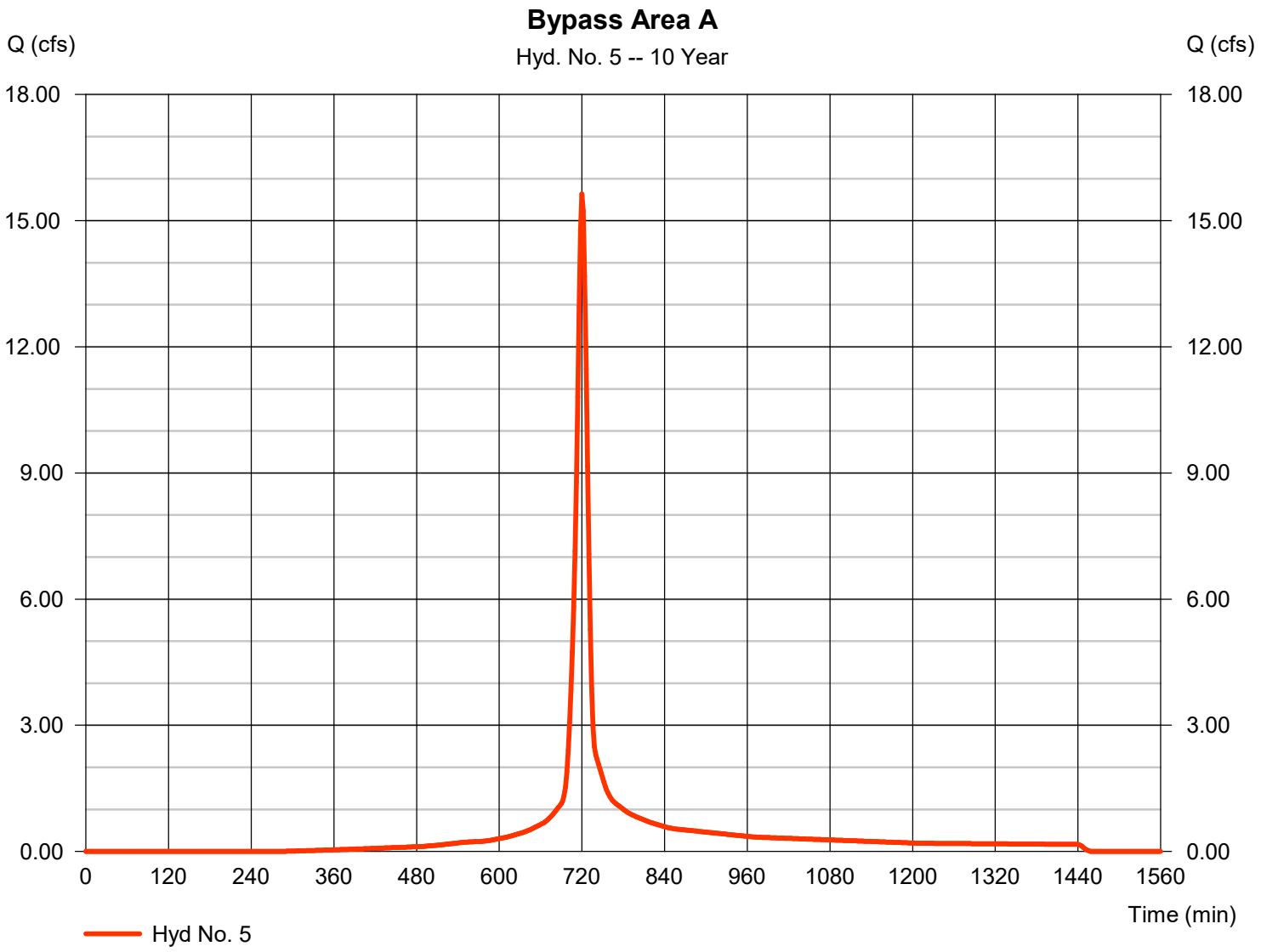
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 5

Bypass Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 15.64 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 41,632 cuft |
| Drainage area | = 2.860 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.60 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# Hydrograph Report

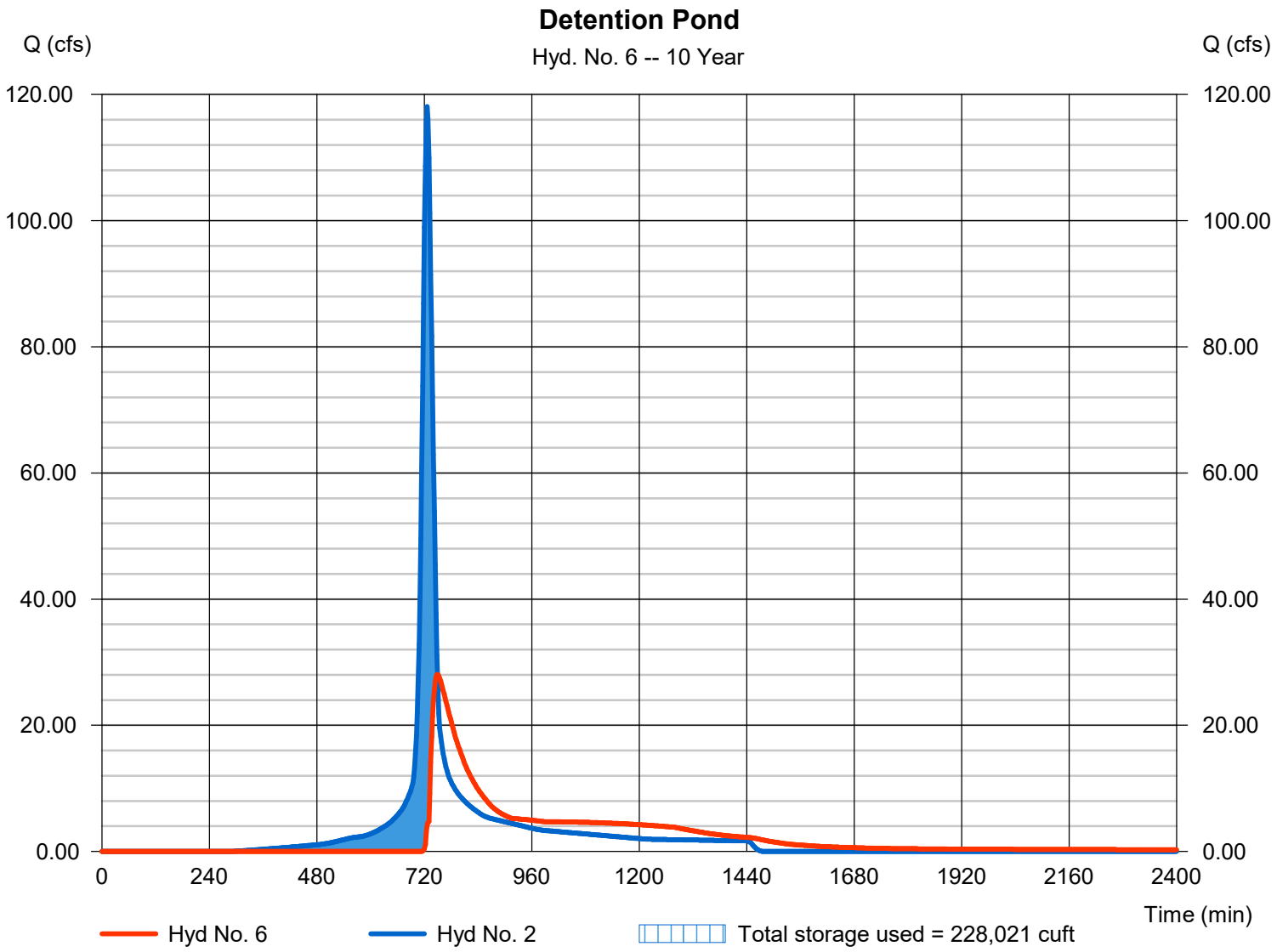
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 28.05 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 750 min |
| Time interval | = 2 min | Hyd. volume | = 327,304 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1015.03 ft |
| Reservoir name | = Detention | Max. Storage | = 228,021 cuft |

Storage Indication method used.



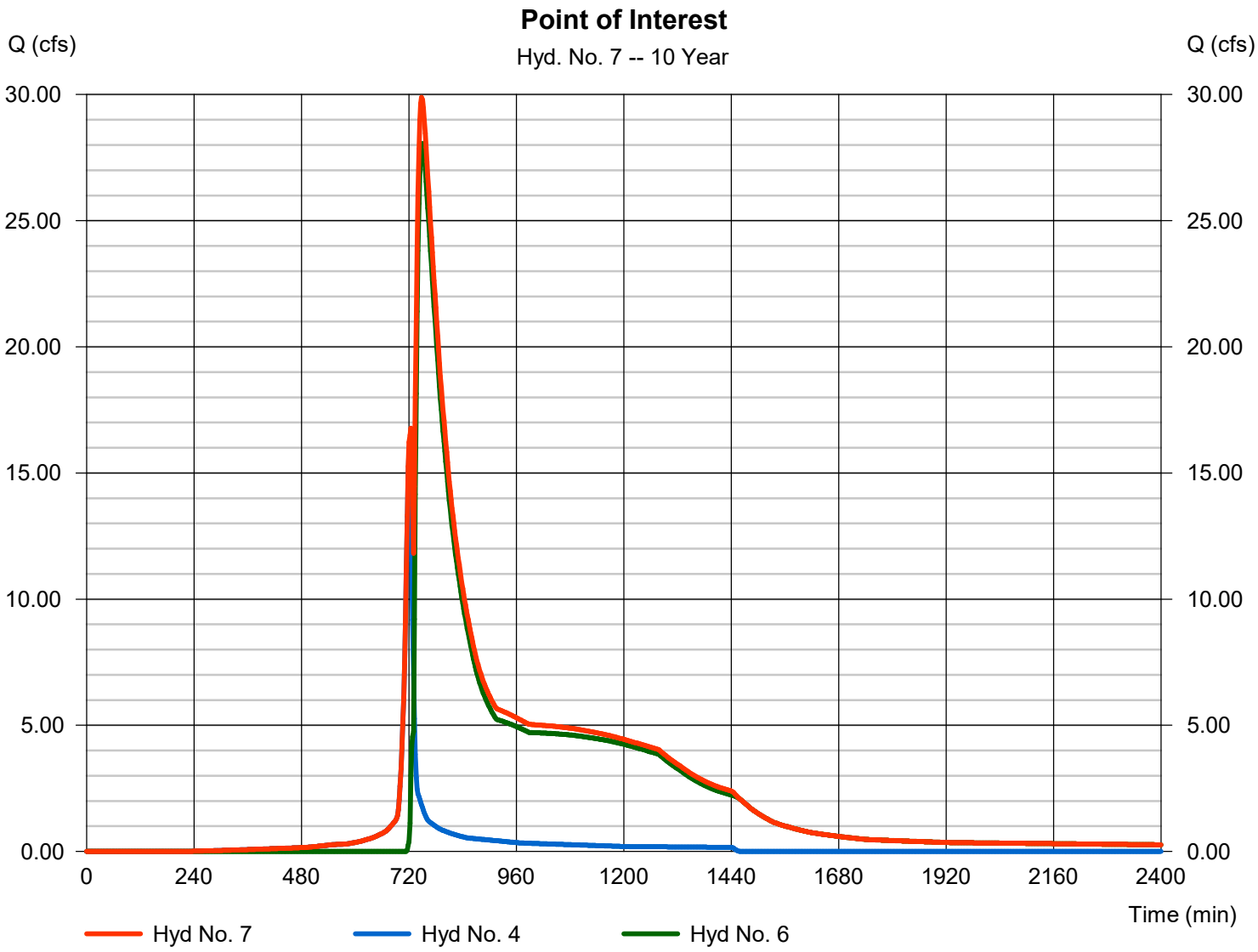
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 7

Point of Interest

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 29.88 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 748 min |
| Time interval | = 2 min | Hyd. volume | = 370,276 cuft |
| Inflow hyds. | = 4, 6 | Contrib. drain. area | = 2.730 ac |



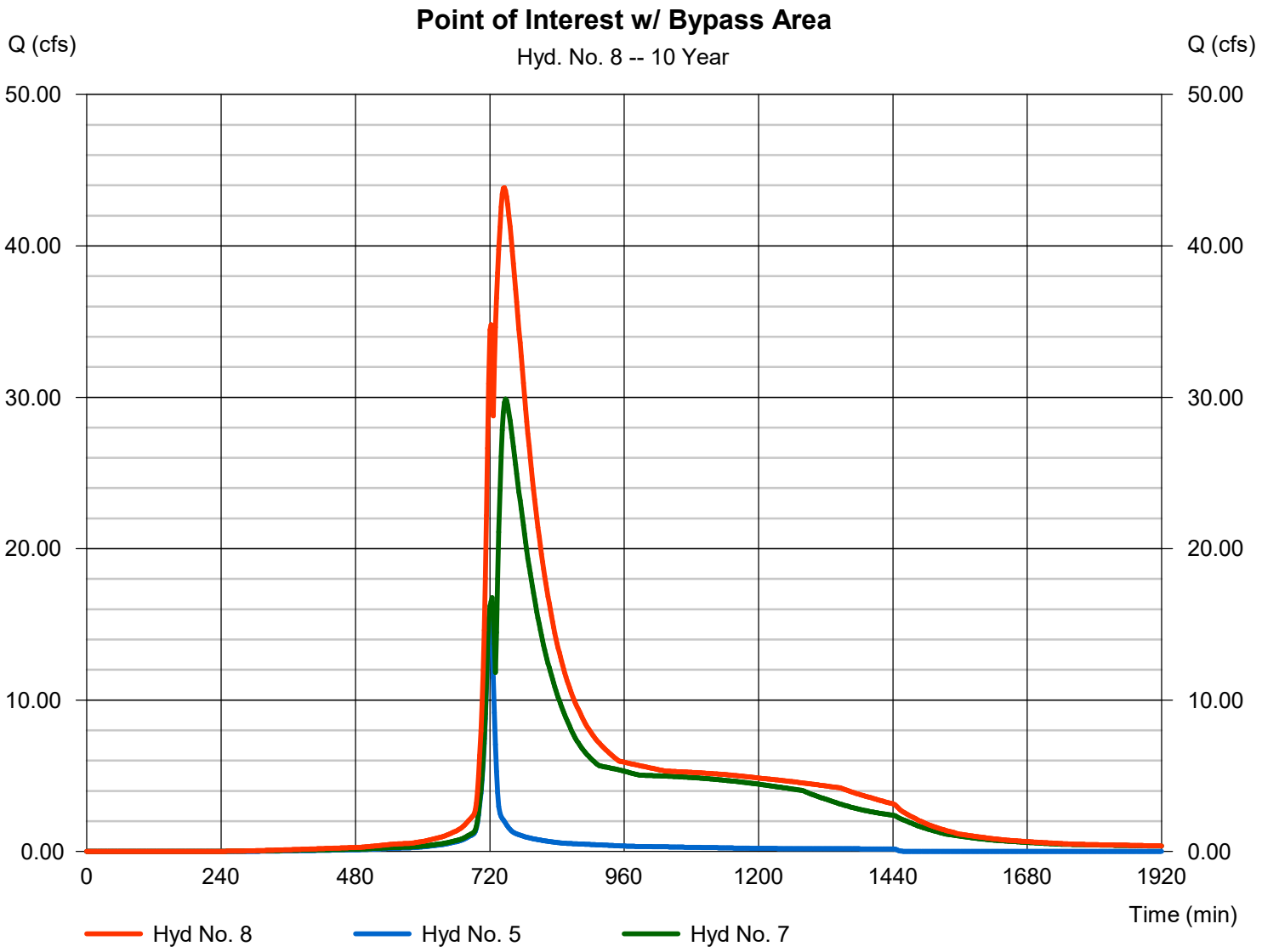
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 8

Point of Interest w/ Bypass Area

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 43.85 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 746 min |
| Time interval | = 2 min | Hyd. volume | = 492,636 cuft |
| Inflow hyds. | = 5, 7 | Contrib. drain. area | = 2.860 ac |



# Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

| 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 | 33.87 | 2 | 724 | 107,981 | ------ | ------ | ------ | Proposed Area A |
| 2 | SCS Runoff | 188.79 | 2 | 726 | 676,432 | ------ | ------ | ------ | Proposed Area B1 |
| 3 | SCS Runoff | 56.74 | 2 | 724 | 183,183 | ------ | ------ | ------ | Proposed Area C |
| 4 | SCS Runoff | 24.59 | 2 | 720 | 68,544 | ------ | ------ | ------ | Proposed Area B2 |
| 5 | SCS Runoff | 24.90 | 2 | 720 | 68,010 | ------ | ------ | ------ | Bypass Area A |
| 6 | Reservoir | 56.31 | 2 | 746 | 589,649 | 2 | 1017.16 | 347,372 | Detention Pond |
| 7 | Combine | 59.28 | 2 | 746 | 658,193 | 4, 6 | ------ | ------ | Point of Interest |
| 8 | Combine | 99.07 | 2 | 742 | 851,611 | 5, 7 | ------ | ------ | Point of Interest w/ Bypass Area |

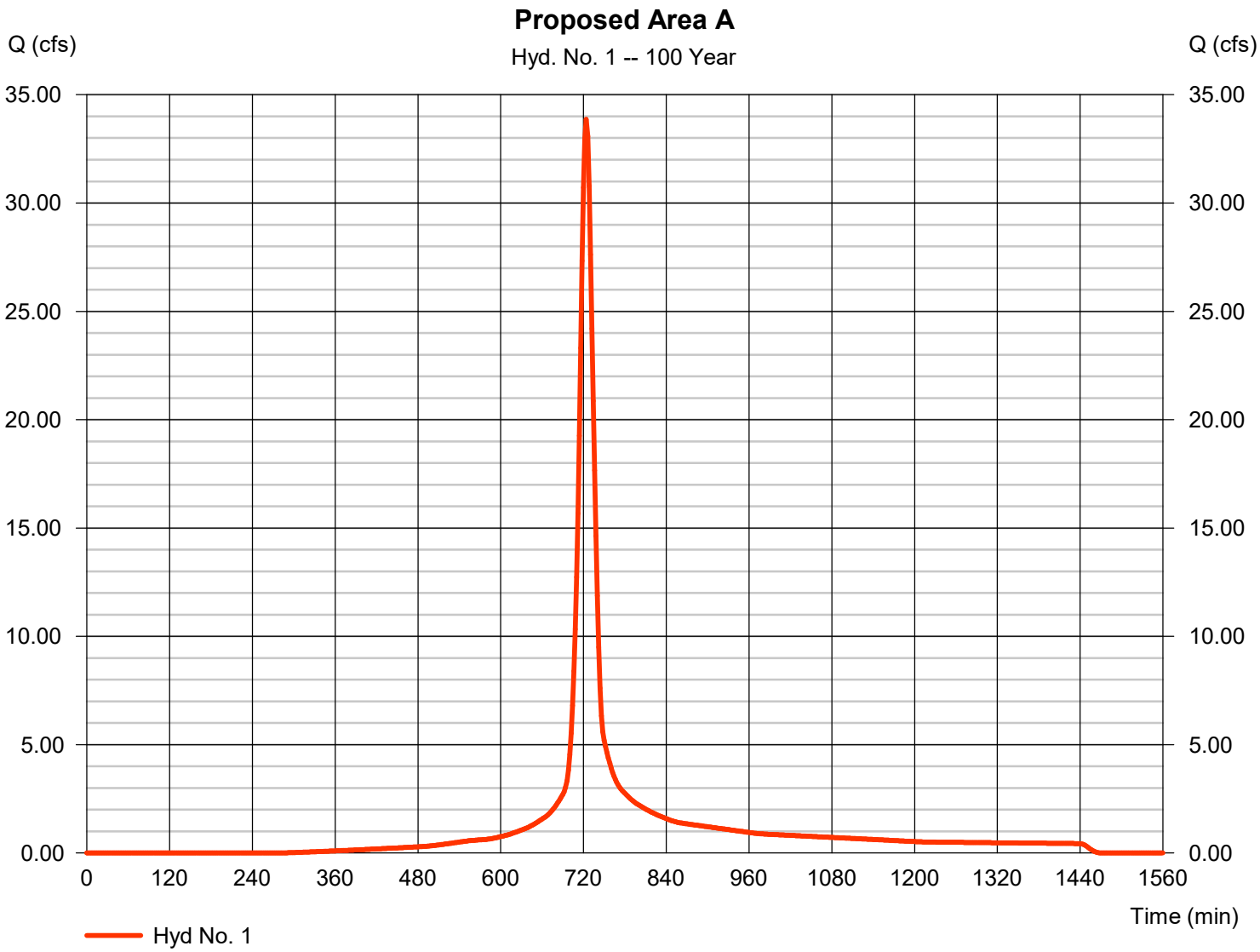
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 1

Proposed Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 33.87 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 107,981 cuft |
| Drainage area | = 5.160 ac | Curve number | = 82 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 20.00 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



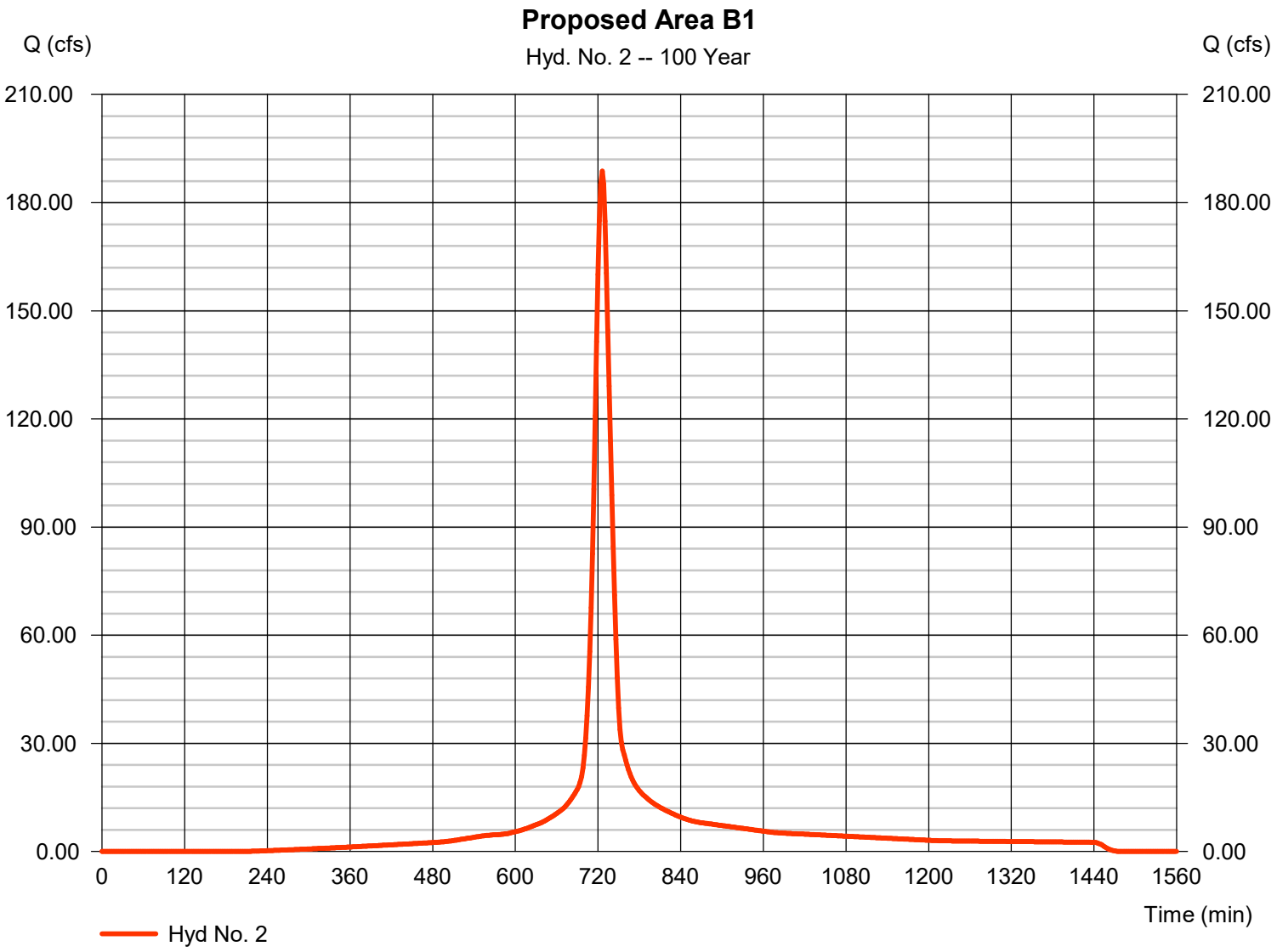
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 2

Proposed Area B1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 188.79 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 676,432 cuft |
| Drainage area | = 28.820 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 21.30 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



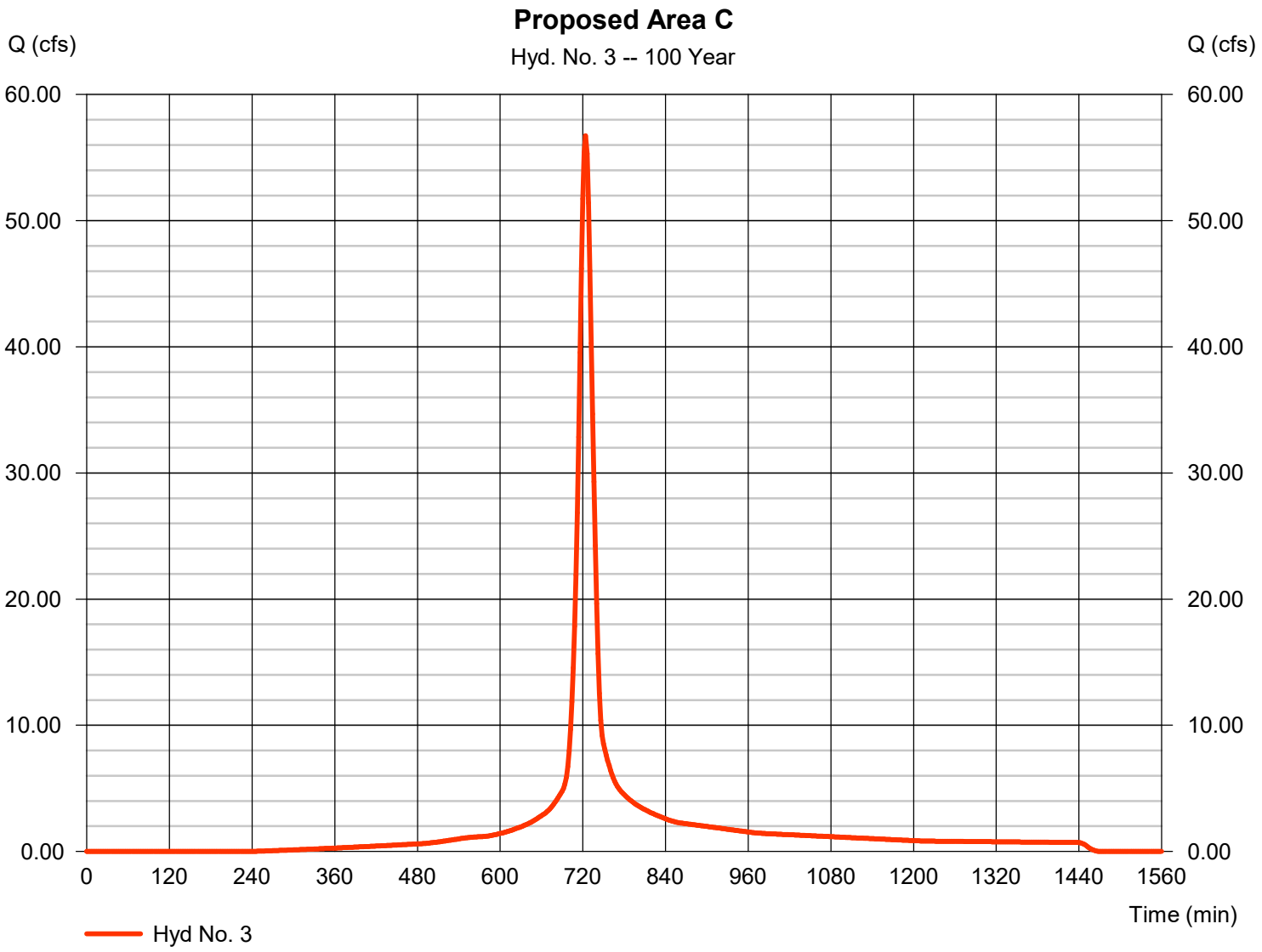
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 3

Proposed Area C

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 56.74 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 724 min |
| Time interval | = 2 min | Hyd. volume | = 183,183 cuft |
| Drainage area | = 8.250 ac | Curve number | = 85 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 19.60 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



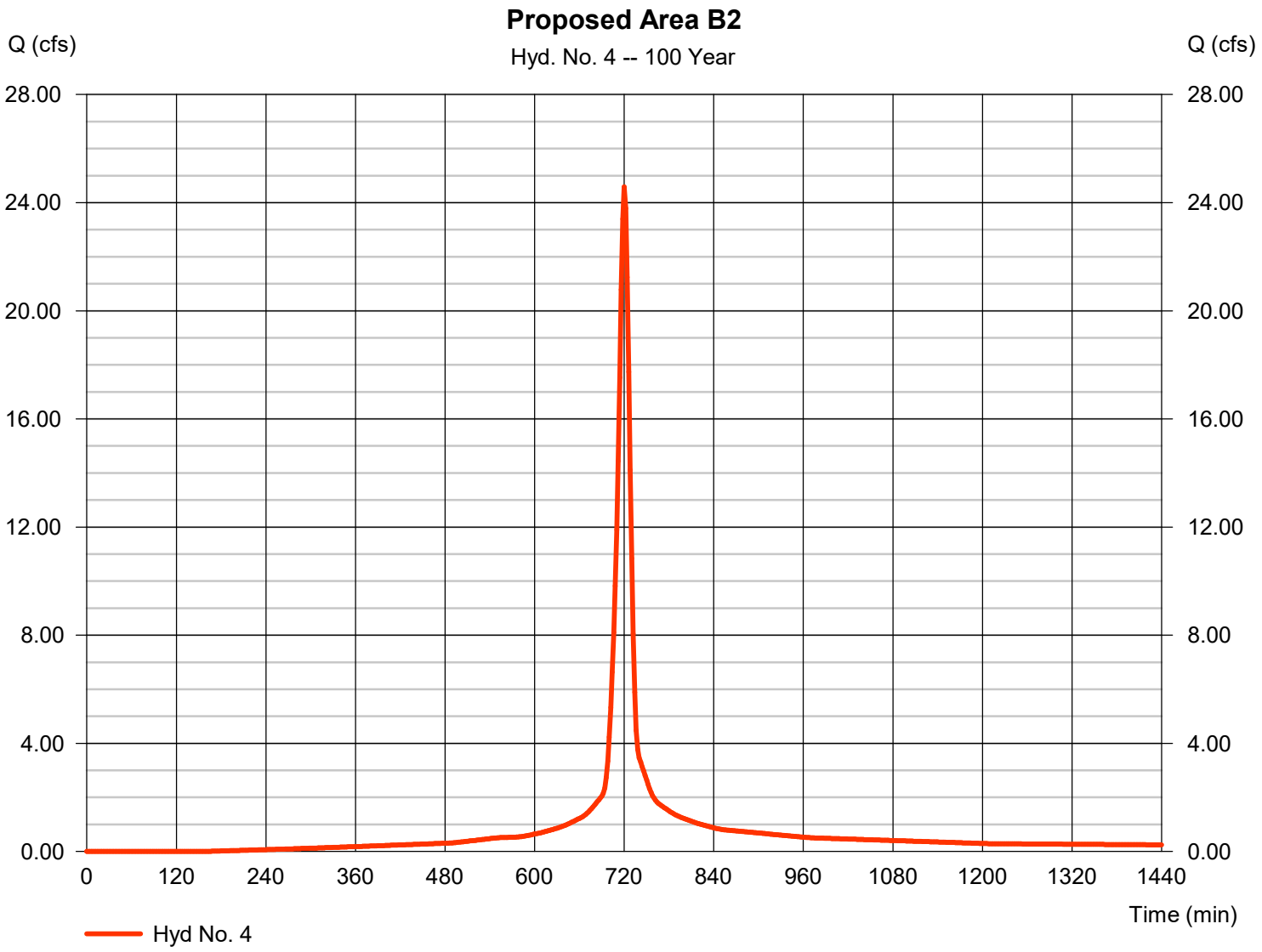
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 4

Proposed Area B2

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 24.59 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 68,544 cuft |
| Drainage area | = 2.730 ac | Curve number | = 90 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.90 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



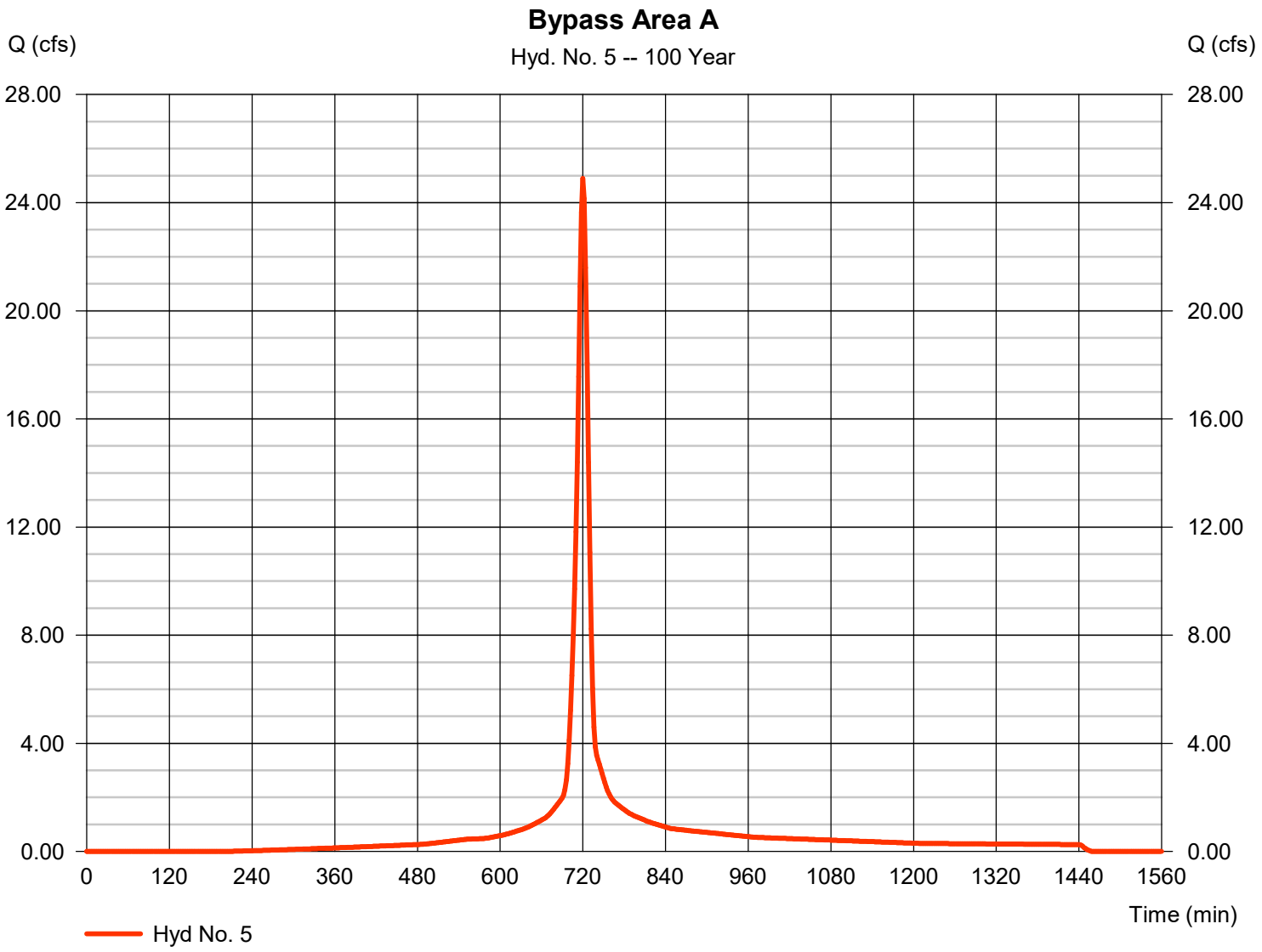
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 5

Bypass Area A

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 24.90 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 720 min |
| Time interval | = 2 min | Hyd. volume | = 68,010 cuft |
| Drainage area | = 2.860 ac | Curve number | = 87 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 10.60 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# Hydrograph Report

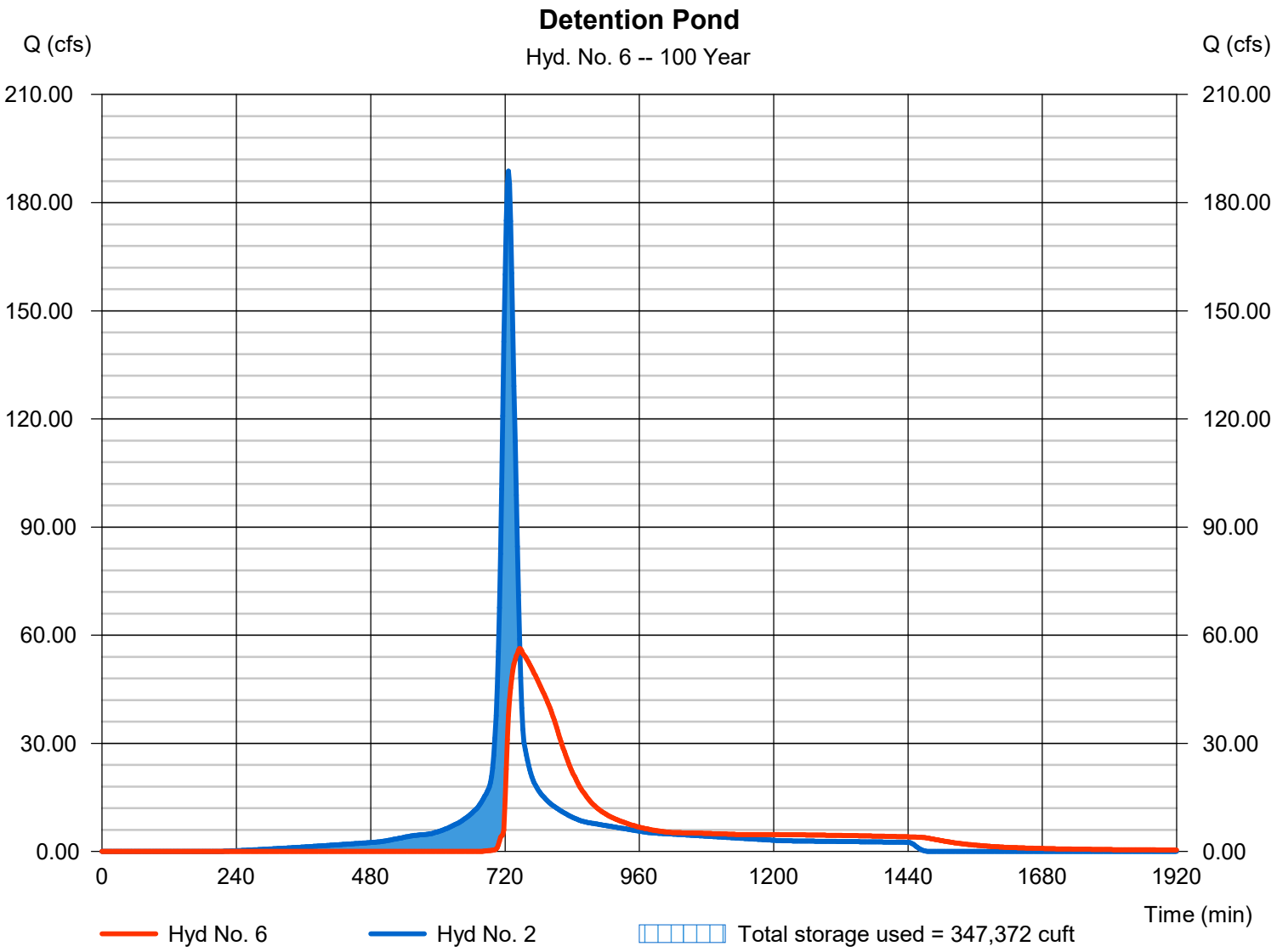
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 56.31 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 746 min |
| Time interval | = 2 min | Hyd. volume | = 589,649 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1017.16 ft |
| Reservoir name | = Detention | Max. Storage | = 347,372 cuft |

Storage Indication method used.



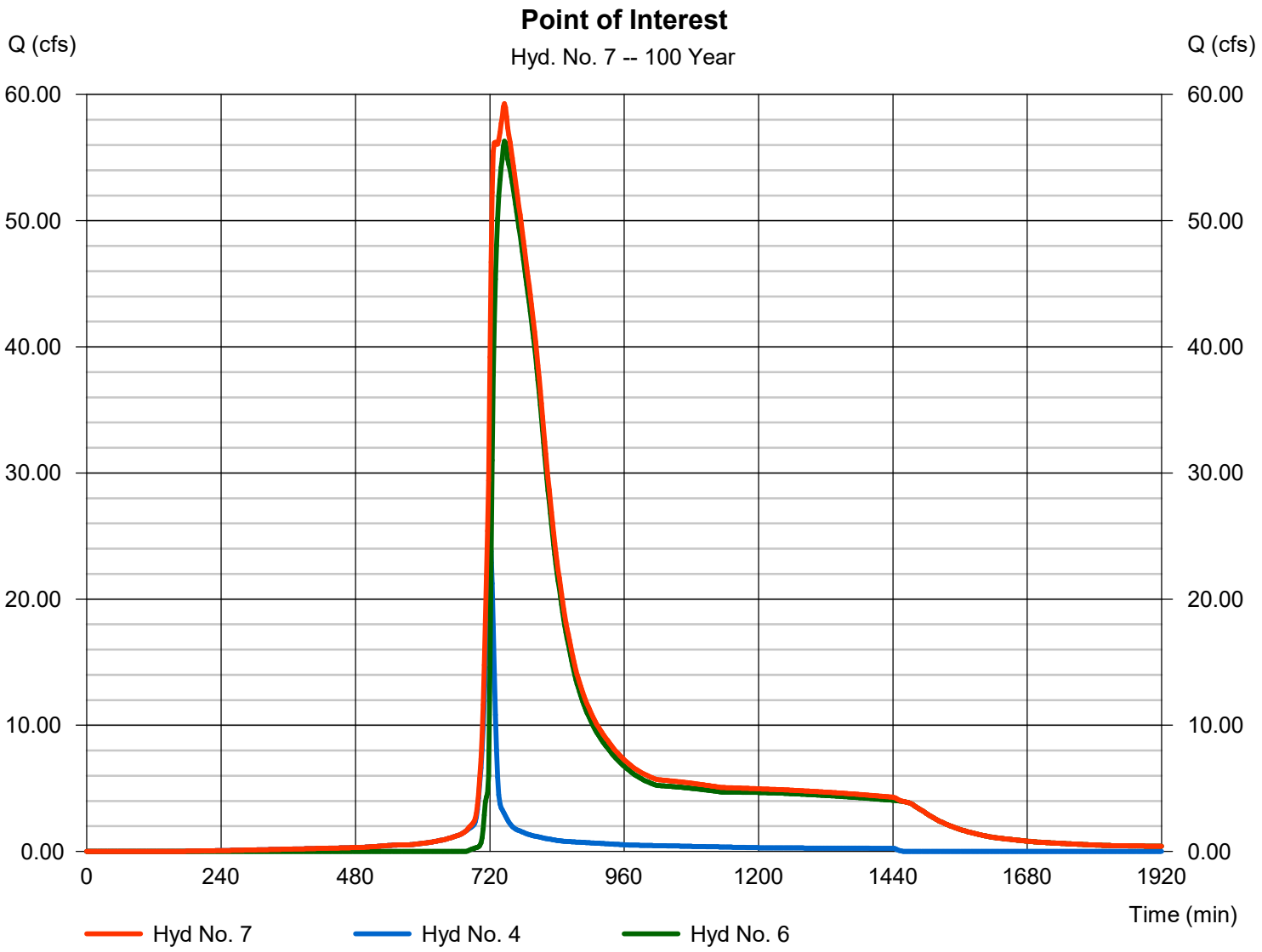
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 7

Point of Interest

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 59.28 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 746 min |
| Time interval | = 2 min | Hyd. volume | = 658,193 cuft |
| Inflow hyds. | = 4, 6 | Contrib. drain. area | = 2.730 ac |



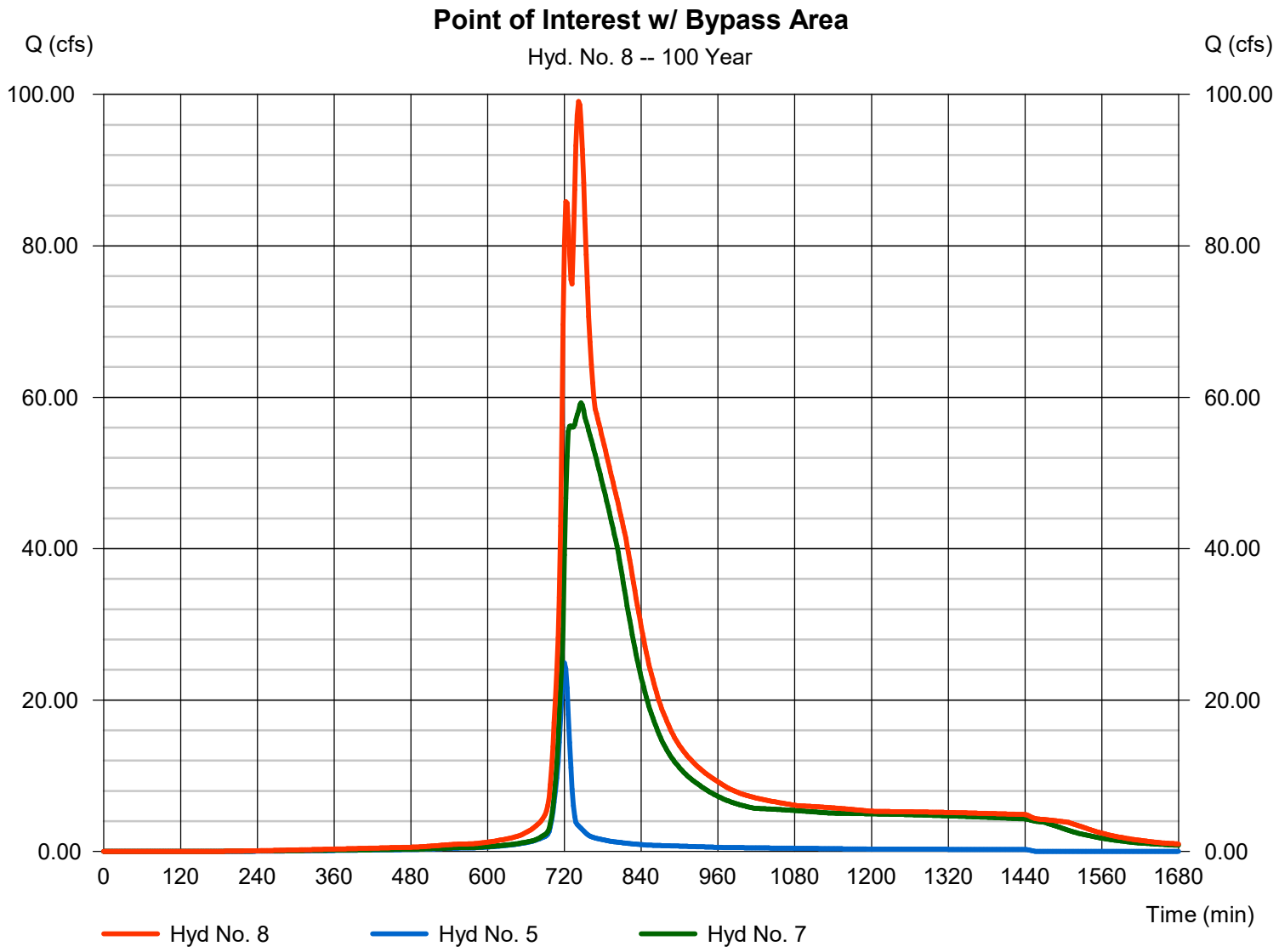
# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Wednesday, 03 / 4 / 2020

## Hyd. No. 8

Point of Interest w/ Bypass Area

| | | | |
|---|---|---|---|
| Hydrograph type | = Combine | Peak discharge | = 99.07 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 742 min |
| Time interval | = 2 min | Hyd. volume | = 851,611 cuft |
| Inflow hyds. | = 5, 7 | Contrib. drain. area | = 2.860 ac |



# APPENDIX D

Hy-8 Input and Results

## Table 1 - Summary of Culvert Flows at Crossing: Pryor Road

| Headwater Elevation (ft) | Discharge Names | Total Discharge (cfs) | Pryor Road Discharge (cfs) | Roadway Discharge (cfs) | Iterations |
|---|---|---|---|---|---|
| 1009.66 | 2 year Proposed | 20.00 | 20.00 | 0.00 | 1 |
| 1010.25 | 10 year Proposed | 40.00 | 40.00 | 0.00 | 1 |
| 1011.07 | 2 year Existing | 69.00 | 69.00 | 0.00 | 1 |
| 1012.16 | 100 year Proposed | 97.00 | 97.00 | 0.00 | 1 |
| 1012.47 | 10 year Existing | 120.00 | 103.50 | 16.35 | 9 |
| 1012.76 | 100 year Existing | 197.00 | 109.31 | 87.43 | 4 |
| 1012.32 | Overtopping | 100.49 | 100.49 | 0.00 | Overtopping |

## Table 2 - Culvert Summary Table: Pryor Road

| Discharge Names | Total Discharge (cfs) | Culvert Discharge (cfs) | Headwater Elevation (ft) | Inlet Control Depth (ft) | Outlet Control Depth (ft) | Flow Type | Normal Depth (ft) | Critical Depth (ft) | Outlet Depth (ft) | Tailwater Depth (ft) | Outlet Velocity (ft/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 year Proposed | 20.00 | 20.00 | 1009.66 | 1.253 | 0.0* | 1-S2n | 0.778 | 0.850 | 0.778 | 0.565 | 4.937 |
| 10 year Proposed | 40.00 | 40.00 | 1010.25 | 1.844 | 0.851 | 1-S2n | 1.134 | 1.228 | 1.134 | 0.836 | 5.957 |
| 2 year Existing | 69.00 | 69.00 | 1011.07 | 2.656 | 1.911 | 5-S2n | 1.593 | 1.629 | 1.593 | 1.127 | 6.764 |
| 100 year Proposed | 97.00 | 97.00 | 1012.16 | 3.747 | 3.519 | 7-M2c | 2.500 | 1.934 | 1.934 | 1.353 | 7.936 |
| 10 year Existing | 120.00 | 103.50 | 1012.47 | 4.055 | 3.725 | 7-M2c | 2.500 | 1.994 | 1.994 | 1.514 | 8.220 |
| 100 year Existing | 197.00 | 109.31 | 1012.76 | 4.348 | 3.995 | 7-M2c | 2.500 | 2.044 | 2.044 | 1.955 | 8.481 |

* Full Flow Headwater elevation is below inlet invert.

**********

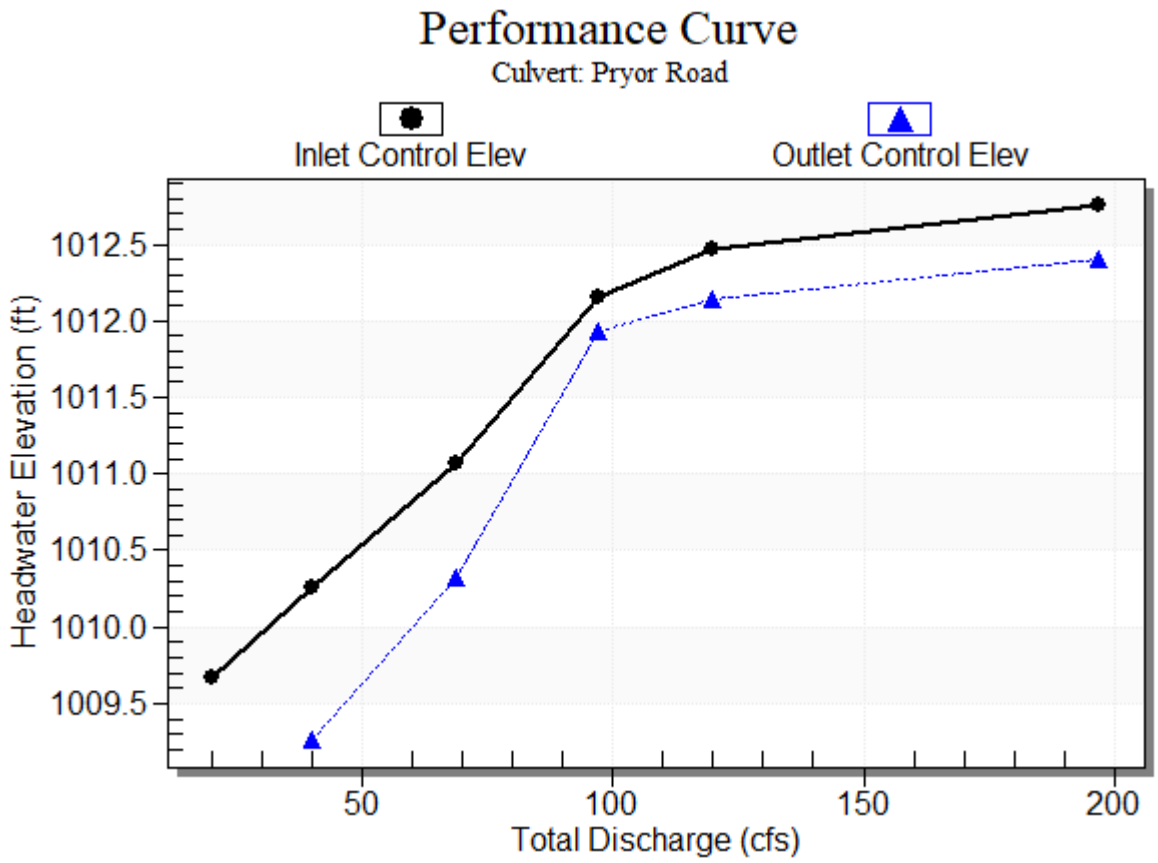
Straight Culvert

Inlet Elevation (invert): 1008.41 ft,  Outlet Elevation (invert): 1007.70 ft

Culvert Length: 38.71 ft,  Culvert Slope: 0.0183

**********

**Culvert Performance Curve Plot: Pryor Road**



**Water Surface Profile Plot for Culvert: Pryor Road**

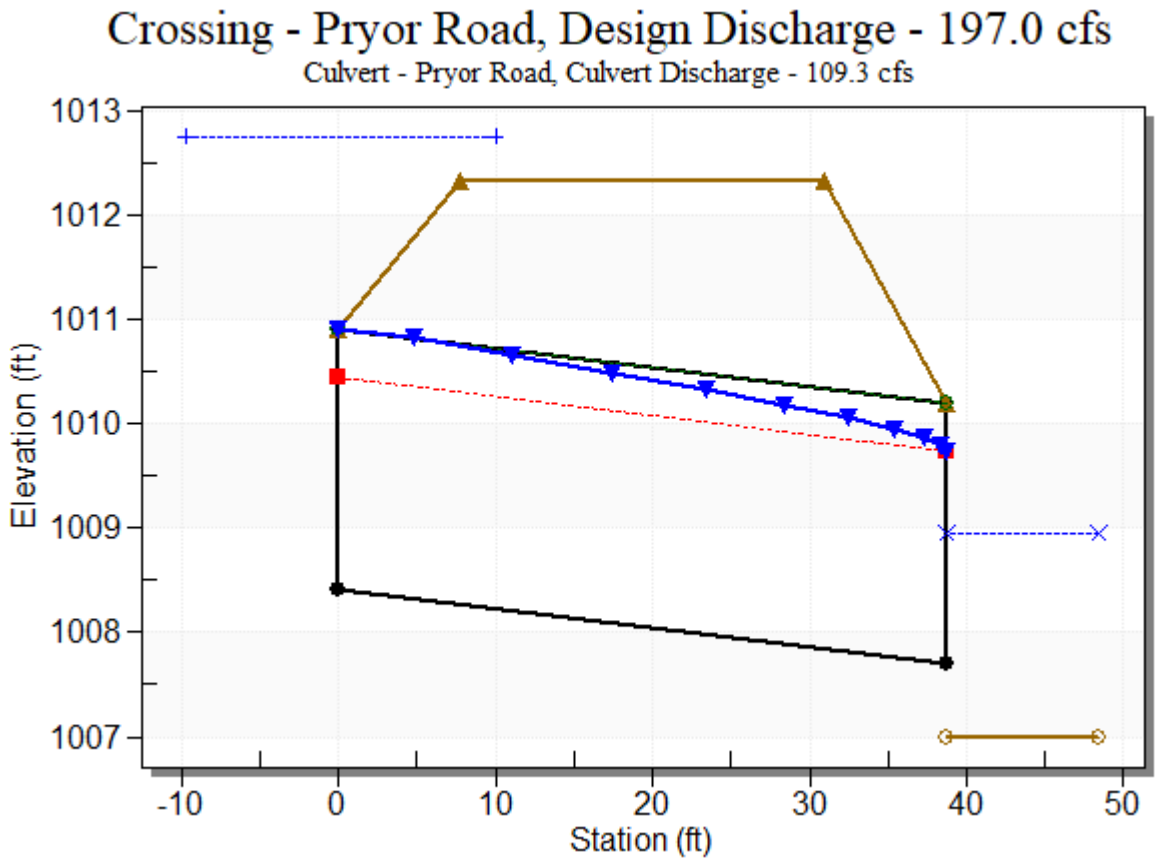


**Table 3 - Downstream Channel Rating Curve (Crossing: Pryor Road)**

| Flow (cfs) | Water Surface Elev (ft) | Depth (ft) | Velocity (ft/s) | Shear (psf) | Froude Number |
|---|---|---|---|---|---|
| 20.00 | 1007.57 | 0.57 | 3.65 | 0.71 | 0.93 |
| 40.00 | 1007.84 | 0.84 | 4.56 | 1.04 | 0.98 |
| 69.00 | 1008.13 | 1.13 | 5.38 | 1.41 | 1.02 |
| 97.00 | 1008.35 | 1.35 | 5.95 | 1.69 | 1.04 |
| 120.00 | 1008.51 | 1.51 | 6.32 | 1.89 | 1.06 |
| 197.00 | 1008.96 | 1.96 | 7.27 | 2.44 | 1.09 |

# APPENDIX E

Additional Future Conditions Calculations

# Curve Number Calculations

# Curve Number Calculations

## Existing Conditions

**Area A**

| Area (ac) | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 2.906 | C | Pasture | 79 | 0.56 | 44.46 |
| 0.243485726 | C | Pasture | 79 | 0.05 | 3.73 |
| 0.613818779 | D | Straight Row Crop | 89 | 0.12 | 10.58 |
| 1.400523294 | C | Straight Row Crop | 85 | 0.27 | 23.05 |
| 5.163827799 | **=Total Area** | | | **Weighted CN=** | 81.8 |
| | | | | **Rounded CN=** | **82** |

**Area B**

| Area (ac) | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 1.312066014 | D | Straight Row Crop | 89 | 0.05 | 4.09 |
| 0.017100042 | D | Pasture | 84 | 0.00 | 0.05 |
| 0.529108307 | C | Straight Row Crop | 85 | 0.02 | 1.57 |
| 0.849328427 | C | Pasture | 79 | 0.03 | 2.35 |
| 3.30E-01 | C | Pasture | 79 | 0.01 | 0.91 |
| 23.41341854 | C | Straight Row Crop | 85 | 0.82 | 69.67 |
| 2.114782111 | C | Pasture | 79 | 0.07 | 5.85 |
| 28.56593904 | **=Total Area** | | | **Weighted CN=** | 84.49 |
| | | | | **Rounded CN=** | **84** |

**Area C**

| Area (ac) | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 0.79150623 | C | Pasture | 79 | 0.07 | 5.55 |
| 7.030021517 | C | Straight Row Crop | 85 | 0.62 | 53.02 |
| 2.474000902 | C | Pasture | 79 | 0.22 | 17.34 |
| 0.266295138 | C | Pasture | 79 | 0.02 | 1.87 |
| 0.708077602 | C | Straight Row Crop | 85 | 0.06 | 5.34 |
| 11.26990139 | **=Total Area** | | | **Weighted CN=** | 83.12 |
| | | | | **Rounded CN=** | **83** |

## Bypass Area

**Bypass Area A**

| Area (ac) | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 0.722 | C | Pasture | 79 | 0.25 | 19.92 |
| 0.722 | D | Pasture | 84 | 0.25 | 21.18 |
| 0.71 | C | Paved Open Ditches | 92 | 0.25 | 22.81 |
| 0.71 | D | Paved Open Ditches | 93 | 0.25 | 23.06 |
| 2.864 | **=Total Area** | | | **Weighted CN** | 86.95 |
| | | | | **Rounded CN=** | 87 |

## Proposed Conditions

**Area A**

| Area (ac) | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 0.128 | D | Multifamily Residentia | 92 | 0.30 | 27.39 |
| 0.302 | C | Multifamily Residentia | 90 | 0.70 | 63.21 |
| 0.43 | **=Total Area** | | | **Weighted CN=** | 90.60 |
| | | | | **Rounded CN=** | **91** |

**Area B1**

| Area (ac) | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 0.823052 | D | Multifamily Residentia | 92 | 0.02 | 2.26 |
| 0.017108 | D | Pasture | 84 | 0.00 | 0.04 |
| 0.248037 | C | Pasture | 79 | 0.01 | 0.58 |
| 2.25E+00 | C | Multifamily Residentia | 90 | 0.07 | 6.04 |
| 1.391016 | C | Straight Row Crop | 85 | 0.04 | 3.53 |
| 2.192 | C | Pasture | 79 | 0.07 | 5.16 |
| 0.839925 | C | Pasture | 79 | 0.03 | 1.98 |
| 23.19 | C | Multifamily Residentia | 90 | 0.69 | 62.23 |
| 0.471729 | C | Straight Row Crop | 85 | 0.01 | 1.20 |
| 2.114399 | C | Pasture | 79 | 0.06 | 4.98 |
| 33.53989 | | | | **Weighted CN=** | 88.00 |
| | | | | **Rounded CN=** | **88** |

**Area C**

| Area (ac) | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 0.543476 | C | Pasture | 79 | 0.07 | 5.20 |
| 1.487245 | C | Pasture | 79 | 0.18 | 14.24 |
| 4.327 | C | Multifamily Residentia | 90 | 0.52 | 47.19 |
| 1.89E+00 | C | Straight Row Crop | 85 | 0.23 | 19.51 |
| 8.252144 | **=Total Area** | | | **Weighted CN=** | 86.15 |
| | | | | **Rounded CN=** | **86** |

**Area (ac)**

| Area | Soil_Type | Land_Use | CN | Weight | CN x Weight |
|---|---|---|---|---|---|
| 0.468749 | D | Multifamily Residentia | 92 | 0.17 | 15.80 |
| 2.261 | C | Multifamily Residentia | 90 | 0.83 | 74.55 |
| 2.729749 | **=Total Area** | | | **Weighted CN=** | 90.34 |
| | | | | **Rounded CN=** | **90** |

# Inflow Hydrographs

# Hydrograph Report

Inflow Hydrograph - 2 Year Storm

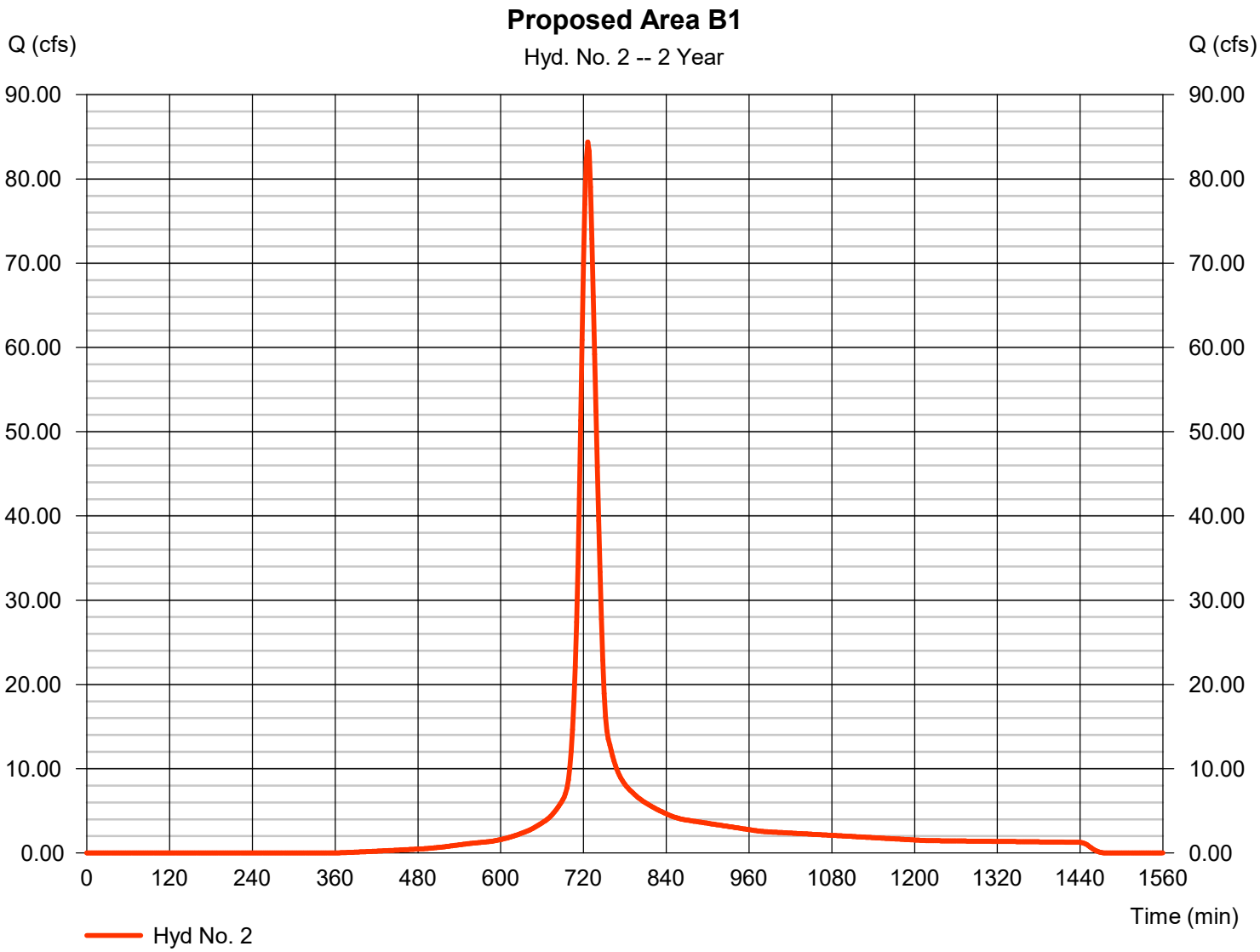
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

Monday, 03 / 2 / 2020

## Hyd. No. 2

Proposed Area B1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 84.38 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 292,466 cuft |
| Drainage area | = 33.540 ac | Curve number | = 88 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 21.30 min |
| Total precip. | = 3.60 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# Hydrograph Report

Inflow Hydrograph - 10 Year Storm

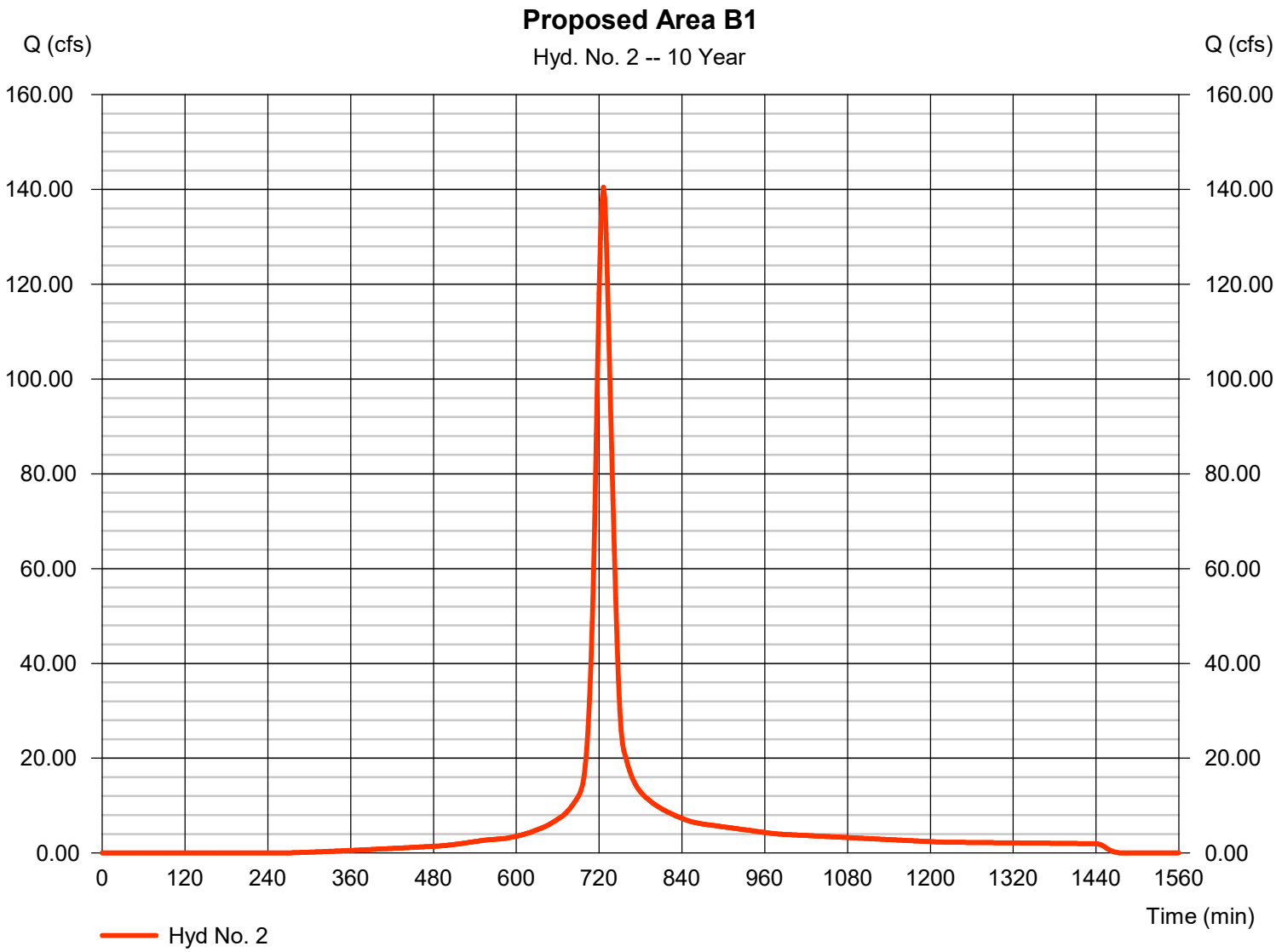
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

Monday, 03 / 2 / 2020

## Hyd. No. 2

Proposed Area B1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 140.46 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 494,803 cuft |
| Drainage area | = 33.540 ac | Curve number | = 88 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 21.30 min |
| Total precip. | = 5.34 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# Hydrograph Report

Inflow Hydrograph - 100 Year Storm

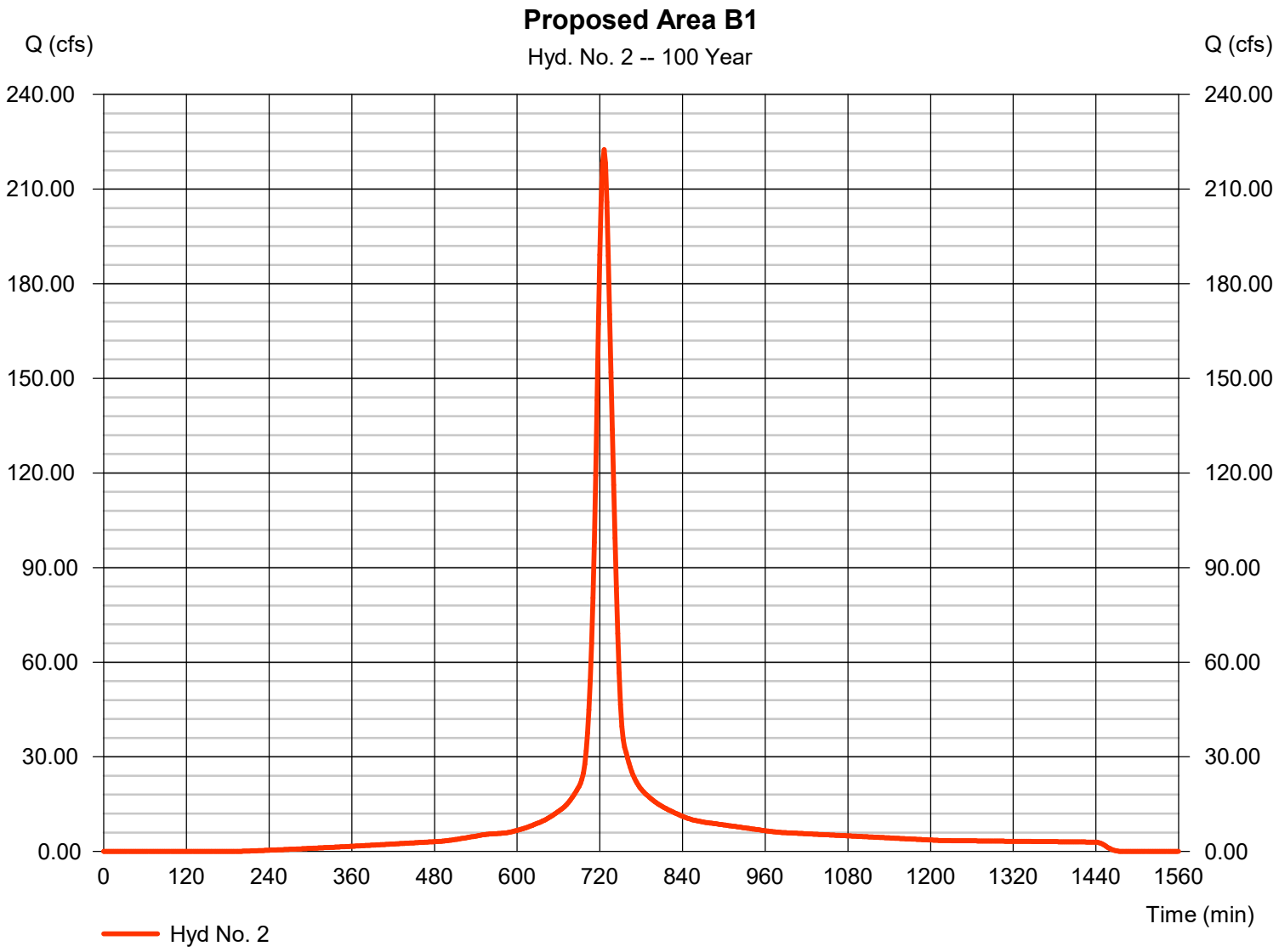
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020

Monday, 03 / 2 / 2020

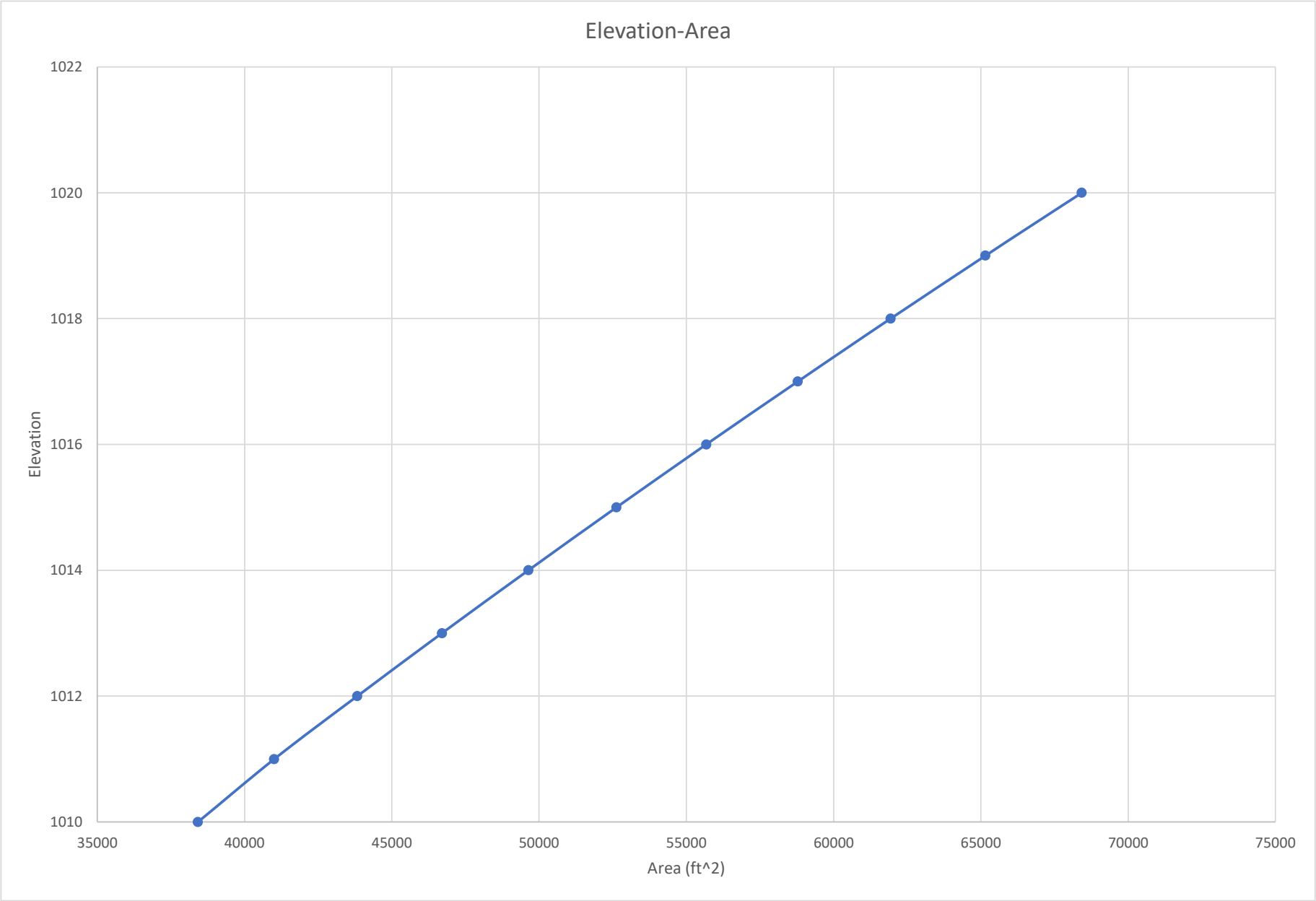
## Hyd. No. 2

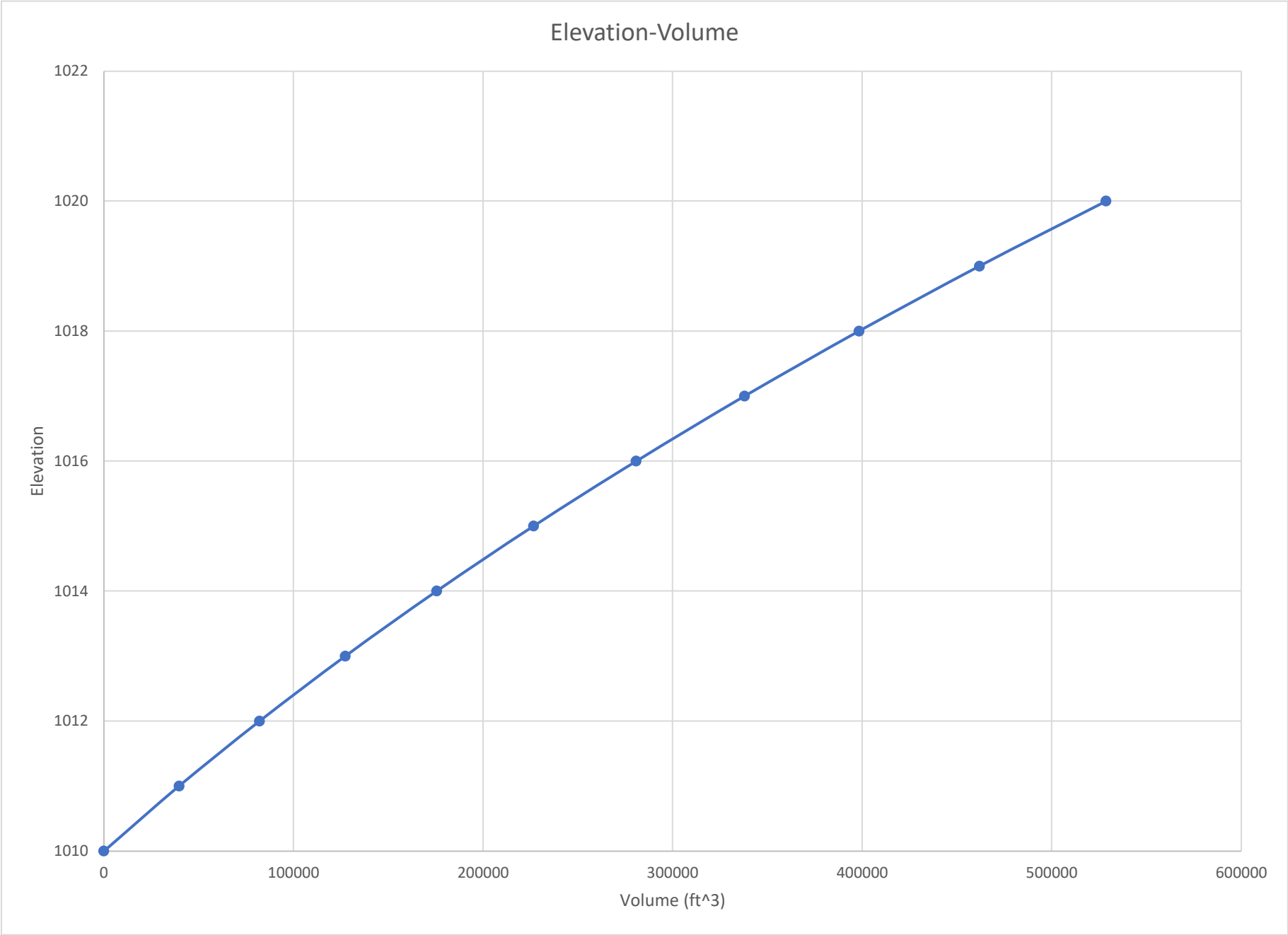
Proposed Area B1

| | | | |
|---|---|---|---|
| Hydrograph type | = SCS Runoff | Peak discharge | = 222.56 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 726 min |
| Time interval | = 2 min | Hyd. volume | = 801,846 cuft |
| Drainage area | = 33.540 ac | Curve number | = 88 |
| Basin Slope | = 0.0 % | Hydraulic length | = 0 ft |
| Tc method | = User | Time of conc. (Tc) | = 21.30 min |
| Total precip. | = 7.90 in | Distribution | = Type II |
| Storm duration | = 24 hrs | Shape factor | = 484 |



# Detention Storage Information


Elevation-Area
1022
1020
1018
1016
1014
1012
1010
Elevation
35000
40000
45000
50000
55000
60000
65000
70000
75000
Area (ft^2)


Elevation-Volume
1022
1020
1018
1016
1014
1012
1010
Elevation
0
100000
200000
300000
400000
500000
600000
Volume (ft^3)

# Outlet Structures Information

# Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Pond No. 1 - Detention

## Pond Data

**Contours -**User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

## Stage / Storage Table

| Stage (ft) | Elevation (ft) | Contour area (sqft) | Incr. Storage (cuft) | Total storage (cuft) |
|---|---|---|---|---|
| 0.00 | 1010.00 | 38,421 | 0 | 0 |
| 1.00 | 1011.00 | 41,007 | 39,703 | 39,703 |
| 2.00 | 1012.00 | 43,827 | 42,405 | 82,108 |
| 3.00 | 1013.00 | 46,706 | 45,254 | 127,362 |
| 4.00 | 1014.00 | 49,638 | 48,160 | 175,522 |
| 5.00 | 1015.00 | 52,631 | 51,122 | 226,644 |
| 6.00 | 1016.00 | 55,675 | 54,141 | 280,785 |
| 7.00 | 1017.00 | 58,781 | 57,215 | 338,000 |
| 8.00 | 1018.00 | 61,937 | 60,346 | 398,346 |
| 9.00 | 1019.00 | 65,152 | 63,531 | 461,877 |
| 10.00 | 1020.00 | 68,424 | 66,775 | 528,652 |

## Culvert / Orifice Structures

| | [A] | [B] | [C] | [PrfRsr] |
|---|---|---|---|---|
| **Rise (in)** | = 48.00 | 36.00 | 4.50 | Inactive |
| **Span (in)** | = 48.00 | 36.00 | 4.50 | 0.00 |
| **No. Barrels** | = 1 | 1 | 1 | 0 |
| **Invert El. (ft)** | = 1010.01 | 1012.60 | 1010.02 | 0.00 |
| **Length (ft)** | = 82.00 | 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 | Yes | Yes | No |

## Weir Structures

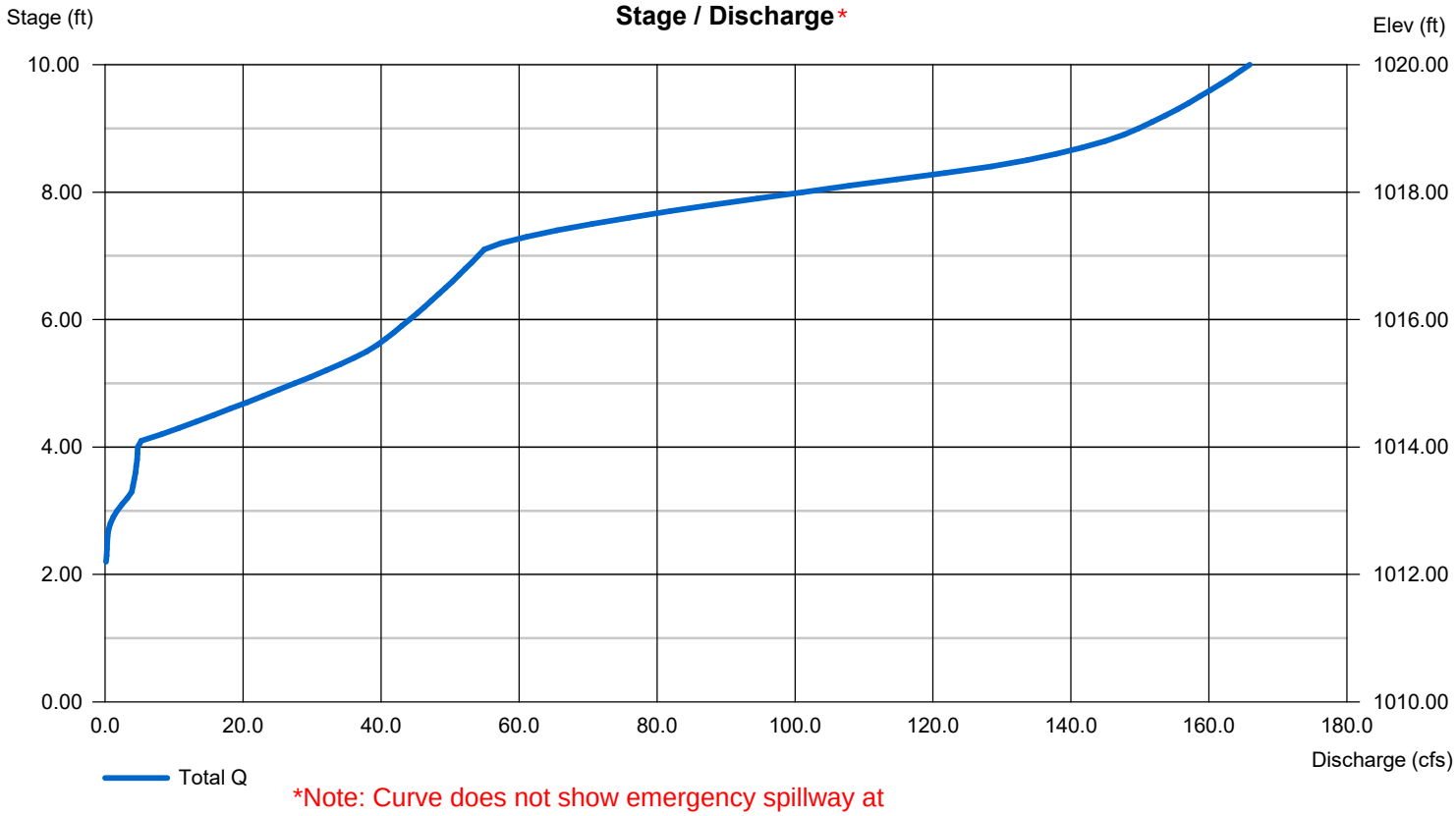
| | [A] | [B] | [C] | [D] |
|---|---|---|---|---|
| **Crest Len (ft)** | = 20.00 | Inactive | Inactive | Inactive |
| **Crest El. (ft)** | = 1017.10 | 0.00 | 0.00 | 0.00 |
| **Weir Coeff.** | = 3.00 | 3.33 | 3.33 | 3.33 |
| **Weir Type** | = Rect | Rect | Rect | --- |
| **Multi-Stage** | = Yes | Yes | Yes | No |

**Exfil.(in/hr)** = 0.000 (by Contour)

**TW Elev. (ft)** = 1012.16

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

Combined Outlet Structure (All Openings)




*Note: Curve does not show emergency spillway at 1018.4. Separate output attached.

# Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Pond No. 1 - Detention

## Pond Data

**Contours -**User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

## Stage / Storage Table

| Stage (ft) | Elevation (ft) | Contour area (sqft) | Incr. Storage (cuft) | Total storage (cuft) |
|---|---|---|---|---|
| 0.00 | 1010.00 | 38,421 | 0 | 0 |
| 1.00 | 1011.00 | 41,007 | 39,703 | 39,703 |
| 2.00 | 1012.00 | 43,827 | 42,405 | 82,108 |
| 3.00 | 1013.00 | 46,706 | 45,254 | 127,362 |
| 4.00 | 1014.00 | 49,638 | 48,160 | 175,522 |
| 5.00 | 1015.00 | 52,631 | 51,122 | 226,644 |
| 6.00 | 1016.00 | 55,675 | 54,141 | 280,785 |
| 7.00 | 1017.00 | 58,781 | 57,215 | 338,000 |
| 8.00 | 1018.00 | 61,937 | 60,346 | 398,346 |
| 9.00 | 1019.00 | 65,152 | 63,531 | 461,877 |
| 10.00 | 1020.00 | 68,424 | 66,775 | 528,652 |

## Culvert / Orifice Structures

| | | [A] | [B] | [C] | [PrfRsr] |
|---|---|---|---|---|---|
| **Rise (in)** | = | 48.00 | 36.00 | 4.50 | Inactive |
| **Span (in)** | = | 48.00 | 36.00 | 4.50 | 0.00 |
| **No. Barrels** | = | 1 | 1 | 1 | 0 |
| **Invert El. (ft)** | = | 1010.01 | 1012.60 | 1010.02 | 0.00 |
| **Length (ft)** | = | 82.00 | 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 | Yes | Yes | No |

## Weir Structures

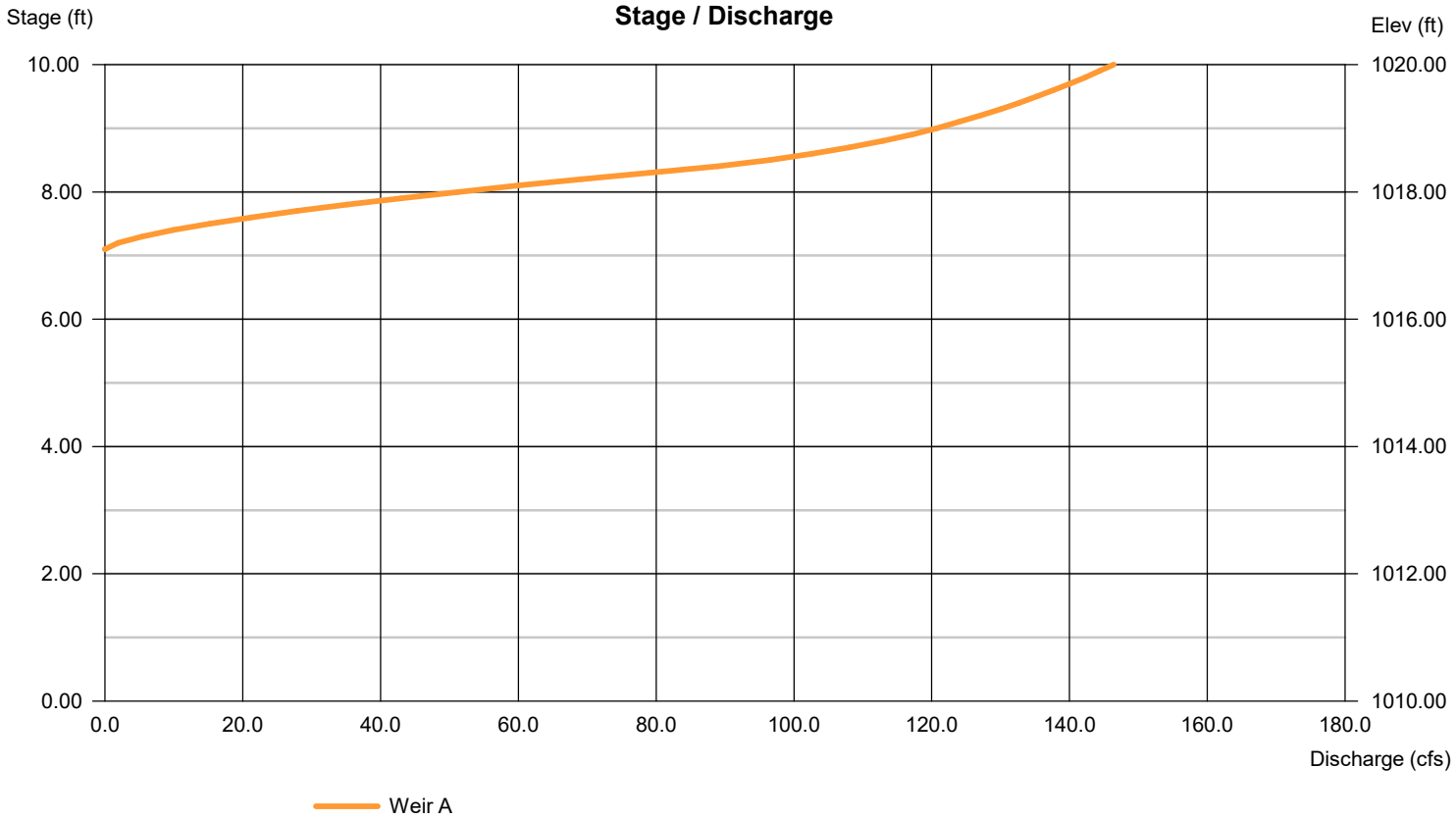
| | | [A] | [B] | [C] | [D] |
|---|---|---|---|---|---|
| **Crest Len (ft)** | = | 20.00 | Inactive | Inactive | Inactive |
| **Crest El. (ft)** | = | 1017.10 | 0.00 | 0.00 | 0.00 |
| **Weir Coeff.** | = | 3.00 | 3.33 | 3.33 | 3.33 |
| **Weir Type** | = | Rect | Rect | Rect | --- |
| **Multi-Stage** | = | Yes | Yes | Yes | No |

**Exfil.(in/hr)** = 0.000 (by Contour)

**TW Elev. (ft)** = 1012.16

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

5'x5' Open Top Concrete Box With Top Elevation 1017.1



# Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Pond No. 1 - Detention

## Pond Data

**Contours -**User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

## Stage / Storage Table

| Stage (ft) | Elevation (ft) | Contour area (sqft) | Incr. Storage (cuft) | Total storage (cuft) |
|---|---|---|---|---|
| 0.00 | 1010.00 | 38,421 | 0 | 0 |
| 1.00 | 1011.00 | 41,007 | 39,703 | 39,703 |
| 2.00 | 1012.00 | 43,827 | 42,405 | 82,108 |
| 3.00 | 1013.00 | 46,706 | 45,254 | 127,362 |
| 4.00 | 1014.00 | 49,638 | 48,160 | 175,522 |
| 5.00 | 1015.00 | 52,631 | 51,122 | 226,644 |
| 6.00 | 1016.00 | 55,675 | 54,141 | 280,785 |
| 7.00 | 1017.00 | 58,781 | 57,215 | 338,000 |
| 8.00 | 1018.00 | 61,937 | 60,346 | 398,346 |
| 9.00 | 1019.00 | 65,152 | 63,531 | 461,877 |
| 10.00 | 1020.00 | 68,424 | 66,775 | 528,652 |

## Culvert / Orifice Structures

| | | [A] | [B] | [C] | [PrfRsr] |
|---|---|---|---|---|---|
| **Rise (in)** | = | 48.00 | 36.00 | 4.50 | Inactive |
| **Span (in)** | = | 48.00 | 36.00 | 4.50 | 0.00 |
| **No. Barrels** | = | 1 | 1 | 1 | 0 |
| **Invert El. (ft)** | = | 1010.01 | 1012.60 | 1010.02 | 0.00 |
| **Length (ft)** | = | 82.00 | 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 | Yes | Yes | No |

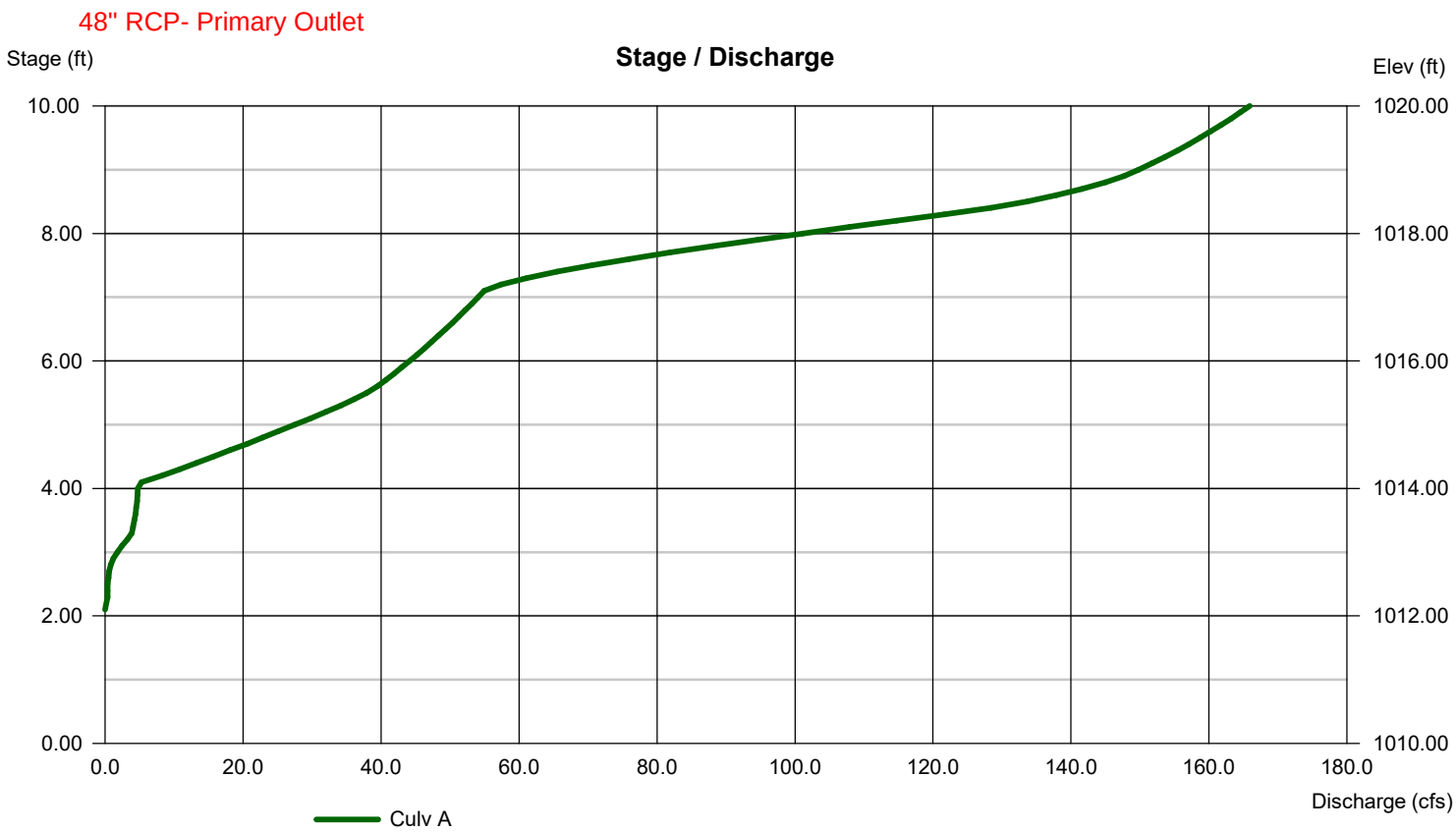
## Weir Structures

| | | [A] | [B] | [C] | [D] |
|---|---|---|---|---|---|
| **Crest Len (ft)** | = | 20.00 | Inactive | Inactive | Inactive |
| **Crest El. (ft)** | = | 1017.10 | 0.00 | 0.00 | 0.00 |
| **Weir Coeff.** | = | 3.00 | 3.33 | 3.33 | 3.33 |
| **Weir Type** | = | Rect | Rect | Rect | --- |
| **Multi-Stage** | = | Yes | Yes | Yes | No |

**Exfil.(in/hr)** = 0.000 (by Contour)

**TW Elev. (ft)** = 1012.16

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



# Pond Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Pond No. 1 - Detention

## Pond Data

**Contours -**User-defined contour areas. Conic method used for volume calculation. Begining Elevation = 1010.00 ft

## Stage / Storage Table

| Stage (ft) | Elevation (ft) | Contour area (sqft) | Incr. Storage (cuft) | Total storage (cuft) |
|---|---|---|---|---|
| 0.00 | 1010.00 | 38,421 | 0 | 0 |
| 1.00 | 1011.00 | 41,007 | 39,703 | 39,703 |
| 2.00 | 1012.00 | 43,827 | 42,405 | 82,108 |
| 3.00 | 1013.00 | 46,706 | 45,254 | 127,362 |
| 4.00 | 1014.00 | 49,638 | 48,160 | 175,522 |
| 5.00 | 1015.00 | 52,631 | 51,122 | 226,644 |
| 6.00 | 1016.00 | 55,675 | 54,141 | 280,785 |
| 7.00 | 1017.00 | 58,781 | 57,215 | 338,000 |
| 8.00 | 1018.00 | 61,937 | 60,346 | 398,346 |
| 9.00 | 1019.00 | 65,152 | 63,531 | 461,877 |
| 10.00 | 1020.00 | 68,424 | 66,775 | 528,652 |

## Culvert / Orifice Structures

| | | [A] | [B] | [C] | [PrfRsr] |
|---|---|---|---|---|---|
| **Rise (in)** | = | 48.00 | 36.00 | 4.50 | Inactive |
| **Span (in)** | = | 48.00 | 36.00 | 4.50 | 0.00 |
| **No. Barrels** | = | 1 | 1 | 1 | 0 |
| **Invert El. (ft)** | = | 1010.01 | 1012.60 | 1010.02 | 0.00 |
| **Length (ft)** | = | 82.00 | 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 | Yes | Yes | No |

## Weir Structures

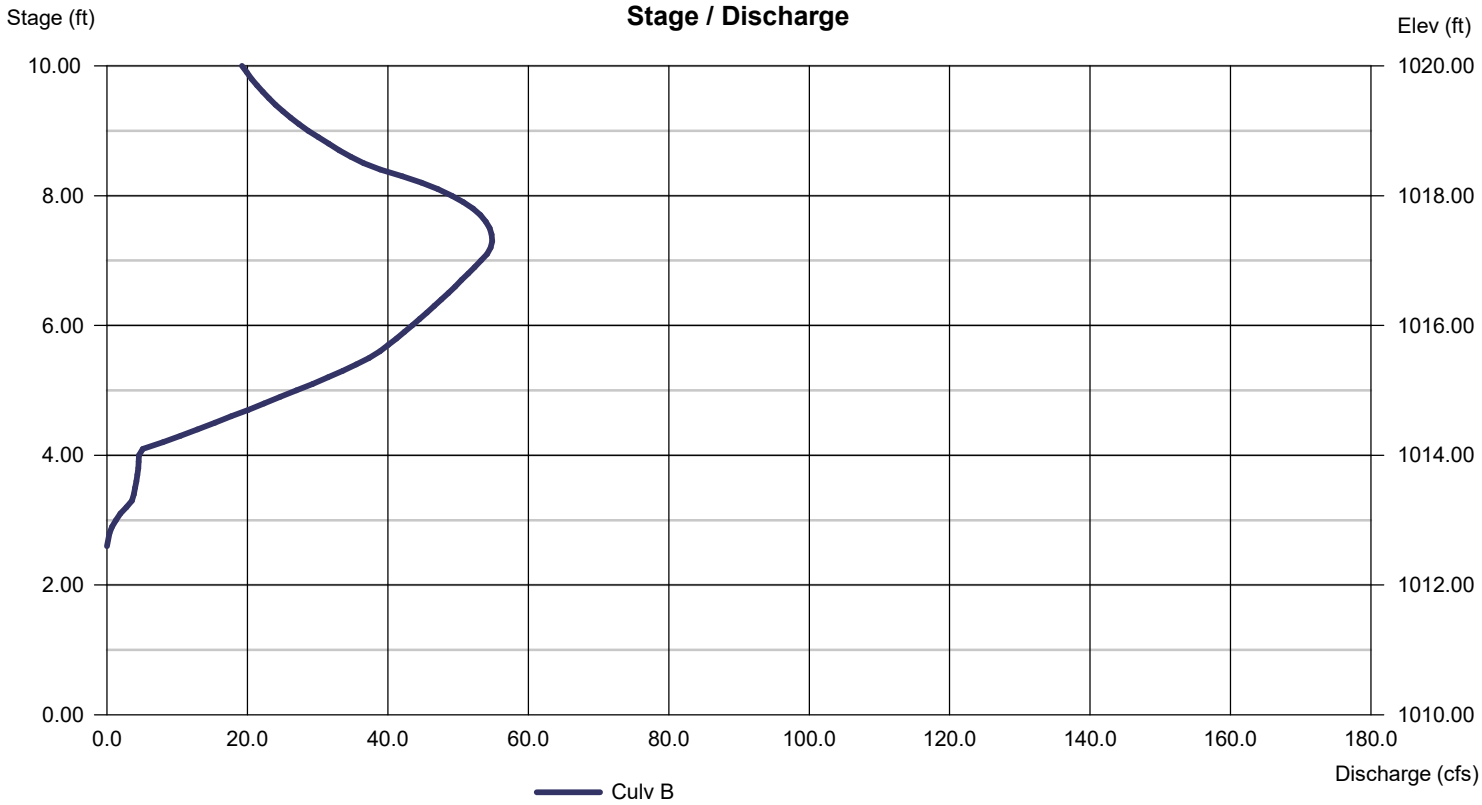
| | | [A] | [B] | [C] | [D] |
|---|---|---|---|---|---|
| **Crest Len (ft)** | = | 20.00 | Inactive | Inactive | Inactive |
| **Crest El. (ft)** | = | 1017.10 | 0.00 | 0.00 | 0.00 |
| **Weir Coeff.** | = | 3.00 | 3.33 | 3.33 | 3.33 |
| **Weir Type** | = | Rect | Rect | Rect | --- |
| **Multi-Stage** | = | Yes | Yes | Yes | No |

**Exfil.(in/hr)** = 0.000 (by Contour)

**TW Elev. (ft)** = 1012.16

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

36" Opening in Box at Elevation 1012.6



# Weir Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Mar 2 2020

## Osage Emergency Spillway

**Rectangular Weir**

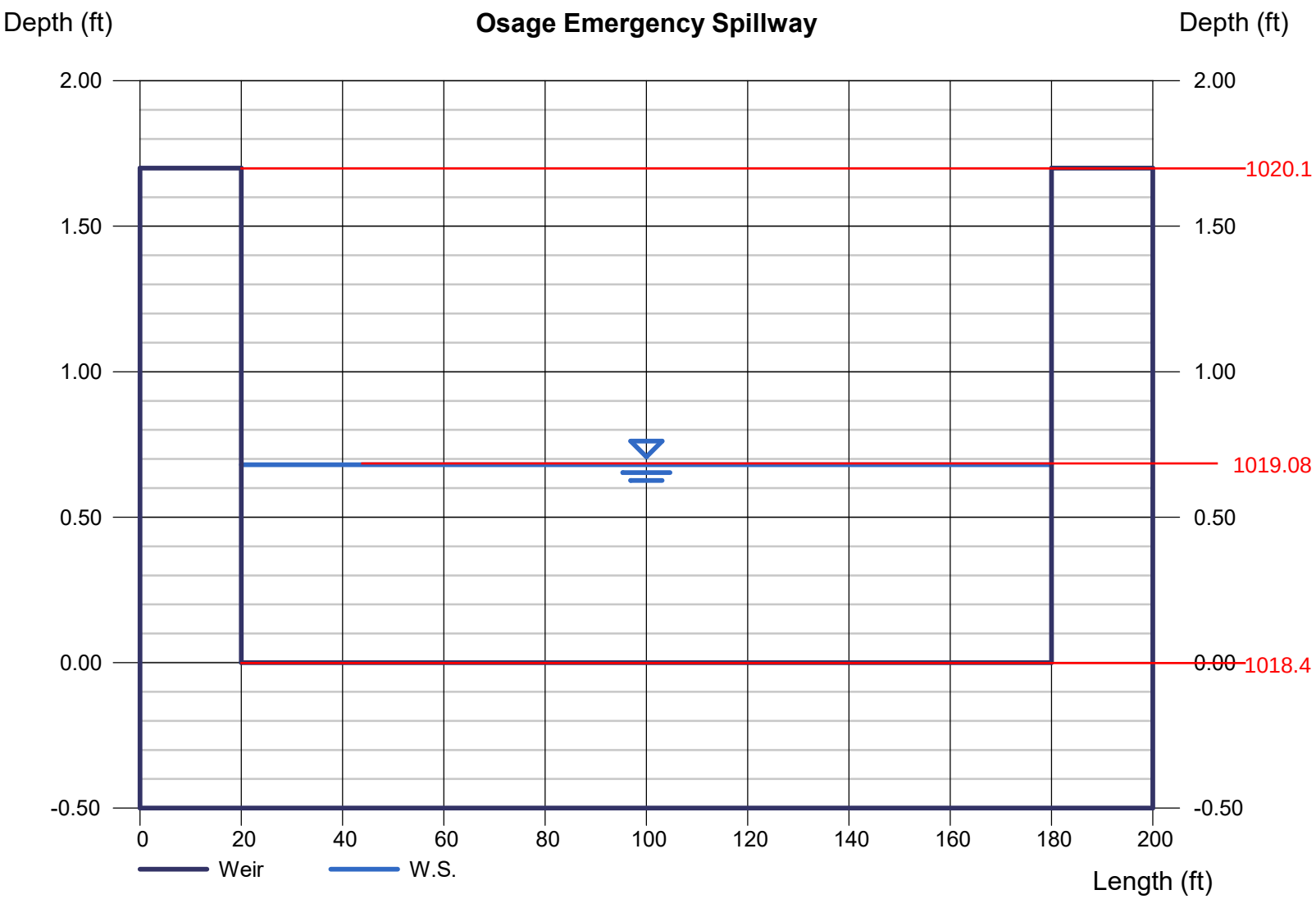
| | | |
|---|---|---|
| Crest | = | Broad |
| Bottom Length (ft) | = | 160.00 |
| Total Depth (ft) | = | 1.70 |

**Calculations**

| | | |
|---|---|---|
| Weir Coeff. Cw | = | 2.60 |
| Compute by: | | Q vs Depth |
| No. Increments | = | 50 |

**Highlighted**

| | | |
|---|---|---|
| Depth (ft) | = | 0.68 |
| Q (cfs) | = | 233.27 |
| Area (sqft) | = | 108.80 |
| Velocity (ft/s) | = | 2.14 |
| Top Width (ft) | = | 160.00 |



# Detention Discharge/Storage vs Time

# Hydrograph Report

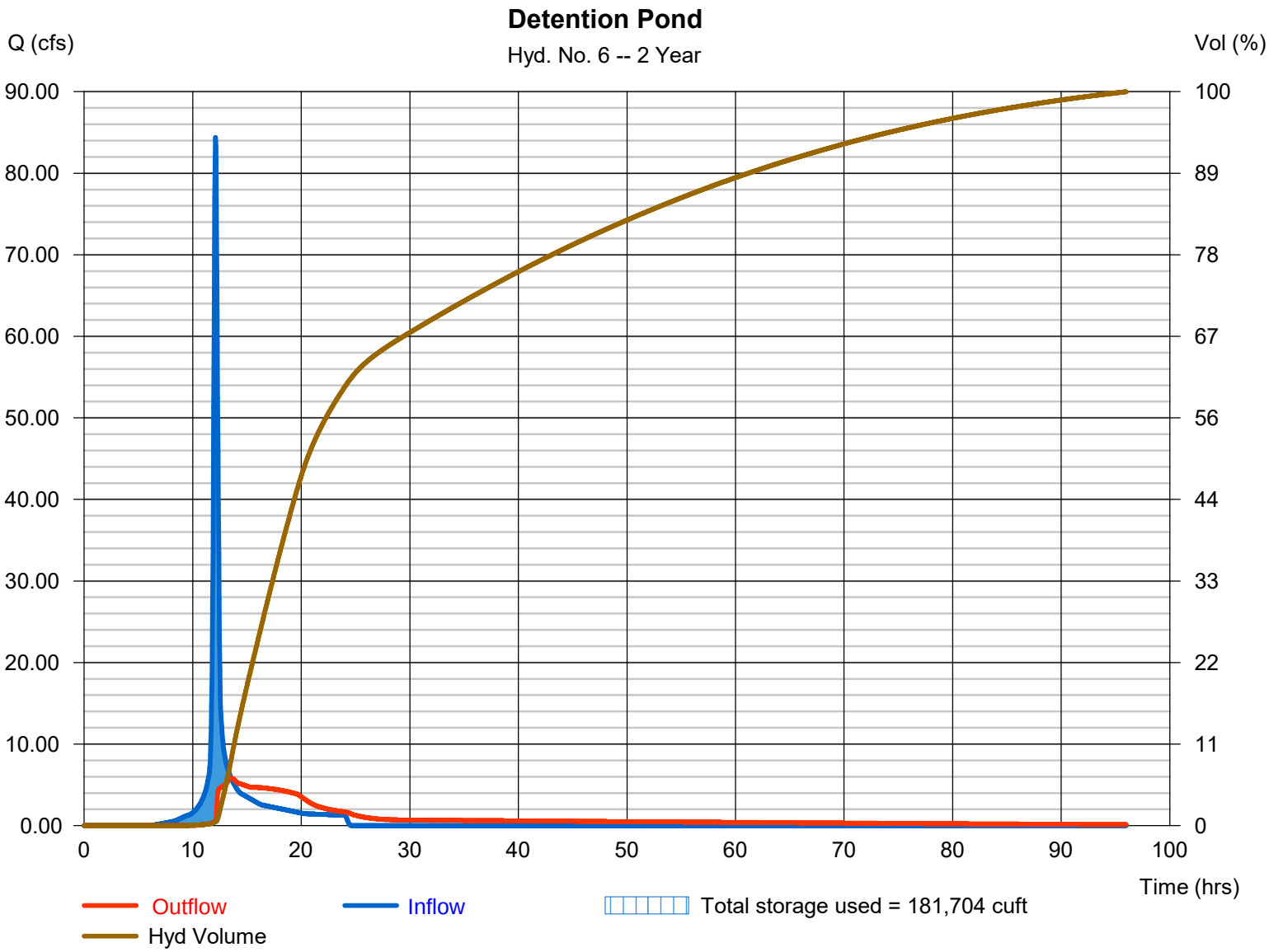
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 5.853 cfs |
| Storm frequency | = 2 yrs | Time to peak | = 13.53 hrs |
| Time interval | = 2 min | Hyd. volume | = 276,519 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1014.12 ft |
| Reservoir name | = Detention | Max. Storage | = 181,704 cuft |

Storage Indication method used.



# Hydrograph Report

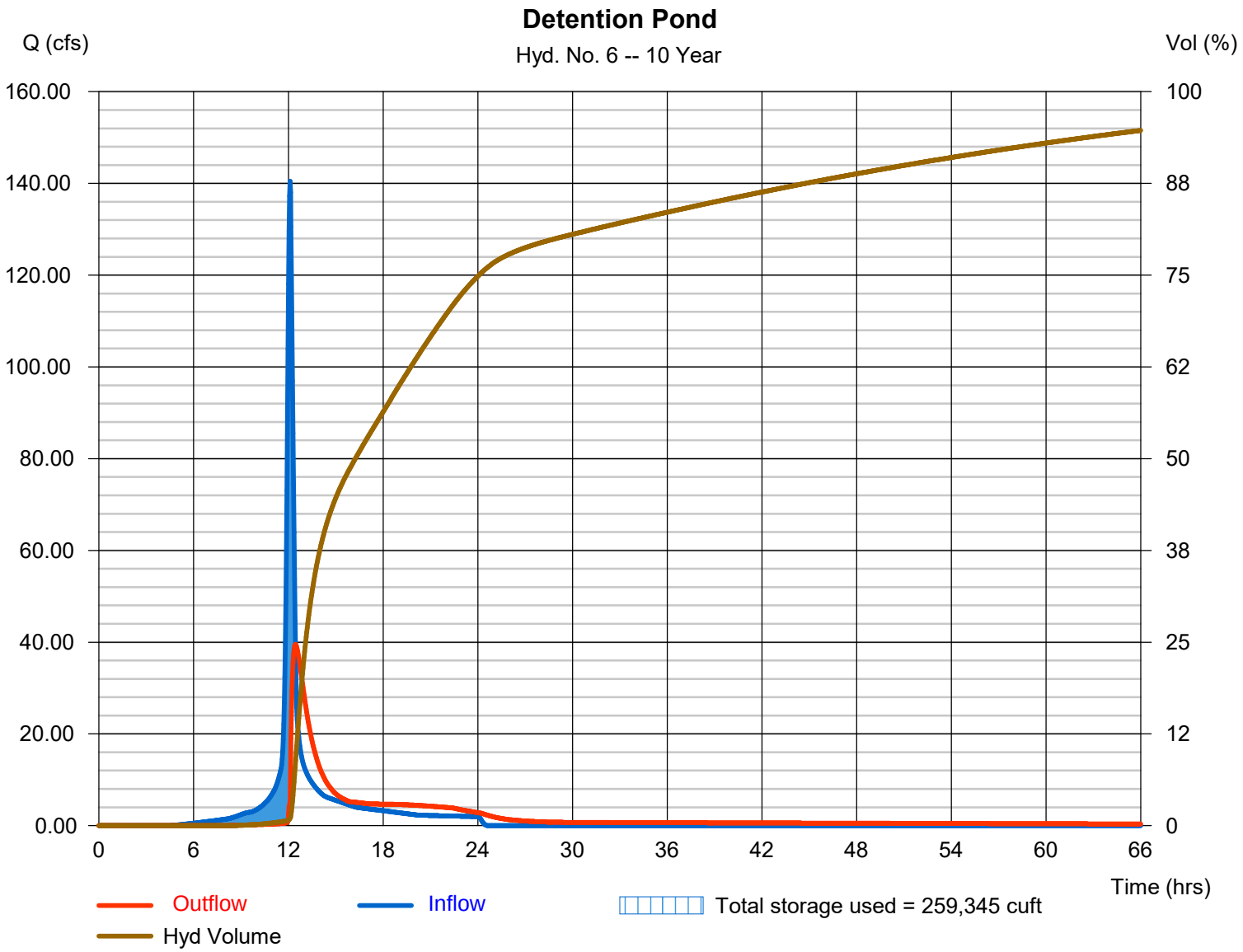
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 39.50 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 12.47 hrs |
| Time interval | = 2 min | Hyd. volume | = 478,332 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1015.60 ft |
| Reservoir name | = Detention | Max. Storage | = 259,345 cuft |

Storage Indication method used.



# Hydrograph Report

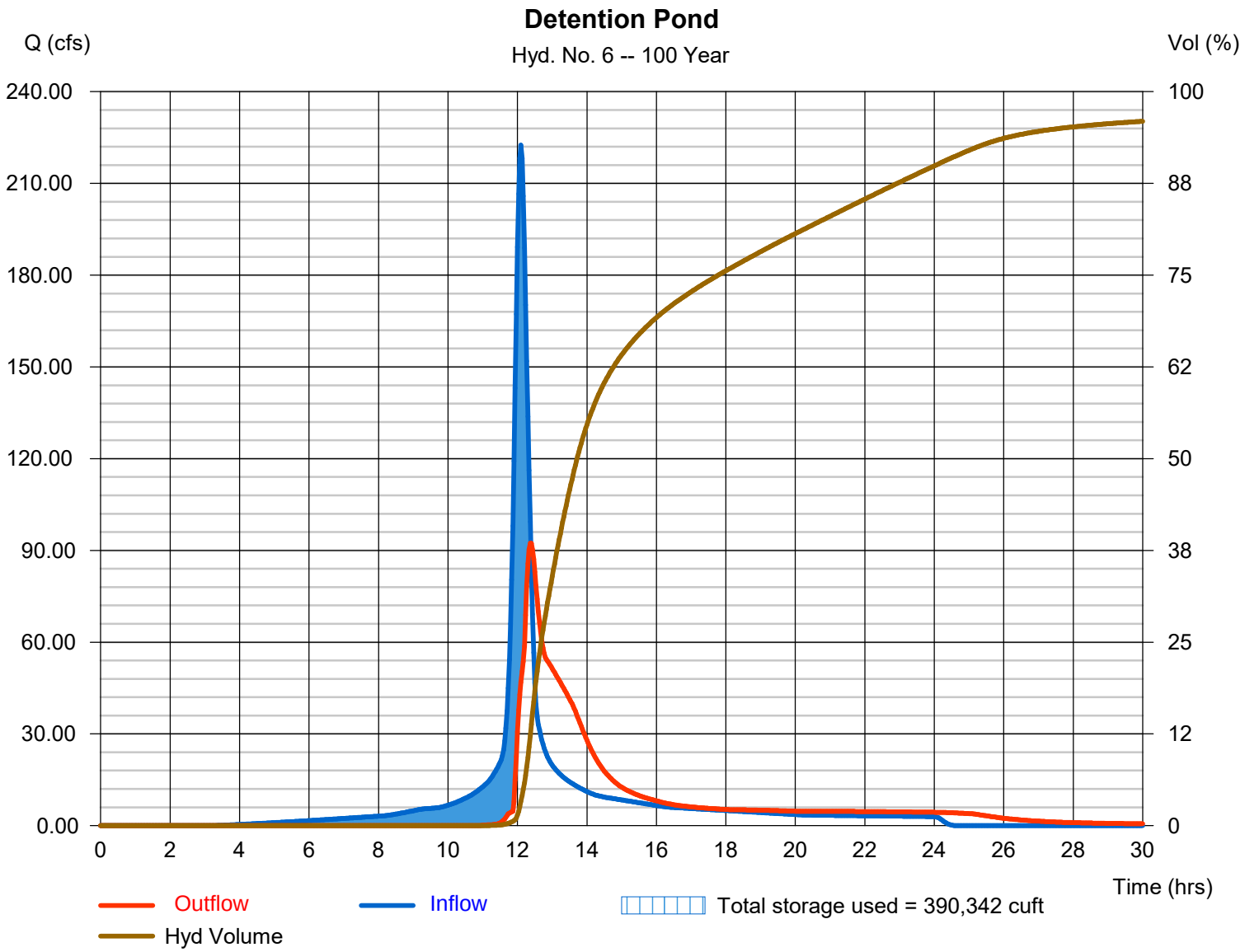
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 92.38 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.37 hrs |
| Time interval | = 2 min | Hyd. volume | = 715,056 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1017.87 ft |
| Reservoir name | = Detention | Max. Storage | = 390,342 cuft |

Storage Indication method used.



# Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Hyd. No. 6

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| | | | |
|---|---|---|---|
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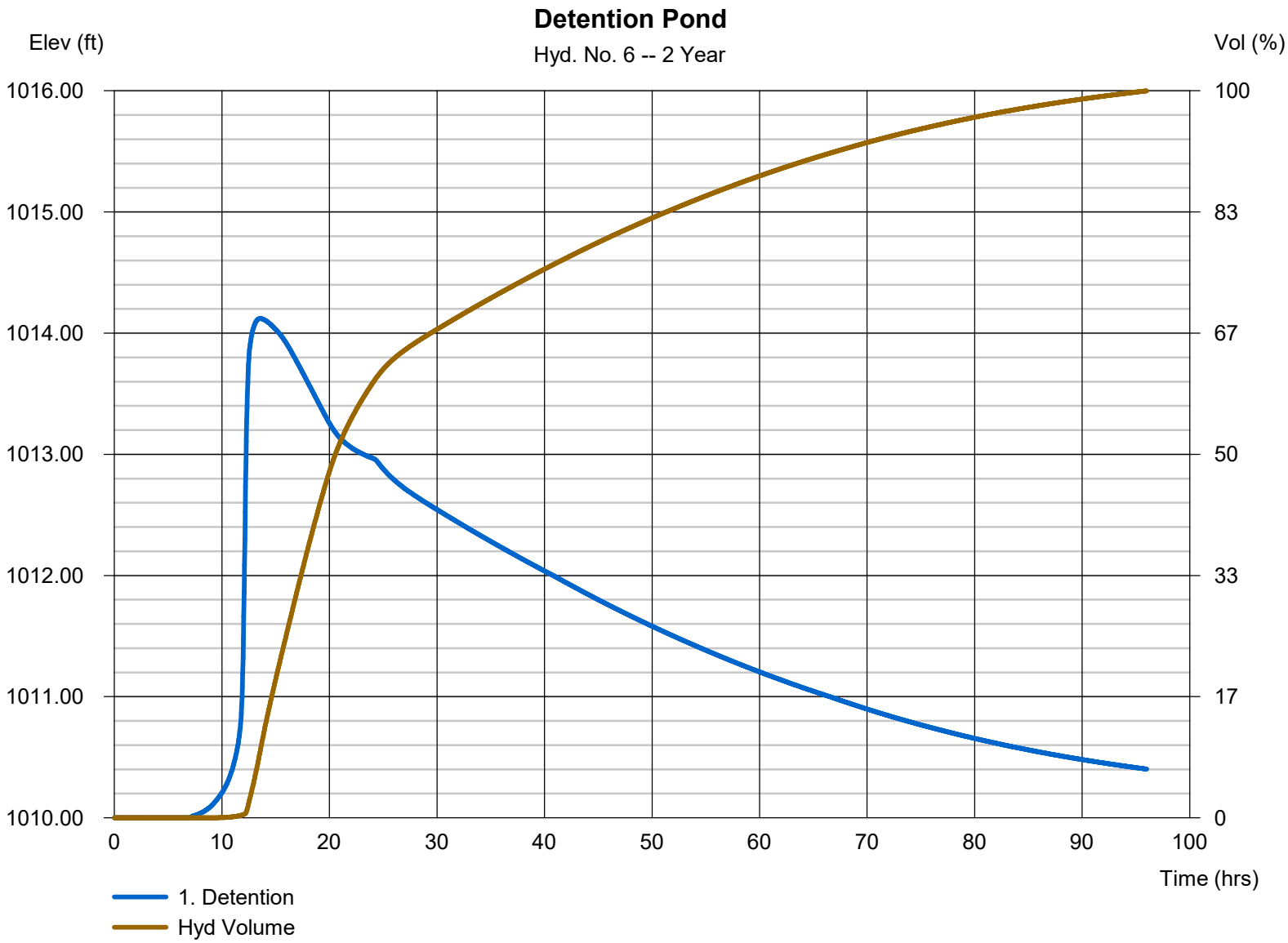
| Reservoir name | = Detention | Max. Storage | = 181,704 cuft |

Storage Indication method used.



# Hydrograph Report

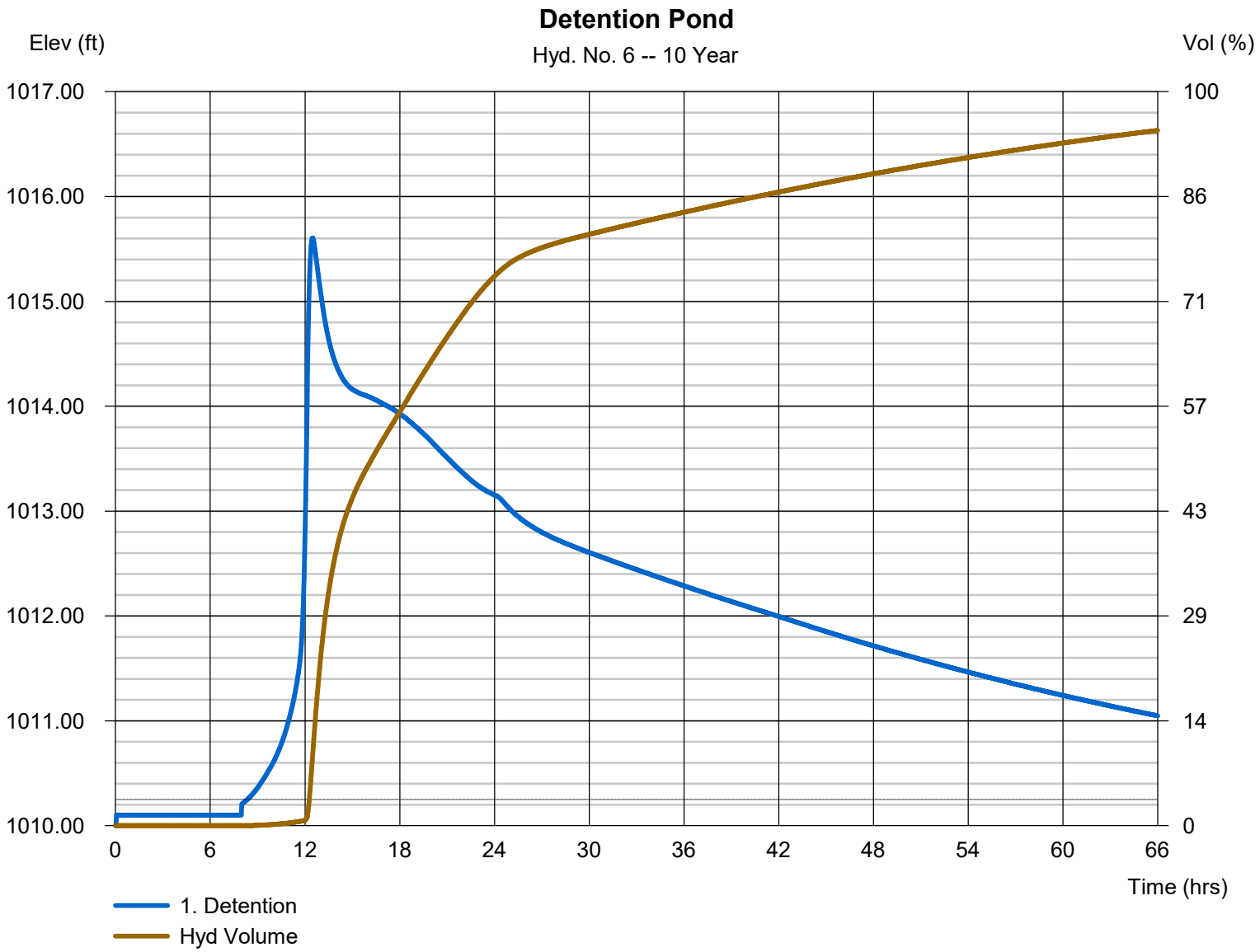
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 39.50 cfs |
| Storm frequency | = 10 yrs | Time to peak | = 12.47 hrs |
| Time interval | = 2 min | Hyd. volume | = 478,332 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1015.60 ft |
| Reservoir name | = Detention | Max. Storage | = 259,345 cuft |

Storage Indication method used.



# Hydrograph Report

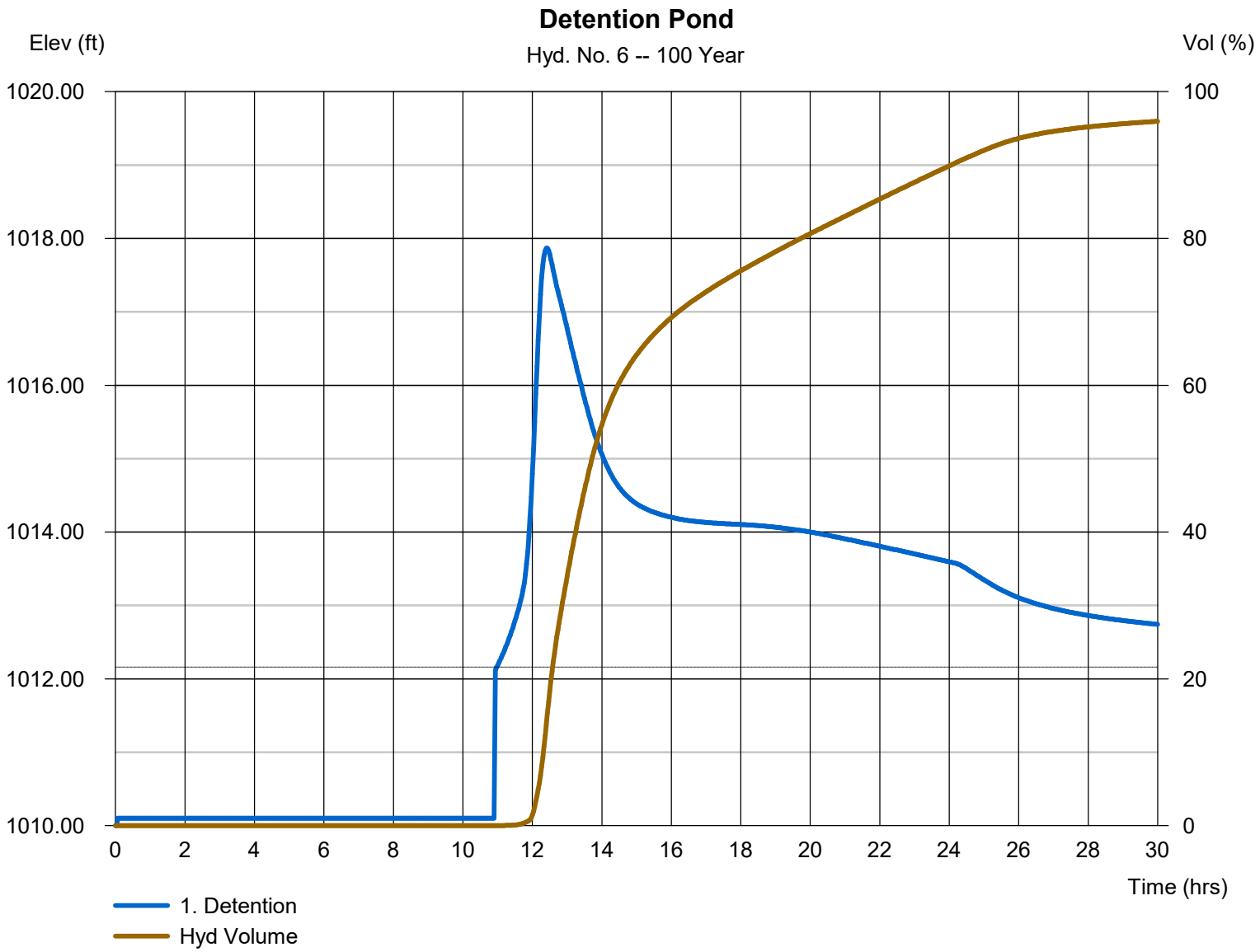
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2020 Monday, 03 / 2 / 2020

## Hyd. No. 6

Detention Pond

| | | | |
|---|---|---|---|
| Hydrograph type | = Reservoir | Peak discharge | = 92.38 cfs |
| Storm frequency | = 100 yrs | Time to peak | = 12.37 hrs |
| Time interval | = 2 min | Hyd. volume | = 715,056 cuft |
| Inflow hyd. No. | = 2 - Proposed Area B1 | Max. Elevation | = 1017.87 ft |
| Reservoir name | = Detention | Max. Storage | = 390,342 cuft |

Storage Indication method used.



# APPENDIX F

Preliminary Stormwater Drainage Study

# OSAGE DEVELOPMENT PRELIMINARY STORMWATER DRAINAGE STUDY

**Prepared for:**

Clayton Properties Group, Inc. DBA Summit Homes
120 SE 30th Street
Lee's Summit, MO 64082

**October 2019**
**Olsson Project No. 019-2339**

olsson

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# APPENDICES

Appendix A: Site Maps
Appendix B: Existing Conditions Hydraflow Hydrographs Model Input and Results
Appendix C: Proposed Conditions Hydraflow Hydrographs Model Input and Results
Appendix D: Hy-8 Input and Results

# 1.0 GENERAL INFORMATION

Osage is a proposed single-family residential development on approximately 36 acres, including a pool, amenity tract reserved for open space, and stormwater detention basin. This project is located in the southwest of the intersection of NW Pryor Road and Highway 150 in Lee's Summit, Missouri

**Figure 1. Location Map**

## 1.1 FEMA Floodplain Classification

FEMA Flood Boundary and Floodway Map Community Panel Number 29095C0531G classifies the Osage property as unshaded "Zone X" Area, which FEMA defines as an area of minimal flood hazard, usually above the 500-year flood level. See Exhibit 1—Floodplain Map in Appendix A for location of site in relation to FEMA flood boundaries.

## 1.2 Soil Classifications

Soil Maps published on the NRCS Web Soil Survey categorize soils on the Osage property as shown in Table 1. See Exhibit 2 in Appendix A for a map of soils on the property.

**Table 1. Soil Classifications**

| Symbol | Name | Slopes | HSG |
|---|---|---|---|
| 10082 | Arisburg-Urban Land Complex | 1-5% | C |
| 10116 | Sampsel Silty Clay Loam | 2-5% | C/D |
| 10117 | Sampsel Silty Clay Loam | 5-9% | C/D |
| 10122 | Sharpsburg Silt Loam | 5-9% | C |

# 2.0 METHODOLOGY

This drainage study has been prepared to evaluate the hydrologic impact generated by development of Osage. The base data for the models prepared for this report has been obtained from available online maps and aerial imagery. Stormwater management is based upon methods and objectives defined in “Kansas City Metropolitan Chapter American Public Works Association (KC-APWA) Section 5600 Storm Drainage Systems & Facilities” (2011).

The following methods were used in this study to model Existing and Proposed Conditions for stormwater runoff:

Hydraflow Hydrographs Extension Version 12

- SCS Unit Hydrograph Method
  - 2-year, 10-year and 100-year Return Frequency Storms
  - AMC II Soil Moisture Conditions
  - 24-Hour SCS Type II Rainfall Distribution
  - SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a – 2-2c)
  - SCS TR-55 methods for determination of Time of Concentration and Travel Time. Where specific data pertaining to channel geometry is not available, “Length & Velocity” estimates for channel flow Travel Time is utilized per Section 5600, KC-APWA Standard Specifications and Design Criteria.

Stormwater runoff models were created for the 2-, 10- and 100-year design storm events. The precipitation depths used in the analysis have been interpolated from the “Technical Paper No. 40 Rainfall Frequency Atlas of the United States” (TP-40) isopluvial maps (May 1961). The following table summarizes the rainfall depths used in this analysis:

**Table 2. Precipitation Depths**

| Return Period | 24-Hour Precipitation Depth (in.) |
|---|---|
| 2-Year (50% Storm) | 3.60 |
| 10-year (10% Storm) | 5.34 |
| 100-Year (1% Storm) | 7.90 |

# 3.0 EXISTING CONDITIONS

To quantify the effects of development of this project, the following areas and points of interest have been used for existing and proposed conditions analysis. See Exhibit 3—Existing Conditions Drainage Map in Appendix A.

**Drainage Area A** represents the area in the southwest corner of the site, which bypasses the proposed detention location. In existing conditions, drainage area A has an area of 5.16 acres.

**Drainage Area B** represents the majority of the site in both the existing and proposed conditions models, which drains to the southeast corner of the site. In existing conditions, drainage area B has an area of 28.57 acres.

**Drainage Area C** is located in the northwest corner of the site and drains north to Highway 150. In existing conditions, drainage area C has an area of 11.27 acres.

Three points of interest were chosen for comparison between existing and proposed conditions based on the three points of discharge from the site. These points can be found in both Exhibits 3 and 4 in Appendix A.

**Point of Interest A1** represents the southwest corner of the site and compares drainage area A for both models.

**Point of Interest B1** represents a point near the southeast corner of the site, just upstream of the triple 30-inch CMP culverts crossing NW Pryor Road. Discharge to this point was compared between drainage area B in the existing conditions model and drainage areas B1 and B2 in the proposed conditions model at the outlet of the detention basin. Drainage area B2 bypasses the basin; flows from drainage areas B1 and B2 were combined before comparison with Existing Conditions. See Exhibit—4 Proposed Conditions Drainage Map and Section 4.0 of this report for a more detailed discussion of the Proposed Conditions drainage areas.

**Point of Interest C1** represents the northwest corner of the site and compares drainage area C for existing and proposed conditions.

**Bypass Area A** was included in the model to account for area that that does not pass through the site but drains to the culvert under NW Pryor Road near the southeast corner of the development. This area was included in the model to calculate tailwater elevations for the proposed detention basin.

The following tables summarize the results of the Existing Conditions analysis. The proposed conditions data is compared to these results in Sections 4 of this report. Refer to Appendix B for output and a schematic for the existing conditions model and detailed calculations for the time of concentration.

Curve Numbers were determined for existing and proposed conditions as shown in Table 3.

**Table 3. Curve Numbers**

| Land Use | HSG* | CN |
|---|---|---|
| Straight Row Crop | C | 85 |
| Straight Row Crop | D | 89 |
| Multi-Family Residential | C | 90 |
| Multi-Family Residential | D | 92 |
| Pasture | C | 79 |
| Pasture | D | 84 |
| Paved Open Ditches with ROW | C | 92 |
| Paved Open Ditched with ROW | D | 93 |

***Hydrologic Soil Group**

**Table 4. Existing Conditions Area Data**

| Area Name | Onsite Area (ac.) | Offsite Area (ac.) | Total Area (ac.) | $T_C$ (hr.) | Weighted CN |
|---|---|---|---|---|---|
| A | 2.10 | 3.06 | 5.16 | 0.33 | 82 |
| B | 25.26 | 3.31 | 28.57 | 0.36 | 84 |
| C | 4.02 | 7.25 | 11.27 | 0.33 | 83 |
| Bypass A | 0 | 2.86 | 2.86 | 0.18 | 87 |

**Table 5. Existing Conditions Point of Interest Peak Flow Rates**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| A1 | 11.1 | 20.2 | 33.9 |
| B1 | 61.8 | 109 | 179 |
| C1 | 25.4 | 45.3 | 75.2 |

Per APWA Section 5608.4 and the City of Lee's Summit criteria, the performance criteria for comprehensive control is to provide detention to limit peak flow rates at downstream points of interest to maximum release rates:

- 50% storm peak rate less than or equal to 0.5 cfs per site acre
- 10% storm peak rate less than or equal to 2.0 cfs per site acre
- 1% storm peak rate less than or equal to 3.0 cfs per site acre

Extended detention of the 90% mean annual event is also required for comprehensive control per APWA Section 5608.4.

Allowable release rates were calculated for the points of interest, allowing that offsite peak discharges would be permitted to bypass the detention. Offsite bypass peak flow rates were calculated as a percentage of the existing conditions, relating to the percentage of offsite area flowing to each point. The release rates for the proposed development on the development site were calculated based on the detention criteria. The development release rates were added to the bypass peak flow rates to calculate an allowable peak flow rate for each point of interest as follows.

**Table 6. Point of Interest Onsite Area**

| Point of Interest | Total Area (ac) | Onsite Area (ac) | Percent Onsite |
|---|---|---|---|
| A1 | 5.16 | 2.10 | 40.7% |
| B1 | 28.57 | 25.26 | 88.4% |
| C1 | 11.27 | 4.02 | 35.7% |

**Table 7. Allowable Peak Flow Rates**

| Point of Interest | Allowable 2-Year Q (cfs) | Allowable 10-Year Q (cfs) | Allowable 100-Year Q (cfs) |
|---|---|---|---|
| A1 | 7.6 | 16.0 | 26.1 |
| B1 | 19.8 | 63.2 | 96.5 |
| C1 | 18.3 | 37.1 | 60.3 |

# 4.0 PROPOSED CONDITIONS

## 4.1 Effects of Development

The proposed conditions analysis assumes completion of the entire Osage development. The modeled subareas and points of interest are similar to the existing conditions model. However, throughout the site, some shifting of ridgelines will occur accommodating proposed detention facilities and anticipated grading activities, which will change the relative areas draining to each point of interest. The following is a summary of the proposed conditions drainage areas, see Exhibit 4—Proposed Conditions Drainage Map in Appendix A.

**Drainage Area A** in proposed conditions has an area of 0.43 acres. Proposed grading shifts 4.72 acres from drainage area A to drainage area B1.

**Drainage Area B1** in proposed conditions has an area is 33.54 acres and will drain to the proposed detention basin. Drainage area from existing conditions is shifted from drainage areas A and C to area B1.

**Drainage Area B2** was previously part of drainage area B in existing conditions. This area was separated in the proposed conditions model because it bypasses the detention basin. For

consistency, the sum of drainage areas B1 and B2 were compared at the same point of interest as drainage area B in existing conditions. Drainage Area B2 has an area of 2.73 acres.

**Drainage Area C** in proposed conditions has a drainage area of 8.30 acres. Proposed grading shifts area from drainage area C to drainage area B1.

The analysis provided in Section 3 established existing conditions of the development's drainage areas and analysis in this section will provide guidance for configuration of detention basin to meet the objectives established in Section 3.

The following tables summarize the results of the proposed conditions analysis. Tables 9 and 10 assume no detention is provided, to demonstrate the effects of development for each drainage area. Refer to Appendix C for output from and a schematic of the proposed conditions Hydraflow Hydrographs model.

**Table 8. Proposed Conditions Area Data**

| Area Name | Area (ac.) | $T_C$ (hr.) | Weighted CN |
|---|---|---|---|
| A | 0.43 | 0.10 | 91 |
| B1 | 33.54 | 0.35 | 88 |
| B2 | 2.73 | 0.10 | 90 |
| C | 8.30 | 0.32 | 86 |
| Bypass A | 2.86 | 0.18 | 87 |

**Table 9. Proposed (No Detention) Conditions Point of Interest Peak Flow Rates**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| A1 | 1.7 | 2.8 | 4.3 |
| B1 | 91.6 | 152.0 | 240.0 |
| C1 | 21.0 | 35.9 | 57.9 |

The following table compares the results of the proposed conditions analysis to the existing conditions from Section 3 at the points of interest. Negative values indicate a reduction in peak flow rate, while positive values indicate an increase. Without detention, flow rates will increase at point B1, but decrease for A1 and C1. The decrease in flow rates at A1 and C1 is due to the proposed changes in grading, which shifts parts of each of these areas to drainage area B1.

**Table 10. Proposed (No Detention) vs. Existing Conditions**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| A1 | -9.4 | -17.4 | -29.6 |
| B1 | 29.8 | 43.0 | 61.0 |
| C1 | -4.4 | -9.4 | -17.3 |

## 4.2 Proposed Detention Facilities

To mitigate the increases in peak flows shown in the previous table and where possible, decrease further to the allowable release rates established in Section 3, detention will be provided for drainage area B1.

The detention facility was placed to capture most of the site runoff and to mitigate increases in peak discharge from the site. The detention facility will be located near the southeast corner of the site and will meet of the requirements outlined in Section 3. It will contain a multistage outlet structure and an independent 160-ft long broad crested weir graded into the east side of the berm. The following points summarize the multistage outlet structure and the emergency spillway:

- The structure itself will be a 5'x5' open-top concrete box with a top elevation of 1017.1, which generally controls the 100-year discharge.
- A 36'' opening is present in the box at an elevation of 1012.6, which generally controls the 10-year and 100-year discharge.
- A 4.5'' orifice is present in the box at the bottom elevation of the pond- 1010.0. This helps control the 90% mean annual storm event. The 2-year discharge is controlled by a combination of the 4.5'' orifice and the 36'' opening.
- The entire structure outlets to a 48'' RCP, which carries the water to Pryor Road.
- The emergency spillway will consist of a 160-ft long broad crested weir set at an elevation of 1018.4.

A 4.5-inch orifice will be set at the bottom of the multi-stage outlet structure to comply with the KC-APWA requirement for 40-hour release of the 90% mean annual event. The total inflow volume from this event is 2.09 acre-feet for this site. This will be released over 40 hours at a rate of 0.63 cfs.

Table 11 includes a summary of the Proposed Detention Facility

Due to constrictions in lot grading, site size limitations, and the relatively small drainage area detention is not planned for drainage area C. The drainage area to this point is reduced from existing conditions with proposed grading. As a result, the peak discharge rates for the 2-, 10-, and 100-year storms are below the existing values shown in Table 5. Table 10 illustrates these reductions. For point C1, the peak discharge values meet the allowable release rates for the 10-year and 100-year storm but exceed the KC-APWA 5600 allowable release rates of 0.5 cfs per

acre for the 2-year storm. A comparison with allowable release rates can be seen in Table 13. To achieve these release rates at point C-1, a small detention facility would need to be placed in the northwest corner of the site. The benefit of installing this detention facility in order to reduce the 2-year peak discharge value by 3.0 cfs is outweighed by the impact the facility would have on the feasibility of the development, especially considering the substantial reduction in peak discharge values already achieved when compared to existing conditions. As such, a waiver is requested for the 2-year storm for point C-1.

**Table 11. Proposed Conditions Detention Flow and Volume Data**

| | Peak Q In (cfs) | TP In (hr) | Peak Q Out (cfs) | TP Out (hr) | Peak W.S.E. (ft) | Stored Volume (ac-ft) |
|---|---|---|---|---|---|---|
| 2-Year | 84.4 | 12.10 | 5.9 | 13.53 | 1014.12 | 4.2 |
| 10-Year | 141.0 | 12.10 | 39.5 | 12.47 | 1015.61 | 6.0 |
| 100-Year | 223.0 | 12.10 | 92.4 | 12.37 | 1017.87 | 9.0 |

## 4.3 Effects of Proposed Detention

The following tables compares the results of the proposed conditions analysis with the detention described above to the existing conditions from Section 3 at the points of interest. In Table 13, negative values indicate a reduction in peak flows, while positive values indicate an increase.

**Table 12. Proposed (with Detention) Point of Interest Peak Flow Rates**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| A1 | 1.7 | 2.8 | 4.3 |
| B1 | 10.3 | 41.4 | 95.7 |
| C1 | 21.3 | 35.9 | 57.9 |

**Table 13. Proposed (with Detention) vs. Allowable Release Rates**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| A1 | -5.9 | -13.2 | -21.8 |
| B1 | -9.5 | -21.8 | -0.9 |
| C1 | 3.0 | -1.2 | -2.4 |

**Table 14. Proposed (with Detention) vs. Existing Conditions**

| Point of Interest | $Q_2$ (cfs) | $Q_{10}$ (cfs) | $Q_{100}$ (cfs) |
|---|---|---|---|
| A1 | -9.4 | -17.4 | -29.6 |
| B1 | -51.5 | -67.6 | -83.3 |
| C1 | -4.1 | -9.4 | -17.3 |

# 5.0 SUMMARY

This stormwater drainage study was prepared to evaluate the hydrologic impact generated by the development of Osage and to provide recommendations for a comprehensive stormwater management plan. The project is a single-family residential development on approximately 36 acres, including a pool and amenity tract and open space which will be reserved for detention.

Increases in peak flow rates caused by development will be mitigated for all points of discharge through the site through a combination of dry detention and drainage area changes.

# 6.0 CONCLUSIONS AND RECOMMENDATIONS

This proposed stormwater management plan was designed to achieve compliance with current design criteria in effect for the City of Lee's Summit, Missouri; however, a waiver is requested at point of interest C1 for the 2-year storm. A final macro and first plat micro stormwater drainage study will be required with submittal of the first plat of this development.

The results of the analysis demonstrate that the proposed stormwater management plan for the project achieves compliance with design criteria, including extended detention of the 90% mean annual event, along with the requested waiver for drainage area C. We therefore request approval of this Osage Stormwater Drainage Study. This approval is conditional and should be substantiated with each future plat of Osage.

# Osage Development Final/First Plat Micro Stormwater Drainage Study

**Lee's Summit, Missouri - 2020**

**June 2020**

**Olsson Project No. A19-2339**