

# Periodic Run-On and Run-Off Control System Plan CCR Landfill



**Evergy Metro, Inc.**

**Montrose Generating Station  
Project No. 103871**

**Revision 1  
10/1/2021**

# **Periodic Run-On and Run-Off Control System Plan CCR Landfill**

prepared for

**Evergy Metro, Inc.  
Montrose Generating Station  
Henry County, MO**

**Project No. 103871**

**Revision 1  
10/1/2021**

prepared by

**Burns & McDonnell Engineering Company, Inc.  
Kansas City, Missouri**

## INDEX AND CERTIFICATION

### Evergy Metro, Inc. Periodic Run-On and Run-Off Control System Plan CCR Landfill Project No. 103871

#### Report Index

| <u>Chapter<br/>Number</u> | <u>Chapter Title</u>                         | <u>Number<br/>of Pages</u> |
|---------------------------|--|----------------------------|
| 1.0                       | Background                                   | 2                          |
| 2.0                       | Landfill Run-on and Run-off Controls         | 3                          |
| 3.0                       | Run-off Control for §257.3-3                 | 1                          |
| 4.0                       | Amendment of Run-on and Run-off Control Plan | 1                          |
| 5.0                       | References                                   | 1                          |
| 6.0                       | Record of Revisions                          | 1                          |
| Appendix A                | Supporting Calculations                      | 70                         |

#### Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge and that this periodic run-on and run-off control system plans meet the applicable requirements of 40 CFR 257.81. This report is not intended or represented to be suitable for reuse by the Evergy Metro, Inc. or others without specific verification or adaptation by the Engineer.



Kira E. Wylam  
Kira Wylam, P.E., Missouri PE-2011000966

Date: 10/1/2021

Sep 30 2021 3:42 PM

**TABLE OF CONTENTS**

|  | <u>Page No.</u> |
|--|-----------------|
| <b>1.0 BACKGROUND .....</b>                                  | <b>1-1</b>      |
| 1.1 Facility Information .....                               | 1-1             |
| 1.2 Regulatory Requirements.....                             | 1-1             |
| <b>2.0 LANDFILL RUN-ON AND RUN-OFF CONTROLS.....</b>         | <b>2-1</b>      |
| 2.1 Run-On Controls.....                                     | 2-1             |
| 2.2 Run-Off Controls .....                                   | 2-2             |
| <b>3.0 RUN-OFF CONTROL FOR §257.3-3 .....</b>                | <b>3-1</b>      |
| <b>4.0 AMENDMENT OF RUN-ON AND RUN-OFF CONTROL PLAN.....</b> | <b>4-1</b>      |
| <b>5.0 REFERENCES.....</b>                                   | <b>5-1</b>      |
| <b>6.0 RECORD OF REVISIONS.....</b>                          | <b>6-1</b>      |
| <br><b>APPENDIX A – SUPPORTING CALCULATIONS</b>              |                 |

## LIST OF TABLES

|   | <b><u>Page No.</u></b> |
|---|------------------------|
| Table 2-1: Run-On Control Performance ..... | 2-1                    |
| Table 2-2: Run-Off Control Performance..... | 2-3                    |

**LIST OF ABBREVIATIONS**

| <b><u>Abbreviation</u></b> | <b><u>Term/Phrase/Name</u></b>              |
|----------------------------|---|
| Burns & McDonnell          | Burns & McDonnell Engineering Company, Inc. |
| CCR                        | Coal Combustion Residuals                   |
| CFR                        | Code of Federal Regulations                 |
| CHDPE                      | corrugated high-density polyethylene        |
| CMP                        | corrugated metal pipe                       |
| EPA                        | Environmental Protection Agency             |
| Evergy                     | Evergy Metro, Inc.                          |
| MDNR                       | Missouri Department of Natural Resources    |
| Montrose                   | Montrose Generating Station                 |
| NAVD88                     | North American Vertical Datum of 1988       |
| RCRA                       | Resource Conservations and Recovery Act     |
| U.S.C.                     | United States Code                          |

## 1.0 BACKGROUND

On April 17, 2015, the Environmental Protection Agency (EPA) issued the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of CCR materials generated at coal-fired units. The rule is being administered as part of the Resource Conservation and Recovery Act [RCRA, 42 United States Code (U.S.C.) §6901 et seq.], under Subtitle D.

Evergy Metro, Inc. (Evergy) is subject to the CCR Rule and as such must develop a run-on and run-off control system plan for the CCR Landfill at Montrose Generating Station (Montrose) per 40 Code of Federal Regulations (CFR) §257.81. This report serves as the periodic update to the run-on and run-off control system plan which was originally developed by Kansas City Power & Light (now Evergy) in 2016 with the support of calculations prepared by URS Corporation (URS), which is now known as AECOM. This run-on and run-off control system plan is in addition to, not in place of, any other applicable site permits, environmental standards, or work safety practices.

### 1.1 Facility Information

|                           |   |
|---------------------------|---|
| Name of Facility:         | Montrose Generating Station   |
| Name of CCR Unit:         | CCR Landfill  |
| Name of Operator:         | Evergy Metro, Inc.  |
| Facility Mailing Address: | 400 Southwest Hwy. P<br>Clinton, MO 64735   |
| Location:                 | Approximately ten miles southwest of Clinton, Missouri  |
| Facility Description:     | The Montrose Generating Station has three recently retired coal-fired units which produced fly ash, economizer ash, and bottom ash. When the units were in operation, CCR was either shipped off-site for beneficial use or transported to the landfill for disposal. Related landfill facilities include a groundwater monitoring system, storm water and leachate management systems, and haul/access roads. The southwest portion of the landfill is currently inactive. The northeast portion of the landfill is the current active area. |

### 1.2 Regulatory Requirements

Per 40 CFR §257.81, the run-on and run-off control system plan must contain documentation (including supporting engineering calculations) that the control system has been designed and constructed to meet the applicable requirements of 40 CFR 257.81. The owner or operator of a CCR unit must prepare a written plan that includes the information specified in 40 CFR 257.81 (a) and (b) which is as follows:

- (a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate and maintain:
- (1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and
  - (2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.
- (b) Run-off from the active portion of CCR unit must be handled in accordance with the surface water requirements under §257.3-3.

These items are addressed in Sections 2.0 and 3.0 of this document. Per 40 CFR §257.81(c)(5), Everygy must obtain certification from a qualified professional engineer that the run-on and run-off control system plan, and subsequent updates to the plan, meet the requirements of 40 CFR §257.81. This sealed document serves as that certification.



## 2.0 LANDFILL RUN-ON AND RUN-OFF CONTROLS

The Montrose CCR Landfill is permitted with the Missouri Department of Natural Resources (MDNR). The landfill is approximately 50 acres. The permitted run-on and run-off control system design was prepared by URS Corporation (URS) in December of 2009. The system consists of benches, letdown channels, ditches, culverts, and stormwater ponds which were designed to control the 25-year, 24-hour storm event in accordance with the MDNR rules for Utility Waste Landfills. The MDNR Solid Waste Management Program reviewed and approved the URS design in 2010.

### 2.1 Run-On Controls

The landfill perimeter berm prevents run-on to the landfill and also serves as an access road for the landfill and stormwater ponds. There are two stormwater ponds on-site. The west stormwater pond is also referred to Prater Pond. The east stormwater pond was formerly the North and South Ash Impoundments. A swale which transitions into a 10-foot flat bottom ditch on the outside of the north and east portion of the berm is used to convey run-on around the landfill to the east stormwater pond and the discharge canal. The flat bottom ditch geometry varies between 0.3% and 0.45% bottom slope with side slopes ranging between 3H:1V to 5H:1V. The landfill perimeter berm is bounded by the west stormwater pond to the west which has a normal pool elevation of approximately 755.0 feet (NAVD88) and the discharge canal to the south which has a normal pool elevation of approximately 750.0 feet (NAVD88). The berm was constructed with a top elevation of 762.5 feet (NAVD88).

Table 2-1 presents the excess capacities of the exterior ditch for the 25-year, 24-hour design storm event. For the purposes of this calculation, the ditch was evaluated at several different points which are intended to represent “typical” geometry and flow conditions.

**Table 2-1: Run-On Control Performance**

| Storm Water System Component |  | Calculated Excess Capacity | Units                 |
|------------------------------|--|----------------------------|-----------------------|
| Channels                     | Exterior Ditch (North) – 0.3% slope, 3H:1V side slopes   | >300                       | cubic feet per second |
|                              | Exterior Ditch (Middle) – 0.45% slope, 5H:1V side slopes | 293.7                      | cubic feet per second |
|                              | Exterior Ditch (South) – 0.45% slope, 3H:1V side slopes  | 123.2                      | cubic feet per second |

Supporting calculations are presented in Appendix A. As indicated in Table 2-1 and Appendix A, the landfill has significant excess capacity beyond the design 25-year, 24-hour storm event, therefore the run-on protection system exceeds the requirement to provide protection from run-on from the 24-hour, 25-year storm event.

## 2.2 Run-Off Controls

Run-off is collected in the landfill perimeter ditch within the interior of the landfill perimeter berm on the north, east and south sides of the landfill. The ditch has a bottom width of approximately 10 feet with variable sides slopes (typically 4H:1V). From the perimeter ditch, runoff is directed to either the west stormwater pond or the east stormwater pond. There is a high point along the north ditch so that flow to the west of the high point is directed to the west stormwater ditch and flow to the east is directed to the east stormwater ditch, with a similar configuration at the south perimeter ditch. Flow enters the east stormwater pond through three, 36-inch diameter corrugated high-density polyethylene (CHDPE) culverts. At the west stormwater pond, runoff may drain either from the west landfill slope across the perimeter berm and directly to the stormwater pond, or by way of two, 30-inch diameter corrugated metal pipe (CMP) culverts at the south perimeter ditch and three, 30-inch diameter CMP culverts at the north perimeter ditch. The east stormwater pond has a normal pool elevation of 752.5 feet (NAVD88) and the west stormwater pond has a normal pool elevation of approximately 755.0 feet (NAVD88). Each pond discharges to the discharge canal (and ultimately Montrose Lake) via NPDES-permitted outfalls.

As the landfill is filled, benches and letdown channels aid in directing runoff to the perimeter ditch and the stormwater ponds. Final cover is placed on the established outside slopes of the landfill. The top portions of the landfill that have received interim or final cover are graded in a manner to gravity drain to letdown channels. Active portions of the landfill that have not received cover are contained by a perimeter berm so stormwater will enter the leachate collection system.

Table 2-2 presents the excess capacities of the storm water run-off system components for the current landfill area for the 25-year, 24-hour design storm event. For the purposes of these calculations, it is assumed the active portion of the landfill has received interim cover with all stormwater runoff directed to the letdown channels. The supporting calculations are presented in Appendix A.

**Table 2-2: Run-Off Control Performance**

| Storm Water System Component |  | Calculated Excess Capacity | Units                 |
|------------------------------|--|----------------------------|-----------------------|
| Channels                     | Letdowns   | >300                       | cubic feet per second |
|                              | Perimeter Ditch – southeast (grassed)            | 102.9                      | cubic feet per second |
|                              | Perimeter Ditch – northwest (riprap)             | 6.9                        | cubic feet per second |
| Culverts                     | 3x30" CMP at north ditch to west stormwater pond | 30.9                       | cubic feet per second |
|                              | 2x30" CMP at south ditch to west stormwater pond | 60.4                       | cubic feet per second |
|                              | 3x36" CHDPE to east stormwater pond              | 159.6                      | cubic feet per second |
| Stormwater Ponds             | West Stormwater Pond                             | 1.42                       | feet of freeboard     |
|                              | East Stormwater Pond                             | 2.26                       | feet of freeboard     |

As indicated in Table 2-2 and Appendix A, the landfill has significant excess capacity beyond the design 25-year, 24-hour storm event; therefore, the run-off protection system exceeds the requirement to provide protection from run-off from the 24-hour, 25-year storm event.

### **3.0 RUN-OFF CONTROL FOR §257.3-3**

The run-off from the Montrose CCR Landfill area is routed to one of two stormwater ponds which discharge to NPDES-permitted outfalls. Per the current NPDES permit, discharged water is tested for pollutants and the discharge meets the minimum regulatory requirements of the permit. The facility does not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the NPDES under Section 402 of the Clean Water Act, and therefore meets the requirements of 40 CFR 257.81(b).

#### **4.0 AMENDMENT OF RUN-ON AND RUN-OFF CONTROL PLAN**

The owner or operator may amend the written run-off and run-on control system plan at any time provided the revised plan is placed in the facility's operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and runoff control system plan whenever there is a change in conditions that would substantially affect the written plan in effect. Additionally, the owner or operator of the CCR unit must prepare periodic run-on and runoff control system plans every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan.

The owner or operator may complete any required plan prior to the required deadline provided the completed plan is placed into the facility's operating record within a reasonable amount of time.

A written certification from a qualified professional engineer that the initial and any amendment of the written run-on and run-off control system plan meets the requirements of §257.81 must be obtained. Plan changes will be documented using the Revision History which follows this Plan. Changes to this Plan will be certified by a Qualified Professional Engineer.

## 5.0 REFERENCES

1. U.S. Environmental Protection Agency, Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments, 40 CFR §257, Federal Register 80, Subpart D, April 17, 2015.
2. Missouri Department of Natural Resources, Code of State Regulations, Rules of Department of Natural Resources, Division 80, Solid Waste Management, Chapter 11, Utility Waste Landfill, 1997.
3. Burns & McDonnell Engineering Company, Inc., Topographic Survey, January 2019.
4. McLaughlin-Mueller, Inc., Planimetric Feature Survey, January 2019.
5. Boundary & Construction Surveying Inc., Contact Water Settling Pond (West Stormwater Pond) Topographic Survey, July 2020.
6. Boundary & Construction Surveying Inc., Ash Pond (East Stormwater Pond) Topographic Survey, August 2020.

**6.0 RECORD OF REVISIONS**

| <b>Revision Number</b> | <b>Date</b> | <b>Revisions Made</b> | <b>By Whom</b>                         |
|------------------------|-------------|-----------------------|--|
| 0                      | 10/17/2016  | Initial Issue         | Kansas City Power & Light (now Evergy) |
| 1                      | 10/01/2021  | Periodic Update       | Burns & McDonnell                      |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |
|                        |             |                       |  |

## **APPENDIX A – SUPPORTING CALCULATIONS**





June 16, 2021

Evergy Metro, Inc.

## **Supporting Calculations for the Montrose CCR Landfill Periodic Run-on and Run-off Control System Plan**

Burns & McDonnell (BMcD) has been retained by Evergy Metro, Inc. (Evergy) to provide engineering support for the periodic update to the Run-on and Run-off Control System Plan for the Montrose CCR Landfill which is required as part of the Federal Coal Combustion Residuals Rule (CCR Rule). Calculations were prepared to evaluate the capacity of the landfill run-on and run-off controls which include the stormwater ponds, letdown channels, perimeter ditches, and culverts which convey flow from the ditches to the ponds. Additionally, calculations were prepared to evaluate the capacity of the exterior ditch which is used for run-on control. HydroCAD 10.00-24 (HydroCAD) was used to model the drainage areas for each of these features in order to determine peak flows and/or peak water surface elevations.

Ground cover types and flow paths were input into HydroCAD to compute the time of concentration, weighted curve numbers, and post-closure peak flows using the SCS Unit Hydrograph method. Cover type curve numbers were selected within the HydroCAD model based on the hydrologic soil group. According to National Resource Conservation Service (NRCS) Web Soil Survey, the majority of the site is rated as soil group C/D; therefore, group D was used. Cover types in the drainage areas include grass, gravel, and water (impervious). The time of concentration ( $T_c$ ) was input based on the flow path for the hydraulically most distant point within each watershed. A minimum  $T_c$  of 6-minutes was used for all drainage areas. The 25-year, 24-hour storm depth was obtained from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server. The design storm depth is 6.50 inches.

FlowMaster was used to determine the full flow capacity of the culvert and channel features. Channel and culvert geometry were determined using existing survey data and design drawings. Channel features were evaluated at typical cross section locations.

The calculations are broken into three groupings: ponds, culverts, and channels. A list of the calculations attached to this memorandum is as follows:

- Attachment 1 – Calculation Summary Sheet and Reference Documents
- Attachment 2 – Pond Calculations:
  - SK-001 – Pond Drainage Areas
  - HydroCAD Report for 25-year, 24-hour storm event
- Attachment 3 – Culvert Calculations:
  - SK-002 – Culvert Drainage Areas
  - HydroCAD Report for 25-year, 24-hour storm event

- FlowMaster Worksheet for 3x30” CMP at north ditch to west stormwater pond
- FlowMaster Worksheet for 2x30” CMP at south ditch to west stormwater pond
- FlowMaster Worksheet for 3x36” CHDPE at east ditch to east stormwater pond
- Attachment 4 – Channel Calculations:
  - SK-003 – Channel Drainage Areas
  - HydroCAD Report for 25-year, 24-hour storm event
  - FlowMaster Worksheet for Letdown Channel
  - FlowMaster Worksheet for Riprapped Perimeter Ditch
  - FlowMaster Worksheet for Grassed Perimeter Ditch
  - FlowMaster Worksheet for Exterior Ditch (North)
  - FlowMaster Worksheet for Exterior Ditch (Middle)
  - FlowMaster Worksheet for Exterior Ditch (South)

### Results

The calculated peak values were compared with the full capacity values in order to determine excess capacity for each of the stormwater run-off and run-on control features. A summary of the calculated excess capacities is included in Table 1 and Table 2 for the run-off and run-on controls, respectively.

**Table 1: Stormwater Run-on Controls – Calculated Excess Capacity**

| Storm Water System Component |  | Capacity | Peak Flow<br>(25-yr, 24-<br>hr event) | Calculated<br>Excess<br>Capacity | Units |
|------------------------------|--|----------|---------------------------------------|----------------------------------|-------|
| Channels                     | Exterior Ditch – North<br>(0.3% slope, 3H:1V side<br>slopes)   | 416.4    | 80.0                                  | 336.5                            | cfs   |
|                              | Exterior Ditch – Middle<br>(0.45% slope, 5H:1V side<br>slopes) | 375.2    | 81.5                                  | 293.7                            | cfs   |
|                              | Exterior Ditch – South<br>(0.45% slope, 3H:1V side<br>slopes)  | 242.8    | 119.6                                 | 123.2                            | cfs   |

**Table 2: Stormwater Run-off Controls – Calculated Excess Capacity**

| Storm Water System Component |  | Capacity | Peak Flow<br>(25-yr, 24-hr event) | Calculated Excess Capacity | Units           |
|------------------------------|--|----------|-----------------------------------|----------------------------|-----------------|
| Stormwater Ponds             | West Stormwater Pond                             | 758.00   | 756.58                            | 1.42                       | ft of freeboard |
|                              | East Stormwater Pond                             | 756.00   | 753.74                            | 2.26                       | ft of freeboard |
| Culverts                     | 3x30" CMP at north ditch to west stormwater pond | 103.2    | 72.3                              | 30.9                       | cfs             |
|                              | 2x30" CMP at south ditch to west stormwater pond | 82.0     | 21.7                              | 60.4                       | cfs             |
|                              | 3x36" CHDPE to east stormwater pond              | 216.8    | 57.2                              | 159.6                      | cfs             |
| Channels                     | Letdowns   | 433.8    | 30.6                              | 403.3                      | cfs             |
|                              | Perimeter Ditch - Northwest (riprap)             | 81.6     | 74.7                              | 6.9                        | cfs             |
|                              | Perimeter Ditch - Southeast (grassed)            | 160.1    | 57.2                              | 102.9                      | cfs             |

Based on the results of the calculations, the run-off and run-on controls at the Montrose CCR Landfill are adequate for conveying and controlling flows from the 25-year, 24-hour storm event.

**ATTACHMENT 1 – CALCULATION SUMMARY SHEET AND REFERENCE  
DOCUMENTS**



**WORKSHEET TITLE:** Evergy - Montrose Run-On and Run-Off Controls  
**CREATED:** 6/7/2021  
**PERFORMED BY:** A. Myers  
**OBJECTIVE:** Check Montrose CCR Landfill run-on and run-off controls for 25-year, 24-hour storm

**CALCULATION NO.:** C - 001  
**REVISION:** A  
**REVIEWED BY:**

**REFERENCES:**

- 1 Natural Resources Conservation Service (June 1986). TR-55: Urban Hydrology for Small Watersheds.  
Retrieved from : [www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/stelprdb1044171.pdf](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf)
- 2 US Department of Agriculture. (June 2021). Custom soil map for Henry County, MO.  
Retrieved from : <http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>
- 3 National Oceanic and Atmospheric Administration. (June 2021). NOAA Atlas 14, Volume 8, Version 2. [Point precipitation frequency estimates for Clinton, Missouri, USA].  
Retrieved from : [https://hdsc.nws.noaa.gov/hdsc/pfds/pfds\\_map\\_cont.html?bkmrk=mo](https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mo)

**SOFTWARE:**

- 1 HydroCAD 10.00-24 (40 node s/n 08510)
- 2 Bentley FlowMaster Connect Edition

**ASSUMPTIONS:**

- 1 Hydrologic Soil Group C/D, assume type D [Reference 2](#)
- 2 Depth for 25-year, 24-hour storm is 6.50" [Reference 3](#)

**CALCULATIONS:**

Refer to the following documents:

- SK-001, SK-002 and SK-003 for drainage area delineations for the ponds, culverts, and channels, respectively
- see HydroCAD reports for Peak Flow calculations
- see FlowMaster reports for Capacity calculations

**RUN-OFF CONTROLS**

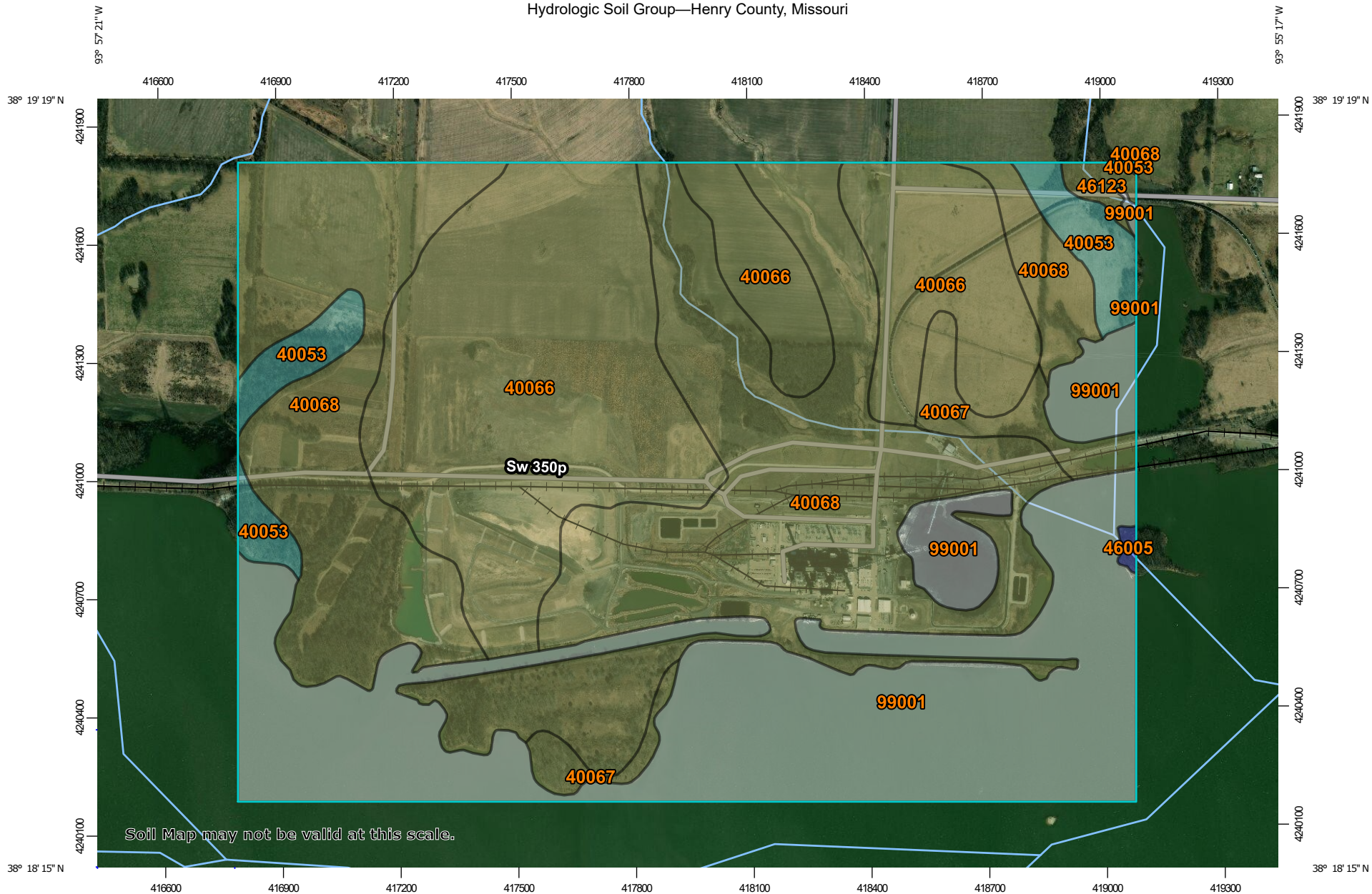
| Storm Water System Component |  | Capacity | Peak Flow (25-yr, 24-hr event) | Calculated Excess Capacity | Units           |
|------------------------------|--|----------|--------------------------------|----------------------------|-----------------|
| Stormwater Ponds             | West Stormwater Pond                             | 758.00   | 756.58                         | 1.42                       | ft of freeboard |
|                              | East Stormwater Pond                             | 756.00   | 753.74                         | 2.26                       | ft of freeboard |
| Culverts                     | 3x30" CMP at north ditch to west stormwater pond | 103.2    | 72.3                           | 30.9                       | cfs             |
|                              | 2x30" CMP at south ditch to west stormwater pond | 82.0     | 21.7                           | 60.4                       | cfs             |
|                              | 3x36" CHDPE to east stormwater pond              | 216.8    | 57.2                           | 159.6                      | cfs             |
| Channels                     | Letdowns   | 433.8    | 30.6                           | 403.3                      | cfs             |
|                              | Perimeter Ditch - Northwest (riprap)             | 81.6     | 74.7                           | 6.9                        | cfs             |
|                              | Perimeter Ditch - Southeast (grassed)            | 160.1    | 57.2                           | 102.9                      | cfs             |

**RUN-ON CONTROLS**

| Storm Water System Component |  | Capacity | Peak Flow (25-yr, 24-hr event) | Calculated Excess Capacity | Units |
|------------------------------|--|----------|--------------------------------|----------------------------|-------|
| Channels                     | Exterior Ditch - North (0.3% slope, 3H:1V side slopes)   | 416.4    | 80.0                           | 336.5                      | cfs   |
|                              | Exterior Ditch - Middle (0.45% slope, 5H:1V side slopes) | 375.2    | 81.5                           | 293.7                      | cfs   |
|                              | Exterior Ditch - South (0.45% slope, 3H:1V side slopes)  | 242.8    | 119.6                          | 123.2                      | cfs   |

Reference 2

Hydrologic Soil Group—Henry County, Missouri



Map Scale: 1:13,800 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

## MAP LEGEND

### Area of Interest (AOI)









 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons





 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Lines


 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Points






 A  
 A/D  
 B  
 B/D

 C  
 C/D  
 D  
 Not rated or not available

### Water Features

 Streams and Canals

### Transportation

 Rails  
 Interstate Highways  
 US Routes  
 Major Roads  
 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: Henry County, Missouri  
 Survey Area Data: Version 26, May 29, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Jun 14, 2017

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



## Hydrologic Soil Group

| Map unit symbol                    | Map unit name  | Rating | Acres in AOI | Percent of AOI |
|------------------------------------|--|--------|--------------|----------------|
| 40053                              | Deepwater silt loam, 2 to 5 percent slopes                       | C      | 30.9         | 3.4%           |
| 40066                              | Hartwell silt loam, 0 to 1 percent slopes                        | C/D    | 255.6        | 27.7%          |
| 40067                              | Hartwell silt loam, 1 to 3 percent slopes, eroded                | C/D    | 24.0         | 2.6%           |
| 40068                              | Hartwell silt loam, 1 to 3 percent slopes                        | C/D    | 361.9        | 39.3%          |
| 46005                              | Verdigris silt loam, 0 to 1 percent slopes, occasionally flooded | B      | 1.1          | 0.1%           |
| 46123                              | Urich silt loam, 1 to 3 percent slopes, occasionally flooded     | C/D    | 4.6          | 0.5%           |
| 99001                              | Water  |        | 243.5        | 26.4%          |
| <b>Totals for Area of Interest</b> |  |        | <b>921.7</b> | <b>100.0%</b>  |

## Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

## Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Higher

Reference 3



**NOAA Atlas 14, Volume 8, Version 2**  
**Location name: Clinton, Missouri, USA\***  
**Latitude: 38.3113°, Longitude: -93.9436°**  
**Elevation: 762.12 ft\*\***  
\* source: ESRI Maps  
\*\* source: USGS



**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffrey Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

[PF\\_tabular](#) | [PF\\_graphical](#) | [Maps & aerals](#)

**PF tabular**

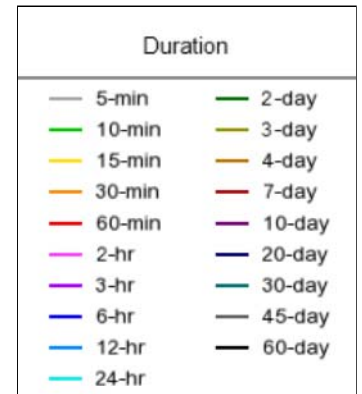
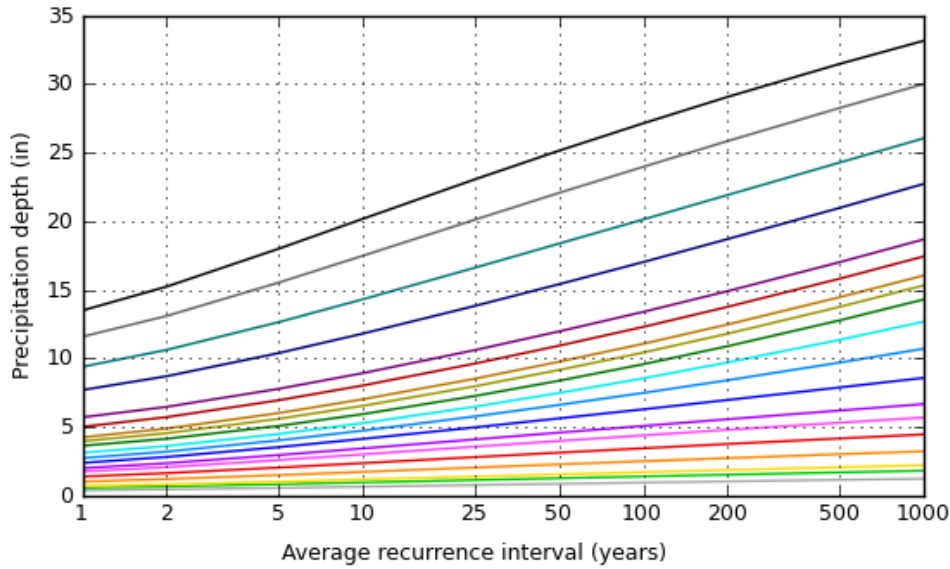
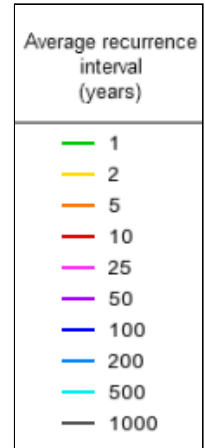
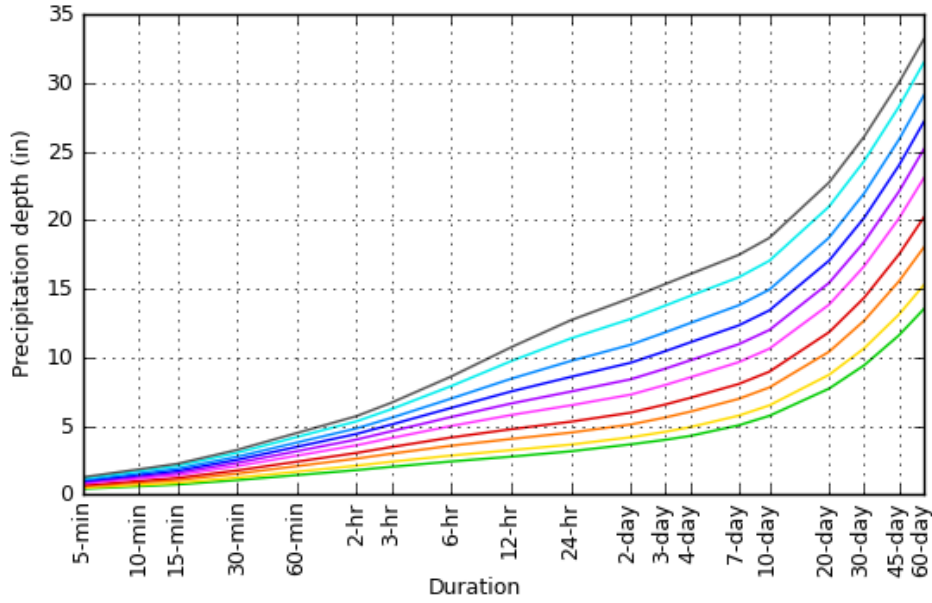
| <b>PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)<sup>1</sup></b> |  |                               |                               |                               |                               |                              |                              |                             |                             |                             |
|--|--|-------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|
| <b>Duration</b>  | <b>Average recurrence interval (years)</b> |                               |                               |                               |                               |                              |                              |                             |                             |                             |
|  | <b>1</b>                                   | <b>2</b>                      | <b>5</b>                      | <b>10</b>                     | <b>25</b>                     | <b>50</b>                    | <b>100</b>                   | <b>200</b>                  | <b>500</b>                  | <b>1000</b>                 |
| <b>5-min</b>   | <b>0.404</b><br>(0.352-0.471)              | <b>0.472</b><br>(0.410-0.551) | <b>0.581</b><br>(0.503-0.680) | <b>0.670</b><br>(0.576-0.787) | <b>0.790</b><br>(0.650-0.951) | <b>0.880</b><br>(0.706-1.08) | <b>0.968</b><br>(0.746-1.21) | <b>1.06</b><br>(0.775-1.36) | <b>1.17</b><br>(0.821-1.54) | <b>1.25</b><br>(0.855-1.68) |
| <b>10-min</b>  | <b>0.592</b><br>(0.515-0.690)              | <b>0.691</b><br>(0.600-0.807) | <b>0.851</b><br>(0.736-0.996) | <b>0.981</b><br>(0.843-1.15)  | <b>1.16</b><br>(0.952-1.39)   | <b>1.29</b><br>(1.03-1.57)   | <b>1.42</b><br>(1.09-1.77)   | <b>1.55</b><br>(1.14-1.99)  | <b>1.71</b><br>(1.20-2.26)  | <b>1.83</b><br>(1.25-2.46)  |
| <b>15-min</b>  | <b>0.722</b><br>(0.628-0.842)              | <b>0.843</b><br>(0.732-0.984) | <b>1.04</b><br>(0.898-1.21)   | <b>1.20</b><br>(1.03-1.41)    | <b>1.41</b><br>(1.16-1.70)    | <b>1.57</b><br>(1.26-1.92)   | <b>1.73</b><br>(1.33-2.16)   | <b>1.89</b><br>(1.39-2.42)  | <b>2.09</b><br>(1.47-2.75)  | <b>2.24</b><br>(1.53-3.00)  |
| <b>30-min</b>  | <b>1.04</b><br>(0.907-1.22)                | <b>1.23</b><br>(1.06-1.43)    | <b>1.52</b><br>(1.31-1.77)    | <b>1.75</b><br>(1.50-2.06)    | <b>2.06</b><br>(1.70-2.48)    | <b>2.30</b><br>(1.84-2.81)   | <b>2.53</b><br>(1.95-3.16)   | <b>2.75</b><br>(2.02-3.53)  | <b>3.04</b><br>(2.13-4.01)  | <b>3.25</b><br>(2.22-4.37)  |
| <b>60-min</b>  | <b>1.41</b><br>(1.22-1.64)                 | <b>1.66</b><br>(1.44-1.94)    | <b>2.06</b><br>(1.78-2.41)    | <b>2.39</b><br>(2.05-2.81)    | <b>2.82</b><br>(2.32-3.40)    | <b>3.15</b><br>(2.53-3.85)   | <b>3.47</b><br>(2.67-4.34)   | <b>3.78</b><br>(2.78-4.85)  | <b>4.18</b><br>(2.94-5.52)  | <b>4.48</b><br>(3.06-6.02)  |
| <b>2-hr</b>  | <b>1.77</b><br>(1.55-2.05)                 | <b>2.10</b><br>(1.83-2.43)    | <b>2.61</b><br>(2.27-3.03)    | <b>3.03</b><br>(2.62-3.53)    | <b>3.59</b><br>(2.96-4.29)    | <b>4.00</b><br>(3.23-4.86)   | <b>4.41</b><br>(3.42-5.48)   | <b>4.81</b><br>(3.56-6.14)  | <b>5.33</b><br>(3.77-6.98)  | <b>5.71</b><br>(3.93-7.62)  |
| <b>3-hr</b>  | <b>2.02</b><br>(1.77-2.32)                 | <b>2.38</b><br>(2.09-2.75)    | <b>2.97</b><br>(2.59-3.44)    | <b>3.46</b><br>(3.00-4.02)    | <b>4.11</b><br>(3.42-4.90)    | <b>4.61</b><br>(3.73-5.57)   | <b>5.10</b><br>(3.97-6.31)   | <b>5.59</b><br>(4.14-7.10)  | <b>6.22</b><br>(4.42-8.13)  | <b>6.69</b><br>(4.62-8.90)  |
| <b>6-hr</b>  | <b>2.40</b><br>(2.12-2.75)                 | <b>2.84</b><br>(2.50-3.25)    | <b>3.55</b><br>(3.12-4.08)    | <b>4.15</b><br>(3.62-4.79)    | <b>4.99</b><br>(4.18-5.94)    | <b>5.65</b><br>(4.61-6.81)   | <b>6.31</b><br>(4.95-7.79)   | <b>6.99</b><br>(5.23-8.86)  | <b>7.90</b><br>(5.66-10.3)  | <b>8.60</b><br>(5.98-11.4)  |
| <b>12-hr</b>   | <b>2.75</b><br>(2.44-3.13)                 | <b>3.23</b><br>(2.86-3.67)    | <b>4.04</b><br>(3.56-4.61)    | <b>4.75</b><br>(4.17-5.44)    | <b>5.79</b><br>(4.90-6.89)    | <b>6.63</b><br>(5.46-7.98)   | <b>7.50</b><br>(5.94-9.25)   | <b>8.43</b><br>(6.36-10.7)  | <b>9.71</b><br>(7.02-12.6)  | <b>10.7</b><br>(7.51-14.1)  |
| <b>24-hr</b>   | <b>3.14</b><br>(2.80-3.55)                 | <b>3.63</b><br>(3.23-4.10)    | <b>4.51</b><br>(4.00-5.10)    | <b>5.30</b><br>(4.67-6.03)    | <b>6.50</b><br>(5.56-7.72)    | <b>7.50</b><br>(6.23-9.01)   | <b>8.57</b><br>(6.84-10.5)   | <b>9.73</b><br>(7.41-12.3)  | <b>11.4</b><br>(8.29-14.7)  | <b>12.7</b><br>(8.95-16.6)  |
| <b>2-day</b>   | <b>3.65</b><br>(3.27-4.09)                 | <b>4.16</b><br>(3.73-4.67)    | <b>5.10</b><br>(4.54-5.73)    | <b>5.96</b><br>(5.28-6.72)    | <b>7.27</b><br>(6.27-8.60)    | <b>8.39</b><br>(7.02-10.0)   | <b>9.59</b><br>(7.72-11.7)   | <b>10.9</b><br>(8.37-13.7)  | <b>12.8</b><br>(9.39-16.5)  | <b>14.3</b><br>(10.2-18.5)  |
| <b>3-day</b>   | <b>3.98</b><br>(3.58-4.44)                 | <b>4.57</b><br>(4.10-5.10)    | <b>5.61</b><br>(5.02-6.28)    | <b>6.56</b><br>(5.83-7.37)    | <b>7.98</b><br>(6.89-9.37)    | <b>9.17</b><br>(7.69-10.9)   | <b>10.4</b><br>(8.42-12.7)   | <b>11.8</b><br>(9.10-14.7)  | <b>13.8</b><br>(10.1-17.6)  | <b>15.3</b><br>(10.9-19.8)  |
| <b>4-day</b>   | <b>4.27</b><br>(3.84-4.74)                 | <b>4.91</b><br>(4.42-5.46)    | <b>6.03</b><br>(5.41-6.73)    | <b>7.04</b><br>(6.27-7.89)    | <b>8.53</b><br>(7.37-9.97)    | <b>9.77</b><br>(8.21-11.5)   | <b>11.1</b><br>(8.96-13.4)   | <b>12.5</b><br>(9.63-15.5)  | <b>14.5</b><br>(10.7-18.5)  | <b>16.1</b><br>(11.5-20.7)  |
| <b>7-day</b>   | <b>5.04</b><br>(4.56-5.57)                 | <b>5.74</b><br>(5.19-6.35)    | <b>6.96</b><br>(6.27-7.72)    | <b>8.05</b><br>(7.20-8.96)    | <b>9.64</b><br>(8.35-11.2)    | <b>10.9</b><br>(9.23-12.8)   | <b>12.3</b><br>(9.99-14.8)   | <b>13.8</b><br>(10.7-17.0)  | <b>15.8</b><br>(11.7-20.0)  | <b>17.4</b><br>(12.5-22.3)  |
| <b>10-day</b>  | <b>5.73</b><br>(5.20-6.31)                 | <b>6.49</b><br>(5.88-7.15)    | <b>7.80</b><br>(7.04-8.61)    | <b>8.94</b><br>(8.03-9.93)    | <b>10.6</b><br>(9.22-12.2)    | <b>12.0</b><br>(10.1-14.0)   | <b>13.4</b><br>(10.9-16.0)   | <b>14.9</b><br>(11.6-18.3)  | <b>17.0</b><br>(12.7-21.5)  | <b>18.7</b><br>(13.5-23.8)  |
| <b>20-day</b>  | <b>7.71</b><br>(7.04-8.43)                 | <b>8.72</b><br>(7.95-9.54)    | <b>10.4</b><br>(9.44-11.4)    | <b>11.8</b><br>(10.7-13.0)    | <b>13.8</b><br>(12.0-15.7)    | <b>15.4</b><br>(13.1-17.8)   | <b>17.0</b><br>(13.9-20.1)   | <b>18.7</b><br>(14.6-22.7)  | <b>21.0</b><br>(15.7-26.2)  | <b>22.7</b><br>(16.5-28.8)  |
| <b>30-day</b>  | <b>9.41</b><br>(8.61-10.2)                 | <b>10.6</b><br>(9.73-11.6)    | <b>12.7</b><br>(11.5-13.8)    | <b>14.3</b><br>(13.0-15.7)    | <b>16.6</b><br>(14.5-18.7)    | <b>18.4</b><br>(15.6-21.0)   | <b>20.1</b><br>(16.5-23.6)   | <b>21.9</b><br>(17.2-26.4)  | <b>24.3</b><br>(18.2-30.1)  | <b>26.1</b><br>(19.0-32.9)  |
| <b>45-day</b>  | <b>11.6</b><br>(10.7-12.6)                 | <b>13.1</b><br>(12.0-14.2)    | <b>15.5</b><br>(14.2-16.9)    | <b>17.5</b><br>(15.9-19.1)    | <b>20.1</b><br>(17.6-22.5)    | <b>22.1</b><br>(18.8-25.1)   | <b>24.0</b><br>(19.7-27.9)   | <b>25.9</b><br>(20.3-31.0)  | <b>28.3</b><br>(21.3-34.8)  | <b>30.0</b><br>(22.0-37.7)  |
| <b>60-day</b>  | <b>13.5</b><br>(12.4-14.6)                 | <b>15.3</b><br>(14.0-16.5)    | <b>18.0</b><br>(16.5-19.5)    | <b>20.2</b><br>(18.4-22.0)    | <b>23.1</b><br>(20.1-25.7)    | <b>25.2</b><br>(21.5-28.4)   | <b>27.1</b><br>(22.3-31.5)   | <b>29.1</b><br>(22.8-34.6)  | <b>31.5</b><br>(23.7-38.6)  | <b>33.2</b><br>(24.4-41.6)  |

<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

[Back to Top](#)

**PF graphical**

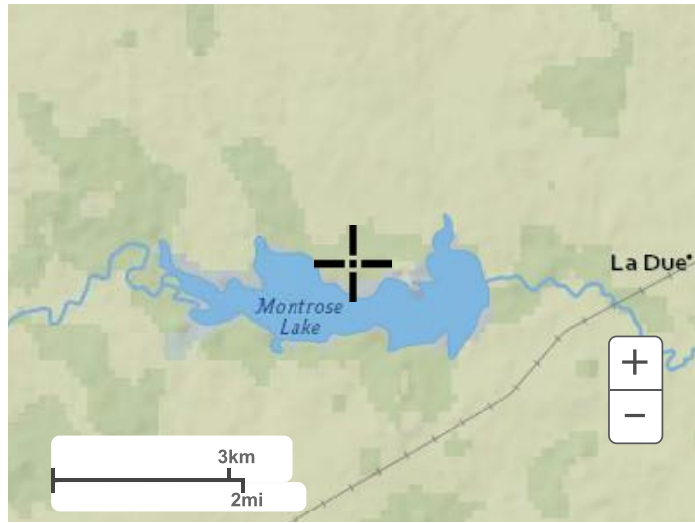
PDS-based depth-duration-frequency (DDF) curves  
 Latitude: 38.3113°, Longitude: -93.9436°



[Back to Top](#)

**Maps & aerials**

**Small scale terrain**



Large scale terrain



Large scale map



Large scale aerial



[Back to Top](#)

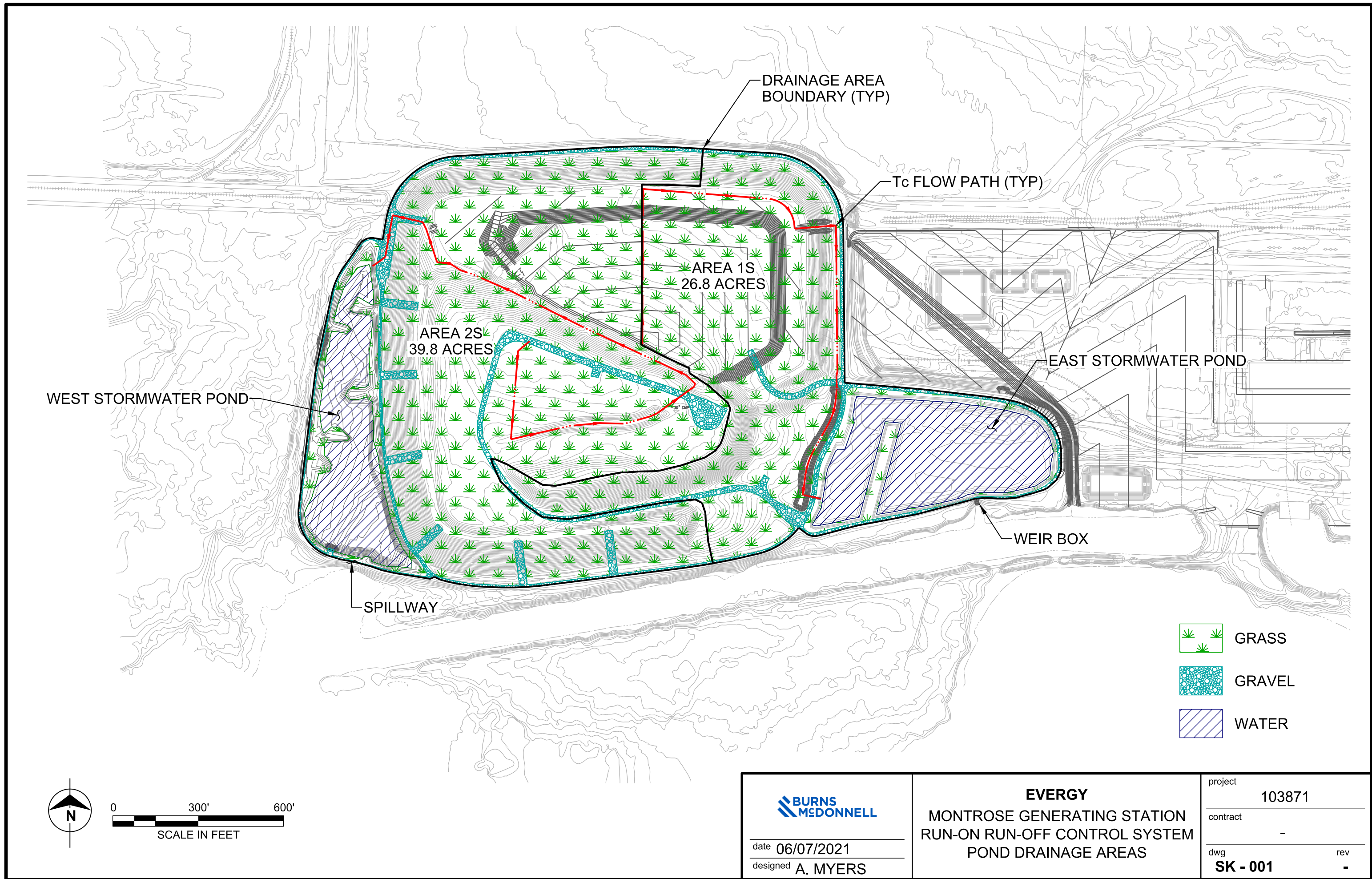
---

[US Department of Commerce](#)  
[National Oceanic and Atmospheric Administration](#)  
[National Weather Service](#)  
[National Water Center](#)  
1325 East West Highway  
Silver Spring, MD 20910  
Questions?: [HDSC.Questions@noaa.gov](mailto:HDSC.Questions@noaa.gov)

[Disclaimer](#)

**ATTACHMENT 2 – POND CALCULATIONS**



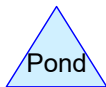
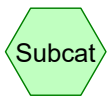
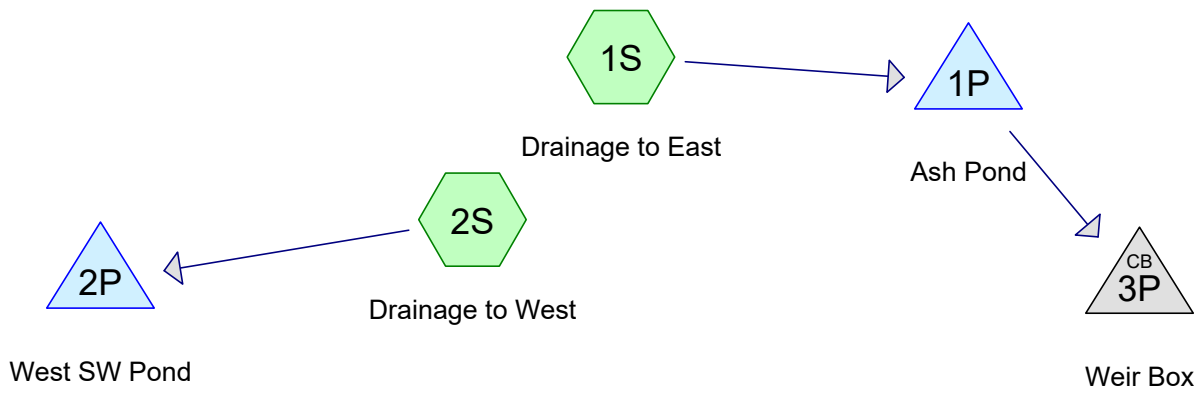


**BURNS  
MCDONNELL**

date 06/07/2021  
designed A. MYERS

**EVERGY**  
MONTROSE GENERATING STATION  
RUN-ON RUN-OFF CONTROL SYSTEM  
POND DRAINAGE AREAS

|          |          |
|----------|----------|
| project  | 103871   |
| contract | -        |
| dwg      | SK - 001 |
| rev      | -        |



# Montrose Landfill RORO

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Printed 6/11/2021

Page 2

## Area Listing (all nodes)

| Area<br>(acres) | CN | Description<br>(subcatchment-numbers)  |
|-----------------|----|--|
| 52.506          | 80 | >75% Grass cover, Good, HSG D (1S, 2S) |
| 4.459           | 91 | Gravel roads, HSG D (1S, 2S)           |
| 9.605           | 98 | Water Surface, HSG D (1S, 2S)          |

**Montrose Landfill RORO**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 3

Time span=0.00-120.00 hrs, dt=0.01 hrs, 12001 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment 1S: Drainage to East**      Runoff Area=26.801 ac   20.39% Impervious   Runoff Depth=4.67"  
Flow Length=2,319'   Tc=42.3 min   CN=84   Runoff=85.40 cfs   10.422 af

**Subcatchment 2S: Drainage to West**      Runoff Area=39.769 ac   10.41% Impervious   Runoff Depth=4.56"  
Flow Length=2,519'   Tc=33.3 min   CN=83   Runoff=145.89 cfs   15.104 af

**Pond 1P: Ash Pond**      Peak Elev=753.74'   Storage=1,769,938 cf   Inflow=85.40 cfs   10.422 af  
24.0" Round Culvert   n=0.012   L=26.7'   S=0.0124 '/'   Outflow=5.69 cfs   9.686 af

**Pond 2P: West SW Pond**      Peak Elev=756.58'   Storage=775,679 cf   Inflow=145.89 cfs   15.104 af  
Outflow=82.70 cfs   11.349 af

**Pond 3P: Weir Box**      Peak Elev=753.37'   Inflow=5.69 cfs   9.686 af  
Outflow=5.69 cfs   9.686 af

**Montrose Landfill RORO**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 4

**Summary for Subcatchment 1S: Drainage to East**

Runoff = 85.40 cfs @ 12.37 hrs, Volume= 10.422 af, Depth= 4.67"

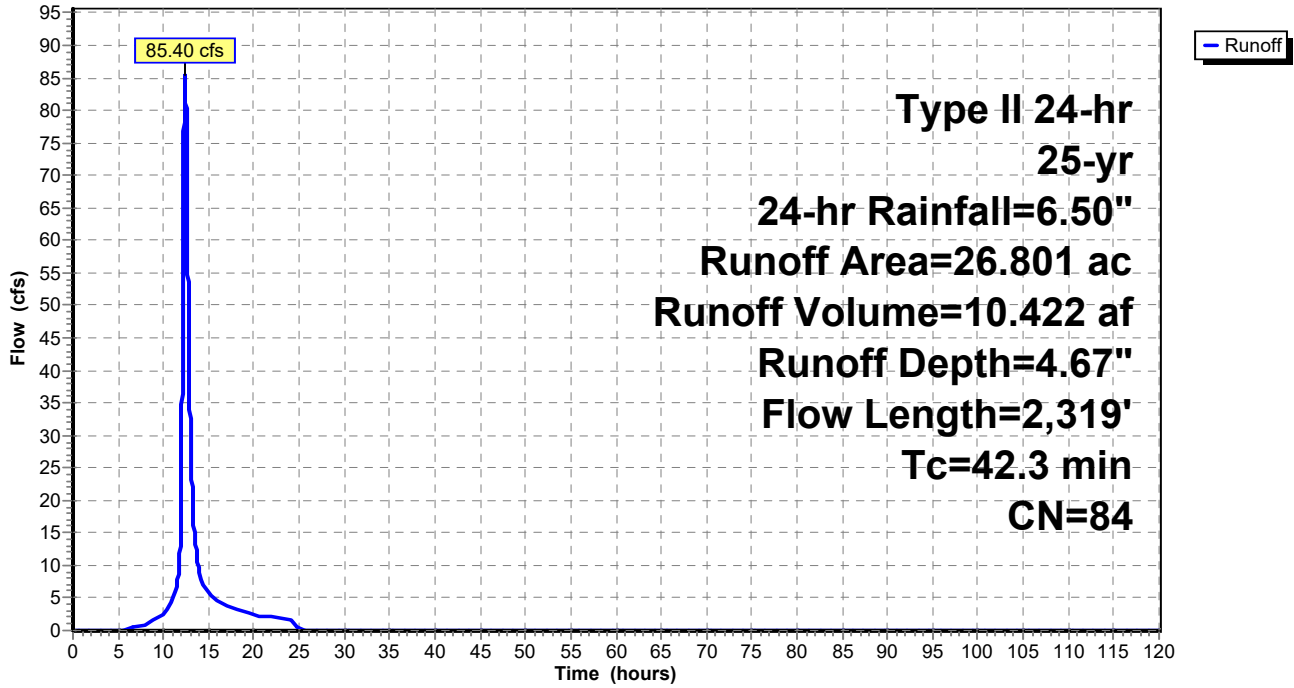
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 19.656    | 80 | >75% Grass cover, Good, HSG D |
| 5.464     | 98 | Water Surface, HSG D          |
| 1.681     | 91 | Gravel roads, HSG D           |
| 26.801    | 84 | Weighted Average              |
| 21.337    |    | 79.61% Pervious Area          |
| 5.464     |    | 20.39% Impervious Area        |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 19.3     | 200           | 0.0125        | 0.17              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"   |
| 3.4      | 347           | 0.0125        | 1.68              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 9.4      | 600           | 0.0050        | 1.06              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 0.6      | 60            | 0.0167        | 1.60              | 9.21           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.069 Riprap, 6-inch           |
| 0.1      | 90            | 0.2500        | 14.26             | 81.99          | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.030 Earth, grassed & winding |
| 5.8      | 525           | 0.0030        | 1.52              | 9.31           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.5 '/' Top.W=14.50'<br>n= 0.030 Earth, grassed & winding |
| 0.3      | 42            | 0.0024        | 2.40              | 16.99          | <b>Pipe Channel,</b><br>36.0" Round Area= 7.1 sf Perim= 9.4' r= 0.75'<br>n= 0.025 Corrugated metal                      |
| 3.3      | 396           | 0.0050        | 2.02              | 11.60          | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.030 Earth, grassed & winding |
| 0.1      | 59            | 0.0100        | 10.22             | 72.26          | <b>Pipe Channel,</b><br>36.0" Round Area= 7.1 sf Perim= 9.4' r= 0.75'<br>n= 0.012                                       |
| 42.3     | 2,319         | Total         |                   |                |   |

Subcatchment 1S: Drainage to East

Hydrograph



**Montrose Landfill RORO**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 6

**Summary for Subcatchment 2S: Drainage to West**

Runoff = 145.89 cfs @ 12.28 hrs, Volume= 15.104 af, Depth= 4.56"

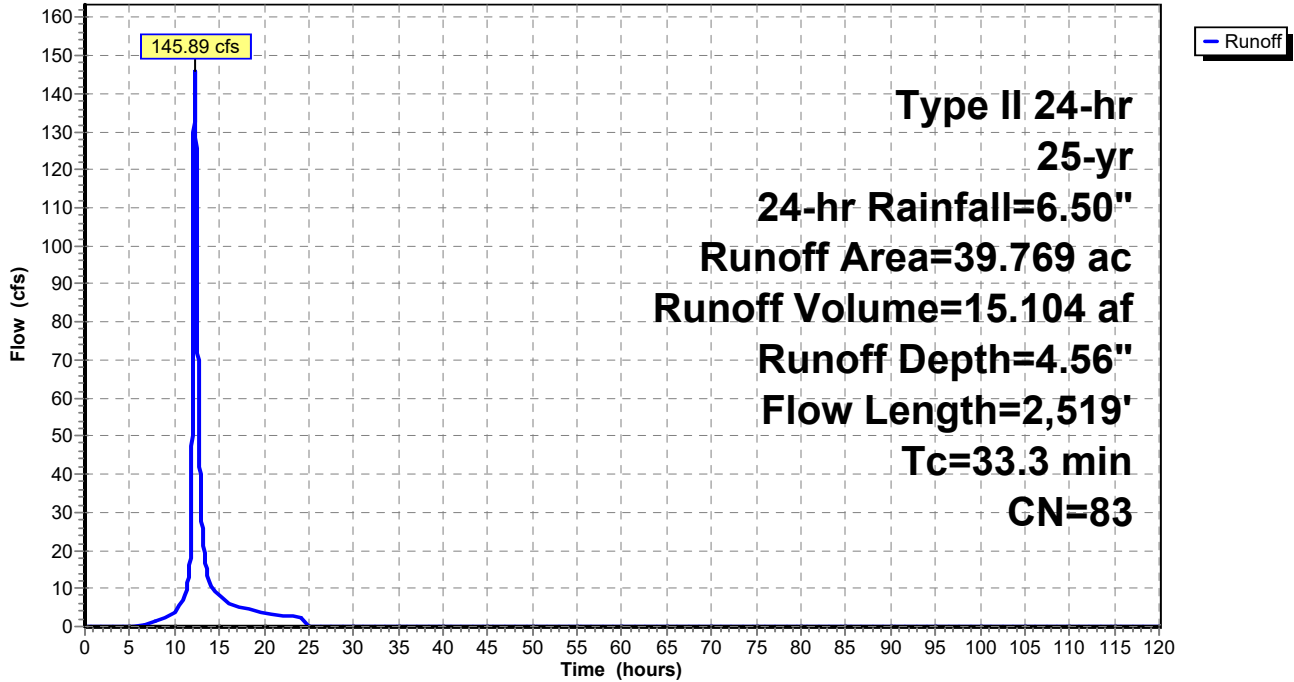
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 2.778     | 91 | Gravel roads, HSG D           |
| 32.850    | 80 | >75% Grass cover, Good, HSG D |
| 4.141     | 98 | Water Surface, HSG D          |
| 39.769    | 83 | Weighted Average              |
| 35.628    |    | 89.59% Pervious Area          |
| 4.141     |    | 10.41% Impervious Area        |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 13.1     | 200           | 0.0333        | 0.26              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"   |
| 1.0      | 165           | 0.0333        | 2.74              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 7.0      | 525           | 0.0020        | 1.25              | 7.51           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.0 '/' Top.W=14.00'<br>n= 0.030 Earth, grassed & winding       |
| 0.5      | 160           | 0.0150        | 5.32              | 26.12          | <b>Pipe Channel,</b><br>30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63'<br>n= 0.025 Corrugated metal                            |
| 6.6      | 1,018         | 0.0100        | 2.56              | 11.54          | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=6.00' D=0.50' Z= 6.0 '/' Top.W=12.00'<br>n= 0.030 Earth, grassed & winding        |
| 0.9      | 150           | 0.0200        | 2.74              | 3.43           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=0.00' D=0.50' Z= 5.0 '/' Top.W=5.00'<br>n= 0.030 Earth, grassed & winding         |
| 0.3      | 108           | 0.2500        | 6.20              | 35.65          | <b>Trap/Vee/Rect Channel Flow, Letdown Channel</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.069 Riprap, 6-inch |
| 3.8      | 150           | 0.0030        | 0.66              | 4.05           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.5 '/' Top.W=14.50'<br>n= 0.069 Riprap, 6-inch                 |
| 0.1      | 43            | 0.0260        | 7.01              | 34.39          | <b>Pipe Channel,</b><br>30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63'<br>n= 0.025 Corrugated metal                            |
| 33.3     | 2,519         | Total         |                   |                |   |

Subcatchment 2S: Drainage to West

Hydrograph





**Montrose Landfill RORO**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 8

**Summary for Pond 1P: Ash Pond**

Inflow Area = 26.801 ac, 20.39% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr event  
 Inflow = 85.40 cfs @ 12.37 hrs, Volume= 10.422 af  
 Outflow = 5.69 cfs @ 15.00 hrs, Volume= 9.686 af, Atten= 93%, Lag= 158.1 min  
 Primary = 5.69 cfs @ 15.00 hrs, Volume= 9.686 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Starting Elev= 752.50' Surf.Area= 242,573 sf Storage= 1,462,393 cf  
 Peak Elev= 753.74' @ 15.01 hrs Surf.Area= 253,956 sf Storage= 1,769,938 cf (307,545 cf above start)  
 Flood Elev= 756.00' Surf.Area= 274,953 sf Storage= 2,367,874 cf (905,480 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)  
 Center-of-Mass det. time= 1,106.2 min ( 1,937.2 - 831.0 )

| Volume              | Invert               | Avail.Storage             | Storage Description  |
|---------------------|----------------------|---------------------------|--|
| #1                  | 740.00'              | 2,367,874 cf              | <b>Custom Stage Data (Prismatic)</b> Listed below (Recalc) |
| Elevation<br>(feet) | Surf.Area<br>(sq-ft) | Inc.Store<br>(cubic-feet) | Cum.Store<br>(cubic-feet)                                  |
| 740.00              | 1,412                | 0                         | 0  |
| 742.00              | 13,000               | 14,412                    | 14,412   |
| 744.00              | 31,877               | 44,877                    | 59,289   |
| 746.00              | 105,186              | 137,063                   | 196,352  |
| 748.00              | 183,668              | 288,854                   | 485,206  |
| 750.00              | 217,701              | 401,369                   | 886,575  |
| 752.00              | 237,979              | 455,680                   | 1,342,255  |
| 754.00              | 256,356              | 494,335                   | 1,836,590  |
| 755.00              | 265,629              | 260,993                   | 2,097,583  |
| 756.00              | 274,953              | 270,291                   | 2,367,874  |

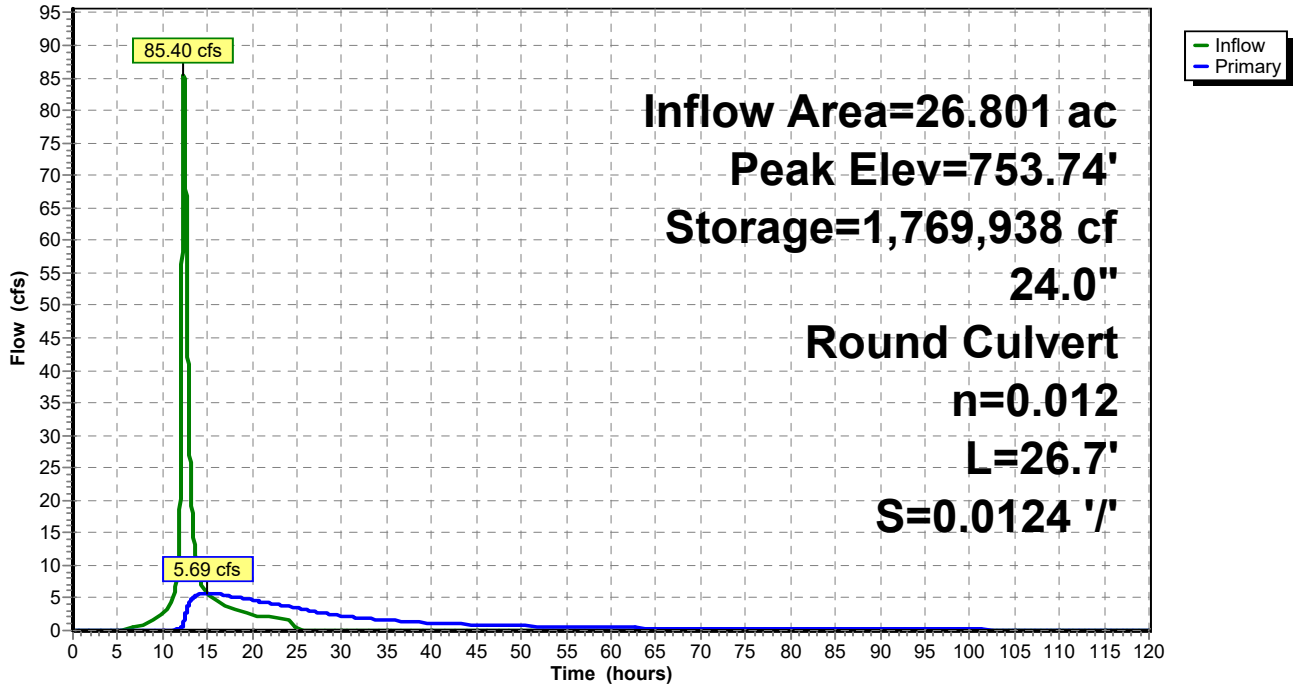
| Device | Routing | Invert  | Outlet Devices  |
|--------|---------|---------|---|
| #1     | Primary | 752.50' | <b>24.0" Round Culvert</b><br>L= 26.7' RCP, groove end w/headwall, Ke= 0.200<br>Inlet / Outlet Invert= 752.50' / 752.17' S= 0.0124 1' Cc= 0.900<br>n= 0.012 Concrete pipe, finished, Flow Area= 3.14 sf |

**Primary OutFlow** Max=5.69 cfs @ 15.00 hrs HW=753.74' TW=753.37' (Dynamic Tailwater)

↑**1=Culvert** (Outlet Controls 5.69 cfs @ 3.98 fps)

Pond 1P: Ash Pond

Hydrograph



**Montrose Landfill RORO**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 10

**Summary for Pond 2P: West SW Pond**

Inflow Area = 39.769 ac, 10.41% Impervious, Inflow Depth = 4.56" for 25-yr, 24-hr event  
 Inflow = 145.89 cfs @ 12.28 hrs, Volume= 15.104 af  
 Outflow = 82.70 cfs @ 12.57 hrs, Volume= 11.349 af, Atten= 43%, Lag= 17.6 min  
 Primary = 82.70 cfs @ 12.57 hrs, Volume= 11.349 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Starting Elev= 755.00' Surf.Area= 146,712 sf Storage= 505,168 cf  
 Peak Elev= 756.58' @ 12.57 hrs Surf.Area= 190,861 sf Storage= 775,679 cf (270,511 cf above start)  
 Flood Elev= 758.00' Surf.Area= 216,607 sf Storage= 1,065,801 cf (560,633 cf above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)  
 Center-of-Mass det. time= 87.9 min ( 913.3 - 825.4 )

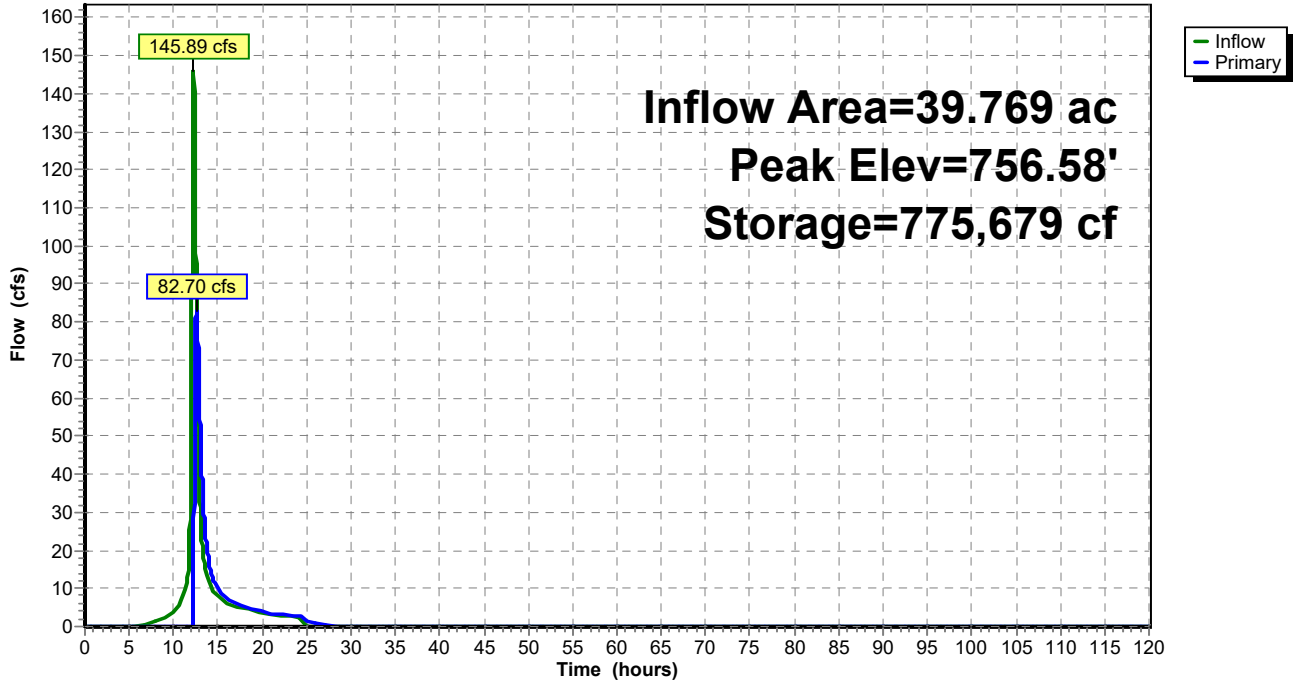
| Volume           | Invert            | Avail.Storage          | Storage Description  |
|------------------|-------------------|------------------------|--|
| #1               | 746.00'           | 1,065,801 cf           | <b>Custom Stage Data (Prismatic)</b> Listed below (Recalc) |
| Elevation (feet) | Surf.Area (sq-ft) | Inc.Store (cubic-feet) | Cum.Store (cubic-feet)                                     |
| 746.00           | 9,274             | 0                      | 0  |
| 748.00           | 24,926            | 34,200                 | 34,200   |
| 750.00           | 36,504            | 61,430                 | 95,630   |
| 752.00           | 65,107            | 101,611                | 197,241  |
| 754.00           | 112,976           | 178,083                | 375,324  |
| 756.00           | 180,447           | 293,423                | 668,747  |
| 758.00           | 216,607           | 397,054                | 1,065,801  |

| Device | Routing | Invert  | Outlet Devices  |
|--------|---------|---------|---|
| #1     | Primary | 756.00' | <b>Custom Weir/Orifice, Cv= 2.62 (C= 3.28)</b><br>Head (feet) 0.00 2.00<br>Width (feet) 55.00 79.00 |

**Primary OutFlow** Max=82.69 cfs @ 12.57 hrs HW=756.58' (Free Discharge)  
 ↑1=Custom Weir/Orifice (Weir Controls 82.69 cfs @ 2.46 fps)

Pond 2P: West SW Pond

Hydrograph



**Montrose Landfill RORO**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 12

**Summary for Pond 3P: Weir Box**

Inflow Area = 26.801 ac, 20.39% Impervious, Inflow Depth > 4.34" for 25-yr, 24-hr event  
 Inflow = 5.69 cfs @ 15.00 hrs, Volume= 9.686 af  
 Outflow = 5.69 cfs @ 15.00 hrs, Volume= 9.686 af, Atten= 0%, Lag= 0.0 min  
 Primary = 5.69 cfs @ 15.00 hrs, Volume= 9.686 af

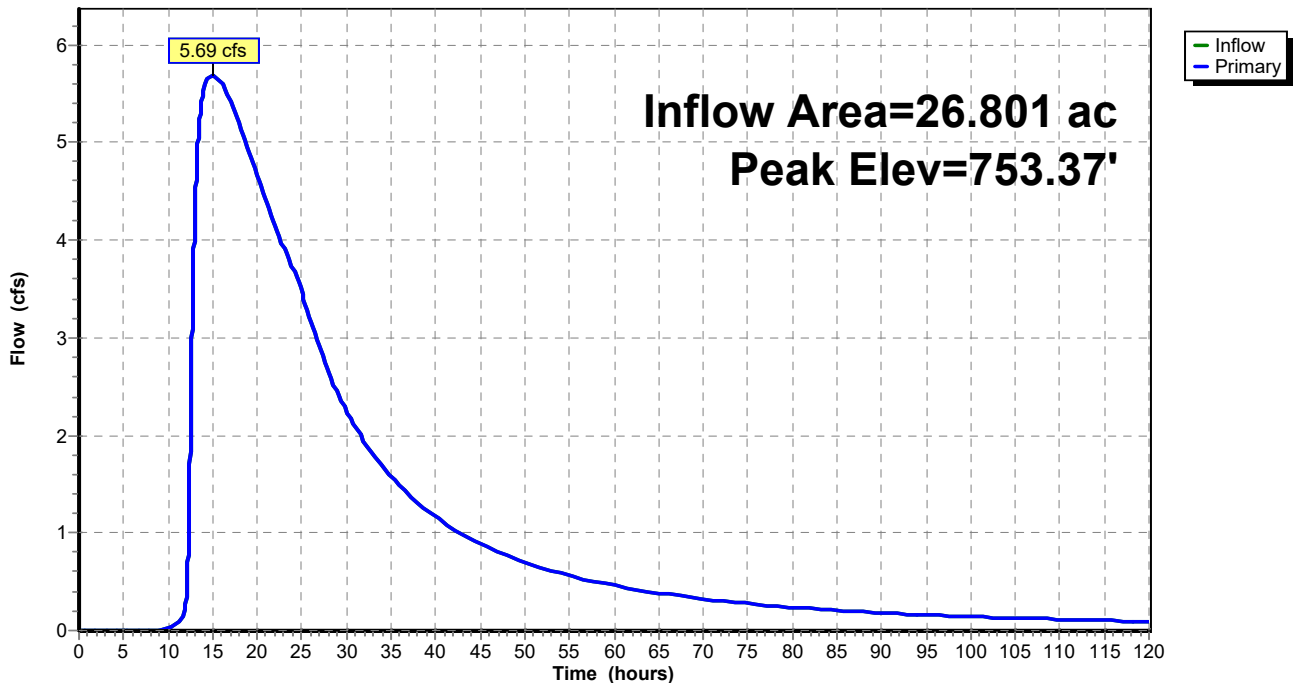
Routing by Dyn-Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Peak Elev= 753.37' @ 15.00 hrs  
 Flood Elev= 755.00'

| Device | Routing | Invert  | Outlet Devices  |
|--------|---------|---------|---|
| #1     | Primary | 752.17' | <b>Custom Weir/Orifice, Cv= 3.30 (C= 4.13)</b><br>Head (feet) 0.00 1.00 1.00 2.17 2.67<br>Width (feet) 0.00 2.00 3.50 3.50 3.50 |

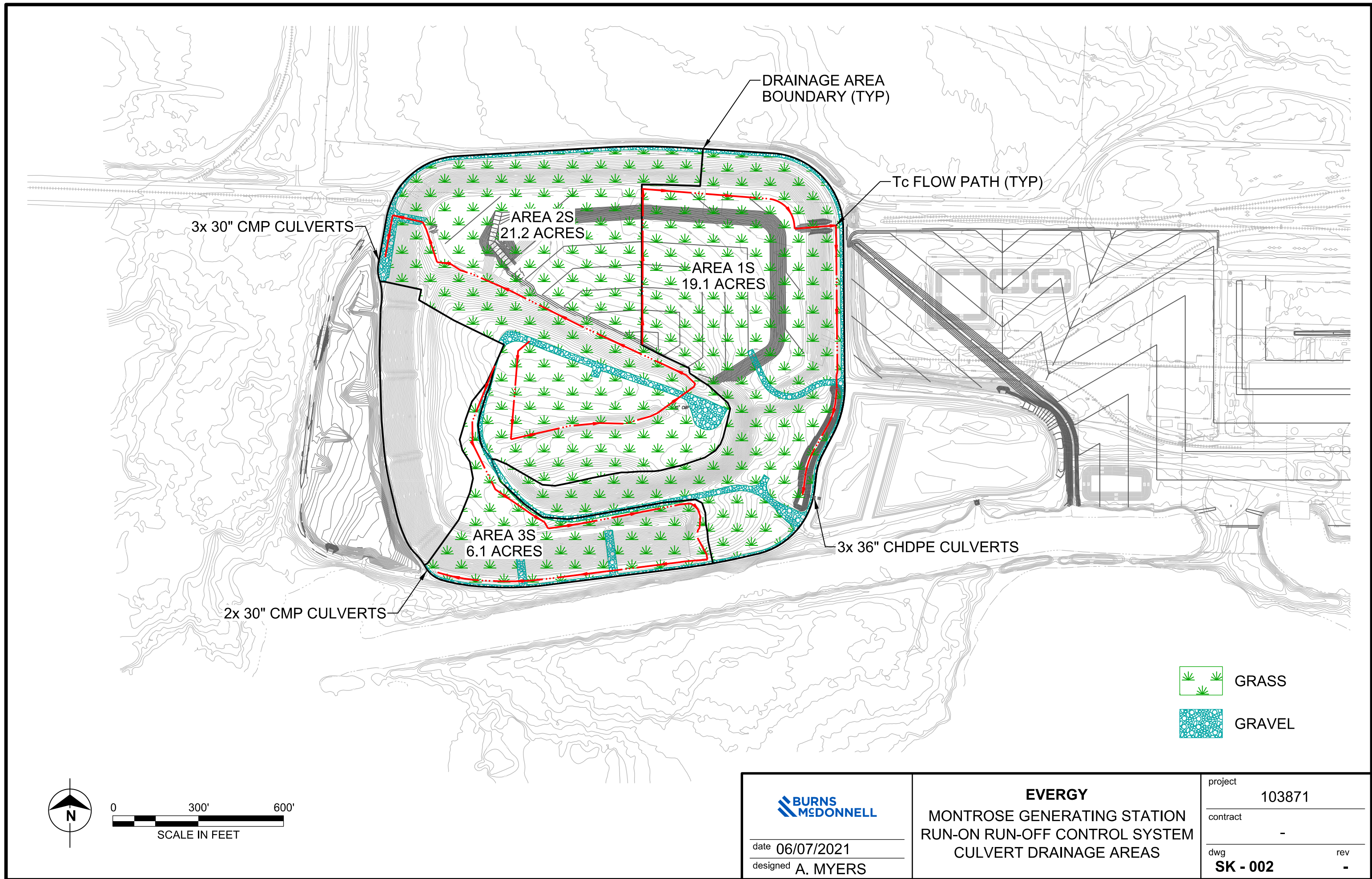
**Primary OutFlow** Max=5.69 cfs @ 15.00 hrs HW=753.37' (Free Discharge)  
 ↳ Custom Weir/Orifice (Weir Controls 5.69 cfs @ 3.35 fps)

**Pond 3P: Weir Box**

Hydrograph



**ATTACHMENT 3 – CULVERT CALCULATIONS**

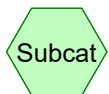
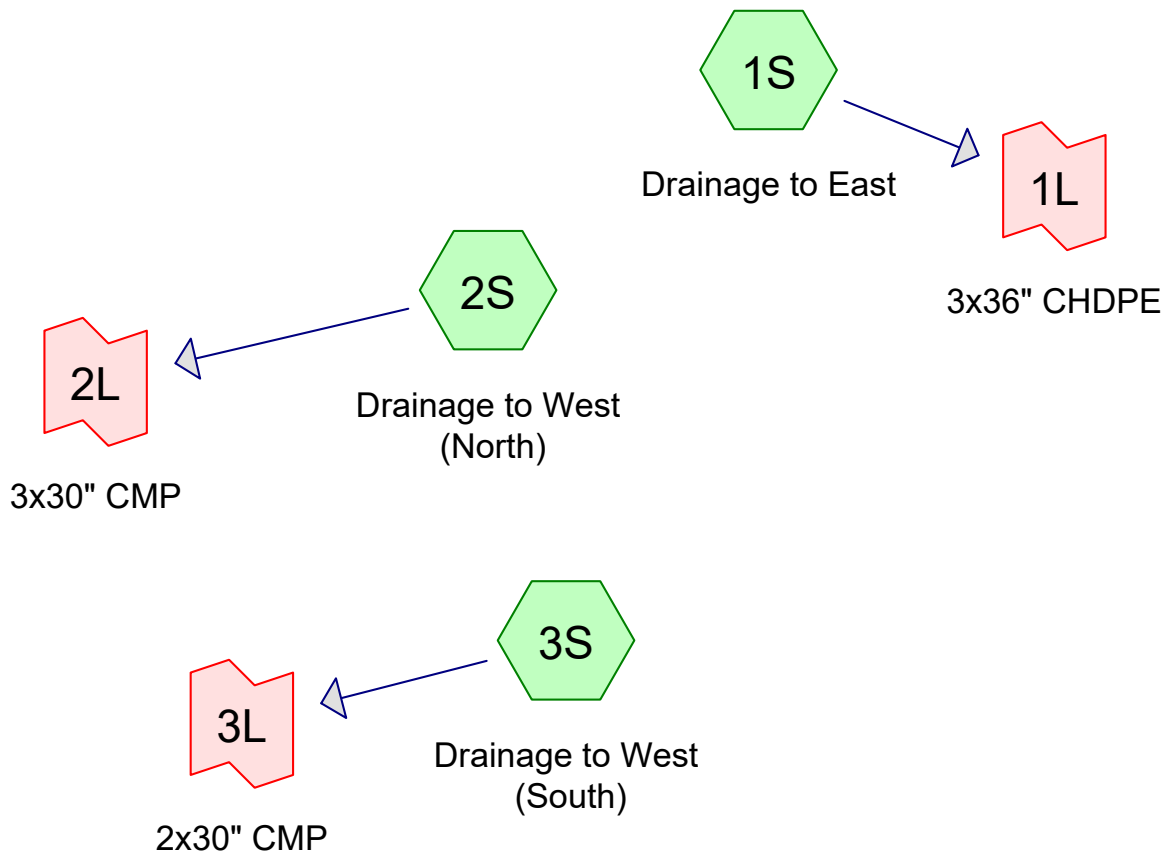


**BURNS  
MCDONNELL**

date 06/07/2021  
designed A. MYERS

**EVERGY**  
MONTROSE GENERATING STATION  
RUN-ON RUN-OFF CONTROL SYSTEM  
CULVERT DRAINAGE AREAS

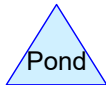
|          |          |
|----------|----------|
| project  | 103871   |
| contract | -        |
| dwg      | SK - 002 |
| rev      | -        |



Subcat



Reach



Pond



Link

**Routing Diagram for Montrose Landfill RORO culverts**  
 Prepared by Burns and McDonnell, Printed 6/11/2021  
 HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC



## Montrose Landfill RORO\_culverts

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Printed 6/11/2021

Page 2

### Area Listing (all nodes)

| Area<br>(acres) | CN | Description<br>(subcatchment-numbers)      |
|-----------------|----|--|
| 43.345          | 80 | >75% Grass cover, Good, HSG D (1S, 2S, 3S) |
| 1.945           | 91 | Gravel roads, HSG D (2S, 3S)               |
| 1.153           | 98 | Water Surface, HSG D (1S)                  |

**Montrose Landfill RORO\_culverts**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 3

Time span=0.00-120.00 hrs, dt=0.01 hrs, 12001 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment 1S: Drainage to East** Runoff Area=19.149 ac 6.02% Impervious Runoff Depth=4.34"  
Flow Length=2,260' Tc=42.2 min CN=81 Runoff=57.15 cfs 6.929 af

**Subcatchment 2S: Drainage to West (North)** Runoff Area=21.210 ac 0.00% Impervious Runoff Depth=4.34"  
Flow Length=2,476' Tc=34.8 min CN=81 Runoff=72.27 cfs 7.675 af

**Subcatchment 3S: Drainage to West (South)** Runoff Area=6.084 ac 0.00% Impervious Runoff Depth=4.34"  
Flow Length=2,390' Tc=32.5 min CN=81 Runoff=21.68 cfs 2.201 af

**Link 1L: 3x36" CHDPE** Inflow=57.15 cfs 6.929 af  
Primary=57.15 cfs 6.929 af

**Link 2L: 3x30" CMP** Inflow=72.27 cfs 7.675 af  
Primary=72.27 cfs 7.675 af

**Link 3L: 2x30" CMP** Inflow=21.68 cfs 2.201 af  
Primary=21.68 cfs 2.201 af

**Montrose Landfill RORO\_culverts**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 4

**Summary for Subcatchment 1S: Drainage to East**

Runoff = 57.15 cfs @ 12.38 hrs, Volume= 6.929 af, Depth= 4.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 17.996    | 80 | >75% Grass cover, Good, HSG D |
| 1.153     | 98 | Water Surface, HSG D          |
| 19.149    | 81 | Weighted Average              |
| 17.996    |    | 93.98% Pervious Area          |
| 1.153     |    | 6.02% Impervious Area         |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 19.3     | 200           | 0.0125        | 0.17              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"   |
| 3.4      | 347           | 0.0125        | 1.68              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 9.4      | 600           | 0.0050        | 1.06              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 0.6      | 60            | 0.0167        | 1.60              | 9.21           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.069 Riprap, 6-inch           |
| 0.1      | 90            | 0.2500        | 14.26             | 81.99          | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.030 Earth, grassed & winding |
| 5.8      | 525           | 0.0030        | 1.52              | 9.31           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.5 '/' Top.W=14.50'<br>n= 0.030 Earth, grassed & winding |
| 0.3      | 42            | 0.0024        | 2.40              | 16.99          | <b>Pipe Channel,</b><br>36.0" Round Area= 7.1 sf Perim= 9.4' r= 0.75'<br>n= 0.025 Corrugated metal                      |
| 3.3      | 396           | 0.0050        | 2.02              | 11.60          | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.030 Earth, grassed & winding |
| 42.2     | 2,260         | Total         |                   |                |   |

**Montrose Landfill RORO\_culverts**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

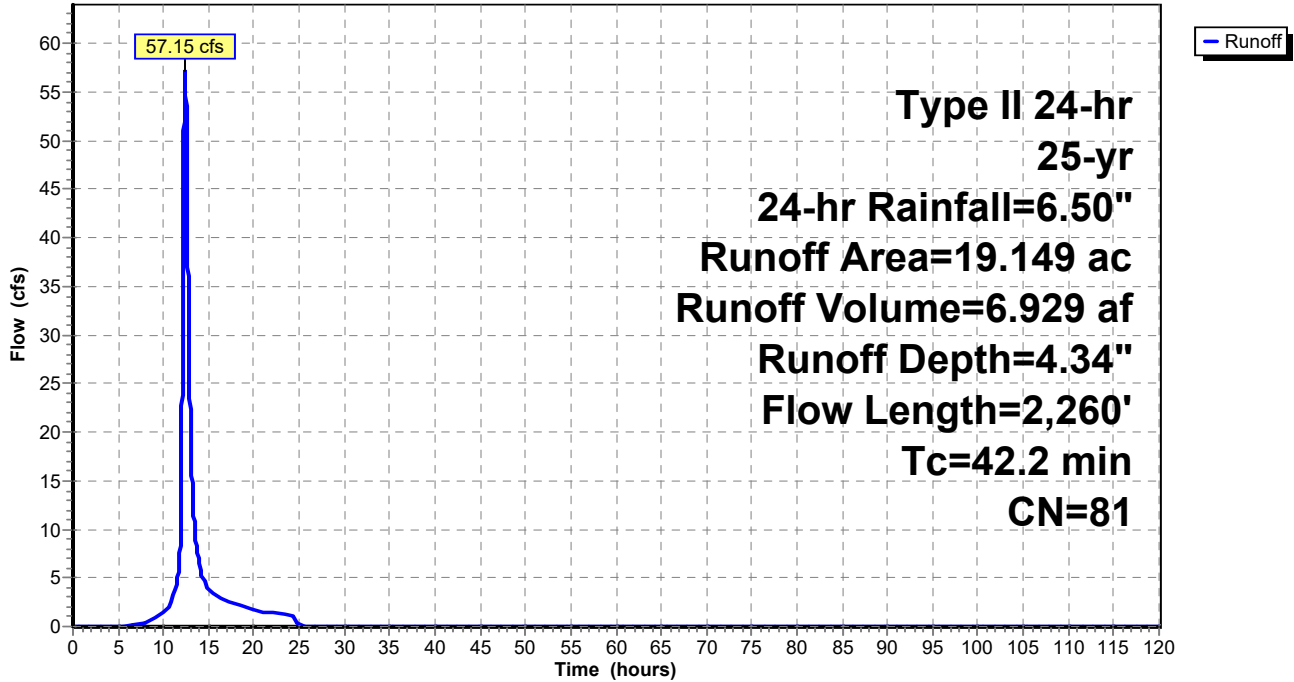
Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 5

**Subcatchment 1S: Drainage to East**

Hydrograph



**Montrose Landfill RORO\_culverts**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 6

**Summary for Subcatchment 2S: Drainage to West (North)**

Runoff = 72.27 cfs @ 12.30 hrs, Volume= 7.675 af, Depth= 4.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 1.344     | 91 | Gravel roads, HSG D           |
| 19.866    | 80 | >75% Grass cover, Good, HSG D |
| 21.210    | 81 | Weighted Average              |
| 21.210    |    | 100.00% Pervious Area         |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 13.1     | 200           | 0.0333        | 0.26              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"   |
| 1.0      | 165           | 0.0333        | 2.74              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 7.0      | 525           | 0.0020        | 1.25              | 7.51           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.0 '/' Top.W=14.00'<br>n= 0.030 Earth, grassed & winding       |
| 0.5      | 160           | 0.0150        | 5.32              | 26.12          | <b>Pipe Channel,</b><br>30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63'<br>n= 0.025 Corrugated metal                            |
| 6.6      | 1,018         | 0.0100        | 2.56              | 11.54          | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=6.00' D=0.50' Z= 6.0 '/' Top.W=12.00'<br>n= 0.030 Earth, grassed & winding        |
| 0.9      | 150           | 0.0200        | 2.74              | 3.43           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=0.00' D=0.50' Z= 5.0 '/' Top.W=5.00'<br>n= 0.030 Earth, grassed & winding         |
| 0.3      | 108           | 0.2500        | 6.20              | 35.65          | <b>Trap/Vee/Rect Channel Flow, Letdown Channel</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.069 Riprap, 6-inch |
| 5.4      | 150           | 0.0030        | 0.46              | 0.52           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=0.00' D=0.50' Z= 4.5 '/' Top.W=4.50'<br>n= 0.069 Riprap, 6-inch                   |
| 34.8     | 2,476         | Total         |                   |                |   |

**Montrose Landfill RORO\_culverts**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

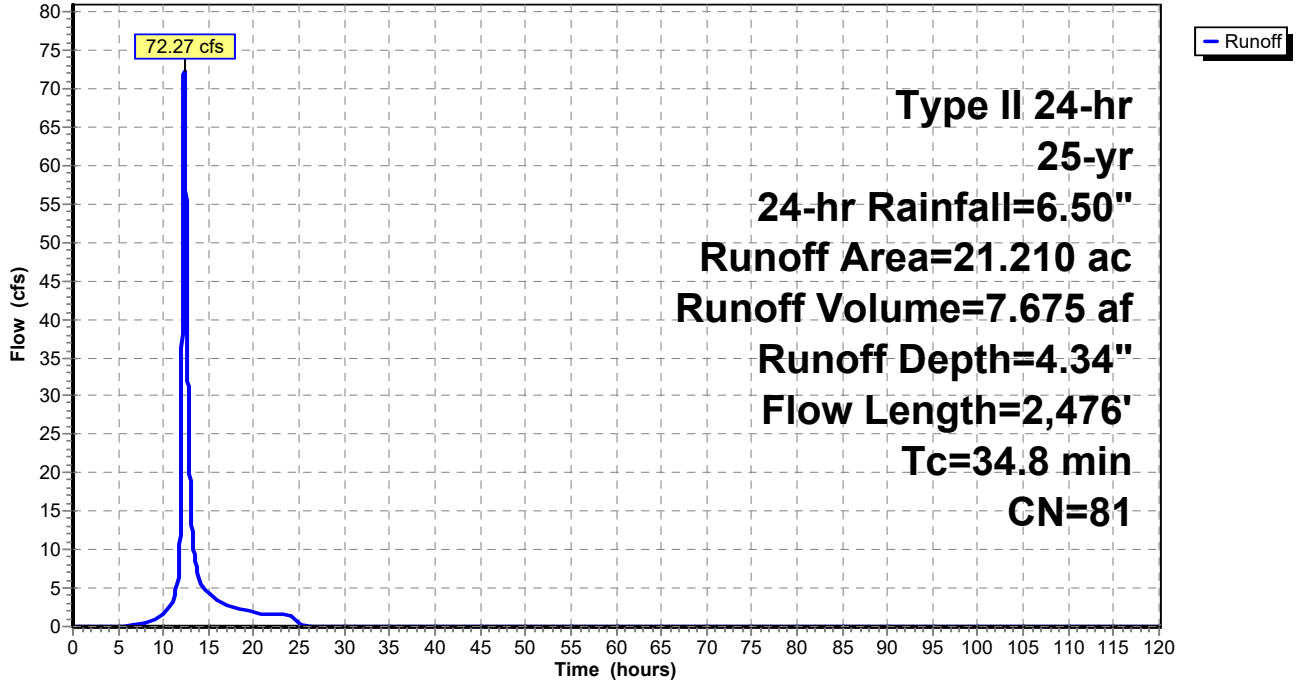
Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 7

**Subcatchment 2S: Drainage to West (North)**

Hydrograph



**Montrose Landfill RORO\_culverts**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 8

**Summary for Subcatchment 3S: Drainage to West (South)**

Runoff = 21.68 cfs @ 12.27 hrs, Volume= 2.201 af, Depth= 4.34"

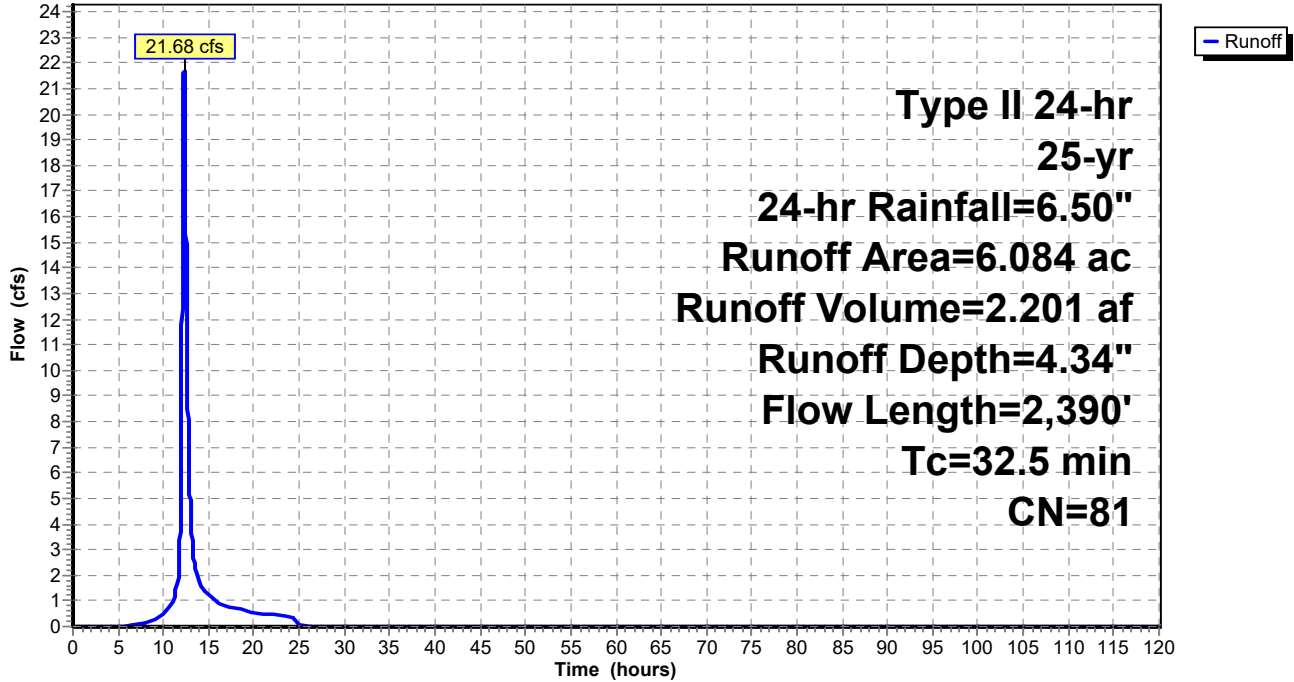
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 0.601     | 91 | Gravel roads, HSG D           |
| 5.483     | 80 | >75% Grass cover, Good, HSG D |
| 6.084     | 81 | Weighted Average              |
| 6.084     |    | 100.00% Pervious Area         |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 13.6     | 200           | 0.0300        | 0.24              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"   |
| 4.1      | 368           | 0.0100        | 1.50              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 0.9      | 134           | 0.0300        | 2.60              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 3.2      | 646           | 0.0300        | 3.34              | 3.34           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=0.00' D=0.50' Z= 4.0 '/' Top.W=4.00'<br>n= 0.030 Earth, grassed & winding   |
| 0.3      | 85            | 0.1000        | 4.74              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 0.8      | 75            | 0.0100        | 1.50              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 9.6      | 882           | 0.0030        | 1.53              | 9.20           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.0 '/' Top.W=14.00'<br>n= 0.030 Earth, grassed & winding |
| 32.5     | 2,390         | Total         |                   |                |   |

Subcatchment 3S: Drainage to West (South)

Hydrograph





**Montrose Landfill RORO\_culverts**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 10

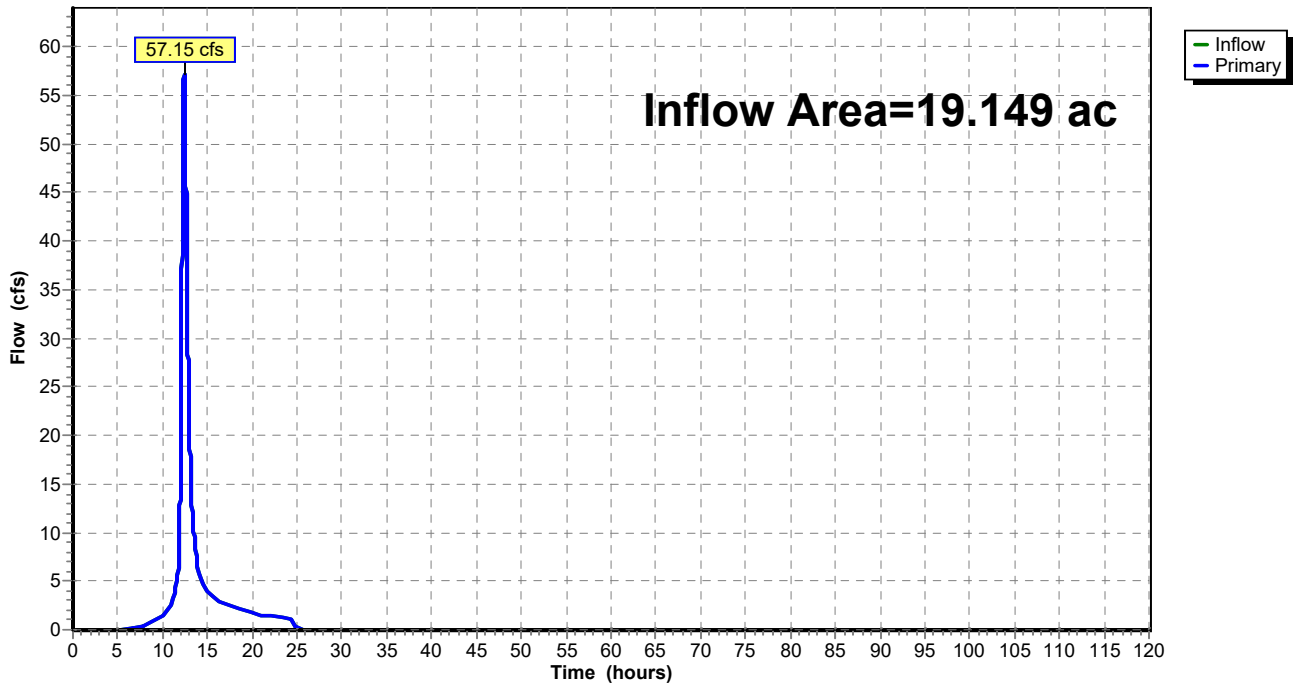
**Summary for Link 1L: 3x36" CHDPE**

Inflow Area = 19.149 ac, 6.02% Impervious, Inflow Depth = 4.34" for 25-yr, 24-hr event  
Inflow = 57.15 cfs @ 12.38 hrs, Volume= 6.929 af  
Primary = 57.15 cfs @ 12.38 hrs, Volume= 6.929 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

**Link 1L: 3x36" CHDPE**

Hydrograph



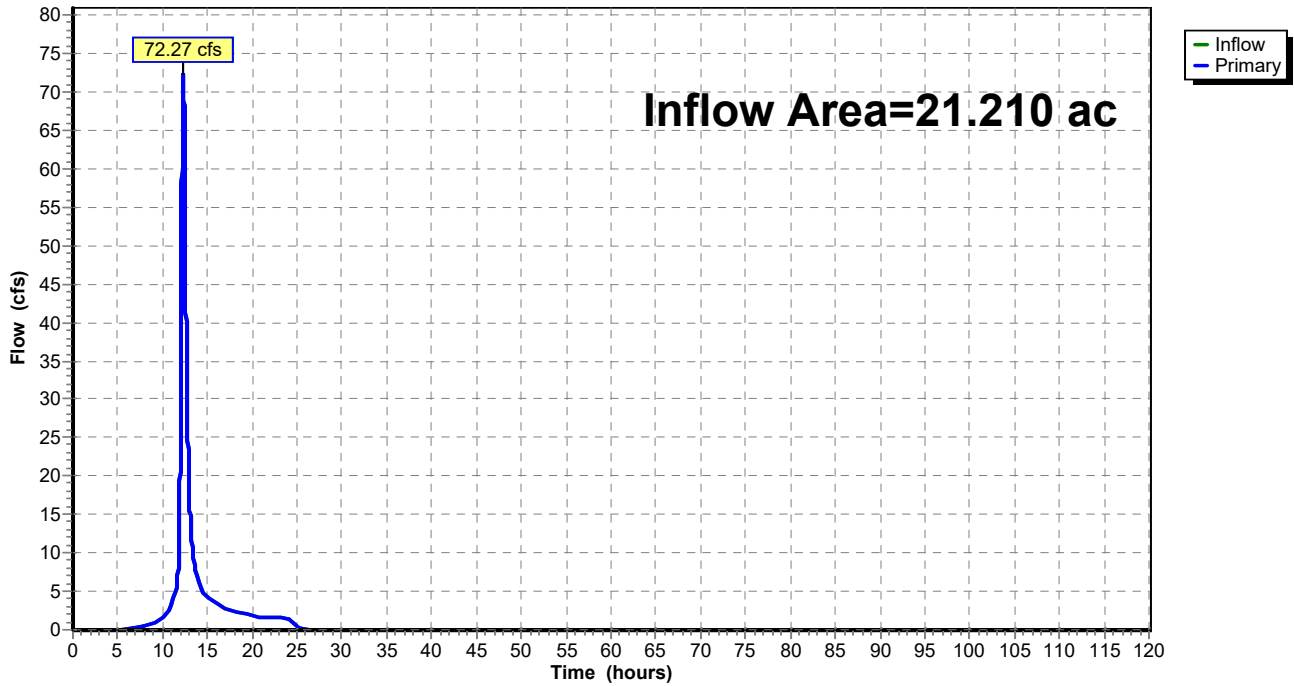
Summary for Link 2L: 3x30" CMP

Inflow Area = 21.210 ac, 0.00% Impervious, Inflow Depth = 4.34" for 25-yr, 24-hr event  
Inflow = 72.27 cfs @ 12.30 hrs, Volume= 7.675 af  
Primary = 72.27 cfs @ 12.30 hrs, Volume= 7.675 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

Link 2L: 3x30" CMP

Hydrograph



# Montrose Landfill RORO\_culverts

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 12

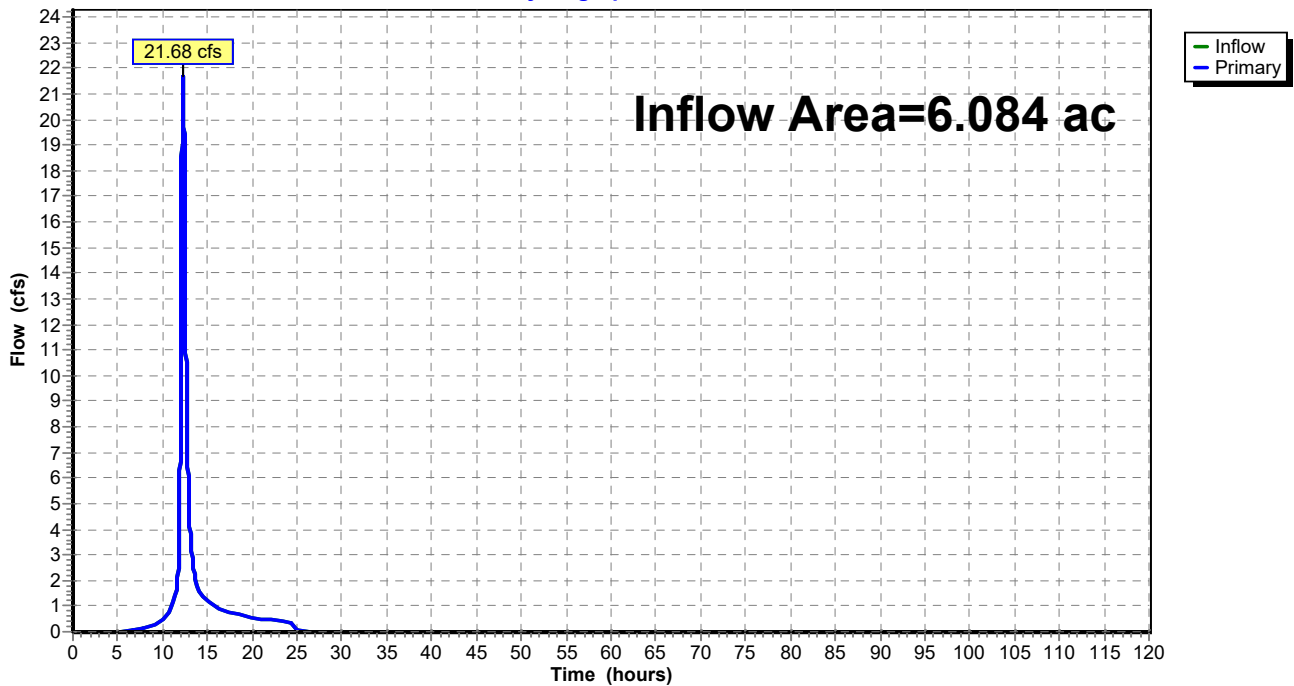
## Summary for Link 3L: 2x30" CMP

Inflow Area = 6.084 ac, 0.00% Impervious, Inflow Depth = 4.34" for 25-yr, 24-hr event  
Inflow = 21.68 cfs @ 12.27 hrs, Volume= 2.201 af  
Primary = 21.68 cfs @ 12.27 hrs, Volume= 2.201 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

## Link 3L: 2x30" CMP

### Hydrograph



## Worksheet for 30" CMP - 0.26%

| Project Description         |   |
|-----------------------------|---|
| Friction Method             | Manning Formula   |
| Solve For                   | Full Flow Capacity  |
| Input Data                  |   |
| Roughness Coefficient       | 0.025   |
| Channel Slope               | 0.026   |
| Normal Depth                | 30.0  |
| Diameter                    | 30.0  |
| Discharge                   | 34.39   |
| Results                     |   |
| Discharge                   | 34.39   |
| Normal Depth                | 30.0  |
| Flow Area                   | 4.9   |
| Wetted Perimeter            | 7.9   |
| Hydraulic Radius            | 7.5   |
| Top Width                   | 0.00  |
| Critical Depth              | 23.9  |
| Percent Full                | 100.0   |
| Critical Slope              | 0.027   |
| Velocity                    | 7.01  |
| Velocity Head               | 0.76  |
| Specific Energy             | 3.26  |
| Froude Number               | (N/A)   |
| Maximum Discharge           | 36.99   |
| Discharge Full              | 34.39 <span style="border: 1px solid magenta; padding: 2px;">x3 = 103.17 cfs</span> |
| Slope Full                  | 0.026   |
| Flow Type                   | Undefined   |
| GVF Input Data              |   |
| Downstream Depth            | 0.0   |
| Length                      | 0.0   |
| Number Of Steps             | 0   |
| GVF Output Data             |   |
| Upstream Depth              | 0.0   |
| Profile Description         | N/A   |
| Profile Headloss            | 0.00  |
| Average End Depth Over Rise | 0.0   |
| Normal Depth Over Rise      | 0.0   |
| Downstream Velocity         | 0.00  |
| Upstream Velocity           | 0.00  |
| Normal Depth                | 30.0  |
| Critical Depth              | 23.9  |
| Channel Slope               | 0.026   |
| Critical Slope              | 0.027   |

## Worksheet for 30" CMP - 0.37%

| Project Description         |                    |
|-----------------------------|--------------------|
| Friction Method             | Manning Formula    |
| Solve For                   | Full Flow Capacity |
| Input Data                  |                    |
| Roughness Coefficient       | 0.025              |
| Channel Slope               | 0.037              |
| Normal Depth                | 30.0               |
| Diameter                    | 30.0               |
| Discharge                   | 41.02              |
| Results                     |                    |
| Discharge                   | 41.02              |
| Normal Depth                | 30.0               |
| Flow Area                   | 4.9                |
| Wetted Perimeter            | 7.9                |
| Hydraulic Radius            | 7.5                |
| Top Width                   | 0.00               |
| Critical Depth              | 25.8               |
| Percent Full                | 100.0              |
| Critical Slope              | 0.034              |
| Velocity                    | 8.36               |
| Velocity Head               | 1.09               |
| Specific Energy             | 3.59               |
| Froude Number               | (N/A)              |
| Maximum Discharge           | 44.13              |
| Discharge Full              | 41.02              |
| Slope Full                  | 0.037              |
| Flow Type                   | Undefined          |
| GVF Input Data              |                    |
| Downstream Depth            | 0.0                |
| Length                      | 0.0                |
| Number Of Steps             | 0                  |
| GVF Output Data             |                    |
| Upstream Depth              | 0.0                |
| Profile Description         | N/A                |
| Profile Headloss            | 0.00               |
| Average End Depth Over Rise | 0.0                |
| Normal Depth Over Rise      | 100.0              |
| Downstream Velocity         | Infinity           |
| Upstream Velocity           | Infinity           |
| Normal Depth                | 30.0               |
| Critical Depth              | 25.8               |
| Channel Slope               | 0.037              |
| Critical Slope              | 0.034              |

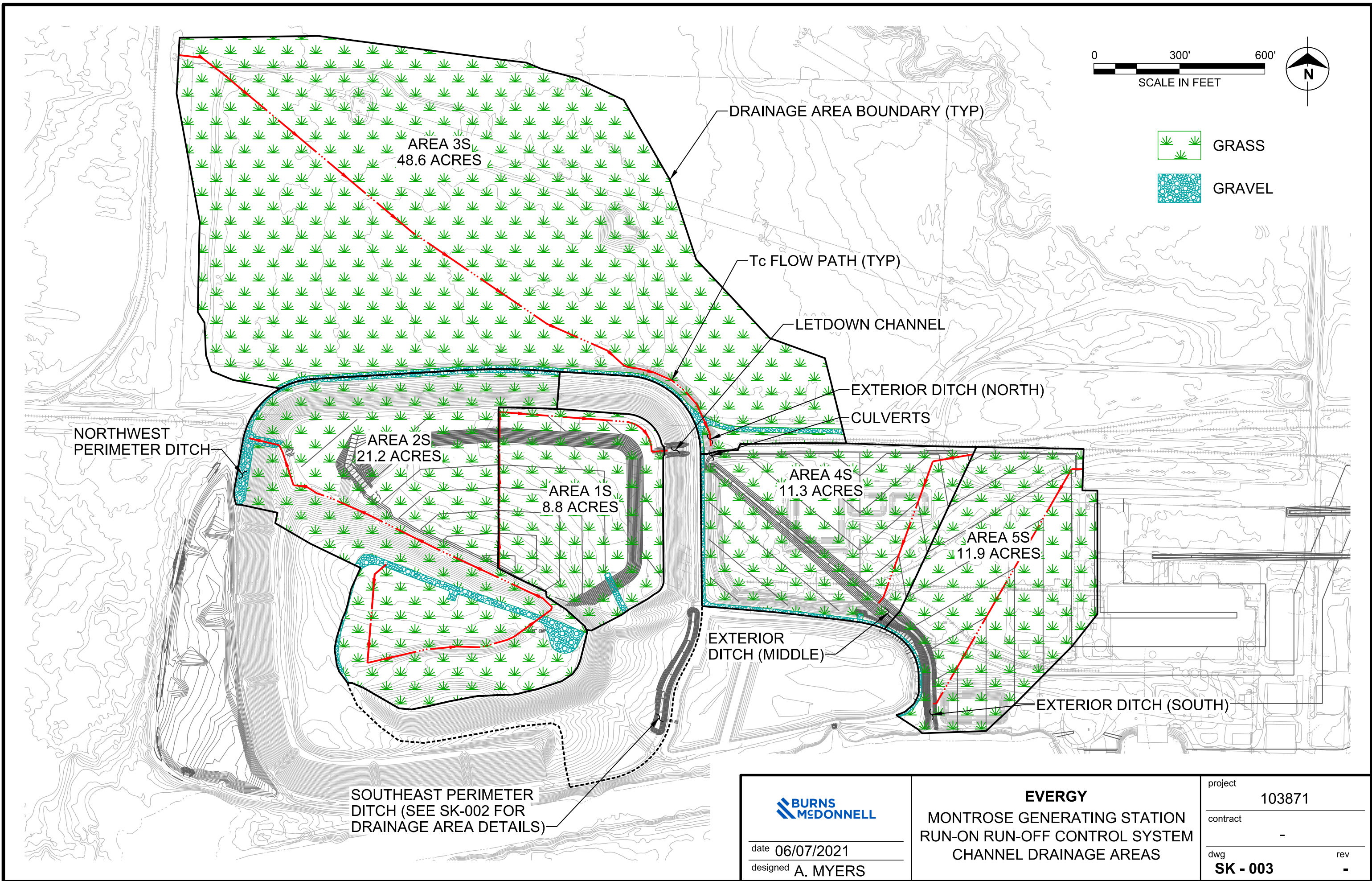
x2 = 82.04 cfs

## Worksheet for 36" CHDPE

| Project Description         |                    |
|-----------------------------|--------------------|
| Friction Method             | Manning Formula    |
| Solve For                   | Full Flow Capacity |
| Input Data                  |                    |
| Roughness Coefficient       | 0.012              |
| Channel Slope               | 0.010              |
| Normal Depth                | 36.0               |
| Diameter                    | 36.0               |
| Discharge                   | 72.25              |
| Results                     |                    |
| Discharge                   | 72.25              |
| Normal Depth                | 36.0               |
| Flow Area                   | 7.1                |
| Wetted Perimeter            | 9.4                |
| Hydraulic Radius            | 9.0                |
| Top Width                   | 0.00               |
| Critical Depth              | 32.2               |
| Percent Full                | 100.0              |
| Critical Slope              | 0.009              |
| Velocity                    | 10.22              |
| Velocity Head               | 1.62               |
| Specific Energy             | 4.62               |
| Froude Number               | (N/A)              |
| Maximum Discharge           | 77.72              |
| Discharge Full              | 72.25              |
| Slope Full                  | 0.010              |
| Flow Type                   | Undefined          |
| GVF Input Data              |                    |
| Downstream Depth            | 0.0                |
| Length                      | 0.0                |
| Number Of Steps             | 0                  |
| GVF Output Data             |                    |
| Upstream Depth              | 0.0                |
| Profile Description         | N/A                |
| Profile Headloss            | 0.00               |
| Average End Depth Over Rise | 0.0                |
| Normal Depth Over Rise      | 100.0              |
| Downstream Velocity         | Infinity           |
| Upstream Velocity           | Infinity           |
| Normal Depth                | 36.0               |
| Critical Depth              | 32.2               |
| Channel Slope               | 0.010              |
| Critical Slope              | 0.009              |

x3 = 216.75 cfs

**ATTACHMENT 4 – CHANNEL CALCULATIONS**



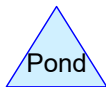
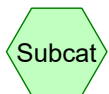
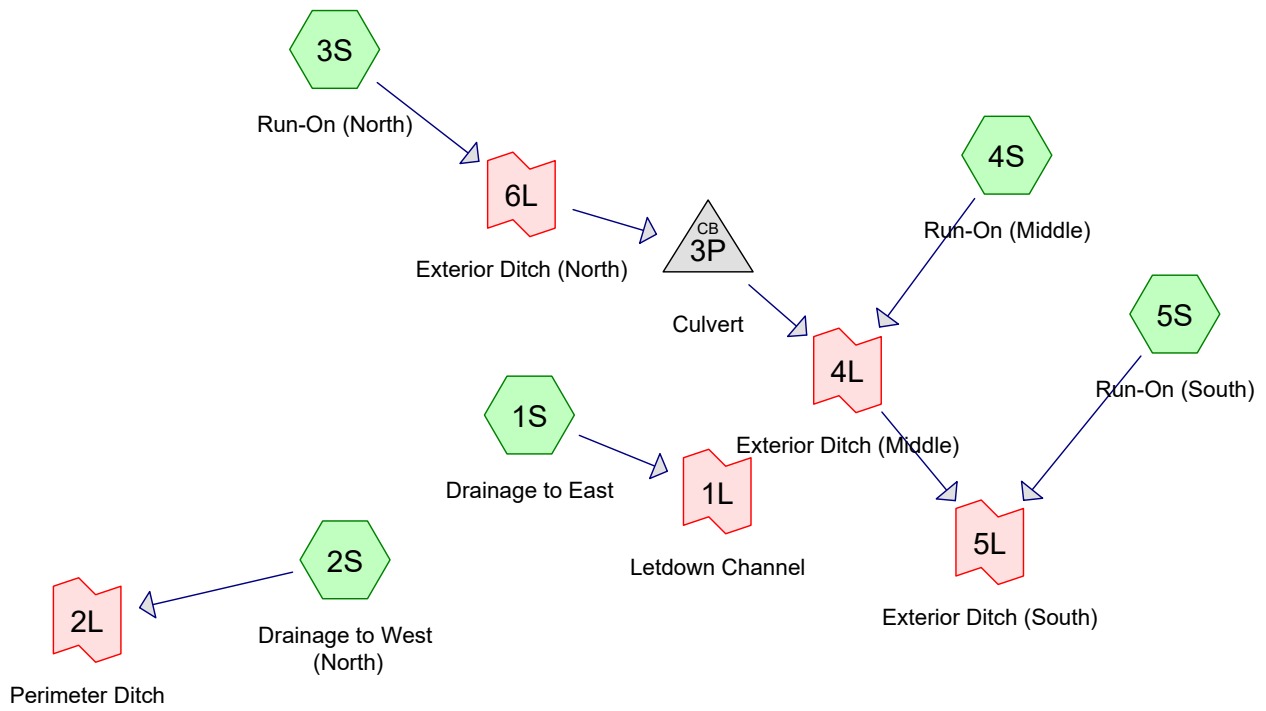
**BURNS  
MCDONNELL**

date 06/07/2021  
designed A. MYERS

**EVERGY**  
MONTROSE GENERATING STATION  
RUN-ON RUN-OFF CONTROL SYSTEM  
CHANNEL DRAINAGE AREAS

|          |          |
|----------|----------|
| project  | 103871   |
| contract | -        |
| dwg      | SK - 003 |
| rev      | -        |





**Routing Diagram for Montrose Landfill RORO\_channels**  
 Prepared by Burns and McDonnell, Printed 6/11/2021  
 HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

## Montrose Landfill RORO\_channels

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Printed 6/11/2021

Page 2

### Area Listing (all nodes)

| Area<br>(acres) | CN | Description<br>(subcatchment-numbers)          |
|-----------------|----|--|
| 47.887          | 84 | 50-75% Grass cover, Fair, HSG D (3S)           |
| 51.394          | 80 | >75% Grass cover, Good, HSG D (1S, 2S, 4S, 5S) |
| 2.457           | 91 | Gravel roads, HSG D (2S, 3S, 4S, 5S)           |
| 0.068           | 98 | Water Surface, HSG D (1S)                      |

# Montrose Landfill RORO\_channels

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 3

Time span=0.00-120.00 hrs, dt=0.01 hrs, 12001 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment 1S: Drainage to East** Runoff Area=8.816 ac 0.77% Impervious Runoff Depth=4.24"  
Flow Length=1,207' Tc=32.7 min CN=80 Runoff=30.56 cfs 3.112 af

**Subcatchment 2S: Drainage to West (North)** Runoff Area=21.210 ac 0.00% Impervious Runoff Depth=4.34"  
Flow Length=2,476' Tc=33.2 min CN=81 Runoff=74.66 cfs 7.675 af

**Subcatchment 3S: Run-On (North)** Runoff Area=48.591 ac 0.00% Impervious Runoff Depth=4.67"  
Flow Length=2,328' Tc=109.8 min CN=84 Runoff=76.96 cfs 18.896 af

**Subcatchment 4S: Run-On (Middle)** Runoff Area=11.331 ac 0.00% Impervious Runoff Depth=4.24"  
Flow Length=677' Tc=24.3 min CN=80 Runoff=47.54 cfs 3.999 af

**Subcatchment 5S: Run-On (South)** Runoff Area=11.858 ac 0.00% Impervious Runoff Depth=4.24"  
Flow Length=1,001' Tc=16.7 min CN=80 Runoff=61.23 cfs 4.185 af

**Pond 3P: Culvert** Peak Elev=757.65' Inflow=76.96 cfs 18.896 af  
36.0" Round Culvert x 3.00 n=0.025 L=72.0' S=0.0044 '/' Outflow=76.96 cfs 18.896 af

**Link 1L: Letdown Channel** Inflow=30.56 cfs 3.112 af  
Primary=30.56 cfs 3.112 af

**Link 2L: Perimeter Ditch** Inflow=74.66 cfs 7.675 af  
Primary=74.66 cfs 7.675 af

**Link 4L: Exterior Ditch (Middle)** Inflow=81.47 cfs 22.895 af  
Primary=81.47 cfs 22.895 af

**Link 5L: Exterior Ditch (South)** Inflow=119.61 cfs 27.080 af  
Primary=119.61 cfs 27.080 af

**Link 6L: Exterior Ditch (North)** Inflow=76.96 cfs 18.896 af  
Primary=76.96 cfs 18.896 af

**Montrose Landfill RORO\_channels**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 4

**Summary for Subcatchment 1S: Drainage to East**

Runoff = 30.56 cfs @ 12.27 hrs, Volume= 3.112 af, Depth= 4.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

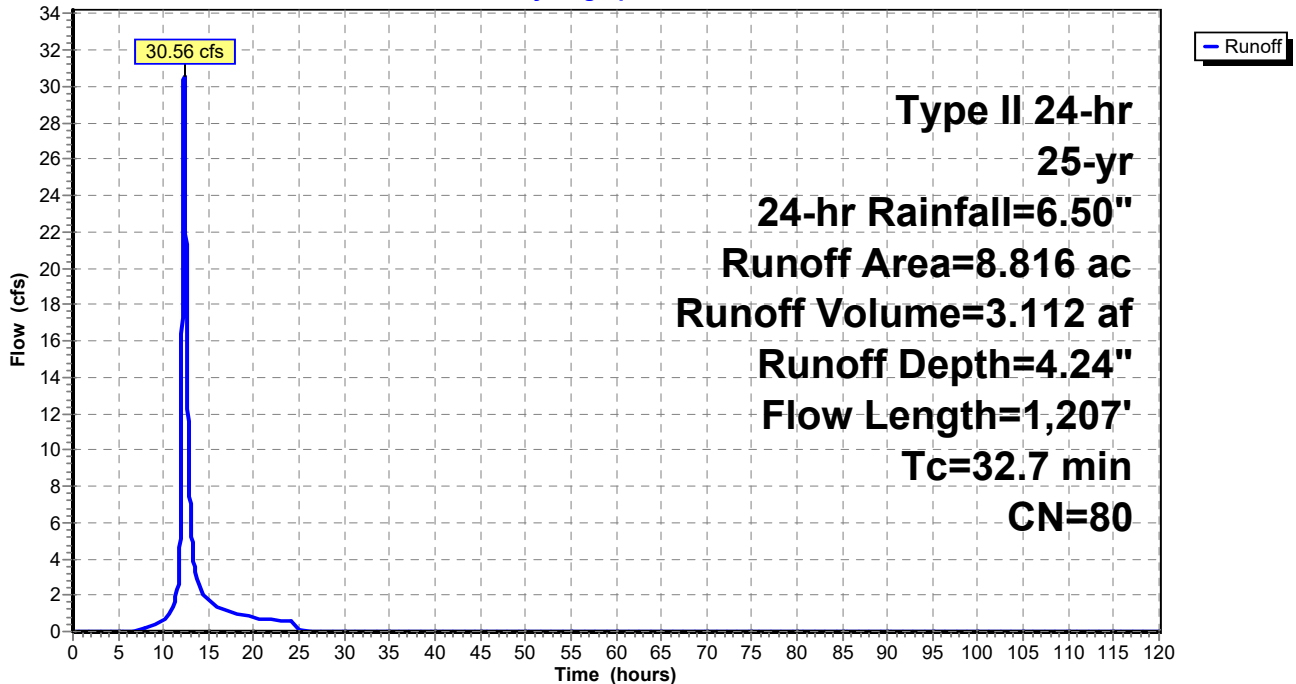
| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 8.748     | 80 | >75% Grass cover, Good, HSG D |
| 0.068     | 98 | Water Surface, HSG D          |
| 8.816     | 80 | Weighted Average              |
| 8.748     |    | 99.23% Pervious Area          |
| 0.068     |    | 0.77% Impervious Area         |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 19.3     | 200           | 0.0125        | 0.17              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"   |
| 3.4      | 347           | 0.0125        | 1.68              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 9.4      | 600           | 0.0050        | 1.06              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 0.6      | 60            | 0.0167        | 1.60              | 9.21           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.069 Riprap, 6-inch |
| 32.7     | 1,207         | Total         |                   |                |   |

**Subcatchment 1S: Drainage to East**

Hydrograph



**Montrose Landfill RORO\_channels**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 5

**Summary for Subcatchment 2S: Drainage to West (North)**

Runoff = 74.66 cfs @ 12.28 hrs, Volume= 7.675 af, Depth= 4.34"

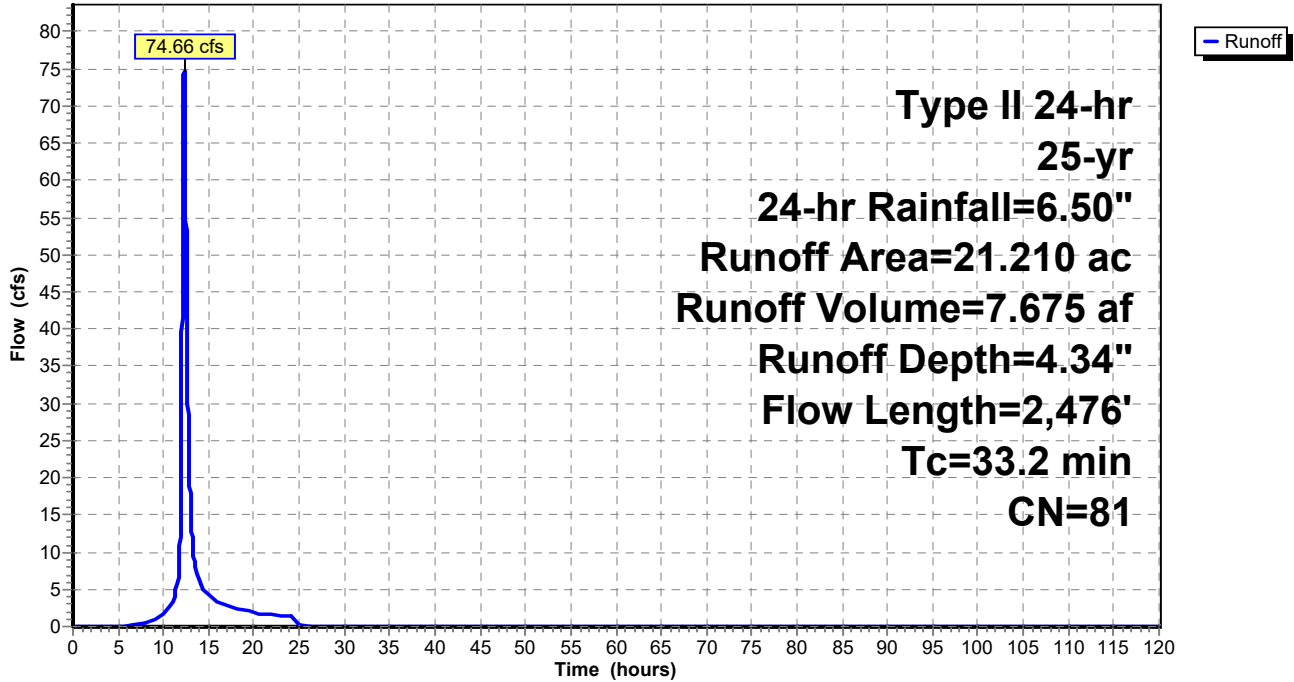
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 1.344     | 91 | Gravel roads, HSG D           |
| 19.866    | 80 | >75% Grass cover, Good, HSG D |
| 21.210    | 81 | Weighted Average              |
| 21.210    |    | 100.00% Pervious Area         |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 13.1     | 200           | 0.0333        | 0.26              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"   |
| 1.0      | 165           | 0.0333        | 2.74              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps  |
| 7.0      | 525           | 0.0020        | 1.25              | 7.51           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.0 '/' Top.W=14.00'<br>n= 0.030 Earth, grassed & winding       |
| 0.5      | 160           | 0.0150        | 5.32              | 26.12          | <b>Pipe Channel,</b><br>30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63'<br>n= 0.025 Corrugated metal                            |
| 6.6      | 1,018         | 0.0100        | 2.56              | 11.54          | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=6.00' D=0.50' Z= 6.0 '/' Top.W=12.00'<br>n= 0.030 Earth, grassed & winding        |
| 0.9      | 150           | 0.0200        | 2.74              | 3.43           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=0.00' D=0.50' Z= 5.0 '/' Top.W=5.00'<br>n= 0.030 Earth, grassed & winding         |
| 0.3      | 108           | 0.2500        | 6.20              | 35.65          | <b>Trap/Vee/Rect Channel Flow, Letdown Channel</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.069 Riprap, 6-inch |
| 3.8      | 150           | 0.0030        | 0.66              | 4.05           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 4.5 '/' Top.W=14.50'<br>n= 0.069 Riprap, 6-inch                 |
| 33.2     | 2,476         | Total         |                   |                |   |

Subcatchment 2S: Drainage to West (North)

Hydrograph



**Montrose Landfill RORO\_channels**

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Prepared by Burns and McDonnell

Printed 6/11/2021

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Page 7

**Summary for Subcatchment 3S: Run-On (North)**

Runoff = 76.96 cfs @ 13.29 hrs, Volume= 18.896 af, Depth= 4.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

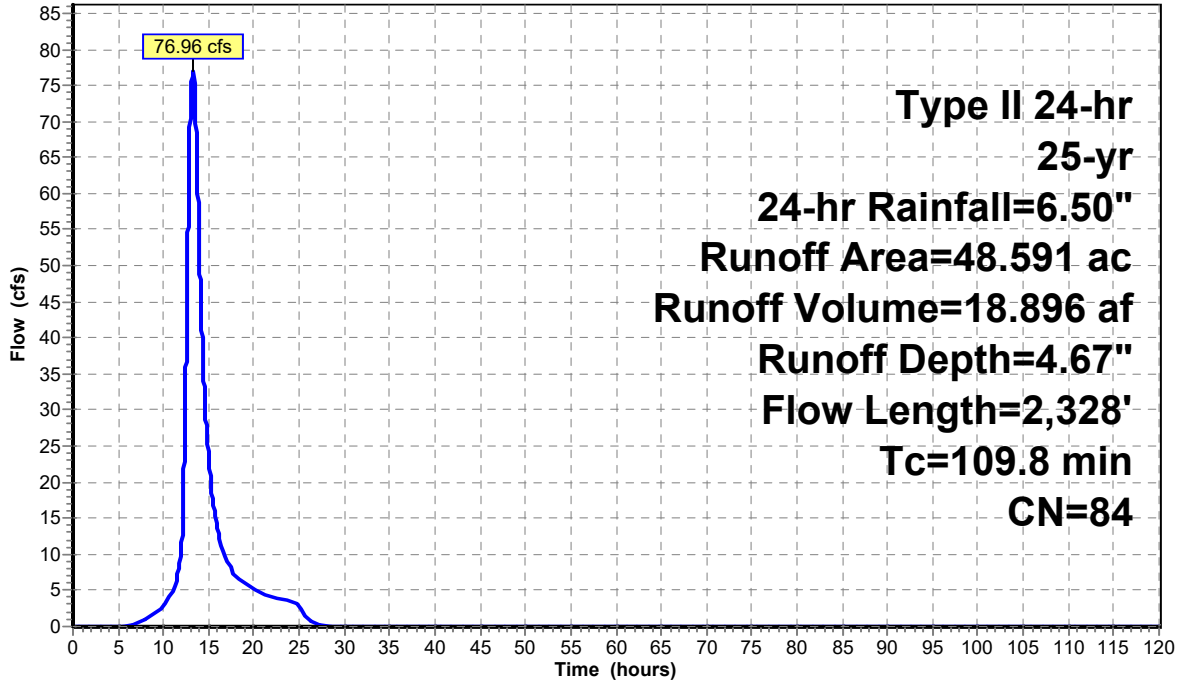
| Area (ac) | CN | Description                     |
|-----------|----|---------------------------------|
| 47.887    | 84 | 50-75% Grass cover, Fair, HSG D |
| 0.704     | 91 | Gravel roads, HSG D             |
| 48.591    | 84 | Weighted Average                |
| 48.591    |    | 100.00% Pervious Area           |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description   |
|----------|---------------|---------------|-------------------|----------------|---|
| 31.6     | 169           | 0.0067        | 0.09              |                | <b>Sheet Flow,</b><br>Grass: Dense n= 0.240 P2= 3.63"   |
| 3.2      | 31            | 0.0667        | 0.16              |                | <b>Sheet Flow,</b><br>Grass: Dense n= 0.240 P2= 3.63"   |
| 71.9     | 1,735         | 0.0033        | 0.40              |                | <b>Shallow Concentrated Flow,</b><br>Short Grass Pasture Kv= 7.0 fps  |
| 3.0      | 283           | 0.0030        | 1.56              | 8.98           | <b>Trap/Vee/Rect Channel Flow,</b><br>Bot.W=10.00' D=0.50' Z= 3.0 '/' Top.W=13.00'<br>n= 0.030 Earth, grassed & winding |
| 0.1      | 110           | 0.2000        | 21.94             | 155.11         | <b>Pipe Channel,</b><br>36.0" Round Area= 7.1 sf Perim= 9.4' r= 0.75'<br>n= 0.025 Corrugated metal                      |
| 109.8    | 2,328         | Total         |                   |                |   |

Subcatchment 3S: Run-On (North)

Hydrograph





**Montrose Landfill RORO\_channels**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 9

**Summary for Subcatchment 4S: Run-On (Middle)**

Runoff = 47.54 cfs @ 12.18 hrs, Volume= 3.999 af, Depth= 4.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

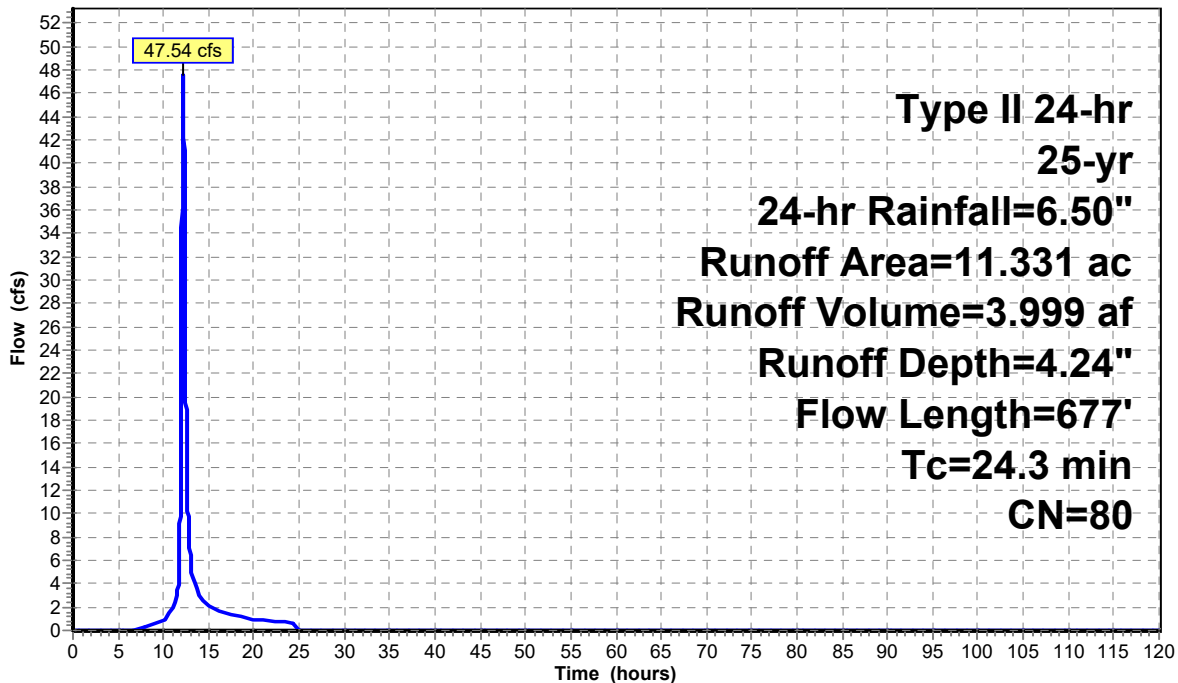
| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 11.012    | 80 | >75% Grass cover, Good, HSG D |
| 0.319     | 91 | Gravel roads, HSG D           |
| 11.331    | 80 | Weighted Average              |
| 11.331    |    | 100.00% Pervious Area         |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description  |
|----------|---------------|---------------|-------------------|----------------|--|
| 16.2     | 143           | 0.0100        | 0.15              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"              |
| 8.0      | 507           | 0.0050        | 1.06              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps |
| 0.1      | 27            | 0.2000        | 6.71              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps |
| 24.3     | 677           | Total         |                   |                |  |

**Subcatchment 4S: Run-On (Middle)**

Hydrograph



**Montrose Landfill RORO\_channels**

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 10

**Summary for Subcatchment 5S: Run-On (South)**

Runoff = 61.23 cfs @ 12.08 hrs, Volume= 4.185 af, Depth= 4.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
 Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

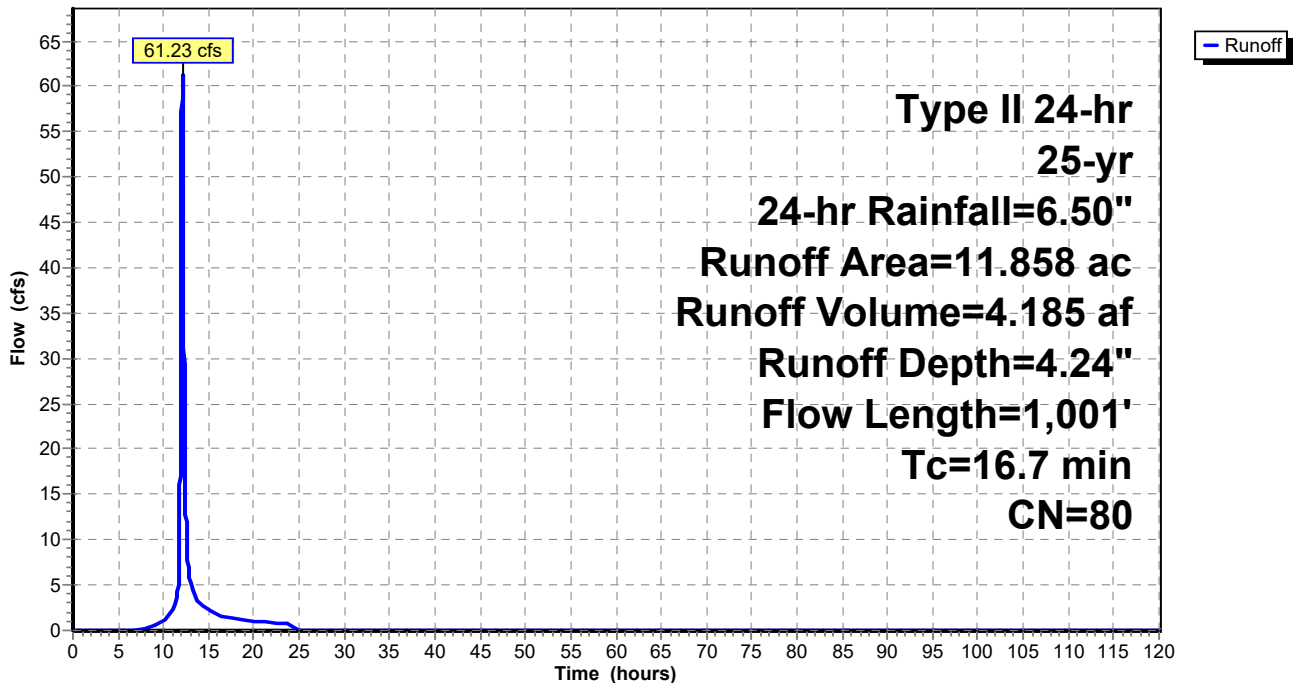
| Area (ac) | CN | Description                   |
|-----------|----|-------------------------------|
| 11.768    | 80 | >75% Grass cover, Good, HSG D |
| 0.090     | 91 | Gravel roads, HSG D           |
| 11.858    | 80 | Weighted Average              |
| 11.858    |    | 100.00% Pervious Area         |

| Tc (min) | Length (feet) | Slope (ft/ft) | Velocity (ft/sec) | Capacity (cfs) | Description  |
|----------|---------------|---------------|-------------------|----------------|--|
| 1.8      | 40            | 0.2000        | 0.38              |                | <b>Sheet Flow,</b><br>Grass: Short n= 0.150 P2= 3.63"              |
| 14.9     | 949           | 0.0050        | 1.06              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps |
| 0.0      | 12            | 0.3333        | 8.66              |                | <b>Shallow Concentrated Flow,</b><br>Grassed Waterway Kv= 15.0 fps |
| 16.7     | 1,001         | Total         |                   |                |  |

**Subcatchment 5S: Run-On (South)**

Hydrograph



# Montrose Landfill RORO\_channels

Prepared by Burns and McDonnell

HydroCAD® 10.00-24 s/n 08510 © 2018 HydroCAD Software Solutions LLC

Type II 24-hr 25-yr, 24-hr Rainfall=6.50"

Printed 6/11/2021

Page 11

## Summary for Pond 3P: Culvert

Inflow Area = 48.591 ac, 0.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr event  
Inflow = 76.96 cfs @ 13.29 hrs, Volume= 18.896 af  
Outflow = 76.96 cfs @ 13.29 hrs, Volume= 18.896 af, Atten= 0%, Lag= 0.0 min  
Primary = 76.96 cfs @ 13.29 hrs, Volume= 18.896 af

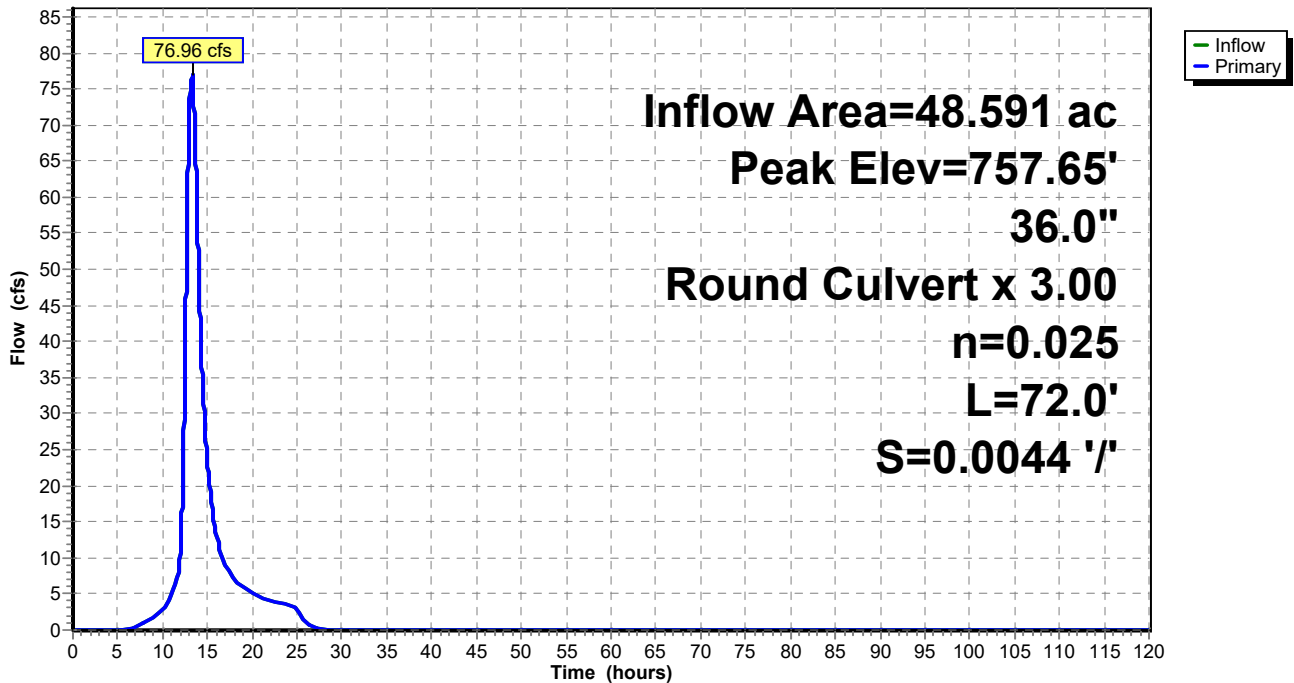
Routing by Dyn-Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs  
Peak Elev= 757.65' @ 13.29 hrs  
Flood Elev= 760.00'

| Device | Routing | Invert  | Outlet Devices  |
|--------|---------|---------|---|
| #1     | Primary | 754.64' | <b>36.0" Round Culvert X 3.00</b><br>L= 72.0' CMP, projecting, no headwall, Ke= 0.900<br>Inlet / Outlet Invert= 754.64' / 754.32' S= 0.0044 '/ Cc= 0.900<br>n= 0.025 Corrugated metal, Flow Area= 7.07 sf |

**Primary OutFlow** Max=76.96 cfs @ 13.29 hrs HW=757.65' TW=0.00' (Dynamic Tailwater)  
↑1=Culvert (Barrel Controls 76.96 cfs @ 4.50 fps)

## Pond 3P: Culvert

### Hydrograph



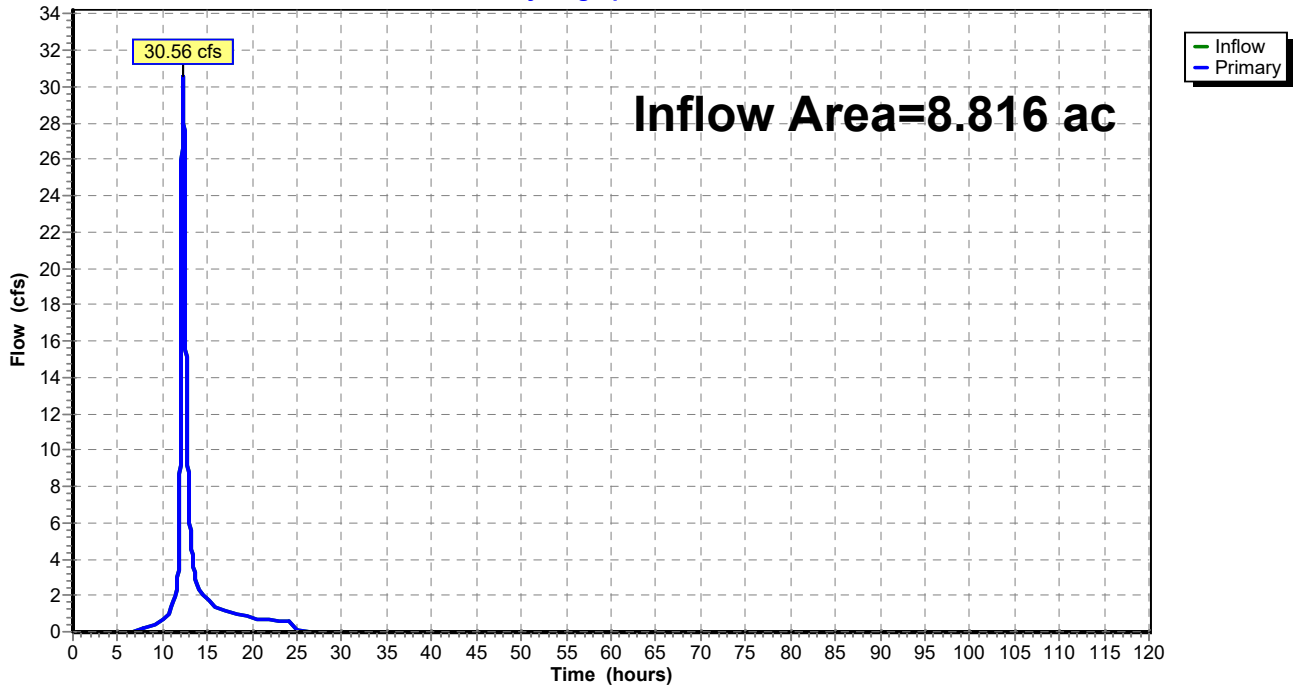
### Summary for Link 1L: Letdown Channel

Inflow Area = 8.816 ac, 0.77% Impervious, Inflow Depth = 4.24" for 25-yr, 24-hr event  
Inflow = 30.56 cfs @ 12.27 hrs, Volume= 3.112 af  
Primary = 30.56 cfs @ 12.27 hrs, Volume= 3.112 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

### Link 1L: Letdown Channel

Hydrograph



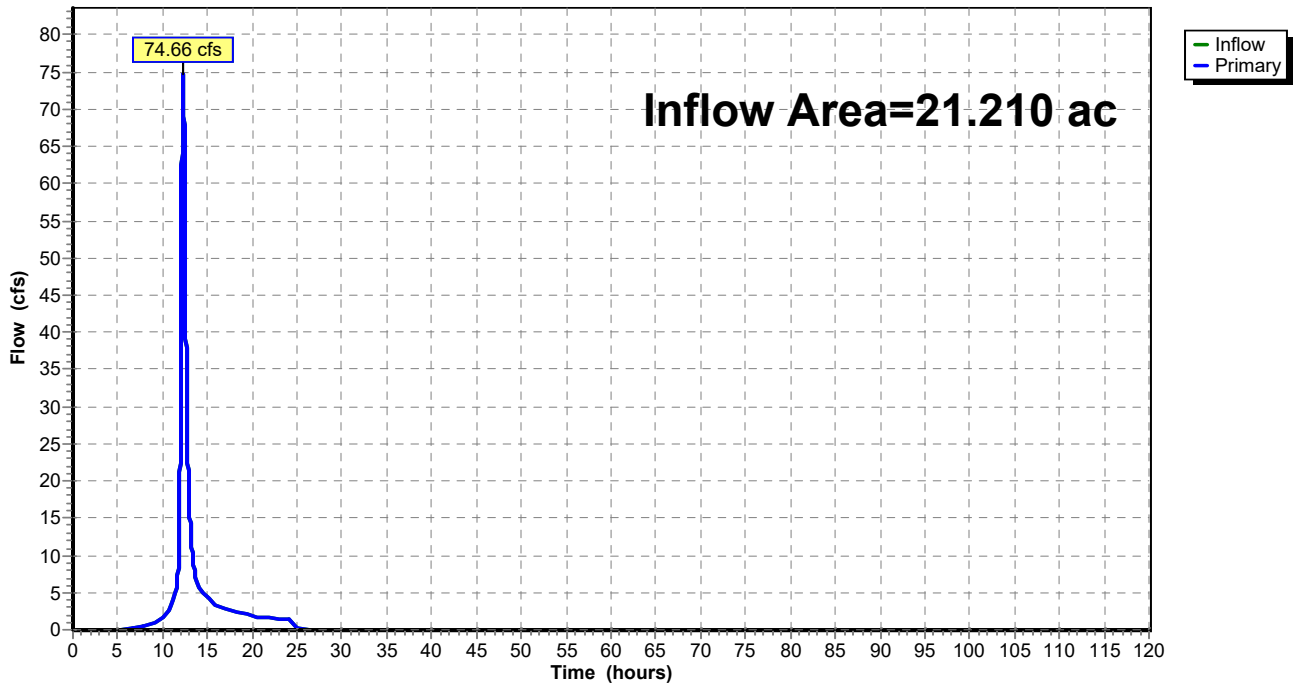
### Summary for Link 2L: Perimeter Ditch

Inflow Area = 21.210 ac, 0.00% Impervious, Inflow Depth = 4.34" for 25-yr, 24-hr event  
Inflow = 74.66 cfs @ 12.28 hrs, Volume= 7.675 af  
Primary = 74.66 cfs @ 12.28 hrs, Volume= 7.675 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

### Link 2L: Perimeter Ditch

Hydrograph



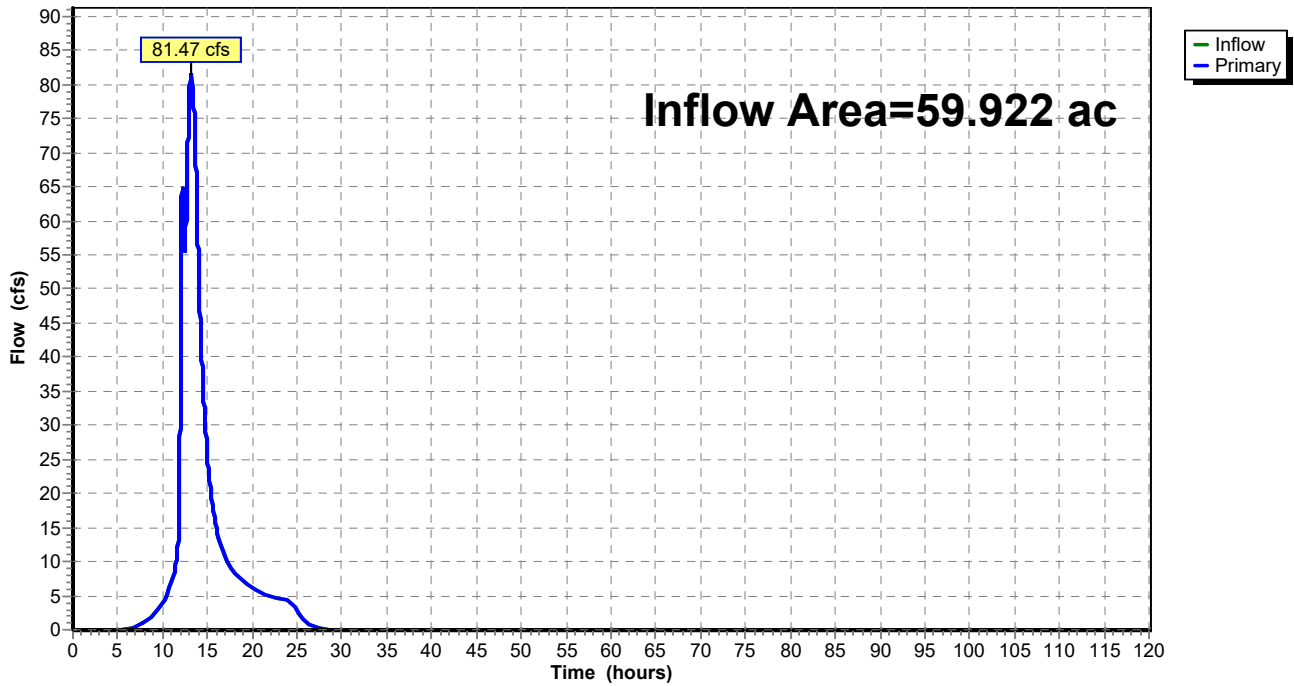
Summary for Link 4L: Exterior Ditch (Middle)

Inflow Area = 59.922 ac, 0.00% Impervious, Inflow Depth = 4.58" for 25-yr, 24-hr event  
Inflow = 81.47 cfs @ 13.18 hrs, Volume= 22.895 af  
Primary = 81.47 cfs @ 13.18 hrs, Volume= 22.895 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

Link 4L: Exterior Ditch (Middle)

Hydrograph



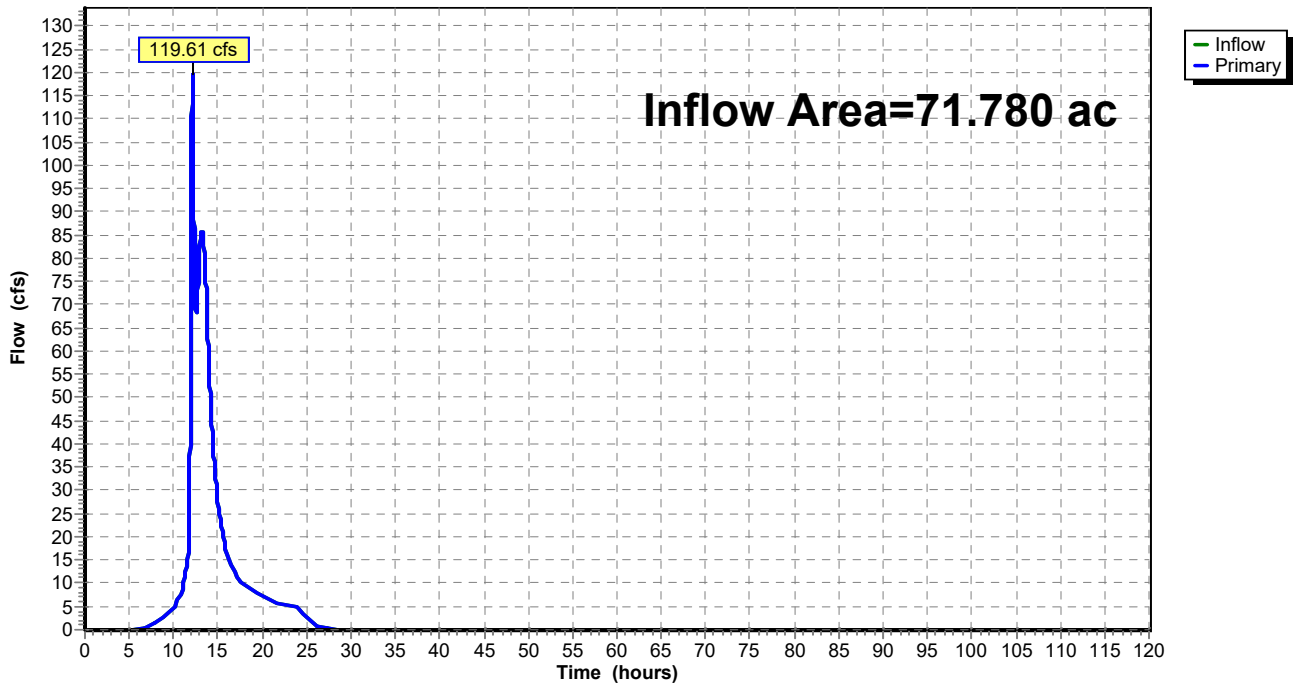
Summary for Link 5L: Exterior Ditch (South)

Inflow Area = 71.780 ac, 0.00% Impervious, Inflow Depth = 4.53" for 25-yr, 24-hr event  
Inflow = 119.61 cfs @ 12.12 hrs, Volume= 27.080 af  
Primary = 119.61 cfs @ 12.12 hrs, Volume= 27.080 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

Link 5L: Exterior Ditch (South)

Hydrograph



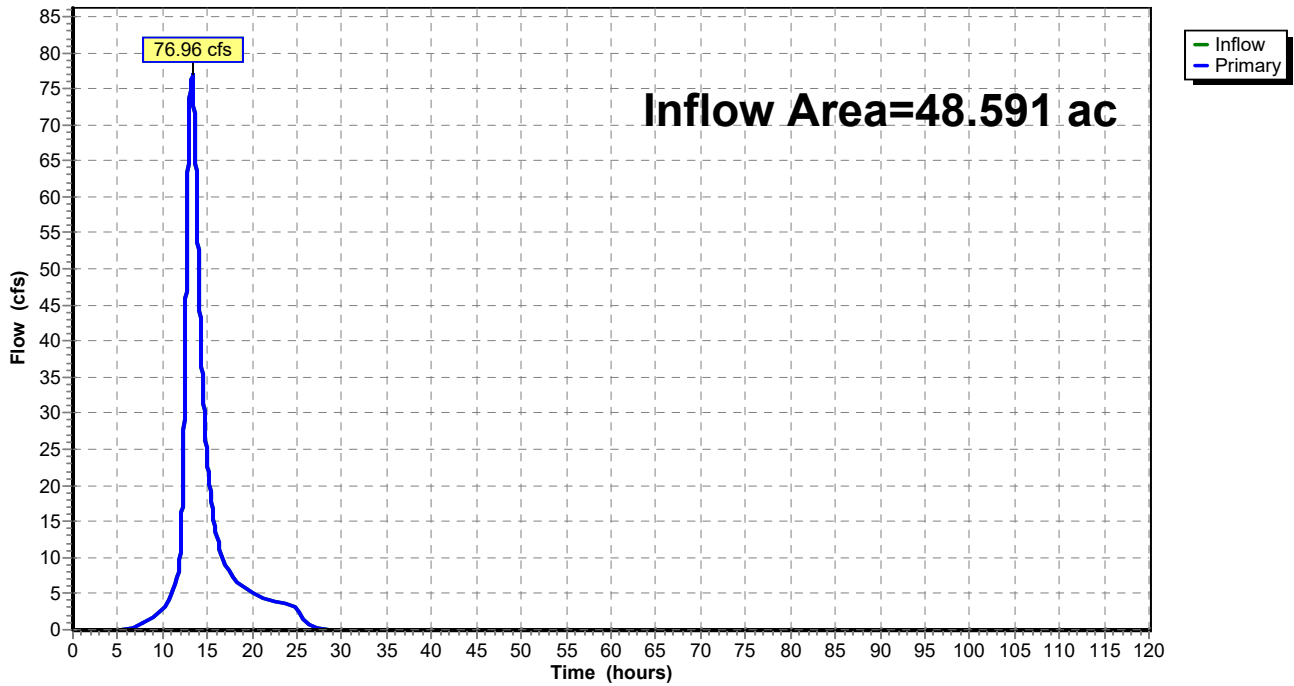
Summary for Link 6L: Exterior Ditch (North)

Inflow Area = 48.591 ac, 0.00% Impervious, Inflow Depth = 4.67" for 25-yr, 24-hr event  
Inflow = 76.96 cfs @ 13.29 hrs, Volume= 18.896 af  
Primary = 76.96 cfs @ 13.29 hrs, Volume= 18.896 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-120.00 hrs, dt= 0.01 hrs

Link 6L: Exterior Ditch (North)

Hydrograph





## Worksheet for Letdown Channel

| Project Description   |                 |
|-----------------------|-----------------|
| Friction Method       | Manning Formula |
| Solve For             | Discharge       |
| Input Data            |                 |
| Roughness Coefficient | 0.069           |
| Channel Slope         | 0.250           |
| Normal Depth          | 24.0            |
| Left Side Slope       | 3.000           |
| Right Side Slope      | 3.000           |
| Bottom Width          | 10.00           |
| Results               |                 |
| Discharge             | 433.84          |
| Flow Area             | 32.0            |
| Wetted Perimeter      | 22.6            |
| Hydraulic Radius      | 17.0            |
| Top Width             | 22.00           |
| Critical Depth        | 34.8            |
| Critical Slope        | 0.058           |
| Velocity              | 13.56           |
| Velocity Head         | 2.86            |
| Specific Energy       | 4.86            |
| Froude Number         | 1.982           |
| Flow Type             | Supercritical   |
| GVF Input Data        |                 |
| Downstream Depth      | 0.0             |
| Length                | 0.0             |
| Number Of Steps       | 0               |
| GVF Output Data       |                 |
| Upstream Depth        | 0.0             |
| Profile Description   | N/A             |
| Profile Headloss      | 0.00            |
| Downstream Velocity   | Infinity        |
| Upstream Velocity     | Infinity        |
| Normal Depth          | 24.0            |
| Critical Depth        | 34.8            |
| Channel Slope         | 0.250           |
| Critical Slope        | 0.058           |

## Worksheet for Perimeter Ditch - Riprap

| Project Description   |                 |
|-----------------------|-----------------|
| Friction Method       | Manning Formula |
| Solve For             | Discharge       |
| Input Data            |                 |
| Roughness Coefficient | 0.069           |
| Channel Slope         | 0.003           |
| Normal Depth          | 30.0            |
| Left Side Slope       | 4.500           |
| Right Side Slope      | 4.500           |
| Bottom Width          | 10.00           |
| Results               |                 |
| Discharge             | 81.57           |
| Flow Area             | 53.1            |
| Wetted Perimeter      | 33.0            |
| Hydraulic Radius      | 19.3            |
| Top Width             | 32.50           |
| Critical Depth        | 12.9            |
| Critical Slope        | 0.076           |
| Velocity              | 1.54            |
| Velocity Head         | 0.04            |
| Specific Energy       | 2.54            |
| Froude Number         | 0.212           |
| Flow Type             | Subcritical     |
| GVF Input Data        |                 |
| Downstream Depth      | 0.0             |
| Length                | 0.0             |
| Number Of Steps       | 0               |
| GVF Output Data       |                 |
| Upstream Depth        | 0.0             |
| Profile Description   | N/A             |
| Profile Headloss      | 0.00            |
| Downstream Velocity   | Infinity        |
| Upstream Velocity     | Infinity        |
| Normal Depth          | 30.0            |
| Critical Depth        | 12.9            |
| Channel Slope         | 0.003           |
| Critical Slope        | 0.076           |

## Worksheet for Perimeter Ditch - Grassed

| Project Description   |                 |
|-----------------------|-----------------|
| Friction Method       | Manning Formula |
| Solve For             | Discharge       |
| Input Data            |                 |
| Roughness Coefficient | 0.030           |
| Channel Slope         | 0.003           |
| Normal Depth          | 30.0            |
| Left Side Slope       | 3.000           |
| Right Side Slope      | 3.000           |
| Bottom Width          | 10.00           |
| Results               |                 |
| Discharge             | 160.07          |
| Flow Area             | 43.8            |
| Wetted Perimeter      | 25.8            |
| Hydraulic Radius      | 20.3            |
| Top Width             | 25.00           |
| Critical Depth        | 20.1            |
| Critical Slope        | 0.013           |
| Velocity              | 3.66            |
| Velocity Head         | 0.21            |
| Specific Energy       | 2.71            |
| Froude Number         | 0.488           |
| Flow Type             | Subcritical     |
| GVF Input Data        |                 |
| Downstream Depth      | 0.0             |
| Length                | 0.0             |
| Number Of Steps       | 0               |
| GVF Output Data       |                 |
| Upstream Depth        | 0.0             |
| Profile Description   | N/A             |
| Profile Headloss      | 0.00            |
| Downstream Velocity   | Infinity        |
| Upstream Velocity     | Infinity        |
| Normal Depth          | 30.0            |
| Critical Depth        | 20.1            |
| Channel Slope         | 0.003           |
| Critical Slope        | 0.013           |

## Exterior Ditch - North

| Project Description |                 |
|---------------------|-----------------|
| Friction Method     | Manning Formula |
| Solve For           | Discharge       |

---

| Input Data            |       |
|-----------------------|-------|
| Roughness Coefficient | 0.030 |
| Channel Slope         | 0.003 |
| Normal Depth          | 48.0  |
| Left Side Slope       | 3.000 |
| Right Side Slope      | 3.000 |
| Bottom Width          | 10.00 |

---

| Results          |             |
|------------------|-------------|
| Discharge        | 416.41      |
| Flow Area        | 88.0        |
| Wetted Perimeter | 35.3        |
| Hydraulic Radius | 29.9        |
| Top Width        | 34.00       |
| Critical Depth   | 34.1        |
| Critical Slope   | 0.011       |
| Velocity         | 4.73        |
| Velocity Head    | 0.35        |
| Specific Energy  | 4.35        |
| Froude Number    | 0.519       |
| Flow Type        | Subcritical |

---

| GVF Input Data   |     |
|------------------|-----|
| Downstream Depth | 0.0 |
| Length           | 0.0 |
| Number Of Steps  | 0   |

---

| GVF Output Data     |          |
|---------------------|----------|
| Upstream Depth      | 0.0      |
| Profile Description | N/A      |
| Profile Headloss    | 0.00     |
| Downstream Velocity | Infinity |
| Upstream Velocity   | Infinity |
| Normal Depth        | 48.0     |
| Critical Depth      | 34.1     |
| Channel Slope       | 0.003    |
| Critical Slope      | 0.011    |

## Exterior Ditch - Middle

| Project Description   |                 |
|-----------------------|-----------------|
| Friction Method       | Manning Formula |
| Solve For             | Discharge       |
| Input Data            |                 |
| Roughness Coefficient | 0.030           |
| Channel Slope         | 0.005           |
| Normal Depth          | 36.0            |
| Left Side Slope       | 5.000           |
| Right Side Slope      | 5.000           |
| Bottom Width          | 10.00           |
| Results               |                 |
| Discharge             | 375.21          |
| Flow Area             | 75.0            |
| Wetted Perimeter      | 40.6            |
| Hydraulic Radius      | 22.2            |
| Top Width             | 40.00           |
| Critical Depth        | 28.9            |
| Critical Slope        | 0.012           |
| Velocity              | 5.00            |
| Velocity Head         | 0.39            |
| Specific Energy       | 3.39            |
| Froude Number         | 0.644           |
| Flow Type             | Subcritical     |
| GVF Input Data        |                 |
| Downstream Depth      | 0.0             |
| Length                | 0.0             |
| Number Of Steps       | 0               |
| GVF Output Data       |                 |
| Upstream Depth        | 0.0             |
| Profile Description   | N/A             |
| Profile Headloss      | 0.00            |
| Downstream Velocity   | Infinity        |
| Upstream Velocity     | Infinity        |
| Normal Depth          | 36.0            |
| Critical Depth        | 28.9            |
| Channel Slope         | 0.005           |
| Critical Slope        | 0.012           |

## Exterior Ditch - South

| Project Description   |                 |
|-----------------------|-----------------|
| Friction Method       | Manning Formula |
| Solve For             | Discharge       |
| Input Data            |                 |
| Roughness Coefficient | 0.030           |
| Channel Slope         | 0.003           |
| Normal Depth          | 36.0            |
| Left Side Slope       | 3.000           |
| Right Side Slope      | 3.000           |
| Bottom Width          | 10.00           |
| Results               |                 |
| Discharge             | 242.79          |
| Flow Area             | 57.0            |
| Wetted Perimeter      | 29.0            |
| Hydraulic Radius      | 23.6            |
| Top Width             | 28.00           |
| Critical Depth        | 25.4            |
| Critical Slope        | 0.012           |
| Velocity              | 4.26            |
| Velocity Head         | 0.28            |
| Specific Energy       | 3.28            |
| Froude Number         | 0.526           |
| Flow Type             | Subcritical     |
| GVF Input Data        |                 |
| Downstream Depth      | 0.0             |
| Length                | 0.0             |
| Number Of Steps       | 0               |
| GVF Output Data       |                 |
| Upstream Depth        | 0.0             |
| Profile Description   | N/A             |
| Profile Headloss      | 0.00            |
| Downstream Velocity   | Infinity        |
| Upstream Velocity     | Infinity        |
| Normal Depth          | 36.0            |
| Critical Depth        | 25.4            |
| Channel Slope         | 0.003           |
| Critical Slope        | 0.012           |



CREATE AMAZING.

Burns & McDonnell World Headquarters  
9400 Ward Parkway  
Kansas City, MO 64114  
O 816-333-9400  
F 816-333-3690  
[www.burnsmcd.com](http://www.burnsmcd.com)