LEE'S SUMMIT
MISSOURI

Apr. 6, 2018

Melissa DeGonia, P.E.
Olsson Associates
1301 Burlington #100
North Kansas City, MO 64116

RE: Request for Waiver – Hawthorn Ridge Subdivision - Project No. PL2017-050
City Engineer Approval of Specified Items

References: a) Hawthorn Ridge Macro and First Plat Micro Drainage Study, dated Mar. 8, 2018
b) Waiver Request dated Apr. 4, 2018 Olsson Associates

The City of Lee's Summit approves your request for the design exceptions listed below based on the request in the referenced waiver request dated Apr. 4, 2018, and in particular, Waiver #1, Waiver #2, and Waiver #3. These exceptions may be incorporated into subsequent submittals necessary to complete the standard review and approval of construction plans by City Staff.

1. Waiver #1 allows a design exception to the peak flow rate to Point A1 for the 2 year storm event. The post-development peak flow rate, however, for the 2 year event will be reduced by 65% of the pre-development peak flow rate at Point A1.
2. Waiver #2 allows a design exception to the peak flow rate to Point B1 for the 2, 10, and 100 year events. The post-development peak flow rates, however, for all events will be reduced by 37%, 35%, and 34% respectively.
3. Waiver #3 allows for a design exception to the peak flow rate to Point C1 for the 2, 10, and 100 year events. The post-development peak flow rates, however, for all events will be reduced by 21%, 20%, and 19% respectively.
4. This waiver is based on the findings contained in the "Hawthorn Ridge Macro and First Plat Micro Drainage Study" dated Mar. 8, 2018.

SIGNED:

George M. Binger III, P.E.
City Engineer / Deputy Director of Public Works

Cvwaiver_Detentionhawthornridge1stplat.Docx

OLSSON ®
ASSOCIATES

March 8, 2018
Revised April 4, 2018

Gene Williams, Senior Staff Engineer
City of Lee's Summit, MO
220 SE Green Street
Kansas City, MO 64106

RE: Hawthorn Ridge First Plat
Olsson No. 017-0188

Dear Mr. Williams:

We are requesting the following waivers from the allowable release rates prescribed within Section 5608.4.C.1.a for the discharge locations and storm events described, below.

Waiver 1
The release rate for the 2-year storm event at Point A1 per the drainage study will be exceeded, but peak flow rate will be less than existing.

See attached Exhibit 1. The detention facility within Watershed A has been placed as far downstream as possible given topographic limitations. The right-of-way is almost immediately downstream of the facility, so additional detention is not feasible. In this location, there will still be a small drainage area (2.31 acres), which will bypass the facility. Additionally, the total drainage area to Point A1 is limited, only 9.26 acres, which creates a very small allowable release rate at Point A1 for the 2-year storm event. In this case, the bypass alone exceeds the allowable release rate of 0.5 cfs/acre. Peak flow from the detention facility in the 2-year storm event is only 0.4 cfs through a 4" orifice, so flow rates to this point appear to be limited as much as possible.

In lieu of detaining to the prescribed release rate, the 2-year event has been analyzed to ensure that the total peak flow does not exceed the existing conditions. Potential benefits to the city that are lost by approval of this waiver and the benefits gained by approval of this waiver are listed, below:

- A potential for comprehensive flowrates at the downstream end of the watershed to be larger than the allowable release rate (Longview Lake) for the 2-yr event is created. Although proposed peak flowrate is greater than the prescribed city standard, it is being reduced from existing site conditions. Reduction of the 2-year

1301 Burlington, Suite 100
North Kansas City, MO 64116
TEL 816.587.4320
FAX 816.587.1393
www.olssonassociates.com

storm event will be 65%, from 20.58 cfs to 7.15 cfs. This results in lower flow velocities in existing downstream channels and lower potential for channel erosion to occur.

- The existing flowrates to the 18" RCP culvert exceed the capacity of the culvert in all storm events, resulting in roadway overtopping in the 10 and 100-year events. By providing formal detention, peak flowrates are reduced so that all storm events, up to, and including, the 100-yr event, are contained on the southern side of the road and conveyed entirely by the 18" RCP culvert. Flows that exceed the capacity of the culvert are detained entirely within the detention pond and the roadside swale resulting in no overtopping of the road. Refer to the attached model of the drainage basin and control/outlet system for supporting calculations.

- Water quality treatment (40-hr detention) is not provided for the entire tributary area; however, treatment is provided for 75% of the tributary area to Point A1. Only public right-of-way and three lot frontages will bypass the detention facility which will limit the amount of pollutants from lawns and private yards that bypass treatment. Further, the area that bypasses the formal treatment will be conveyed through turf grass swales along the roadside which will help to filter and reduce pollutants entering the field inlet.

- With throat openings on all sides and the proposed roadside swale providing pre-treatment of stormwater, the new field inlet will be less likely to clog and will deter animals from entering the system. By providing the capacity for detention and conveyance of all storm events up to the 100-year, roadway deterioration caused by overtopping will be reduced from the existing conditions. Concrete field inlets are also less susceptible to damage than metal end sections, which also affects the performance of the system.

Waiver 2

The release rates for all storm events at Point B1 per the drainage study will be exceeded, but peak flow rates will be less than existing.

See attached Exhibit 2. No detention is provided at this point. The drainage area is only 1.43 acres, which does not lend itself to supporting a detention facility. Additionally, most of this area is open space or back yards. In lieu of detention, the open space in this area will be planted with native vegetation, which will increase the infiltration capability of the soil structure.

Potential benefits to the city that are lost by approval of this waiver and the benefits gained by approval of this waiver are listed, below:

- A potential increase in comprehensive flowrates at the downstream end of the watershed (Longview Lake) to be larger than allowable release rates for all storm events. Although proposed peak flowrates are greater than the prescribed city standard, they are being reduced from existing site conditions in all storm events. Reductions for the 2, 10 and 100-year storm events will be 2.11 cfs (37%), 3.47 cfs

(35%) and 5.52 cfs (34%), respectively. This results in lower flow velocities in existing downstream channels and lower potential for channel erosion to occur.

- The existing flowrates to the 24" RCP culvert exceed the capacity of the culvert in the 100-yr event, resulting in pressurized flow through the culvert. By reducing the tributary area to this culvert, flowrates are reduced to within capacity of the existing culvert during all storm events. Refer to the attached culvert model results for supporting calculations.

- No extended detention of the water quality storm event is provided. The purpose of drawing out the release time of the water quality storm event in an extended dry detention basin is to allow suspended solids and associated pollutants to settle. By providing native vegetation along the downstream end of the proposed residential lots, the stormwater will filter through an area of land with similar characteristics and features as a vegetated filter strip. This area will provide similar benefits as extended detention (i.e. volume reduction through infiltration and transpiration and oil/floatable reduction through sedimentation) while providing greater suspended solids removal. Also, keeping runoff in a sheet flow condition as it exits the site reduces the chance of shallow concentrated and channelized flows by reducing the velocity of offsite flows and thus the potential for erosion of offsite soils.

Waiver 3

The release rates for all storm events at Point C1 per the drainage study will be exceeded, but peak flow rates will be less than existing.

See attached Exhibit 3. No detention is provided at this point. The drainage area is only 5.52 acres, and is quite flat, which does not lend itself to supporting a detention facility. Additionally, most of this area is open space or back yards. In lieu of detention, the open space in this area will be planted with native vegetation, which will increase the infiltration capability of the soil structure.

Potential benefits to the city that are lost by approval of this waiver and the benefits gained by approval of this waiver are listed, below:

- A potential increase in comprehensive flowrates at the downstream end of the watershed (Longview Lake) to be larger than allowable release rates for all storm events. Although proposed peak flowrates are greater than the prescribed city standard, they are being reduced from existing site conditions in all storm events. Reductions for the 2, 10 and 100-year storm events will be 3.92 cfs (21%), 6.42 cfs (20%) and 10.21 cfs (19%), respectively. This results in lower flow velocities in existing downstream channels and lower potential for channel erosion to occur.

- No extended detention of the water quality storm event is provided. The purpose of drawing out the release time of the water quality storm event in an extended dry detention basin is to allow suspended solids and associated pollutants to settle. By providing native vegetation along the downstream end of the proposed residential lots, the stormwater will filter through an area of land with similar characteristics and features as a vegetated filter strip. This area will provide similar benefits as

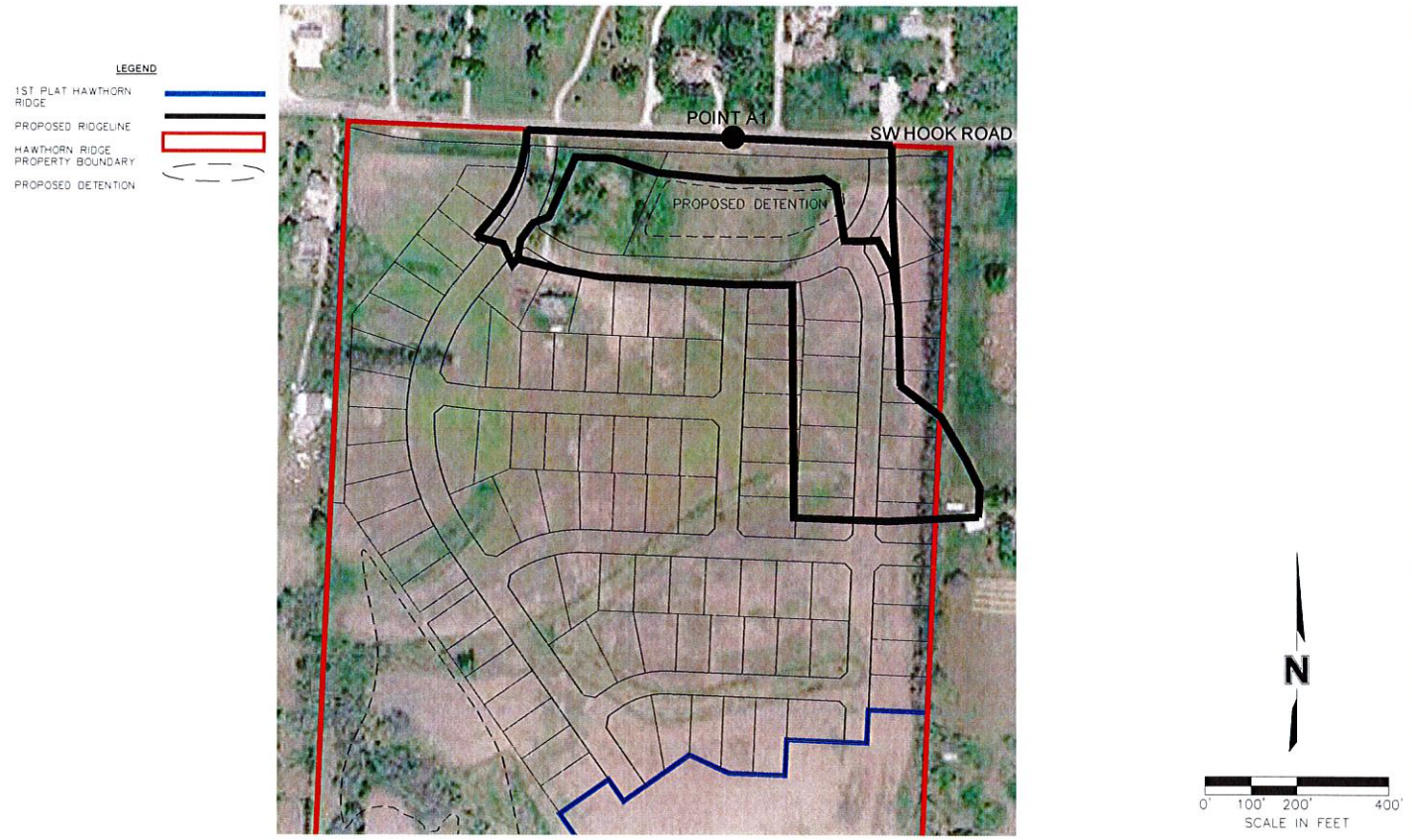
extended detention (i.e. volume reduction through infiltration and transpiration and oil/floatable reduction through sedimentation) while providing greater suspended solids removal. Also, keeping runoff in a sheet flow condition as it exits the site reduces the chance of shallow concentrated and channelized flows by reducing the velocity of offsite flows and thus the potential for erosion of offsite soils.

If you have any questions or need additional information, please do not hesitate to contact me by phone at 816.587.4320.

Sincerely,
Olsson Associates

Melissa DeGonia, PE

DWG: \\oa.ad.oaconsulting.com\te-ns1\projects\2017\0001-0500\017-0188\40-Design\Exhibits\Drainage Study Waivers\18-03-08_WAIVER EXHIBIT 1.dwg USER: dhernandez
DATE: Mar 09, 2018 10:54am XREFS: 01_C_PBASE



PROJECT NO: 017-0188 DRAWN BY: MGD DATE: 3.8.2018	WAIVER 1 FOR POINT A1	OLSSON ASSOCIATES 1301 Burlington, Suite 100 North Kansas City, MO 64116 TEL 816 587 4320 FAX 816 587 1393	EXHIBIT 1

DWG: \\oa.ad.oaconsulting.com\te-ns1\projects\2017\0001-0500\017-0188\40-Design\Exhibits\Drainage Study Waivers\18-03-08_WAIVER EXHIBIT 1.dwg USER: dhernandez
DATE: Mar 09, 2018 11:05am XREFS: 01_C_PBASE

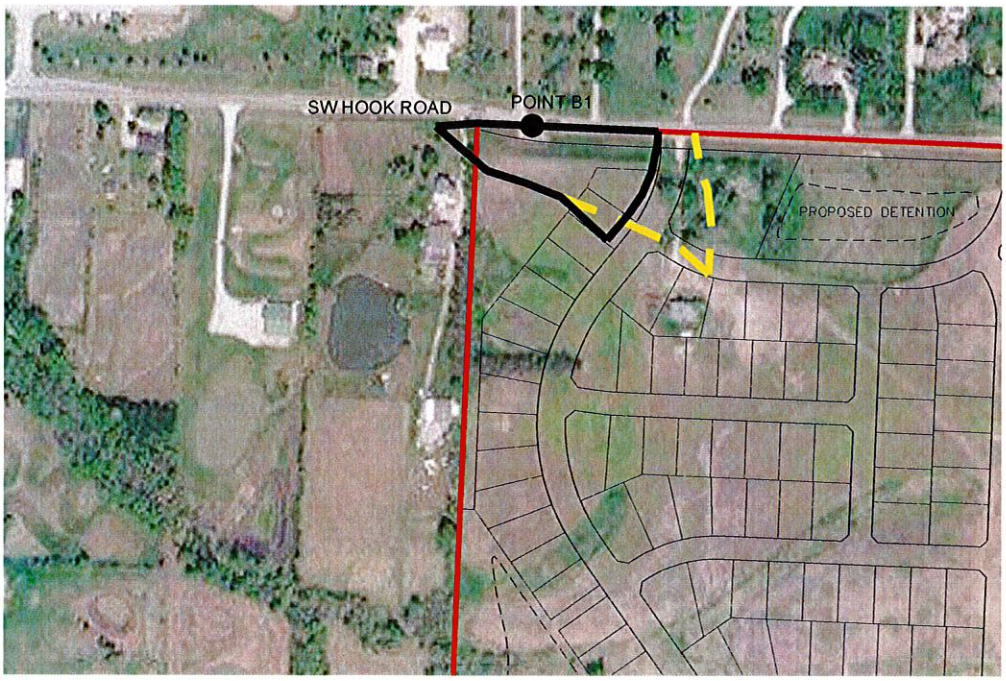
LEGEND

EXISTING RIDGELINE

PROPOSED RIDGELINE

HAWTHORN RIDGE PROPERTY BOUNDARY

PROPOSED DETENTION



N

0' 100' 200' 400'
SCALE IN FEET

PROJECT NO: 017-0188 DRAWN BY: MGD DATE: 3.8.2018	WAIVER 2 FOR POINT B1	OLSSON ASSOCIATES 1301 Burlington, Suite 100 North Kansas City, MO 64116 TEL 816.587.1320 FAX 816.587.1393	EXHIBIT 2

DWG: \\oa.ad.oaconsulting.com\te-ns1\projects\2017\0001-0500\017-0188\40-Design\Exhibits\Drainage Study Waivers\18-03-08_WAIVER EXHIBIT 1.dwg USER: dhernandez
DATE: Mar 09, 2018 11:04am XREFS: 01_C_PBASE

LEGEND

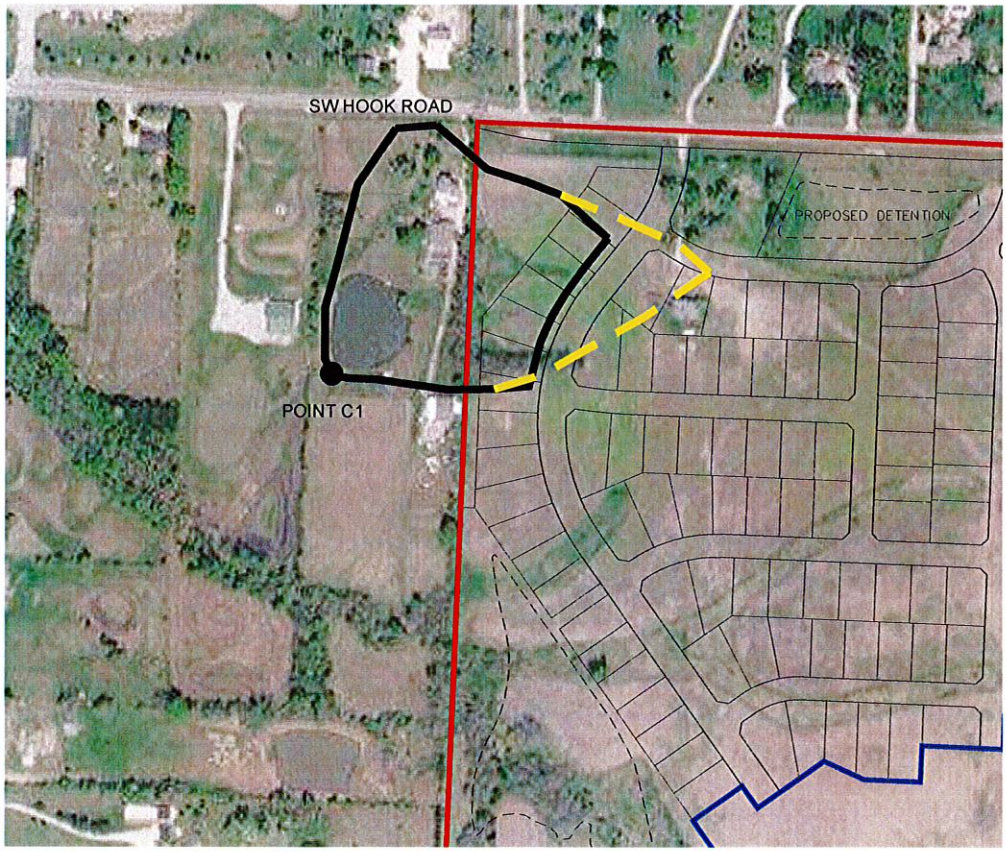
EXISTING RIDGELINE

PROPOSED RIDGELINE

HAWTHORN RIDGE PROPERTY BOUNDARY

PROPOSED DETENTION

1ST PLAT HAWTHORN RIDGE

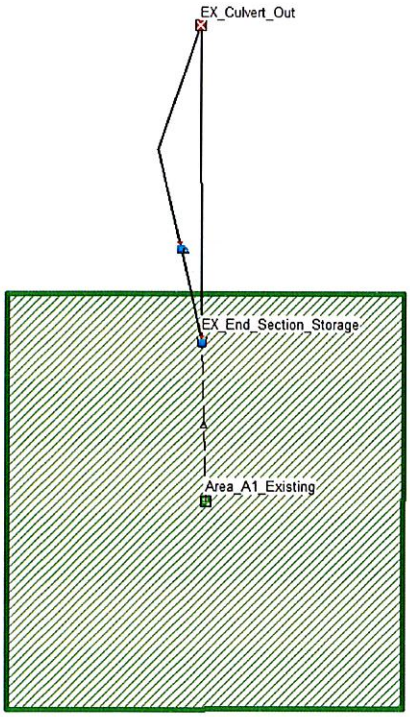


N

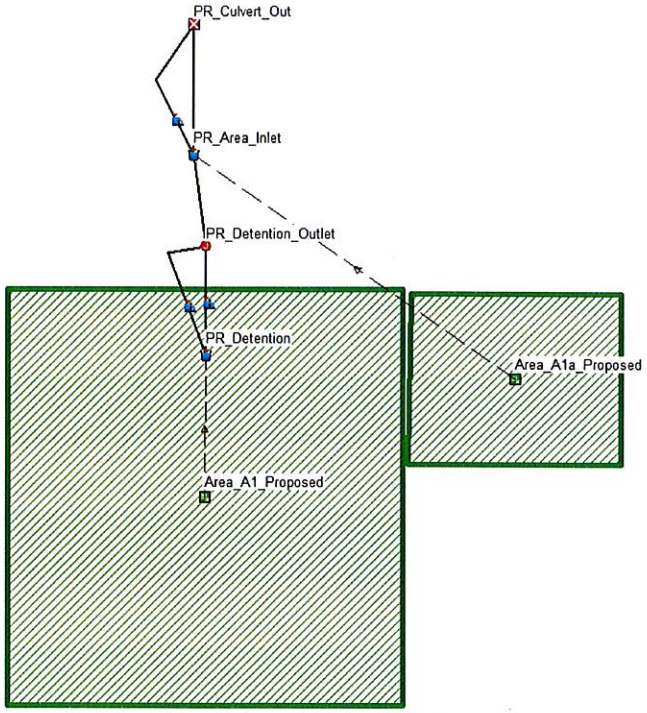
0' 100' 200' 400'
SCALE IN FEET

PROJECT NO: 017-0188 DRAWN BY: MGD DATE 3.8.2018	WAIVER 3 FOR POINT C1	OLSSON ASSOCIATES 1301 Burlington, Suite 100 North Kansas City, MO 64116 TEL 816.587.4100 FAX 816.587.1393	EXHIBIT 3

AREA A1 MODEL
2-YR STORM EVENT



EXISTING CONDITIONS



PROPOSED CONDITIONS

Autodesk Storm and Sanitary Analysis

Project Description

File Name ..... 017-0188_Basin_A1.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Apr 03, 2018	00:00:00
End Analysis On	Apr 04, 2018	00:05:00
Start Reporting On	Apr 03, 2018	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	3
Nodes	6
Junctions	1
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	3
Links	7
Channels	0
Pipes	3
Pumps	0
Orifices	2
Weirs	2
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	Rain Gage-01	Time Series	002-Yr	Cumulative	inches	Missouri	Jackson	2	3.50	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	Area_A1_Existing	7.62	84.00	3.50	1.94	14.75	20.08	0 00:10:51
2	Area_A1_Proposed	6.95	85.00	3.50	2.02	14.01	20.73	0 00:07:22
3	Area_A1a_Proposed	2.31	84.00	3.50	1.94	4.47	6.74	0 00:06:43

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)
1	PR_Detention_Outlet	Junction	1009.66	1028.00	1009.66	16.00	0.40	1012.16
2	EX_Culvert_Out	Outfall	1008.30				13.75	1009.76
3	PR_Culvert_Out	Outfall	1008.30				9.41	1009.23
4	EX_End_Section_Storage	Storage Node	1009.66	1016.06	1009.66	8537.11	20.07	1013.16
5	PR_Area_Inlet	Storage Node	1008.83	1016.06	1008.83	16.00	6.69	1011.63
6	PR_Detention	Storage Node	1022.00	1028.00	1022.00	44431.20	19.46	1023.04

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Outlet Invert Elevation	Average Slope	Diameter or Height	Manning's Roughness	Peak Flow	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Reported Condition
					(ft)	(ft)	(ft)	(%)	(in)		(cfs)	(cfs)		(ft/sec)	(ft)		
1	EX_18-in_Culvert	Pipe	EX_End_Section_Storage	EX_Culvert_Out	84.90	1009.66	1008.30	1.6000	18.000	0.0130	13.75	13.29	1.03	8.98	1.38	0.99	> CAPACITY
2	PR_18-in_Culvert	Pipe	PR_Area_Inlet	PR_Culvert_Out	33.13	1008.83	1008.30	1.6000	18.000	0.0130	9.41	13.29	0.71	8.26	0.77	0.61	Calculated
3	PR_Detention_Out_Pipe	Pipe	PR_Detention_Outlet	PR_Area_Inlet	84.08	1012.00	1009.33	3.1800	15.000	0.0130	0.40	11.51	0.03	4.40	0.16	0.13	Calculated
4	4-in_Orifice	Orifice	PR_Detention	PR_Detention_Outlet		1022.00	1009.66		4.000		0.40						
5	Throat_Opening	Orifice	PR_Detention	PR_Detention_Outlet		1022.00	1009.66		6.000		0.00						
6	EX_Roadway	Weir	EX_End_Section_Storage	EX_Culvert_Out		1009.66	1008.30				0.00						
7	PR_Roadway	Weir	PR_Area_Inlet	PR_Culvert_Out		1008.83	1008.30				0.00						

Subbasin Hydrology

Subbasin : Area_A1_Existing

Input Data

Area (ac) 7.62
Weighted Curve Number 84.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Row crops, contoured, Poor	7.62	C	84.00
Composite Area & Weighted CN	7.62		84.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

User-Defined TOC override (minutes): 10.86

Subbasin Runoff Results

Total Rainfall (in) 3.50
Total Runoff (in) 1.94
Peak Runoff (cfs) 20.08
Weighted Curve Number 84.00
Time of Concentration (days hh:mm:ss) 0 00:10:52

Subbasin : Area_A1_Proposed

Input Data

Area (ac)	6.95
Weighted Curve Number	85.00
Rain Gage ID	Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	7.62	-	85.00
Composite Area & Weighted CN	7.62		85.00

Time of Concentration

User-Defined TOC override (minutes): 7.38

Subbasin Runoff Results

Total Rainfall (in)	3.50
Total Runoff (in)	2.02
Peak Runoff (cfs)	20.73
Weighted Curve Number	85.00
Time of Concentration (days hh:mm:ss)	0 00:07:23

Subbasin : Area_A1a_Proposed

Input Data

Area (ac) 2.31
Weighted Curve Number 84.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	2.31	-	84.00
Composite Area & Weighted CN	2.31		84.00

Time of Concentration

User-Defined TOC override (minutes): 6.72

Subbasin Runoff Results

Total Rainfall (in) 3.50
Total Runoff (in) 1.94
Peak Runoff (cfs) 6.74
Weighted Curve Number 84.00
Time of Concentration (days hh:mm:ss) 0 00:06:43

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft^2)	Minimum Pipe Cover (in)
1	PR_Detention_Outlet	1009.66	1028.00	18.34	1009.66	0.00	1028.00	0.00	16.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)
1	PR_Detention_Outlet	0.40	0.00	1012.16	2.50	0.00	15.84	1012.08	2.42	0 17:43

Pipe Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses
1	EX_18-in_Culvert	84.90	1009.66	0.00	1008.30	0.00	1.36	1.6000	CIRCULAR	18.000	18.000	0.0130	0.5000	0.5000
2	PR_18-in_Culvert	33.13	1008.83	0.00	1008.30	0.00	0.53	1.6000	CIRCULAR	18.000	18.000	0.0130	0.5000	0.5000
3	PR_Detention_Out_Pipe	84.08	1012.00	2.34	1009.33	0.50	2.67	3.1800	CIRCULAR	15.000	15.000	0.0130	0.5000	0.5000

Pipe Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Froude Number	Reported Condition
1	EX_18-in_Culvert	13.75	0 11:59	13.29	1.03	8.98	0.16	1.38	0.99		> CAPACITY
2	PR_18-in_Culvert	9.41	0 12:00	13.29	0.71	8.26	0.07	0.77	0.61		Calculated
3	PR_Detention_Out_Pipe	0.40	0 17:43	11.51	0.03	4.40	0.32	0.16	0.13		Calculated

Storage Nodes

Storage Node : EX_End_Section_Storage

Input Data

Invert Elevation (ft)	1009.66
Max (Rim) Elevation (ft)	1016.06
Max (Rim) Offset (ft)	6.40
Initial Water Elevation (ft)	1009.66
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	8537.11
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : EX_End_Section

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	0	0.000
1	239.91	119.96
3	1691.45	2051.32
5	8537.11	12279.88
5.1	10861.45	13249.81
5.2	11733.57	14379.56
5.3	12536.84	15593.08
5.4	13336.77	16886.76
5.5	14123.515	18259.77
5.6	14831.31	19707.51
5.7	15526.43	21225.40
5.8	16394.28	22821.44
5.9	17192.14	24500.76
6.0	17949.07	26257.82
6.1	18671.26	28088.84
6.2	19374.50	29991.13
6.3	20066.02	31963.16
6.4	20750.07	34003.96

Storage Node : EX_End_Section_Storage (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	EX_Roadway	Trapezoidal	No	1014.13	4.47	63.00	1.30	3.33

Output Summary Results

Peak Inflow (cfs)	20.07
Peak Lateral Inflow (cfs)	20.07
Peak Outflow (cfs)	13.29
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1013.16
Max HGL Depth Attained (ft)	3.5
Average HGL Elevation Attained (ft)	1009.83
Average HGL Depth Attained (ft)	0.17
Time of Max HGL Occurrence (days hh:mm)	0 12:12
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : PR_Area_Inlet

Input Data

Invert Elevation (ft)	1008.83
Max (Rim) Elevation (ft)	1016.06
Max (Rim) Offset (ft)	7.23
Initial Water Elevation (ft)	1008.83
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	16.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : PR_Swale

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	16	0.000
2.64	16	42.24
4.34	4163.79	3595.06
4.64	6415.12	5181.90
4.74	10861.45	6045.73
4.84	11733.57	7175.48
4.94	12536.84	8389.00
5.04	13336.77	9682.68
5.14	14123.515	11055.69
5.24	14831.31	12503.43
5.34	15526.43	14021.32
5.44	16394.28	15617.36
5.54	17192.14	17296.68
5.64	17949.07	19053.74
5.74	18671.26	20884.76
5.84	19374.50	22787.05
5.94	20066.02	24759.08
6.04	20750.07	26799.88

Storage Node : PR_Area_Inlet (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	PR_Roadway	Trapezoidal	No	1014.13	5.30	63.00	1.30	3.33

Output Summary Results

Peak Inflow (cfs)	6.69
Peak Lateral Inflow (cfs)	6.48
Peak Outflow (cfs)	9.10
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1011.63
Max HGL Depth Attained (ft)	2.8
Average HGL Elevation Attained (ft)	1008.97
Average HGL Depth Attained (ft)	0.14
Time of Max HGL Occurrence (days hh:mm)	0 12:02
Total Exfiltration Volume (1000-ft^3)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : PR_Detention

Input Data

Invert Elevation (ft)	1022.00
Max (Rim) Elevation (ft)	1028.00
Max (Rim) Offset (ft)	6.00
Initial Water Elevation (ft)	1022.00
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	44431.20
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : PR_Detention_Basin

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	33410.5	0.000
2	38855.5	72266.00
4	44431.2	155552.70

Storage Node : PR_Detention (continued)

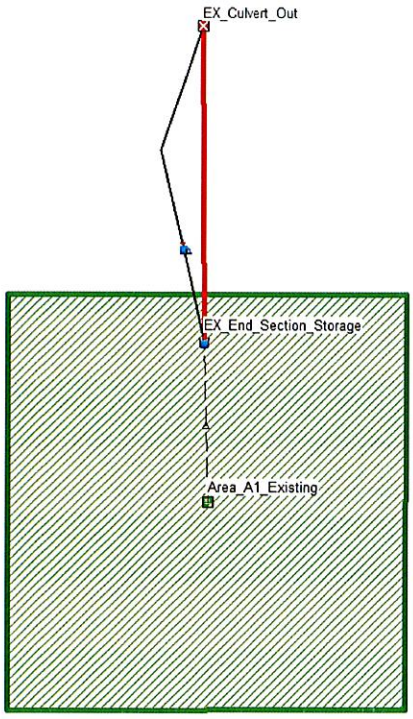
Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	4-in_Orifice	Side	CIRCULAR	No	4.00			1022.00	0.61
2	Throat_Opening	Side	Rectangular	No		6.00	48.00	1023.75	0.63

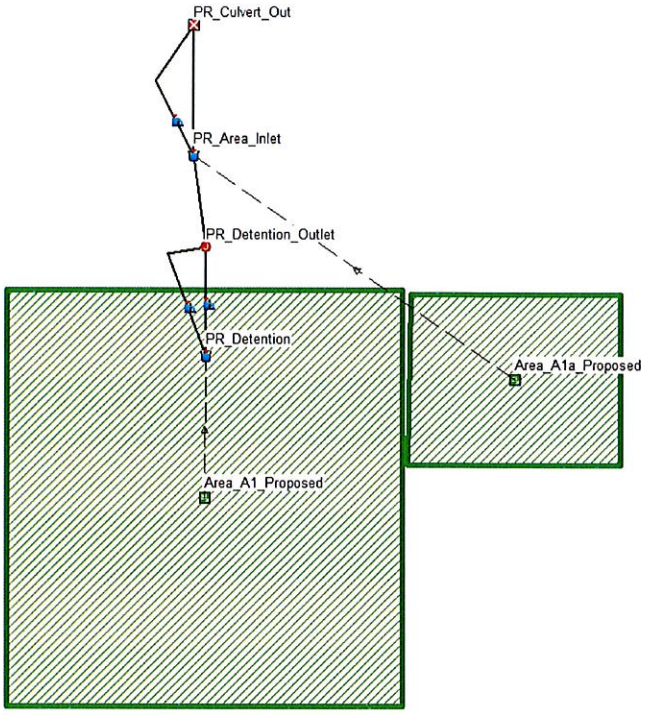
Output Summary Results

Peak Inflow (cfs)	19.46
Peak Lateral Inflow (cfs)	19.46
Peak Outflow (cfs)	0.40
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1023.04
Max HGL Depth Attained (ft)	1.04
Average HGL Elevation Attained (ft)	1022.50
Average HGL Depth Attained (ft)	0.5
Time of Max HGL Occurrence (days hh:mm)	0 17:43
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

AREA A1 MODEL
10-YR STORM EVENT



EXISTING CONDITIONS



PROPOSED CONDITIONS

Autodesk Storm and Sanitary Analysis

Project Description

File Name ..... 017-0188_Basin_A1.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Apr 03, 2018	00:00:00
End Analysis On	Apr 04, 2018	00:05:00
Start Reporting On	Apr 03, 2018	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	3
Nodes	6
Junctions	1
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	3
Links	7
Channels	0
Pipes	3
Pumps	0
Orifices	2
Weirs	2
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	Rain Gage-01	Time Series	010-Yr	Cumulative	inches	Missouri	Jackson	10	5.30	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	Area_A1_Existing	7.62	84.00	5.30	3.55	27.02	36.23	0 00:10:51
2	Area_A1_Proposed	6.95	85.00	5.30	3.65	25.34	36.90	0 00:07:22
3	Area_A1a_Proposed	2.31	84.00	5.30	3.55	8.19	12.20	0 00:06:43

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Ponded Area (ft^2)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)
1	PR_Detention_Outlet	Junction	1009.66	1028.00	1009.66	16.00	0.90	1012.24
2	EX_Culvert_Out	Outfall	1008.30				33.59	1009.77
3	PR_Culvert_Out	Outfall	1008.30				13.44	1009.55
4	EX_End_Section_Storage	Storage Node	1009.66	1016.06	1009.66	8537.11	36.15	1014.32
5	PR_Area_Inlet	Storage Node	1008.83	1016.06	1008.83	16.00	12.21	1011.65
6	PR_Detention	Storage Node	1022.00	1028.00	1022.00	44431.20	35.23	1023.83

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Outlet Invert Elevation	Average Slope	Diameter or Height	Manning's Roughness	Peak Flow	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Reported Condition
					(ft)	(ft)	(ft)	(%)	(in)		(cfs)	(cfs)		(ft/sec)	(ft)		
1	EX_18-in_Culvert	Pipe	EX_End_Section_Storage	EX_Culvert_Out	84.90	1009.66	1008.30	1.6000	18.000	0.0130	13.73	13.29	1.03	8.91	1.37	0.99	> CAPACITY
2	PR_18-in_Culvert	Pipe	PR_Area_Inlet	PR_Culvert_Out	33.13	1008.83	1008.30	1.6000	18.000	0.0130	13.44	13.29	1.01	8.64	1.37	0.91	> CAPACITY
3	PR_Detention_Out_Pipe	Pipe	PR_Detention_Outlet	PR_Area_Inlet	84.08	1012.00	1009.33	3.1800	15.000	0.0130	0.90	11.51	0.08	5.59	0.24	0.19	Calculated
4	4-in_Orifice	Orifice	PR_Detention	PR_Detention_Outlet		1022.00	1009.66		4.000		0.56						
5	Throat_Opening	Orifice	PR_Detention	PR_Detention_Outlet		1022.00	1009.66		6.000		0.35						
6	EX_Roadway	Weir	EX_End_Section_Storage	EX_Culvert_Out		1009.66	1008.30				20.30						
7	PR_Roadway	Weir	PR_Area_Inlet	PR_Culvert_Out		1008.83	1008.30				0.00						

Subbasin Hydrology

Subbasin : Area_A1_Existing

Input Data

Area (ac)	7.62
Weighted Curve Number	84.00
Rain Gage ID	Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Row crops, contoured, Poor	7.62	C	84.00
Composite Area & Weighted CN	7.62		84.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft^2)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

User-Defined TOC override (minutes): 10.86

Subbasin Runoff Results

Total Rainfall (in)	5.30
Total Runoff (in)	3.55
Peak Runoff (cfs)	36.23
Weighted Curve Number	84.00
Time of Concentration (days hh:mm:ss)	0 00:10:52

Subbasin : Area_A1_Proposed

Input Data

Area (ac)	6.95
Weighted Curve Number	85.00
Rain Gage ID	Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	7.62	-	85.00
Composite Area & Weighted CN	7.62		85.00

Time of Concentration

User-Defined TOC override (minutes): 7.38

Subbasin Runoff Results

Total Rainfall (in)	5.30
Total Runoff (in)	3.65
Peak Runoff (cfs)	36.90
Weighted Curve Number	85.00
Time of Concentration (days hh:mm:ss)	0 00:07:23

Subbasin : Area_A1a_Proposed

Input Data

Area (ac)	2.31
Weighted Curve Number	84.00
Rain Gage ID	Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	2.31	-	84.00
Composite Area & Weighted CN	2.31		84.00

Time of Concentration

User-Defined TOC override (minutes): 6.72

Subbasin Runoff Results

Total Rainfall (in)	5.30
Total Runoff (in)	3.55
Peak Runoff (cfs)	12.20
Weighted Curve Number	84.00
Time of Concentration (days hh:mm:ss)	0 00:06:43

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft^2)	Minimum Pipe Cover (in)
1	PR_Detention_Outlet	1009.66	1028.00	18.34	1009.66	0.00	1028.00	0.00	16.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)
1	PR_Detention_Outlet	0.90	0.00	1012.24	2.58	0.00	15.76	1012.11	2.45	0 15:40

Pipe Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses
1	EX_18-in_Culvert	84.90	1009.66	0.00	1008.30	0.00	1.36	1.6000	CIRCULAR	18.000	18.000	0.0130	0.5000	0.5000
2	PR_18-in_Culvert	33.13	1008.83	0.00	1008.30	0.00	0.53	1.6000	CIRCULAR	18.000	18.000	0.0130	0.5000	0.5000
3	PR_Detention_Out_Pipe	84.08	1012.00	2.34	1009.33	0.50	2.67	3.1800	CIRCULAR	15.000	15.000	0.0130	0.5000	0.5000

Pipe Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Froude Number	Reported Condition
1	EX_18-in_Culvert	13.73	0 11:53	13.29	1.03	8.91	0.16	1.37	0.99		> CAPACITY
2	PR_18-in_Culvert	13.44	0 12:01	13.29	1.01	8.64	0.06	1.37	0.91		> CAPACITY
3	PR_Detention_Out_Pipe	0.90	0 15:40	11.51	0.08	5.59	0.25	0.24	0.19		Calculated

Storage Nodes

Storage Node : EX_End_Section_Storage

Input Data

Invert Elevation (ft)	1009.66
Max (Rim) Elevation (ft)	1016.06
Max (Rim) Offset (ft)	6.40
Initial Water Elevation (ft)	1009.66
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	8537.11
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : EX_End_Section

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	0	0.000
1	239.91	119.96
3	1691.45	2051.32
5	8537.11	12279.88
5.1	10861.45	13249.81
5.2	11733.57	14379.56
5.3	12536.84	15593.08
5.4	13336.77	16886.76
5.5	14123.515	18259.77
5.6	14831.31	19707.51
5.7	15526.43	21225.40
5.8	16394.28	22821.44
5.9	17192.14	24500.76
6.0	17949.07	26257.82
6.1	18671.26	28088.84
6.2	19374.50	29991.13
6.3	20066.02	31963.16
6.4	20750.07	34003.96

Storage Node : EX_End_Section_Storage (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	EX_Roadway	Trapezoidal	No	1014.13	4.47	63.00	1.30	3.33

Output Summary Results

Peak Inflow (cfs)	36.15
Peak Lateral Inflow (cfs)	36.15
Peak Outflow (cfs)	33.59
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1014.32
Max HGL Depth Attained (ft)	4.66
Average HGL Elevation Attained (ft)	1009.94
Average HGL Depth Attained (ft)	0.28
Time of Max HGL Occurrence (days hh:mm)	0 12:06
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : PR_Area_Inlet

Input Data

Invert Elevation (ft)	1008.83
Max (Rim) Elevation (ft)	1016.06
Max (Rim) Offset (ft)	7.23
Initial Water Elevation (ft)	1008.83
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	16.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : PR_Swale

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	16	0.000
2.64	16	42.24
4.34	4163.79	3595.06
4.64	6415.12	5181.90
4.74	10861.45	6045.73
4.84	11733.57	7175.48
4.94	12536.84	8389.00
5.04	13336.77	9682.68
5.14	14123.515	11055.69
5.24	14831.31	12503.43
5.34	15526.43	14021.32
5.44	16394.28	15617.36
5.54	17192.14	17296.68
5.64	17949.07	19053.74
5.74	18671.26	20884.76
5.84	19374.50	22787.05
5.94	20066.02	24759.08
6.04	20750.07	26799.88

Storage Node : PR_Area_Inlet (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	PR_Roadway	Trapezoidal	No	1014.13	5.30	63.00	1.30	3.33

Output Summary Results

Peak Inflow (cfs)	12.21
Peak Lateral Inflow (cfs)	11.86
Peak Outflow (cfs)	13.29
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1011.65
Max HGL Depth Attained (ft)	2.82
Average HGL Elevation Attained (ft)	1009.05
Average HGL Depth Attained (ft)	0.22
Time of Max HGL Occurrence (days hh:mm)	0 11:57
Total Exfiltration Volume (1000-ft^3)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : PR_Detention

Input Data

Invert Elevation (ft)	1022.00
Max (Rim) Elevation (ft)	1028.00
Max (Rim) Offset (ft)	6.00
Initial Water Elevation (ft)	1022.00
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	44431.20
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : PR_Detention_Basin

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	33410.5	0.000
2	38855.5	72266.00
4	44431.2	155552.70

Storage Node : PR_Detention (continued)

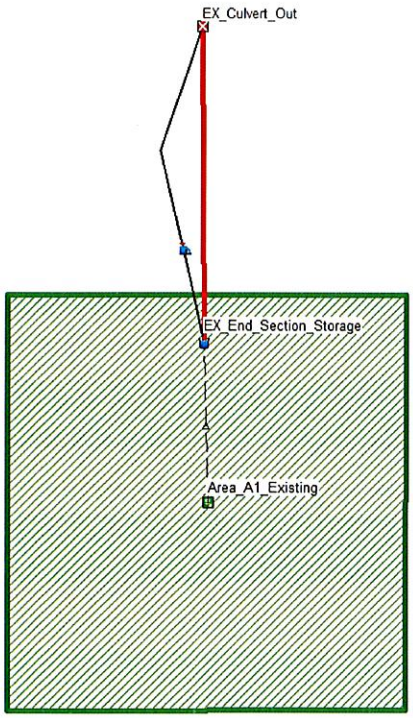
Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	4-in_Orifice	Side	CIRCULAR	No	4.00			1022.00	0.61
2	Throat_Opening	Side	Rectangular	No		6.00	48.00	1023.75	0.63

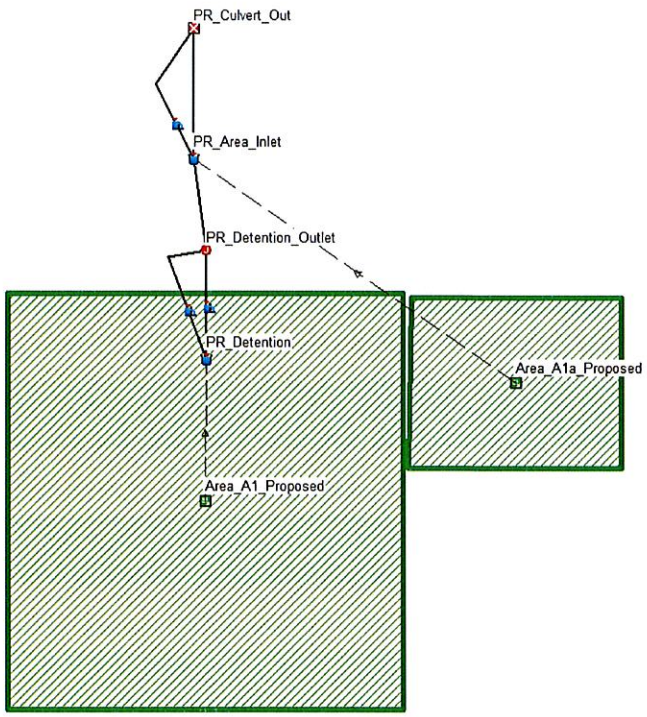
Output Summary Results

Peak Inflow (cfs)	35.23
Peak Lateral Inflow (cfs)	35.23
Peak Outflow (cfs)	0.90
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1023.83
Max HGL Depth Attained (ft)	1.83
Average HGL Elevation Attained (ft)	1022.91
Average HGL Depth Attained (ft)	0.91
Time of Max HGL Occurrence (days hh:mm)	0 15:40
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

AREA A1 MODEL
100-YR STORM EVENT



EXISTING CONDITIONS



PROPOSED CONDITIONS

Project Description

File Name ..... 017-0188_Basin_A1.SPF

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Apr 03, 2018	00:00:00
End Analysis On	Apr 04, 2018	00:05:00
Start Reporting On	Apr 03, 2018	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	1
Subbasins	3
Nodes	6
Junctions	1
Outfalls	2
Flow Diversions	0
Inlets	0
Storage Nodes	3
Links	7
Channels	0
Pipes	3
Pumps	0
Orifices	2
Weirs	2
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1	Rain Gage-01	Time Series	100-Yr	Cumulative	inches	Missouri	Jackson	100	7.70	SCS Type II 24-hr

Subbasin Summary

SN	Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
1	Area_A1_Existing	7.62	84.00	7.70	5.81	44.26	58.05	0 00:10:51
2	Area_A1_Proposed	6.95	85.00	7.70	5.92	41.17	58.68	0 00:07:22
3	Area_A1a_Proposed	2.31	84.00	7.70	5.81	13.42	19.58	0 00:06:43

Node Summary

SN	Element ID	Element Type	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Initial Water Elevation (ft)	Ponded Area (ft²)	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)
1	PR_Detention_Outlet	Junction	1009.66	1028.00	1009.66	16.00	6.56	1012.68
2	EX_Culvert_Out	Outfall	1008.30				57.09	1009.79
3	PR_Culvert_Out	Outfall	1008.30				13.82	1009.76
4	EX_End_Section_Storage	Storage Node	1009.66	1016.06	1009.66	8537.11	57.78	1014.43
5	PR_Area_Inlet	Storage Node	1008.83	1016.06	1008.83	16.00	19.59	1013.07
6	PR_Detention	Storage Node	1022.00	1028.00	1022.00	44431.20	56.22	1024.35

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Outlet Invert Elevation	Average Slope	Diameter or Height	Manning's Roughness	Peak Flow	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Reported Condition
					(ft)	(ft)	(ft)	(%)	(in)		(cfs)	(cfs)		(ft/sec)	(ft)		
1	EX_18-in_Culvert	Pipe	EX_End_Section_Storage	EX_Culvert_Out	84.90	1009.66	1008.30	1.6000	18.000	0.0130	14.28	13.29	1.07	8.92	1.36	1.00	> CAPACITY
2	PR_18-in_Culvert	Pipe	PR_Area_Inlet	PR_Culvert_Out	33.13	1008.83	1008.30	1.6000	18.000	0.0130	13.82	13.29	1.04	8.69	1.36	0.99	> CAPACITY
3	PR_Detention_Out_Pipe	Pipe	PR_Detention_Outlet	PR_Area_Inlet	84.08	1012.00	1009.33	3.1800	15.000	0.0130	6.56	11.51	0.57	9.68	0.68	0.54	Calculated
4	4-in_Orifice	Orifice	PR_Detention	PR_Detention_Outlet		1022.00	1009.66		4.000		0.63						
5	Throat_Opening	Orifice	PR_Detention	PR_Detention_Outlet		1022.00	1009.66		6.000		5.92						
6	EX_Roadway	Weir	EX_End_Section_Storage	EX_Culvert_Out		1009.66	1008.30				43.79						
7	PR_Roadway	Weir	PR_Area_Inlet	PR_Culvert_Out		1008.83	1008.30				0.00						

Subbasin Hydrology

Subbasin : Area_A1_Existing

Input Data

Area (ac) 7.62
Weighted Curve Number 84.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
Row crops, contoured, Poor	7.62	C	84.00
Composite Area & Weighted CN	7.62		84.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

User-Defined TOC override (minutes): 10.86

Subbasin Runoff Results

Total Rainfall (in) 7.70
Total Runoff (in) 5.81
Peak Runoff (cfs) 58.05
Weighted Curve Number 84.00
Time of Concentration (days hh:mm:ss) 0 00:10:52

Subbasin : Area_A1_Proposed

Input Data

Area (ac)	6.95
Weighted Curve Number	85.00
Rain Gage ID	Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	7.62	-	85.00
Composite Area & Weighted CN	7.62		85.00

Time of Concentration

User-Defined TOC override (minutes): 7.38

Subbasin Runoff Results

Total Rainfall (in)	7.70
Total Runoff (in)	5.92
Peak Runoff (cfs)	58.68
Weighted Curve Number	85.00
Time of Concentration (days hh:mm:ss)	0 00:07:23

Subbasin : Area_A1a_Proposed

Input Data

Area (ac) 2.31
Weighted Curve Number 84.00
Rain Gage ID ..... Rain Gage-01

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	2.31	-	84.00
Composite Area & Weighted CN	2.31		84.00

Time of Concentration

User-Defined TOC override (minutes): 6.72

Subbasin Runoff Results

Total Rainfall (in) 7.70
Total Runoff (in) 5.81
Peak Runoff (cfs) 19.58
Weighted Curve Number 84.00
Time of Concentration (days hh:mm:ss) 0 00:06:43

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft^2)	Minimum Pipe Cover (in)
1	PR_Detention_Outlet	1009.66	1028.00	18.34	1009.66	0.00	1028.00	0.00	16.00	0.00

Junction Results

SN	Element ID	Peak Inflow (cfs)	Peak Lateral Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)
1	PR_Detention_Outlet	6.56	0.00	1012.68	3.02	0.00	15.32	1012.18	2.52	0 12:30

Pipe Input

SN	Element ID	Length (ft)	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses
1	EX_18-in_Culvert	84.90	1009.66	0.00	1008.30	0.00	1.36	1.6000	CIRCULAR	18.000	18.000	0.0130	0.5000	0.5000
2	PR_18-in_Culvert	33.13	1008.83	0.00	1008.30	0.00	0.53	1.6000	CIRCULAR	18.000	18.000	0.0130	0.5000	0.5000
3	PR_Detention_Out_Pipe	84.08	1012.00	2.34	1009.33	0.50	2.67	3.1800	CIRCULAR	15.000	15.000	0.0130	0.5000	0.5000

Pipe Results

SN	Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Froude Number	Reported Condition
1	EX_18-in_Culvert	14.28	0 11:48	13.29	1.07	8.92	0.16	1.36	1.00		> CAPACITY
2	PR_18-in_Culvert	13.82	0 11:56	13.29	1.04	8.69	0.06	1.36	0.99		> CAPACITY
3	PR_Detention_Out_Pipe	6.56	0 12:30	11.51	0.57	9.68	0.14	0.68	0.54		Calculated

Storage Nodes

Storage Node : EX_End_Section_Storage

Input Data

Invert Elevation (ft)	1009.66
Max (Rim) Elevation (ft)	1016.06
Max (Rim) Offset (ft)	6.40
Initial Water Elevation (ft)	1009.66
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	8537.11
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : EX_End_Section

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	0	0.000
1	239.91	119.96
3	1691.45	2051.32
5	8537.11	12279.88
5.1	10861.45	13249.81
5.2	11733.57	14379.56
5.3	12536.84	15593.08
5.4	13336.77	16886.76
5.5	14123.515	18259.77
5.6	14831.31	19707.51
5.7	15526.43	21225.40
5.8	16394.28	22821.44
5.9	17192.14	24500.76
6.0	17949.07	26257.82
6.1	18671.26	28088.84
6.2	19374.50	29991.13
6.3	20066.02	31963.16
6.4	20750.07	34003.96

Storage Node : EX_End_Section_Storage (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	EX_Roadway	Trapezoidal	No	1014.13	4.47	63.00	1.30	3.33

Output Summary Results

Peak Inflow (cfs)	57.78
Peak Lateral Inflow (cfs)	57.78
Peak Outflow (cfs)	57.09
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1014.43
Max HGL Depth Attained (ft)	4.77
Average HGL Elevation Attained (ft)	1010.03
Average HGL Depth Attained (ft)	0.37
Time of Max HGL Occurrence (days hh:mm)	0 12:05
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : PR_Area_Inlet

Input Data

Invert Elevation (ft)	1008.83
Max (Rim) Elevation (ft)	1016.06
Max (Rim) Offset (ft)	7.23
Initial Water Elevation (ft)	1008.83
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	16.00
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : PR_Swale

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	16	0.000
2.64	16	42.24
4.34	4163.79	3595.06
4.64	6415.12	5181.90
4.74	10861.45	6045.73
4.84	11733.57	7175.48
4.94	12536.84	8389.00
5.04	13336.77	9682.68
5.14	14123.515	11055.69
5.24	14831.31	12503.43
5.34	15526.43	14021.32
5.44	16394.28	15617.36
5.54	17192.14	17296.68
5.64	17949.07	19053.74
5.74	18671.26	20884.76
5.84	19374.50	22787.05
5.94	20066.02	24759.08
6.04	20750.07	26799.88

Storage Node : PR_Area_Inlet (continued)

Outflow Weirs

SN	Element ID	Weir Type	Flap Gate	Crest Elevation (ft)	Crest Offset (ft)	Length (ft)	Weir Total Height (ft)	Discharge Coefficient
1	PR_Roadway	Trapezoidal	No	1014.13	5.30	63.00	1.30	3.33

Output Summary Results

Peak Inflow (cfs)	19.59
Peak Lateral Inflow (cfs)	19.11
Peak Outflow (cfs)	13.29
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1013.07
Max HGL Depth Attained (ft)	4.24
Average HGL Elevation Attained (ft)	1009.28
Average HGL Depth Attained (ft)	0.45
Time of Max HGL Occurrence (days hh:mm)	0 12:10
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Storage Node : PR_Detention

Input Data

Invert Elevation (ft)	1022.00
Max (Rim) Elevation (ft)	1028.00
Max (Rim) Offset (ft)	6.00
Initial Water Elevation (ft)	1022.00
Initial Water Depth (ft)	0.00
Ponded Area (ft²)	44431.20
Evaporation Loss	0.00

Storage Area Volume Curves

Storage Curve : PR_Detention_Basin

Stage (ft)	Storage Area (ft²)	Storage Volume (ft³)
0	33410.5	0.000
2	38855.5	72266.00
4	44431.2	155552.70

Storage Node : PR_Detention (continued)

Outflow Orifices

SN	Element ID	Orifice Type	Orifice Shape	Flap Gate	Circular Orifice Diameter (in)	Rectangular Orifice Height (in)	Rectangular Orifice Width (in)	Orifice Invert Elevation (ft)	Orifice Coefficient
1	4-in_Orifice	Side	CIRCULAR	No	4.00			1022.00	0.61
2	Throat_Opening	Side	Rectangular	No		6.00	48.00	1023.75	0.63

Output Summary Results

Peak Inflow (cfs)	56.22
Peak Lateral Inflow (cfs)	56.22
Peak Outflow (cfs)	6.56
Peak Exfiltration Flow Rate (cfm)	0.00
Max HGL Elevation Attained (ft)	1024.35
Max HGL Depth Attained (ft)	2.35
Average HGL Elevation Attained (ft)	1023.03
Average HGL Depth Attained (ft)	1.03
Time of Max HGL Occurrence (days hh:mm)	0 12:30
Total Exfiltration Volume (1000-ft³)	0.000
Total Flooded Volume (ac-in)	0
Total Time Flooded (min)	0
Total Retention Time (sec)	0.00

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Apr 3 2018

Culvert B1 - Existing 2-Yr

Invert Elev Dn (ft)	= 1009.98
Pipe Length (ft)	= 49.50
Slope (%)	= 2.36
Invert Elev Up (ft)	= 1011.15
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.020
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Mitered to slope (C)
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7

Embankment

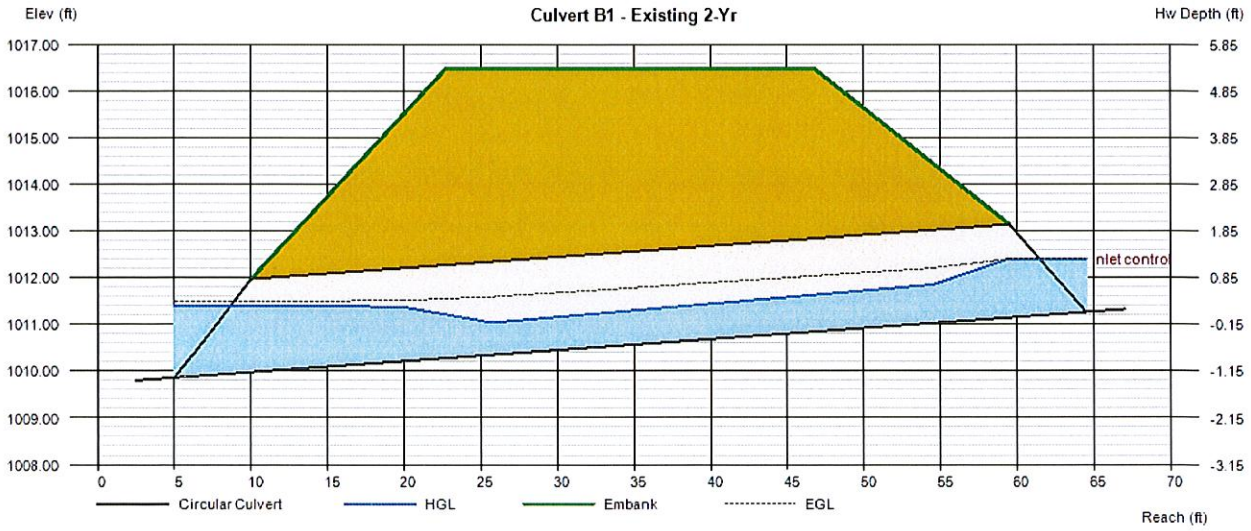
Top Elevation (ft)	= 1016.50
Top Width (ft)	= 24.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 5.72
Qmax (cfs)	= 5.72
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 5.72
Qpipe (cfs)	= 5.72
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 2.39
Veloc Up (ft/s)	= 4.54
HGL Dn (ft)	= 1011.40
HGL Up (ft)	= 1011.99
Hw Elev (ft)	= 1012.41
Hw/D (ft)	= 0.63
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Apr 3 2018

Culvert B1 - Proposed 2-Yr

Invert Elev Dn (ft)	= 1009.98
Pipe Length (ft)	= 49.50
Slope (%)	= 2.36
Invert Elev Up (ft)	= 1011.15
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.020
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Mitered to slope (C)
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7

Embankment

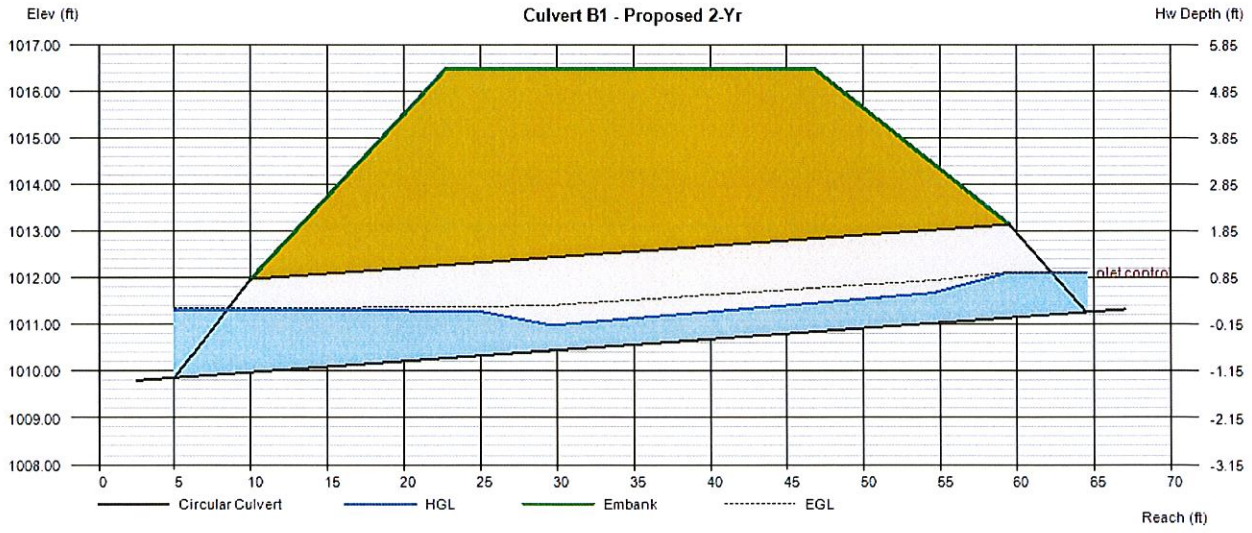
Top Elevation (ft)	= 1016.50
Top Width (ft)	= 24.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 3.61
Qmax (cfs)	= 3.61
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 3.61
Qpipe (cfs)	= 3.61
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 1.62
Veloc Up (ft/s)	= 3.95
HGL Dn (ft)	= 1011.31
HGL Up (ft)	= 1011.82
Hw Elev (ft)	= 1012.12
Hw/D (ft)	= 0.49
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Apr 3 2018

Culvert B1 - Existing 10-Yr

Invert Elev Dn (ft)	= 1009.98
Pipe Length (ft)	= 49.50
Slope (%)	= 2.36
Invert Elev Up (ft)	= 1011.15
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.020
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Mitered to slope (C)
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7

Embankment

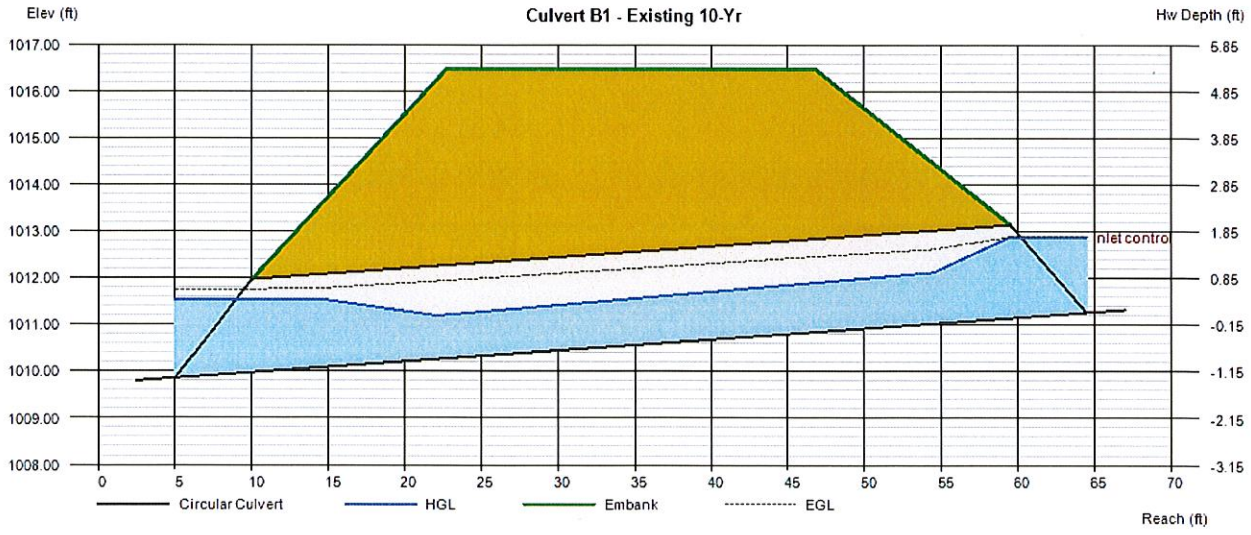
Top Elevation (ft)	= 1016.50
Top Width (ft)	= 24.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 9.88
Qmax (cfs)	= 9.88
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 9.88
Qpipe (cfs)	= 9.88
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 3.75
Veloc Up (ft/s)	= 5.44
HGL Dn (ft)	= 1011.54
HGL Up (ft)	= 1012.27
Hw Elev (ft)	= 1012.89
Hw/D (ft)	= 0.87
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Apr 3 2018

Culvert B1 - Proposed 10-Yr

Invert Elev Dn (ft)	= 1009.98
Pipe Length (ft)	= 49.50
Slope (%)	= 2.36
Invert Elev Up (ft)	= 1011.15
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.020
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Mitered to slope (C)
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7

Embankment

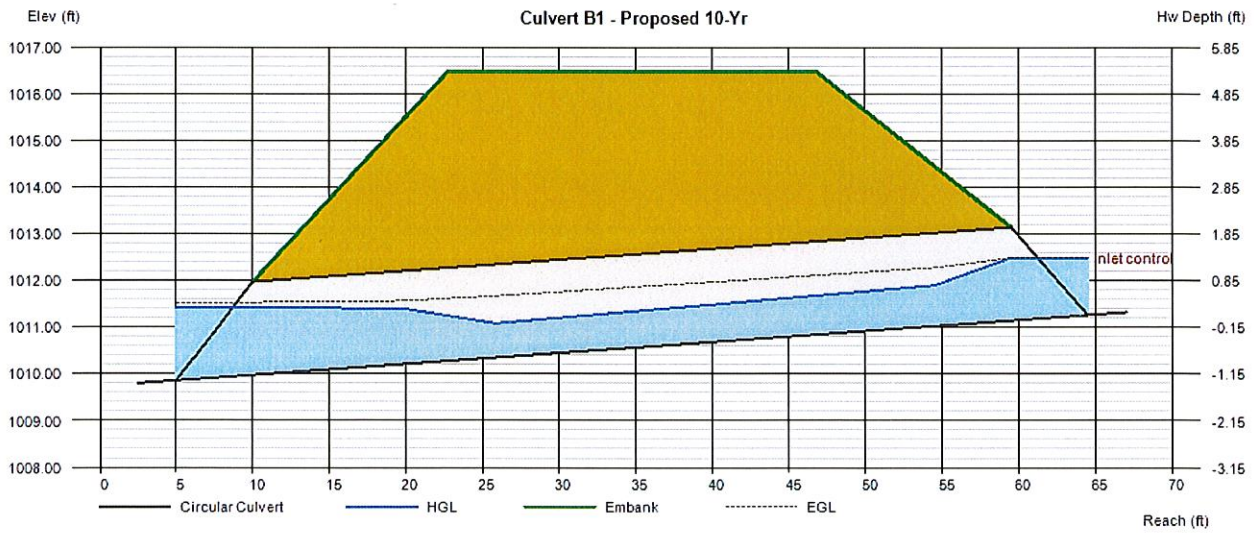
Top Elevation (ft)	= 1016.50
Top Width (ft)	= 24.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 6.41
Qmax (cfs)	= 6.41
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 6.41
Qpipe (cfs)	= 6.41
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 2.63
Veloc Up (ft/s)	= 4.70
HGL Dn (ft)	= 1011.43
HGL Up (ft)	= 1012.05
Hw Elev (ft)	= 1012.49
Hw/D (ft)	= 0.67
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Apr 3 2018

Culvert B1 - Existing 100-Yr

Invert Elev Dn (ft)	= 1009.98
Pipe Length (ft)	= 49.50
Slope (%)	= 2.36
Invert Elev Up (ft)	= 1011.15
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.020
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Mitered to slope (C)
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7

Embankment

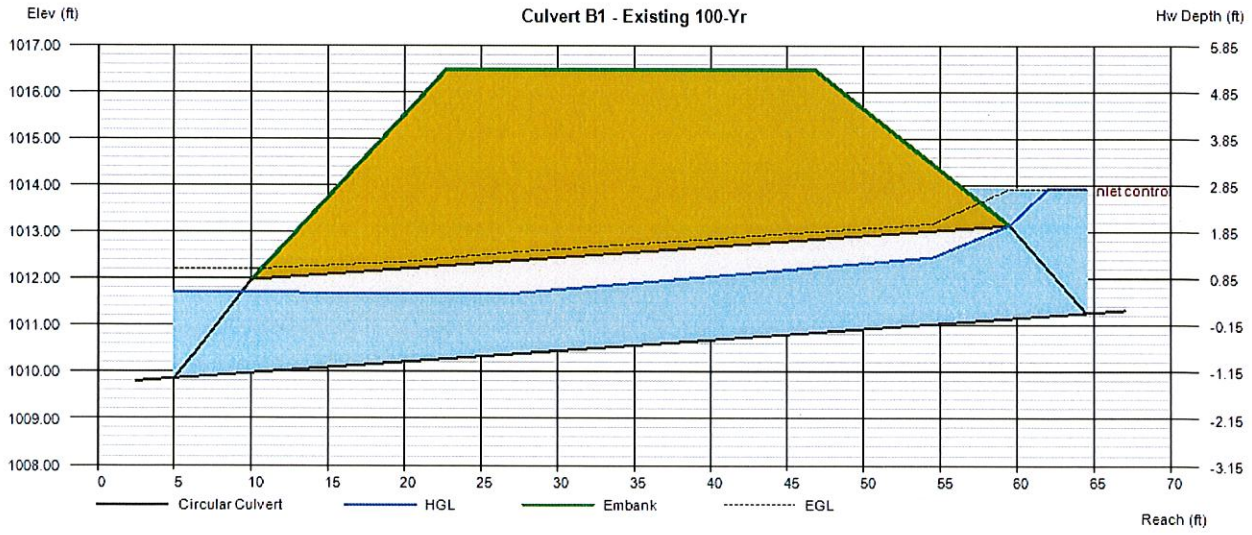
Top Elevation (ft)	= 1016.50
Top Width (ft)	= 24.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 16.29
Qmax (cfs)	= 16.29
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 16.29
Qpipe (cfs)	= 16.29
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.65
Veloc Up (ft/s)	= 6.66
HGL Dn (ft)	= 1011.71
HGL Up (ft)	= 1012.60
Hw Elev (ft)	= 1013.93
Hw/D (ft)	= 1.39
Flow Regime	= Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Apr 3 2018

Culvert B1 - Proposed 100-Yr

Invert Elev Dn (ft)	= 1009.98
Pipe Length (ft)	= 49.50
Slope (%)	= 2.36
Invert Elev Up (ft)	= 1011.15
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 1
n-Value	= 0.020
Culvert Type	= Circular Corrugate Metal Pipe
Culvert Entrance	= Mitered to slope (C)
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7

Embankment

Top Elevation (ft)	= 1016.50
Top Width (ft)	= 24.00
Crest Width (ft)	= 100.00

Calculations

Qmin (cfs)	= 10.77
Qmax (cfs)	= 10.77
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

Qtotal (cfs)	= 10.77
Qpipe (cfs)	= 10.77
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 4.03
Veloc Up (ft/s)	= 5.61
HGL Dn (ft)	= 1011.57
HGL Up (ft)	= 1012.33
Hw Elev (ft)	= 1012.98
Hw/D (ft)	= 0.92
Flow Regime	= Inlet Control