

FINAL STORMWATER REPORT FOR Lee's Summit Joint Operations Campus

Project Location:

10 NE Tudor Road, Lee's Summit, MO 64086

BHC Project # 041470.00.01

**10/16/2024
Rev : 11/15/2024**



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1.0 Introduction

This Final Stormwater Management Study is prepared for the expansion of the existing Lee's Summit Joint Operations Campus located at 10 NE Tudor Road, Lee's Summit, Missouri. The purpose of this study is to evaluate the existing on-site detention pond and the impacts of the expanded development on the existing detention pond and surrounding area. The project will result in the construction of a new Fire Administration building and associated Parking.

Governing design criteria is based on the APWA 5600 comprehensive control and the capacity of the downstream system to convey discharge during the systems design events.



Figure 1: Project Location Aerial

1.1 Methodology

The unit hydrograph modeling for this report was conducted using TR-55 methodologies within HydroCAD.

Runoff for this report was determined using a SCS Type II 24-Hour rainfall event.

The design storms used for this report were the 2-year (50%), 10-year (10%), and 100-year (1%) events. Rainfall depths for these events were determined from NOAA Atlas 14. The table below contains these rainfall depths.

Table I: Report Design Storms

Report Design Storms	
Storm Event	Rainfall Depth (in)
2-Year	3.70
10-Year	5.66
100-Year	9.23

The following documents were used as the design criteria for this report:

- Kansas City Metropolitan Chapter of APWA Standards, Specification and Design Criteria, Section 5600 (2011)

Controlling Design Requirement

APWA 5600 requires that rainfall events are held to the following to the following release rates. 0.5 cfs for the 2-year, 2.0 cfs for the 10-yr, and 3.0 cfs for the 100-yr for any newly developed area. For this site the area considered new development would be the eastern third of the site where the Fire Administration be located. BHC and the City of Lee's Summit have been unable to find the existing drainage study for the project and have not quantified release rates. BHC has reached out to the engineer of record (Bartlett and West), but was unable to obtain that information.

Additionally, BHC reviewed the receiving system to evaluate potential flooding issues down stream of the site. In this case the down stream system is the proposed storm sewer installed as part of the development of the Douglas Station Multifamily site to the north. This site is not yet developed, therefore BHC has relied on the final development plans prepared by the developer and their engineer, dated March 8, 2024. From that review BHC has determined that the developer has considered release rates from our proposed pond that pass through to the Douglas Station Commercial Park Regional Pond. **From conversations between BHC and City Staff (Gene Williams and Grant White), BHC has determined that the assumed Joint Operations Center pond release rates contained within the Douglas Station Multifamily Final Development Plans should be considered the controlling design requirement.**

2.0 Existing Conditions

2.1 Project Site

The existing project site is currently occupied by the existing Lee's Summit Municipal Court Facility basin on the site grading, the project site has 11.41 acres tributary to the detention pond, and additional 0.78 acres of off-site runoff from the right-of-way of Tudor. Total tributary area is 12.19 acres.

2.2 Hydrology

A majority of the project site drains towards the existing detention pond. This drainage area is summarized below in Table II.

Table II: Existing Drainage Areas

		AREA		PERVIOUS		IMPERVIOUS		CN-Value	C-VALUE
	Total	631,858 SF	(14.51 ac)	294518.55 SF	(6.76 ac)	337,339 SF	(7.74 ac)	90	0.62
To Pond	Onsite	497,121 SF	(11.41 ac)	237177.93 SF	(5.44 ac)	259,943 SF	(5.97 ac)	89	0.61
	Offsite	33,883 SF	(0.78 ac)	12318.70 SF	(0.28 ac)	21,564 SF	(0.50 ac)	91	0.68
Not to Pond	Onsite	26,149 SF	(0.60 ac)	21777.89 SF	(0.50 ac)	4,371 SF	(0.10 ac)	83	0.40
	Offsite	74,704 SF	(1.71 ac)	23244.02 SF	(0.53 ac)	51,460 SF	(1.18 ac)	92	0.71

The drainage area was analyzed in HydroCAD, using TR-55 methodologies to calculate the peak runoff from the existing site in the 2-, 10-, and 100-year storm events to the existing detention pond. These calculations are found in Appendix A1. Table III below summarizes these quantities.

Table III: Existing Site Generated Runoff

Existing Site Generated Runoff (cfs)		
2-Year	10-Year	100-Year
47.16	78.42	134.50

2.3 Existing Detention

The existing detention pond was evaluated in all runoff events. The storm events are attenuated through the pond by two existing 30" CMP culvert pipes. During the 2013 modifications to the site a 2-ft plate with multiple orifices was added to detention pond, an image of this control structure is below. The Stormwater Management Study from 2013 modification has not been found at the time this report was submitted, therefore, BHC evaluated the flow through the pond based on the conditions that presently exist. This results in the following pond peak release rates:

Existing Detention Pond				
Storm Event	Primary Spillway Peak Release (cfs)	Overflow Spillway Peak Release (cfs)	Combined Peak Release (CFS)	Stage Storage Elevation
2-year	29.89	0	29.89	1002.57
10-year	53.31	1.89	55.21	1003.29
100-year	73.08	42.83	115.91	1003.97

Due to the activation of the overflow spillway in the 10-year event, BHC believes that the existing pond is undersized, based on the established Design Methodology Section 1.1 of this report. Therefore, additional volume is needed with the proposed modification to address the current undersized pond.

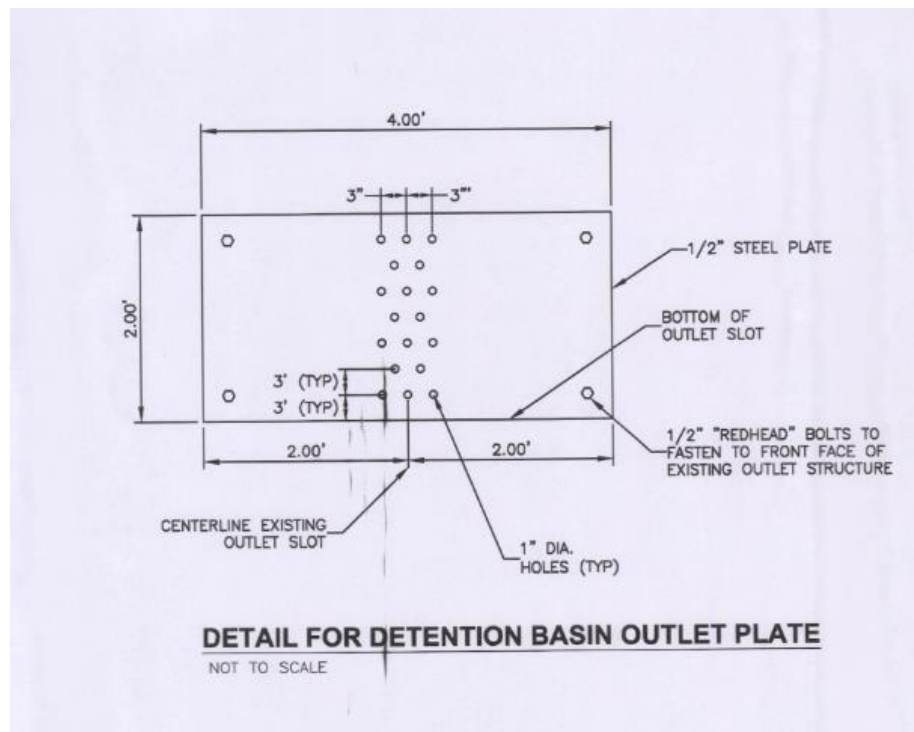


Image: 2013 Pond Modifications

3.0 Proposed Condition

3.1 Project Site

The project will result in the construction of a Fire Administration building, associated parking and site grading changes. This will result in an increase of the tributary area to the detention pond from 12.19 acres to 12.39 (11.59 acres from project site and 0.8 acres from Tudor right-of-way).

3.2 Hydrology

A majority of the project site drains towards the existing detention pond. This drainage area is summarized below in Table IV.

Table IV: Proposed Drainage Areas

		AREA		PERVIOUS		IMPERVIOUS		CN-Value	C-VALUE
	Total	632,704 SF	(14.52 ac)	226,996 SF	(5.21 ac)	405,708 SF	(9.31 ac)	92	0.68
To Pond	Onsite	504,869 SF	(11.59 ac)	175,873 SF	(4.04 ac)	328,996 SF	(7.55 ac)	92	0.69
	Offsite	34,740 SF	(0.80 ac)	13,154 SF	(0.30 ac)	21,586 SF	(0.50 ac)	91	0.67
Not to Pond	Onsite	19,248 SF	(0.44 ac)	15,814 SF	(0.36 ac)	3,434 SF	(0.08 ac)	83	0.41
	Offsite	73,848 SF	(1.70 ac)	22,155 SF	(0.51 ac)	51,692 SF	(1.19 ac)	93	0.72

The drainage area was analyzed in HydroCAD, using TR-55 methodologies to calculate the peak runoff from the existing site in the 2-, 10-, and 100-year storm events. These calculations are found in Appendix A1. Table V below summarizes these quantities.

Table V: Proposed Site Generated Runoff

Proposed Site Generated Runoff (cfs)		
2-Year	10-Year	100-Year
50.58	82.12	138.64

The proposed development of the site results in an increase in peak runoff rates in all analyzed storm events. To manage runoff to pre-development levels the existing detention pond will need to be expanded.

3.3 Controlling Release Rate

Downstream Analysis

The City of Lee's Summit provided the Final Development Plans submitted by for the multi-family development located north of the project site. BHC has reviewed the plans and sheet C202 indicates that a release rate from the pond located on the Joint Operations Center property considered a release rate of 36 cfs in the 10-year storm, and 54 CFS in the 100-year storm.

Additionally, the current overflow spillway discharges to the proposed Douglas Station Multi-Family Project. The current spillway location creates a potential of flooding of downstream Multi-Family site. Therefore, this proposed design includes raising the top of the north berm elevation of the detention pond to 1005.50. This allows for the construction of spillway to west towards Commerce Drive and minimizes downstream flooding during an emergency overflow event.

3.3 Proposed Detention

Detention will be provided by modification of the existing dry detention pond. Presently, the outlet of the pond includes two 30" CMP outlet pipes, the proposed solutions considers replacing the existing CMP structures an outlet control structure with a weir wall. The weir wall will have a 3" opening for the water quality storm (extended dry detention released over 40 hours). The 10 and 100-yr events will be controlled by 4" wide by 18" tall opening. The depth an area of the pond has been increased to allow for (1) additional detention and (2) a direct connection to the proposed inlet 1-6 located on the development to the north.

Information regarding the downstream system has been provided in Appendix A2.

This controls the release rate to the flows assumed for the project.

Proposed Detention Pond		
Storm Event	Peak Release (cfs)	Stage Storage Elevation
Water Quality	0.37	997.5
*2-year	23.73	999.49
10-year	34.50	1000.85
100-year	55.61	1002.75
Bottom of Spillway	--	1003.75
**Top of Spillway	--	1004.70
Top of Berm	--	1005.50

*The 2-year event was not defined in the downstream system.

**Spillway sizing is provided in Appendix A3.

Emergency Overflow Spillway

As previously discussed, the current emergency overflow spillway discharges onto property proposed for multifamily construction. This creates potential for downstream flooding during an event that activates the emergency spillway. To prevent this the proposed design raises the top of berm height to 1005.50 and relocates the spillway to the discharge on Commerce Drive. To provide the flow required for the 100-year event the spillway will need to be constructed of concrete and include a retaining wall to stabilize the berm along the northside of the site. This location and detailing of the spillway are indicated on Sheet C3.3 in the project plans.

The current spillway design provides 0.8-ft of freeboard between the top of spillway flow elevation and the top of berm. Per Gene Williams review comments dated November 1, 2024, if 0.8-ft of freeboard can be provided a waiver from APWA 5600 is not required.

4.0 Downstream Analysis

As previously discussed BHC reviewed downstream infrastructure as part of this analysis. The site discharges to a currently undeveloped site that has an active Final Development Plan in review by the City of Lee's Summit. The proposed development includes installation of an enclosed storm sewer system through the property replacing the existing channel. The proposed detention meets the allowed release rates to that system from the on-site pond. However, the site does not have surface flow capacity for the emergency overflow event required by APWA 5600. Therefore, the proposed design relocates the existing overflow spillway to discharge to Commerce Drive. As part of the Stormwater Management Study. Downstream conditions were considered.

Additionally, BHC recommends a direct connection to the Douglas Station Multi-Family system to in lieu of an overland flow.

4.0 Water Quality

Per the Lee Summit design and construction manual “volumetric and/or extended detention control of the 90% mean annual event storm event shall be provided for broad protection of the receiving system, including channel erosion protection and flood peak reductions over a range of return periods.”

This is achieved as described above with the use of the restricted 3” orifice to manage runoff from the 1.37 inch event.

6.0 Permitting

6.1 United State Army Corps of Engineers (USACE)

The National Wetland Inventory and USGS Mapping does not Identify and jurisdictional waters within the site area. There are no known USACE regulated levees with 500-feet of the site.

6.2 Federal Emergency Management Agency (FEMA)

The site is located within the Zone X, and outside of the 1% and 0.2% annual chance flood hazard, as shown on FEMA FIRM Map 29095C0417G, effective 1/20/2017. The FEMA Firmette for the project site can be found in Appendix A4

6.3 Missouri Department of Natural Resources (MoDNR)

The area to be disturbed by the project site exceeds 1-acre; a Notice of Intent (NOI) is required to be submitted to MoDNR and a Stormwater Pollution Prevention Plan (SWPPP) will be prepared for the project.

6.0 Conclusion

Multiple stormwater control criteria were considered for the development of the proposed project. It was also determined that the existing pond is undersized as the overflow spillway is activated in the 10-year event. Therefore, the existing undersize of this pond needs addressed as part of the proposed improvements.

It was determined that limiting release rate criteria is the capacity of the proposed Douglas Station Multifamily storm sewer system. The design rates of the Joint Operations Center to the receiving storm sewer system were considered the controlling design criteria.

The existing overflow spillway discharging to the Douglas Station project is proposed to be relocated to discharge to Commerce Drive.

Additionally, the stormwater design meets the Lee's Summit Design and Construction manual requirements for water quality control through the use of an Extended Dry Detention system.

Appendix A – Reference Documents

A1 – HyrdoCAD Output Summary

A2 – Douglass Station Commercial Park Reference Documents

A3 – Spillway Design

A4 – FEMA Firmette

A5 – Drainage Maps

Appendix A – Reference Documents

A1 – HyrdoCAD Output Summary

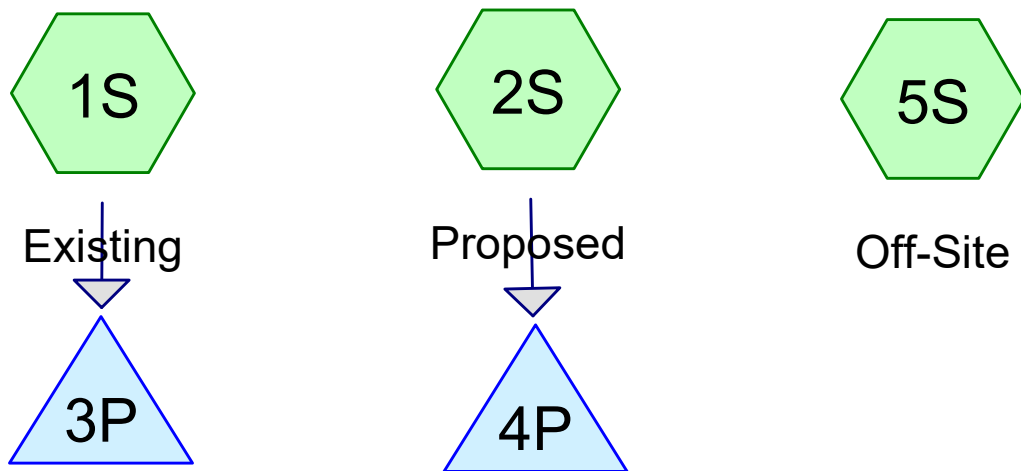
A2 – Douglass Station Commercial Park Reference Documents

A3 – Spillway Design

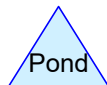
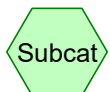
A4 – FEMA Firmette

A5 – Drainage Maps

Appendix A1



Existing Detention Proposed Detention



Routing Diagram for LS Joint Ops

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LS Joint Ops

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Page 2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
12.190	90	(1S)
12.390	92	(2S)
0.500	91	(5S)
25.080	91	TOTAL AREA

LS Joint Ops

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Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
25.080	Other	1S, 2S, 5S
25.080		TOTAL AREA

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Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	25.080	25.080		1S, 2S, 5S
0.000	0.000	0.000	0.000	25.080	25.080	TOTAL AREA	

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Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	3P	999.50	999.00	40.0	0.0125	0.025	30.0	0.0	0.0
2	4P	994.90	994.50	40.0	0.0100	0.012	30.0	0.0	0.0

LS Joint Ops*Type II 24-hr 2-year Rainfall=3.70"*

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Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: ExistingRunoff Area=12.190 ac 0.00% Impervious Runoff Depth>2.64"
Tc=10.0 min CN=90 Runoff=47.16 cfs 2.677 af**Subcatchment 2S: Proposed**Runoff Area=12.390 ac 0.00% Impervious Runoff Depth>2.83"
Tc=10.0 min CN=92 Runoff=50.58 cfs 2.918 af**Subcatchment 5S: Off-Site**Runoff Area=0.500 ac 0.00% Impervious Runoff Depth>2.73"
Tc=5.0 min CN=91 Runoff=2.33 cfs 0.114 af**Pond 3P: Existing Detention**Peak Elev=1,002.57' Storage=33,368 cf Inflow=47.16 cfs 2.677 af
Primary=29.89 cfs 2.670 af Secondary=0.00 cfs 0.000 af Outflow=29.89 cfs 2.670 af**Pond 4P: Proposed Detention**Peak Elev=999.49' Storage=49,259 cf Inflow=50.58 cfs 2.918 af
Outflow=23.73 cfs 2.918 af**Total Runoff Area = 25.080 ac Runoff Volume = 5.709 af Average Runoff Depth = 2.73"**
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

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Type II 24-hr 2-year Rainfall=3.70"

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Summary for Subcatchment 1S: Existing

Runoff = 47.16 cfs @ 12.01 hrs, Volume= 2.677 af, Depth> 2.64"

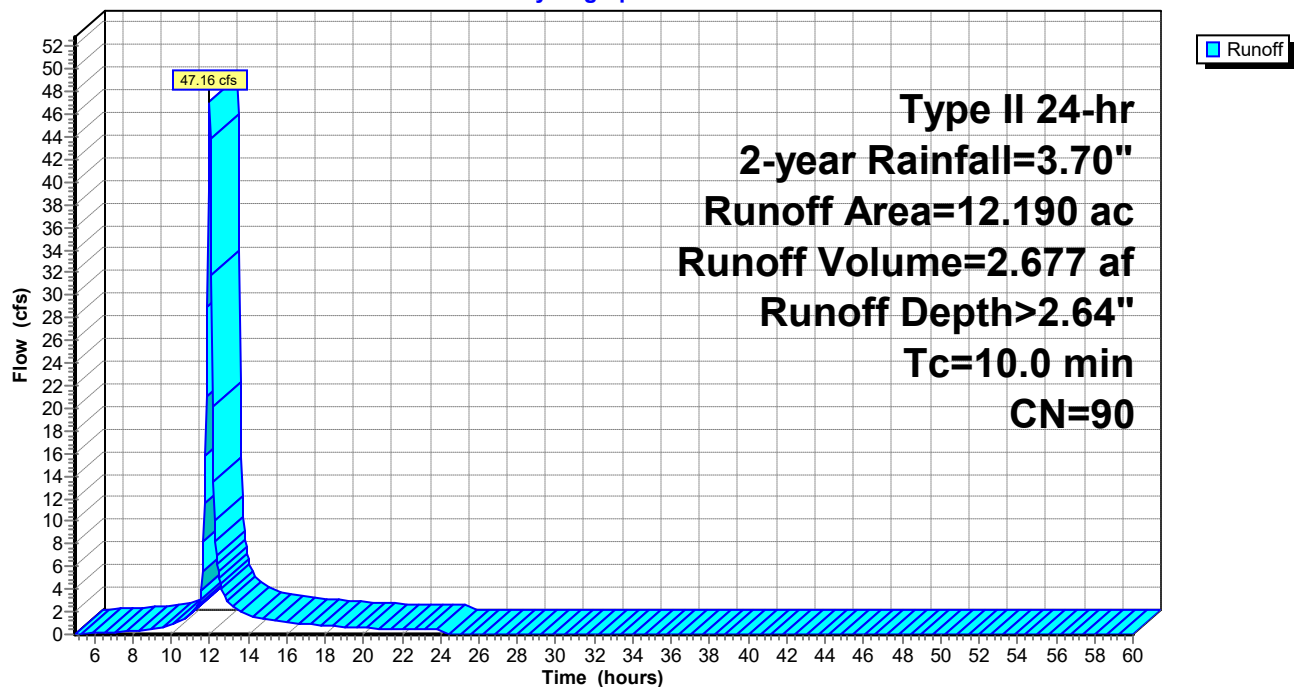
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-year Rainfall=3.70"

Area (ac)	CN	Description
* 12.190	90	
12.190		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 1S: Existing

Hydrograph



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Type II 24-hr 2-year Rainfall=3.70"

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Summary for Subcatchment 2S: Proposed

Runoff = 50.58 cfs @ 12.01 hrs, Volume= 2.918 af, Depth> 2.83"

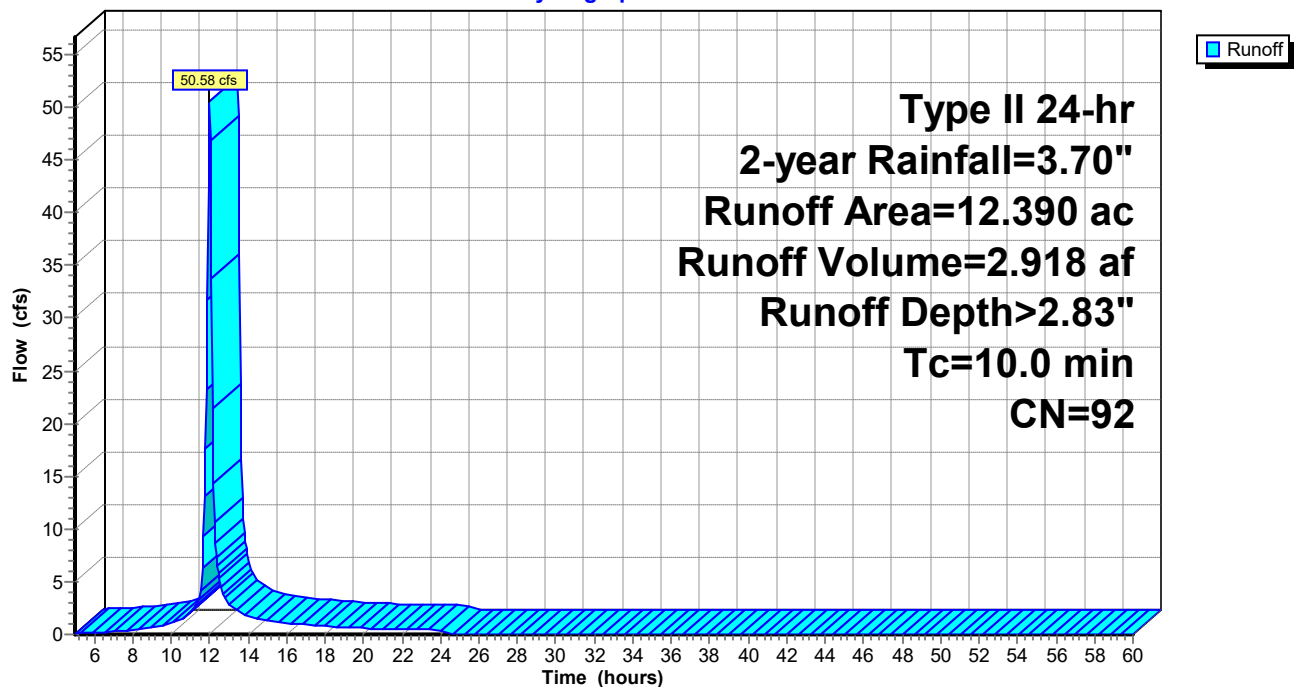
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-year Rainfall=3.70"

Area (ac)	CN	Description
* 12.390	92	
12.390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 2S: Proposed

Hydrograph



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Type II 24-hr 2-year Rainfall=3.70"

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Summary for Subcatchment 5S: Off-Site

[49] Hint: $T_c < 2dt$ may require smaller dt

Runoff = 2.33 cfs @ 11.95 hrs, Volume= 0.114 af, Depth> 2.73"

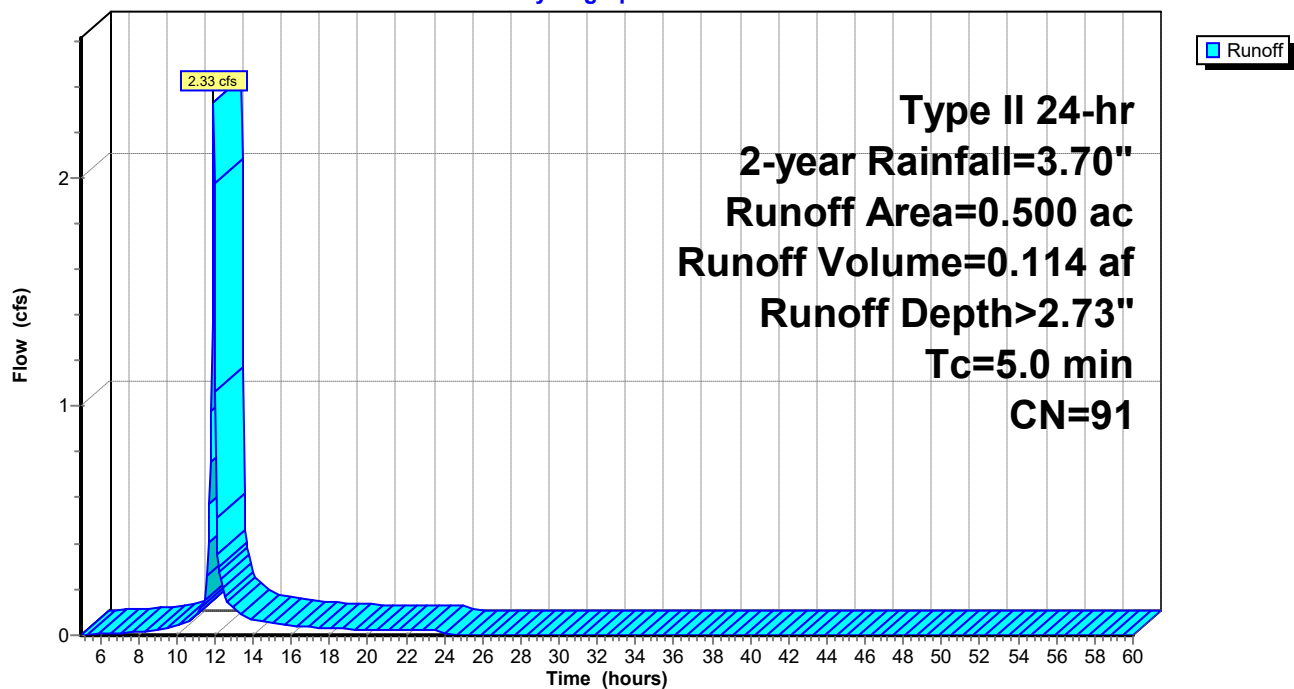
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, $dt=0.05$ hrs
Type II 24-hr 2-year Rainfall=3.70"

Area (ac)	CN	Description
* 0.500	91	
0.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry,

Subcatchment 5S: Off-Site

Hydrograph



LS Joint Ops

Type II 24-hr 2-year Rainfall=3.70"

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Summary for Pond 3P: Existing Detention

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth > 2.64" for 2-year event
 Inflow = 47.16 cfs @ 12.01 hrs, Volume= 2.677 af
 Outflow = 29.89 cfs @ 12.11 hrs, Volume= 2.670 af, Atten= 37%, Lag= 6.0 min
 Primary = 29.89 cfs @ 12.11 hrs, Volume= 2.670 af
 Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,002.57' @ 12.11 hrs Surf.Area= 18,484 sf Storage= 33,368 cf

Plug-Flow detention time= 87.9 min calculated for 2.668 af (100% of inflow)
 Center-of-Mass det. time= 86.7 min (888.6 - 802.0)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	30.0" Round CMP_Round 30" X 2.00 L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#3	Device 1	999.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#4	Device 1	999.75'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#5	Device 1	1,000.00'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#6	Device 1	1,000.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#7	Device 1	1,000.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#8	Device 1	1,000.75'	3.0" Vert. Orifice/Grate X 3.00 C= 0.600
#9	Secondary	1,003.20'	24.0' long x 22.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#10	Device 1	1,001.00'	4.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 1.0' Crest Height

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Type II 24-hr 2-year Rainfall=3.70"

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Primary OutFlow Max=29.57 cfs @ 12.11 hrs HW=1,002.56' (Free Discharge)

1=CMP_Round 30" (Passes 29.57 cfs of 52.84 cfs potential flow)

2=Orifice/Grate (Orifice Controls 0.14 cfs @ 8.42 fps)

3=Orifice/Grate (Orifice Controls 0.09 cfs @ 8.37 fps)

4=Orifice/Grate (Orifice Controls 0.13 cfs @ 8.01 fps)

5=Orifice/Grate (Orifice Controls 0.08 cfs @ 7.64 fps)

6=Orifice/Grate (Orifice Controls 0.12 cfs @ 7.25 fps)

7=Orifice/Grate (Orifice Controls 0.07 cfs @ 6.84 fps)

8=Orifice/Grate (Orifice Controls 0.92 cfs @ 6.25 fps)

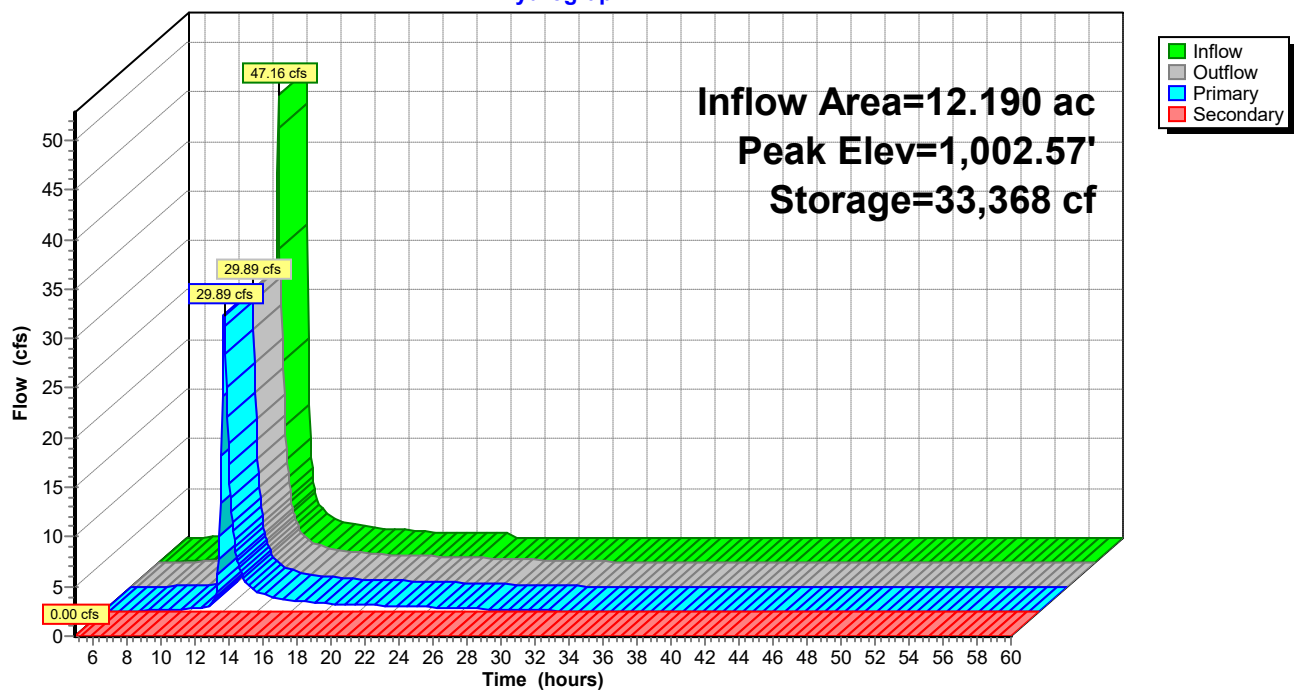
10=Sharp-Crested Rectangular Weir (Weir Controls 28.01 cfs @ 4.87 fps)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=999.00' (Free Discharge)

9=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 3P: Existing Detention

Hydrograph



LS Joint Ops

Type II 24-hr 2-year Rainfall=3.70"

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Summary for Pond 4P: Proposed Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth > 2.83" for 2-year event
 Inflow = 50.58 cfs @ 12.01 hrs, Volume= 2.918 af
 Outflow = 23.73 cfs @ 12.15 hrs, Volume= 2.918 af, Atten= 53%, Lag= 8.2 min
 Primary = 23.73 cfs @ 12.15 hrs, Volume= 2.918 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
 Peak Elev= 999.49' @ 12.15 hrs Surf.Area= 17,706 sf Storage= 49,259 cf

Plug-Flow detention time= 238.1 min calculated for 2.915 af (100% of inflow)
 Center-of-Mass det. time= 239.1 min (1,032.7 - 793.6)

Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

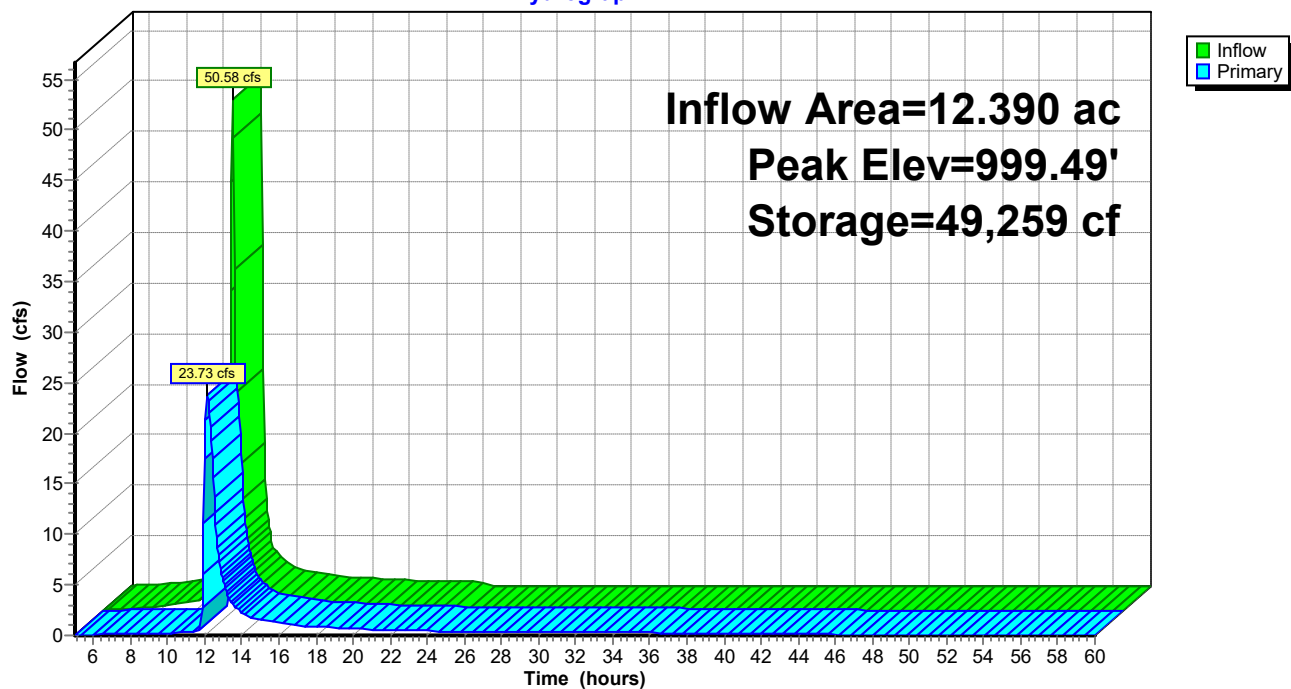
Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	30.0" Round Culvert L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 ' / Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	3.0" Vert. Orifice/Grate C= 0.600
#3	Device 1	997.62'	42.0" W x 15.0" H Vert. Orifice/Grate C= 0.600
#4	Primary	1,001.10'	24.0" W x 12.0" H Vert. Orifice/Grate C= 0.600

Primary OutFlow Max=23.70 cfs @ 12.15 hrs HW=999.49' (Free Discharge)

1=Culvert (Passes 23.70 cfs of 43.17 cfs potential flow)
 2=Orifice/Grate (Orifice Controls 0.49 cfs @ 10.05 fps)
 3=Orifice/Grate (Orifice Controls 23.20 cfs @ 5.30 fps)
 4=Orifice/Grate (Controls 0.00 cfs)

Pond 4P: Proposed Detention

Hydrograph



LS Joint Ops*Type II 24-hr 10-year Rainfall=5.66"*

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Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: ExistingRunoff Area=12.190 ac 0.00% Impervious Runoff Depth>4.50"
Tc=10.0 min CN=90 Runoff=78.42 cfs 4.575 af**Subcatchment 2S: Proposed**Runoff Area=12.390 ac 0.00% Impervious Runoff Depth>4.71"
Tc=10.0 min CN=92 Runoff=82.12 cfs 4.862 af**Subcatchment 5S: Off-Site**Runoff Area=0.500 ac 0.00% Impervious Runoff Depth>4.61"
Tc=5.0 min CN=91 Runoff=3.81 cfs 0.192 af**Pond 3P: Existing Detention**Peak Elev=1,003.29' Storage=47,320 cf Inflow=78.42 cfs 4.575 af
Primary=53.31 cfs 4.559 af Secondary=1.89 cfs 0.009 af Outflow=55.21 cfs 4.568 af**Pond 4P: Proposed Detention**Peak Elev=1,000.85' Storage=75,559 cf Inflow=82.12 cfs 4.862 af
Outflow=34.50 cfs 4.862 af**Total Runoff Area = 25.080 ac Runoff Volume = 9.629 af Average Runoff Depth = 4.61"**
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

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Summary for Subcatchment 1S: Existing

Runoff = 78.42 cfs @ 12.01 hrs, Volume= 4.575 af, Depth> 4.50"

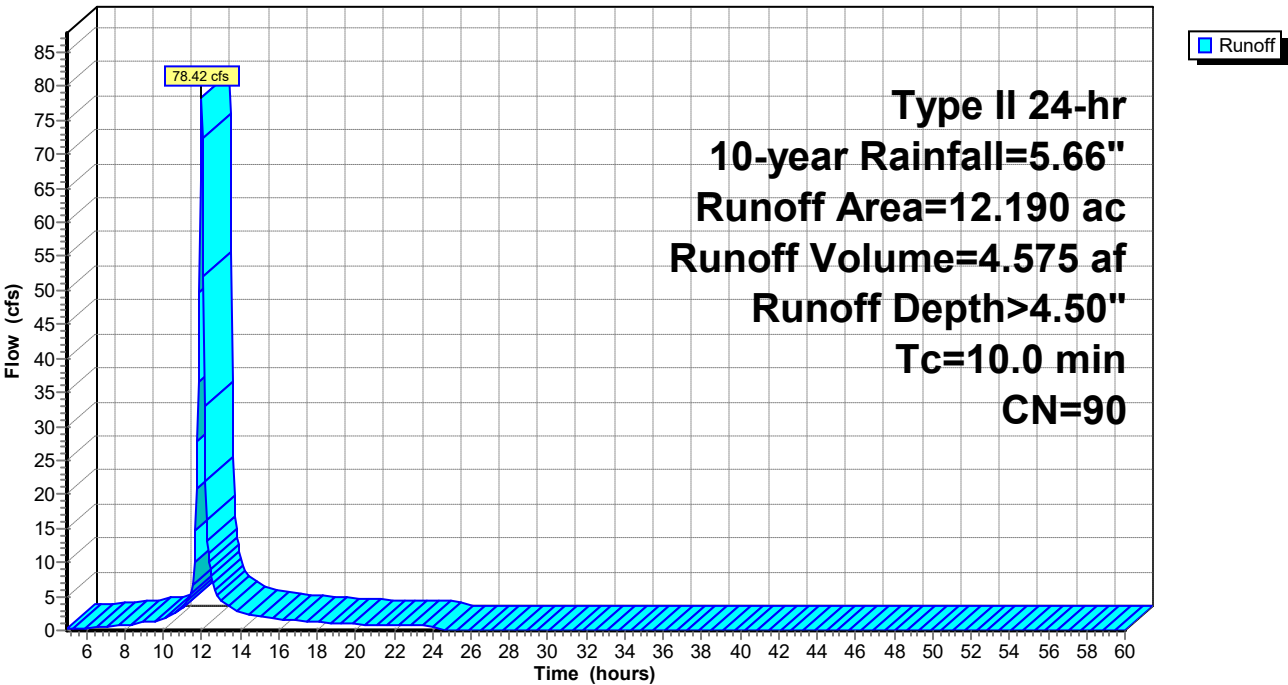
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-year Rainfall=5.66"

Area (ac)	CN	Description
* 12.190	90	
12.190		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 1S: Existing

Hydrograph



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Summary for Subcatchment 2S: Proposed

Runoff = 82.12 cfs @ 12.01 hrs, Volume= 4.862 af, Depth> 4.71"

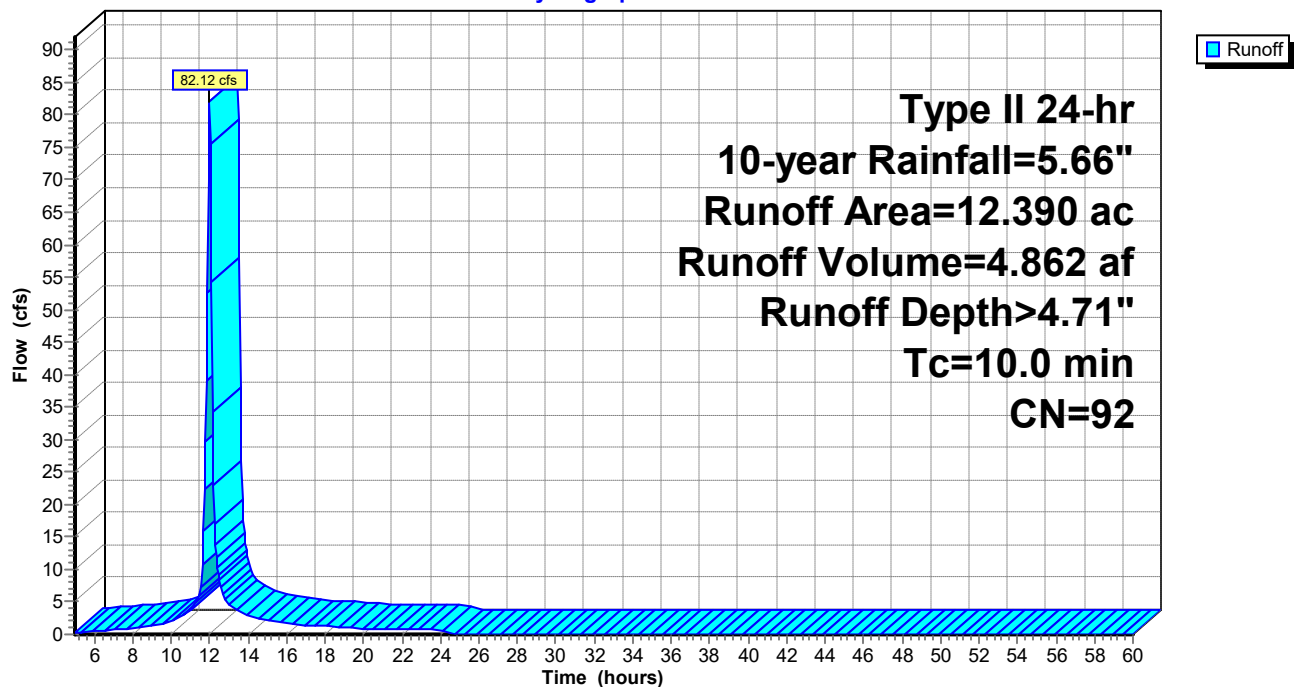
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-year Rainfall=5.66"

Area (ac)	CN	Description
* 12.390	92	
12.390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 2S: Proposed

Hydrograph



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Type II 24-hr 10-year Rainfall=5.66"

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Summary for Subcatchment 5S: Off-Site

[49] Hint: $T_c < 2dt$ may require smaller dt

Runoff = 3.81 cfs @ 11.95 hrs, Volume= 0.192 af, Depth> 4.61"

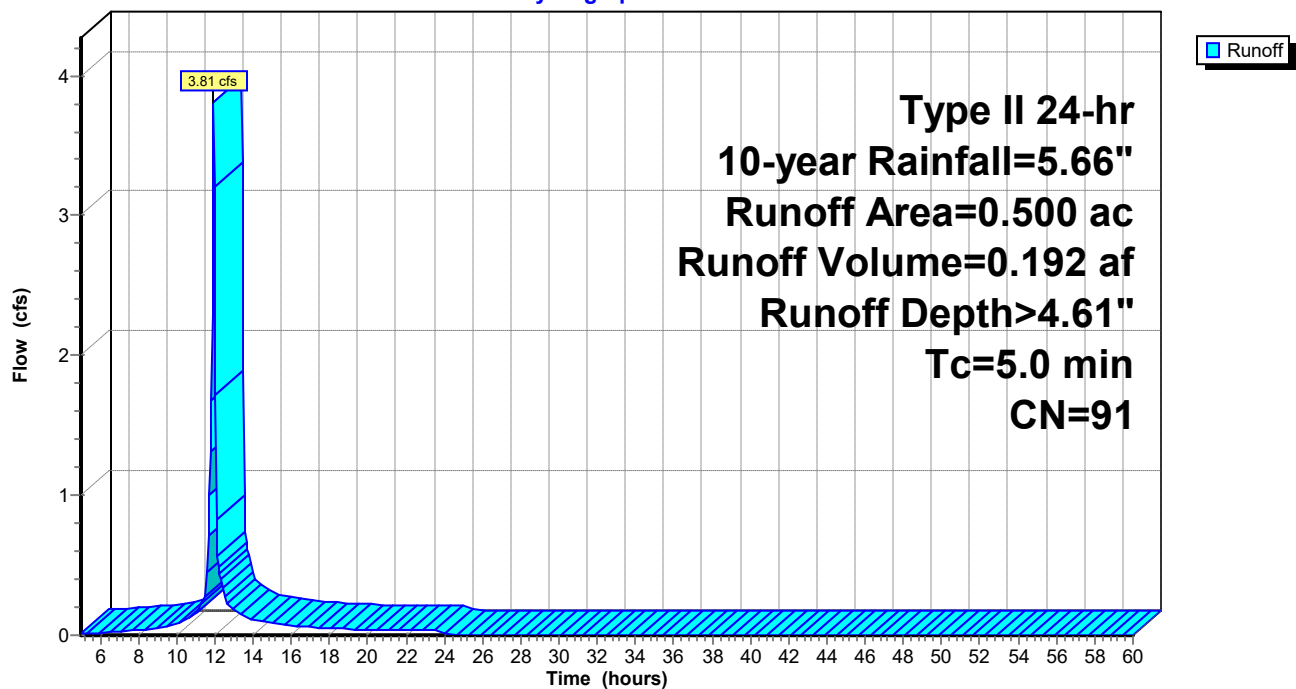
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, $dt=0.05$ hrs
Type II 24-hr 10-year Rainfall=5.66"

Area (ac)	CN	Description
* 0.500	91	
0.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry,

Subcatchment 5S: Off-Site

Hydrograph



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Summary for Pond 3P: Existing Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth > 4.50" for 10-year event
 Inflow = 78.42 cfs @ 12.01 hrs, Volume= 4.575 af
 Outflow = 55.21 cfs @ 12.10 hrs, Volume= 4.568 af, Atten= 30%, Lag= 5.4 min
 Primary = 53.31 cfs @ 12.10 hrs, Volume= 4.559 af
 Secondary = 1.89 cfs @ 12.10 hrs, Volume= 0.009 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,003.29' @ 12.10 hrs Surf.Area= 20,273 sf Storage= 47,320 cf

Plug-Flow detention time= 66.2 min calculated for 4.567 af (100% of inflow)
 Center-of-Mass det. time= 64.4 min (852.7 - 788.3)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	30.0" Round CMP_Round 30" X 2.00 L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#3	Device 1	999.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#4	Device 1	999.75'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#5	Device 1	1,000.00'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#6	Device 1	1,000.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#7	Device 1	1,000.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#8	Device 1	1,000.75'	3.0" Vert. Orifice/Grate X 3.00 C= 0.600
#9	Secondary	1,003.20'	24.0' long x 22.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#10	Device 1	1,001.00'	4.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 1.0' Crest Height

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Primary OutFlow Max=53.25 cfs @ 12.10 hrs HW=1,003.29' (Free Discharge)

↑ **1=CMP_Round 30"** (Passes 53.25 cfs of 62.25 cfs potential flow)

↑ **2=Orifice/Grate** (Orifice Controls 0.15 cfs @ 9.38 fps)

↑ **3=Orifice/Grate** (Orifice Controls 0.10 cfs @ 9.32 fps)

↑ **4=Orifice/Grate** (Orifice Controls 0.15 cfs @ 9.01 fps)

↑ **5=Orifice/Grate** (Orifice Controls 0.09 cfs @ 8.68 fps)

↑ **6=Orifice/Grate** (Orifice Controls 0.14 cfs @ 8.34 fps)

↑ **7=Orifice/Grate** (Orifice Controls 0.09 cfs @ 7.98 fps)

↑ **8=Orifice/Grate** (Orifice Controls 1.10 cfs @ 7.48 fps)

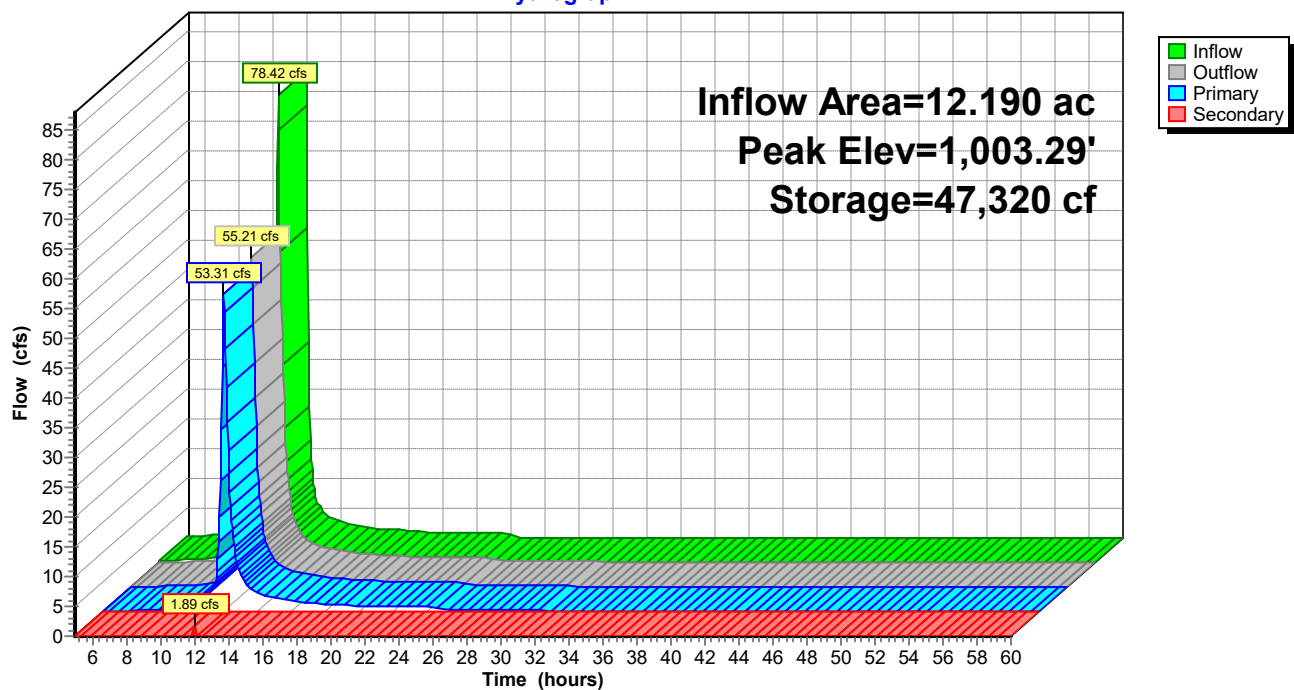
↑ **10=Sharp-Crested Rectangular Weir** (Weir Controls 51.43 cfs @ 6.34 fps)

Secondary OutFlow Max=1.79 cfs @ 12.10 hrs HW=1,003.29' (Free Discharge)

↑ **9=Broad-Crested Rectangular Weir** (Weir Controls 1.79 cfs @ 0.81 fps)

Pond 3P: Existing Detention

Hydrograph



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Type II 24-hr 10-year Rainfall=5.66"

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Summary for Pond 4P: Proposed Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth > 4.71" for 10-year event
 Inflow = 82.12 cfs @ 12.01 hrs, Volume= 4.862 af
 Outflow = 34.50 cfs @ 12.16 hrs, Volume= 4.862 af, Atten= 58%, Lag= 8.9 min
 Primary = 34.50 cfs @ 12.16 hrs, Volume= 4.862 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,000.85' @ 12.16 hrs Surf.Area= 20,893 sf Storage= 75,559 cf

Plug-Flow detention time= 164.0 min calculated for 4.857 af (100% of inflow)
 Center-of-Mass det. time= 164.9 min (947.0 - 782.2)

Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	30.0" Round Culvert L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	3.0" Vert. Orifice/Grate C= 0.600
#3	Device 1	997.62'	42.0" W x 15.0" H Vert. Orifice/Grate C= 0.600
#4	Primary	1,001.10'	24.0" W x 12.0" H Vert. Orifice/Grate C= 0.600

Primary OutFlow Max=34.45 cfs @ 12.16 hrs HW=1,000.84' (Free Discharge)

1=Culvert (Passes 34.45 cfs of 51.21 cfs potential flow)
 2=Orifice/Grate (Orifice Controls 0.57 cfs @ 11.52 fps)
 3=Orifice/Grate (Orifice Controls 33.88 cfs @ 7.74 fps)
 4=Orifice/Grate (Controls 0.00 cfs)

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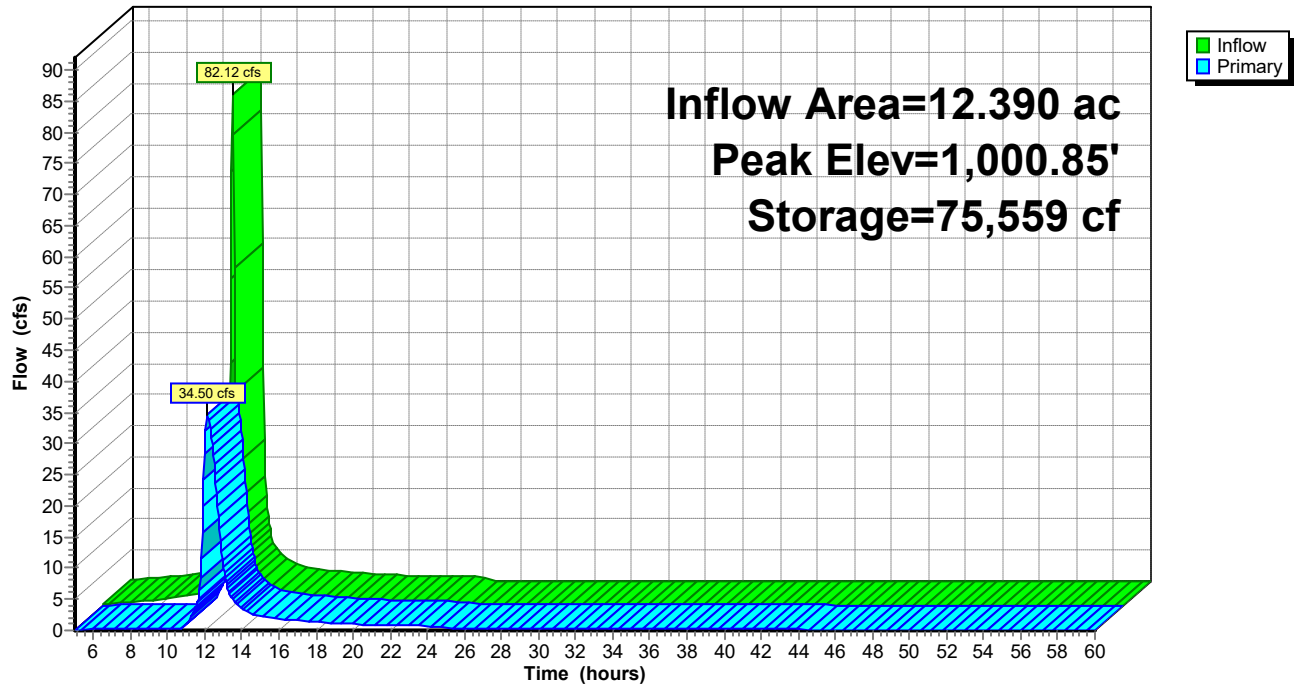
Type II 24-hr 10-year Rainfall=5.66"

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Pond 4P: Proposed Detention

Hydrograph



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Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN

Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: ExistingRunoff Area=12.190 ac 0.00% Impervious Runoff Depth>7.94"
Tc=10.0 min CN=90 Runoff=134.50 cfs 8.068 af**Subcatchment 2S: Proposed**Runoff Area=12.390 ac 0.00% Impervious Runoff Depth>8.15"
Tc=10.0 min CN=92 Runoff=138.64 cfs 8.411 af**Subcatchment 5S: Off-Site**Runoff Area=0.500 ac 0.00% Impervious Runoff Depth>8.04"
Tc=5.0 min CN=91 Runoff=6.47 cfs 0.335 af**Pond 3P: Existing Detention**Peak Elev=1,003.97' Storage=61,626 cf Inflow=134.50 cfs 8.068 af
Primary=73.08 cfs 7.468 af Secondary=42.83 cfs 0.592 af Outflow=115.91 cfs 8.060 af**Pond 4P: Proposed Detention**Peak Elev=1,002.75' Storage=119,612 cf Inflow=138.64 cfs 8.411 af
Outflow=55.61 cfs 8.411 af**Total Runoff Area = 25.080 ac Runoff Volume = 16.814 af Average Runoff Depth = 8.04"**
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

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Type II 24-hr 100-year Rainfall=9.23"

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Summary for Subcatchment 1S: Existing

Runoff = 134.50 cfs @ 12.01 hrs, Volume= 8.068 af, Depth> 7.94"

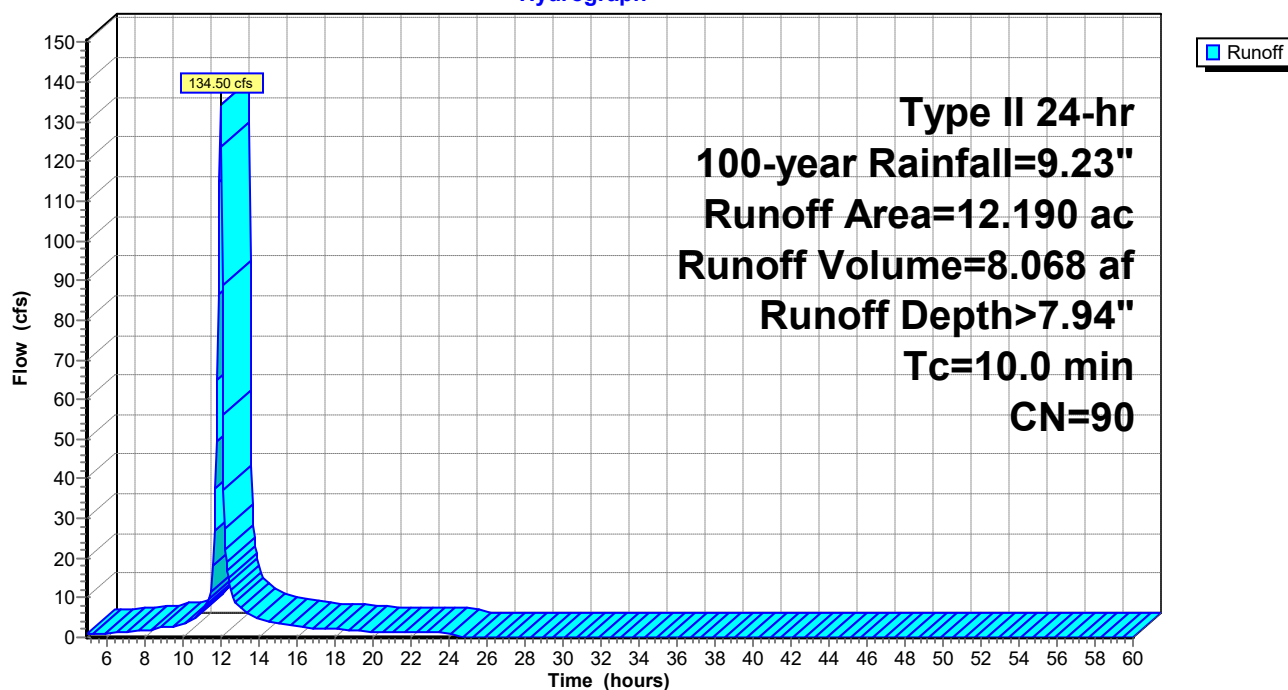
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=9.23"

Area (ac)	CN	Description
* 12.190	90	
12.190		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 1S: Existing

Hydrograph



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Type II 24-hr 100-year Rainfall=9.23"

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Summary for Subcatchment 2S: Proposed

Runoff = 138.64 cfs @ 12.01 hrs, Volume= 8.411 af, Depth> 8.15"

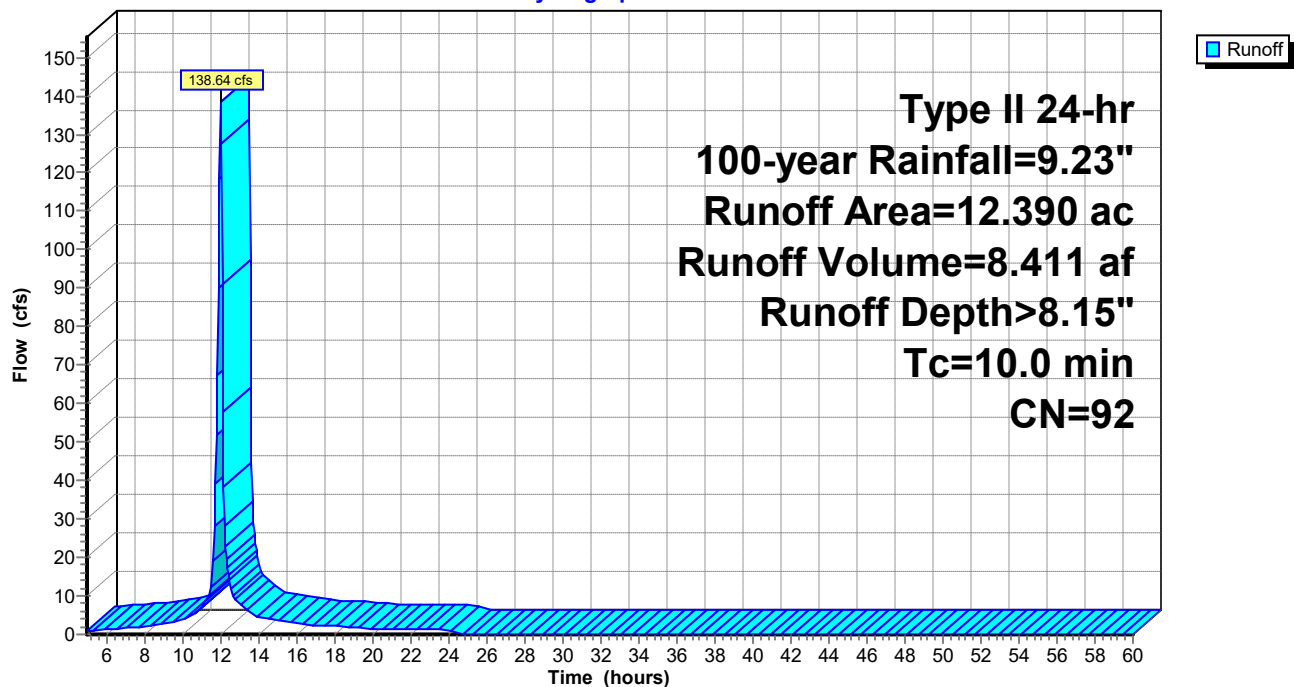
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=9.23"

Area (ac)	CN	Description
* 12.390	92	
12.390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 2S: Proposed

Hydrograph



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Type II 24-hr 100-year Rainfall=9.23"

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Summary for Subcatchment 5S: Off-Site

[49] Hint: $T_c < 2dt$ may require smaller dt

Runoff = 6.47 cfs @ 11.95 hrs, Volume= 0.335 af, Depth> 8.04"

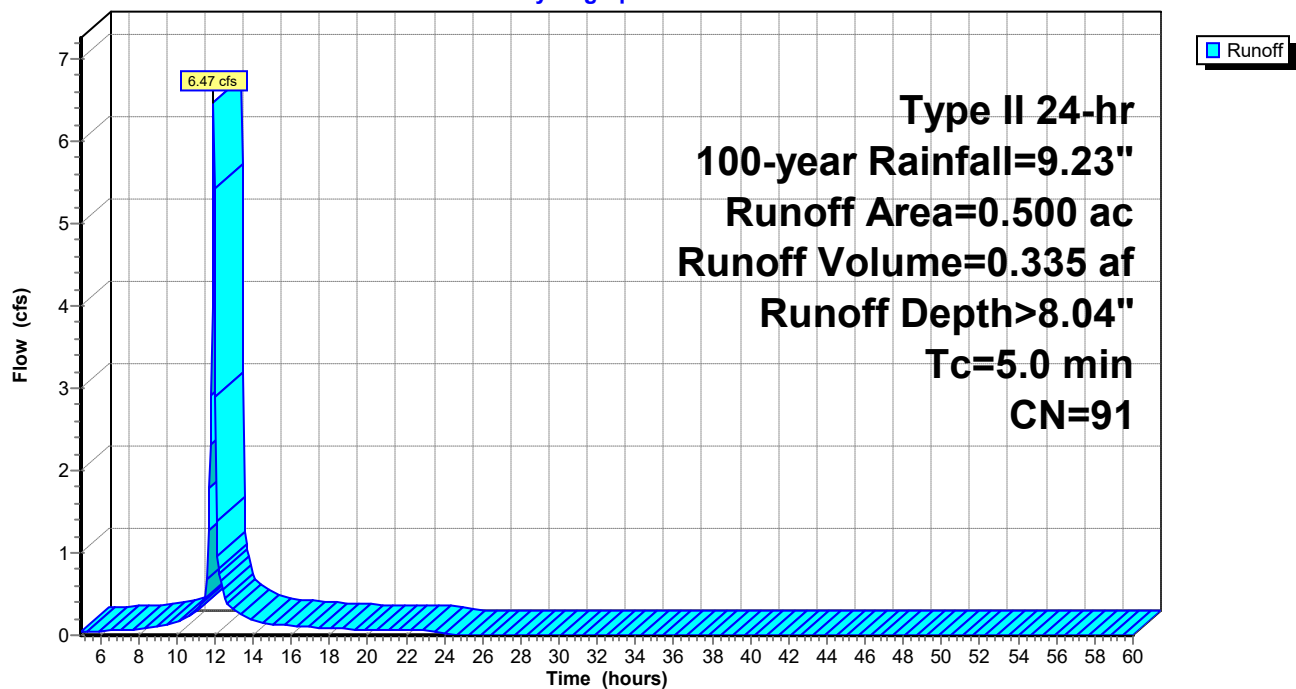
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, $dt=0.05$ hrs
Type II 24-hr 100-year Rainfall=9.23"

Area (ac)	CN	Description
* 0.500	91	
0.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry,

Subcatchment 5S: Off-Site

Hydrograph



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Summary for Pond 3P: Existing Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth > 7.94" for 100-year event
 Inflow = 134.50 cfs @ 12.01 hrs, Volume= 8.068 af
 Outflow = 115.91 cfs @ 12.06 hrs, Volume= 8.060 af, Atten= 14%, Lag= 3.4 min
 Primary = 73.08 cfs @ 12.06 hrs, Volume= 7.468 af
 Secondary = 42.83 cfs @ 12.06 hrs, Volume= 0.592 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,003.97' @ 12.06 hrs Surf.Area= 22,058 sf Storage= 61,626 cf

Plug-Flow detention time= 46.9 min calculated for 8.059 af (100% of inflow)
 Center-of-Mass det. time= 45.4 min (822.5 - 777.1)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	30.0" Round CMP_Round 30" X 2.00 L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#3	Device 1	999.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#4	Device 1	999.75'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#5	Device 1	1,000.00'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#6	Device 1	1,000.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#7	Device 1	1,000.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#8	Device 1	1,000.75'	3.0" Vert. Orifice/Grate X 3.00 C= 0.600
#9	Secondary	1,003.20'	24.0' long x 22.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#10	Device 1	1,001.00'	4.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 1.0' Crest Height

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Primary OutFlow Max=72.73 cfs @ 12.06 hrs HW=1,003.95' (Free Discharge)

↑ **1=CMP_Round 30"** (Barrel Controls 72.73 cfs @ 7.41 fps)

↑ **2=Orifice/Grate** (Passes < 0.17 cfs potential flow)

↑ **3=Orifice/Grate** (Passes < 0.11 cfs potential flow)

↑ **4=Orifice/Grate** (Passes < 0.16 cfs potential flow)

↑ **5=Orifice/Grate** (Passes < 0.10 cfs potential flow)

↑ **6=Orifice/Grate** (Passes < 0.15 cfs potential flow)

↑ **7=Orifice/Grate** (Passes < 0.10 cfs potential flow)

↑ **8=Orifice/Grate** (Passes < 1.24 cfs potential flow)

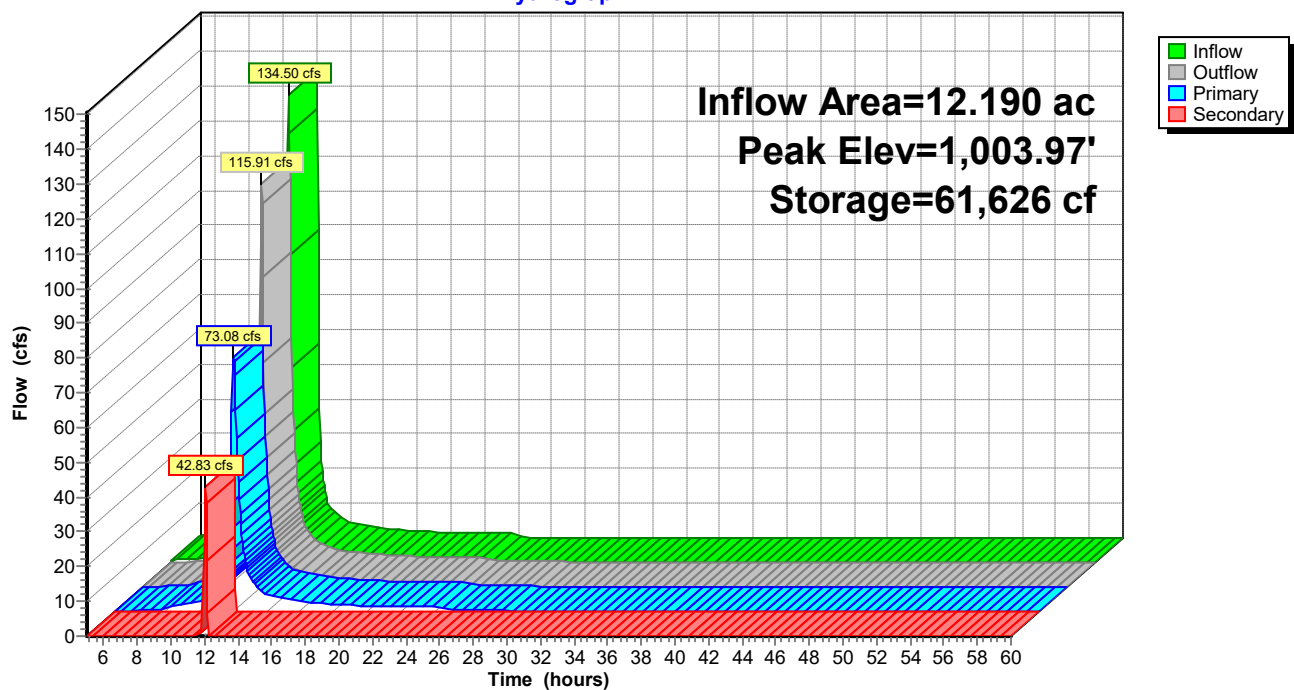
↑ **10=Sharp-Crested Rectangular Weir** (Passes < 76.70 cfs potential flow)

Secondary OutFlow Max=41.07 cfs @ 12.06 hrs HW=1,003.95' (Free Discharge)

↑ **9=Broad-Crested Rectangular Weir** (Weir Controls 41.07 cfs @ 2.29 fps)

Pond 3P: Existing Detention

Hydrograph



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Type II 24-hr 100-year Rainfall=9.23"

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Summary for Pond 4P: Proposed Detention

[82] Warning: Early inflow requires earlier time span

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth > 8.15" for 100-year event
 Inflow = 138.64 cfs @ 12.01 hrs, Volume= 8.411 af
 Outflow = 55.61 cfs @ 12.16 hrs, Volume= 8.411 af, Atten= 60%, Lag= 9.3 min
 Primary = 55.61 cfs @ 12.16 hrs, Volume= 8.411 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs

Peak Elev= 1,002.75' @ 12.16 hrs Surf.Area= 25,501 sf Storage= 119,612 cf

Plug-Flow detention time= 113.0 min calculated for 8.402 af (100% of inflow)

Center-of-Mass det. time= 113.9 min (886.8 - 773.0)

Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

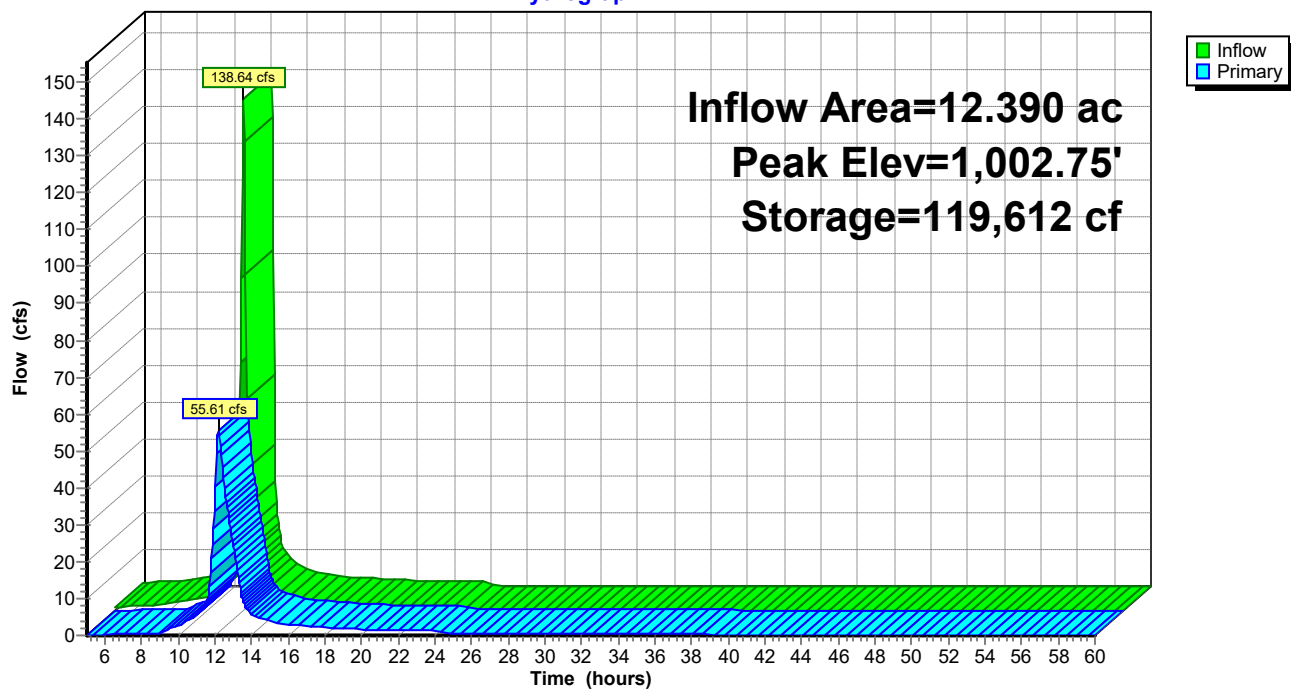
Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	30.0" Round Culvert L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	3.0" Vert. Orifice/Grate C= 0.600
#3	Device 1	997.62'	42.0" W x 15.0" H Vert. Orifice/Grate C= 0.600
#4	Primary	1,001.10'	24.0" W x 12.0" H Vert. Orifice/Grate C= 0.600

Primary OutFlow Max=55.44 cfs @ 12.16 hrs HW=1,002.74' (Free Discharge)

1=Culvert (Passes 45.26 cfs of 60.66 cfs potential flow)
 2=Orifice/Grate (Orifice Controls 0.65 cfs @ 13.28 fps)
 3=Orifice/Grate (Orifice Controls 44.61 cfs @ 10.20 fps)
 4=Orifice/Grate (Orifice Controls 10.18 cfs @ 5.09 fps)

Pond 4P: Proposed Detention

Hydrograph



LS Joint Ops

Type II 24-hr Wqv Rainfall=1.37"

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Time span=5.00-60.00 hrs, dt=0.05 hrs, 1101 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing

Runoff Area=12.190 ac 0.00% Impervious Runoff Depth=0.58"
Tc=10.0 min CN=90 Runoff=10.74 cfs 0.592 af

Subcatchment 2S: Proposed

Runoff Area=12.390 ac 0.00% Impervious Runoff Depth=0.69"
Tc=10.0 min CN=92 Runoff=13.00 cfs 0.715 af

Subcatchment 5S: Off-Site

Runoff Area=0.500 ac 0.00% Impervious Runoff Depth=0.64"
Tc=5.0 min CN=91 Runoff=0.57 cfs 0.026 af

Pond 3P: Existing Detention

Peak Elev=1,001.18' Storage=10,894 cf Inflow=10.74 cfs 0.592 af
Primary=1.88 cfs 0.585 af Secondary=0.00 cfs 0.000 af Outflow=1.88 cfs 0.585 af

Pond 4P: Proposed Detention

Peak Elev=997.52' Storage=18,980 cf Inflow=13.00 cfs 0.715 af
Outflow=0.37 cfs 0.715 af

Total Runoff Area = 25.080 ac Runoff Volume = 1.334 af Average Runoff Depth = 0.64"
100.00% Pervious = 25.080 ac 0.00% Impervious = 0.000 ac

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Type II 24-hr Wqv Rainfall=1.37"

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Summary for Subcatchment 1S: Existing

Runoff = 10.74 cfs @ 12.02 hrs, Volume= 0.592 af, Depth= 0.58"

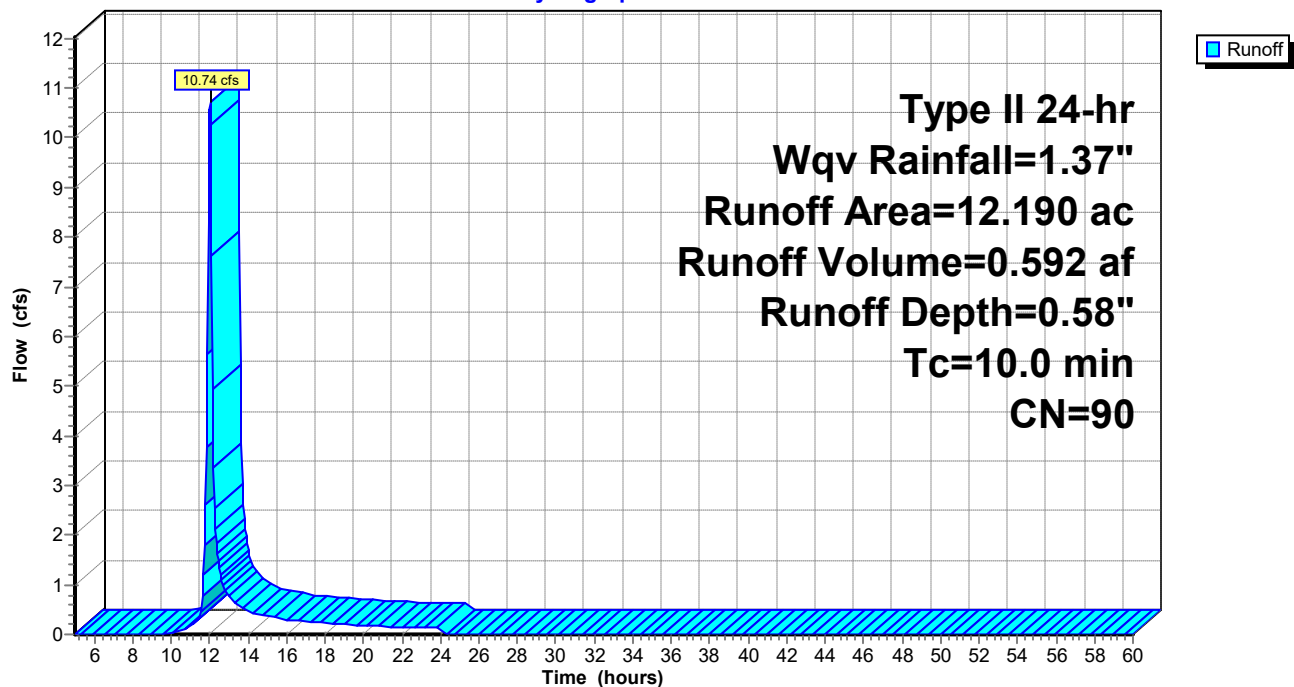
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr Wqv Rainfall=1.37"

Area (ac)	CN	Description
* 12.190	90	
12.190		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 1S: Existing

Hydrograph



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Type II 24-hr Wqv Rainfall=1.37"

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Summary for Subcatchment 2S: Proposed

Runoff = 13.00 cfs @ 12.02 hrs, Volume= 0.715 af, Depth= 0.69"

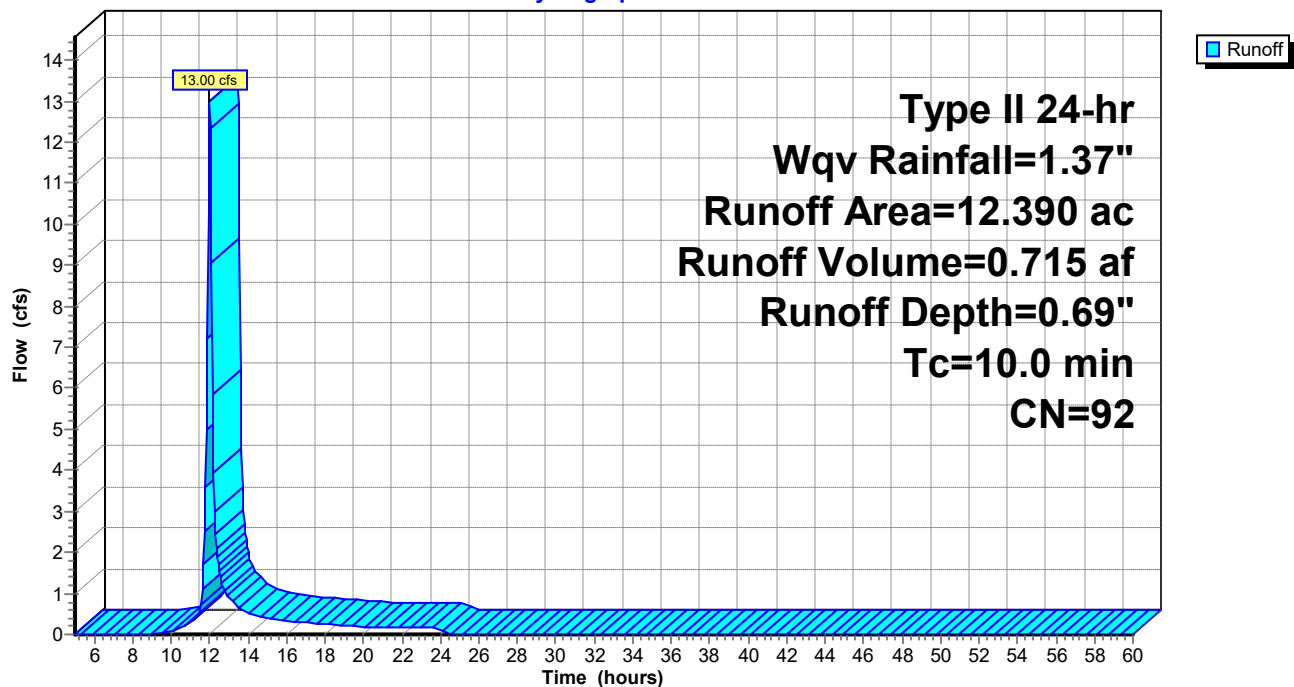
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
Type II 24-hr Wqv Rainfall=1.37"

Area (ac)	CN	Description
* 12.390	92	
12.390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					Direct Entry,

Subcatchment 2S: Proposed

Hydrograph



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Type II 24-hr Wqv Rainfall=1.37"

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Summary for Subcatchment 5S: Off-Site

[49] Hint: $T_c < 2dt$ may require smaller dt

Runoff = 0.57 cfs @ 11.96 hrs, Volume= 0.026 af, Depth= 0.64"

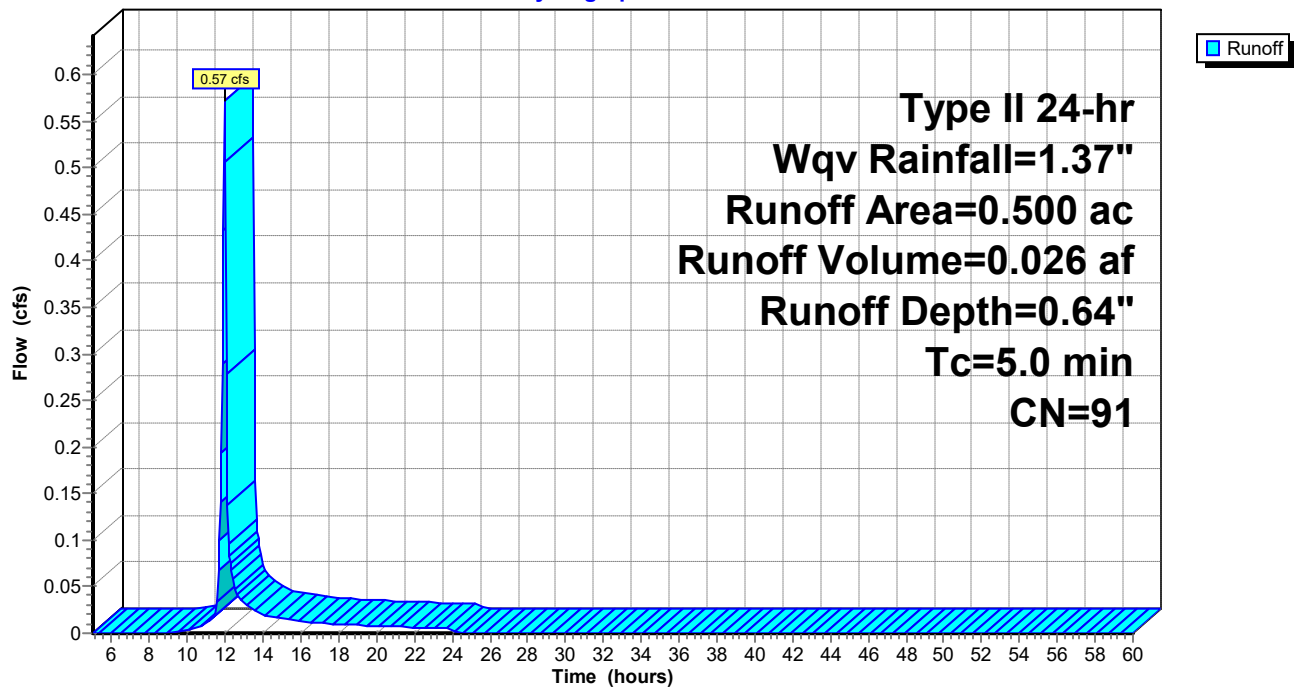
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-60.00 hrs, $dt=0.05$ hrs
Type II 24-hr Wqv Rainfall=1.37"

Area (ac)	CN	Description
* 0.500	91	
0.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry,

Subcatchment 5S: Off-Site

Hydrograph



LS Joint Ops

Type II 24-hr Wqv Rainfall=1.37"

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Summary for Pond 3P: Existing Detention

Inflow Area = 12.190 ac, 0.00% Impervious, Inflow Depth = 0.58" for Wqv event
 Inflow = 10.74 cfs @ 12.02 hrs, Volume= 0.592 af
 Outflow = 1.88 cfs @ 12.34 hrs, Volume= 0.585 af, Atten= 83%, Lag= 19.5 min
 Primary = 1.88 cfs @ 12.34 hrs, Volume= 0.585 af
 Secondary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,001.18' @ 12.34 hrs Surf.Area= 12,968 sf Storage= 10,894 cf

Plug-Flow detention time= 201.2 min calculated for 0.585 af (99% of inflow)
 Center-of-Mass det. time= 193.0 min (1,038.2 - 845.1)

Volume	Invert	Avail.Storage	Storage Description
#1	999.00'	88,385 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
999.00	10	0	0
1,000.00	2,580	1,295	1,295
1,001.00	12,035	7,308	8,603
1,002.00	17,125	14,580	23,183
1,003.00	19,500	18,313	41,495
1,004.00	22,140	20,820	62,315
1,005.00	30,000	26,070	88,385

Device	Routing	Invert	Outlet Devices
#1	Primary	999.50'	30.0" Round CMP_Round 30" X 2.00 L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 999.50' / 999.00' S= 0.0125 '/' Cc= 0.900 n= 0.025, Flow Area= 4.91 sf
#2	Device 1	999.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#3	Device 1	999.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#4	Device 1	999.75'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#5	Device 1	1,000.00'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#6	Device 1	1,000.25'	1.0" Vert. Orifice/Grate X 3.00 C= 0.600
#7	Device 1	1,000.50'	1.0" Vert. Orifice/Grate X 2.00 C= 0.600
#8	Device 1	1,000.75'	3.0" Vert. Orifice/Grate X 3.00 C= 0.600
#9	Secondary	1,003.20'	24.0' long x 22.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#10	Device 1	1,001.00'	4.0' long Sharp-Crested Rectangular Weir 2 End Contraction(s) 1.0' Crest Height

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Type II 24-hr Wqv Rainfall=1.37"

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Primary OutFlow Max=1.87 cfs @ 12.34 hrs HW=1,001.18' (Free Discharge)

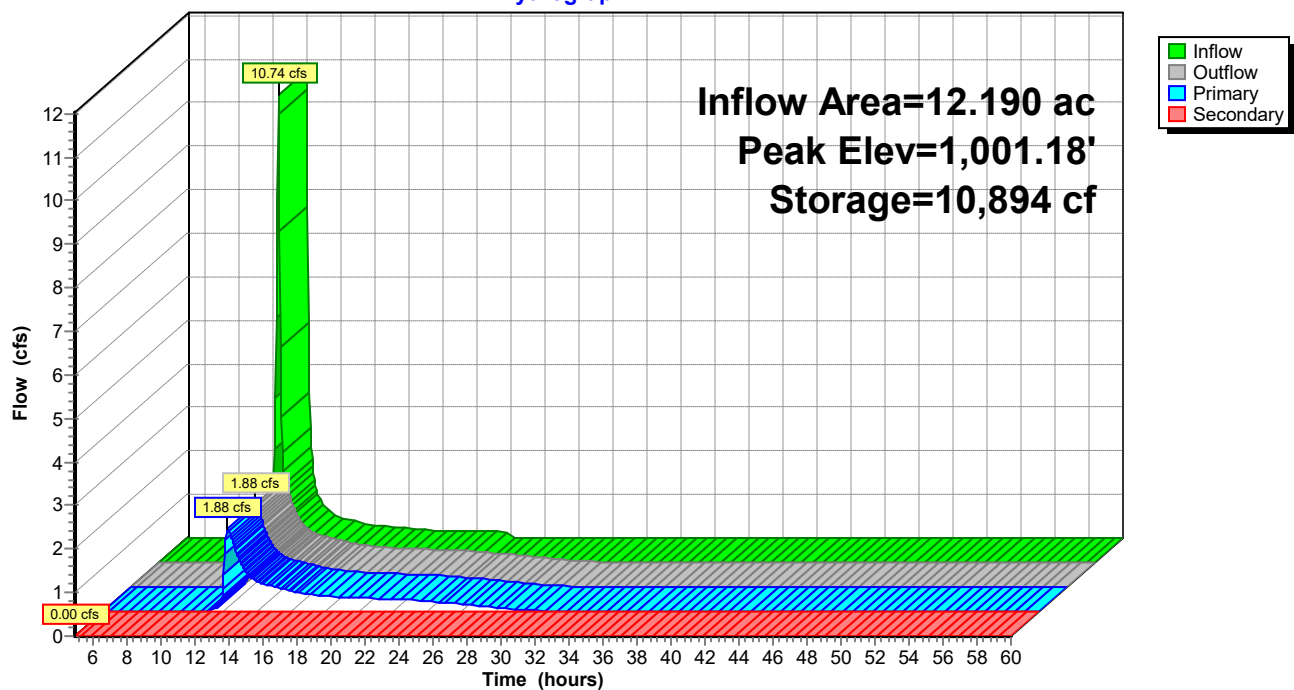
- 1=CMP_Round 30" (Passes 1.87 cfs of 22.64 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.10 cfs @ 6.25 fps)
- 3=Orifice/Grate (Orifice Controls 0.07 cfs @ 6.17 fps)
- 4=Orifice/Grate (Orifice Controls 0.09 cfs @ 5.68 fps)
- 5=Orifice/Grate (Orifice Controls 0.06 cfs @ 5.14 fps)
- 6=Orifice/Grate (Orifice Controls 0.07 cfs @ 4.55 fps)
- 7=Orifice/Grate (Orifice Controls 0.04 cfs @ 3.86 fps)
- 8=Orifice/Grate (Orifice Controls 0.39 cfs @ 2.67 fps)
- 10=Sharp-Crested Rectangular Weir (Weir Controls 1.04 cfs @ 1.43 fps)

Secondary OutFlow Max=0.00 cfs @ 5.00 hrs HW=999.00' (Free Discharge)

- 9=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 3P: Existing Detention

Hydrograph



LS Joint Ops

Type II 24-hr Wqv Rainfall=1.37"

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Summary for Pond 4P: Proposed Detention

Inflow Area = 12.390 ac, 0.00% Impervious, Inflow Depth = 0.69" for Wqv event
 Inflow = 13.00 cfs @ 12.02 hrs, Volume= 0.715 af
 Outflow = 0.37 cfs @ 15.56 hrs, Volume= 0.715 af, Atten= 97%, Lag= 212.6 min
 Primary = 0.37 cfs @ 15.56 hrs, Volume= 0.715 af

Routing by Stor-Ind method, Time Span= 5.00-60.00 hrs, dt= 0.05 hrs
 Peak Elev= 997.52' @ 15.56 hrs Surf.Area= 12,241 sf Storage= 18,980 cf

Plug-Flow detention time= 617.6 min calculated for 0.714 af (100% of inflow)
 Center-of-Mass det. time= 618.1 min (1,451.1 - 833.1)

Volume	Invert	Avail.Storage	Storage Description
#1	995.00'	153,448 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
995.00	50	0	0
996.00	8,213	4,132	4,132
997.00	10,000	9,107	13,238
998.00	14,340	12,170	25,408
999.00	16,580	15,460	40,868
1,000.00	18,880	17,730	58,598
1,001.00	21,240	20,060	78,658
1,002.00	23,640	22,440	101,098
1,003.00	26,110	24,875	125,973
1,004.00	28,840	27,475	153,448

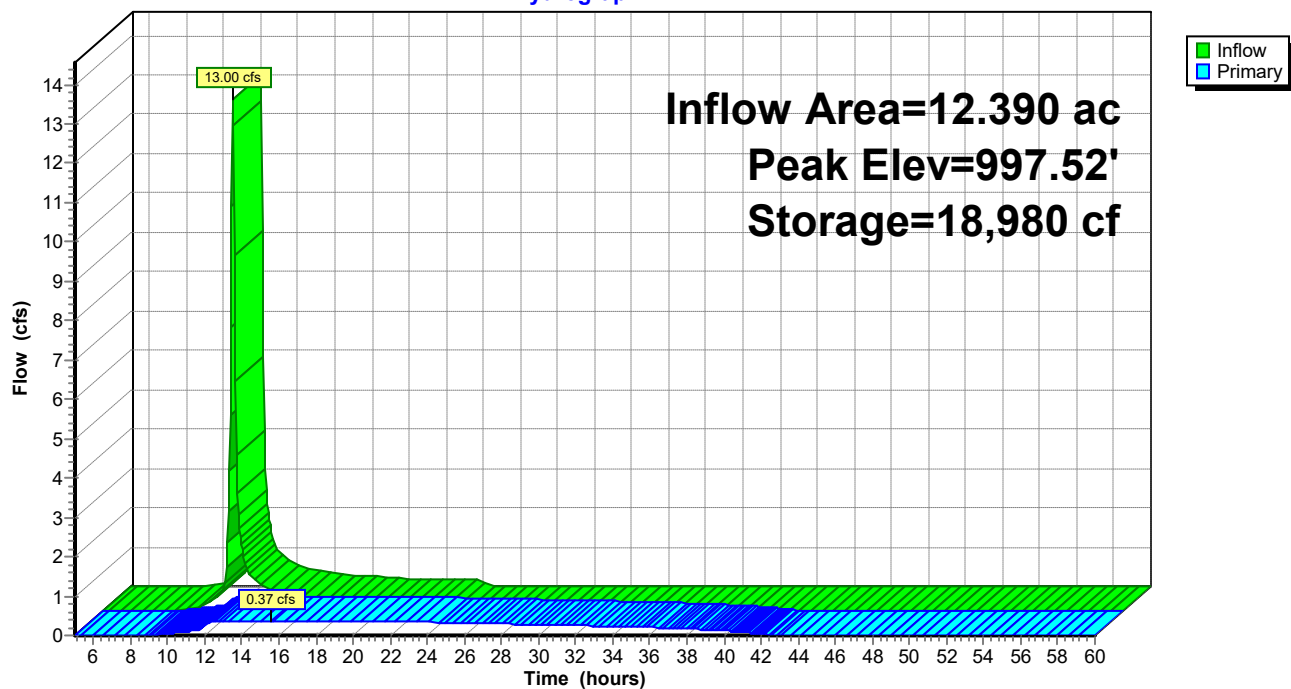
Device	Routing	Invert	Outlet Devices
#1	Primary	994.90'	30.0" Round Culvert L= 40.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 994.90' / 994.50' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 4.91 sf
#2	Device 1	995.00'	3.0" Vert. Orifice/Grate C= 0.600
#3	Device 1	997.62'	42.0" W x 15.0" H Vert. Orifice/Grate C= 0.600
#4	Primary	1,001.10'	24.0" W x 12.0" H Vert. Orifice/Grate C= 0.600

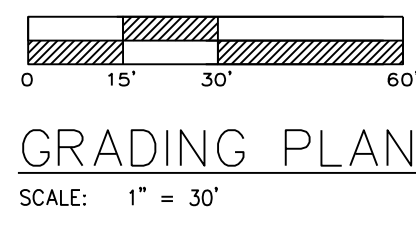
Primary OutFlow Max=0.37 cfs @ 15.56 hrs HW=997.52' (Free Discharge)

1=Culvert (Passes 0.37 cfs of 25.79 cfs potential flow)
 2=Orifice/Grate (Orifice Controls 0.37 cfs @ 7.45 fps)
 3=Orifice/Grate (Controls 0.00 cfs)
 4=Orifice/Grate (Controls 0.00 cfs)

Pond 4P: Proposed Detention

Hydrograph



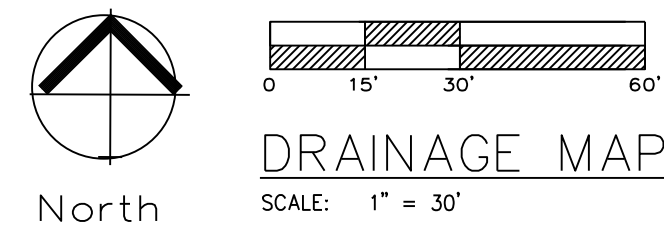
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Professional Registration
Missouri
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Surveying 2005008319-D
Kansas
Engineering E-1695
Surveying LS-218
Oklahoma
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LSMO

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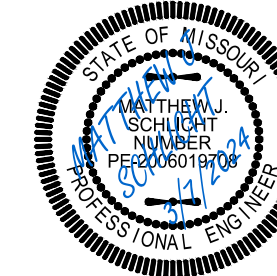
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Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

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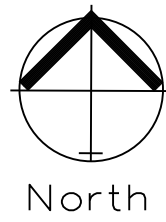
Drainage Map
Construction Plans for:
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1	REV. 3/7/2024	



STORM SEWER PLAN AND PROFILE

SCALE: 1" = 50'

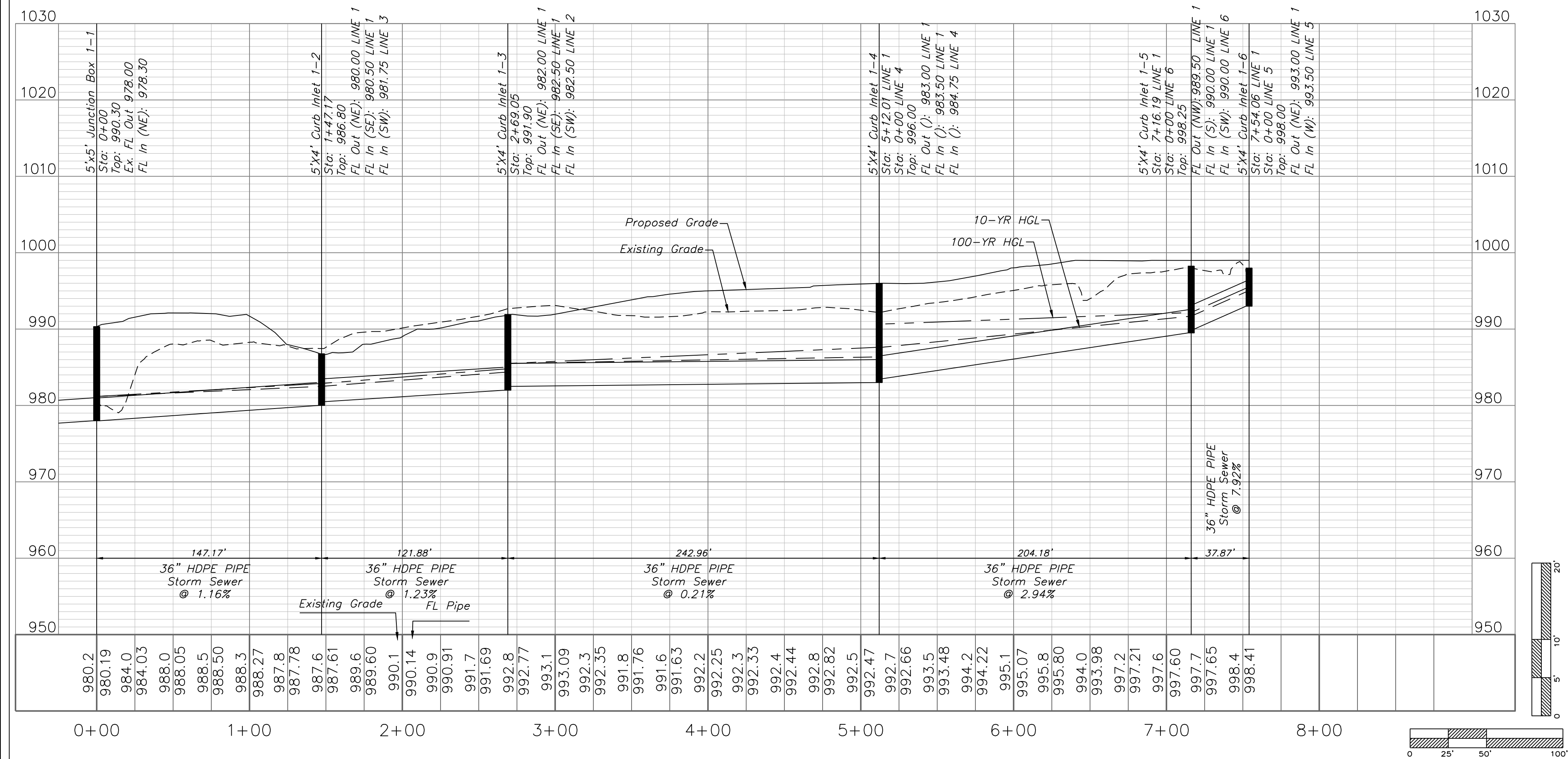


STORM SEWER PLAN AND PROFILE

SCALE: 1" = 50'

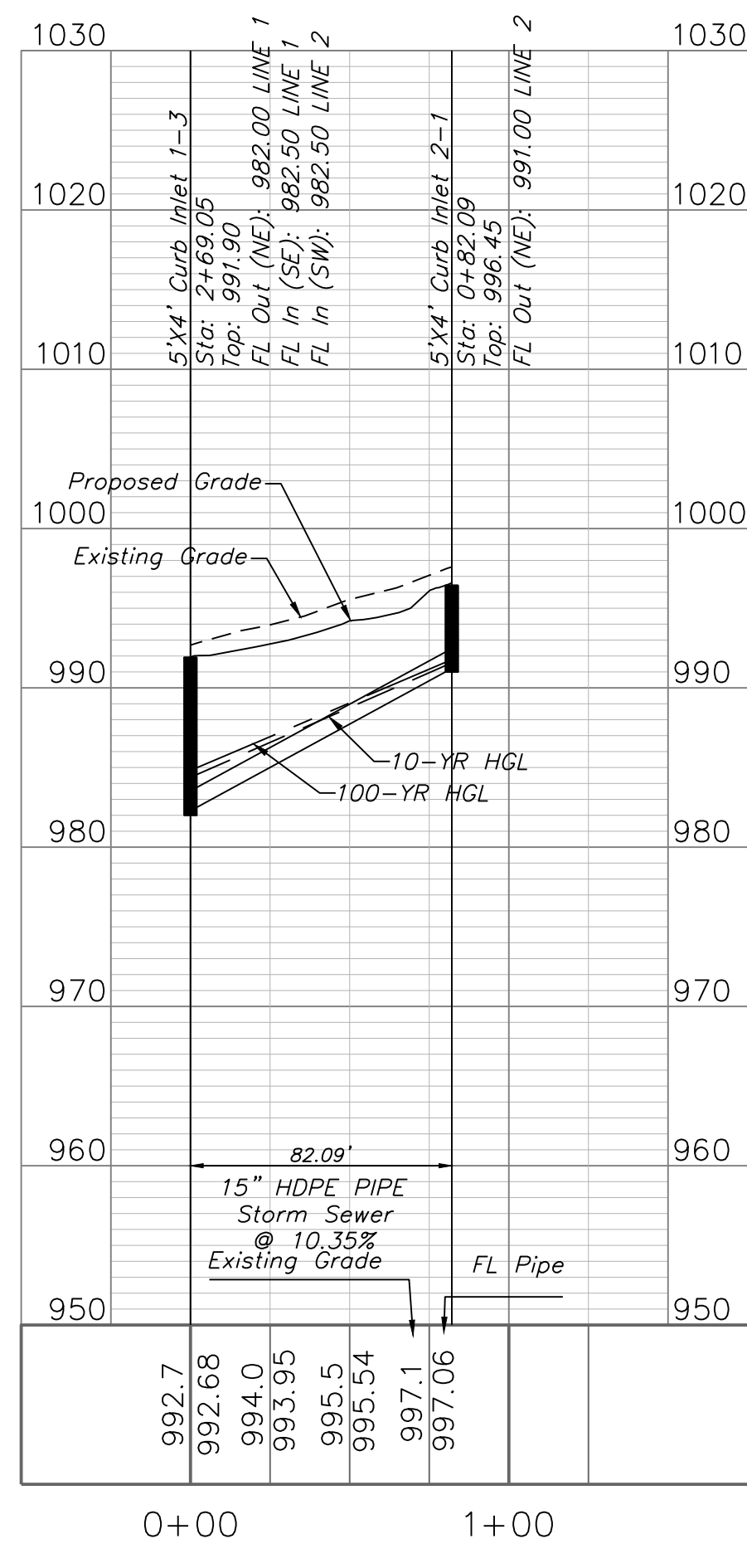
REVISED SCALE.

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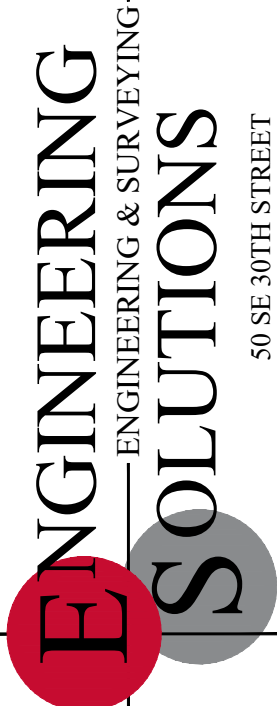


0 25 50 100'

STORM LINE 2



0 25 50 100'

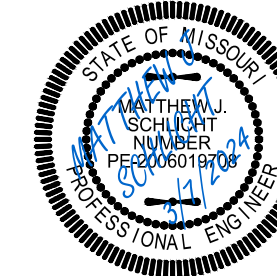


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Surveying LS-218
Oklahoma
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Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

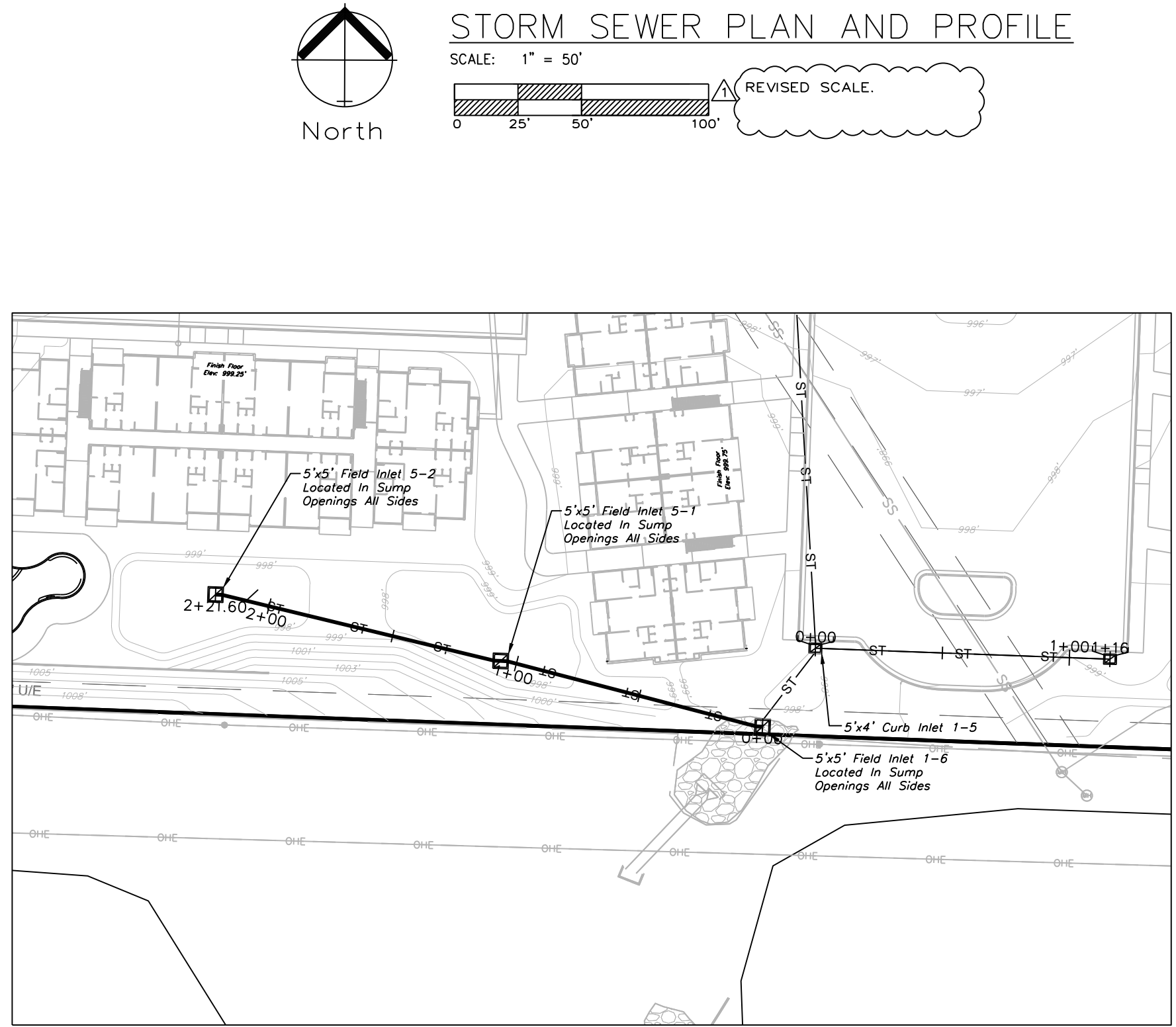
Project: L.S. STATION
LSMO
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Storm Sewer Plan and Profile
Construction Plans for:
Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

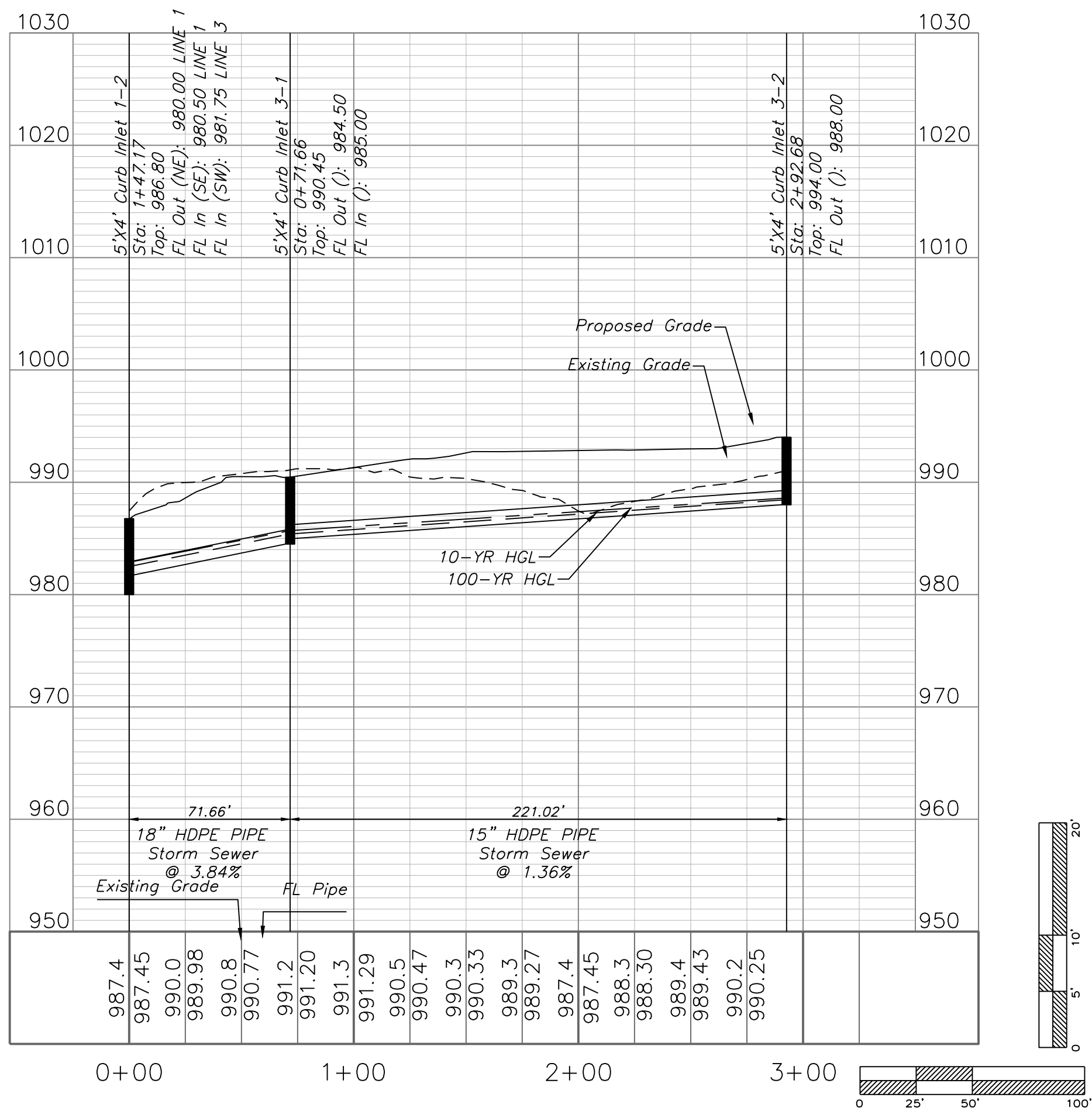


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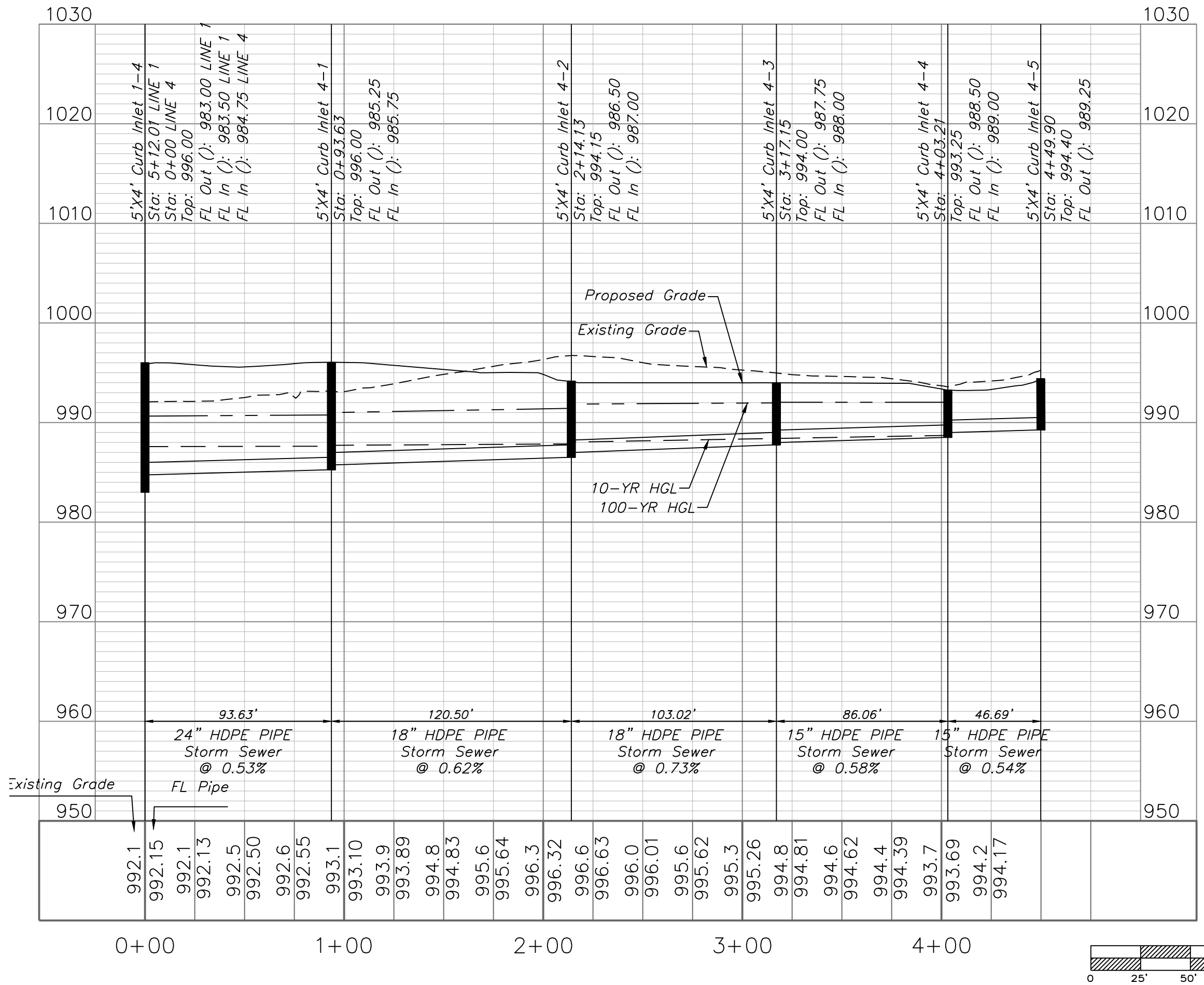
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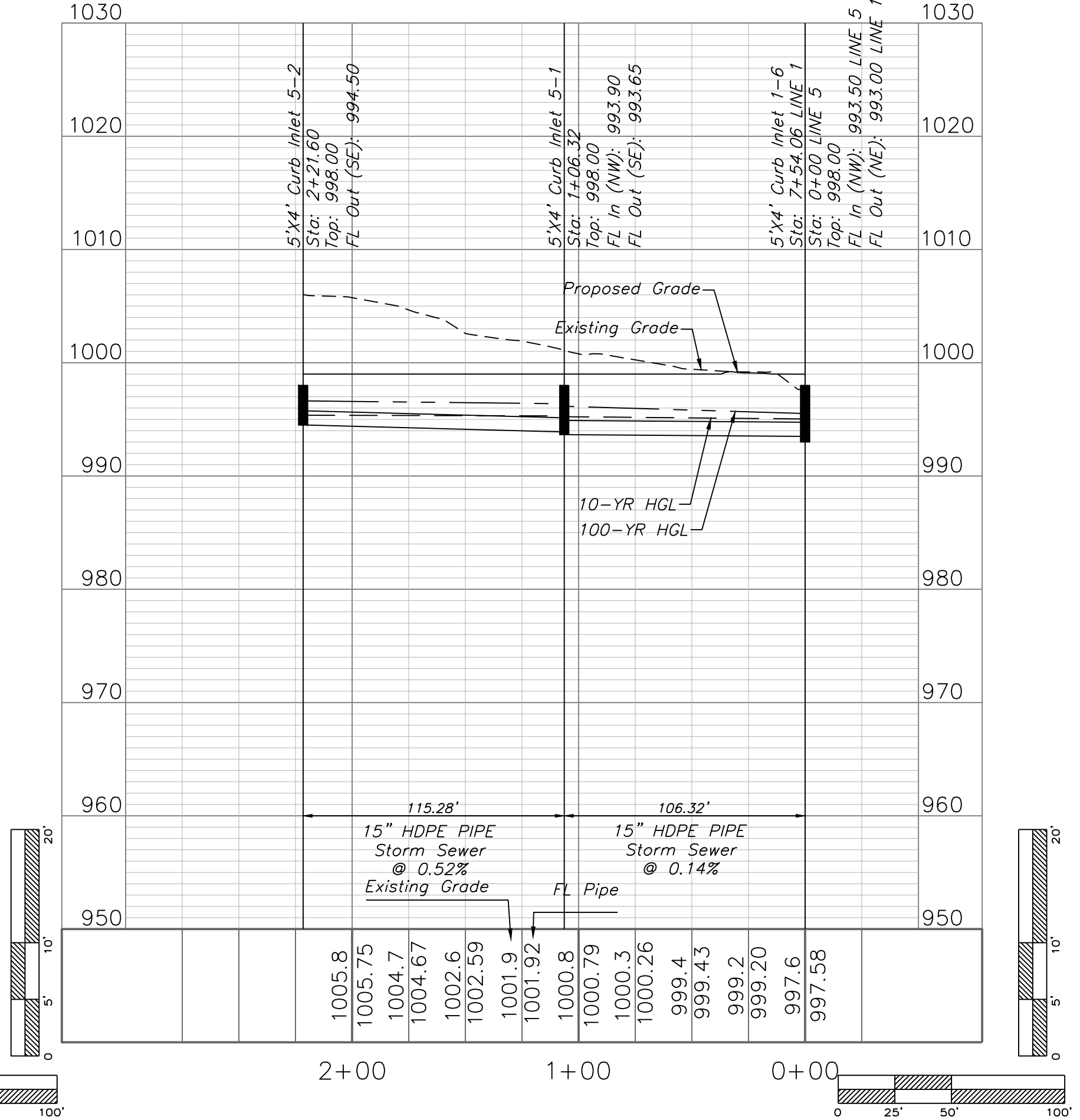
STORM LINE 3



STORM LINE 4



STORM LINE 5

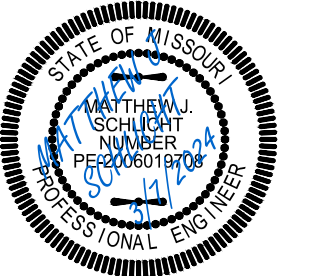


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Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

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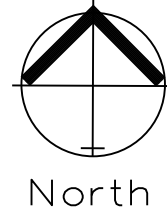
Storm Sewer Plan and Profile
Construction Plans for:
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Lee's Summit, Jackson County, Missouri



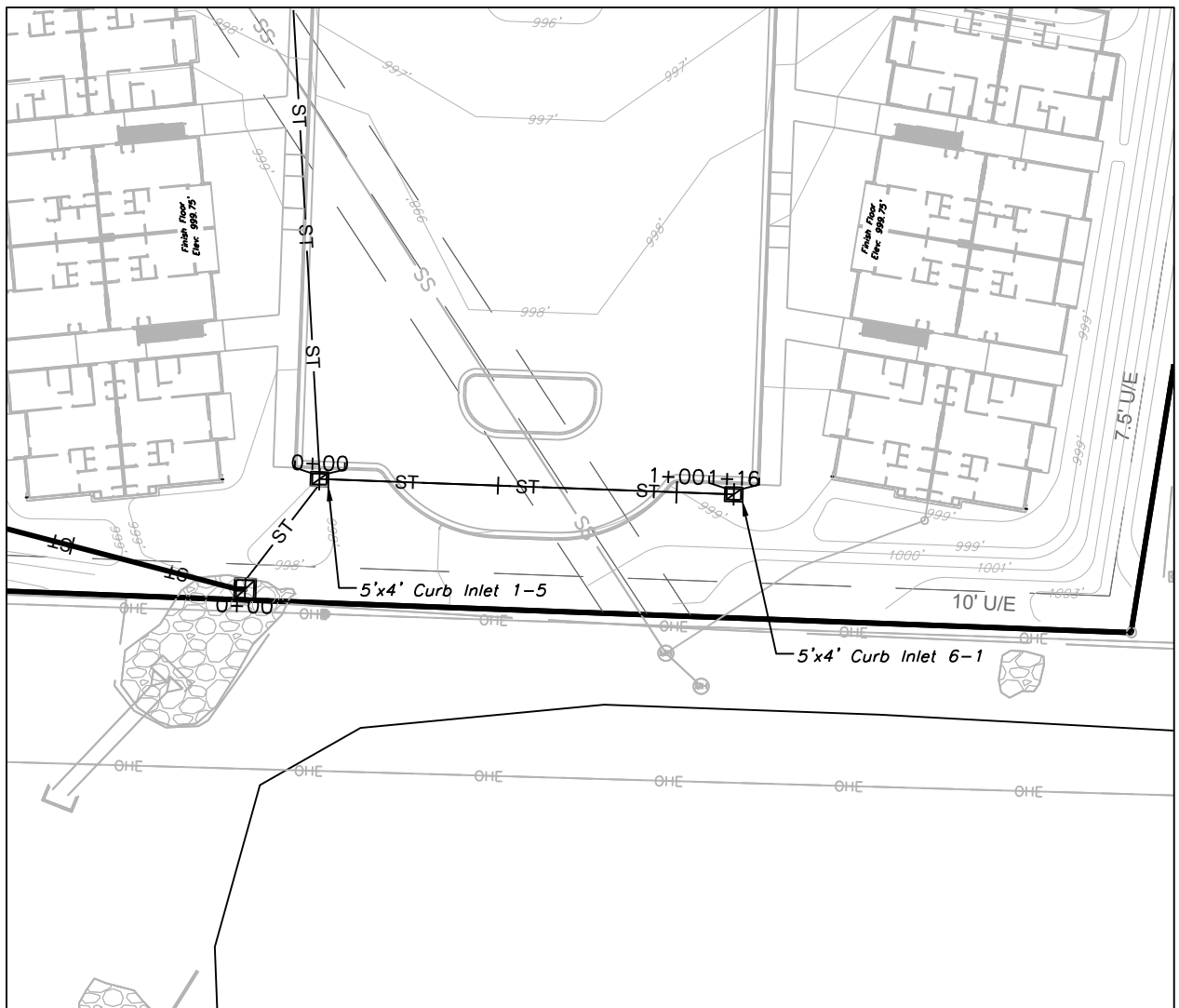
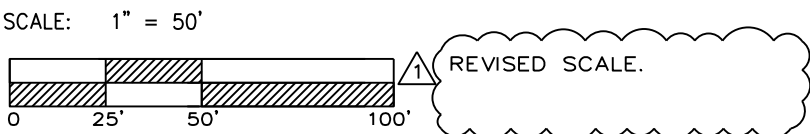
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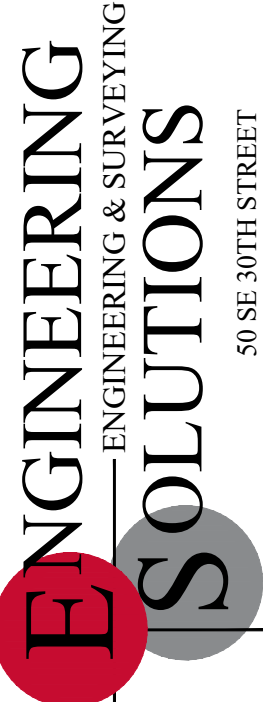
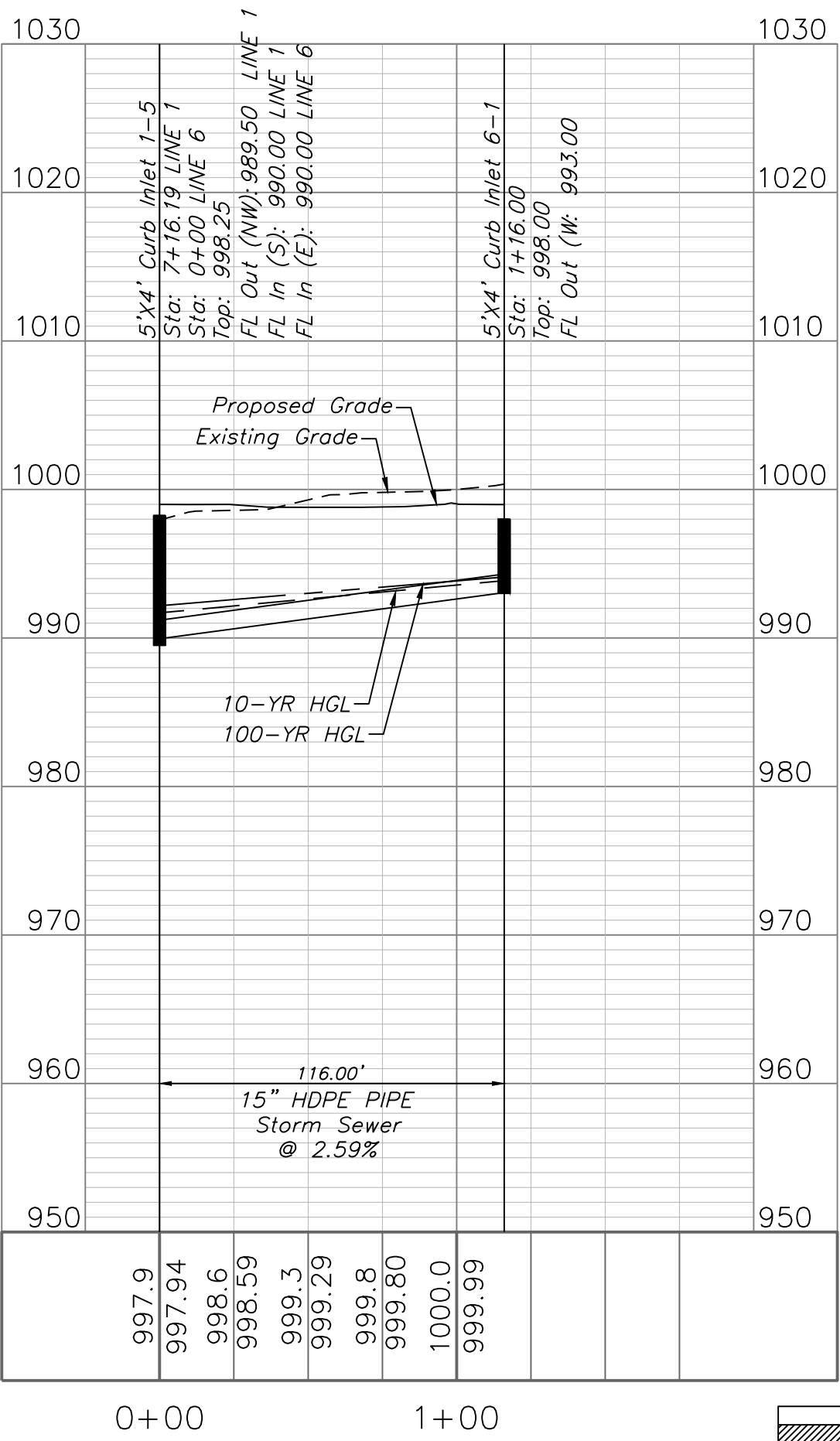
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STORM SEWER PLAN AND PROFILE



STORM LINE 6

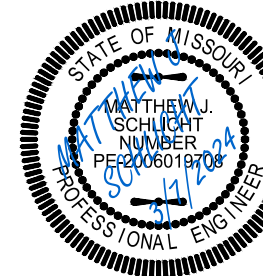


Professional Registration
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Surveying 2005008319-D
Kansas
Engineering E-1685
Surveying LS-218
Oklahoma
Engineering 6254
Nebraska
Engineering CA2821

Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

Project: LSWO
Issue Date:
August 11, 2023

Storm Sewer Plan and Profile
Construction Plans for:
Douglas Station Commercial Park
Lee's Summit, Jackson County, Missouri

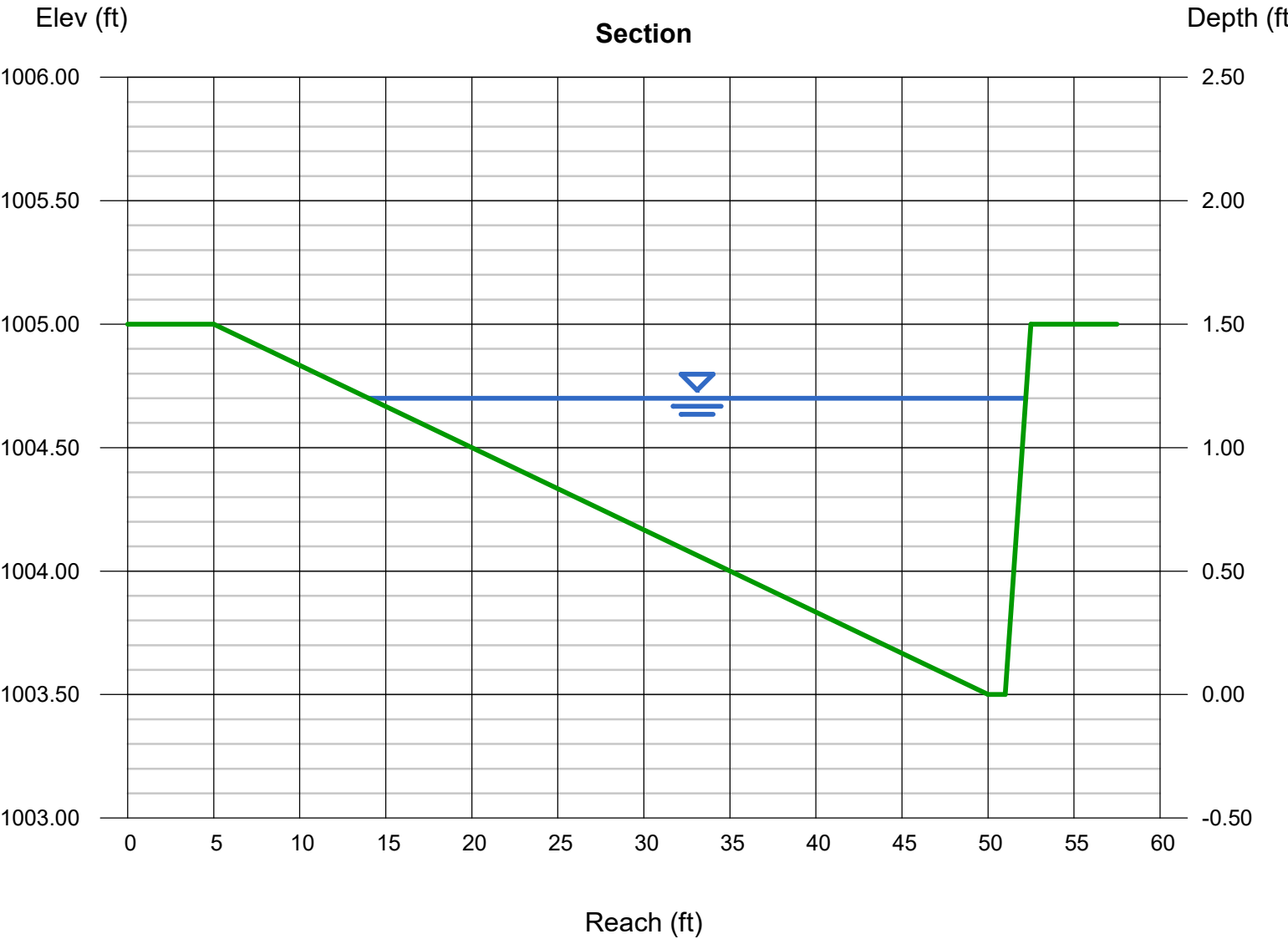


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KS PE 19071
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NE PE E-14335

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REV. 3/7/2024	

Overflow Spillway

Trapezoidal		Highlighted	
Bottom Width (ft)	= 1.00	Depth (ft)	= 1.20
Side Slopes (z:1)	= 30.00, 1.00	Q (cfs)	= 167.10
Total Depth (ft)	= 1.50	Area (sqft)	= 23.52
Invert Elev (ft)	= 1003.50	Velocity (ft/s)	= 7.10
Slope (%)	= 1.00	Wetted Perim (ft)	= 38.72
N-Value	= 0.015	Crit Depth, Yc (ft)	= 1.46
Calculations		Top Width (ft)	= 38.20
Compute by:	Q vs Depth	EGL (ft)	= 1.98
No. Increments	= 10		

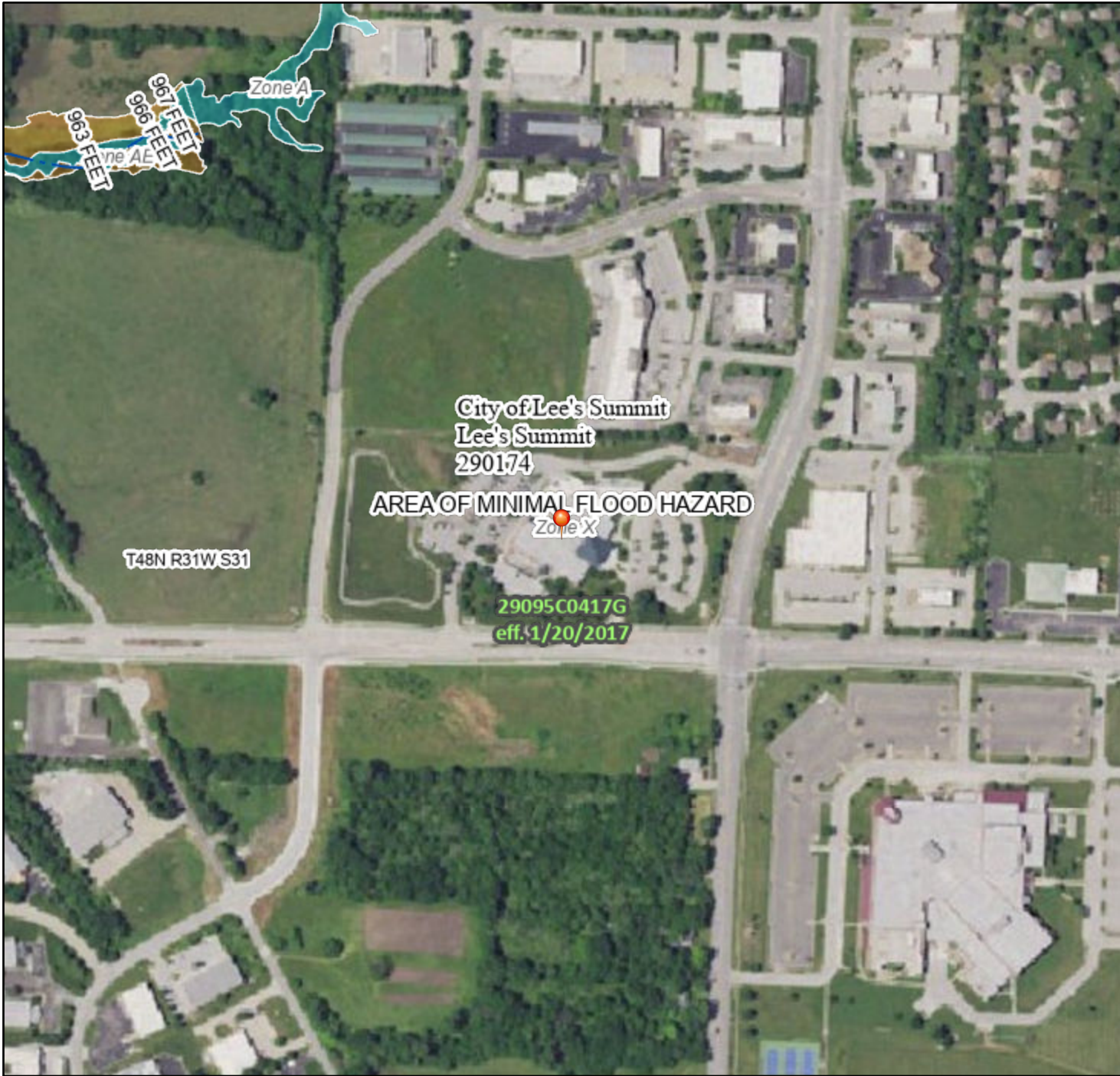


National Flood Hazard Layer FIRMette



Appendix A4

94°23'11"W 38°56'7"N



0 250 500 1,000 1,500 2,000 Feet 1:6,000

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
		Area of Undetermined Flood Hazard Zone D
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

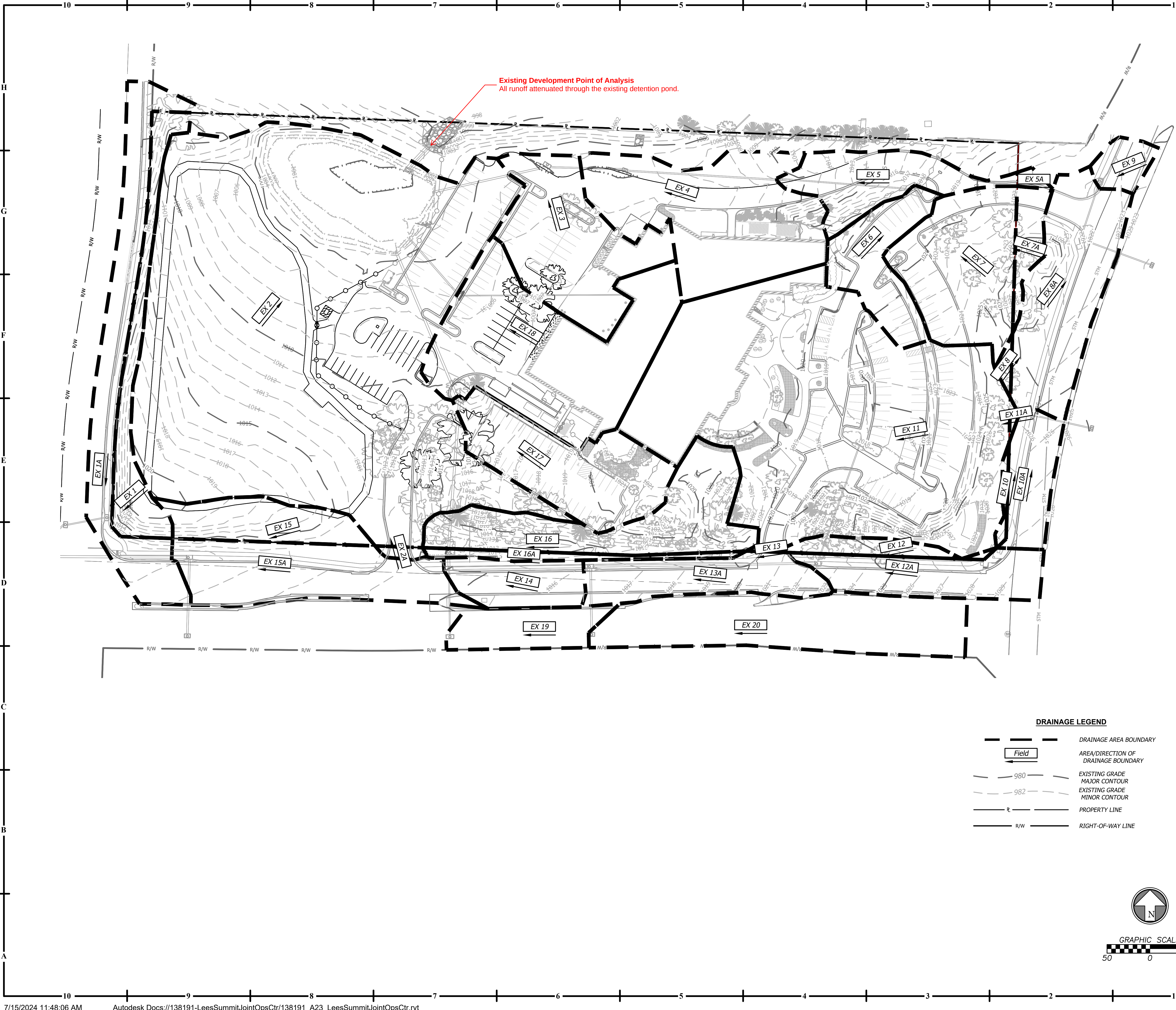


The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

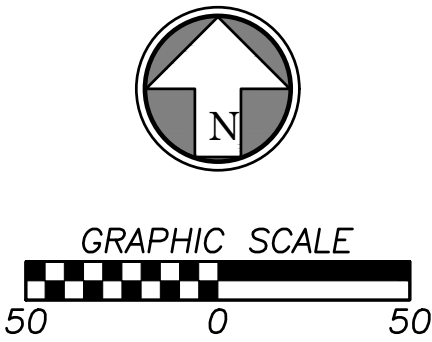
The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 8/27/2024 at 1:29 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



DRAINAGE LEGEND

- DRAINAGE AREA BOUNDARY
- Field
- AREA/DIRECTION OF DRAINAGE BOUNDARY
- EXISTING GRADE MAJOR CONTOUR
- EXISTING GRADE MINOR CONTOUR
- PROPERTY LINE
- RIGHT-OF-WAY LINE



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LEE'S SUMMIT JOINT OPERATIONS FACILITY
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PRELIMINARY DEVELOPMENT PLAN

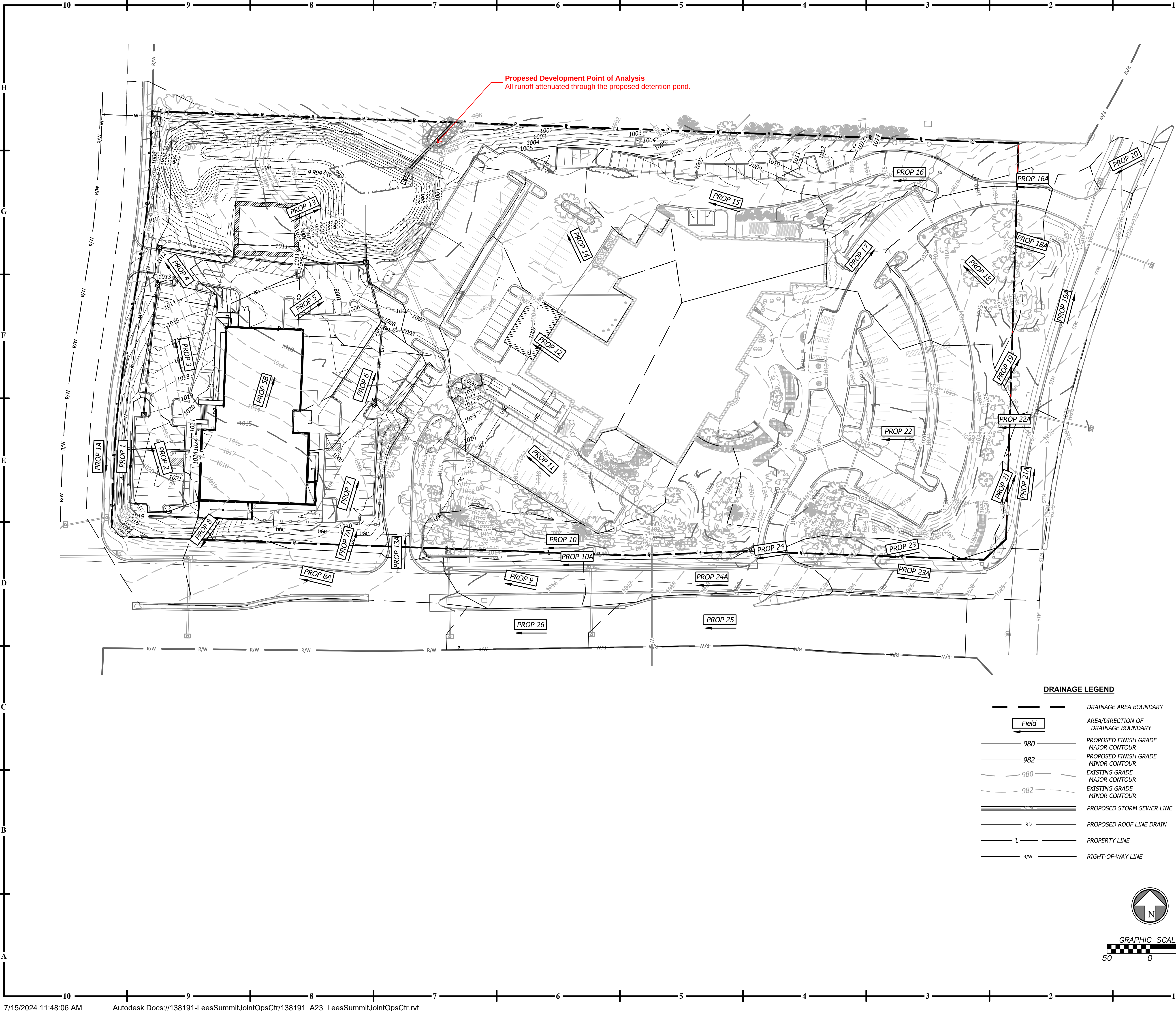
REVISION DATES:
REV 1: 2024-08-27

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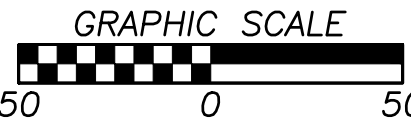
EXISTING DRAINAGE MAP



Proposed Development Point of Analysis
All runoff attenuated through the proposed detention pond.

DRAINAGE LEGEND

	DRAINAGE AREA BOUNDARY
	AREA/DIRECTION OF DRAINAGE BOUNDARY
	PROPOSED FINISH GRADE MAJOR CONTOUR
	PROPOSED FINISH GRADE MINOR CONTOUR
	EXISTING GRADE MAJOR CONTOUR
	EXISTING GRADE MINOR CONTOUR
	PROPOSED STORM SEWER LINE
	PROPOSED ROOF LINE DRAIN
	PROPERTY LINE
	RIGHT-OF-WAY LINE



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PROPOSED DRAINAGE MAP