

STORMWATER REPORT

Fire Station #4



5031 NE Lakewood Way
Lee's Summit, MO 64064

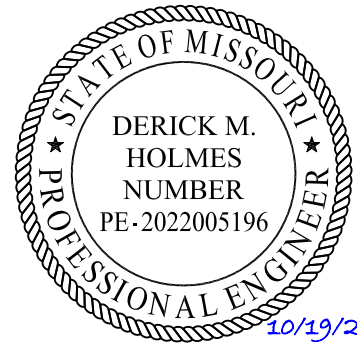
GLMVArchitecture

PREPARED BY: Derick Holmes, P.E.

Revision 0: January 5, 2022

Revision 1: February 11, 2022

Revision 2: October 14, 2022



REVISION NUMBER	DESCRIPTION	DATE	PROFESSIONAL	NOTES
0	INITIAL ISSUE	01/05/22	DERICK HOLMES	
1	REVISED PER CITY COMMENTS	02/11/22	DERICK HOLMES	STORMWATER NARRATIVE REVISED PER CITY COMMENTS PROVIDED 02/04/2022
2	REVISED FOR FINAL DEVELOPMENT PLAN SUBMITTAL	10/14/2022	DERICK HOLMES	INCLUDED FIELD OBSERVATIONS FOR REGIONAL DETENTION BASIN

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- D.1 – Section 5600 – Storm Drainage Systems & Facilities, City of Lee’s Summit, MO Design Criteria
- D.2 - Select Pages, APWA Section 5600
- D.3 – City of Lee’s Summit Watershed & Outfall Map
- D.4 – NOAA Point Precipitation Data
- D.5 – Select Pages, NRCS Web Soil Survey

References:

1. City of Lee's Summit, MO (January 13, 2022). *Section 5600 – Storm Drainage System & Facilities; City of Lee's Summit, Missouri Design Criteria*. Retrieved from <https://cityofls.net/development-services/design/design-criteria/design-construction-manual-infrastructure>
2. Kansas City Metropolitan Chapter of American Public Works Association (January 13, 2022). *Section 5600; Storm Drainage Systems & Facilities; February 16, 2011*. Retrieved from <https://cityofls.net/development-services/design/design-criteria/design-construction-manual-infrastructure>
3. City of Lee's Summit, MO (January 13, 2022). *City of Lee's Summit Watershed with Outfall Map*. Retrieved from <https://cityofls.net/map-gallery/index.html?group=98ce512922a144cdbad6a03516df5897>
4. NOAA. (January 5, 2022). *Point Precipitation Frequency (PF) Estimates*. Retrieved from https://hdsc.new.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nc
5. United States Department of Agriculture Natural Resources Conservation Service. (January 5, 2022). *Web Soil Survey*. Retrieved from <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>
6. Autodesk Civil 3D 2021
7. Autodesk Storm and Sanitary Analysis 2021

1.0 INTRODUCTION

1.1 PURPOSE STATEMENT

The purpose of this Report is to document the steps taken to size the stormwater system for the proposed Fire Station #4 in Lee's Summit, MO.

1.2 PROJECT BACKGROUND

The purpose of this proposed Project is to construct a new Fire Station #4. The project will be located at 5031 NE Lakewood Way, Lee's Summit, MO 64064. As shown in Figure 1, the site is located at the intersection of Bowlin Road and NE Lakewood Way.

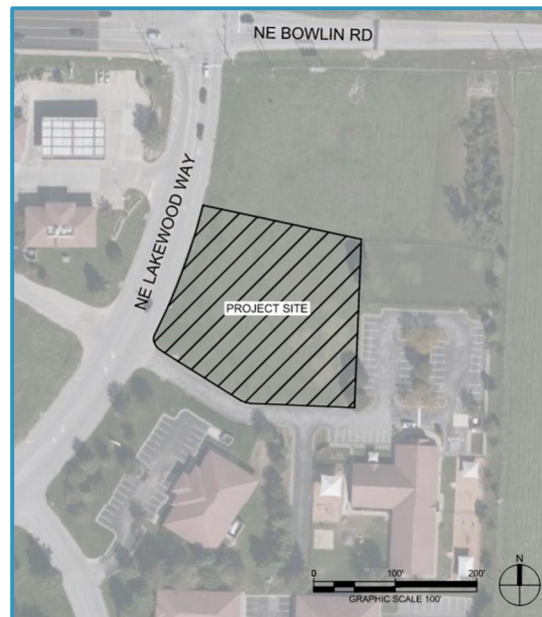


Figure 1 - Site Vicinity Map

1.3 EXISTING LAND USES

The Project currently consists of 1.17 acres of undeveloped grassland. Surrounding land uses consists of a mixture of both developed and undeveloped commercial properties. Adjacent properties that are developed include an animal health center, Montessori school, and a gas station.

This project will require a minor plat of Lot 6-A to acquire an additional 0.10 acres from Lot 7 to the north (see Appendix A).

1.4 EXISTING STORMWATER RUNOFF

The topography for the property generally slopes from southeast to northwest with elevations varying between 913 feet above mean sea level on the southeast side of the site to 907 feet at the site's lowest point at the northwest corner of the property.

Existing site runoff is primarily captured in the stormwater conveyance system on NE Lakewood Way. A curb inlet located at the NW corner of Lot 6-A then discharges stormwater east along Lot 6-A's northern property line. A stormwater manhole located east of the property then directs stormwater discharge to a regional detention basin located on Tract E (see Figure 2 and Appendix A).

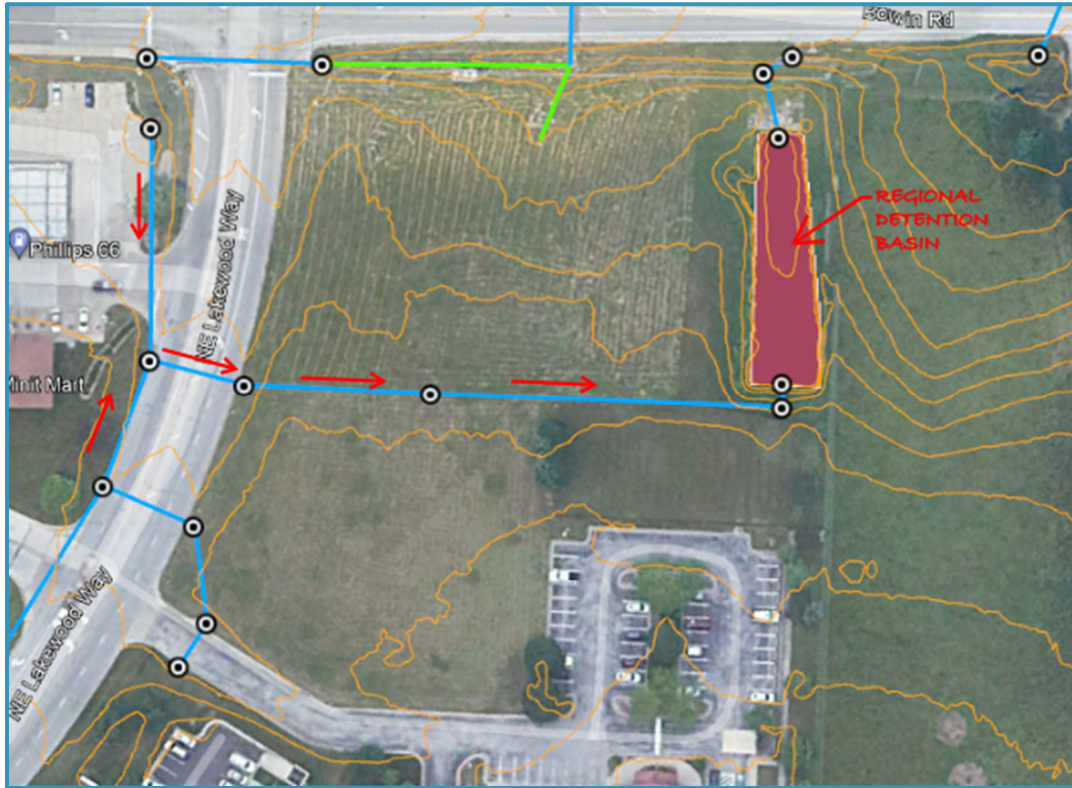


Figure 2 - Existing Stormwater Drainage

As shown in Appendix D.3, the Project is in the Blue Springs Watershed.

1.5 EXISTING SOIL CONDITIONS

A United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey was performed and is documented in Appendix D.5. The report outlines the following soil classifications found:

Table 1 - USDA NRCS Web Soil Survey Soil Classifications

MAP UNIT SYMBOL	MAP UNIT NAME	HYDROLOGIC SOIL GROUP
10082	Arisburg-Urban land complex, 1 to 5 percent slopes	C
10113	Oska silty clay loam, 5 to 9 percent slopes, eroded	D

1.6 PROPOSED DRAINAGE CONCEPT

The proposed drainage concept is shown on Drawing C-104 (see Appendix A). A series of curb and area inlets will collect stormwater throughout the site. The Project's stormwater conveyance system will discharge stormwater to the existing detention basin on Tract E, east of the site. A new curb inlet will be installed on NE Lakewood Way to replace the existing curb inlet that will be converted to a junction box on the front apron of the fire station. The existing public stormwater pipes on the northern property line of Lot 6-A will be relocated to the new northern property line as part of the minor plat of Lots 6-A and 7. A new 15' utility easement will be established along the new property line (7.5' on each property). A new manhole will be

installed on the northeast corner of Lot 6-A. This manhole will serve to collect the Project's stormwater runoff and to direct it east to the detention basin. A new stormwater conveyance pipe will be installed from this manhole to the existing manhole to the east, just upstream of the detention basin's inlet; the proposed invert elevation at the existing manhole will remain unchanged.

2.0 DESIGN BASIS

Per the City of Lee's Summit, MO (References 1 and 2), the following applies to stormwater design of the Project:

Table 2 - Design Basis

#	REFERENCE, SECTION	DESIGN BASIS ITEM	NOTES
1	2 5601.3 B2	<p>5601.3 General Requirements and Applicability</p> <p><i>The design shall be accomplished under the direction of a Registered Professional Engineer qualified in the field of stormwater design. The design shall be based on land use in the tributary area as zoned, actually developed, or indicated by an adopted future land use plan, whichever basis produces the greatest runoff.</i></p> <p><i>This design criterion shall apply to all development, including subdivision, which alters the surface of the land to create additional impervious surfaces, including, but not limited to, pavement, buildings, and structures with the following exceptions:</i></p> <p>B. New Construction Meeting the Following Criteria</p> <p><i>2. Construction of any buildings, structures, and/or appurtenant service roads, drives, and walks on a site having previously provided stormwater management, as defined in Section 5601.5 A4 as part of a larger unit of development, OR a site previously relieved of stormwater management requirements.</i></p>	Because the existing regional detention basin exists, this project is not required to utilize the Comprehensive Protection Method, as outlined in 5601.5 of Reference 1, for stormwater design. A field review of the existing detention basin was conducted and documented in Appendix C.
2	2 5601.8	<p>5601.8 Levels of Service</p> <p><i>A storm drainage system shall be provided that is capable of conveying the peak discharge generated by the 1% storm. If the in-system capacity established in this section is less the 1% storm peak discharge, then an overflow system as specified in Section 5601.5 -A-3 may provide the additional system capacity.</i></p> <p>B. Protection for Streets</p> <p>1. Gutter Spread: <i>Water spread in streets shall meet the requirements in Section 5604.2 for the 10% design storm. These values are intended to establish a standard of accessibility for the widths (classes) of roadways listed during the 10% storm. When the local jurisdiction requires a higher standard for curb inlets, the conveyance system connected to the roadway must</i></p>	

		<i>also meet that higher standard. If the roadway conveyance system connects to an underground system with lesser capacity, the system must be constructed to allow the discharge of that excess capacity into the overflow system.</i>													
3	2 5602.2	5602.2 Computation Methods for Runoff <i>B. Baseline Unit Hydrograph Method: The following computer implementations of the unit hydrograph method are acceptable for all watersheds:</i> <ul style="list-style-type: none">SCS Technical Release No. 55 "Urban Hydrology for Small Watersheds", 2nd Edition, June 1986.													
4	1 5603.1	Hydraulic Calculation for Pipes, Culverts, and Open Channels <i>"Enclosed systems will use the open channel, or gravity, flow design method for the appropriate design storm."</i>													
5	2 5604.2	5604.2 Gutter Flow <i>Inlets shall be located to limit the width of flow in street gutters at the time of peak discharge for the design storm specified in 5601.8 B to the limits indicated in Table 5604-2.</i> <table><tr><th colspan="2">Table 5604-2: Gutter Spread Criteria</th></tr><tr><th>Back to Back of Curb Street Width (feet)</th><th>Maximum Allowable Spread in Each Outside Curb Lane from Back of Curb* (feet)</th></tr><tr><td>28 or Less</td><td>12.0</td></tr><tr><td>Over 28 to 36</td><td>12.0</td></tr><tr><td>Over 36</td><td>12.0</td></tr><tr><td>Divided Roadways</td><td>As above for each direction roadway</td></tr></table> <p>* spread may exceed these limits within 50 feet of a sump inlet.</p>	Table 5604-2: Gutter Spread Criteria		Back to Back of Curb Street Width (feet)	Maximum Allowable Spread in Each Outside Curb Lane from Back of Curb* (feet)	28 or Less	12.0	Over 28 to 36	12.0	Over 36	12.0	Divided Roadways	As above for each direction roadway	
Table 5604-2: Gutter Spread Criteria															
Back to Back of Curb Street Width (feet)	Maximum Allowable Spread in Each Outside Curb Lane from Back of Curb* (feet)														
28 or Less	12.0														
Over 28 to 36	12.0														
Over 36	12.0														
Divided Roadways	As above for each direction roadway														

2.1 METHODOLOGY

To satisfy the requirements set forth in Table 2 above, the following design steps were taken:

1. Size the Project's stormwater conveyance system for the 1 (100%), 10 (10%) and 100-year (1%), 24-hr storm event utilizing the SCS TR-55 Unit Hydrograph Method.
 - a. The site's post-development drainage characteristics were computed and documented in Appendix B.
 - i. Each drainage area was assigned a composite curve number utilizing Table 5602-3 of Reference 2 (see Appendix D.2).
 - ii. A minimum system time of concentration of 5 minutes was assumed per Reference 2 (Appendix D.2).
 - iii. Point precipitation frequency estimates were found utilizing Reference 4 (Appendix D.4).

- b. A stormwater model was created in AutoCAD Storm & Sanitary Analysis (SSA) (Reference 7). The peak discharges for the 1-, 10-, and 100-year, 24-hour storm events were documented in Appendix B. Gutter spreads for the system were checked for the 10-year, 24-hr storm event. Existing pipe capacities for new proposed public stormwater lines were compared with existing lines being demolished in Appendix B.4.
2. Conduct a field investigation to verify the existing regional detention basin is currently functioning. As per the City of Lee's Summit, the following items were documented (see Appendix C):
 - a. The condition of the basin.
 - b. Siltation within the basin and any measures needed to remove silt.
 - c. Brush or vegetation within the basin that may need removal.
 - d. Condition of the retaining wall within the basin to determine whether it is leaning or has other structural issues.
 - e. The basin is working as intended.

3.0 SUMMARY

In summary, all stormwater conveyance pipes can safely pass the 100-year, 24-hour stormwater event. All inlet gutter spreads were checked against the 10-year, 24-hour storm event and were found to be satisfactory against the design criteria. All new public stormwater piping proposed has a design capacity equal to or greater than existing piping being removed.

APPENDIX A

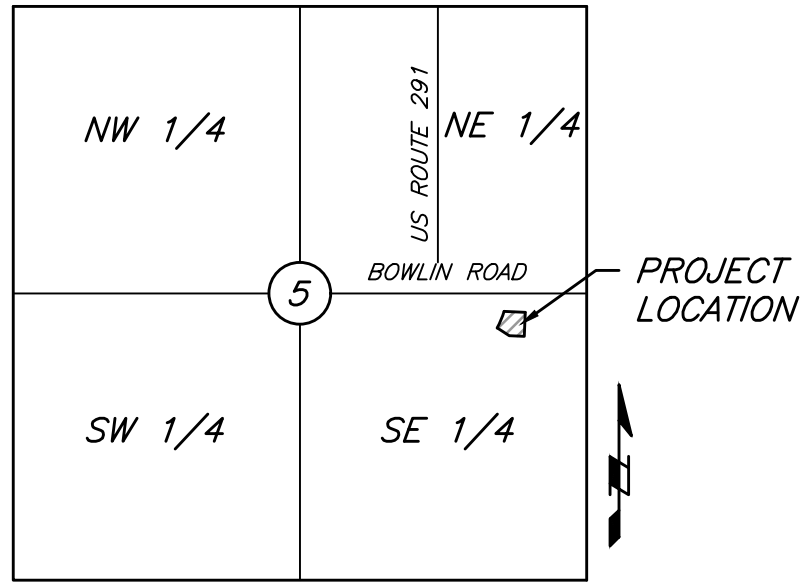
PROJECT DRAWINGS



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NOTE: THE DRAWINGS PRESENTED IN THIS
APPENDIX ARE FOR REFERENCE ONLY AND ARE
NOT TO BE USED AS THE BASIS OF
CONSTRUCTION.

ALTA/NSPS LAND TITLE SURVEY
LOT 6-A; EXECUTIVE LAKES CENTER, LOTS 6-A and 8-B
LEE'S SUMMIT, JACKSON COUNTY, MISSOURI



CLIENT:
GLMV
9229 Ward Parkway
Kansas City, Mo 64114

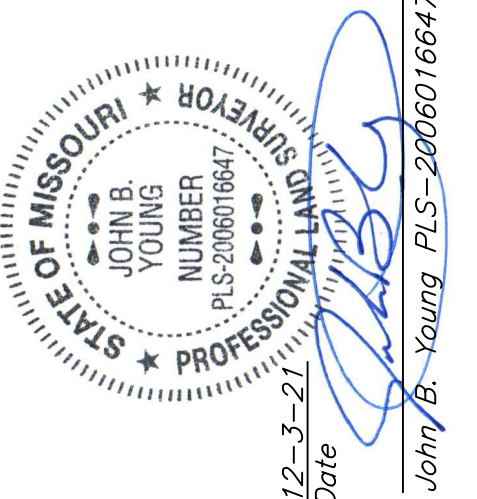
PROPERTY ADDRESS:
5031 NE Lakewood Way
Lee's Summit, Mo 64064

PROPERTY DESCRIPTION:
All of Lot 6-A, EXECUTIVE LAKES CENTER
Lots 6-A and 8-B, a subdivision in the
SE 1/4 of Section 5- T 48 N - R 31
W, Lee's Summit, Jackson County,
Missouri

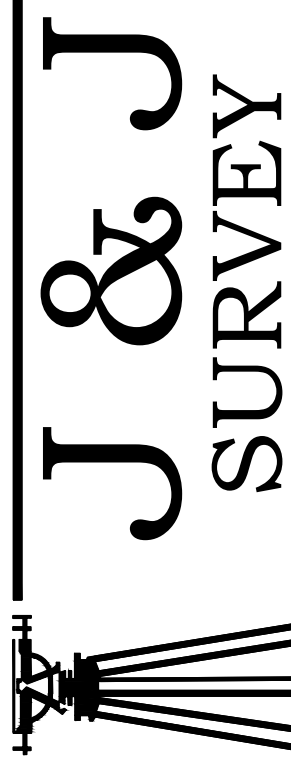
CERTIFICATION:

To: First American Title Insurance Company, and
Bahman Tehrani, D.D.S P.C., dba Lakewood Dental
Center, and Jaleh Nikfarjam, his wife.

This is to certify that this map or plat and the survey
on which it is based were made in accordance with
the 2021 Minimum Standard Detail Requirements for
ALTA/NSPS Land Title Surveys, jointly established and
adopted by ALTA and NSPS, and includes Items 1, 2,
3, 4, 5, 6, 7, 8, 9, 11, 13 and 15 of Table A
thereof. The field work was completed on the 12th day
of July, 2021.

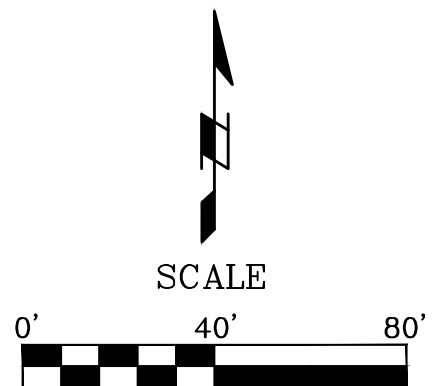
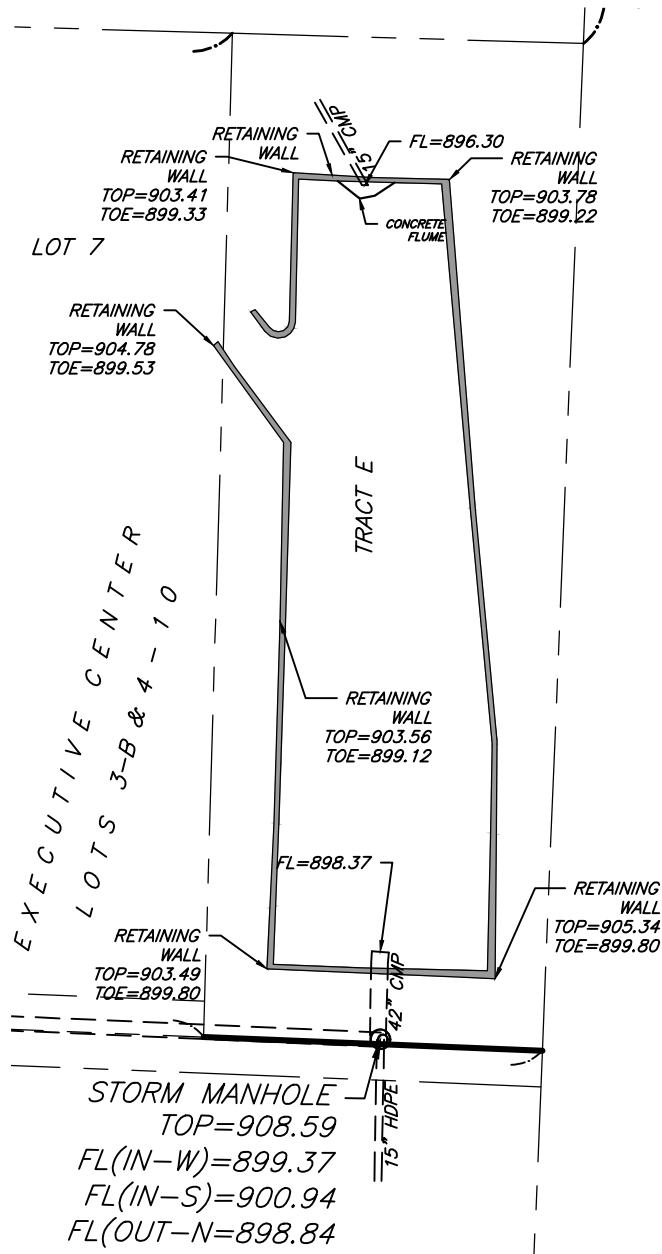


Location: S:\21.071 - Lee's Summit, Fire Stations\DRAWINGS\5031 NE LAKEWOOD WAY\21.071-12-3-21\21.071-ALTA 12-3-21 (G.dwg)-Dec. 07, 2021-1:26pm

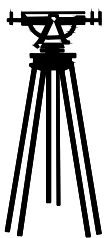


6500 NW TOWER DR., SUITE 102 • PLATTE WOODS, MO 64151
PHONE (816) 941-1017 • FAX (816) 941-1018

1	INITIAL SUBMITTAL	07-30-21
2	REVISED DWG	08-26-21
3	REVISED PER COMMENTS	12-3-21
4	REVISED PER COMMENTS	12-07-21



Location: S:\21.071 - Lees Summit Fire Stations\DRAWINGS\5031 NE LAKEWOOD WAY\21.071- 12-3-21\21.071-ALTA 12-3-21 LG.dwg-Dec 03, 2021-10:58am



J & J
SURVEY
LLC

6500 NW TOWER DR., SUITE 102 • PLATTE WOODS, MO 64151
PHONE (816)741-1017 • FAX (816)741-1018

DETENTION EXHIBIT

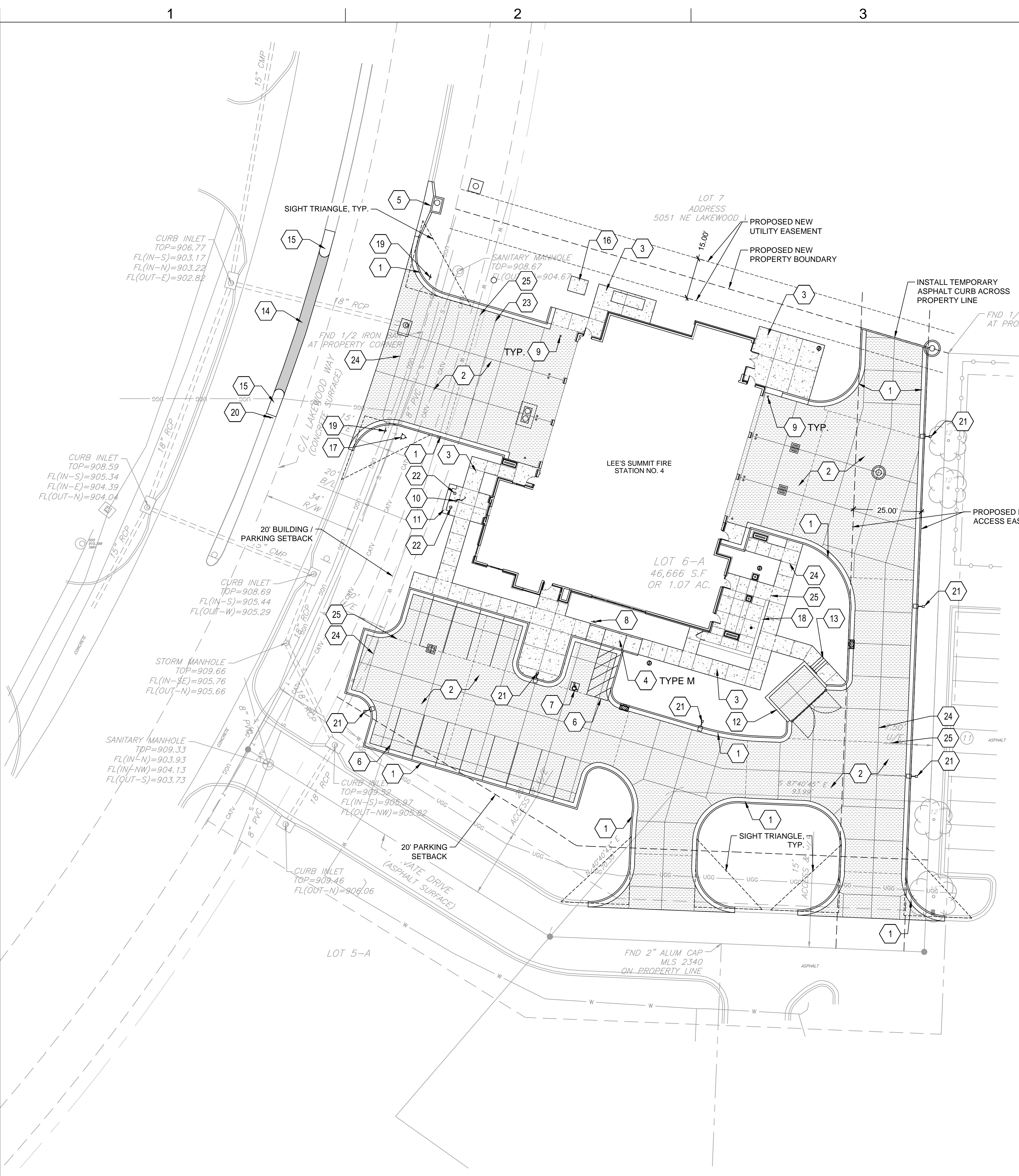
TRACT E, STORM WATER DETENTION,
LEE'S SUMMIT, JACKSON COUNTY,
MISSOURI

D

C

B

A



SITE NOTES

1. PRIOR TO STARTING CONSTRUCTION THE CONTRACTOR SHALL BE RESPONSIBLE TO MAKE SURE THAT ALL REQUIRED PERMITS AND APPROVALS HAVE BEEN OBTAINED. NO CONSTRUCTION OR FABRICATION SHALL BEGIN UNTIL THE CONTRACTOR HAS RECEIVED AND THOROUGHLY REVIEWED ALL PLANS AND OTHER DOCUMENTS APPROVED BY ALL OF THE PERMITTING AUTHORITIES.
2. ALL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THESE PLANS, SPECIFICATIONS, AND THE REQUIREMENTS AND STANDARDS OF THE LOCAL GOVERNING AUTHORITY.
3. CONTRACTOR SHALL CONTACT DIG SAFE PRIOR TO ANY EXCAVATION/DIGGING.
4. ALL EXISTING CONDITIONS, DIMENSIONS, AND GRADES SHOWN ON THE PLANS SHALL BE FIELD VERIFIED BY THE CONTRACTOR PRIOR TO CONSTRUCTION. CONTRACTOR SHALL NOTIFY THE CONSTRUCTION MANAGER IF ANY DISCREPANCIES EXIST. PRIOR TO PROCEEDING WITH CONSTRUCTION, FOR NECESSARY PLAN OR GRADE CHANGES, NO EXTRA COMPENSATION SHALL BE PAID TO THE CONTRACTOR FOR WORK HAVING TO BE REDONE DUE TO DIMENSIONS OR GRADES SHOWN INCORRECTLY ON THESE PLANS IF SUCH NOTIFICATION HAS NOT BEEN GIVEN.
5. CONTRACTOR SHALL REPAIR ALL DISTURBED LANDSCAPING.
6. REFERENCE GRADING & DRAINAGE PLAN FOR DETAILED CURB TRANSITION POINTS.

KEYNOTES

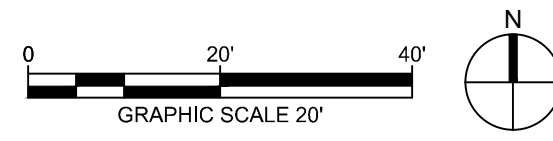
- 1 TYPE CG-1 CURB & GUTTER
LEE'S SUMMIT STANDARD DETAIL
REF: 3/C-502
- 2 TYP. CONCRETE PAVING
REF: 1/C-500
- 3 CONCRETE SIDEWALK PAVING
REF: 1/C-503
- 4 ADA SIDEWALK RAMP
REF: 4/C-503
- 5 CURB INLET
REF: C-104
- 6 PAVEMENT STRIPING
REF: 4/C-500
- 7 ADA PAVEMENT MARKING
REF: 5/C-500
- 8 ADA PARKING SIGN
REF: 6/C-500
- 9 TYP. SAFETY BOLLARD
REF: 3/C-500
- 10 FLAG POLE
REF: 8/C-500
- 11 MONUMENT SIGN
REF: 9/C-500
- 12 DUMPSTER ENCLOSURE
REF: 1-6/C-501
- 13 CONCRETE STEPS WITH RAILING
REF: 12/C-500
- 14 ROADWAY ASPHALT PATCH
LEE'S SUMMIT STANDARD DETAIL
REF: 2/C-503
- 15 MEDIAN TRANSITION
LEE'S SUMMIT STANDARD DETAIL
REF: 3/C-503
- 16 TRANSFORMER CONCRETE PAD
REF: MEP
- 17 RELOCATED FIRE HYDRANT
REF: C-220
- 18 SCREEN WALL
REF: ARCH
- 19 DO NOT ENTER SIGN
REF: 7/C-500
- 20 NO LEFT/TURN SIGN
REF: 2/C-500
- 21 TYP. AREA LIGHTING
REF: ELECTRICAL
- 22 TYP. FLAG POLE LIGHTING
REF: ELECTRICAL
- 23 LIMITS OF SNOW MELT SYSTEM
REF: MEP
- 24 CONSTRUCTION JOINT
REF: 2/C-502
- 25 ISOLATION JOINT
REF: 2/C-502

LEGEND

- TYP. CURB & GUTTER
- TYP. CONCRETE PAVING
- ASPHALT PATCH
- CONCRETE SIDEWALK

SITE PLAN

1" = 20'-0"



9229 WARD PARKWAY
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KANSAS CITY, MO 64114
TEL: (816) 444-4200
FAX: (316) 265-5646
www.glmv.com

GLMV ARCHITECTURE, INC.
MISSOURI STATE CERTIFICATE OF AUTHORITY
#00008

CIVIL ENGINEER & LANDSCAPE ARCH.
GLMV ARCHITECTURE, INC.
MISSOURI CIVIL COA #2019033898
MISSOURI LANDSCAPE COA #000008
9229 WARD PARKWAY, SUITE # 210
KANSAS CITY, MO 64114
TEL: (816) 444-4200

STRUCTURAL ENGINEER
LEIGH + O'KANE
MISSOURI COA #001644
250 NE MURBERRY, SUITE 201
LEE'S SUMMIT, MO, 64086
(816) 444-3144 PHONE

MECH. ELEC. & PLUMBING ENGINEERS
HOSS & BROWN ENGINEERS
MISSOURI COA #01022
15902 MIDLAND DRIVE
SHAWNEE, KS 66217
(913) 362-9090 PHONE

SECURITY & IT ENGINEERS
HENDERSON ENGINEERS
MISSOURI COA # 000556
1801 MAIN STREET, SUITE 300
KANSAS CITY, MO 64108
(816) 663-8700 PHONE

FIRE STATION #4 CITY OF LEE'S SUMMIT

5031 NORTHEAST LAKEWOOD WAY
LEE'S SUMMIT, MISSOURI 64064

REVISIONS:		
#	Description	Date

DERICK HOLMES - CIVIL ENGINEER
MO# PE-2022005196

The Professional Engineers and Architectural seal on this sheet applies only to the material and items shown on this sheet. It is not valid for any other work or for any other project. The seal of the Professional Engineer or Architect is not valid if it is not accompanied by the seal of the Professional Engineer or Architect. The seal of the Professional Engineer or Architect is not valid if it is not accompanied by the seal of the Professional Engineer or Architect.

PROJECT NO:	18225R21001
DATE:	10.19.2022
DRAWN BY:	KDW
CHKD BY:	DMH

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SITE PLAN

C-100

D

C

B

A

GENERAL GRADING & DRAINAGE NOTES:

1. SITE GRADING MUST BE PERFORMED IN ACCORDANCE WITH THESE PLANS, SPECIFICATIONS, AND THE RECOMMENDATIONS SET FORTH IN THE GEOTECHNICAL REPORT AS REFERENCED IN THIS PLAN SET. THE CONTRACTOR MUST FOLLOW THE REQUIREMENTS OF ALL MUNICIPAL, COUNTY, STATE, AND FEDERAL LAWS, WHICH HAVE JURISDICTION OVER THIS PROJECT.
2. ALL PROPOSED CONTOUR LINES AND SPOT ELEVATIONS SHOWN ARE FINISH GROUND ELEVATIONS. CONTRACTOR SHALL ACCOUNT FOR PAVEMENT DEPTHS, BUILDING PADS, LOW VOLUME CHANGE MATERIAL, TOPSOIL, ETC. WHEN GRADING THE SITE.
3. ALL DISTURBED AREAS THAT ARE NOT TO BE PAVED (GREEN SPACES) SHALL BE FINISH GRADED WITH A MINIMUM OF SIX INCHES OF TOPSOIL.
4. ALL EXCAVATIONS AND EMBANKMENTS SHALL COMPLY WITH THE RECOMMENDATIONS PROVIDED BY THE GEOTECHNICAL ENGINEER.
5. FINISHED GRADES SHALL NOT BE STEEPER THAN 3:1, UNLESS NOTED OTHERWISE ON THE PLANS.
6. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING ELEVATIONS OF CONNECTION POINTS AS SHOWN ON GRADING PLANS. NOTIFY ENGINEER IF DISCREPANCY EXISTS FOR DIRECTION.
7. ALL GRADES SHALL BE CONTOURED SMOOTHLY WITH GENTLE ROUNDING/SHAPING OF ALL AFFECTED LAND SURFACES. ABRUPT TRANSITIONS AT THE TOP OF SLOPES WHERE PROPOSED GRADES MEET EXISTING ARE NOT ACCEPTABLE. GRADING SHALL BE APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO THE ADDITION OF THE TOPSOIL LAYER.
8. SEE DRAWINGS C-230 AND C-231 FOR STORMWATER PROFILE DRAWINGS.

ADA NOTES

1. ALL ACCESSIBLE (A.K.A. ADA) COMPONENTS AND ACCESSIBLE ROUTES MUST BE CONSTRUCTED TO MEET, AT A MINIMUM, THE MORE STRINGENT OF: (A) THE REQUIREMENTS OF THE "AMERICANS WITH DISABILITIES ACT" (ADA) CODE (42 U.S.C. § 12101 ET SEQ. AND 42 U.S.C. § 4151 ET SEQ.); AND (B) ANY APPLICABLE LOCAL AND STATE GUIDELINES, AND ANY AND ALL AMENDMENTS TO BOTH, WHICH ARE IN EFFECT WHEN THESE PLANS WERE COMPLETED.
2. THE CONTRACTOR MUST REVIEW ALL DOCUMENTS REFERENCED IN THESE NOTES FOR ACCURACY, COMPLIANCE, AND CONSISTENCY WITH INDUSTRY GUIDELINES.
3. THE CONTRACTOR MUST EXERCISE APPROPRIATE CARE AND PRECISION IN CONSTRUCTION OF ACCESSIBLE (ADA) COMPONENTS AND ACCESSIBLE ROUTES FOR THE SITE. FINISHED SURFACES ALONG THE ACCESSIBLE ROUTE OF TRAVEL FROM PARKING SPACES, PUBLIC TRANSPORTATION, PEDESTRIAN ACCESS, AND INTER-BUILDING ACCESS TO POINTS OF ACCESSIBLE BUILDING ENTRANCE/EXIT MUST COMPLY WITH THE ACCESSIBLE GUIDELINES AND REQUIREMENTS WHICH INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING:
 - 3.1. ACCESSIBLE PARKING SPACES AND ACCESS AISLES SLOPES MUST NOT EXCEED 1:50 (2.0%) IN ANY DIRECTION.
 - 3.2. PATH OF TRAVEL ALONG ACCESSIBLE ROUTE MUST PROVIDE A 48-INCHES MINIMUM WIDTH. UNOBSTRUCTED WIDTH OF TRAVEL (CAR OVERHANGS AND/OR HANDRAILS MUST BE EXCLUDED) THIS MINIMUM WIDTH. THE SLOPE MUST NOT EXCEED 1:20 (5.0%) IN THE DIRECTION OF TRAVEL AND MUST NOT EXCEED 1:50 (2.0%) IN CROSS SLOPE. WHERE ACCESSIBLE PATH OF TRAVEL IS GREATER THAN 1:20 (5.0%), AN ACCESSIBLE RAMP MUST BE PROVIDED. ALONG THE ACCESSIBLE PATH OF TRAVEL, OPENINGS MUST NOT EXCEED 1/2-INCH IN WIDTH. VERTICAL CHANGES OF UP TO 1/2-INCH ARE PERMITTED ONLY IF THEY INCLUDE A 1/4-INCH BEVEL AT A SLOPE NOT STEEPER THAN 1:2. NO VERTICAL CHANGES OVER 1/4-INCH ARE PERMITTED.
 - 3.3. ACCESSIBLE RAMPS MUST NOT EXCEED A SLOPE OF 1:12 (8.3%) AND A RISE OF 30-INCHES. LEVEL LANDINGS MUST BE PROVIDED AT EACH END OF ACCESSIBLE RAMPS. LANDING MUST PROVIDE POSITIVE DRAINAGE AWAY FROM STRUCTURES, AND MUST NOT EXCEED 1:50 (2.0%) SLOPE IN ANY DIRECTION. RAMPS THAT CHANGE DIRECTION BETWEEN RUNS AT LANDINGS MUST HAVE A CLEAR LANDING OF A MINIMUM OF 60-INCHES BY 60-INCHES HANDRAILS ON BOTH SIDES OF THE RAMP MUST BE PROVIDED ON AN ACCESSIBLE RAMP WITH A RISE GREATER THAN 6-INCHES. ACCESSIBLE CURB RAMPS MUST NOT EXCEED A SLOPE OF 1:12 (8.3%). WHERE FLARED SIDES ARE PROVIDED, THEY MUST NOT EXCEED 1:10 (10%) SLOPE. LEVEL LANDING MUST BE PROVIDED AT RAMPS TOP AT A MINIMUM OF 36-INCHES LONG (48-INCHES PREFERRED). IN ALTERATIONS, WHEN THERE IS NO LANDING AT THE TOP, FLARE SIDES SLOPES MUST NOT EXCEED A SLOPE OF 1:12 (8.3%).
 - 3.5. DOORWAY LANDINGS AREAS MUST BE PROVIDED ON THE EXTERIOR SIDE OF ANY DOOR LEADING TO AN ACCESSIBLE PATH OF TRAVEL. THIS LANDING MUST BE SLOPED AWAY FROM THE DOOR NO MORE THAN 1:50 (2.0%) FOR POSITIVE DRAINAGE. THIS LANDING AREA MUST BE NO FEWER THAN 60-INCHES (5 FEET) LONG, EXCEPT WHERE OTHERWISE CLEARLY PERMITTED BY ACCESSIBLE STANDARDS FOR ALTERNATIVE DOORWAY OPENING CONDITIONS. (SEE ICC/ANSI A117.1-2009 AND OTHER REFERENCES INCORPORATED BY CODE).
 - 3.6. WHEN THE PROPOSED CONSTRUCTION INVOLVES RECONSTRUCTION, MODIFICATION, REVISION OR EXTENSION OF OR TO ACCESSIBLE COMPONENTS FROM EXISTING DOORWAYS OR SURFACES, THE CONTRACTOR MUST VERIFY ALL EXISTING ELEVATIONS SHOWN ON THE PLAN. NOTE THAT TABLE 405.2 OF THE DEPARTMENT OF JUSTICE'S ADA STANDARDS FOR ACCESSIBLE DESIGN ALLOWS FOR STEEPER RAMP SLOPES IN RARE CIRCUMSTANCES. THE CONTRACTOR MUST IMMEDIATELY NOTIFY THE ENGINEER OF RECORD, IN WRITING, OF ANY DISCREPANCIES AND/OR FIELD CONDITIONS THAT DIFFER IN ANY WAY OR IN ANY RESPECT FROM WHAT IS SHOWN ON THE PLANS BEFORE COMMENCING. ANY CONSTRUCTED IMPROVEMENTS MUST FALL WITHIN THE MAXIMUM AND MINIMUM LIMITATIONS IMPOSED BY THE BARRIER FREE REGULATIONS AND THE ACCESSIBLE GUIDELINES.
 - 3.7. THE CONTRACTOR MUST VERIFY ALL OF THE SLOPES OF THE CONTRACTOR'S FORMS PRIOR TO POURING CONCRETE. IF ANY NON-CONFORMANCE EXISTS OR IS OBSERVED OR DISCOVERED, THE CONTRACTOR MUST IMMEDIATELY NOTIFY THE ENGINEER OF RECORD, IN WRITING, PRIOR TO POURING CONCRETE. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR ALL COSTS TO REMOVE, REPAIR AND/OR REPLACE NON-CONFORMING CONCRETE AND/OR PAVEMENT SURFACES.
4. IT IS STRONGLY RECOMMENDED THAT THE CONTRACTOR REVIEW THE INTENDED CONSTRUCTION TO ENSURE SAME IS CONSISTENT WITH THE LOCAL BUILDING CODE PRIOR TO COMMENCING CONSTRUCTION.

GRADING & DRAINAGE KEYNOTES

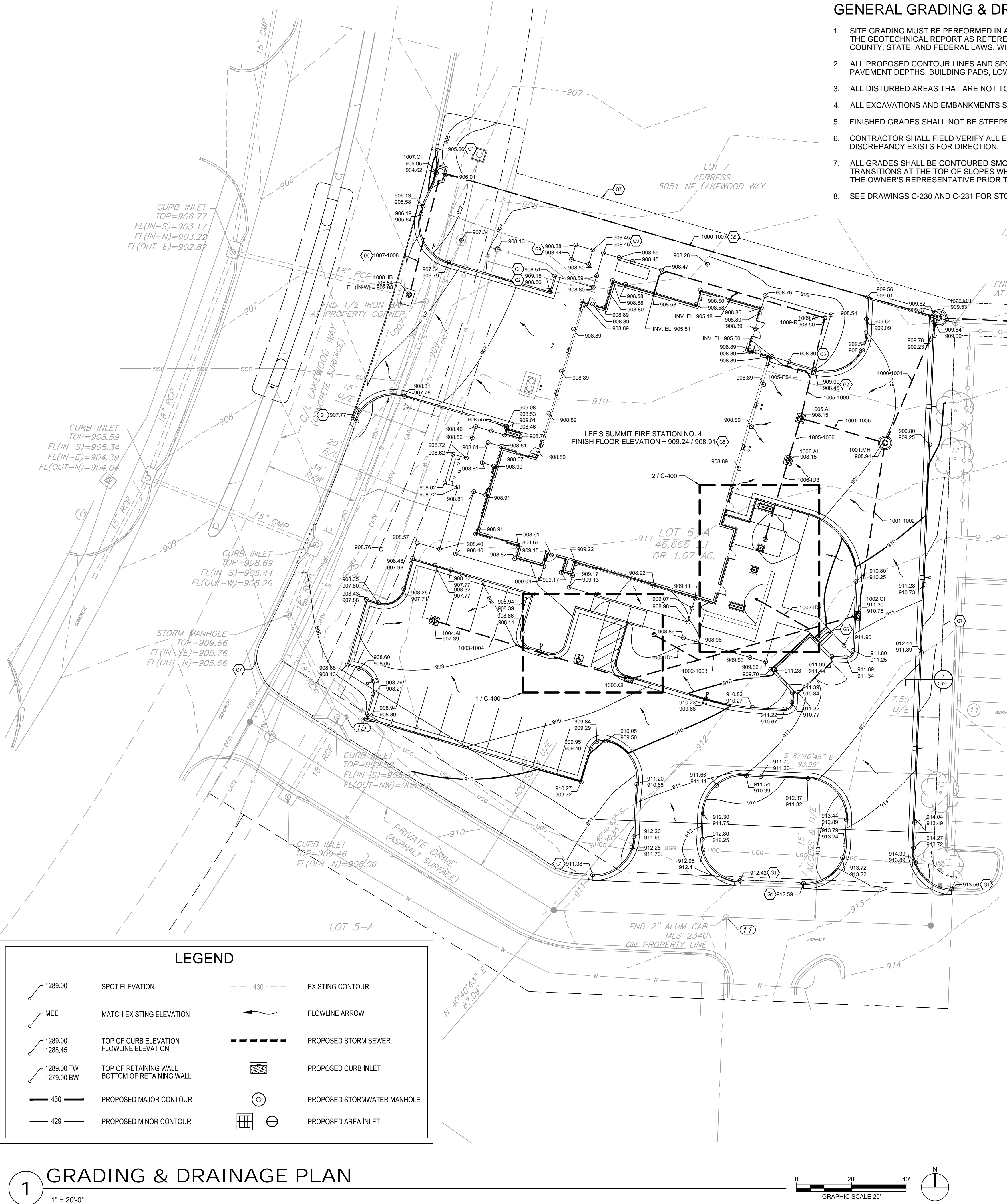
- G1 (+/-) MATCH EXISTING ELEVATION. NOTIFY ENGINEER IF SIGNIFICANT DISCREPANCY EXISTS.
- G2 START TRANSITION FROM FULL-DEPTH CURB
- G3 FLUSH CURB
- G4 4" CURB
- G5 PUBLIC STORMWATER LINE. STORMWATER LINES NOT DENOTED WITH KEYNOTE G5 SHALL BE PUBLIC LINES.
- G6 CONCRETE STEPS
REF: 12 / C-500
- G7 LIMITS OF DISTURBANCE
- G8 FINISH GRADE AT DOORS SET 3" BELOW FINISH FLOOR ELEVATIONS TO ACCOUNT FOR THRESHOLDS
- G9 ELEVATION DENOTES FINISH GRADE AT PAD EDGE AND NOT TOP OF PAD.

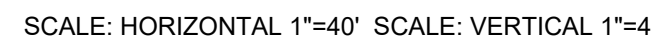
STORMWATER PIPE TABLE		
NAME	3D LENGTH, SIZE, MATERIAL & SLOPE	
EX MH-1000	152.83 LF OF 36" HDPP @ 0.50%	
1000-1007	185.42 LF OF 30" HDPP @ 0.50%	
1000-1001	45.21 LF OF 12" HDPP @ 1.00%	
1001-1005	28.61 LF OF 12" HDPP @ 3.75%	
1001-1002	60.86 LF OF 12" HDPP @ 1.00%	
1002-ID2	22.23 LF OF 12" HDPP @ 3.00%	
1002-ID1	18.72 LF OF 12" HDPP @ 3.00%	
1002-1003	84.59 LF OF 12" HDPP @ 1.00%	
1003-1004	72.02 LF OF 12" HDPP @ 1.00%	
1005-FS4	11.57 LF OF 6" HDPE @ 3.00%	
1005-1009	35.83 LF OF 12" HDPP @ 3.00%	
1005-1006	13.75 LF OF 12" HDPP @ 2.00%	
1006-ID3	28.17 LF OF 12" HDPP @ 2.00%	
1007-1008	41.14 LF OF 24" HDPP @ 0.70%	
1009-RD	72.89 LF OF 6" HDPE @ 1.00%	

STORMWATER PIPE & STRUCTURE TABLE NOTES:

- * LENGTH OF PIPE AND SLOPE SHOWN EXCLUDE VERTICAL PORTION OF INLINE DRAIN.
- ** EXISTING INCOMING OR OUTGOING PIPES TO REMAIN ARE NOT SHOWN IN TABLE FOR CLARITY. CONTRACTOR TO PLUG AND GROUT EXISTING PENETRATIONS IN STRUCTURE NO LONGER REQUIRED PER CITY OF LEE'S SUMMIT STANDARDS.

STORMWATER STRUCTURE TABLE					
STRUCTURE NAME	GRATE / RIM ELEVATION	PIPES IN	PIPES OUT	CL NORTHING & EASTING	NOTES
1000.MH	909.53	1000-1001, 12" INV IN =900.63 1000-1007, 30" INV IN =900.33	EX MH-1000, 36" INV OUT =900.13	N: 1032977.32 E: 2830362.52	STANDARD PRECAST MANHOLE REF: 3-4 / C-530 & 3 / C-540
1001.MH	908.94	1001-1002, 12" INV IN =901.28 1001-1005, 12" INV IN =901.58	1000-1001, 12" INV OUT =901.08	N: 1032931.67 E: 2830342.87	STANDARD PRECAST MANHOLE REF: 3-4 / C-530 & 3 / C-540
1002.CI	910.75	1002-1003, 12" INV IN =902.39	1001-1002, 12" INV OUT =901.89	N: 1032868.61 E: 2830332.81	2'X3' CURB INLET REF: 1-2 / C-531 & 2 / C-532
1003.CI	908.71	1003-1004, 12" INV IN =903.74	1002-1003, 12" INV OUT =903.24	N: 1032845.41 E: 2830249.41	2'X3' CURB INLET REF: 1-2 / C-531 & 2 / C-532
1004.AI	907.39		1003-1004, 12" INV OUT =904.46	N: 1032866.83 E: 2830178.44	STANDARD DOUBLE GRATE INLET REF: 5 / C-530
1005.AI	908.15	1005-1006, 12" INV IN =903.15 1005-1009, 12" INV IN =903.25	1001-1005, 12" INV OUT =902.65	N: 1032940.69 E: 2830312.07	STANDARD DOUBLE GRATE INLET REF: 5 / C-530
1006.AI	908.15	1006-ID3, 12" INV IN =903.62	1005-1006, 12" INV OUT =903.42	N: 1032925.34 E: 2830307.57	STANDARD DOUBLE GRATE INLET REF: 5 / C-530
1007.CI	905.98	1007-1008, 24" INV IN =901.56	1000-1007, 30" INV OUT =901.26	N: 1033029.98 E: 2830180.60	STANDARD CURB INLET REF: 1, 3, & 4 / C-530
1008.JB	906.54	1007-1008, 24" INV OUT =901.85		N: 1032984.96 E: 2830168.78	CONVERT CI TO JUNCTION BOX** REF: 2-4 / C-530 & 4 / C-532
1009.AI	908.50	1009-RD, 6" INV IN =904.82	1005-1009, 12" INV OUT =904.32	N: 1032977.32 E: 2830320.93	18" DRAIN BASIN & STANDARD GRATE REF: 1, 4 / C-531 & 4 / C-532
EX MH	908.59	EX MH-1000, 36" INV IN =899.37		N: 1032970.53 E: 2830516.95	EXISTING MANHOLE**





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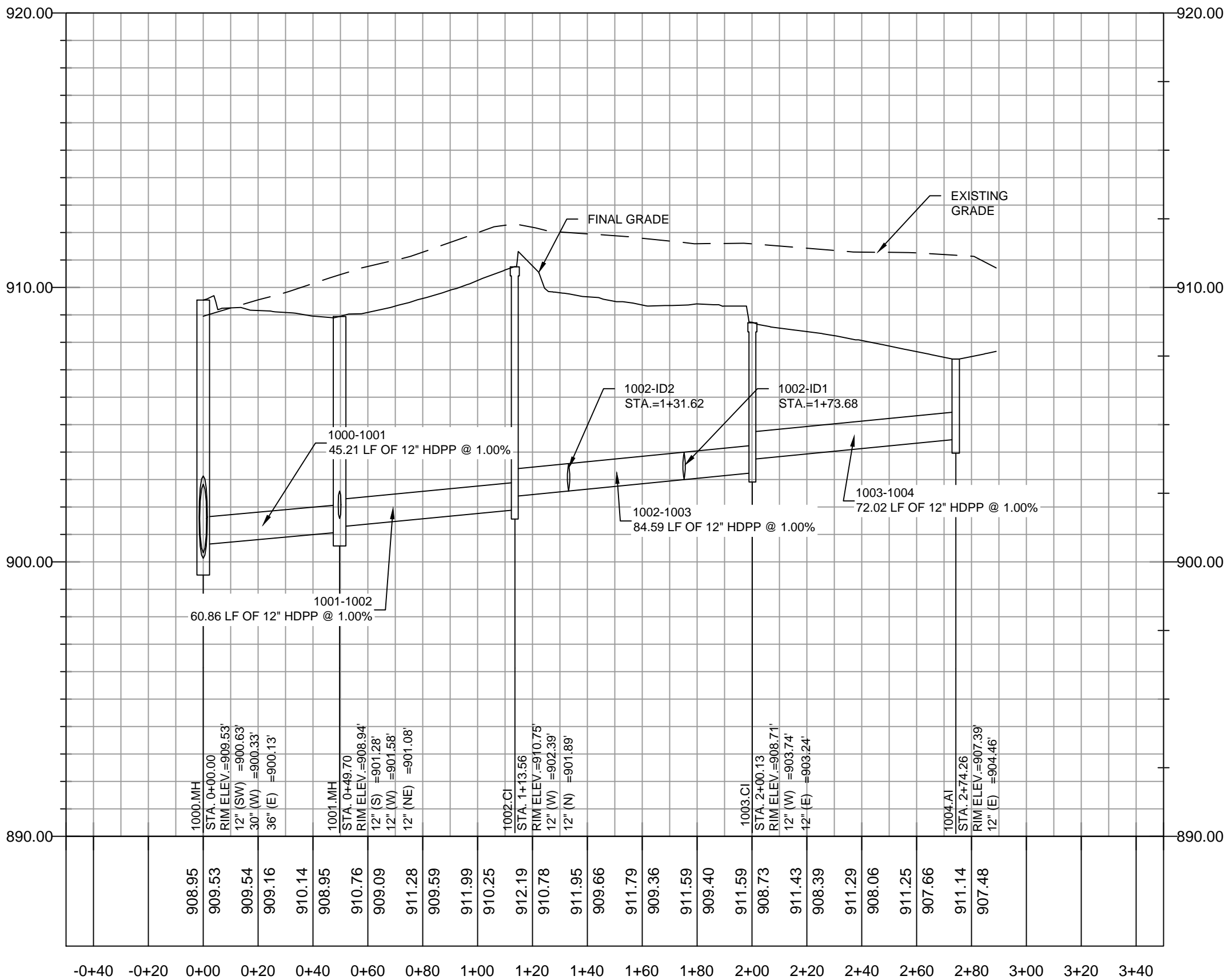
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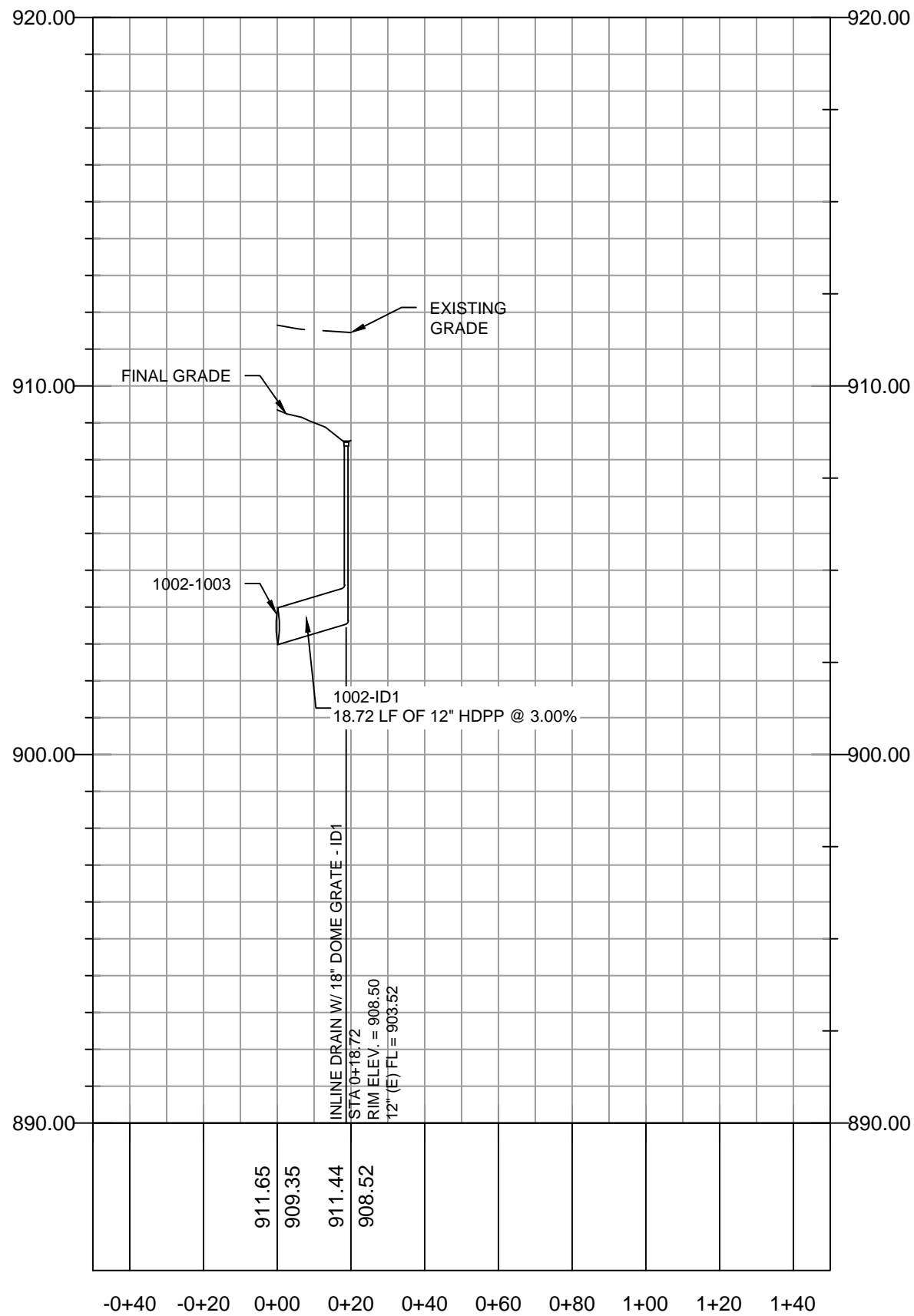
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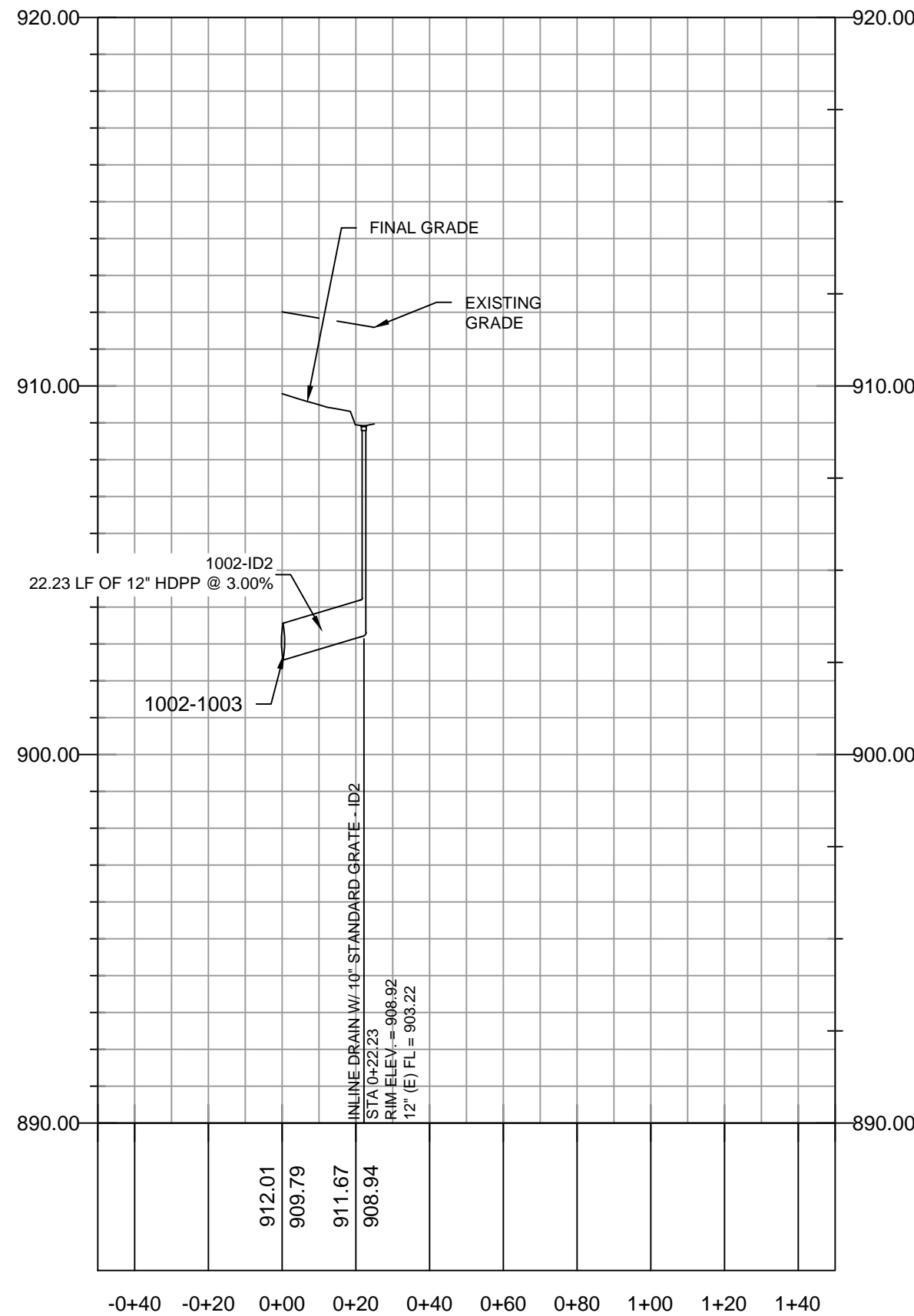
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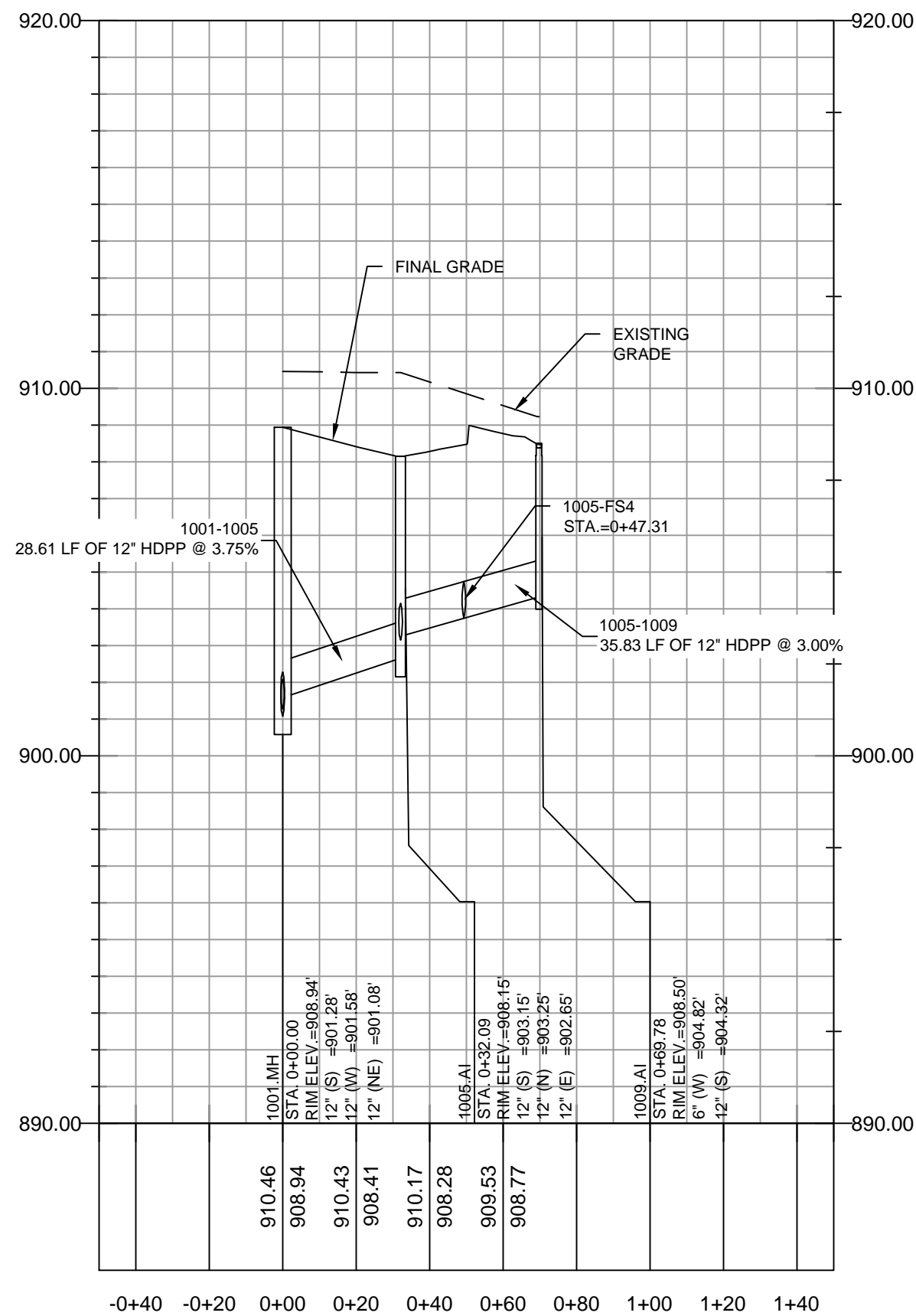
1 1000.MH - 10004.AI STORMWATER PROFILE
SCALE: HORIZONTAL 1"=40' SCALE: VERTICAL 1"=4'



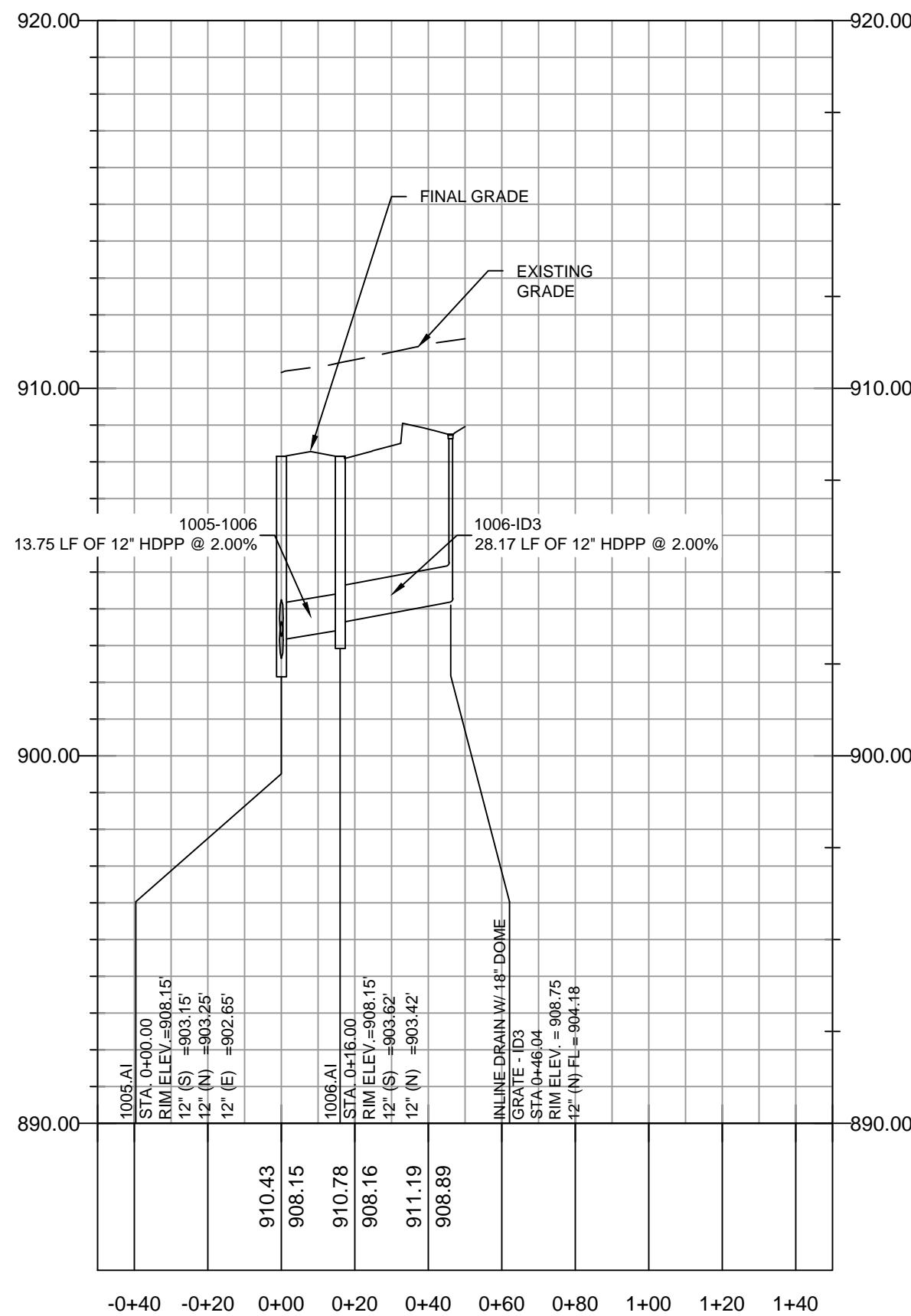
2 PIPE 1002-1003 - INLINE DRAIN 1
SCALE: HORIZONTAL 1"=40' SCALE: VERTICAL 1"=4'



3 PIPE 1002-1003 - INLINE DRAIN 2
SCALE: HORIZONTAL 1"=40' SCALE: VERTICAL 1"=4'



4 1001.MH - 1009.AI
SCALE: HORIZONTAL 1"=40' SCALE: VERTICAL 1"=4'



5 1005.AI - INLINE DRAIN 3
SCALE: HORIZONTAL 1"=40' SCALE: VERTICAL 1"=4'

GENERAL NOTES:

- SEE DRAWING C-104 FOR GENERAL NOTES APPLICABLE TO THIS DRAWING.
- ALL STORMWATER STRUCTURES AND PIPES SHOWN ON THIS DRAWING ARE PRIVATE, UNLESS NOTED OTHERWISE.



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FIRE STATION #4
CITY OF LEE'S SUMMIT
5031 NORTHEAST LAKEWOOD WAY
LEE'S SUMMIT, MISSOURI 64064

#	Description	Date
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DERICK HOLMES - CIVIL ENGINEER
MOR PE-2022005196

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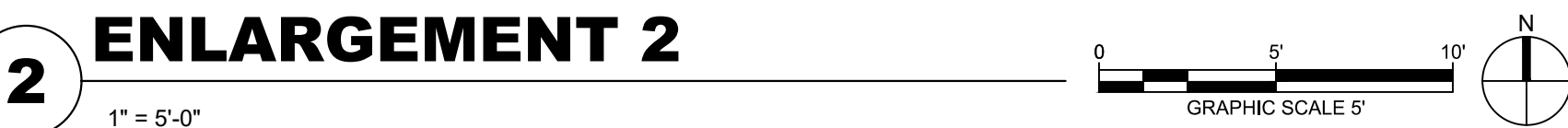
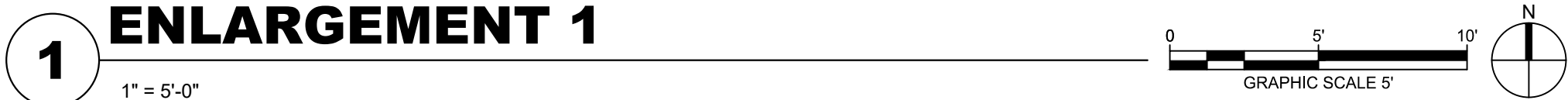
**PRIVATE
STORMWATER
PROFILES**

C-231

1. SEE DRAWING C-104 FOR GENERAL GRADING & DRAINAGE NOTES APPLICABLE TO THIS DRAWING.

1. SEE DRAWING C-104 FOR GENERAL ADA NOTES APPLICABLE TO THIS DRAWING

G1	NOT USED
G2	START TRANSITION FROM FULL-DEPTH CURB
G3	FLUSH CURB
G4	4" CURB
G5	INLINE DRAIN WITH 18" DOME GRATE. REF: C-231 & C-532
G6	INLINE DRAIN WITH 10" STANDARD GRATE. REF: C-231, C-531, AND C-532
G7	FINISH GRADE AT DOORS SET $\frac{3}{4}$ " BELOW FINISH FLOOR ELEVATIONS TO ACCOUNT FOR THRESHOLDS



APPENDIX B

STORMWATER ANALYSIS

APPENDIX B.1

POST-DEVELOPMENT DRAINAGE MAPS

D

C

B

A

GRADING & DRAINAGE PLAN

1" = 20'-0"

LEGEND

IMPERVIOUS SURFACE

TURFED SURFACES

SCS Unit Hydrograph Method, Curve Number				
Catchment Number	Total Area (ft ²)	Impervious Area C = 98 (ft ²)	Turfed Area C = 74 (ft ²)	Composite Curve Number
Post-Development				
ID.1	1885.56	377.90	1507.66	78.8
ID.2	398.97	398.97	0.00	98.0
ID.3	1806.92	647.32	1159.60	82.6
ID.4	1070.79	518.78	552.01	85.6
1002.CI	596.05	512.13	83.92	94.6
1003.CI	5893.44	3935.68	1957.76	90.0
1004.AI	12323.06	6894.18	5428.88	87.4
1005.AI	2718.33	2539.37	178.96	96.4
1006.AI	3301.67	2829.15	142.63	87.2
1007.CI	13887.57	9046.14	4841.43	89.6
FIRE STATION 4	8046.29	8046.29	0.00	98.0

GRADING & DRAINAGE KEYNOTES

- G1
- TRANSITION FROM 6" CURB TO FLUSH CURB.
- G2
- FLUSH CURB.
- G3
- 4" CURB.
- G4
- INLINE DRAIN WITH 18" DOME GRATE.
-
- REF: C-532
- G5
- INLINE DRAIN WITH 10" STANDARD GRATE.
-
- REF: C-531 AND C-532
- G6
- INLINE DRAIN WITH 18" STANDARD GRATE.
-
- REF: C-531 AND C-532
- G7
- (+/-) MATCH EXISTING ELEVATION. NOTIFY ENGINEER IF
-
- SIGNIFICANT DISCREPANCY EXISTS.

LEGEND

1289.00

SPOT ELEVATION

MEE

MATCH EXISTING ELEVATION

1289.00

TOP OF CURB ELEVATION

1289.00

TOP OF RETAINING WALL

1279.00

BOTTOM OF RETAINING WALL

430

PROPOSED MAJOR CONTOUR

429

PROPOSED MINOR CONTOUR

430

EXISTING CONTOUR

430

FLOWLINE ARROW

PROPOSED STORM SEWER

PROPOSED STORM SEWER

PROPOSED CURB INLET

PROPOSED CURB INLET

PROPOSED STORMWATER MANHOLE

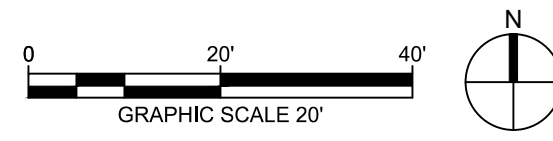
PROPOSED STORMWATER MANHOLE

PROPOSED AREA INLET

PROPOSED AREA INLET

STORMWATER PIPE TABLE			
NAME	SIZE	3D LENGTH, SLOPE, & MATERIAL	
EX MH-1000	36"	150.24 LF @ 0.50%, HDPP	
1000-1007	36"	188.02 LF @ 0.50%, HDPP	
1000-1001	12"	46.18 LF @ 1.00%, HDPP	
1001-1005	12"	28.61 LF @ 3.75%, HDPP	
1001-1002	12"	60.86 LF @ 1.00%, HDPP	
1002-ID2	12"	22.00 LF @ 3.00%, HDPP	
1002-ID1	12"	17.89 LF @ 3.00%, HDPP	
1002-1003	12"	84.59 LF @ 1.00%, HDPP	
1003-1004	12"	74.52 LF @ 1.00%, HDPP	
1005-FS4	6"	11.57 LF @ 3.00%, HDPP	
1005-ID	12"	35.83 LF @ 3.00%, HDPP	
1005-1006	12"	13.75 LF @ 2.00%, HDPP	
1006-ID	12"	28.17 LF @ 2.00%, HDPP	
1007-1008	24"	41.14 LF @ 0.50%, HDPP	

- * LENGTH OF PIPE AND SLOPE SHOWN EXCLUDE VERTICAL
PORTION OR INLINE DRAIN.
- ** EXISTING INCOMING OR OUTGOING PIPES TO REMAIN ARE
NOT SHOWN IN TABLE FOR CLARITY. CONTRACTOR TO
PLUG AND GROUT EXISTING PENETRATIONS IN
STRUCTURE NO LONGER REQUIRED PER CITY OF LEE'S
SUMMIT STANDARDS.



GENERAL GRADING NOTES:

1. CONTRACTOR SHALL OBTAIN A COPY OF THE GEOTECHNICAL REPORT
BEFORE STARTING CONSTRUCTION.
2. ALL PROPOSED CONTOUR LINES AND SPOT ELEVATIONS SHOWN ARE FINISH
GROUND ELEVATIONS. CONTRACTOR SHALL ACCOUNT FOR PAVEMENT
DEPTHS, BUILDING PADS, TOPSOIL, ETC. WHEN GRADING THE SITE.
3. ALL DISTURBED AREAS THAT ARE NOT TO BE PAVED (GREEN SPACES)
SHALL BE FINISH GRADED WITH A MINIMUM OF SIX INCHES OF TOPSOIL.
4. ALL EXCAVATIONS AND EMBANKMENTS SHALL COMPLY WITH THE
RECOMMENDATIONS PROVIDED BY THE GEOTECHNICAL ENGINEER.
5. FINISHED GRADES SHALL NOT BE STEEPER THAN 3:1, UNLESS NOTED
OTHERWISE ON THE PLANS.
6. ALL SITE WORK FOR THIS PROJECT IS CONSIDERED "UNCLASSIFIED". THE
TERM "UNCLASSIFIED" EXCAVATION SHALL BE DEFINED AS MEANING THE
CONTRACTOR BEARS THE ENTIRE RISK OF THE SOIL QUANTITIES AND/OR
TYPE (E.G. ROCK, CLAY, PEAT, SILT, SHALE, ETC.) ENCOUNTERED EITHER
ABOVE OR BELOW PROPOSED SUBGRADES. IN THE EVENT IT BECOMES
NECESSARY FOR UNSUITABLE SOIL TO BE HANDLED, REMOVED FROM THE
SITE, OR FOR SUITABLE MATERIAL TO BE IMPORTED TO THE SITE, THE
CONTRACTOR SHALL BEAR THE ENTIRE COST OF SUCH ADDITIONAL WORK.
"UNUSABLE" SOIL ALSO INCLUDES SATURATED SOILS THAT MAY NEED
REPLACING AND/OR TREATING IN ORDER TO MEET SCHEDULE DATES. THIS
DEFINITION OF "UNCLASSIFIED" SUPERCEDES ANY CONTRARY DEFINITIONS
OR STATEMENTS WHICH MAY BE CONTAINED IN SPECIFICATIONS, PLANS, OR
OTHER DOCUMENTS.
7. CONTRACTOR SHALL FIELD VERIFY ALL EXISTING ELEVATIONS OF
CONNECTION POINTS AS SHOWN ON GRADING PLANS. NOTIFY ENGINEER IF
DISCREPANCY EXISTS FOR DIRECTION.
8. ALL GRADES SHALL BE CONTOURED SMOOTHLY WITH GENTLE
ROUNDING/SHAPING OF ALL AFFECTED LAND SURFACES. ABRUPT
TRANSITIONS AT THE TOP OF SLOPES WHERE PROPOSED GRADES MEET
EXISTING ARE NOT ACCEPTABLE. GRADING SHALL BE APPROVED BY THE
OWNER'S REPRESENTATIVE PRIOR TO THE ADDITION OF THE TOPSOIL
LAYER.

ADA NOTES

1. ANY AND ALL NEW SITE "ADA" FEATURES SHALL BE BUILT IN COMPLIANCE
TO CURRENT FEDERAL, STATE, AND LOCAL ACCESSIBILITY RULES AND
REGULATIONS. THE CONTRACTOR SHALL BE RESPONSIBLE TO KNOW AND
UNDERSTAND ALL CURRENT ACCESSIBILITY REGULATIONS AS THEY
PERTAIN TO THE CONSTRUCTION OF ACCESSIBLE SITE FEATURES.
2. ALL NEW CONCRETE SIDEWALK PAVEMENT SHALL BE INSTALLED WITH A
MAXIMUM 5% RUNNING SLOPE AND A MAXIMUM 2% CROSS SLOPE.
3. SURFACES OF ALL NEW CONCRETE PAVEMENT PATHWAYS SHALL BE
SMOOTH AND EVEN WITH NO ABRUPT CHANGES IN ELEVATION OF 1/4" OR
GREATER AS REQUIRED BY THE ACCESSIBILITY DESIGN REGULATIONS.

STORMWATER STRUCTURE TABLE					
STRUCTURE NAME	GRATE / RIM ELEVATION	PIPES IN	PIPES OUT	CL NORTHING & EASTING	NOTES
1000.MH	909.18	1000-1001, 12" INV IN =900.62 1000-1007, 36" INV IN =900.32	EX MH-1000, 36" INV OUT =900.12	N: 1032977.21 E: 2830365.11	STANDARD PRECAST MANHOLE REF: DETAIL 3/C-540
1001.MH	908.99	1001-1002, 12" INV IN =901.28 1001-1005, 12" INV IN =901.58	1000-1001, 12" INV OUT =901.08	N: 1032931.67 E: 2830342.87	STANDARD PRECAST MANHOLE REF: DETAIL 3/C-540
1002.CI	910.80	1002-1003, 12" INV IN =902.39	1001-1002, 12" INV OUT =901.89	N: 1032868.61 E: 2830332.81	2'x3' CURB INLET REF: DETAIL 2/C-532
1003.CI	908.76	1003-1004, 12" INV IN =903.74	1002-1003, 12" INV OUT =903.24	N: 1032845.41 E: 2830249.41	2'x3' CURB INLET REF: DETAIL 2/C-532
1004.AI	907.40		1003-1004, 12" INV OUT =904.49	N: 1032867.55 E: 2830176.04	STANDARD DOUBLE GRATE INLET REF: DETAIL 5/C-530
1005.AI	908.20	1005-1006, 12" INV IN =903.15 1005-ID, 12" INV IN =903.25	1001-1005, 12" INV OUT =902.65	N: 1032940.69 E: 2830312.07	STANDARD DOUBLE GRATE INLET REF: DETAIL 5/C-530
1006.AI	908.13	1006-ID, 12" INV IN =903.62	1005-1006, 12" INV OUT =903.42	N: 1032925.34 E: 2830307.57	STANDARD DOUBLE GRATE INLET REF: DETAIL 5/C-530
1007.CI	906.56	1007-1008, 24" INV IN =901.64	1000-1007, 36" INV OUT =901.26	N: 1033029.98 E: 2830180.60	STANDARD CURB INLET REF: DETAIL 1/C-530
1008.JB	906.49		1007-1008, 24" INV OUT =901.85	N: 1032984.96 E: 2830168.78	CONVERT CI TO JUNCTION BOX** REF: DETAIL 2/C-530
EX MH	908.59	EX MH-1000, 36" INV IN =899.37		N: 1032970.53 E: 2830516.95	EXISTING MANHOLE**

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CITY OF LEE'S SUMMIT

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100% DESIGN DEVELOPMENT DRAWINGS

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PROJECT NO: 18225R21001

DATE: 01.20.2022

DRAWN BY: DMH

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GRADING &
DRAINAGE PLAN

C-104

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APPENDIX B.2

1-YR, 24-HR STORM EVENT SSA REPORT

Project Description

File Name 18225R21001_FS4_R0_220112.SPF
Description Site_Design\Lakewood_FS4\Calculations\Stormwater\Working Files\Analysis\CAD
C:\Users\DERICK-1.HOL\AppData\Local\Temp\18225R21001_FS4_R0_220112_1_32208_2325f38b.sv\$

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 00:00:00 0:00:00
End Analysis On 00:00:00 0:00:00
Start Reporting On 00:00:00 0:00:00
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 5 seconds

Number of Elements

Qty
Rain Gages 1
Subbasins..... 11
Nodes..... 18
 Junctions 6
 Outfalls 2
 Flow Diversions 0
 Inlets 10
 Storage Nodes 0
Links..... 18
 Channels 2
 Pipes 16
 Pumps 0
 Orifices 0
 Weirs 0
 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
49		Time Series	100-YR, 24-HR	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	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	{Site 1}.1002	0.01	484.00	94.60	9.25	8.48	0.12	0.03	0 00:06:00
2	{Site 1}.1003	0.14	484.00	90.00	9.25	8.04	1.08	0.29	0 00:06:00
3	{Site 1}.1004	0.28	484.00	87.40	9.25	7.72	2.18	0.61	0 00:06:00
4	{Site 1}.1005	0.06	484.00	96.40	9.25	8.81	0.55	0.14	0 00:06:00
5	{Site 1}.1006	0.08	484.00	87.20	9.25	7.69	0.58	0.17	0 00:06:00
6	{Site 1}.1007	0.32	484.00	89.60	9.25	7.99	2.54	0.70	0 00:06:00
7	{Site 1}.1009.AI	0.03	484.00	85.60	9.25	7.46	0.19	0.05	0 00:06:00
8	{Site 1}.FS4	0.18	484.00	98.00	9.25	9.01	1.66	0.42	0 00:06:00
9	{Site 1}.ID.1	0.04	484.00	78.80	9.25	6.64	0.29	0.09	0 00:06:00
10	{Site 1}.ID.2	0.01	484.00	98.00	9.25	8.03	0.07	0.01	0 00:06:00
11	{Site 1}.ID.3	0.04	484.00	82.60	9.25	7.11	0.29	0.08	0 00:06:00

Node Summary

SN	Element ID	Element Type	Invert Elevation	Ground/Rim (Max) Elevation	Initial Water Elevation	Surcharge Elevation	Ponded Area	Peak Inflow	Max HGL Elevation Attained	Max Surcharge Depth Attained	Min Freeboard Attained	Time of Peak Flooding Occurrence	Total Flooded Volume	Total Time Flooded
			(ft)	(ft)	(ft)	(ft)	(ft²)	(cfs)	(ft)	(ft)	(ft)	(days hh:mm)	(ac-in)	(min)
1	1000.MH	Junction	900.13	909.53	900.13	909.53	0.00	2.60	901.08	0.00	8.45	0 00:00	0.00	0.00
2	1001.MH	Junction	901.08	908.94	901.08	908.94	0.00	1.89	901.79	0.00	7.15	0 00:00	0.00	0.00
3	1008.JB	Junction	901.85	906.54	901.85	906.54	10.00	0.00	901.85	0.00	4.69	0 00:00	0.00	0.00
4	ELBOW.1	Junction	902.98	902.98	902.98	902.98	0.00	0.99	903.29	0.00	0.69	0 00:00	0.00	0.00
5	ELBOW.2	Junction	902.56	902.56	902.56	902.56	0.00	1.00	902.88	0.00	0.68	0 00:00	0.00	0.00
6	EX.MH	Junction	898.84	908.59	898.84	908.59	0.00	2.60	899.79	0.00	8.80	0 00:00	0.00	0.00
7	Out-01	Outfall	898.37					2.63	898.76					
8	Out-02	Outfall	0.00					0.00	901.46					

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Diameter or Height (in)	Manning's Roughness	Peak Flow (cfs)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Reported Surcharged (min)	Condition
1	1000-1001	Pipe	1001.MH	1000.MH	45.21	901.08	900.63	1.0000	12.000	0.0100	1.89	4.62	0.41	5.59	0.45	0.45	0.00	Calculated
2	1000-1007	Pipe	1007.CI	1000.MH	185.42	901.26	900.33	0.5000	30.000	0.0100	0.70	37.76	0.02	3.01	0.24	0.09	0.00	Calculated
3	1001-1002	Pipe	1002.CI	1001.MH	60.86	901.89	901.28	1.0000	12.000	0.0100	1.03	4.64	0.22	4.76	0.32	0.32	0.00	Calculated
4	1001-1005	Pipe	1005.AI	1001.MH	28.61	902.65	901.58	3.7400	12.000	0.0100	0.86	8.96	0.10	7.22	0.21	0.21	0.00	Calculated
5	1002-1003-A	Pipe	1003.CI	ELBOW.1	25.39	903.24	902.98	1.0200	12.000	0.0100	0.90	4.69	0.19	4.61	0.30	0.30	0.00	Calculated
6	1002-1003-B	Pipe	ELBOW.1	ELBOW.2	41.98	902.98	902.56	1.0000	12.000	0.0100	0.99	4.63	0.21	4.70	0.31	0.31	0.00	Calculated
7	1002-1003-C	Pipe	ELBOW.2	1002.CI	17.22	902.56	902.39	0.9900	12.000	0.0100	1.00	4.60	0.22	4.69	0.32	0.32	0.00	Calculated
8	1002-ID1	Pipe	ID1	ELBOW.1	18.72	903.52	902.98	2.8800	12.000	0.0100	0.09	7.87	0.01	3.34	0.08	0.08	0.00	Calculated
9	1002-ID2	Pipe	ID2	ELBOW.2	22.23	903.22	902.56	2.9700	12.000	0.0100	0.01	7.98	0.00	1.92	0.03	0.03	0.00	Calculated
10	1003-1004	Pipe	1004.AI	1003.CI	72.02	904.49	903.74	1.0400	12.000	0.0100	0.61	4.73	0.13	4.16	0.24	0.24	0.00	Calculated
11	1005-1006	Pipe	1006.AI	1005.AI	13.75	903.42	903.15	1.9600	12.000	0.0100	0.25	6.49	0.04	3.98	0.13	0.13	0.00	Calculated
12	1005-1009	Pipe	1009.AI	1005.AI	35.83	904.32	903.25	2.9900	12.000	0.0100	0.47	8.00	0.06	5.58	0.16	0.16	0.00	Calculated
13	1006-ID	Pipe	ID3	1006.AI	28.17	904.18	903.62	1.9900	12.000	0.0100	0.08	6.53	0.01	2.84	0.08	0.08	0.00	Calculated
14	1007-1008	Pipe	1008.JB	1007.CI	41.14	901.85	901.56	0.7000	24.000	0.0100	0.00	24.69	0.00	0.00	0.00	0.00	0.00	Calculated
15	EP1	Pipe	EX.MH	Out-01	18.25	898.84	898.37	2.5800	42.000	0.0210	2.63	99.95	0.03	4.50	0.40	0.11	0.00	Calculated
16	EX.MH-1000	Pipe	1000.MH	EX.MH	154.58	900.13	899.37	0.4900	36.000	0.0100	2.60	60.80	0.04	4.32	0.42	0.14	0.00	Calculated
17	BP_1006-1002	Channel	1002.CI	1006.AI	66.85	910.80	908.13	3.9900	6.000	0.0170	0.00	6.73	0.00	1.11	0.03	0.07	0.00	
18	BP_1007-Out-02	Channel	1007.CI	Out-02	10.00	905.98	901.46	45.2000	6.000	0.0320	0.00	12.14	0.00	0.00	0.00	0.00	0.00	

Inlet Summary

SN	Element	Inlet ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation	Max (Rim) Elevation	Initial Water Elevation	Ponded Area	Peak Flow	Peak Flow Intercepted by Inlet	Peak Flow Bypassing Inlet	Inlet Efficiency during Peak Flow	Allowable Spread	Max Gutter Spread during Peak Flow	Max Gutter Water Elev. during Peak Flow
							(ft)	(ft)	(ft)	(ft²)	(cfs)	(cfs)	(cfs)	(%)	(ft)	(ft)	(ft)
1	1002.CI		FHWA HEC-22 GENERIC	N/A	On Grade	1	901.89	910.75	0.00	N/A	0.03	0.00	0.00	0.00	7.00	0.84	910.79
2	1003.CI		FHWA HEC-22 GENERIC	N/A	On Sag	1	903.24	908.71	0.00	10.00	0.29	N/A	N/A	N/A	7.00	1.98	908.79
3	1004.AI		FHWA HEC-22 GENERIC	N/A	On Sag	1	904.39	907.46	0.00	10.00	0.61	N/A	N/A	N/A	7.00	5.54	907.66
4	1005.AI		NEENAH FOUNDRY	R-3338-G	On Sag	1	902.65	908.15	0.00	10.00	0.14	N/A	N/A	N/A	7.00	0.00	908.18
5	1006.AI		NEENAH FOUNDRY	R-3338-G	On Sag	1	903.42	908.15	0.00	10.00	0.17	N/A	N/A	N/A	7.00	0.00	908.18
6	1007.CI		FHWA HEC-22 GENERIC	N/A	On Grade	1	901.26	905.98	0.00	N/A	0.70	0.70	0.00	100.00	7.00	6.10	906.14
7	1009.AI		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.32	908.50	0.00	10.00	0.47	N/A	N/A	N/A	7.00	5.07	908.60
8	ID1		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.52	908.50	0.00	10.00	0.09	N/A	N/A	N/A	7.00	1.32	908.53
9	ID2		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.22	908.92	0.00	10.00	0.01	N/A	N/A	N/A	7.00	0.39	908.93
10	ID3		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.18	908.75	0.00	10.00	0.08	N/A	N/A	N/A	7.00	1.18	908.77

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 (ft²)	Minimum Pipe Cover (in)
1	1000.MH	900.13	909.53	9.40	900.13	0.00	909.53	0.00	0.00	76.80
2	1001.MH	901.08	908.94	7.86	901.08	0.00	908.94	0.00	0.00	76.32
3	1008.JB	901.85	906.54	4.69	901.85	0.00	906.54	0.00	10.00	32.28
4	ELBOW.1	902.98	902.98	0.00	902.98	0.00	902.98	0.00	0.00	0.00
5	ELBOW.2	902.56	902.56	0.00	902.56	0.00	902.56	0.00	0.00	0.00
6	EX.MH	898.84	908.59	9.75	898.84	0.00	908.59	0.00	0.00	74.64

Junction Results

SN	Element ID	Peak Inflow	Peak Lateral Inflow	Max HGL Elevation Attained	Max HGL Depth Attained	Max Surcharge Depth Attained	Min Freeboard Attained	Average HGL Elevation Attained	Average HGL Depth Attained	Time of Max HGL Occurrence	Time of Peak Flooding Occurrence	Total Flooded Volume	Total Time Flooded
		(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(days hh:mm)	(days hh:mm)	(ac-in)	(min)
1	1000.MH	2.60	0.00	901.08	0.95	0.00	8.45	900.77	0.64	0 12:05	0 00:00	0.00	0.00
2	1001.MH	1.89	0.00	901.79	0.71	0.00	7.15	901.65	0.57	0 12:05	0 00:00	0.00	0.00
3	1008.JB	0.00	0.00	901.85	0.00	0.00	4.69	901.85	0.00	0 00:00	0 00:00	0.00	0.00
4	ELBOW.1	0.99	0.00	903.29	0.31	0.00	0.69	903.08	0.10	0 12:05	0 00:00	0.00	0.00
5	ELBOW.2	1.00	0.00	902.88	0.32	0.00	0.68	902.66	0.10	0 12:05	0 00:00	0.00	0.00
6	EX.MH	2.60	0.00	899.79	0.95	0.00	8.80	899.51	0.67	0 12:05	0 00:00	0.00	0.00

Channel Input

SN	Element ID	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Total Drop	Average Slope	Shape	Height	Width	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow	Flap Gate
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(%)		(ft)	(ft)					(cfs)	
1	BP_1006-1002	66.85	910.80	8.91	908.13	4.71	2.67	3.9900	Triangular	0.500	4.000	0.0170	0.5000	0.5000	0.0000	0.00	No
2	BP_1007-Out-02	10.00	905.98	4.72	901.46	901.46	4.52	45.2000	Triangular	0.500	4.000	0.0320	0.5000	0.5000	0.0000	0.00	No

Channel Results

SN	Element ID	Peak Flow	Time of Peak Flow Occurrence	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Travel Time	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Froude Number	Reported Condition
		(cfs)	(days hh:mm)	(cfs)		(ft/sec)	(min)	(ft)		(min)		
1	BP_1006-1002	0.00	0 12:05	6.73	0.00	1.11	1.00	0.03	0.07	0.00		
2	BP_1007-Out-02	0.00	0 00:00	12.14	0.00	0.00		0.00	0.00	0.00		

Pipe Input

SN Element ID	Length	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Average Slope (%)	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	No. of Barrels
1 1000-1001	45.21	901.08	0.00	900.63	0.50	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
2 1000-1007	185.42	901.26	0.00	900.33	0.20	0.5000	30.000	30.000	0.0100	0.5000	0.4000	0.0000	0.00	1
3 1001-1002	60.86	901.89	0.00	901.28	0.20	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
4 1001-1005	28.61	902.65	0.00	901.58	0.50	3.7400	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
5 1002-1003-A	25.39	903.24	0.00	902.98	0.00	1.0200	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
6 1002-1003-B	41.98	902.98	0.00	902.56	0.00	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
7 1002-1003-C	17.22	902.56	0.00	902.39	0.50	0.9900	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
8 1002-ID1	18.72	903.52	0.00	902.98	0.00	2.8800	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
9 1002-ID2	22.23	903.22	0.00	902.56	0.00	2.9700	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
10 1003-1004	72.02	904.49	0.10	903.74	0.50	1.0400	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
11 1005-1006	13.75	903.42	0.00	903.15	0.50	1.9600	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
12 1005-1009	35.83	904.32	0.00	903.25	0.60	2.9900	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
13 1006-ID	28.17	904.18	0.00	903.62	0.20	1.9900	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
14 1007-1008	41.14	901.85	0.00	901.56	0.30	0.7000	24.000	24.000	0.0100	0.5000	0.4000	0.0000	0.00	1
15 EP1	18.25	898.84	0.00	898.37	0.00	2.5800	42.000	42.000	0.0210	0.5000	0.4000	0.0000	0.00	1
16 EX.MH-1000	154.58	900.13	0.00	899.37	0.53	0.4900	36.000	36.000	0.0100	0.5000	0.4000	0.0000	0.00	1

Pipe Results

SN Element ID	Peak Flow	Time of Peak Flow Occurrence	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Travel Time	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Froude Number	Reported Condition
	(cfs)	(days hh:mm)	(cfs)		(ft/sec)	(min)	(ft)		(min)		
1 1000-1001	1.89	0 12:05	4.62	0.41	5.59	0.13	0.45	0.45	0.00		Calculated
2 1000-1007	0.70	0 12:05	37.76	0.02	3.01	1.03	0.24	0.09	0.00		Calculated
3 1001-1002	1.03	0 12:05	4.64	0.22	4.76	0.21	0.32	0.32	0.00		Calculated
4 1001-1005	0.86	0 12:05	8.96	0.10	7.22	0.07	0.21	0.21	0.00		Calculated
5 1002-1003-A	0.90	0 12:05	4.69	0.19	4.61	0.09	0.30	0.30	0.00		Calculated
6 1002-1003-B	0.99	0 12:05	4.63	0.21	4.70	0.15	0.31	0.31	0.00		Calculated
7 1002-1003-C	1.00	0 12:05	4.60	0.22	4.69	0.06	0.32	0.32	0.00		Calculated
8 1002-ID1	0.09	0 12:05	7.87	0.01	3.34	0.09	0.08	0.08	0.00		Calculated
9 1002-ID2	0.01	0 10:15	7.98	0.00	1.92	0.19	0.03	0.03	0.00		Calculated
10 1003-1004	0.61	0 12:05	4.73	0.13	4.16	0.29	0.24	0.24	0.00		Calculated
11 1005-1006	0.25	0 12:05	6.49	0.04	3.98	0.06	0.13	0.13	0.00		Calculated
12 1005-1009	0.47	0 11:40	8.00	0.06	5.58	0.11	0.16	0.16	0.00		Calculated
13 1006-ID	0.08	0 12:05	6.53	0.01	2.84	0.17	0.08	0.08	0.00		Calculated
14 1007-1008	0.00	0 00:00	24.69	0.00	0.00		0.00	0.00	0.00		Calculated
15 EP1	2.63	0 11:35	99.95	0.03	4.50	0.07	0.40	0.11	0.00		Calculated
16 EX.MH-1000	2.60	0 12:05	60.80	0.04	4.32	0.60	0.42	0.14	0.00		Calculated

Inlet Input

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Inlet Depth (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Ponded Area (ft ²)	Grate Clogging Factor (%)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	901.89	910.75	8.86	0.00	0.00	N/A	0.00
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Sag	1	903.24	908.71	5.47	0.00	0.00	10.00	0.00
3	1004.AI	FHWA HEC-22 GENERIC	N/A	On Sag	1	904.39	907.46	3.07	0.00	0.00	10.00	0.00
4	1005.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	902.65	908.15	5.50	0.00	0.00	10.00	0.00
5	1006.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	903.42	908.15	4.73	0.00	0.00	10.00	0.00
6	1007.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	901.26	905.98	4.72	0.00	0.00	N/A	0.00
7	1009.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.32	908.50	4.18	0.00	0.00	10.00	0.00
8	ID1	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.52	908.50	4.98	0.00	0.00	10.00	0.00
9	ID2	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.22	908.92	5.70	0.00	0.00	10.00	0.00
10	ID3	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.18	908.75	4.57	0.00	0.00	10.00	0.00

Roadway & Gutter Input

SN	Element ID	Roadway Longitudinal Slope (ft/ft)	Roadway Cross Slope (ft/ft)	Roadway Manning's Roughness	Gutter Cross Slope (ft/ft)	Gutter Width (ft)	Gutter Depression (in)	Allowable Spread (ft)
1	1002.Cl	0.0396	0.0200	0.0170	0.0521	1.33	0.0272	7.00
2	1003.Cl	N/A	0.0200	0.0170	0.0521	1.33	0.0272	7.00
3	1004.Al	N/A	0.0200	0.0170	0.0521	1.33	0.0656	7.00
4	1005.Al	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
5	1006.Al	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
6	1007.Cl	0.0100	0.0200	0.0170	0.0521	1.33	0.2051	7.00
7	1009.Al	N/A	0.0200					
8	ID1	N/A	0.0200					
9	ID2	N/A	0.0200					
10	ID3	N/A	0.0200					

Inlet Results

SN	Element ID	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Peak Flow Intercepted (cfs)	Peak Flow Bypassing (cfs)	Inlet Efficiency during Peak Flow (%)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1002.CI	0.03	0.03	0.00	0.00	0.00	0.84	910.79	0.04	0 12:05	0.00	0.00
2	1003.CI	0.29	0.29	N/A	N/A	N/A	1.98	908.79	0.08	0 12:05	0.00	0.00
3	1004.AI	0.61	0.61	N/A	N/A	N/A	5.54	907.66	0.20	0 12:05	0.00	0.00
4	1005.AI	0.14	0.14	N/A	N/A	N/A	0.00	908.18	0.03	0 11:40	0.00	0.00
5	1006.AI	0.17	0.17	N/A	N/A	N/A	0.00	908.18	0.03	0 10:07	0.00	0.00
6	1007.CI	0.70	0.70	0.70	0.00	100.00	6.10	906.14	0.16	0 00:00	0.00	0.00
7	1009.AI	0.47	0.47	N/A	N/A	N/A	5.07	908.60	0.10	0 11:40	0.00	0.00
8	ID1	0.09	0.09	N/A	N/A	N/A	1.32	908.53	0.03	0 12:05	0.00	0.00
9	ID2	0.01	0.01	N/A	N/A	N/A	0.39	908.93	0.01	0 10:15	0.00	0.00
10	ID3	0.08	0.08	N/A	N/A	N/A	1.18	908.77	0.02	0 12:05	0.00	0.00

APPENDIX B.3

10-YR, 24-HR STORM EVENT SSA REPORT

Project Description

File Name 18225R21001_FS4_R0_220112.SPF
Description Site_Design\Lakewood_FS4\Calculations\Stormwater\Working Files\Analysis\CAD
C:\Users\DERICK-1.HOL\AppData\Local\Temp\18225R21001_FS4_R0_220112_1_32208_2325f38b.sv\$

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 00:00:00 0:00:00
End Analysis On 00:00:00 0:00:00
Start Reporting On 00:00:00 0:00:00
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 5 seconds

Number of Elements

Qty
Rain Gages 1
Subbasins..... 11
Nodes..... 18
 Junctions 6
 Outfalls 2
 Flow Diversions 0
 Inlets 10
 Storage Nodes 0
Links..... 18
 Channels 2
 Pipes 16
 Pumps 0
 Orifices 0
 Weirs 0
 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
49		Time Series	100-YR, 24-HR	Cumulative	inches				0.00	

Subbasin Summary

SN Subbasin ID	Area (ac)	Peak Rate Factor	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 {Site 1}.1002	0.01	484.00	94.60	9.25	8.48	0.12	0.03	0 00:06:00
2 {Site 1}.1003	0.14	484.00	90.00	9.25	8.04	1.08	0.29	0 00:06:00
3 {Site 1}.1004	0.28	484.00	87.40	9.25	7.72	2.18	0.61	0 00:06:00
4 {Site 1}.1005	0.06	484.00	96.40	9.25	8.81	0.55	0.14	0 00:06:00
5 {Site 1}.1006	0.08	484.00	87.20	9.25	7.69	0.58	0.17	0 00:06:00
6 {Site 1}.1007	0.32	484.00	89.60	9.25	7.99	2.54	0.70	0 00:06:00
7 {Site 1}.1009.AI	0.03	484.00	85.60	9.25	7.46	0.19	0.05	0 00:06:00
8 {Site 1}.FS4	0.18	484.00	98.00	9.25	9.01	1.66	0.42	0 00:06:00
9 {Site 1}.ID.1	0.04	484.00	78.80	9.25	6.64	0.29	0.09	0 00:06:00
10 {Site 1}.ID.2	0.01	484.00	98.00	9.25	8.03	0.07	0.01	0 00:06:00
11 {Site 1}.ID.3	0.04	484.00	82.60	9.25	7.11	0.29	0.08	0 00:06:00

Node Summary

SN	Element ID	Element Type	Invert Elevation	Ground/Rim (Max) Elevation	Initial Water Elevation	Surcharge Elevation	Ponded Area	Peak Inflow	Max HGL Elevation Attained	Max Surcharge Depth Attained	Min Freeboard Attained	Time of Peak Flooding Occurrence	Total Flooded Volume	Total Time Flooded
			(ft)	(ft)	(ft)	(ft)	(ft²)	(cfs)	(ft)	(ft)	(ft)	(days hh:mm)	(ac-in)	(min)
1	1000.MH	Junction	900.13	909.53	900.13	909.53	0.00	2.60	901.08	0.00	8.45	0 00:00	0.00	0.00
2	1001.MH	Junction	901.08	908.94	901.08	908.94	0.00	1.89	901.79	0.00	7.15	0 00:00	0.00	0.00
3	1008.JB	Junction	901.85	906.54	901.85	906.54	10.00	0.00	901.85	0.00	4.69	0 00:00	0.00	0.00
4	ELBOW.1	Junction	902.98	902.98	902.98	902.98	0.00	0.99	903.29	0.00	0.69	0 00:00	0.00	0.00
5	ELBOW.2	Junction	902.56	902.56	902.56	902.56	0.00	1.00	902.88	0.00	0.68	0 00:00	0.00	0.00
6	EX.MH	Junction	898.84	908.59	898.84	908.59	0.00	2.60	899.79	0.00	8.80	0 00:00	0.00	0.00
7	Out-01	Outfall	898.37					2.63	898.76					
8	Out-02	Outfall	0.00					0.00	901.46					

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Diameter or Height (in)	Manning's Roughness	Peak Flow (cfs)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Reported Surcharged (min)	Condition
1	1000-1001	Pipe	1001.MH	1000.MH	45.21	901.08	900.63	1.0000	12.000	0.0100	1.89	4.62	0.41	5.59	0.45	0.45	0.00	Calculated
2	1000-1007	Pipe	1007.CI	1000.MH	185.42	901.26	900.33	0.5000	30.000	0.0100	0.70	37.76	0.02	3.01	0.24	0.09	0.00	Calculated
3	1001-1002	Pipe	1002.CI	1001.MH	60.86	901.89	901.28	1.0000	12.000	0.0100	1.03	4.64	0.22	4.76	0.32	0.32	0.00	Calculated
4	1001-1005	Pipe	1005.AI	1001.MH	28.61	902.65	901.58	3.7400	12.000	0.0100	0.86	8.96	0.10	7.22	0.21	0.21	0.00	Calculated
5	1002-1003-A	Pipe	1003.CI	ELBOW.1	25.39	903.24	902.98	1.0200	12.000	0.0100	0.90	4.69	0.19	4.61	0.30	0.30	0.00	Calculated
6	1002-1003-B	Pipe	ELBOW.1	ELBOW.2	41.98	902.98	902.56	1.0000	12.000	0.0100	0.99	4.63	0.21	4.70	0.31	0.31	0.00	Calculated
7	1002-1003-C	Pipe	ELBOW.2	1002.CI	17.22	902.56	902.39	0.9900	12.000	0.0100	1.00	4.60	0.22	4.69	0.32	0.32	0.00	Calculated
8	1002-ID1	Pipe	ID1	ELBOW.1	18.72	903.52	902.98	2.8800	12.000	0.0100	0.09	7.87	0.01	3.34	0.08	0.08	0.00	Calculated
9	1002-ID2	Pipe	ID2	ELBOW.2	22.23	903.22	902.56	2.9700	12.000	0.0100	0.01	7.98	0.00	1.92	0.03	0.03	0.00	Calculated
10	1003-1004	Pipe	1004.AI	1003.CI	72.02	904.49	903.74	1.0400	12.000	0.0100	0.61	4.73	0.13	4.16	0.24	0.24	0.00	Calculated
11	1005-1006	Pipe	1006.AI	1005.AI	13.75	903.42	903.15	1.9600	12.000	0.0100	0.25	6.49	0.04	3.98	0.13	0.13	0.00	Calculated
12	1005-1009	Pipe	1009.AI	1005.AI	35.83	904.32	903.25	2.9900	12.000	0.0100	0.47	8.00	0.06	5.58	0.16	0.16	0.00	Calculated
13	1006-ID	Pipe	ID3	1006.AI	28.17	904.18	903.62	1.9900	12.000	0.0100	0.08	6.53	0.01	2.84	0.08	0.08	0.00	Calculated
14	1007-1008	Pipe	1008.JB	1007.CI	41.14	901.85	901.56	0.7000	24.000	0.0100	0.00	24.69	0.00	0.00	0.00	0.00	0.00	Calculated
15	EP1	Pipe	EX.MH	Out-01	18.25	898.84	898.37	2.5800	42.000	0.0210	2.63	99.95	0.03	4.50	0.40	0.11	0.00	Calculated
16	EX.MH-1000	Pipe	1000.MH	EX.MH	154.58	900.13	899.37	0.4900	36.000	0.0100	2.60	60.80	0.04	4.32	0.42	0.14	0.00	Calculated
17	BP_1006-1002	Channel	1002.CI	1006.AI	66.85	910.80	908.13	3.9900	6.000	0.0170	0.00	6.73	0.00	1.11	0.03	0.07	0.00	
18	BP_1007-Out-02	Channel	1007.CI	Out-02	10.00	905.98	901.46	45.2000	6.000	0.0320	0.00	12.14	0.00	0.00	0.00	0.00	0.00	

Inlet Summary

SN	Element	Inlet ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation	Max (Rim) Elevation	Initial Water Elevation	Ponded Area	Peak Flow	Peak Flow Intercepted by Inlet	Peak Flow Bypassing Inlet	Inlet Efficiency during Peak Flow	Allowable Spread	Max Gutter Spread during Peak Flow	Max Gutter Water Elev. during Peak Flow
							(ft)	(ft)	(ft)	(ft²)	(cfs)	(cfs)	(cfs)	(%)	(ft)	(ft)	(ft)
1	1002.CI		FHWA HEC-22 GENERIC	N/A	On Grade	1	901.89	910.75	0.00	N/A	0.03	0.00	0.00	0.00	7.00	0.84	910.79
2	1003.CI		FHWA HEC-22 GENERIC	N/A	On Sag	1	903.24	908.71	0.00	10.00	0.29	N/A	N/A	N/A	7.00	1.98	908.79
3	1004.AI		FHWA HEC-22 GENERIC	N/A	On Sag	1	904.39	907.46	0.00	10.00	0.61	N/A	N/A	N/A	7.00	5.54	907.66
4	1005.AI		NEENAH FOUNDRY	R-3338-G	On Sag	1	902.65	908.15	0.00	10.00	0.14	N/A	N/A	N/A	7.00	0.00	908.18
5	1006.AI		NEENAH FOUNDRY	R-3338-G	On Sag	1	903.42	908.15	0.00	10.00	0.17	N/A	N/A	N/A	7.00	0.00	908.18
6	1007.CI		FHWA HEC-22 GENERIC	N/A	On Grade	1	901.26	905.98	0.00	N/A	0.70	0.70	0.00	100.00	7.00	6.10	906.14
7	1009.AI		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.32	908.50	0.00	10.00	0.47	N/A	N/A	N/A	7.00	5.07	908.60
8	ID1		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.52	908.50	0.00	10.00	0.09	N/A	N/A	N/A	7.00	1.32	908.53
9	ID2		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.22	908.92	0.00	10.00	0.01	N/A	N/A	N/A	7.00	0.39	908.93
10	ID3		GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.18	908.75	0.00	10.00	0.08	N/A	N/A	N/A	7.00	1.18	908.77

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 (ft²)	Minimum Pipe Cover (in)
1	1000.MH	900.13	909.53	9.40	900.13	0.00	909.53	0.00	0.00	76.80
2	1001.MH	901.08	908.94	7.86	901.08	0.00	908.94	0.00	0.00	76.32
3	1008.JB	901.85	906.54	4.69	901.85	0.00	906.54	0.00	10.00	32.28
4	ELBOW.1	902.98	902.98	0.00	902.98	0.00	902.98	0.00	0.00	0.00
5	ELBOW.2	902.56	902.56	0.00	902.56	0.00	902.56	0.00	0.00	0.00
6	EX.MH	898.84	908.59	9.75	898.84	0.00	908.59	0.00	0.00	74.64

Junction Results

SN	Element ID	Peak Inflow	Peak Lateral Inflow	Max HGL Elevation Attained	Max HGL Depth Attained	Max Surcharge Depth Attained	Min Freeboard Attained	Average HGL Elevation Attained	Average HGL Depth Attained	Time of Max HGL Occurrence	Time of Peak Flooding Occurrence	Total Flooded Volume	Total Time Flooded
		(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(days hh:mm)	(days hh:mm)	(ac-in)	(min)
1	1000.MH	2.60	0.00	901.08	0.95	0.00	8.45	900.77	0.64	0 12:05	0 00:00	0.00	0.00
2	1001.MH	1.89	0.00	901.79	0.71	0.00	7.15	901.65	0.57	0 12:05	0 00:00	0.00	0.00
3	1008.JB	0.00	0.00	901.85	0.00	0.00	4.69	901.85	0.00	0 00:00	0 00:00	0.00	0.00
4	ELBOW.1	0.99	0.00	903.29	0.31	0.00	0.69	903.08	0.10	0 12:05	0 00:00	0.00	0.00
5	ELBOW.2	1.00	0.00	902.88	0.32	0.00	0.68	902.66	0.10	0 12:05	0 00:00	0.00	0.00
6	EX.MH	2.60	0.00	899.79	0.95	0.00	8.80	899.51	0.67	0 12:05	0 00:00	0.00	0.00

Channel Input

SN	Element ID	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Total Drop	Average Slope	Shape	Height	Width	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow	Flap Gate
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(%)		(ft)	(ft)					(cfs)	
1	BP_1006-1002	66.85	910.80	8.91	908.13	4.71	2.67	3.9900	Triangular	0.500	4.000	0.0170	0.5000	0.5000	0.0000	0.00	No
2	BP_1007-Out-02	10.00	905.98	4.72	901.46	901.46	4.52	45.2000	Triangular	0.500	4.000	0.0320	0.5000	0.5000	0.0000	0.00	No

Channel Results

SN	Element ID	Peak Flow	Time of Peak Flow Occurrence	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Travel Time	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Froude Number	Reported Condition
		(cfs)	(days hh:mm)	(cfs)		(ft/sec)	(min)	(ft)		(min)		
1	BP_1006-1002	0.00	0 12:05	6.73	0.00	1.11	1.00	0.03	0.07	0.00		
2	BP_1007-Out-02	0.00	0 00:00	12.14	0.00	0.00		0.00	0.00	0.00		

Pipe Input

SN Element ID	Length	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Average Slope (%)	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	No. of Barrels
1 1000-1001	45.21	901.08	0.00	900.63	0.50	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
2 1000-1007	185.42	901.26	0.00	900.33	0.20	0.5000	30.000	30.000	0.0100	0.5000	0.4000	0.0000	0.00	1
3 1001-1002	60.86	901.89	0.00	901.28	0.20	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
4 1001-1005	28.61	902.65	0.00	901.58	0.50	3.7400	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
5 1002-1003-A	25.39	903.24	0.00	902.98	0.00	1.0200	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
6 1002-1003-B	41.98	902.98	0.00	902.56	0.00	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
7 1002-1003-C	17.22	902.56	0.00	902.39	0.50	0.9900	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
8 1002-ID1	18.72	903.52	0.00	902.98	0.00	2.8800	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
9 1002-ID2	22.23	903.22	0.00	902.56	0.00	2.9700	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
10 1003-1004	72.02	904.49	0.10	903.74	0.50	1.0400	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
11 1005-1006	13.75	903.42	0.00	903.15	0.50	1.9600	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
12 1005-1009	35.83	904.32	0.00	903.25	0.60	2.9900	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
13 1006-ID	28.17	904.18	0.00	903.62	0.20	1.9900	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
14 1007-1008	41.14	901.85	0.00	901.56	0.30	0.7000	24.000	24.000	0.0100	0.5000	0.4000	0.0000	0.00	1
15 EP1	18.25	898.84	0.00	898.37	0.00	2.5800	42.000	42.000	0.0210	0.5000	0.4000	0.0000	0.00	1
16 EX.MH-1000	154.58	900.13	0.00	899.37	0.53	0.4900	36.000	36.000	0.0100	0.5000	0.4000	0.0000	0.00	1

Pipe Results

SN Element ID	Peak Flow	Time of Peak Flow Occurrence	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Travel Time	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Froude Number	Reported Condition
	(cfs)	(days hh:mm)	(cfs)		(ft/sec)	(min)	(ft)		(min)		
1 1000-1001	1.89	0 12:05	4.62	0.41	5.59	0.13	0.45	0.45	0.00		Calculated
2 1000-1007	0.70	0 12:05	37.76	0.02	3.01	1.03	0.24	0.09	0.00		Calculated
3 1001-1002	1.03	0 12:05	4.64	0.22	4.76	0.21	0.32	0.32	0.00		Calculated
4 1001-1005	0.86	0 12:05	8.96	0.10	7.22	0.07	0.21	0.21	0.00		Calculated
5 1002-1003-A	0.90	0 12:05	4.69	0.19	4.61	0.09	0.30	0.30	0.00		Calculated
6 1002-1003-B	0.99	0 12:05	4.63	0.21	4.70	0.15	0.31	0.31	0.00		Calculated
7 1002-1003-C	1.00	0 12:05	4.60	0.22	4.69	0.06	0.32	0.32	0.00		Calculated
8 1002-ID1	0.09	0 12:05	7.87	0.01	3.34	0.09	0.08	0.08	0.00		Calculated
9 1002-ID2	0.01	0 10:15	7.98	0.00	1.92	0.19	0.03	0.03	0.00		Calculated
10 1003-1004	0.61	0 12:05	4.73	0.13	4.16	0.29	0.24	0.24	0.00		Calculated
11 1005-1006	0.25	0 12:05	6.49	0.04	3.98	0.06	0.13	0.13	0.00		Calculated
12 1005-1009	0.47	0 11:40	8.00	0.06	5.58	0.11	0.16	0.16	0.00		Calculated
13 1006-ID	0.08	0 12:05	6.53	0.01	2.84	0.17	0.08	0.08	0.00		Calculated
14 1007-1008	0.00	0 00:00	24.69	0.00	0.00		0.00	0.00	0.00		Calculated
15 EP1	2.63	0 11:35	99.95	0.03	4.50	0.07	0.40	0.11	0.00		Calculated
16 EX.MH-1000	2.60	0 12:05	60.80	0.04	4.32	0.60	0.42	0.14	0.00		Calculated

Inlet Input

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Inlet Depth (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Ponded Area (ft ²)	Grate Clogging Factor (%)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	901.89	910.75	8.86	0.00	0.00	N/A	0.00
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Sag	1	903.24	908.71	5.47	0.00	0.00	10.00	0.00
3	1004.AI	FHWA HEC-22 GENERIC	N/A	On Sag	1	904.39	907.46	3.07	0.00	0.00	10.00	0.00
4	1005.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	902.65	908.15	5.50	0.00	0.00	10.00	0.00
5	1006.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	903.42	908.15	4.73	0.00	0.00	10.00	0.00
6	1007.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	901.26	905.98	4.72	0.00	0.00	N/A	0.00
7	1009.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.32	908.50	4.18	0.00	0.00	10.00	0.00
8	ID1	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.52	908.50	4.98	0.00	0.00	10.00	0.00
9	ID2	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.22	908.92	5.70	0.00	0.00	10.00	0.00
10	ID3	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.18	908.75	4.57	0.00	0.00	10.00	0.00

Roadway & Gutter Input

SN	Element ID	Roadway Longitudinal Slope (ft/ft)	Roadway Cross Slope (ft/ft)	Roadway Manning's Roughness	Gutter Cross Slope (ft/ft)	Gutter Width (ft)	Gutter Depression (in)	Allowable Spread (ft)
1	1002.Cl	0.0396	0.0200	0.0170	0.0521	1.33	0.0272	7.00
2	1003.Cl	N/A	0.0200	0.0170	0.0521	1.33	0.0272	7.00
3	1004.Al	N/A	0.0200	0.0170	0.0521	1.33	0.0656	7.00
4	1005.Al	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
5	1006.Al	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
6	1007.Cl	0.0100	0.0200	0.0170	0.0521	1.33	0.2051	7.00
7	1009.Al	N/A	0.0200					
8	ID1	N/A	0.0200					
9	ID2	N/A	0.0200					
10	ID3	N/A	0.0200					

Inlet Results

SN	Element ID	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Peak Flow Intercepted (cfs)	Peak Flow Bypassing Inlet (cfs)	Inlet Efficiency during Peak Flow (%)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1002.Cl	0.03	0.03	0.00	0.00	0.00	0.84	910.79	0.04	0 12:05	0.00	0.00
2	1003.Cl	0.29	0.29	N/A	N/A	N/A	1.98	908.79	0.08	0 12:05	0.00	0.00
3	1004.Al	0.61	0.61	N/A	N/A	N/A	5.54	907.66	0.20	0 12:05	0.00	0.00
4	1005.Al	0.14	0.14	N/A	N/A	N/A	0.00	908.18	0.03	0 11:40	0.00	0.00
5	1006.Al	0.17	0.17	N/A	N/A	N/A	0.00	908.18	0.03	0 10:07	0.00	0.00
6	1007.Cl	0.70	0.70	0.70	0.00	100.00	6.10	906.14	0.16	0 00:00	0.00	0.00
7	1009.Al	0.47	0.47	N/A	N/A	N/A	5.07	908.60	0.10	0 11:40	0.00	0.00
8	ID1	0.09	0.09	N/A	N/A	N/A	1.32	908.53	0.03	0 12:05	0.00	0.00
9	ID2	0.01	0.01	N/A	N/A	N/A	0.39	908.93	0.01	0 10:15	0.00	0.00
10	ID3	0.08	0.08	N/A	N/A	N/A	1.18	908.77	0.02	0 12:05	0.00	0.00

APPENDIX B.4

100-YR, 24-HR STORM EVENT SSA REPORT

Project Description

File Name 18225R21001_FS4_R0_220112.SPF
Description Site_Design\Lakewood_FS4\Calculations\Stormwater\Working Files\Analysis\CAD
C:\Users\DERICK-1.HOL\AppData\Local\Temp\18225R21001_FS4_R0_220112_1_32208_2325f38b.sv\$

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 00:00:00 0:00:00
End Analysis On 00:00:00 0:00:00
Start Reporting On 00:00:00 0:00:00
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 5 seconds

Number of Elements

Qty
Rain Gages 1
Subbasins..... 11
Nodes..... 18
 Junctions 6
 Outfalls 2
 Flow Diversions 0
 Inlets 10
 Storage Nodes 0
Links..... 18
 Channels 2
 Pipes 16
 Pumps 0
 Orifices 0
 Weirs 0
 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
49		Time Series	100-YR, 24-HR	Cumulative	inches				0.00	

Subbasin Summary

SN	Subbasin ID	Area (ac)	Peak Rate Factor	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	{Site 1}.1002	0.01	484.00	94.60	9.25	8.48	0.12	0.03	0 00:06:00
2	{Site 1}.1003	0.14	484.00	90.00	9.25	8.04	1.08	0.29	0 00:06:00
3	{Site 1}.1004	0.28	484.00	87.40	9.25	7.72	2.18	0.61	0 00:06:00
4	{Site 1}.1005	0.06	484.00	96.40	9.25	8.81	0.55	0.14	0 00:06:00
5	{Site 1}.1006	0.08	484.00	87.20	9.25	7.69	0.58	0.17	0 00:06:00
6	{Site 1}.1007	0.32	484.00	89.60	9.25	7.99	2.54	0.70	0 00:06:00
7	{Site 1}.1009.AI	0.03	484.00	85.60	9.25	7.46	0.19	0.05	0 00:06:00
8	{Site 1}.FS4	0.18	484.00	98.00	9.25	9.01	1.66	0.42	0 00:06:00
9	{Site 1}.ID.1	0.04	484.00	78.80	9.25	6.64	0.29	0.09	0 00:06:00
10	{Site 1}.ID.2	0.01	484.00	98.00	9.25	8.03	0.07	0.01	0 00:06:00
11	{Site 1}.ID.3	0.04	484.00	82.60	9.25	7.11	0.29	0.08	0 00:06:00

Node Summary

SN	Element ID	Element Type	Invert Elevation	Ground/Rim (Max) Elevation	Initial Water Elevation	Surcharge Elevation	Ponded Area	Peak Inflow	Max HGL Elevation Attained	Max Surcharge Depth Attained	Min Freeboard Attained	Time of Peak Flooding Occurrence	Total Flooded Volume	Total Time Flooded
			(ft)	(ft)	(ft)	(ft)	(ft²)	(cfs)	(ft)	(ft)	(ft)	(days hh:mm)	(ac-in)	(min)
1	1000.MH	Junction	900.13	909.53	900.13	909.53	0.00	2.60	901.08	0.00	8.45	0 00:00	0.00	0.00
2	1001.MH	Junction	901.08	908.94	901.08	908.94	0.00	1.89	901.79	0.00	7.15	0 00:00	0.00	0.00
3	1008.JB	Junction	901.85	906.54	901.85	906.54	10.00	0.00	901.85	0.00	4.69	0 00:00	0.00	0.00
4	ELBOW.1	Junction	902.98	902.98	902.98	902.98	0.00	0.99	903.29	0.00	0.69	0 00:00	0.00	0.00
5	ELBOW.2	Junction	902.56	902.56	902.56	902.56	0.00	1.00	902.88	0.00	0.68	0 00:00	0.00	0.00
6	EX.MH	Junction	898.84	908.59	898.84	908.59	0.00	2.60	899.79	0.00	8.80	0 00:00	0.00	0.00
7	Out-01	Outfall	898.37					2.63	898.76					
8	Out-02	Outfall	0.00					0.00	901.46					

Link Summary

SN	Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Diameter or Height (in)	Manning's Roughness	Peak Flow (cfs)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Reported Surcharged (min)	Condition
1	1000-1001	Pipe	1001.MH	1000.MH	45.21	901.08	900.63	1.0000	12.000	0.0100	1.89	4.62	0.41	5.59	0.45	0.45	0.00	Calculated
2	1000-1007	Pipe	1007.CI	1000.MH	185.42	901.26	900.33	0.5000	30.000	0.0100	0.70	37.76	0.02	3.01	0.24	0.09	0.00	Calculated
3	1001-1002	Pipe	1002.CI	1001.MH	60.86	901.89	901.28	1.0000	12.000	0.0100	1.03	4.64	0.22	4.76	0.32	0.32	0.00	Calculated
4	1001-1005	Pipe	1005.AI	1001.MH	28.61	902.65	901.58	3.7400	12.000	0.0100	0.86	8.96	0.10	7.22	0.21	0.21	0.00	Calculated
5	1002-1003-A	Pipe	1003.CI	ELBOW.1	25.39	903.24	902.98	1.0200	12.000	0.0100	0.90	4.69	0.19	4.61	0.30	0.30	0.00	Calculated
6	1002-1003-B	Pipe	ELBOW.1	ELBOW.2	41.98	902.98	902.56	1.0000	12.000	0.0100	0.99	4.63	0.21	4.70	0.31	0.31	0.00	Calculated
7	1002-1003-C	Pipe	ELBOW.2	1002.CI	17.22	902.56	902.39	0.9900	12.000	0.0100	1.00	4.60	0.22	4.69	0.32	0.32	0.00	Calculated
8	1002-ID1	Pipe	ID1	ELBOW.1	18.72	903.52	902.98	2.8800	12.000	0.0100	0.09	7.87	0.01	3.34	0.08	0.08	0.00	Calculated
9	1002-ID2	Pipe	ID2	ELBOW.2	22.23	903.22	902.56	2.9700	12.000	0.0100	0.01	7.98	0.00	1.92	0.03	0.03	0.00	Calculated
10	1003-1004	Pipe	1004.AI	1003.CI	72.02	904.49	903.74	1.0400	12.000	0.0100	0.61	4.73	0.13	4.16	0.24	0.24	0.00	Calculated
11	1005-1006	Pipe	1006.AI	1005.AI	13.75	903.42	903.15	1.9600	12.000	0.0100	0.25	6.49	0.04	3.98	0.13	0.13	0.00	Calculated
12	1005-1009	Pipe	1009.AI	1005.AI	35.83	904.32	903.25	2.9900	12.000	0.0100	0.47	8.00	0.06	5.58	0.16	0.16	0.00	Calculated
13	1006-ID	Pipe	ID3	1006.AI	28.17	904.18	903.62	1.9900	12.000	0.0100	0.08	6.53	0.01	2.84	0.08	0.08	0.00	Calculated
14	1007-1008	Pipe	1008.JB	1007.CI	41.14	901.85	901.56	0.7000	24.000	0.0100	0.00	24.69	0.00	0.00	0.00	0.00	0.00	Calculated
15	EP1	Pipe	EX.MH	Out-01	18.25	898.84	898.37	2.5800	42.000	0.0210	2.63	99.95	0.03	4.50	0.40	0.11	0.00	Calculated
16	EX.MH-1000	Pipe	1000.MH	EX.MH	154.58	900.13	899.37	0.4900	36.000	0.0100	2.60	60.80	0.04	4.32	0.42	0.14	0.00	Calculated
17	BP_1006-1002	Channel	1002.CI	1006.AI	66.85	910.80	908.13	3.9900	6.000	0.0170	0.00	6.73	0.00	1.11	0.03	0.07	0.00	
18	BP_1007-Out-02	Channel	1007.CI	Out-02	10.00	905.98	901.46	45.2000	6.000	0.0320	0.00	12.14	0.00	0.00	0.00	0.00	0.00	

Inlet Summary

SN	Element	Inlet ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation	Max (Rim) Elevation	Initial Water Elevation	Ponded Area	Peak Flow	Peak Flow Intercepted by Inlet	Peak Flow Bypassing Inlet	Inlet Efficiency during Peak Flow	Allowable Spread	Max Gutter Spread during Peak Flow	Max Gutter Water Elev. during Peak Flow
							(ft)	(ft)	(ft)	(ft²)	(cfs)	(cfs)	(cfs)	(%)	(ft)	(ft)	(ft)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	N/A	On Grade	1	901.89	910.75	0.00	N/A	0.03	0.00	0.00	0.00	7.00	0.84	910.79
2	1003.CI	FHWA HEC-22 GENERIC	N/A	N/A	On Sag	1	903.24	908.71	0.00	10.00	0.29	N/A	N/A	N/A	7.00	1.98	908.79
3	1004.AI	FHWA HEC-22 GENERIC	N/A	N/A	On Sag	1	904.39	907.46	0.00	10.00	0.61	N/A	N/A	N/A	7.00	5.54	907.66
4	1005.AI	NEENAH FOUNDRY	R-3338-G	R-3338-G	On Sag	1	902.65	908.15	0.00	10.00	0.14	N/A	N/A	N/A	7.00	0.00	908.18
5	1006.AI	NEENAH FOUNDRY	R-3338-G	R-3338-G	On Sag	1	903.42	908.15	0.00	10.00	0.17	N/A	N/A	N/A	7.00	0.00	908.18
6	1007.CI	FHWA HEC-22 GENERIC	N/A	N/A	On Grade	1	901.26	905.98	0.00	N/A	0.70	0.70	0.00	100.00	7.00	6.10	906.14
7	1009.AI	GUTTER DEPTH CAPTURE CURVE	N/A	N/A	On Sag	1	904.32	908.50	0.00	10.00	0.47	N/A	N/A	N/A	7.00	5.07	908.60
8	ID1	GUTTER DEPTH CAPTURE CURVE	N/A	N/A	On Sag	1	903.52	908.50	0.00	10.00	0.09	N/A	N/A	N/A	7.00	1.32	908.53
9	ID2	GUTTER DEPTH CAPTURE CURVE	N/A	N/A	On Sag	1	903.22	908.92	0.00	10.00	0.01	N/A	N/A	N/A	7.00	0.39	908.93
10	ID3	GUTTER DEPTH CAPTURE CURVE	N/A	N/A	On Sag	1	904.18	908.75	0.00	10.00	0.08	N/A	N/A	N/A	7.00	1.18	908.77

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 (ft²)	Minimum Pipe Cover (in)
1	1000.MH	900.13	909.53	9.40	900.13	0.00	909.53	0.00	0.00	76.80
2	1001.MH	901.08	908.94	7.86	901.08	0.00	908.94	0.00	0.00	76.32
3	1008.JB	901.85	906.54	4.69	901.85	0.00	906.54	0.00	10.00	32.28
4	ELBOW.1	902.98	902.98	0.00	902.98	0.00	902.98	0.00	0.00	0.00
5	ELBOW.2	902.56	902.56	0.00	902.56	0.00	902.56	0.00	0.00	0.00
6	EX.MH	898.84	908.59	9.75	898.84	0.00	908.59	0.00	0.00	74.64

Junction Results

SN	Element ID	Peak Inflow	Peak Lateral Inflow	Max HGL Elevation Attained	Max HGL Depth Attained	Max Surcharge Depth Attained	Min Freeboard Attained	Average HGL Elevation Attained	Average HGL Depth Attained	Time of Max HGL Occurrence	Time of Peak Flooding Occurrence	Total Flooded Volume	Total Time Flooded
		(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(days hh:mm)	(days hh:mm)	(ac-in)	(min)
1	1000.MH	2.60	0.00	901.08	0.95	0.00	8.45	900.77	0.64	0 12:05	0 00:00	0.00	0.00
2	1001.MH	1.89	0.00	901.79	0.71	0.00	7.15	901.65	0.57	0 12:05	0 00:00	0.00	0.00
3	1008.JB	0.00	0.00	901.85	0.00	0.00	4.69	901.85	0.00	0 00:00	0 00:00	0.00	0.00
4	ELBOW.1	0.99	0.00	903.29	0.31	0.00	0.69	903.08	0.10	0 12:05	0 00:00	0.00	0.00
5	ELBOW.2	1.00	0.00	902.88	0.32	0.00	0.68	902.66	0.10	0 12:05	0 00:00	0.00	0.00
6	EX.MH	2.60	0.00	899.79	0.95	0.00	8.80	899.51	0.67	0 12:05	0 00:00	0.00	0.00

Channel Input

SN	Element ID	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Total Drop	Average Slope	Shape	Height	Width	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow	Flap Gate
		(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(%)		(ft)	(ft)					(cfs)	
1	BP_1006-1002	66.85	910.80	8.91	908.13	4.71	2.67	3.9900	Triangular	0.500	4.000	0.0170	0.5000	0.5000	0.0000	0.00	No
2	BP_1007-Out-02	10.00	905.98	4.72	901.46	901.46	4.52	45.2000	Triangular	0.500	4.000	0.0320	0.5000	0.5000	0.0000	0.00	No

Channel Results

SN	Element ID	Peak Flow	Time of Peak Flow Occurrence	Design Flow Capacity	Peak Flow/ Design Flow Ratio	Peak Flow Velocity	Travel Time	Peak Flow Depth	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged	Froude Number	Reported Condition
		(cfs)	(days hh:mm)	(cfs)		(ft/sec)	(min)	(ft)		(min)		
1	BP_1006-1002	0.00	0 12:05	6.73	0.00	1.11	1.00	0.03	0.07	0.00		
2	BP_1007-Out-02	0.00	0 00:00	12.14	0.00	0.00		0.00	0.00	0.00		

Pipe Input

SN Element ID	Length	Inlet Invert Elevation (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Outlet Invert Offset (ft)	Average Slope (%)	Pipe Diameter or Height (in)	Pipe Width (in)	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow (cfs)	No. of Barrels
1 1000-1001	45.21	901.08	0.00	900.63	0.50	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
2 1000-1007	185.42	901.26	0.00	900.33	0.20	0.5000	30.000	30.000	0.0100	0.5000	0.4000	0.0000	0.00	1
3 1001-1002	60.86	901.89	0.00	901.28	0.20	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
4 1001-1005	28.61	902.65	0.00	901.58	0.50	3.7400	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
5 1002-1003-A	25.39	903.24	0.00	902.98	0.00	1.0200	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
6 1002-1003-B	41.98	902.98	0.00	902.56	0.00	1.0000	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
7 1002-1003-C	17.22	902.56	0.00	902.39	0.50	0.9900	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
8 1002-ID1	18.72	903.52	0.00	902.98	0.00	2.8800	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
9 1002-ID2	22.23	903.22	0.00	902.56	0.00	2.9700	12.000	12.000	0.0100	0.5000	0.3000	0.0000	0.00	1
10 1003-1004	72.02	904.49	0.10	903.74	0.50	1.0400	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
11 1005-1006	13.75	903.42	0.00	903.15	0.50	1.9600	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
12 1005-1009	35.83	904.32	0.00	903.25	0.60	2.9900	12.000	12.000	0.0100	0.5000	0.4000	0.0000	0.00	1
13 1006-ID	28.17	904.18	0.00	903.62	0.20	1.9900	12.000	12.000	0.0100	0.5000	0.1500	0.0000	0.00	1
14 1007-1008	41.14	901.85	0.00	901.56	0.30	0.7000	24.000	24.000	0.0100	0.5000	0.4000	0.0000	0.00	1
15 EP1	18.25	898.84	0.00	898.37	0.00	2.5800	42.000	42.000	0.0210	0.5000	0.4000	0.0000	0.00	1
16 EX.MH-1000	154.58	900.13	0.00	899.37	0.53	0.4900	36.000	36.000	0.0100	0.5000	0.4000	0.0000	0.00	1

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	Total Time Surcharged (min)	Froude Number	Reported Condition
1 1000-1001	1.89	0 12:05	4.62	0.41	5.59	0.13	0.45	0.45	0.00		Calculated
2 1000-1007	0.70	0 12:05	37.76	0.02	3.01	1.03	0.24	0.09	0.00		Calculated
3 1001-1002	1.03	0 12:05	4.64	0.22	4.76	0.21	0.32	0.32	0.00		Calculated
4 1001-1005	0.86	0 12:05	8.96	0.10	7.22	0.07	0.21	0.21	0.00		Calculated
5 1002-1003-A	0.90	0 12:05	4.69	0.19	4.61	0.09	0.30	0.30	0.00		Calculated
6 1002-1003-B	0.99	0 12:05	4.63	0.21	4.70	0.15	0.31	0.31	0.00		Calculated
7 1002-1003-C	1.00	0 12:05	4.60	0.22	4.69	0.06	0.32	0.32	0.00		Calculated
8 1002-ID1	0.09	0 12:05	7.87	0.01	3.34	0.09	0.08	0.08	0.00		Calculated
9 1002-ID2	0.01	0 10:15	7.98	0.00	1.92	0.19	0.03	0.03	0.00		Calculated
10 1003-1004	0.61	0 12:05	4.73	0.13	4.16	0.29	0.24	0.24	0.00		Calculated
11 1005-1006	0.25	0 12:05	6.49	0.04	3.98	0.06	0.13	0.13	0.00		Calculated
12 1005-1009	0.47	0 11:40	8.00	0.06	5.58	0.11	0.16	0.16	0.00		Calculated
13 1006-ID	0.08	0 12:05	6.53	0.01	2.84	0.17	0.08	0.08	0.00		Calculated
14 1007-1008	0.00	0 00:00	24.69	0.00	0.00		0.00	0.00	0.00		Calculated
15 EP1	2.63	0 11:35	99.95	0.03	4.50	0.07	0.40	0.11	0.00		Calculated
16 EX.MH-1000	2.60	0 12:05	60.80	0.04	4.32	0.60	0.42	0.14	0.00		Calculated

PRE-CONSTRUCTION CAPACITY OF EXISTING PIPE 1000-1007

Q (cfs) 19.113 8579.094 (GPM)

DIA (in) 24.000 SUGGESTED SLOPES SUGGESTED "n"

DIA (ft) 2.000

S (ft/ft) 0.0071

n 0.013

Pipe Type RCP

SUGGESTED SLOPES		SUGGESTED "n"	
4-.012	18-.0012	CISP	.012
6-.006	20-.0010	VCP	.011
8-.004	24-.0008	RCP	.013
10-.0029	36-.0006	DIP	.012
12-.0022	48-.0004	HDPE	.010 (N12)
15-.0015	60-.0002	HDPE	.018 (Corr)
		PVC	.010
		CMP	.022

FULL FLOW

DIA	S	n	A	P	R	Q	V
2.000	0.0071	0.013	3.142	6.283	0.500	19.113	6.084

Q_{design}/Q_{full} 100.00

PARTIAL FLOW

% OF FULL	Q	V
10	1.911	3.650
15	2.867	4.137
20	3.823	4.624
25	4.778	4.928
30	5.734	5.232
35	6.690	5.475
40	7.645	5.597
45	8.601	5.901
50	9.556	6.084

% OF FULL	Q	V
55	10.512	6.205
60	11.468	6.327
65	12.423	6.449
70	13.379	6.571
75	14.335	6.692
80	15.290	6.814
85	16.246	6.875
90	17.202	6.936
95	18.157	6.996
100	19.113	6.084

PROGRAM FOR CIRCULAR PIPE FLOWING FULL OR PARTIALLY FULL

DIA=DIAMETER OF PIPE (FT)
S=SLOPE OF PIPE (FT/FT)
n=MANNING ROUGHNESS COEFFICIENT

Q = A(1.486)/n * R^{2/3} * S^{1/2} (cfs)
A = CROSS SECTIONAL AREA OF FLOW (ft²)
R = HYDRAULIC RADIUS (R = D/4) (ft)
P = WETTED PERIMETER (3.14*DIA) (ft)
V = Q/A (ft/sec)

% OF FULL = APPROX % OF FULL FLOW VALUE OF HYDRAULIC ELEMENTS

37.76 cfs capacity provided > 19.11 cfs existing capacity
●● pipe ok

PRE-CONSTRUCTION CAPACITY OF EXISTING PIPE EX MH-1000

Q (cfs) 56.352 25294.255 (GPM)

DIA (in) 36.000 SUGGESTED SLOPES SUGGESTED "n"

DIA (ft) 3.000

S (ft/ft) 0.0071

n 0.013

Pipe Type CMP

SUGGESTED SLOPES		SUGGESTED "n"	
4-.012	18-.0012	CISP	.012
6-.006	20-.0010	VCP	.011
8-.004	24-.0008	RCP	.013
10-.0029	36-.0006	DIP	.012
12-.0022	48-.0004	HDPE	.010 (N12)
15-.0015	60-.0002	HDPE	.018 (Corr)
		PVC	.010
		CMP	.022

FULL FLOW

DIA	S	n	A	P	R	Q	V
3.000	0.0071	0.013	7.069	9.425	0.750	56.352	7.972

Q_{design}/Q_{full} 100.00

PARTIAL FLOW

% OF FULL	Q	V
10	5.635	4.783
15	8.453	5.421
20	11.270	6.059
25	14.088	6.457
30	16.906	6.856
35	19.723	7.175
40	22.541	7.334
45	25.358	7.733
50	28.176	7.972

% OF FULL	Q	V
55	30.994	8.132
60	33.811	8.291
65	36.629	8.450
70	39.446	8.610
75	42.264	8.769
80	45.082	8.928
85	47.899	9.088
90	50.717	9.248
95	53.534	9.408
100	56.352	7.972

PROGRAM FOR CIRCULAR PIPE FLOWING FULL OR PARTIALLY FULL

DIA=DIAMETER OF PIPE (FT)
S=SLOPE OF PIPE (FT/FT)
n=MANNING ROUGHNESS COEFFICIENT

Q = A(1.486)/n * R^{2/3} * S^{1/2} (cfs)
A = CROSS SECTIONAL AREA OF FLOW (ft²)
R = HYDRAULIC RADIUS (R = D/4) (ft)
P = WETTED PERIMETER (3.14*DIA) (ft)
V = Q/A (ft/sec)

% OF FULL = APPROX % OF FULL FLOW VALUE OF HYDRAULIC ELEMENTS

60.80 cfs capacity provided > 56.35 cfs existing capacity
●● pipe ok

Inlet Input

SN	Element ID	Inlet Manufacturer	Manufacturer Part Number	Inlet Location	Number of Inlets	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Inlet Depth (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Ponded Area (ft ²)	Grate Clogging Factor (%)
1	1002.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	901.89	910.75	8.86	0.00	0.00	N/A	0.00
2	1003.CI	FHWA HEC-22 GENERIC	N/A	On Sag	1	903.24	908.71	5.47	0.00	0.00	10.00	0.00
3	1004.AI	FHWA HEC-22 GENERIC	N/A	On Sag	1	904.39	907.46	3.07	0.00	0.00	10.00	0.00
4	1005.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	902.65	908.15	5.50	0.00	0.00	10.00	0.00
5	1006.AI	NEENAH FOUNDRY	R-3338-G	On Sag	1	903.42	908.15	4.73	0.00	0.00	10.00	0.00
6	1007.CI	FHWA HEC-22 GENERIC	N/A	On Grade	1	901.26	905.98	4.72	0.00	0.00	N/A	0.00
7	1009.AI	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.32	908.50	4.18	0.00	0.00	10.00	0.00
8	ID1	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.52	908.50	4.98	0.00	0.00	10.00	0.00
9	ID2	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	903.22	908.92	5.70	0.00	0.00	10.00	0.00
10	ID3	GUTTER DEPTH CAPTURE CURVE	N/A	On Sag	1	904.18	908.75	4.57	0.00	0.00	10.00	0.00

Roadway & Gutter Input

SN	Element ID	Roadway Longitudinal Slope (ft/ft)	Roadway Cross Slope (ft/ft)	Roadway Manning's Roughness	Gutter Cross Slope (ft/ft)	Gutter Width (ft)	Gutter Depression (in)	Allowable Spread (ft)
1	1002.Cl	0.0396	0.0200	0.0170	0.0521	1.33	0.0272	7.00
2	1003.Cl	N/A	0.0200	0.0170	0.0521	1.33	0.0272	7.00
3	1004.Al	N/A	0.0200	0.0170	0.0521	1.33	0.0656	7.00
4	1005.Al	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
5	1006.Al	N/A	0.0200	0.0160	0.0620	2.00	0.0656	7.00
6	1007.Cl	0.0100	0.0200	0.0170	0.0521	1.33	0.2051	7.00
7	1009.Al	N/A	0.0200					
8	ID1	N/A	0.0200					
9	ID2	N/A	0.0200					
10	ID3	N/A	0.0200					

Inlet Results

SN	Element ID	Peak Flow	Peak Lateral Inflow	Peak Flow Intercepted	Peak Flow Bypassing Inlet	Inlet Efficiency during Peak Flow (%)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
1	1002.Cl	0.03	0.03	0.00	0.00	0.00	0.84	910.79	0.04	0 12:05	0.00	0.00
2	1003.Cl	0.29	0.29	N/A	N/A	N/A	1.98	908.79	0.08	0 12:05	0.00	0.00
3	1004.Al	0.61	0.61	N/A	N/A	N/A	5.54	907.66	0.20	0 12:05	0.00	0.00
4	1005.Al	0.14	0.14	N/A	N/A	N/A	0.00	908.18	0.03	0 11:40	0.00	0.00
5	1006.Al	0.17	0.17	N/A	N/A	N/A	0.00	908.18	0.03	0 10:07	0.00	0.00
6	1007.Cl	0.70	0.70	0.70	0.00	100.00	6.10	906.14	0.16	0 00:00	0.00	0.00
7	1009.Al	0.47	0.47	N/A	N/A	N/A	5.07	908.60	0.10	0 11:40	0.00	0.00
8	ID1	0.09	0.09	N/A	N/A	N/A	1.32	908.53	0.03	0 12:05	0.00	0.00
9	ID2	0.01	0.01	N/A	N/A	N/A	0.39	908.93	0.01	0 10:15	0.00	0.00
10	ID3	0.08	0.08	N/A	N/A	N/A	1.18	908.77	0.02	0 12:05	0.00	0.00

APPENDIX C

REGIONAL DETENTION BASIN FIELD REVIEW



October 12, 2022

Lee's Summit Development Services Department
220 SE Green
Lee's Summit, MO 64063

To Whom It May Concern:

A field investigation of the existing regional detention basin shown in Figure 1 was performed by the Engineer the morning of October 12, 2022. The regional detention basin will serve the proposed Fire Station No. 4, located at 5031 Northeast Lakewood Way, Lee's Summit, Missouri.

The Engineer's Findings are as Follows:

- The existing regional detention basin, located in Tract E, is currently heavily vegetated (reference Figures 2 and 4). The City of Lee's Summit Development Services Department is unable to produce the original design drawings or stormwater report for the basin. Therefore, the original vegetation intent of the basin is unclear. The Engineer concludes that the vegetation currently residing inside the basin promotes enhanced water quality but cannot comment on the basin's original designed volume and how that volume has been reduced due to the vegetation that currently exists.
- Due to the dense vegetation currently in the basin, the Engineer cannot make any conclusions regarding siltation within the basin. The Engineer was able to visibly see the outlet pipe, located on the north side of the basin (see Figure 5). The outlet pipe had standing water from the rain that occurred the night before but did not appear blocked or obstructed to let stormwater pass. Figure 6 shows the outlet pipe on the south side of Bowlin Road. The outlet pipe appears functional and did not show signs of being blocked or clogged during the time of the site visit. A camera inspection inside the outlet pipe is required to determine the pipe's current condition.
- As shown in Figure 1, the detention basin currently has retaining walls along its perimeter. Figures 4 and 5 document the top edge of the retaining wall. The Engineer did not document any noticeable leaning or structural defects with the wall during the site visit. It is important to note, however, that the dense vegetation existing within the basin prohibited a detailed review of existing conditions.

The Engineer concludes that the existing detention basin is functioning currently. Major blockages of the inlet and outlet pipes or structural defects of the retaining wall were not observed. Due to the unknown design intent of the existing basin, no statements or conclusions can be made regarding the current versus designed volume of the basin.

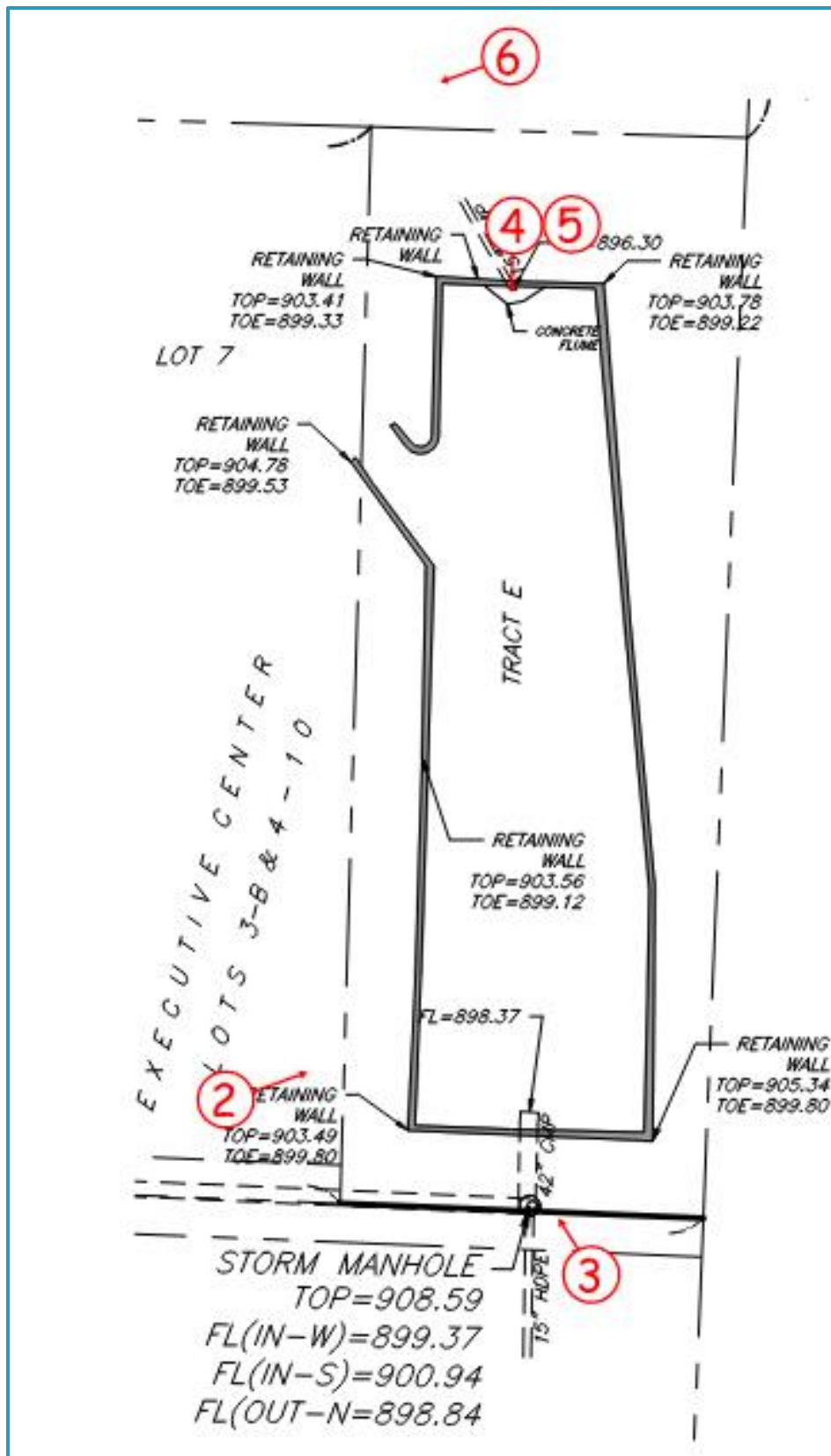


Figure 1 - Detention Basin Plan View



Figure 2 - Detention Basin, Looking Northeast



Figure 3 - Detention Basin Inlet Manhole Cover, Looking North/Northwest



Figure 4 - Detention Basin, Looking North



Figure 5 - Detention Basin Outlet Pipe



Figure 6 - Detention Basin Outlet North of Bowlin Road

GLMV Architecture



Derick Holmes, PE
Civil Engineer

DMH/cmv

c: 18225R21001

APPENDIX D

TECHNICAL REFERENCES

D.1 - SECTION 5600 – STORM DRAINAGE SYSTEMS & FACILITIES, CITY OF LEE'S SUMMIT, MO DESIGN CRITERIA	PAGE #
D.2 - SELECT PAGES, APWA SECTION 5600	D2
D.3 - CITY OF LEE'S SUMMIT WATERSHED & OUTFALL MAP	D6
D.4 - NOAA POINT PRECIPITATION DATA	D32
D.5 - SELECT PAGES, NRCS WEB SOIL SURVEY	D34
	D39

APPENDIX D.1

SECTION 5600 – STORM DRAINAGE SYSTEMS & FACILITIES, CITY OF LEE'S SUMMIT, MO DESIGN CRITERIA

**SECTION 5600 - STORM DRAINAGE SYSTEMS & FACILITIES
CITY OF LEE'S SUMMIT, MISSOURI
DESIGN CRITERIA**

This is Lee's Summit, Missouri's supplement to Section 5600 of the Kansas City Metropolitan Chapter of APWA Design Criteria, current edition. The following additions, deletions and/or revisions are adopted as a part of Section 5600 for use within Lee's Summit, Missouri.

5601.5 System Types and Applications, Under A. General Guidelines:

DELETE the fourth paragraph and REPLACE it with the following:

The engineered drainage system shall begin where the tributary area reaches 2 acres.

Table 5601-1: Level of Service for Street Crossings

CHANGE Minimum Design Storm Capacity for Arterial Streets to the following:
"1%".

CHANGE Minimum Design Storm Capacity for Collector Streets to the following:
"2%".

ADD the following note at the bottom of Table 5601-1:

"Water backing up onto adjacent properties for 1% storm capacity will require an inundation (drainage) easement."

5601.5.A.4.a Default Strategy: Comprehensive Protection

Delete this section in its entirety and insert the following:

"The City has adopted the Default Strategy: Comprehensive Protection method. Under this strategy, peak runoff control will be required for the 1%, 10%, and 50% annual chance storm event. Peak runoff control is required where there are known downstream flooding problems or where an increase in the peak runoff from a development has the potential to create flooding of property, structures, stormwater infrastructure, roads, bridges, and dams. Under this strategy, 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. Volumetric and/or extended detention control of the 90% mean annual event storm shall be implemented for all sites unless otherwise exempt by Section 5601.3. Performance standards and sizing criteria are provided in Section 5608."

5601.8.A. Protection of Property

ADD the following subparagraphs 3 and 4.

3. Master Drainage Plans

To address level of service issues on an individual building lot basis, the Developer shall submit a Master Drainage Plan with the engineering plans for each development. The plan shall cover all

portions of the development whether it is to be developed as single or multiple final plats, and shall cover all areas outside of the existing or proposed public rights-of-way. All lots must be graded in accordance with the approved Master Drainage Plan to the extent that swales, channels, diversion berms and grading activities are provided to establish the overall drainage patterns. The Master Drainage Plan is not intended to replace good lot grading practices during construction, but rather to establish overall drainage patterns for each lot and the development as a whole. Information on the plan shall include, but not be limited to, the following.

- a. Overall drainage map, including off-site tributary areas contributing to the runoff in the development.*
 - b. Existing and proposed contours at two-foot or smaller contour intervals.*
 - c. Property boundary, lot lines and numbers, and streets.*
 - d. Location(s) of all existing and proposed swales and channels, either natural or improved, along with design flows, typical sections, details, upstream and downstream elevations, and approximate slope.*
 - e. Limits of regulatory floodplain, where applicable.*
 - f. Limits of 1% storm water surface elevation for all swales and channels not within regulatory floodplain.*
 - g. Required buffer zones for natural streams.*
 - h. The elevation of the minimum, or lowest, building opening elevation (MBOE) for each lot. If a lot is adjacent to or contains a designated swale or channel, the MBOE must be set at the 1% water surface elevation plus two feet. If there is significant change in elevation along a swale or channel, as determined by the City Engineer, multiple MBOEs may be required for different sides of the building.*
 - i. Lots where walkout basements and daylight basement plans will be allowed.*
 - j. Finished elevations at all corners of each lot with a minimum of four elevations per lot.*
- 4. The Developer shall include on the plats for the development covered by the Master Drainage Plan, a restriction that the individual lot owner(s) shall not change or obstruct the overall drainage flow lines or paths on the lots, as shown on the Master Drainage Plan, unless specific application is made and approved by the City Engineer.*

Section 5603.1 Hydraulic Calculation for Pipes, Culverts, and Open Channels

Add the following:

“Enclosed systems will use the open channel, or gravity, flow design method for the appropriate design storm.”

5604.1.B Inlet Design - Type

REVISE the dimension for opening length as follows:

Opening length, inside 4.0 ft (min), 8.0 ft. (max)

5604.1.C Inlet Design – Design Method

REVISE references to Figures 5604-37 and 5604-38 to *Figures 5604-19 and 5604-21 respectively.*

ADD the following sentences to the paragraph:

Figures 5604-2 through 5604-19 apply to a curb inlet with a 10-inch throat opening height, similar to Standard Drawing CI-2. For curb inlets with different opening heights, specific design calculations must be submitted.

5604.1 Inlet Design

Add the following as Paragraph D:

D. Location: Curb inlets shall not be located in the radius of two intersecting streets. Maximum spacing of inlets shall be 400 feet.

Section 5608.7.B Additional Requirements, Underground Storage

Add the following:

“Underground detention systems typically allow some storage volume for voids in open-graded aggregate backfill around the storage chambers. Industry standard assumes the aggregate has 40% voids in the aggregate; the City will allow up to 30% voids in the aggregate. Storage in aggregate voids may be further reduced based on design conditions, maintenance programs, site conditions, etc. The Design Engineer will provide a maintenance program for underground detention systems to ensure the system will continue to function as intended.”

Table 5603-1

Add the following under Closed Conduits

High Density Polyethylene Pipe (HDPE)	0.010
---------------------------------------	-------

Section 5605.7.E Culverts, Bridges, and Above Grade Crossings

Delete the last sentence and replace with the following:

“Culverts shall be designed so the headwater to opening dimension ratio (i.e., generally referred to as HW/D) is no greater than 1.5 for the 4% design storm. All other design parameters, including the requirement that the 1% water surface elevation within the unregulated, non-special flood hazard area remain unchanged on adjacent properties unless appropriate easements are obtained, shall apply.”

Section 5605.10 Floodplain Fills

Delete the entire paragraph and replace with the following:

“Fills placed within areas designated as special flood hazard areas by the Federal Emergency Management Agency (FEMA) shall comply with the City of Lee’s Summit Unified Development Ordinance (UDO) “Floodplain Overlay District”. Fills placed outside these limits shall not cause a rise in the 1% water surface elevation beyond the limits controlled by the developer or owner, unless appropriate easements have been obtained from adjacent property owners.”

APPENDIX D.2

SELECT PAGES, APWA SECTION 5600

DIVISION V

SECTION 5600

STORM DRAINAGE SYSTEMS & FACILITIES

(February 16, 2011)

[DMH 4.20.2021] - ALL ADDITIONS, DELETIONS, AND REVISIONS
TO THIS DOCUMENT ARE PER CITY OF LEE'S SUMMIT DESIGN
CRITERIA, REVISED JULY 2020

DIVISION V
DESIGN CRITERIA
SECTION 5600 STORM DRAINAGE SYSTEMS & FACILITIES

SECTION 5601 ADMINISTRATIVE

5601.1 Introduction

These criteria provide uniform procedures for designing and checking the design of storm drainage systems under the rainfall and land characteristics typical of the Kansas City Metropolitan Area. This manual generally focuses on water quantity concerns including: conveyance, flow rates, and construction design parameters of stormwater systems. For an in-depth discussion of water quality design standards and Best Management Practices (BMPs) for the Kansas City Metropolitan area see the “Mid-America Regional Council and American Public Works Association; Manual for Best Management Practices for Stormwater Quality”.

Federal law requires that “Waters of the United States may be disturbed only after permission is received from the City/County and permitted by the U.S. Army Corps of Engineers, if applicable. A jurisdictional determination by the U.S. Army Corps of Engineers shall be obtained prior to beginning design.” Besides federal guidelines, specific criteria have been developed and are applicable to the types of drainage systems and facilities ordinarily encountered in local urban and suburban areas. Other special situations may be encountered that require added criteria or more complex technology than included herein such as maintaining or improving water quality. Any design procedure conforming to current accepted engineering practice may be used for the design of storm drainage systems in lieu of the computation methods presented in this manual, providing equivalent results are obtained and have been approved by the City/County Engineer. Drainage systems for all developments shall be designed assuming ultimate or built-out land-use conditions. The decision flowchart in Figure 5601-1, “Guide to Stormwater Management for Site Development”, shall be used to determine the appropriate runoff controls (see end of this section).

5601.2 Definitions

Best Management Practice (BMP): Stormwater management practice used to prevent or control the discharge of pollutants to water of the U.S. BMPs may include structural or non-structural solutions, a schedule of activities, prohibition of practices, maintenance procedures, or other management practices. For a comprehensive discussion on BMPs refer to the “Mid-America Regional Council and American Public Works Association; Manual for Best Management Practices for Stormwater Quality”.

City/County: The municipality or body having jurisdiction and authority to govern.

City/County Engineer: The municipal or county public works official or body having jurisdiction and authority to review and approve plans and designs for storm drainage systems.

Channel Lining: Includes any type of material used to stabilize the banks or bed of an engineered channel.

Design Storm: The combination of rainfall depth, duration, and distribution of a hypothetical rainfall event with a given likelihood of occurring in any year.

Detention Facility: A storm water management facility controlling storm water runoff from a site or watershed. The allowable runoff specified for detention facilities in Section 5608 is intended to manage maximum storm water release rates to minimize flooding and downstream erosion.

Detention Storage: The volume occupied by water above the level of the principal spillway crest during operation of a stormwater detention facility.

5601.3 General Requirements and Applicability

The design shall be accomplished under the direction of a Registered Professional Engineer qualified in the field of stormwater design. The design shall be based on land use in the tributary area as zoned, actually developed, or indicated by an adopted future land use plan, whichever basis produces the greatest runoff.

This design criterion shall apply to all development, including subdivision, which alters the surface of the land to create additional impervious surfaces, including, but not limited to, pavement, buildings, and structures with the following exceptions:

A. Redevelopment, Expansion, Renovation, Repair and Maintenance Activities Listed Below

1. Additions to, improvements, and repair of existing single-family and duplex dwellings.
2. Remodeling, repair, replacement, or other improvements to any existing structure or facility and appurtenances that does not cause an increased area of impervious surface on the site.
3. Remodeling, repair, replacement or other improvements to any existing structure or facility and appurtenances on sites smaller than two acres that does not cause an increased area of impervious surface on the site in excess of 10 percent of that previously existing.
4. Remodeling, repair, replacement, or other improvements to any existing structure or facility and appurtenances that does not cause an increased area of impervious surface on the site in excess of 10 percent of that previously existing, provided the total impervious area of the site is less than 5,000 square feet. (See "Site Planning for Urban Stream Protection" provided by the "Center for Watershed Protection" for a discussion on imperviousness and its effect on watershed health; <http://www.cwp.org/SPSP/TOC.htm>).

B. New Construction Meeting the Following Criteria

1. Construction of any one new single family or duplex dwelling unit, irrespective of the site area on which the structure may be situated, provided the total impervious area of the site is less than 5,000 square feet.
2. Construction of any buildings, structures, and/or appurtenant service roads, drives, and walks on a site having previously provided stormwater management, as defined in Section 5601.5 A4 as part of a larger unit of development, OR a site previously relieved of stormwater management requirements.

5601.4 Existing Drainage System

Existing drainage system component pipes, structures, and appurtenances within the project limits may be retained as elements of an improved system providing:

- They are in sound structural condition.
- Their hydraulic capacity, including surcharge, is equal to or greater than the capacity required by these criteria.
- Easements exist or are dedicated to allow operation and maintenance.

Discharge from an existing upstream storm drainage system shall be computed assuming its capacity is adequate to meet the performance criteria listed in Section 5601.8. The computed discharge shall be used to design the new downstream system even if the actual capacity of the existing upstream system is less.

5601.5 System Types and Applications

- A. **General Guidelines:** Natural channels are to be preserved to the maximum extent practicable as site conditions permit. Design standards for natural channels are addressed in Section 5605. Engineered channels, the next highest priority system component, shall be designated and coordinated with the design

of building lots and streets in accordance with the design criteria and performance standards addressed in section 5607.

To the maximum extent possible, drainage systems, street layout and grades, lot patterns and placement of curbs, inlets and site drainage, and overflow swales shall be concurrently designed in accordance with the design criteria and performance standards set forth in this document. Curb and gutter may be omitted or modified where approved by the City/County Engineer and deemed feasible in conjunction with other stormwater management practices including water quality BMPs.

Enclosed conveyance systems consisting of inlets, conduits, and manholes may be used to convey stormwater runoff where site conditions and open space requirements will not permit the use of natural or engineered channels. Where used, such systems must be designed in accordance with design criteria and performance standards addressed in section 5606.

Generally, a drainage system is engineered and constructed when the drainage area exceeds 2 acres.

1. **Open Systems:** Where feasible, open systems consisting of open or engineered channels shall be used if all of the following design criteria and the conditions of Section 5601.8 are met:
 - a. The channel slope is less than or equal to 5 percent or where appropriate armoring techniques are used to prevent erosion.
 - b. The 50% storm velocity is less than or equal to 5 feet per second (fps) or where appropriate armoring techniques are used to prevent erosion.
 - c. When 60 feet or farther away from top of bank to any existing or proposed habitable building, regardless of system design capacity.
2. **Enclosed Systems:** Enclosed systems consisting of underground pipes, culverts, and similar underground structures shall be used to convey stormwater at all locations whenever one of the following design criteria and the conditions of 5601.8 are met:
 - a. Where natural channels or open systems are not feasible per the requirements set forth in Section 5605 and Section 5601.5-A1
 - b. Within the right-of-way of streets with curbs, regardless of system design capacity.
3. **Overflow Systems:** Each conveyance element of the stormwater drainage system (whether open, enclosed, or detention) shall include an overflow element. Overflow systems shall:
 - a. Be designed to route downstream any amount of the 1% storm exceeding the in-system design capacity specified in Section 5601.8.
 - b. Include streets, engineered channels, redundant piping, spillways, parking lots, drives or combinations thereof.
 - c. Limit the maximum water surface elevation generated by the 1% storm as specified in Section 5601.8.
 - d. Conform to local standards regarding dedicated easements and/or restricted uses for overflow systems; consult with the local authority for requirements.
 - e. Be limited to the natural drainage basins, unless overflows transferred out of a natural drainage basin (e.g. a thoroughfare straight-graded through a drainage basin with a sump in another drainage basin) are added to the overflows in the receiving drainage basin and the combined overflow still meets the criteria at 5601.5 A 3C
4. **Stormwater Management:** New development or redevelopment as defined in Section 5601.2 shall incorporate stormwater management measures to control runoff from the site. Allowable runoff from a site may be limited by the need to minimize downstream flood damage, prevent erosion, and/or

minimize impacts to the ecology and water quality of the downstream drainage system. It is recognized for site-level runoff controls to be effective, consistent application across a watershed is necessary to realize measurable benefits along the downstream system. This section presents four site runoff control strategies that can be applied to sites within a watershed based on watershed protection goals and identified problems. The City/County or local authority shall pre-determine which strategy is to be applied within its watersheds or subsheds. If watershed control strategies are not defined by the local authority, the default strategy for new development shall be the Comprehensive Protection strategy.

a. Default Strategy: Comprehensive Protection

Under this strategy, peak runoff control is provided for the 1%, 10% and 50% chance storms and volumetric and/or extended detention control of the 90% mean annual event storm for broad protection of the receiving system, including channel erosion protection and flood peak reductions over a range of return periods. This strategy shall be the default strategy unless otherwise designated or approved by the local authority. Performance standards and sizing criteria are provided in Section 5608.

b. Reduced Control Strategies

1) **Frequent Event Control for Stream Erosion Protection:** This strategy provides runoff control for the 10% and 50% chance storms and volumetric and/or extended detention control of the 90% mean annual event storm in order to protect downstream channels from erosion. This strategy is appropriate for largely undeveloped watersheds containing natural streams where downstream flooding of existing structures is not present and would not occur under future upstream full-development conditions.

2) **Extreme Flood Event Control Only:** Under this strategy, detention is provided solely to reduce peak runoff rates for the 10% and 1% storm events. Over-detention of the peak release rates at the discharge point (i.e. requiring the post-development rate to be less than the pre-development rate) is used to ensure a cumulative benefit for a reasonable distance downstream. If known flooding occurs downstream in flood events more frequent than the 10% event, the local authority may require control of these events.

This strategy is not effective at protecting stream channels and banks from erosion. It is most applicable in certain redevelopment and in-fill situations where flooding problems are known, existing downstream stream conditions are already poor, and economic barriers to redevelopment preclude more extensive control.

3) **Special Locally-Defined Strategies:** The City/County may develop alternative strategies that are tailored to the unique circumstances of their watersheds. Such strategies may apply globally to the City/County or only to certain designated areas. The City/County will identify each alternative strategy with a unique descriptor and publish the requirements for each.

Such alternative strategies may involve increased or decreased allowable release rates, relaxed or more stringent controls for certain storm return intervals, reliance on infiltration or low-impact development practices for added volume control, planning and open space controls, and/or special requirements to participate in regional control facilities instead of development-scale facilities.

Stormwater management for site development may include structural facilities and/or non-structural solutions. Where runoff controls are required, low-impact development practices or, off-site control of runoff in addition to or instead of the standard wet or dry bottom basins may be used.

5601.6 Waivers

The Developer may submit a study by a registered professional engineer that quantifies the problems and demonstrates that a waiver (exemption) of the requirement to provide stormwater management is appropriate. The City/County Engineer may waive requirements to address *unique* conditions or constraints:

- A. **Stormwater Management Facilities:** Stormwater management facilities may be waived and/or release rates other than those permitted by Section 5608 when supported by a developer's Drainage Study performed in accordance with Section 5609 and approved by the City/County Engineer.
- B. **Overflow Channels:** In previously developed areas, requirements to provide for 1% storm conveyance may be reduced by the City/County Engineer in circumstances where flood protection for the 1% storm is not reasonably attainable due to the location of damageable improvements with respect to the drainage system and where non-attainment is supported by an approved Drainage Study.

5601.7 Other Requirements

Rules and regulations of other agencies also pertain to drainage systems which may or may not complement these criteria. When conflicts are encountered, the more stringent criteria shall govern.

The following agencies have jurisdiction over streams and/or drainage systems and often require permits. Other regulations, permits and requirements may not be limited to these agencies.

- Federal Emergency Management Agency.
- U.S. Army Corps of Engineers.
- Missouri Department of Natural Resources.
- Kansas Department of Agriculture – Division of Water Resources.
- Kansas Department of Health and Environment
- Municipal Ordinances.

5601.8 Levels of Service

Drainage systems shall be designed to meet all levels of service described below. In addition, natural streams include requirements specified in Section 5605.

A storm drainage system shall be provided that is capable of conveying the peak discharge generated by the 1% storm. If the in-system capacity established in this section is less the 1% storm peak discharge, then an overflow system as specified in Section 5601.5 -A-3 may provide the additional system capacity.

A. Protection of Property

1. Property not reserved or designed for conveying storm water shall be protected from frequent inundation:
 - a. When the total drainage area is less than 2 acres, protection may be provided by following good lot grading practices or by one of the conveyances described below.
 - b. When the total drainage area is 2 acres or more, one of the following conveyances must be used to convey the 10% storm:
 - 1) Pipe system conveying the design storm under a regime of pressure flow with no overflow at inlets or manholes, or
 - 2) An engineered open channel conveying the 10% storm at bank full
 - 3) A street gutter
 - 4) A natural stream

- d. Location(s) of all existing and proposed swales and channels, either natural or improved, along with design flows, typical sections, details, upstream and downstream elevations, and approximate slope.
- e. Limits of regulatory floodplain, where applicable.
- f. Limits of 1% storm water surface elevation for all swales and channels not within regulatory floodplain.
- g. Required buffer zones for natural streams.
- h. The elevation of the minimum, or lowest, building opening elevation (MBOE) for each lot. If a lot is adjacent to or contains a designated swale or channel, the MBOE must be set at the 1% water surface elevation plus two feet. If there is significant change in elevation along a swale or channel, as determined by the City Engineer, multiple MBOEs may be required for different sides of the building.
- i. Lots where walkout basements and daylight basement plans will be allowed.
- j. Finished elevations at all corners of each lot with a minimum of four elevations per lot.

4. The Developer shall include on the plats for the development covered by the Master Drainage Plan, a restriction that the individual lot owner(s) shall not change or obstruct the overall drainage flow lines or paths on the lots, as shown on the Master Drainage Plan, unless specific application is made and approved by the City Engineer.

2. Buildings shall be protected from infrequent flooding by:

- Providing a minimum of one-foot freeboard above the 1% storm stage, at any point along the drainage system, for openings in a building. For lakes and detention basins the 1% storm stage will be the water surface of flow through the emergency spillway.
- Flood-proofing a building below the 1% storm water surface elevation plus one foot of freeboard, in accordance with the current edition of the International Building Code or as required by the City/County.
- Non habitable accessory buildings are sometimes provided less protection by local City/County ordinances or policies. Consult the local authority for exceptions.

B. Protection for Streets

- Gutter Spread:** Water spread in streets shall meet the requirements in Section 5604.2 for the 10% design storm. These values are intended to establish a standard of accessibility for the widths (classes) of roadways listed during the 10% storm. When the local jurisdiction requires a higher standard for curb inlets, the conveyance system connected to the roadway must also meet that higher standard. If the roadway conveyance system connects to an underground system with lesser capacity, the system must be constructed to allow the discharge of that excess capacity into the overflow system.
- Street Crossings:** Concentrated flow not conveyed in the gutter system, shall be conveyed under streets to prevent vehicles from being swept from the roadway in infrequent storms. These crossings may be bridges, culverts or underground systems. A common practice is to construct the low point in the roadway so that it does not fall on the bridge or culvert. This practice protects the structure from damage in an overflow condition, but does not change this requirement. Crossings will be designed to completely convey flood flows without street overtopping in accordance with Table 5601-1.

Table 5601-1: Level of Service for Street Crossings

Street Classification	Min. Design Storm Capacity
Arterial	2% 1%
Collector	4% 2%
Residential	10%
Residential with open channel downstream	4%

* Water backing up onto adjacent properties for 1% storm capacity will require an inundation (drainage) easement.

Further, concentrated flow in excess of the minimum design storm may only overtop the roadway if the following conditions are met:

- The span of the structure opening is less than 20 feet.
- The peak stormwater runoff from the 1% storm is 250 cfs or less unless a guard fence is installed on the downstream side of the roadway.

Such overflow depths at low points in roadways during the 1% storm will be limited to 7 inches measured at the high point in the roadway cross section; except that it also shall not exceed 14 inches at the deepest point in the roadway cross section. Depths may be limited where necessary by reverse grading the downstream right of way area, by lengthening the vertical curve of the roadway, by reducing roadway crown, or by other similar means. Roadway overtopping depths shall be determined by integrating the broad crested weir formula across the roadway profile. Each incremental flow can be determined by using the formula:

$$q = C \cdot l \cdot h^{2/3}$$

Where:

- q = the flow for an increment of profile length (width of flow)
- l = the incremental width
- C = a flow coefficient that shall not exceed 3.0
- h = the average depth of flow at each increment

The total flow Q is the sum of the incremental flows. Depth determinations can be made through an iterative process where successive depths are chosen; Q is calculated for each depth and then compared to the known Q at the overtopping point.

Overflow protection criteria provides additional accessibility criteria at major stream crossings for emergency personnel, and provides the public with protection against injury and property damage.

C. Downstream Impacts

1. The negative impacts of development on flooding problems in the downstream system shall be mitigated through detention as specified in Section 5601.5-A-4, or through other means approved by the City/County.
 - a. Impacts on natural channels are regulated in Section 5605.
 - b. Communities that have adopted the recommended "Manual of Best Management Practices (BMPs) for Stormwater Quality" should also mitigate the negative impact of development on natural channels through the installation of water quality BMPs and closely adhere to practices specified in Section 5605 on natural channels.

D. Adjoining Property: State and Federal regulations often establish requirements for a storm drainage project that impacts adjoining property, especially when a project causes a rise in water surface elevations. In addition to all Federal and State regulations the following shall be met:

1. **Drainageways not designated a Special Flood Hazard Area (FEMA 1% Floodplain):** Construction of a storm drainage system, including grading and filling within a natural drainage way, requires agreement from adjoining property owners if the work will cause a rise in the water surface elevation on the adjoining property for the 1% storm. Agreement shall be considered granted by recording a document which reserves the affected property for inundation during the 1% storm, or by other means approved by the City/County.
2. **Drainageways designated a Special Flood Hazard Areas (FEMA 1% Floodplain) and City/County participates in the National Flood Insurance Program:** When impacting adjoining properties, refer to the local community's adopted Floodplain Management Ordinance for any requirements, in addition to all current FEMA regulation.

SECTION 5602 HYDROLOGY

5602.1 Scope

This section sets forth the hydrologic parameters to be used for computations involving the definition of runoff mass and peak rates to be accommodated by the storm drainage system. The methods to be used for calculating runoff mass and peak rates are intended for the design of drainage systems. Refer to the "Mid-America Regional Council and American Public Works Association; Manual for Best Management Practices for Stormwater Quality" for design methods and calculations of runoff water quality.

5602.2 Computation Methods for Runoff

Runoff rates to be accommodated by each element of the proposed storm drainage system shall be calculated using the criteria of this section for land use runoff factors, rainfall, and system time. The following methods of computations are allowed:

- A. Watersheds Less than 200 Acres:** The Rational Method may be used to calculate peak rates of runoff to elements of enclosed and open channel systems, including inlets, when the total upstream area tributary to the point of consideration is less than 200 acres. The Rational Method is defined as follows:

$$Q = K \cdot C \cdot i \cdot A$$

Where:

Q = Peak rate of runoff to system in cfs

C = Runoff coefficient as determined in accordance with Paragraph 5602.3

i = Rainfall intensity in inches per hour as determined in accordance with Paragraph 5602.6

K = Dimensionless coefficient to account for antecedent precipitation as follows, except the product of C·K shall not exceed 1.0. See Table 5602-1.

Table 5602-1: Antecedent Coefficient

Design Storm	K
10% and more frequent	1.0
4%	1.1
2%	1.2
1%	1.25

- B. Baseline Unit Hydrograph Method:** The following computer implementations of the unit hydrograph method are acceptable for all watersheds:

- SCS Technical Release No. 55 "Urban Hydrology for Small Watersheds", 2nd Edition, June 1986.
- 2. SCS Technical Release No. 20 "Project Formulation - Hydrology", 2nd Edition, May 1983.
- 3. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-1Flood Hydrograph Package".
- 4. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-HMS Hydrologic Modeling System", current version.

Copies of the above publications and micro-computer programs based thereon are available for purchase through National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

Table 5602-2 Documented Extreme Stream Flows in Kansas City Area and Surrounding Region

ID No.	USGS Station Number	Station Name	Contributing Drainage Area (sq. miles)	Date of Max. Discharge	Max. Recorded Discharge (cfs)	Max. Discharge per Basin Area (cfs/acre)	Period of Record (Water Yr.)	References
45.	--	Stratton Creek near Washta, Iowa	1.9	9-Aug-61	11,000	9.0	--	2
46.	--	West Fork Big Blue River trib. near York, Nebr.	6.9	9-Jul-50	23,000	5.2	--	2
47.	08057140	Cottonwood Creek at Forest Lane, Dallas, Tx.	8.5	28-Apr-66	17,600	3.2	1962-78	5,7
48.	--	Ranch Creek near Halley, Okla.	17.1	4-Sep-40	32,400	3.0	--	2

References Cited:

1. Alexander and Wilson. Technique for Estimating the 2-to 500-Year Flood Discharges on Unregulated Streams in Rural Missouri. USGS WRIR 95-4231. 1995
2. Crippen and Bue. Maximum Floodflows in the Conterminous United States. USGS WSP 1887. 1977.
3. Hauth. Floods in Kansas City, Missouri and Kansas, September 12-13, 1977. USGS Prof. Paper 1169. 1981.
4. Rasmussen and Perry. Estimate of Peak Streamflows for Unregulated Rural Streams in Kansas. USGS WRIR 00-4079. 2000.
5. Sauer et al. Flood Characteristics of Urban Watersheds in the United States. USGS WSP 2207. 1983.
6. USGS. Kansas-Missouri - Floods of July 1951. USGS WSP 1139. 1952.
7. USGS. Surface-Water Data for the Nation. Peak flow database at <http://waterdata.usgs.gov/nwis/sw>. Queried January 2003.

5602.3 Runoff Coefficients

- A. Basis of Curve Number Coefficients:** All Curve Number coefficients in this section are values for Hydrologic Group "C" soils. For soils in other Hydrologic Groups, equivalent SCS Curve Numbers can be found in SCS Technical Release No. 55. No soil disturbed by construction shall be assigned a Hydrologic Group classification of 'A' or 'B'.
- B. Standard Land Use/Zoning Classifications:** Runoff Coefficients relative to development, undeveloped land and land use shall have the values indicated in Table 5602-3.

Table 5602-3: Runoff Parameters

Land Use / Zoning	Average Percent Impervious	Average Percent Pervious	Rational Method "C"	SCS Curve Number
Business				
Downtown Area	95	5	0.87	97
Neighborhood Areas	85	15	0.81	94
Residential				
Single Family Areas	35	65	0.51	82
Multifamily Areas	60	40	0.66	88
Churches & Schools	75	25	0.75	92

Table 5602-3: Runoff Parameters

Land Use / Zoning	Average Percent Impervious	Average Percent Pervious	Rational Method "C"	SCS Curve Number
Industrial				
Light Areas	60	40	0.66	88
Heavy Areas	80	20	0.78	93
Parks, Cemeteries	10	90	0.36	76
Railroad Yard Areas	25	75	0.45	80
Undeveloped Areas	0	100	0.30	74
All Surfaces				
Impervious: Asphalt, Concrete, Roofs, etc.	100	0	0.90	98
Turfed	0	100	0.30	74
Wet Detention Basins	100	0	0.90	98

- C. Rational Method "C" for Non-Standard Land Use/Zoning Classifications:** The "C" value can be calculated from any type of land use and known percent impervious surface from the following equation:

$$C = 0.3 + 0.6 \cdot I$$

Where:

I = percent impervious divided by 100

- D. Un-zoned, but Master Planned Areas:** Areas whose future land use is defined by an adopted land use plan shall be assigned runoff coefficients for the land use indicated on such plan.
- E. Agricultural and Unplanned Areas**
- Existing Conditions:** For purposes of determination of development impact, undeveloped areas whose current land use is agriculture (crops, pasture, meadow) shall be assigned a maximum of 0% impervious surface or a maximum Curve Number equivalent to good condition pasture, grassland or range ($C=0.30$, $CN=74$).
 - Proposed Conditions:** Undeveloped areas designated as agricultural or those areas for which no specific land use is indicated shall be assigned a minimum of 35% impervious surface for purposes of the design of storm drainage systems ($C=0.51$, $CN = 82$).
- F. Composite Coefficients:** As an alternative to the above coefficients and for areas not listed above (office parks, shopping centers, trailer parks, etc.), a composite runoff coefficient based on the actual percentages of pervious and impervious surfaces shall be used.

5602.4 Rainfall Mass

The U.S. Soil Conservation Service (SCS) Type 2 twenty-four hour rainfall distribution shall be used for all computations that employ the use of rainfall mass. That rainfall distribution is reproduced in Table 5602-4.

Table 5602-4: Rainfall Mass

TOTAL RAINFALL DEPTH
ACQUIRED FROM NOAA
POINT PRECIPITATION
FREQUENCY TABLES

Time in Hours	Accumulated Rainfall in Percent of 24-hour Rainfall
0.0	0.00
2.0	2.20
4.0	4.80
6.0	8.00
8.0	12.00
9.0	14.70
9.5	16.30
10.0	18.10
10.5	20.40
11.0	23.50
11.5	28.30
11.75	38.70
12.0	66.30
12.5	73.50
13.0	77.20
13.5	79.90
14.0	82.00
16.0	88.00
20.0	95.20
24.0	100.00

5602.5 Unit Hydrographs

The SCS Dimensionless Unit Hydrograph (either curvilinear or triangular) shall be the basis for computation of runoff hydrographs.

5602.6 Rainfall Intensity

Rainfall intensity shall be determined from Figure 5602-1 or Table 5602-5 using a calculated Time of Concentration.

Table 5602-5: Design Aide for Calculating Rainfall Intensity Kansas City
Metropolitan Area

Return Period	Equation 1	Equation 2
	$5 \leq T_c \leq 15$	$15 < T_c \leq 60$
2 yr.	$i = \frac{119}{T_c + 17}$	$i = \frac{134}{T_c + 21.4}$
5 yr.	$i = \frac{154}{T_c + 18.8}$	$i = \frac{182}{T_c + 25}$

Table 5602-5: Design Aide for Calculating Rainfall Intensity Kansas City Metropolitan Area

Return Period	Equation 1	Equation 2
	$5 \leq T_c \leq 15$	$15 < T_c \leq 60$
10 yr.	$i = \frac{175}{T_c + 18.8}$	$i = \frac{214}{T_c + 26.7}$
25 yr.	$i = \frac{203}{T_c + 18.8}$	$i = \frac{262}{T_c + 28.8}$
50 yr.	$i = \frac{233}{T_c + 19.8}$	$i = \frac{296}{T_c + 29.6}$
100 yr.	$i = \frac{256}{T_c + 19.8}$	$i = \frac{331}{T_c + 30}$

5602.7 Time of Concentration and Lag Time

Time of Concentration (T_C) is equal to the overland flow time to the most upstream inlet or other point of entry to the system, Inlet Time (T_I), plus the time for flow in the system to travel to the point under consideration, Travel Time (T_T).

$$T_C = T_I + T_T$$

- A. Inlet Time:** T_I shall be calculated by the following formula or determined graphically from Figure 5602-2, but shall not be less than 5.0 minutes nor greater than 15.0 minutes:

$$T_I = 1.8 \cdot (1.1 - C) \cdot \frac{D^{1/2}}{S^{1/3}}$$

Where:

T_I = Inlet Time in minutes

C = Rational Method Runoff Coefficient as determined in accordance with paragraph 5602.3

D = Overland flow distance parallel to slope in feet (100 feet shall be the maximum distance used for overland flow)

S = Slope of tributary area surface perpendicular to contour in percent.

"Enclosed systems will use the open channel, or gravity, flow design method for the appropriate design storm."

SECTION 5603 HYDRAULICS

5603.1 Hydraulic Calculations for Pipes, Culverts, and Open Channels

- A. Gravity versus Pressure Flow for Enclosed Systems:** Two design philosophies exist for sizing storm drains under the steady uniform flow assumption. The first is referred to as open channel, or gravity flow design, in which the water surface within the conduit remains open to atmospheric pressure. Pressure flow design, on the other hand, requires that the flow in the conduit be at a pressure greater than atmospheric. For a given flow rate, design based on open channel flow requires larger conduit sizes than those sized based on pressure flow. While it may be more expensive to construct storm drainage systems designed based on open channel flow, this design procedure provides a margin of safety by providing additional headroom in the conduit to accommodate an increase in flow above the design discharge. Under most ordinary conditions, it is recommended that storm drains be sized based on a gravity flow criteria at full flow or near full. Pressure flow design may be justified in certain instances. As hydraulic calculations are performed, frequent verification of the existence of the desired flow condition should be made.

Storm drainage systems can often alternate between pressure and open channel flow conditions from one section to another (U.S. Department of Transportation Federal Highway Administration, 1996).

For gravity flow conditions, Manning's formula shall be used as described below.

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where:

Q = Discharge, cubic feet per second

A = Cross sectional area of flow, square feet

n = Manning's roughness coefficient (see Table 5603-1)

R = Hydraulic radius, feet

$$R = \frac{A}{P}$$

S = Slope in feet per foot

P = Wetted perimeter in feet

In closed conduits flowing under pressure flow, the energy grade line (EGL) will be above the crown of the pipe. In this case, the Bernoulli equation shall be used to calculate pipe capacity:

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_f + h_m$$

Where:

$\frac{p_1}{\gamma}$ = pressure head in the upstream system segment, feet

$\frac{V_1^2}{2g}$ = velocity head in the upstream system segment, feet

z_1 = elevation of the system invert in the upstream system segment, feet

$\frac{p_2}{\gamma}$ = pressure head in the upstream system segment, feet

$\frac{V_2^2}{2g}$ = velocity head in the upstream system segment, feet

z_2 = elevation of the system invert in the upstream system segment, feet

h_f = friction loss in the downstream system segment in feet

h_m = minor system losses in the downstream segment in feet

Pipe friction losses, h_f , may be calculated the friction slope method.

B. Friction Slope Method

This derivation of Manning's equation is from (FHWA, 1996).

$$h_f = S_f L$$

$$S_f = \frac{(Q \cdot n)^2}{\left(1.486 A \cdot R^{\frac{2}{3}}\right)^2}$$

S_f = friction slope, feet/foot (which is also the slope of the HGL)

Minor losses, h_m , shall be calculated by:

$$h_m = k \cdot \frac{v^2}{2g}$$

Where:

k = Coefficient as shown in Table 5603-2

A step-by-step procedure for manual calculation of the EGL using the energy loss method is presented in Section 7.5 of (FHWA, 1996). For most drainage systems, computer methods such as HYDRA, StormCAD, CulvertMaster, or SWMM are the most efficient means of evaluating the EGL and designing the system elements.

Table 5603-1: Manning's Roughness Coefficient

Type of Channel	n
Closed Conduits	
Reinforced Concrete Pipe (RCPs)	0.013
Reinforced Concrete Elliptical Pipe	0.013
Corrugated Metal Pipe (CMPs):	
2 $\frac{2}{3}$ x $\frac{1}{2}$ in. Annular or Helical Corrugations unpaved - plain	0.024
2 $\frac{2}{3}$ x $\frac{1}{2}$ in. Annular or Helical Corrugations paved invert	0.021
3x1 in. Annular or Helical Corrugations unpaved - plain	0.027
3x1 in. Annular or Helical Corrugations paved invert	0.023
6x2 in. Corrugations unpaved - plain	0.033
6x2 in. Corrugations paved invert	0.028
24" diameter and smaller with Helical Corrugations.*	0.020
Vitrified Clay Pipe	0.013
Asbestos Cement Pipe	0.012
High Density Polyethylene Pipe (HDPE)	0.010
Open Channels (Lined)	
Gabions	0.025
Concrete	
Trowel Finish	0.013

Table 5603-1: Manning's Roughness Coefficient

Type of Channel	n
Float Finish	0.015
Unfinished	0.017
Concrete, bottom float finished, with sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble masonry	0.025
Dry Rubble or Riprap	0.030
Gravel bottom, side of	
Random Stone	0.023
Riprap	0.033
Grass (Sod)	0.030
Riprap	0.035
Grouted Riprap	0.030
Open Channels (Unlined) Excavated or Dredged	
Earth, straight and uniform	0.027
Earth, winding and sluggish	0.035
Channels, not maintained, weeds & brush uncut	0.090
Natural Stream	
Clean stream, straight	0.030
Stream with pools, sluggish reaches, heavy underbrush	0.100
Flood Plains	
Grass, no brush	0.030
With some brush	0.090
Street Curbing	0.014

*Allowed only when the pipe length between structures is at least 20 pipe diameters.

Table 5603-2: Head Loss Coefficients

Condition	k
Manhole, junction boxes and inlets with shaped inverts:	
Thru flow	0.15
Junction	0.40
Contraction transition	0.10
Expansion transition	0.20
90 degree bend	0.40
45 degree and less bends	0.30
Culvert Inlets:	
Pipe, Concrete	
Projecting from fill, socket end (groove end)	0.20

Table 5603-2: Head Loss Coefficients

Condition	k
Projecting from fill, sq. cut end	0.50
Headwall or headwall and wingwalls	
Socket end of pipe (groove end)	0.20
Square edge	0.50
Round (radius=1/12D)	0.20
Mitered to conform to fill slope	0.70
Standard end section	0.50
Beveled edges, 33.7° or 45° bevels	0.20
Side or slope-tapered inlet	0.20
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.90
Headwall or headwall and wingwalls square edge	0.50
Mitered to conform to fill slope, paved or unpaved slope	0.70
Standard end section	0.50
Beveled edges, 33.7° or 45° bevels	0.20
Side or slope-tapered inlet	0.20
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square edged on 3 edges	0.50
Rounded on 3 edges to radius of 1/12 barrel dim. or beveled edges on 3 sides	0.20
Wingwalls at 30° to 75° to barrel	
Square edged at crown	0.40
Crown edge rounded to radius of 1/12 barrel dimension or beveled top edge	0.20
Wingwalls at 10° to 25° to barrel - square edged at crown	0.50
Wingwalls parallel (extension of sides) - square edged at crown	0.70
Side or slope-tapered inlet	0.20

Note: When 50 percent or more of the discharge enters the structure from the surface, "k" shall be 1.0.

C. Culverts: Classified as having either entrance or outlet control. Either the inlet opening (entrance control), or friction loss within the culvert or backwater from the downstream system (outlet control) will control the discharge capacity.

- 1. Entrance Control:** Entrance control occurs when the culvert is hydraulically short (when the culvert is not flowing full) and steep. Flow at the entrance would be critical as the water falls over the brink. If the tailwater covers the culvert completely (i.e., a submerged exit), the culvert will be full at that point, even though the inlet control forces the culvert to be only partially full at the inlet. The transition from partially full to full occurs in a hydraulic jump, the location of which depends on the flow resistance and water levels. If the flow resistance is very high, or if the headwater and tailwater levels are high

SECTION 5604 INLETS, MANHOLES AND JUNCTION BOXES

5604.1 Inlet Design

- A. **Type:** Only curb opening inlets shall be used on public streets, except as approved by the City/County Engineer.
- B. **Configuration:** These minimum dimensions (shown in Table 5604-1 and illustrated by Figure 5604-1) apply to either the lazy-back or steep-face type curbs:

Table 5604-1: Inlet Configuration Dimensions

Description	Dimension
Opening length, inside	4.0 ft (min), 8.0 ft. (max)
Width, perpendicular to curb line, inside	3.0 ft (min)
Setback curb line to face	1.0 ft (min)
Opening, clear height	6.0 in. (min)
Gutter depression at inlet	6 ¼ in. (min)
Gutter transition length	
(a) Both sides in sump and upstream side on slopes	5.0 ft (min)
(b) Downstream on slopes	3.0 ft (min)

5604.1.C Inlet Design - Design Method -- > [DMH 4.20.2021] I couldn't find these references.

REVISE references to Figures 5604-37 and 5604-38 to Figures 5604-19 and 5604-21 respectively.

- C. **Design Method:** Inlets should be designed using the methods prescribed in Section 5604.8 and/or Figures 5604-2 through 5604-19. Note that the Theoretical Captured Discharge (right side of chart) is the design capacity, 80 percent clogging factor should not be used for inlets on grade, unless deemed necessary by the engineer. Figures 5604-2 through 5604-19 describe inlet efficiency as a function of street slope (See Figure 5604-3 for design example) and in most cases will require the designer to add bypassed flow to the next downstream inlet. Figure 5604-21 describes inlet capacity for sump regions using HEC-22 equation 4-31a. Inlet capacity for sump regions shall be rated at 80 percent of the theoretical capacity to allow for partial obstruction and clogging. "Type CG-2 Curb" and "Type CG-1 Curb", as indicated on these figures, refers to the lazy-back and steep-face style curbs, respectively.

Figures 5604-2 through 5604-19 apply to a curb inlet with a 10-inch throat opening height, similar to Standard Drawing C1-2. For curb inlets with different opening heights, specific design calculations must be submitted.

5604.2 Gutter Flow

D. **Location:** Curb inlets shall not be located in the radius of two intersecting streets. Maximum spacing of inlets shall be 400 feet.

Inlets shall be located to limit the width of flow in street gutters at the time of peak discharge for the design storm specified in 5601.8 B to the limits indicated in Table 5604-2.

Table 5604-2: Gutter Spread Criteria

Back to Back of Curb Street Width (feet)	Maximum Allowable Spread in Each Outside Curb Lane from Back of Curb* (feet)
28 or Less	12.0
Over 28 to 36	12.0
Over 36	12.0
Divided Roadways	As above for each direction roadway

* spread may exceed these limits within 50 feet of a sump inlet.

In addition to the inlet spacing requirements for limiting width of flow, inlets shall be located to limit gutter flow from crossing the street centerline at the time of peak discharge for the design storm to the limits shown in Table 5604-3.

Table 5604-3: Inlet Bypass Spread Criteria

Condition Causing Flow Crossing Street Centerline	Maximum Discharge (cfs)
Sump at intersection return*	1.0
Transitions to superelevation	1.0
Sump at midblock	Not Allowed
Overflow of non-gutter flow	Per 5601.8.B

* For new development, inlets at intersections shall be positioned outside the curb return.

5604.3 Gutter Capacity

Izzard's Formula shall be used to determine gutter capacity (see Figure 5604-20 for graphical solution):

$$Q = \frac{0.56z \cdot S^{1/2} \cdot D^{8/3}}{n}$$

Where:

- Q = The gutter capacity in cubic feet per second
- z = The reciprocal of the average cross-slope, including gutter section, in feet per foot
- S = The longitudinal street grade in feet per foot
- D = The depth of flow at curb face in feet
- n = Manning's "n" (see Table 5603-1)

5604.4 Freeboard Requirements

Any opening which surface water is intended to enter (or may backflow from) the system shall be 0.5 feet or more above the hydraulic grade line in the inlet during the design storm, specified in Section 5601.8, where such calculation must include minor losses.

5604.5 Inverts and Pipes

The crown(s) of pipe(s) entering a drainage structure shall be at or above the crown of the pipe exiting from the structure and provide a minimum fall of the invert in the structure of 0.2 feet for straight flow through the structure or 0.5 feet fall for all other types of flow (bends more than 22.5 deflection angle, multiple lines entering, enlargement transition, etc.) through the structure. The desirable minimum fall across the invert is 0.5 feet. Alternatively, the crowns of the pipes may be at or above the EGL of normal flow at design frequency.

The maximum spacing between manholes shall be 500 feet.

5604.6 Loading Conditions for Structures

Loading shall be in accordance with Section 5710.3.

5604.7 Street Grade on Vertical Curves

The following formula shall be used to determine the street grade (S_x) at any point on a vertical curve using plus for grades ascending forward and minus for grades descending forward, in feet per foot.

$$S_x = S_1 + \frac{x \cdot (S_2 - S_1)}{L}$$

Where:

S_x = the street grade on a vertical curve at point x, in feet per foot

S_1 = the street grade at the PC of a vertical curve, in feet per foot

S_2 = the street grade at the PT of a vertical curve, in feet per foot

x = the distance measured from the PC to point x on a vertical curve, in feet

L = the total length of a vertical curve, in feet

5604.8 Curb Inlet Intercept Equations¹

- A. For any given set of conditions (curb type, inlet length, street grade and cross-slope), the relationship between the captured discharge and the total discharge can be approximated satisfactorily by an equation

$$Q_c = \begin{cases} Q_t & \text{for } Q_t \leq Q_o \\ Q_o + (Q_a - Q_o) \left\{ 1 - \exp \left[- \left(\frac{Q_t - Q_o}{Q_a - Q_o} \right) \right] \right\} & \text{for } Q_t > Q_o \end{cases}$$

of the form:

Q_o and Q_a are constants. The constant Q_o represents the largest discharge that is captured completely, and the constant Q_a represents the upper limit on the captured discharge, which is approached asymptotically with increasing total discharge. For a particular curb type and street cross-slope, Q_o and Q_a vary with inlet length (L_o) and street grade (S_o) according to the formulas

$$Q_o = (a + b \cdot L_o)(S_o)^x$$

$$Q_a = (c + d \cdot L_o)(S_o)^x$$

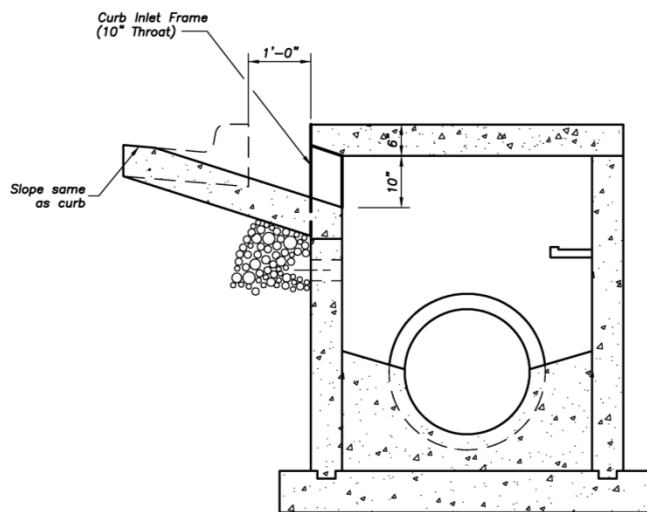
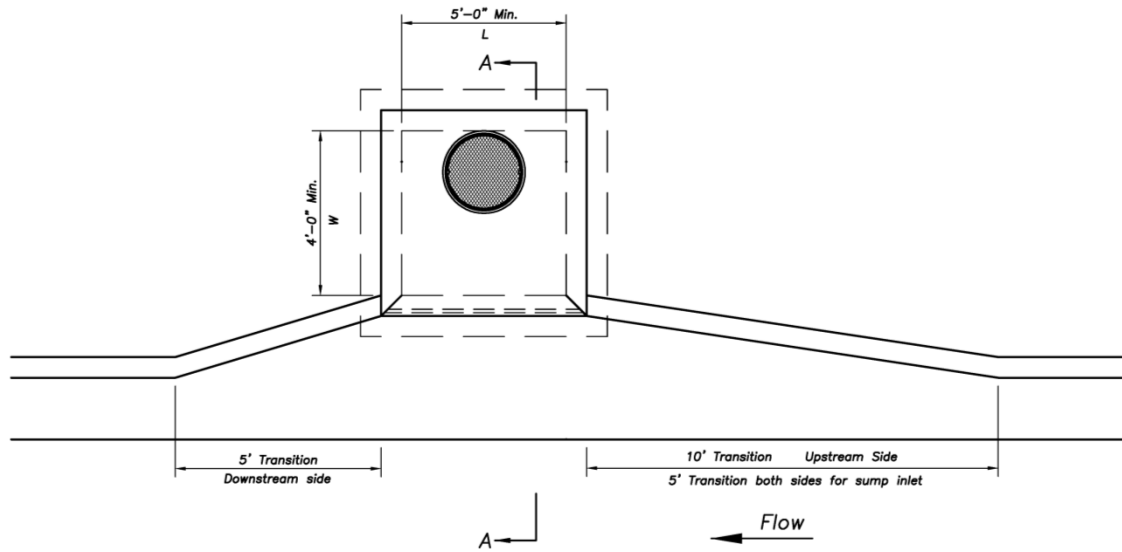
Where a, b, c, d and x are constants. Table 5604-4 shows these constants in U.S. customary units.

Table 5604-4: Values of Coefficients and Exponent

Curb Type	Sx, %	a	b	c	d	x
CG-1 (B)	2	1.0	0	3.2	1.7	-0.5
CG-1 (B)	4	1.5	0.5	2.6	1.9	-0.5
CG-2 (A)	2	-0.4	0.1	3.5	0.8	-0.7
CG-2 (A)	4	-0.3	0.3	4.3	2.5	-0.8

- B. Appendix A provides a Microsoft Visual Basic function that can be added to a Microsoft Excel (97 or later) worksheet or template for inlet intercept calculations.

¹ "Hydraulic Performance of Set-Back Curb Inlets", McEnroe et al., University of Kansas, 1998.



SECTION A-A
Not to Scale

Figure 5604-1: Curb Inlet (10' Throat) Minimum Hydraulic Dimensions

SECTION 5606 ENCLOSED PIPE SYSTEMS

5606.1 Easements

Permanent easements shall be dedicated to the City/County for operation and maintenance of the storm drainage facilities. Easement width shall not be less than 15 feet, or the outside width of the pipe or conveyance structure plus 10 feet; whichever is greater. Easements shall be centered on the pipe.

- A. **Permanent:** The City/County Engineer may require wider easements when other utilities are located within the same easement and/or when the depth of cover is greater than 4 feet.
- B. **Temporary:** Temporary construction easements of sufficient width to provide access for construction shall be acquired when the proposed work is located in areas developed prior to construction.

5606.2 Capacity

Capacity shall be determined in accordance with Section 5603. Minimum design pipe size shall be 15-inch in diameter. For partially full pipe flow, Figure 5606-1 can be used to obtain hydraulic parameters of the flow.

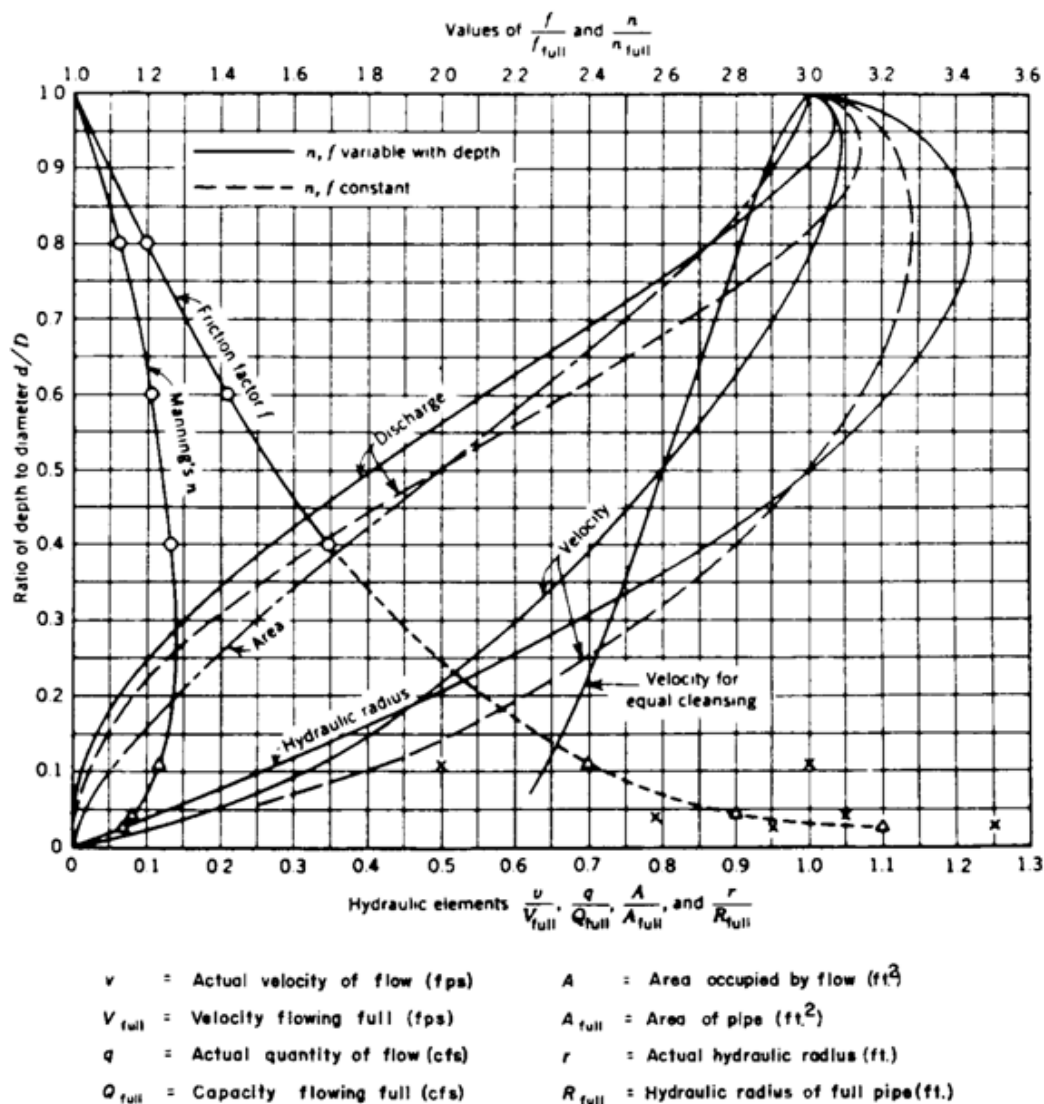


Figure 5606-1: Hydraulic Elements of Circular Conduits

5606.3 Pressure Flow

After considering the discussion presented in Section 5603.1 A, an enclosed system may be designed to operate with pressure flow, for the design storms specified in Section 5601.8, if all the following conditions are met:

- A. The Hydraulic Grade Line (HGL) must be 0.5 feet below any openings to the ground or street at all locations.
- B. Watertight joints capable of withstanding the internal surcharge pressure are used in the construction.
- C. Appropriate energy losses for bends, transitions, manholes, inlets, and outlets, are used in computing the HGL.
- D. Energy methods (Bernoulli's equation) must be used for the computations.

5606.4 Energy Dissipation:

The outfall, as defined in Section 5605.6, of all enclosed systems shall include energy dissipation sufficient to transition outlet flows to velocities and applied shear stresses consistent with the normal flow conditions in the receiving channel for the range of flows up to and including the 1% storm. Calculations, at a minimum, should include the 100%, the 10% and the 1% storms.

Energy dissipation for lateral outflows to natural streams and edge of buffer outfalls to riparian buffers shall follow the guidance in Section 5605.6. Effective energy dissipating structures shall be provided if necessary to meet the requirements stated in Tables 5605-2 and 5606-1. Examples of energy dissipating structures are:

- Check Dams
- Level Spreaders
- Hydraulic Jump Basins
- Impact Baffle Basins
- Plunge Pool and Plunge Basin
- Slotted-Grating or Slotted Bucket Dissipaters
- Stilling Basins
- Rock Revetment
- Internal Pipe Rings

Grade control shall be provided downstream of the dissipator or shall be constructed integrally with it.

The suitability of each method is site dependent and subject to approval by the City/County Engineer. Table 5606-1 lists methods and applicability.

Table 5606-1: Energy Dissipation Counter Measures

Counter Measure	Functional Applications		Suitable Environment			References
	Vertical Control	Horizontal Control	Dam Outlets	Small Culverts	Large Culvert	
Check Dam	X	O	X	X	X	2, 6
Level Spreaders	X	X	O	X	O	1
Hydraulic Jump Basins	X	X	X	X	X	1, 3
Impact Baffle Basins	X	X	X	X	X	1
Plunge Pool & Plunge	X	O	X	X	X	1

Table 5606-1: Energy Dissipation Counter Measures

Counter Measure	Functional Applications		Suitable Environment			References
	Vertical Control	Horizontal Control	Dam Outlets	Small Culverts	Large Culvert	
Basin						
Slotted-Grating or Slotted Bucket Dissipators	X	X	X	O	X	1
Stilling Basins	X	O	X	X	X	1, 2, 3, 4, 5, 6
Rock Revetment	X	X	X	X	X	1, 2, 6
Internal Pipe Rings	X	O	N/A	X	N/A	

LEGEND

X = Suitable Countermeasure

O = Marginal Countermeasure

REFERENCES

1. Design of Small Dams 1987 United States Department of Interior
2. HEC 23
3. Hydraulic Design of Stilling Basins and Energy Dissipaters
4. HEC-14 FHWA Hydraulic Design of Energy Dissipaters for Culverts and Channels
5. U.S. Army Corps of Engineers, 1994 Hydraulic Design of Flood Control Channels
6. Hydraulic Design Series (HDS-6)

NOTE: Other means may be used for Energy Dissipation and Stream Stability by designers as accepted by the local governing agency.

Energy dissipaters shall be designed according to the criteria and procedures defined in professionally acceptable references. Several such references include:

- United States. Department of the Interior. Bureau of Reclamation. Design of Small Dams. 1987 ed. Denver: GPO, 1987.
- United States. Department of the Interior. Bureau of Reclamation. A Water Resource Technical Publication. Engineering Monograph No. 25. Hydraulic Design of Stilling Basins and Energy Dissipaters. 1978 ed. GPO, 1978.
- Federal Highway Administration (FHWA), 1983. Hydraulic Design of Energy Dissipaters for Culverts and Channels, Hydraulic Engineering Circular (HEC) No. 14.
- US Army Corps of Engineers, 1994. Hydraulic Design of Flood Control Channels, US Army Corps of Engineers Engineer Manual EM 1110-2-1601.
- Bridge Scour and Stream Instability Countermeasures Experience, Selection, and Design Guidance (Latest Edition), National Highway Institute, HEC No. 23.
- River Engineering for Highway Encroachments, Highways in the River Environment, U.S. Department of Transportation, Federal Highway Administration, Publication No. FHWA NHI 01-004, December 2001.

5606.5 Velocity within the System

The velocity within the system shall be between 3 and 20 feet per second.

5606.6 Loading

- A. Cover:** Minimum depth of cover shall be 18 inches.
- B. Minimum Loading Conditions:**
 - 1. Live load: H-20.
 - 2. Unit Weight of soil cover: 120 lbs/ft³.
 - 3. Rigid pipes shall be bedded and backfilled to provide a minimum factor of safety of 1.5 at the 0.01-inch crack loading condition.

APPENDIX D.3

CITY OF LEE'S SUMMIT WATERSHED & OUTFALL MAP

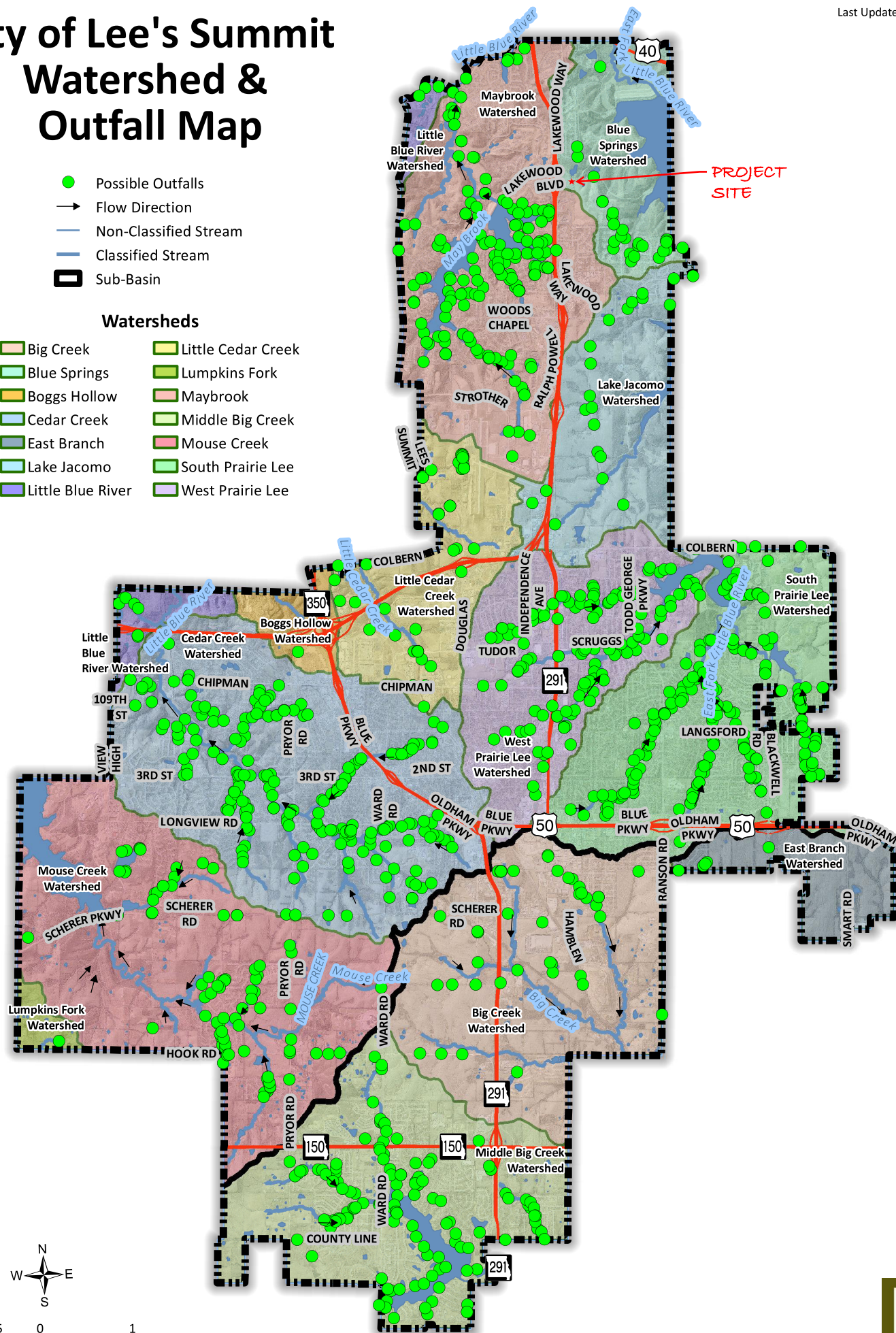
City of Lee's Summit Watershed & Outfall Map

Last Updated: March 2021

- Possible Outfalls
- Flow Direction
- Non-Classified Stream
- Classified Stream
- ▭ Sub-Basin

Watersheds

- | | |
|-------------------|--------------------|
| Big Creek | Little Cedar Creek |
| Blue Springs | Lumpkins Fork |
| Boggs Hollow | Maybrook |
| Cedar Creek | Middle Big Creek |
| East Branch | Mouse Creek |
| Lake Jacomo | South Prairie Lee |
| Little Blue River | West Prairie Lee |



APPENDIX D.4

NOAA POINT PRECIPITATION DATA



NOTE: 24-HR RAINFALL
DEPTHS HIGHLIGHTED
WERE DISTRIBUTED PER
TABLE 5602-4 IN
APPENDIX C.2 TO CREATE
THE DESIGN STORMS FOR
THIS PROJECT.

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

[PF_tabular](#) | [PF_graphical](#) | [Maps & aerals](#)

PF tabular

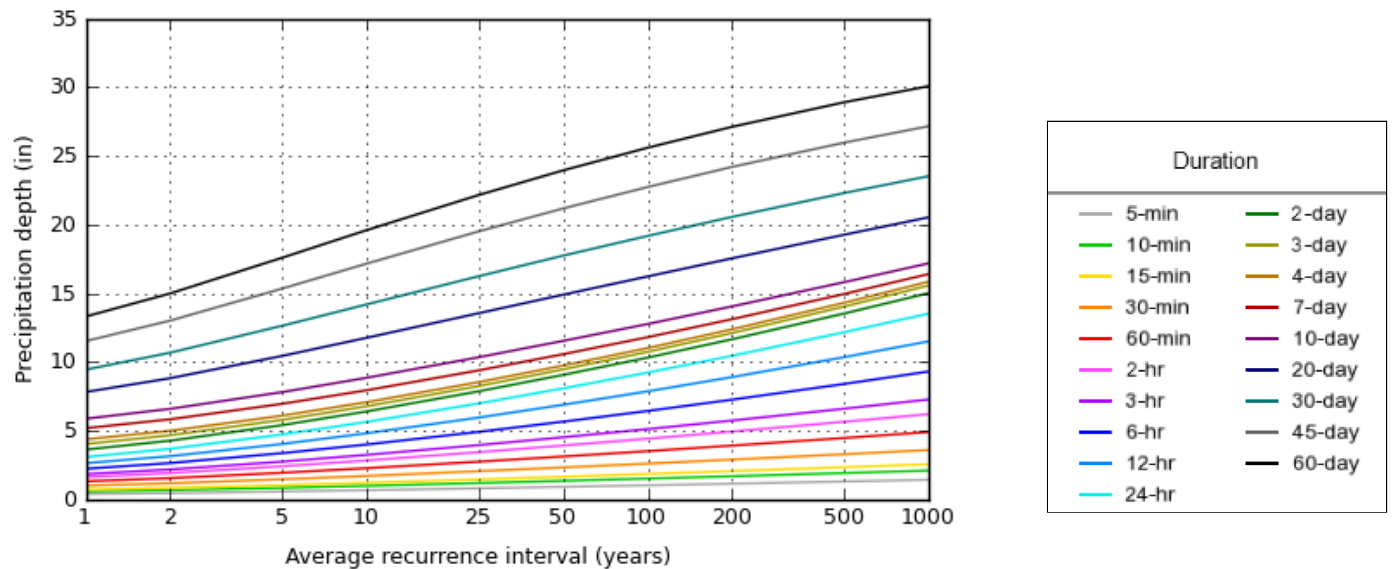
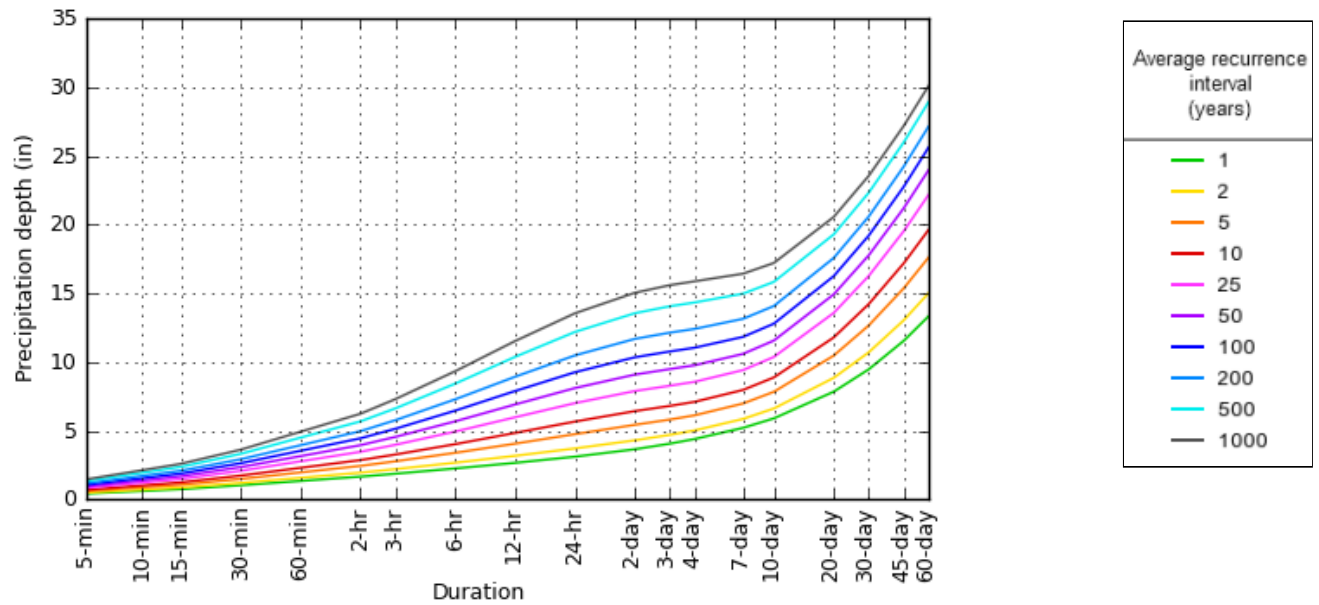
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.413 (0.324-0.522)	0.480 (0.376-0.608)	0.594 (0.464-0.754)	0.691 (0.537-0.880)	0.828 (0.627-1.09)	0.937 (0.695-1.25)	1.05 (0.756-1.42)	1.17 (0.811-1.62)	1.32 (0.892-1.89)	1.45 (0.952-2.09)
10-min	0.604 (0.474-0.765)	0.703 (0.551-0.891)	0.870 (0.679-1.10)	1.01 (0.786-1.29)	1.21 (0.918-1.59)	1.37 (1.02-1.82)	1.54 (1.11-2.09)	1.71 (1.19-2.37)	1.94 (1.31-2.76)	2.12 (1.39-3.05)
15-min	0.737 (0.578-0.933)	0.858 (0.672-1.09)	1.06 (0.828-1.35)	1.23 (0.959-1.57)	1.48 (1.12-1.94)	1.67 (1.24-2.22)	1.87 (1.35-2.54)	2.08 (1.45-2.89)	2.37 (1.59-3.37)	2.59 (1.70-3.72)
30-min	1.02 (0.803-1.30)	1.20 (0.937-1.52)	1.48 (1.16-1.88)	1.73 (1.34-2.20)	2.08 (1.57-2.73)	2.35 (1.74-3.12)	2.63 (1.89-3.57)	2.92 (2.03-4.05)	3.31 (2.23-4.71)	3.61 (2.38-5.21)
60-min	1.34 (1.05-1.69)	1.57 (1.23-1.99)	1.96 (1.53-2.49)	2.29 (1.78-2.92)	2.77 (2.10-3.64)	3.14 (2.33-4.18)	3.53 (2.55-4.80)	3.94 (2.74-5.48)	4.49 (3.02-6.39)	4.92 (3.24-7.09)
2-hr	1.65 (1.30-2.08)	1.94 (1.53-2.44)	2.43 (1.91-3.07)	2.86 (2.24-3.61)	3.46 (2.64-4.52)	3.94 (2.95-5.21)	4.44 (3.22-5.99)	4.96 (3.48-6.85)	5.67 (3.85-8.03)	6.23 (4.12-8.91)
3-hr	1.86 (1.48-2.33)	2.20 (1.74-2.76)	2.77 (2.19-3.48)	3.26 (2.56-4.11)	3.97 (3.05-5.18)	4.54 (3.41-5.99)	5.14 (3.75-6.92)	5.76 (4.06-7.94)	6.62 (4.51-9.34)	7.29 (4.85-10.4)
6-hr	2.25 (1.80-2.80)	2.67 (2.13-3.32)	3.39 (2.69-4.22)	4.02 (3.18-5.03)	4.93 (3.82-6.40)	5.68 (4.30-7.44)	6.46 (4.75-8.65)	7.28 (5.17-9.98)	8.42 (5.78-11.8)	9.32 (6.24-13.2)
12-hr	2.66 (2.13-3.28)	3.17 (2.55-3.91)	4.05 (3.25-5.02)	4.83 (3.85-6.01)	5.97 (4.66-7.71)	6.90 (5.27-9.00)	7.88 (5.84-10.5)	8.92 (6.38-12.2)	10.4 (7.17-14.5)	11.5 (7.77-16.2)
24-hr	3.10 (2.52-3.81)	3.70 (3.00-4.55)	4.74 (3.83-5.84)	5.66 (4.55-6.99)	7.00 (5.50-8.98)	8.10 (6.22-10.5)	9.25 (6.90-12.2)	10.5 (7.55-14.2)	12.2 (8.48-16.9)	13.5 (9.19-18.9)
2-day	3.64 (2.97-4.44)	4.29 (3.50-5.23)	5.42 (4.41-6.62)	6.42 (5.19-7.87)	7.88 (6.24-10.0)	9.08 (7.03-11.7)	10.3 (7.77-13.6)	11.7 (8.47-15.7)	13.5 (9.50-18.6)	15.0 (10.3-20.9)
3-day	4.05 (3.32-4.91)	4.69 (3.84-5.69)	5.81 (4.74-7.06)	6.80 (5.52-8.30)	8.27 (6.58-10.5)	9.48 (7.37-12.1)	10.8 (8.13-14.1)	12.1 (8.84-16.3)	14.0 (9.90-19.3)	15.6 (10.7-21.6)
4-day	4.39 (3.61-5.31)	5.02 (4.12-6.07)	6.11 (5.01-7.42)	7.10 (5.78-8.64)	8.55 (6.83-10.8)	9.76 (7.62-12.5)	11.0 (8.36-14.4)	12.4 (9.07-16.6)	14.3 (10.1-19.6)	15.9 (10.9-21.9)
7-day	5.20 (4.30-6.26)	5.85 (4.84-7.04)	6.97 (5.75-8.41)	7.96 (6.53-9.64)	9.40 (7.54-11.8)	10.6 (8.30-13.4)	11.8 (9.00-15.3)	13.1 (9.65-17.4)	15.0 (10.6-20.3)	16.4 (11.4-22.5)
10-day	5.89 (4.89-7.06)	6.61 (5.48-7.93)	7.83 (6.47-9.40)	8.87 (7.30-10.7)	10.4 (8.31-12.9)	11.6 (9.08-14.5)	12.8 (9.76-16.4)	14.1 (10.4-18.5)	15.8 (11.3-21.4)	17.2 (12.0-23.5)
20-day	7.83 (6.55-9.32)	8.84 (7.39-10.5)	10.5 (8.72-12.5)	11.8 (9.77-14.1)	13.6 (10.9-16.6)	14.9 (11.8-18.5)	16.2 (12.4-20.6)	17.6 (13.0-22.9)	19.3 (13.8-25.7)	20.5 (14.4-27.9)
30-day	9.46 (7.95-11.2)	10.7 (8.98-12.7)	12.7 (10.6-15.0)	14.2 (11.8-16.9)	16.3 (13.1-19.8)	17.8 (14.0-21.9)	19.2 (14.7-24.2)	20.6 (15.3-26.6)	22.3 (16.0-29.6)	23.5 (16.6-31.8)
45-day	11.5 (9.74-13.6)	13.0 (11.0-15.4)	15.4 (12.9-18.2)	17.2 (14.4-20.4)	19.5 (15.8-23.6)	21.2 (16.8-26.0)	22.7 (17.5-28.5)	24.2 (18.0-31.1)	26.0 (18.7-34.2)	27.2 (19.2-36.6)
60-day	13.3 (11.3-15.7)	15.0 (12.7-17.7)	17.6 (14.8-20.8)	19.6 (16.5-23.2)	22.2 (17.9-26.7)	24.0 (19.1-29.3)	25.6 (19.8-32.0)	27.1 (20.2-34.7)	28.9 (20.8-38.0)	30.1 (21.3-40.4)
¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.										

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PF graphical

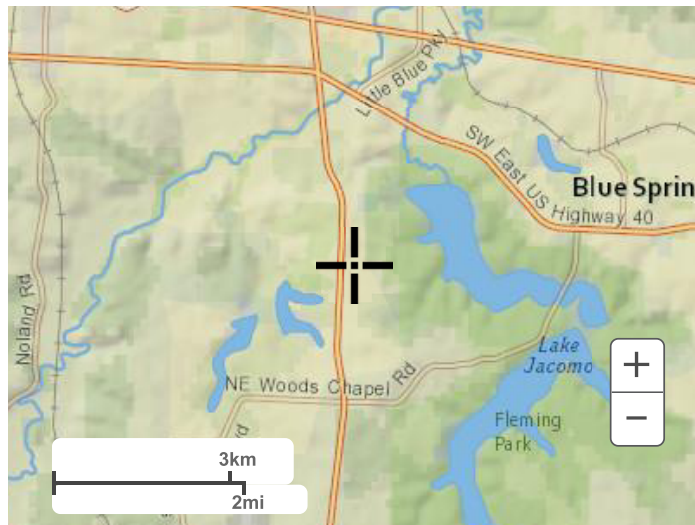
PDS-based depth-duration-frequency (DDF) curves

Latitude: 39.0033°, Longitude: -94.3540°

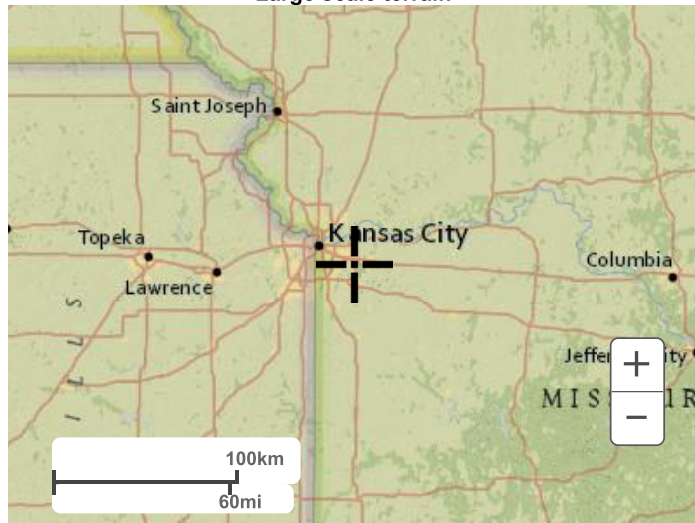


Maps & aerials

Small scale terrain



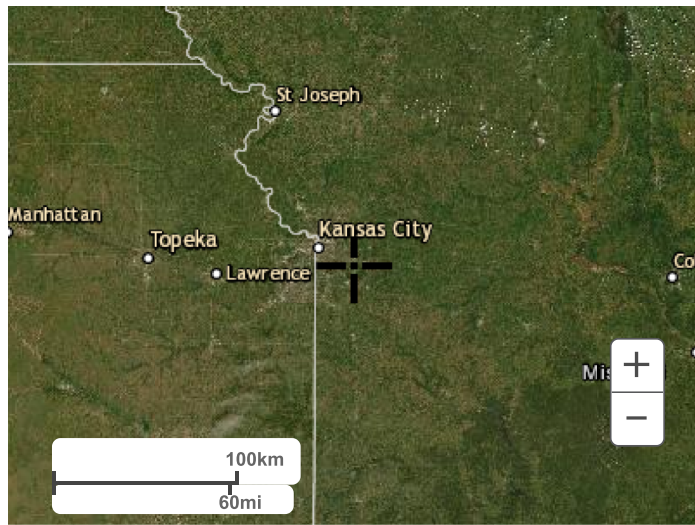
Large scale terrain



Large scale map



Large scale aerial



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APPENDIX D.5

SELECT PAGES, NRCS WEB SOIL SURVEY



United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National
Cooperative Soil Survey,
a joint effort of the United
States Department of
Agriculture and other
Federal agencies, State
agencies including the
Agricultural Experiment
Stations, and local
participants

Custom Soil Resource Report for **Jackson County, Missouri**




Custom Soil Resource Report Soil Map



MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)


Soils


 Soil Map Unit Polygons


 Soil Map Unit Lines


 Soil Map Unit Points

Special Point Features

 Blowout

 Borrow Pit

 Clay Spot

 Closed Depression

 Gravel Pit

 Gravelly Spot

 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry


 Miscellaneous Water


 Perennial Water

 Rock Outcrop


 Saline Spot

 Sandy Spot

 Severely Eroded Spot


 Sinkhole


 Slide or Slip

 Sodic Spot

 Spoil Area

 Stony Spot


 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

Water Features

 Streams and Canals


Transportation

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

Background

 Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Jackson County, Missouri
Survey Area Data: Version 23, Sep 1, 2021

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

Date(s) aerial images were photographed: Sep 6, 2019—Nov 16, 2019

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10082	Arisburg-Urban land complex, 1 to 5 percent slopes	0.2	21.2%
10113	Oska silty clay loam, 5 to 9 percent slopes, eroded	0.8	78.8%
Totals for Area of Interest		1.0	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however,

onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Jackson County, Missouri

10082—Arisburg-Urban land complex, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2w7ld
Elevation: 750 to 1,130 feet
Mean annual precipitation: 39 to 45 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 177 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Arisburg and similar soils: 61 percent
Urban land: 30 percent
Minor components: 9 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Arisburg

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess

Typical profile

Ap - 0 to 6 inches: silt loam
A - 6 to 13 inches: silt loam
Bt - 13 to 19 inches: silty clay loam
Btg - 19 to 56 inches: silty clay loam
BCg - 56 to 79 inches: silty clay loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: R107BY007MO - Loess Upland Prairie
Hydric soil rating: No

Description of Urban Land

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 8

Hydric soil rating: No

Minor Components

Sampsel

Percent of map unit: 3 percent

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Concave

Ecological site: R109XY010MO - Interbedded Sedimentary Upland Savanna

Hydric soil rating: Yes

Greenton

Percent of map unit: 3 percent

Landform: Hillslopes

Landform position (two-dimensional): Shoulder

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Convex

Ecological site: R109XY002MO - Loess Upland Prairie

Hydric soil rating: No

Sharpsburg

Percent of map unit: 3 percent

Landform: Ridges

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Linear

Ecological site: R109XY002MO - Loess Upland Prairie

Hydric soil rating: No

10113—Oska silty clay loam, 5 to 9 percent slopes, eroded

Map Unit Setting

National map unit symbol: yrm7

Elevation: 600 to 1,200 feet

Mean annual precipitation: 33 to 41 inches

Mean annual air temperature: 50 to 55 degrees F

Frost-free period: 177 to 220 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Oska and similar soils: 90 percent

Minor components: 5 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Oska

Setting

Landform: Ridges

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Crest

Down-slope shape: Convex

Across-slope shape: Convex

Parent material: Residuum

Typical profile

A - 0 to 7 inches: silty clay loam

Bt - 7 to 34 inches: silty clay loam

R - 34 to 80 inches: bedrock

Properties and qualities

Slope: 5 to 9 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: D

Ecological site: R106XY015KS - Loamy Upland (PE 30-37)

Other vegetative classification: Grass/Prairie (Herbaceous Vegetation)

Hydric soil rating: No

Minor Components

Sampsel

Percent of map unit: 5 percent

Landform: Hillslopes

Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Concave

Ecological site: R109XY010MO - Interbedded Sedimentary Upland Savanna

Other vegetative classification: Grass/Prairie (Herbaceous Vegetation)

Hydric soil rating: No