SANITARY SEWER CAPACITY ANALYSIS: MIDDLE SCHOOL 4

Prepared for:

Lee's Summit School District 7

Lee's Summit, Missouri

DRAFT

June 2020

Olsson Project No. 020-0103

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1. BACKGROUND

Lee's Summit R-7 School District has proposed the development of a new middle school on a 52 acre (ac) site located on the south side of Bailey Road at the intersection of Country Lane and SE Bailey Road in Lee's Summit, Missouri (City). This development includes the school and an athletic complex. A capacity analysis was performed on the City's existing sanitary sewer from the proposed connection point on an interceptor downstream. The purpose of this analysis was to determine if the existing sanitary sewer could accommodate future flows following the completion of the proposed development of the middle school.

The proposed development will tie into the existing sanitary sewer manhole (MH) #47-019. For the proposed connection, the following three (3) analyses were performed:

- Existing Conditions – Estimated sanitary sewer design flow generated by land within the drainage basin that currently has sanitary service. Exhibit 1 of Appendix A shows the existing drainage areas and land uses for this condition.
- Proposed Conditions – Estimated sanitary sewer design flow generated by the existing conditions (above) and the proposed development. Exhibit 2 of Appendix A shows the anticipated drainage areas and land uses for this condition.
- Ultimate Basin Build-Out Conditions – Estimated sanitary sewer design flow generated by the entire drainage basin. Exhibit 3 of Appendix A shows the anticipated drainage areas for this condition.

The analysis presented here considers the capacity of sewer from the proposed connection point at MH #47-019 to MH #47-020.

2. METHODOLOGY

Wastewater flows were estimated and modeled for the existing, proposed, and ultimate build-out conditions of the sanitary sewer system from the proposed connection point to the interceptor downstream. The City’s Design Criteria Section 6501.C.1 was used to assign flows to residential areas and non-residential areas greater than 100 ac. Agricultural areas were treated as residential land and design flows were estimated per section 6501.C.1. In the existing and proposed conditions, sections of sewer main through undeveloped areas were assumed to receive inflow and infiltration from an area 100 feet on either side of the pipe. Peak base flow for the Sunset Valley Elementary School (Area 12) was estimated using the equivalent dwelling unit (EDU) methodology of section 6501.C.2. Design peak infiltration and inflow rates were estimated per section 6501.C.1 for non-residential areas. Area 11 encompassed the existing gravity main through Silvia Bailey Park.

Based on conversation with the City, the inflow k-factor of 0.006 for residential and 0.003 for non-residential land prescribed in section 6501.C.1.c.ii. does not accurately reflect existing conditions in the sewer system. An adjusted k-factor of 0.002 was applied to the existing development areas only. Table 1 shows the flow calculation of sanitary sewer flow for the existing conditions.

Table 1. Projected Sanitary Sewer Flow for Existing Conditions.

Existing Conditions – Current Basin Build-Out						
Existing Development Area	Area (ac)	Base Flow (gpd)	Peak Infiltration (gpd)	Peak Inflow (cfs*)	Design Flow Rate (MGD**)	Design Flow Rate (cfs*)
Area 1	185.8	278,640	92,880	1.14	1.11	1.71
Area 2	186.0	279,000	46,500	1.14	1.06	1.64
Area 3	6.7	10,050	3,350	0.07	0.06	0.09
Area 4	5.7	8,550	2,850	0.06	0.05	0.08
Area 5	6.8	22,400	1,700	0.07	0.07	0.11
					Total	3.63

*cfs = cubic feet per second; **MGD = million gallons per day

The proposed development consists of a middle school main building, athletic complex, and the surrounding area. Design flow peak base flow was estimated in accordance with the EDU methodology of section 6501.C.2. The first and second floors of the middle school were considered separately because the second floor has a lower occupied area. Design peak infiltration and inflow rates were estimated per section 6501.C.1 for non-residential areas. The k-factor for the middle school was not adjusted from the city specs. Table 2 shows the projected sanitary sewer flow calculation for the proposed development.

Table 2. Projected Sanitary Sewer Flow for Proposed Development.

Proposed Middle School					
Building Area	Value (sq. ft.)	EDU	Parameter	Stories	Base Flow (gpd)
Main Building First Floor	129.7	1	per 1,000 sq. ft.	1	38,920
Main Building Second Floor	60.3	1	per 1,000 sq. ft.	1	17,080
Athletics Building	5.0	1	Per 1,000 sq. ft.	1	1,500
				Total Base Flow (gpd)	58,500
				Total Area (Ac)	52.6
				Peak Infiltration (gpd)	13,150
				Peak Inflow (cfs)	0.60
				Design Flow (cfs)	0.72

The ultimate basin build-out condition estimates the impact on the sanitary system when all land in the drainage basin upstream of MH #47-020 is developed for residential or non-residential use. It was assumed that the elementary school (Area 12) and park (Area 11) would be serviced by gravity mains following contours to the south and tie into the interceptor downstream of the area of study. For all areas not currently developed, the k-factors were not adjusted. Table 3 shows the projected sanitary sewer flow calculations for the ultimate build-out condition.

Table 3. Projected Sanitary Sewer Flow for Ultimate Basin Build-out Condition.

Ultimate Conditions - Basin Build-Out						
Existing Development Area	Area (ac)	Base Flow (gpd)	Peak Infiltration (gpd)	Peak Inflow (cfs)	Design Flow Rate (MGD)	Design Flow Rate (cfs)
Development Area	52.6	58,499	13,150	0.60	0.46	0.72
Area 1	185.8	278,700	92,900	1.14	1.11	1.72
Area 2	270.8	406,200	67,700	2.37	2.01	3.10
Area 3	66.9	100,350	33,450	1.45	1.07	1.65
Area 6	10.5	15,750	5,250	0.30	0.21	0.33
Area 7	173.8	260,700	86,900	3.22	2.43	3.76
					Total	11.28

* cfs = cubic feet per second; ** MGD = million gallons per day

3. ANALYSIS

Information for the existing sanitary sewer system was taken from the City's GIS data and record drawings. Where the GIS data and record drawings conflicted, the data from the record drawings was used. The slope of each pipe segment was calculated using the upstream and downstream inverts and the length of pipe listed in the record drawings. Existing sub-basin boundaries were determined using the current sanitary sewer layout and parcel maps. Ultimate condition sub-basin boundaries were determined using area contours. Sub-basin areas for each condition are shown in Appendix A. Per the Lee's Summit design criteria, flows were estimated based on drainage area and time of concentration. Manning's equation was used to determine current pipe flow capacities. The Manning's n roughness coefficient used was 0.014 for PVC pipe. The calculations and results of the analyses are shown in Appendix B.

Hydraulic grade lines (HGL) were also calculated for each analysis using a flow modeling extension in AutoCAD Civil 3D. For the model, it was assumed that the flow at the downstream end discharged to open air with a starting HGL equal to the normal depth. A line is considered inadequate if the HGL is higher than the pipe crown. A sanitary sewer overflow occurs when the HGL rises above the manhole rim elevation. The HGL model for each analysis is shown in Appendix C.

4. RESULTS

The existing sanitary sewer has capacity to handle anticipated flows from the proposed development. Hydraulic analysis of the existing and proposed conditions for the pipe segment from MH #47-019 to MH #47-020 show that the HGL is below the crown of the pipe. The pipe capacity calculations for this segment can be found in Tables 1 and 2 of Appendix B. Profiles of the existing and proposed condition HGLs are shown in Appendix C.

Estimated flows from the ultimate build-out condition will exceed the capacity of the existing sanitary sewer system. Hydraulic analysis of the ultimate build-out conditions indicates surcharging of the pipe segment from MH #47-019 to MH #47-020. The pipe capacity calculations for this segment can be found in Table 3 of Appendix B. A profile of the ultimate build-out condition HGL is shown in Appendix C.

4.1 Main Extension Sizing

The main extension to serve the proposed middle school was sized to accommodate flows from the ultimate build-out condition. To convey the design flow rate, the main extension must be at least 15” diameter with a minimum slope of 0.70%. The pipe capacity calculations for the main extension can be found in Tables 2 and 3 of Appendix B. Profiles of the proposed and ultimate build-out condition HGLs for a representative pipe segment are shown in Appendix C. Because the HGL of the existing sanitary sewer from MH #47-019 to MH #47-020 is above the pipe crown in the ultimate build-out condition, the main extension was also modeled with an outfall at MH #47-019 to determine the pipe HGL assuming the existing sewer is not surcharged.

5. CONCLUSION

The addition of estimated flows from the proposed middle school would not cause surcharges in the segment of pipe from MH #47-019 to MH #47-020. Flows from the ultimate development condition, however, would exceed the capacity of the existing sanitary sewer.

The main extension to provide service to the proposed middle school will connect to the existing sanitary sewer system at MH #47-019. The extension will be 15" diameter with a minimum slope of 0.70% to handle flows from the proposed middle school and future residential development to the east.

APPENDIX A
Sub-Basin Maps

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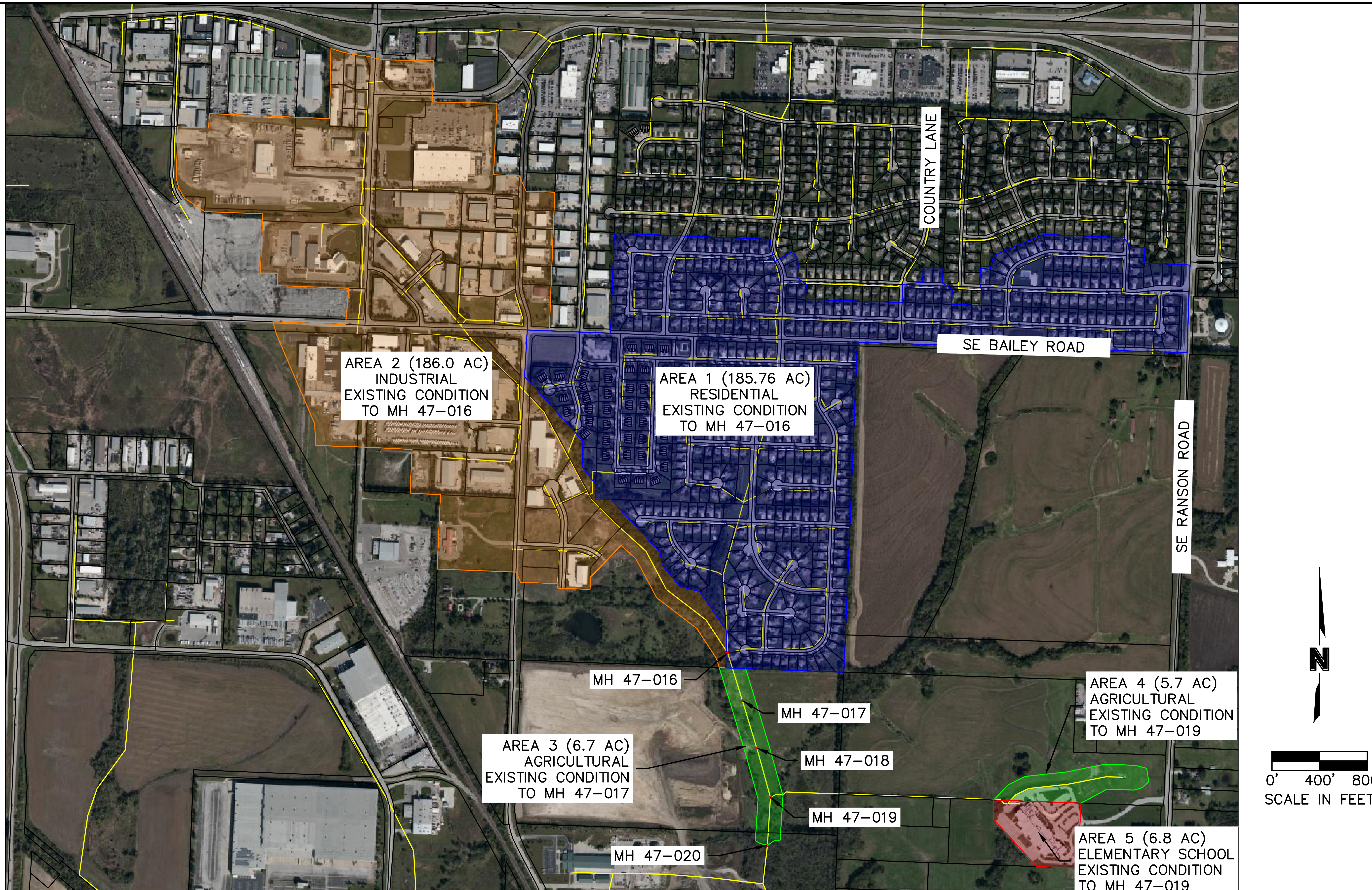

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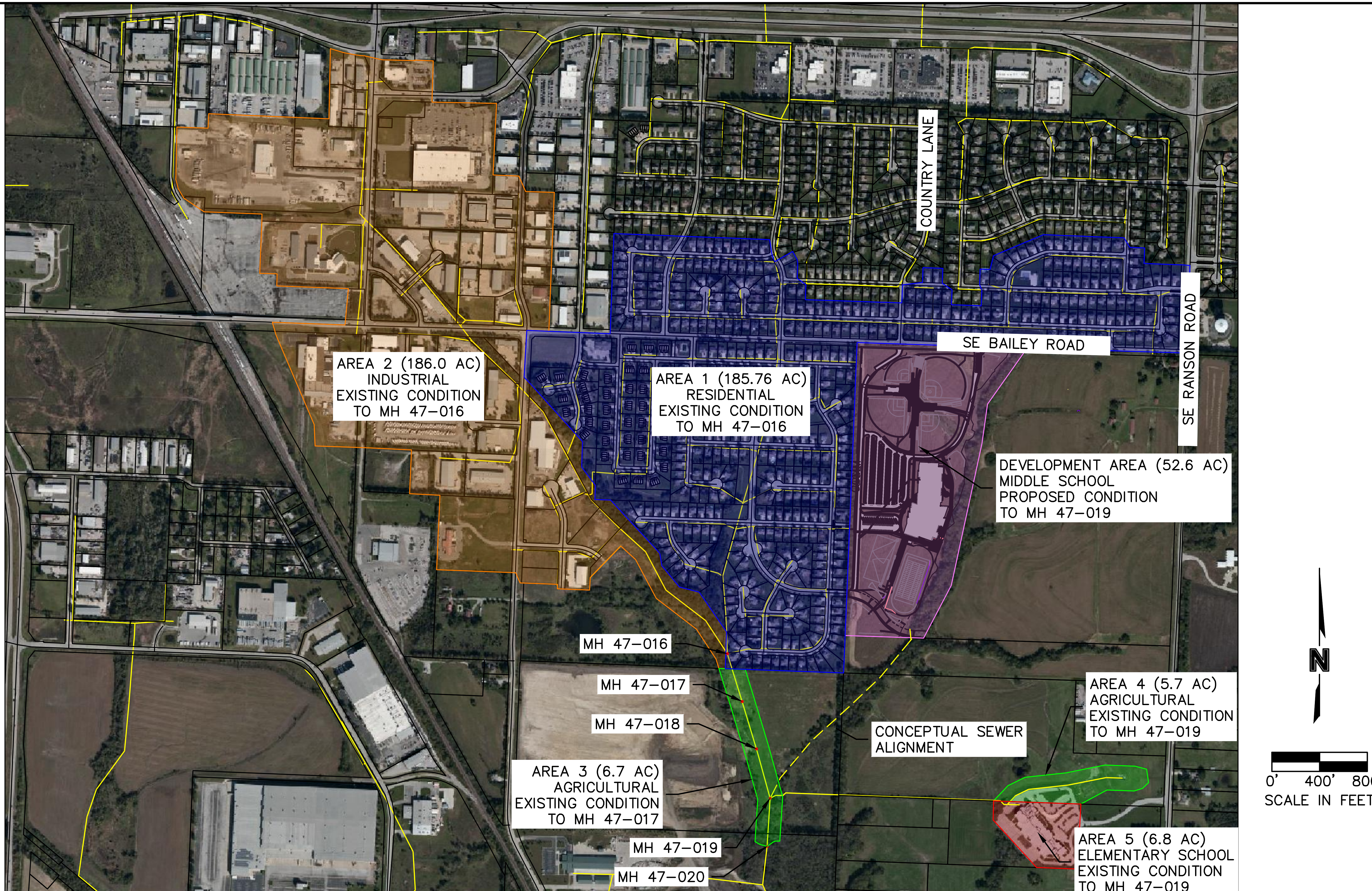
DATE:	4/21/2020

LEE'S SUMMIT DISTRICT 7 MIDDLE SCHOOL 4
EXISTING DEVELOPMENT CONDITIONS

olsson
1301 Burlington Street
North Kansas City, MO 64116
TEL 816.361.1177

EXHIBIT
1



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PROJECT NO: 020-0103	LEE'S SUMMIT DISTRICT 7 MIDDLE SCHOOL 4 PROPOSED DEVELOPMENT CONDITIONS	olsson 1301 Burlington Street North Kansas City, MO 64116 TEL 816.361.1177	EXHIBIT
DRAWN BY: NMG			2
DATE: 4/21/2020			

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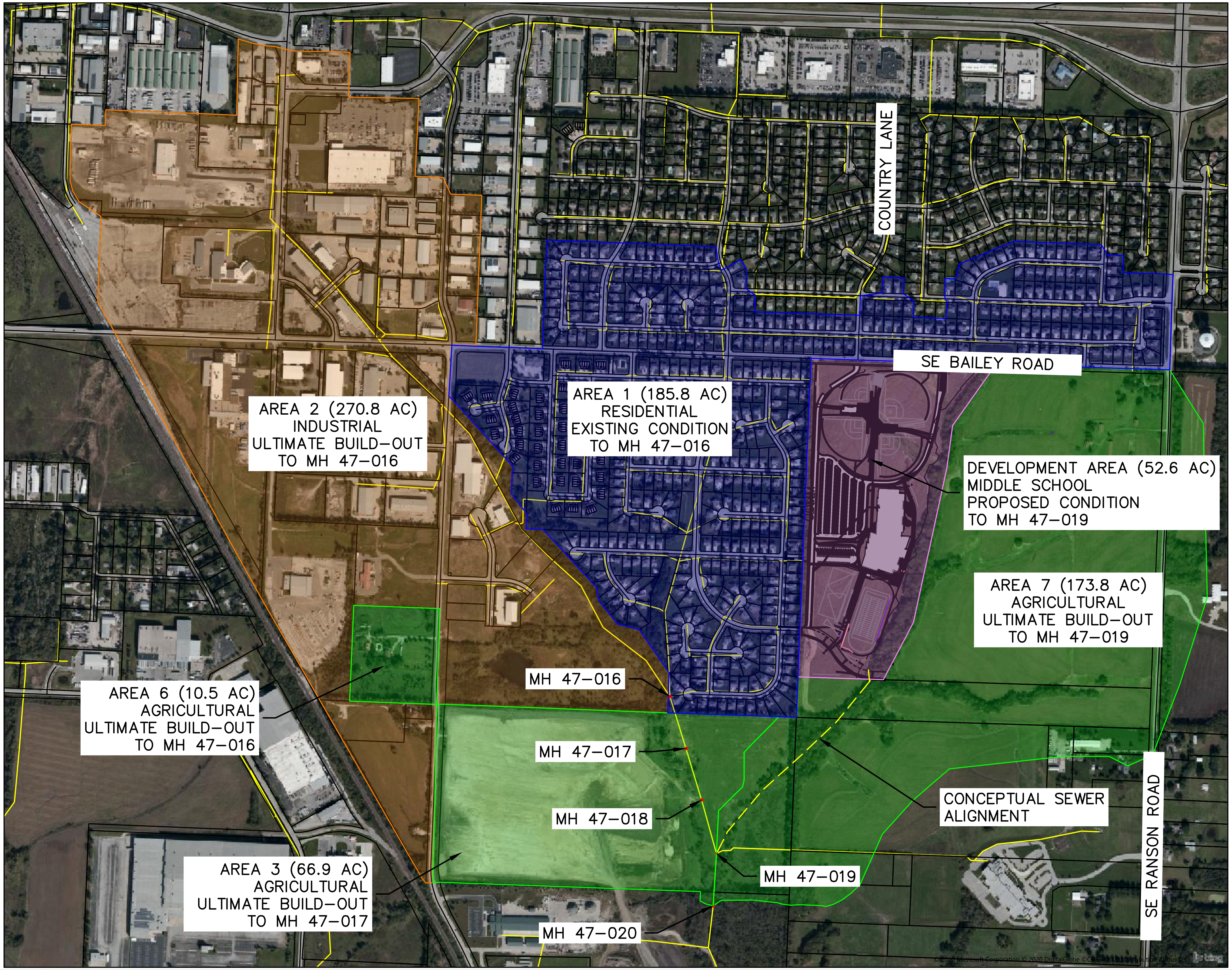
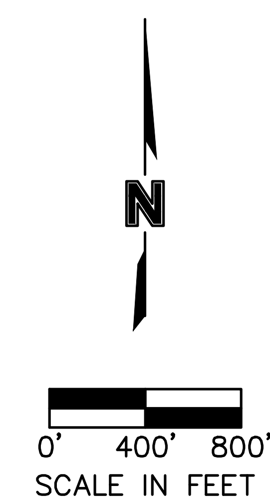




PROJECT NO: 020-0103	LEE'S SUMMIT DISTRICT 7 MIDDLE SCHOOL 4 ULTIMATE BASIN BUILD-OUT	olsson 1301 Burlington Street North Kansas City, MO 64116 TEL 816.361.1177	EXHIBIT
DRAWN BY: NMG			3
DATE: 4/21/2020			

APPENDIX B
Sanitary Sewer Analysis Calculations

Table 1 - Existing Conditions

US MH	DS MH	Pipe No.	Drainage Area (acre)	Cumulative Drainage Area (acre)	Design Flow Rate (cfs/acre)	Design Flow Rate (cfs)	Design Flow Rate (gpd)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Pipe Diam. (in)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (gpd)	Percent Pipe Capacity (%)	US HGL Elev.
MH 47-019	MH 47-020	P-56543	391.0	391.0	0.0093	3.63	2,344,908	960.95	959.55	970.00	0.35%	18.00	400.0	6.22	4,022,982	58.3%	961.81

=HGL above crown

Table 2 - Proposed Conditions

US MH	DS MH	Pipe No.	Drainage Area (acre)	Cumulative Drainage Area (acre)	Design Flow Rate (cfs/acre)	Design Flow Rate (cfs)	Design Flow Rate (gpd)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Pipe Diam. (in)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (gpd)	Percent Pipe Capacity (%)	US HGL Elev.
MH 47-019	MH 47-020	P-56543	443.6	443.6	0.0098	4.34	2,806,601	960.95	959.55	970.00	0.35%	18.00	400.0	6.22	4,022,982	69.8%	961.92
Future	MH 47-019	Future	52.6	52.6	0.0136	0.72	462,634	963.60	961.40	Future	0.70%	15.00	400.0	5.41	3,498,751	13.2%	962.07

=HGL above crown

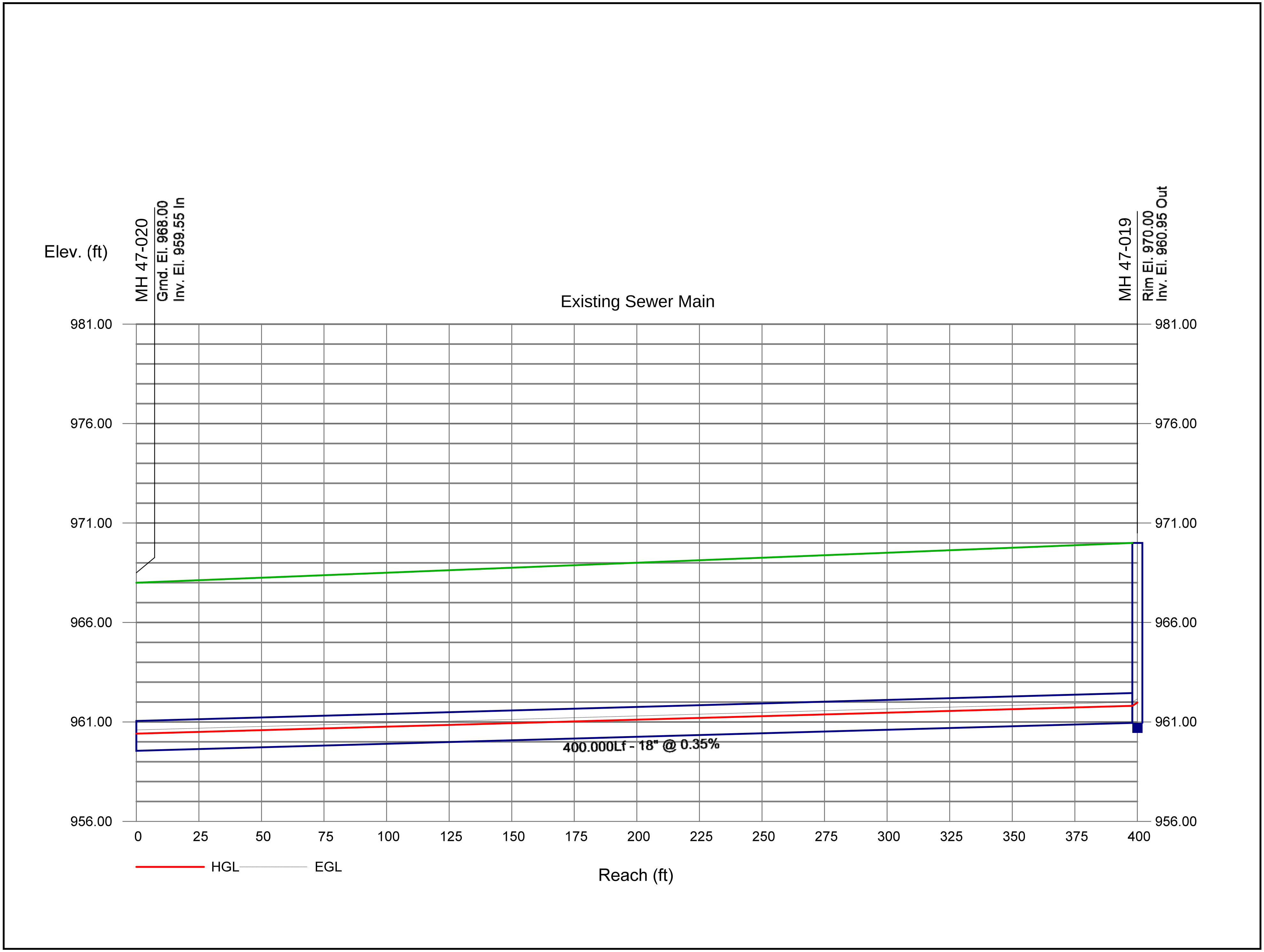
Table 3 - Ultimate Build-Out Conditions

US MH	DS MH	Pipe No.	Drainage Area (acre)	Cumulative Drainage Area (acre)	Design Flow Rate (cfs/acre)	Design Flow Rate (cfs)	Design Flow Rate (gpd)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Pipe Diam. (in)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (gpd)	Percent Pipe Capacity (%)	US HGL Elev.
MH 47-019	MH 47-020	P-56543	760.4	760.4	0.0148	11.28	7,288,344	960.95	959.55	970.00	0.35%	18.00	400.0	6.22	4,022,982	181.2%	966.41
Future	MH 47-019	Future	226.4	226.4	0.0198	4.47	2,892,139	963.60	961.40	Future	0.70%	15.00	400.0	5.41	3,498,751	82.7%	968.94

=HGL above crown

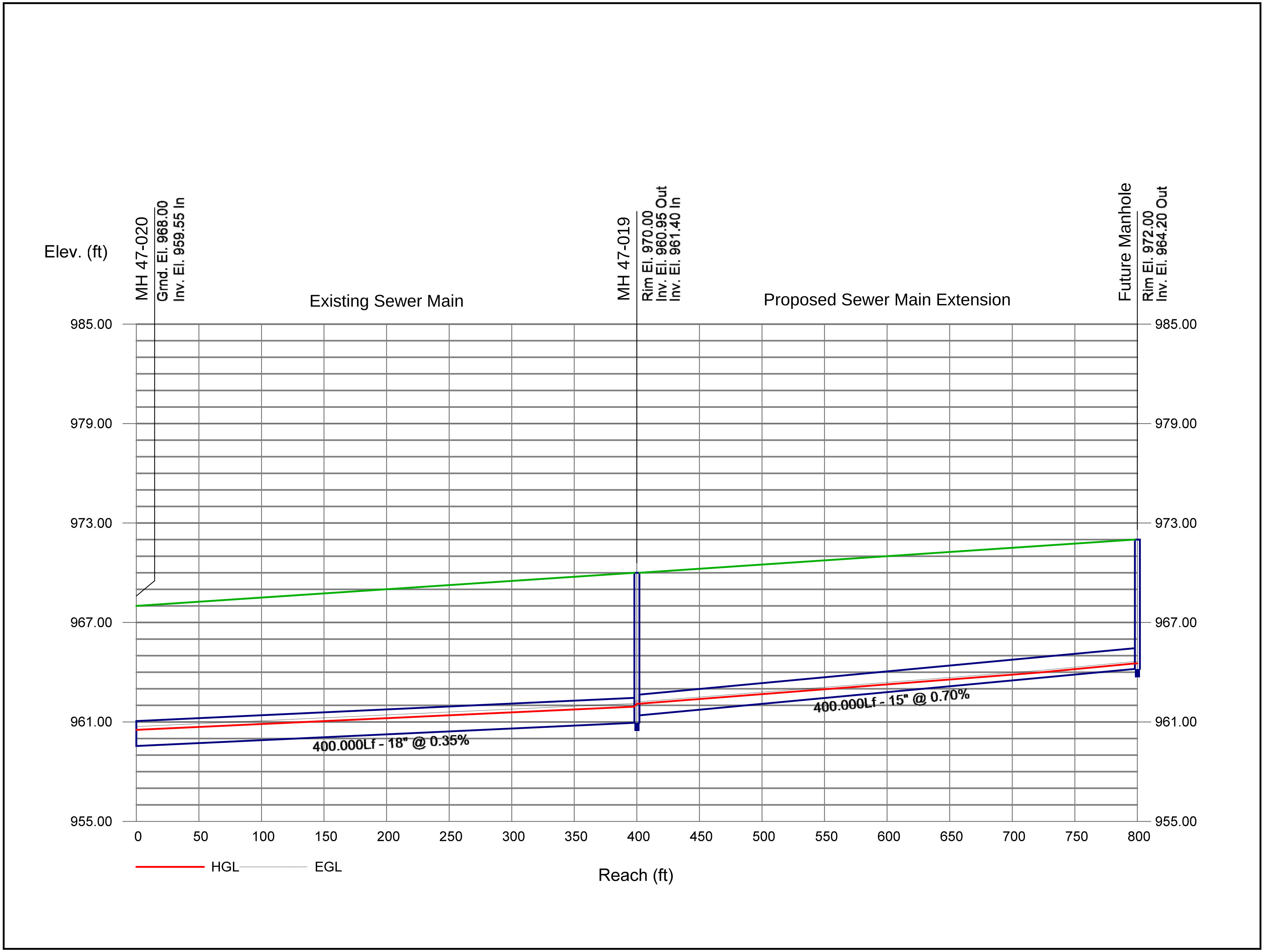
APPENDIX C
Sanitary Sewer Hydraulic Grade Line

Sanitary Sewer Existing Conditions HGL



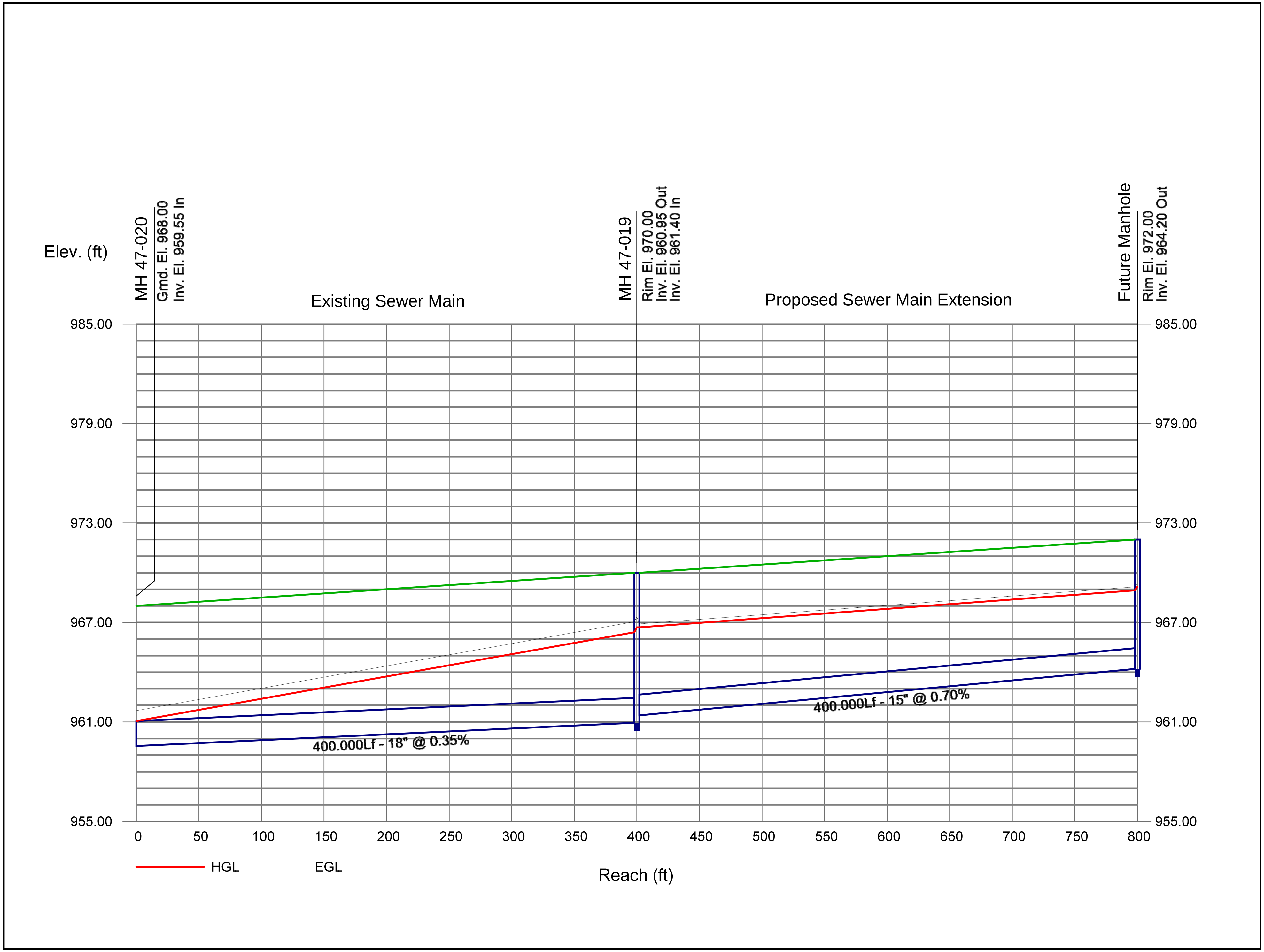
Storm Sewers

Sanitary Sewer Proposed Conditions HGL

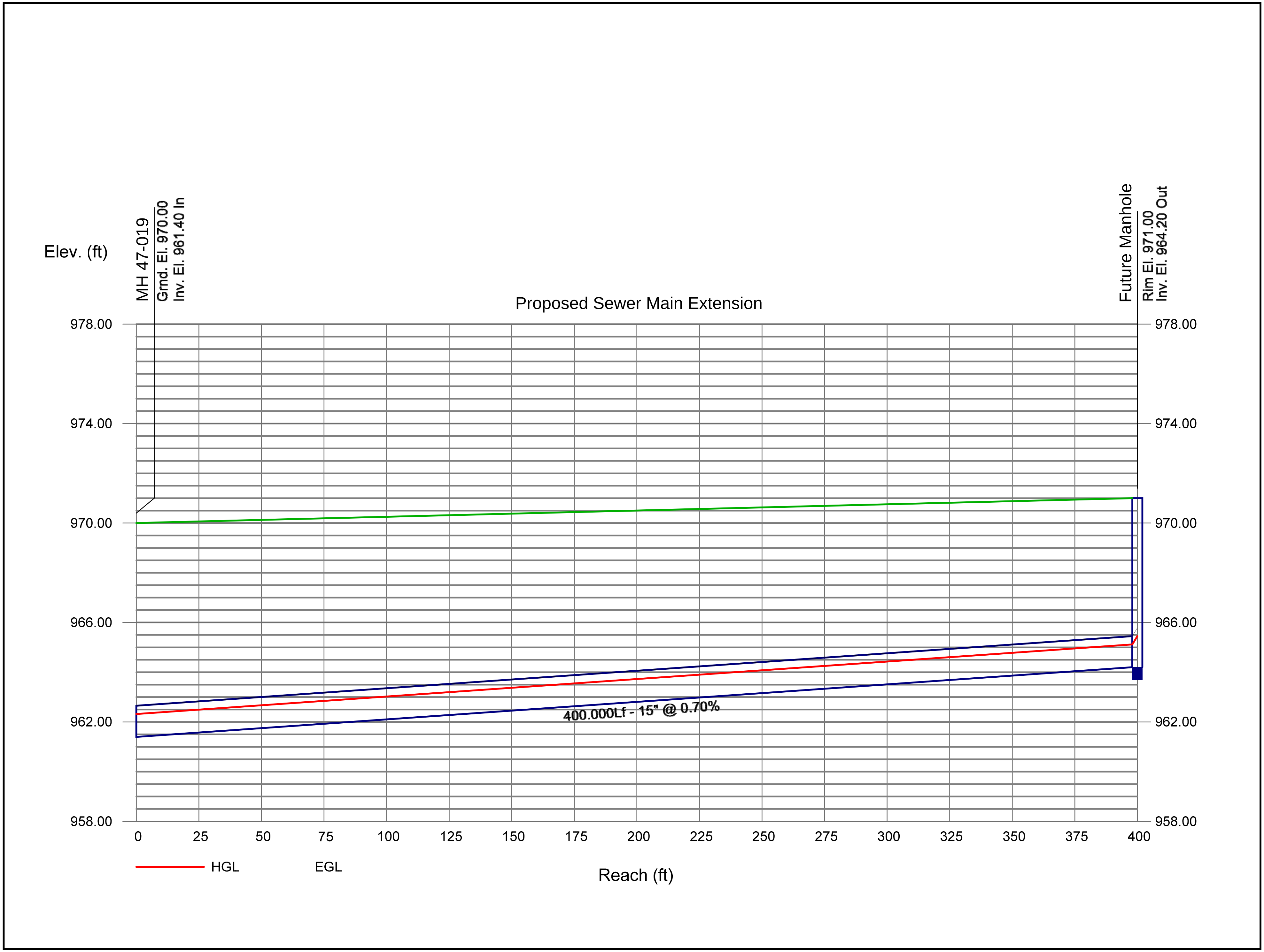


Storm Sewers

Sanitary Sewer Ultimate Build-Out Conditions HGL



Sanitary Sewer Ultimate Build-Out Conditions HGL



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