SANITARY SEWER SYSTEM CAPACITY ANALYSIS: DISCOVERY PARK

Prepared for:

Discovery Park Lee's Summit, LLC

May 2023

Olsson Project No. A21-04643

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ACRONYMS AND ABBREVIATIONS

AC……..Acres
CFS……Cubic Feet per Second
DIP……Ductile-Iron Pipe
EDU……..Equivalent Dwelling Unit
EFHB……..Excess Flow Holding Basin
GIS……..Geographic Information System
GPD……Gallons per Day
GPM……...Gallons per Minute
HGL……Hydraulic Grade Line
LSRPS.....Lee's Summit Road Pump Station
MG……Million Gallons
MGD……...Million Gallons per Day
PVC……Polyvinyl Chloride

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APPENDICES

1. INTRODUCTION

This report is being prepared for Discovery Park Lee's Summit, LLC for the purpose of reviewing the capacity of existing wastewater collection facilities to serve the proposed Discovery Park development and to recommend improvements and additions where needed. To perform this analysis, the proposed development plan was used to estimate wastewater flow rates that would be generated, then the capacities of the existing facilities were analyzed to evaluate their ability to accommodate the projected flows. Based upon the various analyses, general recommendations were developed concerning improvements that are needed to provide adequate wastewater service for the development.

The proposed development is divided into five (5) zones as shown in Exhibit 1 in Appendix A. Zone numbers are assigned based on planned sequence of development. Flow-contributing sections of the drainage basin upstream and downstream from the Discovery Park development are identified by randomly assigned numbers to distinguish flows generated from these areas from those produced by the Discovery Park properties.

For this analysis and report, the Discovery Park development was divided into two (2) sections, which were designated as Discovery Park East and Discovery Park South. Discovery Park East includes Zones 1, 2, and 5, whereas Zones 3 and 4 are in Discovery Park South. The reason for this division is that Discovery Park East is anticipated to be served by existing sewers that flow into the area from the east and discharge into the Lee's Summit Road Pump Station (LSRPS). Wastewater flow generated by Discovery Park South will be transported to the Little Cedar Interceptor, which runs along the western edge of the development.

2. BACKGROUND

The Discovery Park development is proposed to be constructed in the northwestern section of the City of Lee's Summit, Missouri (City). A portion of the project extends north along the west side of NE Douglas Street from NW Colbern Road to approximately the east end of Unity Lake No. 2, whereas the remainder occupies the entire area bounded by NW Colbern Road on the north, NE Douglas Street on the east, Interstate 470 on the south, and N Main Street on the west. The site includes approximately 267 acres (ac) of mixed residential and commercial development.

Discovery Park East will be served by two existing 12-inch sanitary sewers that run through Zone 1 and feed into the LSRPS, which is situated at the northwest corner of Zone 1 (southwest corner of Zone 5). An excess flow holding basin (EFHB) operates in conjunction with the pump station to store excess flow produced during wet-weather periods. All these facilities are owned and operated by the City of Lee's Summit. A map showing the proposed Zone 1 and Zone 2 development and the existing sanitary sewer layout is presented in Exhibit 2 of Appendix B. It is worth noting that 5.7 acres in the middle west section of Zone 1 is dedicated to a park/runoff pond and will not be generating any wastewater flow.

The sanitary sewer analysis for this site took three (3) conditions into consideration:

- Existing Conditions – Estimated sanitary sewer design flow generated by land upstream of Discovery Park but within the same drainage basin that is currently developed.

- Proposed Condition – Estimated sanitary sewer design flow generated by the existing conditions (above) as well as the addition of flow generated by the proposed development in Zones 1 and 2. Exhibit 3 of Appendix B shows the anticipated drainage areas and flows for this condition.

- Ultimate Basin Build-out Condition – Estimated sanitary sewer design flow generated by full build-out within the drainage basin. This includes full build-out of Areas 6, 7, and 8, the development identified for Zones 1 and 2, along with the addition of flow from Zone 5 and Area 9. Exhibit 4 of Appendix B shows the anticipated drainage areas and flows for this condition.

The only sewer line available to provide gravity sewer service for Discovery Park South is the Little Cedar Interceptor, which runs along the western boundary of Discovery Park South Zone 4. This line is also owned and operated by the City of Lee's Summit.

Preliminary layouts were prepared for sewer system extensions from the Little Cedar Interceptor to serve this portion of the development, as well as the undeveloped property that is sandwiched between Discovery Park South and Unity Lake No. 1. Discharge flow rates were calculated for

Discovery Park Zones 3 and 4, as well as for the downstream basins, which were designated as Areas 10 through 13. These are shown on Exhibit 5 in Appendix B. All development in the downstream basins was assumed to be residential. Only the ultimate basin build-out condition was analyzed for this section.

Evaluation of the flow capacity and hydraulic grade lines for the Little Cedar Interceptor was not performed as part of this analysis.

3. METHODOLOGY

3.1 Sanitary Sewer

Olsson estimated wastewater flows for the existing and proposed development conditions in accordance with the City of Lee's Summit's Sanitary Sewer Design Criteria (Section 6500). The analysis presented herein for Discovery Park East is an update of an analysis that was performed in 2018. The results of this earlier analysis were presented in the Olsson report titled "Sanitary Sewer Capacity Analysis – Aria and Summit Village North."

Information for the existing sanitary sewer system was taken from the City's geographic information system (GIS) maps and record drawings. GIS data was also used to identify currently developed areas located upstream of the Discovery Park development. Boundaries for the existing conditions were determined using the current sanitary sewer layout and parcel maps. Boundaries for ultimate build-out of developed areas were determined using area contours.

Section 6501.C.1 of the City's Design Criteria was used to assign flows to residential areas and non-residential areas greater than 100 acres. Based on conversations with the City at the time the 2018 report was prepared, it was agreed that the inflow rate (or K-factor) of 0.006 does not accurately describe existing conditions. Peak inflow calculations were initially made based upon a K-value of 0.002 and a 50-year design storm. Following city review a request was made that these calculations be revised based on a K-factor of 0.004 and a 10-year design storm. This will bring the analysis into conformance with recommendations provided in the 2021 Lee's Summit Wastewater Master Plan.

Anticipated flows were calculated for non-residential areas of the proposed development using the equivalent dwelling unit (EDU) method, as described in Section 6501.C.2 of the City's Design Criteria. Peak infiltration and inflow values were calculated using Section 6501.C.1 and the adjusted K-factor of 0.004. Design flows for the proposed residential areas were computed using the same method as for the existing conditions (Section 6501.C.1).

Flow rate calculations for each of the five (5) zones in the Discovery Park development based upon this stated methodology are provided in Appendix C.

Manning's Equation was used to determine the gravity-flow capacities of both the existing and proposed sewer lines. Per the City's design criteria, a Manning's roughness coefficient "n" of 0.014 was used for polyvinyl chloride (PVC) pipe, whereas an "n" value of 0.015 was used for ductile-iron pipe (DIP).

Hydraulic grade lines (HGLs) for the North and South Sanitary Sewers that will serve the Discovery Park East development were hand calculated at each manhole based on projected flow depths in the sewers and entrance losses at the upstream end of each line. For the system

surcharge event produced by the ultimate basin build-out condition, the HGL in MH 16-005 was calculated based on the depth of flow in the 16-inch overflow line plus an inlet loss equal to one half the velocity head. Headlosses through fully surcharged pipe sections were computed based on the Hazen-Williams Equation with an assumed “C” value of 120.

HGLs for the new sewers to serve the Discovery Park South development were generated using a flow modeling extension in AutoCAD Civil 3D.

Sanitary sewers were designed in accordance with City standards with respect to minimum pipe size and minimum slopes. Efforts were made to keep the design installation depth for the sewer below 20 feet in accordance with City standards; however, this limit was exceeded at several locations. The plan and profile presented for the proposed sewers is a preliminary effort only and would need to be more thoroughly investigated during detailed design. It is possible that additional investigations could result in establishing an alignment where the maximum depth limitation can be met.

This analysis does not include an evaluation of the capacity of the existing sewers to the east of NE Douglas Street that transport flow from the existing developments around the Lee’s Summit Airport to the LSRPS. It was assumed that these sewers have adequate capacity to deliver the projected maximum design flows from basin build-out to manholes MH 16-001 and 16-011. Evaluation of any deficiencies in this regard is beyond the scope of this investigation.

3.2 Lee's Summit Road Pump Station

The North and South Sanitary Sewers join at MH 16-005, which is immediately upstream of the LSRPS. A 20-inch pipe connects MH 16-005 with the pump station wet well. All dry-weather flow is sent directly to the pump station. During wet-weather periods, it is possible for the station’s pumping capacity to be exceeded, which will cause wastewater to back up in MH 16-005. Whenever this happens, the water level in the manhole will rise. While the sewer flow rate exceeds the pump station capacity, the water level in the manhole will continue to rise. Eventually it will reach a level that will cause wastewater to be discharged through the 16-inch bypass line that joins MH 16-005 with the EFHB. Excess flow is collected in this basin and then returned to the pump station by opening a sluice gate on the discharge end of a pipe within the pump station wet well.

The original LSRPS pumps were replaced with Xylem pumps in 2009. The pump curve for the replacement pumps is provided in Appendix D. Record drawings for the pump station and force main were used to develop a theoretical system curve for the LSRPS force main.

3.3 Excess Flow Holding Basin

A capacity analysis was developed for the EFHB that is located downstream from the proposed Zone 1 development. Methodology for developing this capacity analysis was based on the Wastewater Excess Flow Holding Basin Facilities Design Criteria (Design Criteria Attachment 6501-3). Design criteria require that all EFHBs be designed for peak excess flow from the sanitary sewer drainage area during a 50-year storm event. Peak excess flow rates from a 50-year event were estimated for the existing, proposed, and ultimate basin build-out conditions.

The Lee's Summit design guidelines for EFHBs were used in this analysis to determine whether excess capacity is available within the EFHB for each condition.

4. DISCOVERY PARK EAST ANALYSIS AND RESULTS

4.1 Sanitary Sewer Design Flows

Flow rates generated from the Discovery Park East development and from properties upstream of the development were computed using the methodology outlined in Section 3. Summaries of the projected flow rates for the existing, proposed development, and ultimate basin build-out conditions are provided in Tables 1 through 3. Detailed flow rate calculations for the entire LSRPS service area are provided in Appendix E.

Table 1. Projected Sanitary Sewer Flows for Existing Conditions.

Existing Conditions – Current Basin Build-Out						
Development Area	**Area (ac)**	**Base Flow (gpd)**	**Peak Infiltration (gpd)**	**Peak Inflow (gpd)**	**Design Flow Rate (MGD)**	**Design Flow Rate (cfs)**
Area 6	74	111,000	37,000	505,060	0.65	1.01
Area 7	16	24,000	8,000	139,600	0.17	0.27
Area 8	92	138,000	46,000	606,500	0.79	1.23
				Total	1.62	2.50

*gpd = gallons per day, *MGD = million gallons per day, *cfs = cubic feet per second

Table 2. Projected Sanitary Sewer Flows for Proposed Development Condition.

Proposed Condition – Development of Discovery Park Zones 1 and 2						
Development Area	**Area (ac)**	**Base Flow (gpd)**	**Peak Infiltration (gpd)**	**Peak Inflow (gpd)**	**Design Flow Rate (MGD)**	**Design Flow Rate (cfs)**
Zone 1A	27	40,650	13,450	215,600	0.27	0.42
Zone 1B	29	69,920	9,600	231,000	0.31	0.48
Zone 2	20	26,300	4,950	164,300	0.20	0.30
Area 6	74	111,000	37,000	505,100	0.65	1.01
Area 7	16	24,000	8,000	139,600	0.17	0.27
Area 8	92	138,000	46,000	606,500	0.79	1.23
				Total	2.39	3.71

Table 3. Projected Sanitary Sewer Flows for Ultimate Basin Build-Out Condition.

Ultimate Condition – Ultimate Basin Build-Out						
Development Area	**Area (ac)**	**Base Flow (gpd)**	**Peak Infiltration (gpd)**	**Peak Inflow (gpd)**	**Design Flow Rate (MGD)**	**Design Flow Rate (cfs)**
Zone 1A	27	40,650	13,450	215,600	0.27	0.42
Zone 1B	29	69,920	9,600	231,000	0.31	0.48
Zone 2	20	26,300	4,950	164,300	0.20	0.30
Zone 5	69	106,260	26,660	476,680	0.61	0.94
Area 6	92	138,000	46,000	606,500	0.79	1.23
Area 7	114	171,000	57,000	725,000	0.95	1.48
Area 8	104	156,000	52,000	672,200	0.88	1.36
Area 9	64	96,600	32,200	449,500	0.58	0.90
				Total	4.59	7.11

4.2 Sanitary Sewer Hydraulic Analysis

For the Discovery Park East hydraulic calculations, flows from Areas 6 and 7 were introduced at MH 16-001 for all three (3) analysis conditions. Likewise, design flows for Area 8 were added at MH 16-011. Because the northern portion of Zone 1 is completely residential development and the south half is primarily commercial, independent flow calculations were prepared for these two (2) sections, which were designated as Zones 1A and 1B. The flows from these two (2) areas were assumed to enter the South Sewer at manholes 16-007 and 16-010, respectively. The flow from Zone 2 was also assumed to enter at manhole 16-010. The flow from Zone 5, which is only included in the ultimate build-out analysis, was assumed to enter the system at MH 16-002. The flow from Area 9, which like Zone 5 is only included in the ultimate build-out analysis, was assumed to enter the system at MH 16-007. Refer to Exhibit 2 for manhole locations. The hydraulic grade line computations are presented in Appendix F.

The hydraulic analysis of the existing conditions for the Discovery Park East development indicates that the pumping capacity of the LSRPS exceeds the maximum flow rate received at the pump station, thus the sewers upstream of the pump station will not surcharge based on inadequate pumping capacity. All sewers within the study area also have adequate capacity to transport the projected flow rates, thus in no instance will the HGL within a manhole exceed the

crown elevation of the upstream sewer. Based upon these observations, no surcharging will occur in either the North or South sewers for the existing flow conditions.

Although the flow rates are slightly higher, the same situation was found to be true for both sewers for the proposed development condition. Both pumps at the LSRPS were assumed to be in operation for this analysis.

The hydraulic analysis of the ultimate basin build-out condition revealed that the maximum flow rate to the LSRPS (4.59 MGD) exceeds the overall pump station capacity (2.52 MGD), thus surcharging of the sewers upstream from the pump station will occur. The HGL in MH 16-005 was computed based on the head required to send 2.07 MGD (influent flow rate minus pumping capacity) to the EFHB via the 16-inch bypass line. Calculations indicate that surcharging will extend upstream beyond MH 16-001 along the North Sewer and to MH 16-006 on the South Sewer. It should be noted that surcharging remains contained within the sewer at all locations. Of the three (3) conditions that were evaluated, the full build-out condition is the only one under which the EFHB will function if both pumps are operating at the LSRPS.

Except for the sewer line between manholes 16-004 and 16-005, individual sewer segments within the study area have adequate capacity to handle the peak design flows produced by the ultimate basin build-out condition. Surcharging of the North and South Sanitary Sewers is primarily attributable to inadequate pumping capacity for this scenario. Preliminary calculations indicate that the surcharging within the North sewer that is not attributable to pumping limitations could be eliminated by upsizing the pipe from MH16-004 to 16-005 from 12-inch size to 15-inch size.

HGL elevations for all three (3) conditions for both the North and South sewers are provided in Appendix F.

4.3 Lee's Summit Road Pump Station

A system head curve for the LSRPS was developed based on record drawing information provided by the city. Pipe friction losses in these calculations were derived based on an assumed Hazen-Williams "C" value of 100 for the existing ductile-iron pipe force main. A summary of the calculations that were made to produce this curve are included in Appendix D. Plotting the head-capacity curve for the current pumps on the same graph as the system head curve allowed us to determine that the theoretical firm pumping capacity of the LSRPS is approximately 1,400 gallons per minute (gpm). When both pumps operate together, the station capacity increases to 1,750 gpm. The graph that presents these results is included in Appendix D.

4.4 Excess Flow Holding Basin

HDR, Inc. completed an engineering report in 2012 that assessed the storage capacity of the EFHB and recommended improvements to reduce groundwater inflow into the basin. The HDR report recommended reducing the holding capacity of the EFHB from 1.25 million gallons (MG) to 0.67 MG. The total volume required for the EFHB for each condition described in Section 2 was compared to the total volume of the EFHB after the recommended improvements.

Table 4 on the following page shows the design parameters and computed flows for each of the three conditions. The ultimate basin build-out condition was the only one that made significant use of the storage capacity in the excess holding basin. It is worth noting that the firm pumping capacity of the LSRPS was used in performing these calculations, thus the storage requirement would be less if operation of both pumps is considered. The hydrograph for this condition is included in Appendix D.

The pumping capacity provided in the LSRPS is adequate to handle the peak flows for both the current and proposed development conditions. Because of this no sewer surcharging will occur for these conditions. Calculations indicate that the EFHB has adequate storage capacity for the ultimate basin build-out condition; however, significant surcharging will occur within the sewer system, especially the North Sanitary Sewer. This surcharging occurs because of inadequate pumping capacity, not the sewer line capacity. The elevated location of the diversion line to the EFHB also plays a role in how far surcharging extends along both sewers.

Table 4. Excess Flow Holding Basin Analysis.

Design Parameter	Existing Conditions	Proposed Condition	Ultimate Basin Build-out Condition
Total Sewer Acreage (ac)	182	258	519
Peak Dry-Weather Flow (MGD)	0.27	0.39	0.78
Peak Infiltration (MGD)	0.09	0.13	0.26
Time of Concentration (T_c) (min)	69.0	75.4	89.9
Rainfall Intensity (i_{50})	2.99	2.83	2.51
K-factor	0.004	0.004	0.004
Peak Inflow (MGD)	1.40	1.88	3.36
Total Peak Flow (MGD)	1.77	2.40	4.40
Total Rainfall (inches)	3.44	3.57	3.76
Total Rainfall Entering System (MG)	0.25	0.37	0.80
Inflow Hydrograph Duration (min)	415	448	520
Firm Capacity of LSRPS (MGD)*	2.02	2.02	2.02
Total Storage Available (MG)	0.67	0.67	0.67
Total Storage Required (MG)	0.00	0.01	0.31
Excess Capacity Available (MG)	0.67	0.66	0.36

* Estimated based on as-built drawings with pump curve information provided by City. The firm capacity of the LSRPS was used for the EFHB analysis, but the station's full capacity was used in the sewer capacity analysis.

5. DISCOVERY PARK SOUTH ANALYSIS AND RESULTS

5.1 Sanitary Sewer

Flow rates for the Discovery Park South development and from properties downstream of the development were computed using the methodology outlined in Section 3 of this report. A summary of the projected flow rates for the ultimate basin build-out condition is provided in Table 5. HGLs for the new sewers to serve the Discovery Park South development were generated using a flow modeling extension in AutoCAD Civil 3D. Summary reports from this work are provided in Appendix G.

Table 5. Projected Sanitary Sewer Flows for Ultimate Basin Build-Out Conditions.

Ultimate Conditions – Ultimate Basin Build-Out						
Development Area	**Area (ac)**	**Base Flow (gpd)**	**Peak Infiltration (gpd)**	**Peak Inflow (gpd)**	**Design Flow Rate (MGD)**	**Design Flow Rate (cfs)**
Zone 3	39	116,940	11,180	294,900	0.42	0.65
Zone 4A	26	10,800	6,900	207,400	0.23	0.36
Area 10	15	22,650	7,550	131,600	0.16	0.25
Area 11	16	24,450	8,150	141,200	0.17	0.26
Area 12	28	41,550	13,850	219,850	0.28	0.43
Area 13	19	29,100	9,700	163,000	0.20	0.31
				Total	1.46	2.26
Zone 4B	51	119,250	22,400	368,600	0.51	0.79
				Total	0.51	0.79

A collector sewer system would extend southeast from existing manhole 7527 on the Little Cedar Interceptor to serve Zones 3 and 4A of Discovery Park South, along with intervening properties in Unity Village, Missouri which are designated as Areas 10 through 13. These are shown on Exhibit 5 in Appendix B.

A separate line running to the east from existing manhole 7516 would serve Zone 4B in Discovery Park South.

The flow from Zone 3 was introduced at MH-1, and flow from Zone 4A was introduced at MH-18. The flow from Zone 4B was introduced at MH-19. The flows generated from Areas 10 through 13

were distributed to nodes throughout the collection system as shown on Exhibit 5. Refer to Appendix G for the flow allocations to the various nodes and the HGL elevations for the collector sewers required to serve Discovery Park South. Preliminary layout drawings for these sewers are presented in Exhibits 6A, 6B, and 6C in Appendix H.

6. CONCLUSIONS

6.1 Discover Park East - North Sanitary Sewer

The ultimate basin build-out condition for the North Sanitary Sewer results in surcharged conditions which extend from MH 16-005 to beyond MH 16-001. Based upon the City's design requirements, this situation is unacceptable.

The line running between MH 16-004 and 16-005 lacks sufficient capacity to handle the peak build-out flow. Upsizing of this line through pipe bursting or direct replacement would be necessary to eliminate this bottleneck.

There are several options available to address the surcharging associated with inadequate pumping capacity. One option would be to lower the discharge elevation of the EFHB diversion line. This would reduce the surcharge elevation in manhole 16-005. This benefit would then carry on upstream of this manhole. Additional study would be required to determine the feasibility of this modification and what impact it would have on EFHB operation.

A second option would be to upgrade the pumping capacity of the Lee's Summit Road Pump Station. If the existing pumps can be replaced with larger pumps that have a capacity equal to the maximum flow rate delivered to the station, the surcharge condition would be eliminated, as would the need for the EFHB. This option would almost certainly require an electrical system upgrade for the station, including upsizing of the emergency generator. Further investigation would need to be performed to determine whether upgrading the station is feasible and to evaluate the cost for such an upgrade.

A third approach would be to eliminate both the LSRPS and the EFHB through the installation of a gravity sewer extension from MH 16-005. This extension would be routed around the north side of Unity Lake No. 1 and connect to the Cedar Creek Interceptor northwest of the lake. Evaluation of this option is outside the scope of this study but should be considered for further investigation.

6.2 Discovery Park East - South Sanitary Sewer

Surcharging of the South Sanitary Sewer will occur under the full basin build-out condition between MH 16-005 and 16-006. The proposed connection point for the new gravity sewers from Zone 1A and Area 9 is at MH 16-007, thus the layout of these sewers will not be impacted by surcharging. The improvement options described for the North Sanitary Sewer in Paragraph 7.1 are equally applicable to the South Sanitary Sewer.

6.3 Lee's Summit Road Pump Station

The surcharge condition in both the North and South Sanitary Sewers occurs because the peak flow rate for the ultimate basin build-out condition (3.30 MGD) exceeds the two-pump operating

capacity of the LSRPS (2.52 MGD). Upsizing the pump station capacity to match the peak flow rate could eliminate the surcharging. Modification of the EFHB diversion line could be performed in conjunction with the pump station upgrade.

Upgrading the pump station to increase the pumping capacity by 0.78 MGD (540 gpm) would be an expensive proposition. It is unknown whether pumps capable of meeting this design condition will fit in the existing wet well. The horsepower rating for the motors required to drive the new pumps would increase, which would potentially require an electrical service upgrade for the station, as well as upsizing of the standby generator. The operating cost of the LSRPS would increase because of the higher operating horsepower.

As pointed out in Paragraph 7.1, both the LSRPS and the EFHB could be decommissioned if the existing sanitary sewer is extended around the north side of Unity Lake No. 1 to carry flow to the Little Cedar Interceptor. Further investigation of both the pump station upgrade and decommissioning options is recommended.

6.4 Emergency Flow Holding Basin

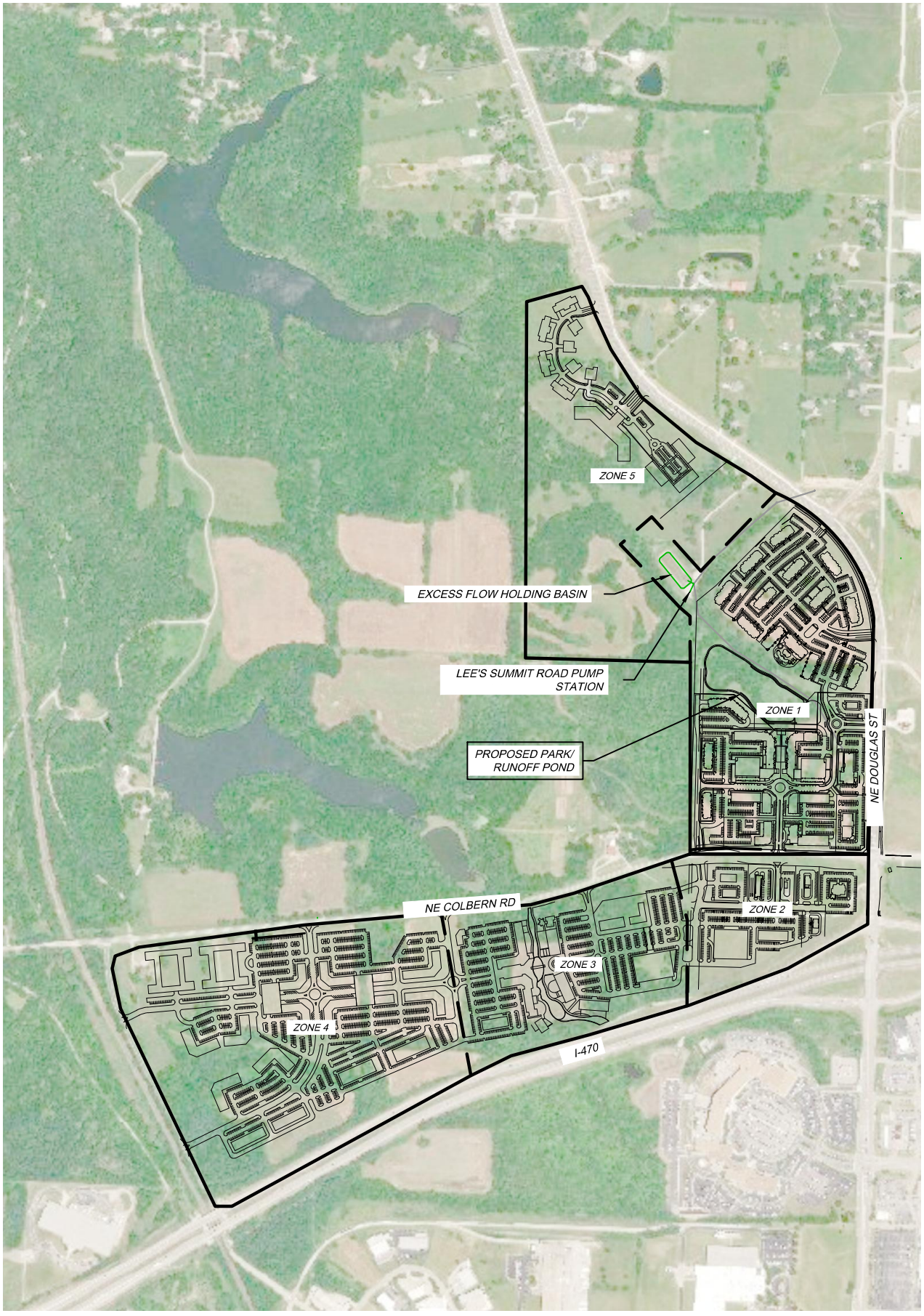
The EFHB is adequately sized to store the excess flow generated by a 50-year storm event for the ultimate basin build-out condition. Reconfiguring the diversion pipe that sends flow into the basin could reduce surcharging within the North Sanitary Sewer for this condition. This is recommended for further investigation. Decommissioning of the basin is also a possibility as discussed in the previous paragraph.

6.5 Discovery Park South Sewers

Discovery Park South can be served through the installation of approximately 5,800 linear feet of gravity sewers ranging from eight (8) to eighteen (18) inches in diameter as shown on Exhibits 5A, 5B, and 5C in Appendix H. This footage does not include the length of sewers that would need to be constructed within each of the various development zones. The alignments shown are preliminary and have been developed to demonstrate that gravity sewer service for Discovery Park South is practical. The ultimate design of these sewers may be impacted by the installation of a gravity sewer under Interstate 470 to serve the drainage basin to the south. This work is currently being evaluated by Olsson as part of an independent authorization from the City. A detailed alignment study to confirm the final routes would need to be undertaken after a topographic survey, geotechnical investigations, and streamway and wetlands delineations are completed.

APPENDIX A

Discovery Park Development Plan



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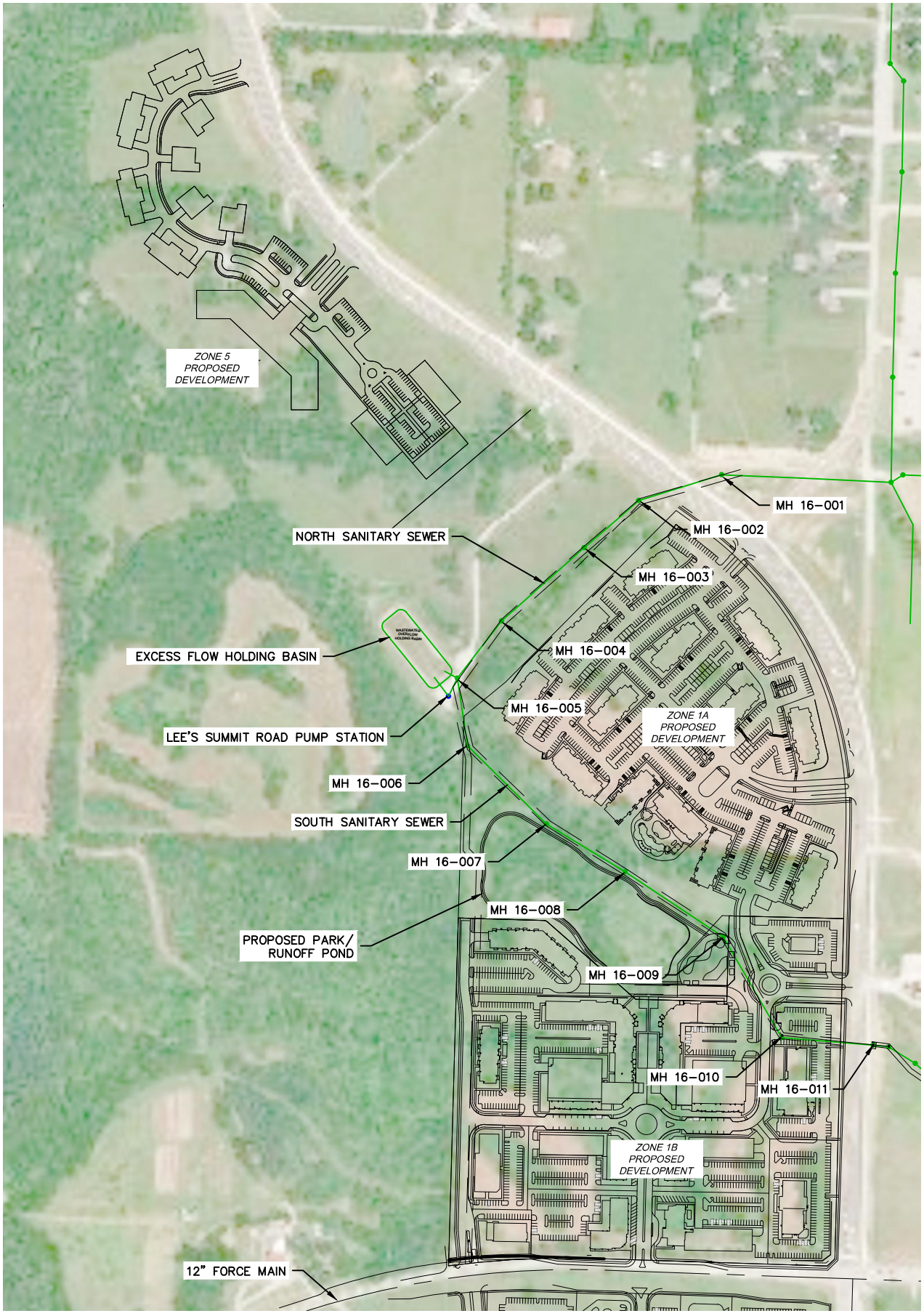
DRAWN BY: KTM		1301 Burlington Street North Kansas City, MO 64116 TEL 816.361.1177 FAX 816.361.1888	1
DATE: 05/15/2022			

APPENDIX B

Discovery Park Subbasin Maps



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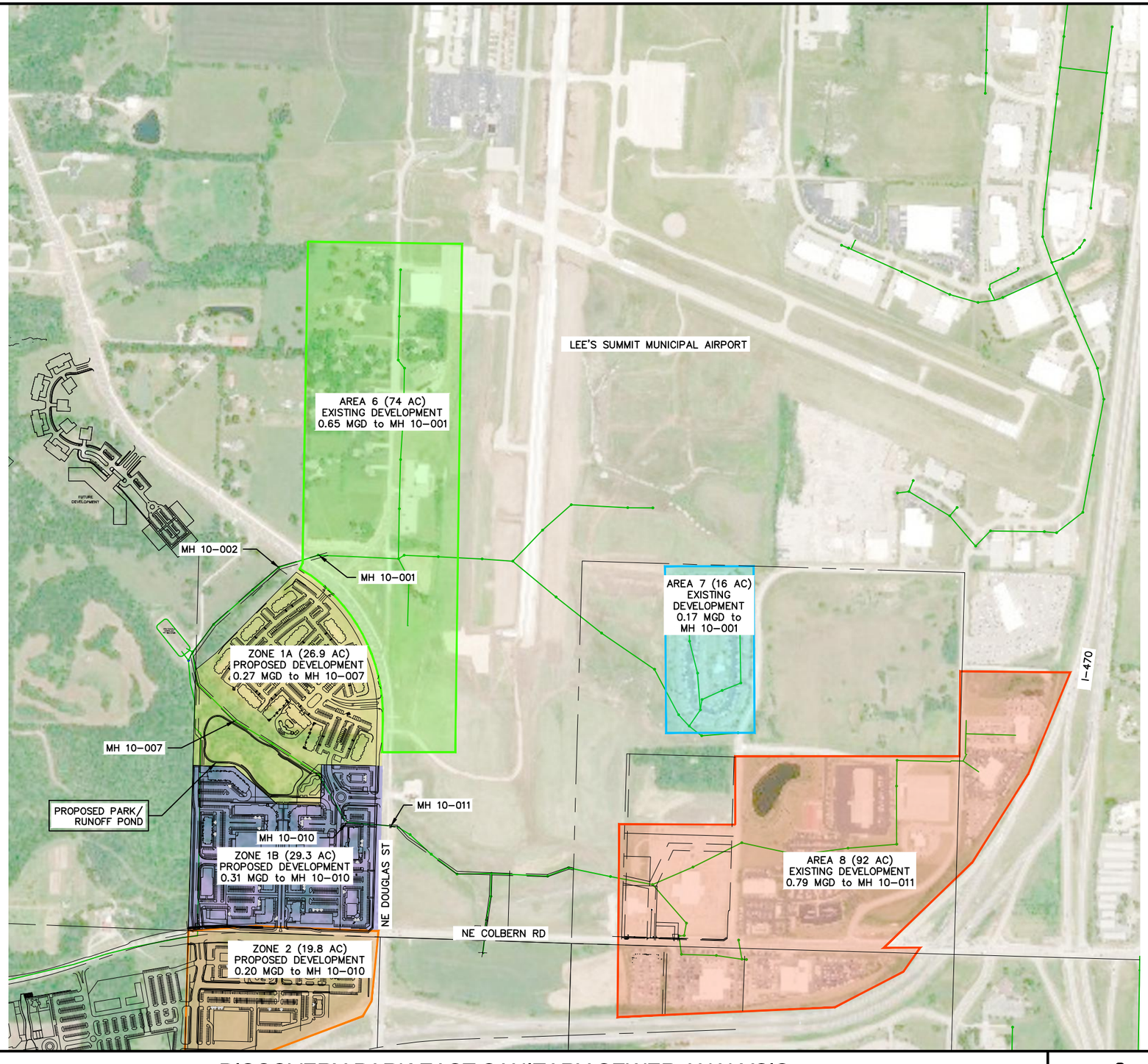

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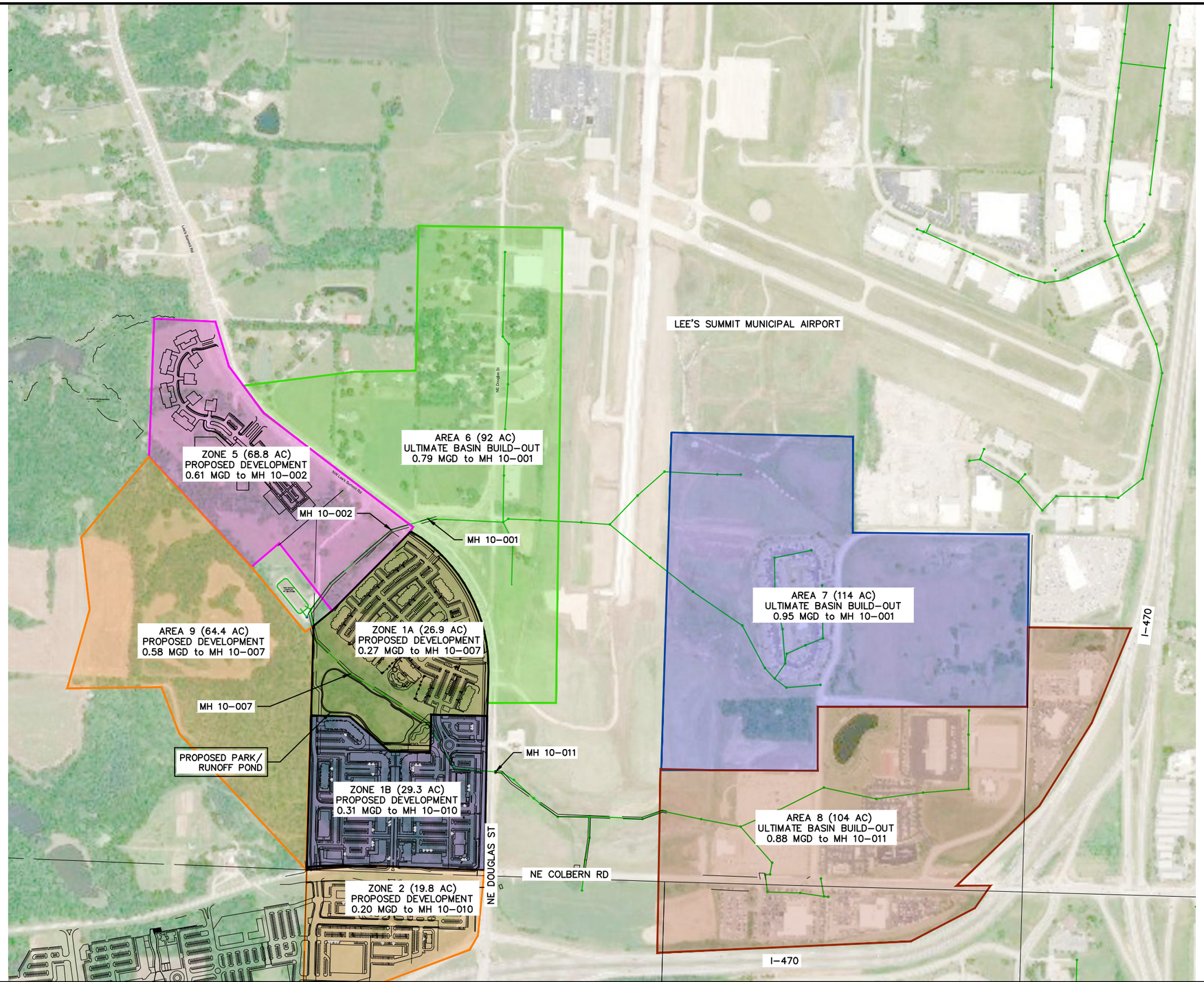

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DATE: 4/24/2023		

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North Kansas City, MO 64116
TEL 816.361.1177
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EXISTING LITTLE CEDAR INTERCEPTOR

AREA 12 (27.7 AC)
PROPOSED DEVELOPMENT
0.26 MGD TO MH-11
0.08 MGD TO MH-17

MH-13

MH-7

MH-5

AREA 11 (16.3 AC)
PROPOSED DEVELOPMENT
0.08 MGD TO MH-5
0.10 MGD TO MH-7

AREA 10 (15.1 AC)
PROPOSED DEVELOPMENT
0.25 MGD TO MH-3

AREA 13 (19.4 AC)
PROPOSED DEVELOPMENT
0.48 MGD TO MH-13

MH-11

MH-3

MH-17

MH-18

ZONE 4A (25.8 AC)
PROPOSED DEVELOPMENT
0.36 MGD TO MH-18

ZONE 3 (42.1 AC)
PROPOSED DEVELOPMENT
0.65 MGD TO MH-1

MH-19

ZONE 4B (51.1 AC)
PROPOSED DEVELOPMENT
0.79 MGD TO MH-19

EXISTING GRAVITY SEWER

DWG: F:\202104501-05000\021-04643-A140-Design\Exhibits\Exhibit Report\Exhibits2_4_A210464 3.dwg
DATE: May 04, 2023 - 8:35am
XREFS: 01_C_PBASE C_PBASE_A2104643 C_FBASE_A2104643 C_FBASE02_A2104643 C_FROAD_A2104643
USER: cwynd
01_C_PBASE_revised

PROJECT NO: A21-04643	DISCOVERY PARK SOUTH SANITARY SEWER ANALYSIS ULTIMATE BASIN BUILD-OUT	EXHIBIT
DRAWN BY:		5
DATE: 4/24/2023		

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APPENDIX C

Discovery Park Flow Calculations – Zones 1 through 5

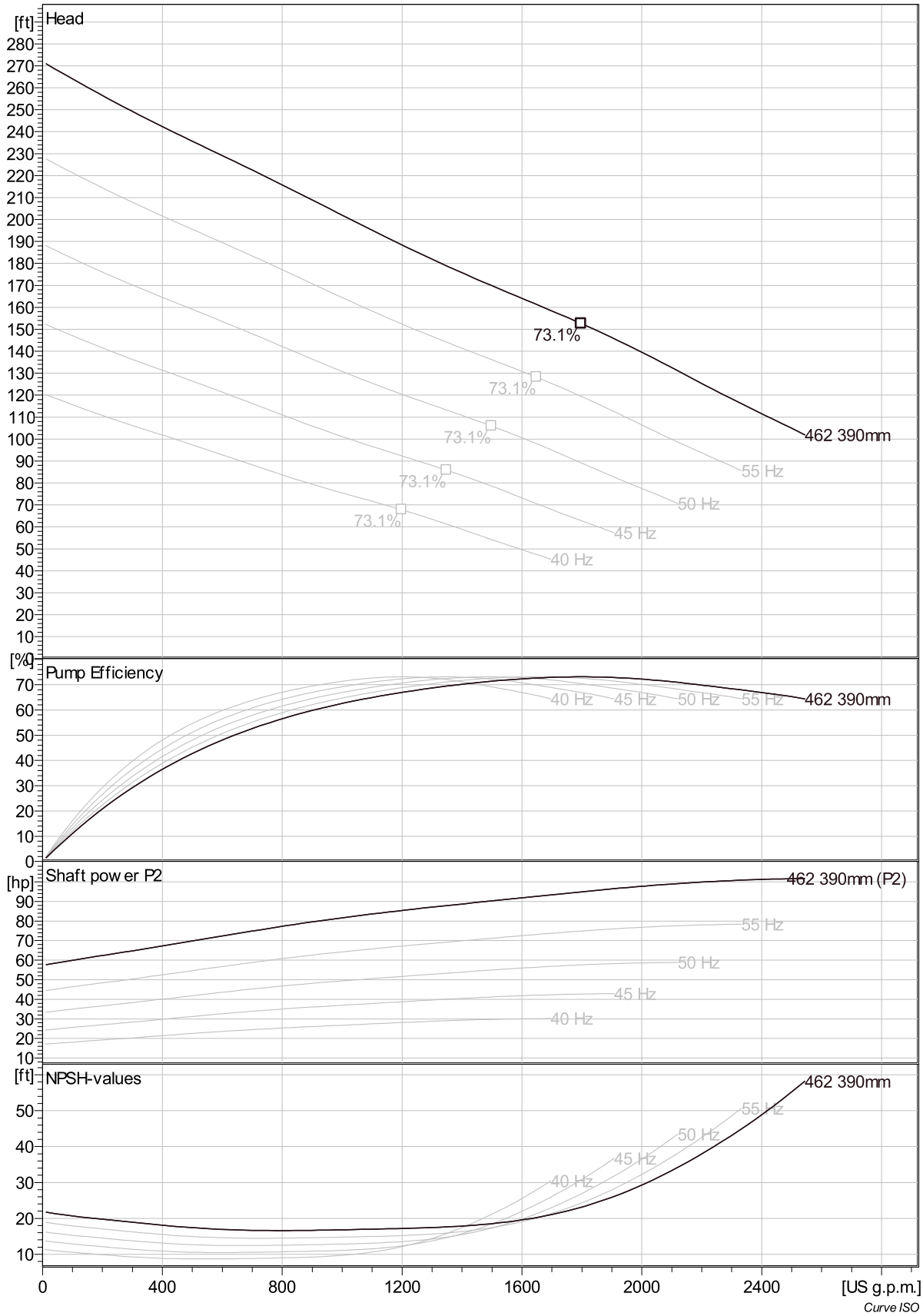
	Commercial				Residential			Composite					
Zone	Area (Acres)	ΣEDU	Base Flow (gpd)	Peak Infiltration (gpd)	Area (Acres)	Base Flow (gpd)	Peak Infiltration (gpd)	Total Area (Acres)	Time of Conc. (minutes)	Rainfall Intensity (in/hr)	Base Flow (gpd)	Peak Inflow (gpd)	Design Flow (MGD)
1A	0	1	300	0	26.9	40,350	13,450	26.9	42.6	3.08	40,650	214,200	0.268
1B	20.2	187.6	56,280	5,050	9.1	13,650	4,550	29.3	43.5	3.05	69,930	231,000	0.311
2	19.8	87.7	26,300	4,950	0	0	0	19.8	39.4	3.23	26,300	165,300	0.197
3	33.7	362.3	108,700	8,400	5.5	8,250	2,750	39.2	46.9	2.90	116,950	293,900	0.422
4A	24	27	8,100	6,000	1.8	2,700	900	25.8	42.2	3.10	10,800	206,800	0.225
4B	12.6	205	61,500	3,200	38.5	57,750	19,250	51.1	50.1	2.79	119,250	368,600	0.510
5	41.3	418.4	64,980	10,320	27.5	41,280	13,760	68.8	54.0	2.65	106,260	474,900	0.605

APPENDIX D

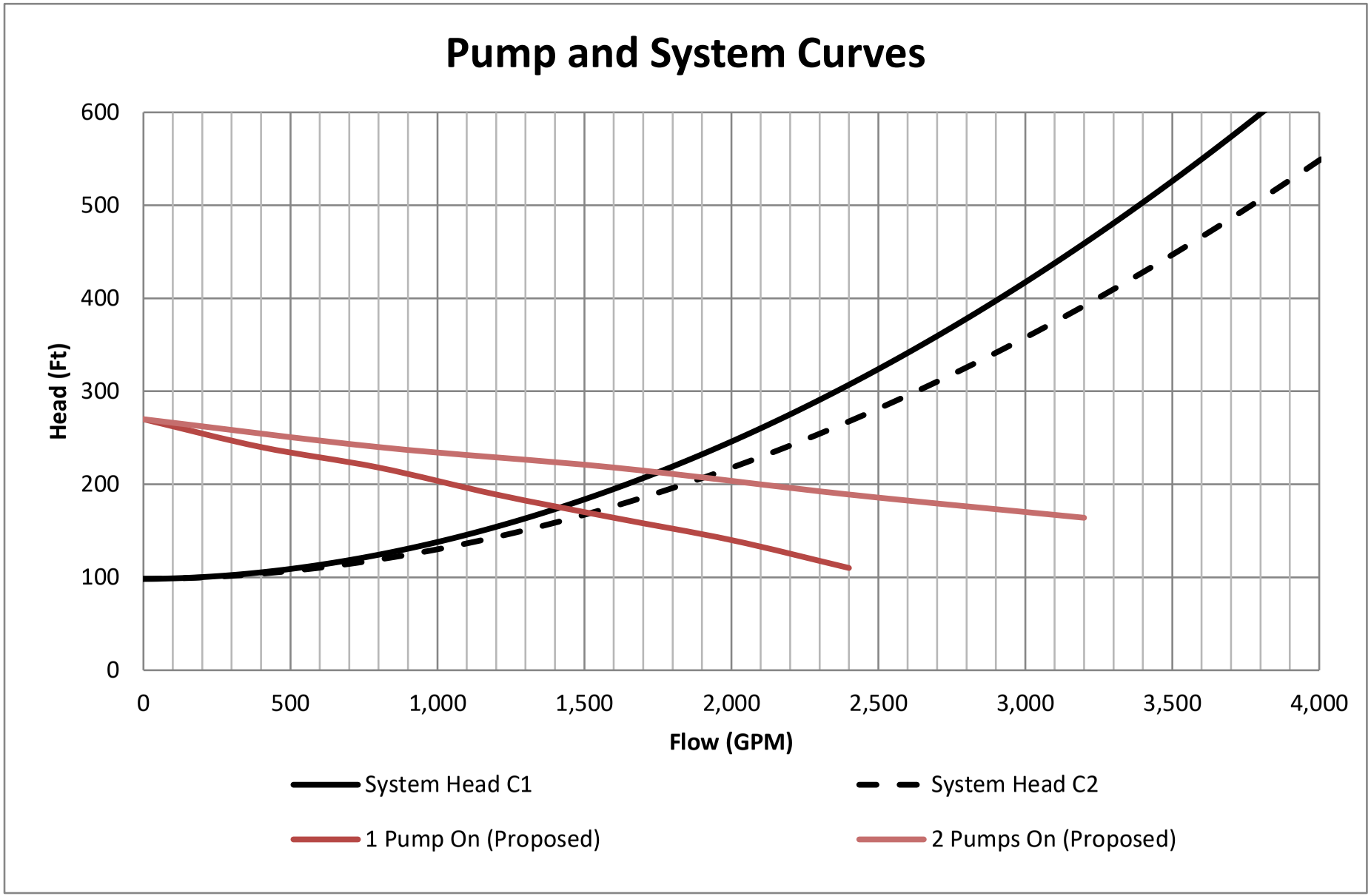
Lee's Summit Road Pump Station and Excess Flow Holding Basin

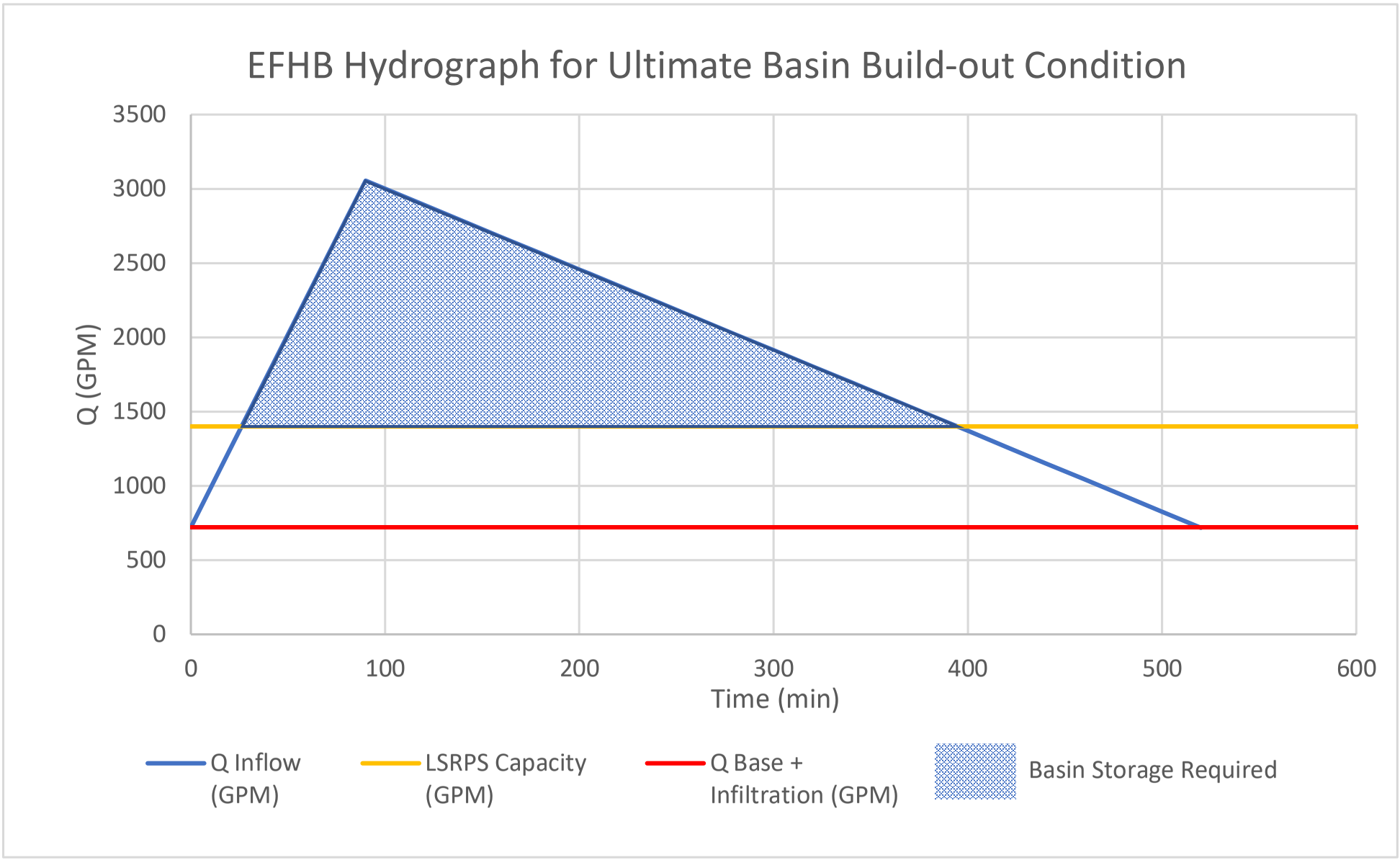
NP 3301 HT 3~ 462

VFD Curve



Project	Project ID	Created by	Created on	Last update
			1/16/2019	


Pump and System Curves
600
500
400
300
200
100
0
Head (Ft)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
Flow (GPM)
System Head C1
System Head C2
1 Pump On (Proposed)
2 Pumps On (Proposed)


EFHB Hydrograph for Ultimate Basin Build-out Condition
3500
3000
2500
2000
1500
1000
500
0
Q (GPM)
0
100
200
300
400
500
600
Time (min)
Q Inflow (GPM)
LSRPS Capacity (GPM)
Q Base + Infiltration (GPM)
Basin Storage Required

APPENDIX E

Discovery Park East Flow Calculations

EXISTING DEVELOPMENT DESIGN FLOW

	EXISTING DEVELOPMENT	TIME OF CONCENTRATION	INTENSITY	BASE FLOW	PEAK INFILTRATION	PEAK INFLOW	PEAK INFLOW	TOTAL PEAK FLOW	TOTAL PEAK FLOW	TOTAL PEAK FLOW
	(ac)	(min)	(in/hr)	(gpd)	(gpd)	(cfs)	(gpd)	(gpd)	(MGD)	(cfs)
AREA 6	74	55.00	3.44	111,000	37,000				0.00	0.00
AREA 7	16	37.37	4.40	24,000	8,000				0.00	0.00
AREA 8	92	58.11	3.32	138,000	46,000				0.00	0.00
TOTAL	182	69.03	2.99	273,000	91,000	2.1767	1,406,753	1,770,753	1.77	2.74

PROPOSED DEVELOPMENT DESIGN FLOW

	PROPOSED DEVELOPMENT	TIME OF CONCENTRATION	INTENSITY	BASE FLOW	PEAK INFILTRATION	PEAK INFLOW	PEAK INFLOW	TOTAL PEAK FLOW	TOTAL PEAK FLOW	TOTAL PEAK FLOW
	(ac)	(min)	(in/hr)	(gpd)	(gpd)	(cfs)	(gpd)	(gpd)	(MGD)	(cfs)
ZONE 1A	26.9	42.60	4.06	40,650	13,450				0.00	0.00
ZONE 1B	29.3	43.53	4.00	69,924	9,600				0.00	0.00
ZONE 2	19.8	39.43	4.25	26,320	4,950				0.00	0.00
AREA 6	74	55.00	3.44	111,000	37,000				0.00	0.00
AREA 7	16	37.37	4.40	24,000	8,000				0.00	0.00
AREA 8	92	58.11	3.32	138,000	46,000				0.00	0.00
TOTAL	258	75.38	2.83	409,894	119,000	2.9206	1,887,476	2,416,370	2.42	3.75

ULTIMATE BASIN BUILD-OUT DESIGN FLOW

	ULTIMATE BASIN BUILD-OUT	TIME OF CONCENTRATION	INTENSITY	BASE FLOW	PEAK INFILTRATION	PEAK INFLOW	PEAK INFLOW	TOTAL PEAK FLOW	TOTAL PEAK FLOW	TOTAL PEAK FLOW
	(ac)	(min)	(in/hr)	(gpd)	(gpd)	(cfs)	(gpd)	(gpd)	(MGD)	(cfs)
ZONE 1A	26.9	42.60	4.06	40,650	13,450				0.00	0.00
ZONE 1B	29.3	43.53	4.00	69,924	9,600				0.00	0.00
ZONE 2	19.8	39.43	4.25	26,320	4,950				0.00	0.00
ZONE 5	68.8	54.00	3.48	106,260	24,080				0.00	0.00
AREA 6	92	58.11	3.32	138,000	46,000				0.00	0.00
AREA 7	114	61.34	3.24	171,000	57,000				0.00	0.00
AREA 8	104	59.93	3.26	156,000	52,000				0.00	0.00
AREA 9	64.4	53.11	3.52	96,600	32,200				0.00	0.00
TOTAL	519.2	89.93	2.51	708,154	207,080	5.2128	3,368,866	4,284,100	4.28	6.64

APPENDIX F

Discovery Park East Hydraulic Grade Line (HGL) Calculations

Table N1 - North Sanitary Sewer Flow - Existing Conditions

US MH	DS MH	Design Flow Rate (MGD)	Cumulative Design Flow Rate (MGD)	Cumulative Design Flow Rate (cfs)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Depth of Flow (ft)	Pipe Dia (inches)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (MGD)	Percent Pipe Capacity	Velocity (fps)	HGL Elev. at USMH	Crown of US Pipe
MH 16-005	LS Road PS	0.79	1.62	2.50	894.18	894.18	908.00	0.00%		20	35.00					894.91	895.85
MH 16-004	MH 16-005	0.00	0.82	1.28	896.87	894.18	908.00	1.00%	0.43	12	268.47	3.57	2.30	35.8%	3.9	897.42	897.87
MH 16-003	MH 16-004	0.00	0.82	1.28	903.93	898.97	912.00	1.37%	0.40	12	361.42	4.18	2.70	30.6%	4.5	904.48	904.93
MH 16-002	MH 16-003	0.00	0.82	1.28	907.82	904.03	917.00	1.60%	0.38	12	236.48	4.52	2.91	28.3%	4.7	908.37	908.82
MH 16-001	MH 16-002	0.82	0.82	1.28	911.48	908.32	921.00	1.11%	0.42	12	284.75	3.76	2.43	34.0%	4.1	912.03	912.48

Table N2 - North Sanitary Sewer Flow - Proposed Conditions

US MH	DS MH	Design Flow Rate (MGD)	Cumulative Design Flow Rate (MGD)	Cumulative Design Flow Rate (cfs)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Depth of Flow (ft)	Pipe Dia (inches)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (MGD)	Percent Pipe Capacity	Velocity (fps)	HGL Elev. at USMH	Crown of US Pipe
MH 16-005	LS Road PS	1.37	2.19	3.40	894.18	894.18	908.00	0.00%		20	35.00					895.00	895.85
MH 16-004	MH 16-005	0.00	0.82	1.28	896.87	894.18	908.00	1.00%	0.43	12	268.47	3.57	2.30	35.8%	3.9	897.42	897.87
MH 16-003	MH 16-004	0.00	0.82	1.28	903.93	898.97	912.00	1.37%	0.40	12	361.42	4.18	2.70	30.6%	4.5	904.48	904.93
MH 16-002	MH 16-003	0.00	0.82	1.28	907.82	904.03	917.00	1.60%	0.38	12	236.48	4.52	2.91	28.3%	4.7	908.37	908.82
MH 16-001	MH 16-002	0.82	0.82	1.28	911.48	908.32	921.00	1.11%	0.42	12	284.75	3.76	2.43	34.0%	4.1	912.03	912.48

Table N3 - North Sanitary Sewer Flow - Ultimate Basin Build-Out

US MH	DS MH	Design Flow Rate (MGD)	Cumulative Design Flow Rate (MGD)	Cumulative Design Flow Rate (cfs)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Depth of Flow (ft)	Pipe Dia (inches)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (MGD)	Percent Pipe Capacity	Velocity (fps)	HGL Elev. at USMH	Crown of US Pipe
MH 16-005	EFHB		1.87	2.90	903.00	901.80	908.00	2.40%	0.51	16	50.00	11.11	7.17	26.1%	6.5	903.83	904.33
MH 16-005	LS Road PS	2.04	2.52	3.91	894.18	894.18	908.00	0.00%		20	35.00					903.83	895.85
MH 16-004	MH 16-005	0.00	2.35	3.65	896.87	894.18	908.00	1.00%	1.00	12	268.47	3.57	2.30	102.1%	4.7	906.32	897.87
MH 16-003	MH 16-004	0.00	2.35	3.65	903.93	898.97	912.00	1.37%	0.77	12	361.42	4.18	2.70	87.2%	5.6	909.49	904.93
MH 16-002	MH 16-003	0.61	2.35	3.65	907.82	904.03	917.00	1.60%	0.72	12	236.48	4.52	2.91	80.7%	6.0	911.74	908.82
MH 16-001	MH 16-002	1.74	1.74	2.70	911.48	908.32	921.00	1.11%	0.66	12	284.75	3.76	2.43	71.9%	4.9	913.22	912.48

903.47 Indicates location where HGL is above crown of pipe

Table S1 - South Sanitary Sewer Flow - Existing Conditions

US MH	DS MH	Design Flow Rate (MGD)	Cumulative Design Flow Rate (MGD)	Cumulative Design Flow Rate (cfs)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Depth of Flow (ft)	Pipe Dia (inches)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (MGD)	Percent Pipe Capacity	Velocity (fps)	HGL Elev. at USMH	Crown of US Pipe
MH 16-005	LS Road PS	0.82	1.62	2.50	894.18	894.18	908.00	0.00%		20	35.00					894.91	895.85
MH 16-006	MH 16-005	0.00	0.79	1.23	902.75	896.68	909.00	3.04%	0.31	12	199.4	6.23	4.02	19.7%	5.8	903.32	903.75
MH 16-007	MH 16-006	0.00	0.79	1.23	910.92	903.05	917.50	2.05%	0.35	12	384.0	5.11	3.30	24.0%	5.1	911.47	911.92
MH 16-008	MH 16-007	0.00	0.79	1.23	922.97	911.02	931.00	3.98%	0.29	12	300.0	7.12	4.59	17.2%	6.4	923.58	923.97
MH 16-009	MH 16-008	0.00	0.79	1.23	926.78	923.07	935.00	0.97%	0.43	12	381.0	3.52	2.27	34.8%	3.9	927.33	927.78
MH 16-010	MH 16-009	0.00	0.79	1.23	931.85	926.98	940.50	1.28%	0.40	12	380.3	4.04	2.61	30.3%	4.3	932.39	932.85
MH 16-011	MH 16-010	0.79	0.79	1.23	940.00	931.95	949.29	2.67%	0.32	12	301.0	5.84	3.77	21.0%	5.5	940.56	941.00

Table S2 - South Sanitary Sewer Flow - Proposed Conditions

US MH	DS MH	Design Flow Rate (MGD)	Cumulative Design Flow Rate (MGD)	Cumulative Design Flow Rate (cfs)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Depth of Flow (ft)	Pipe Dia (inches)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (MGD)	Percent Pipe Capacity	Velocity (fps)	HGL Elev. at USMH	Crown of US Pipe
MH 16-005	LS Road PS	0.82	2.19	3.40	894.18	894.18	908.00	0.00%		20	35.00					895.00	895.85
MH 16-006	MH 16-005	0.00	1.37	2.12	902.75	896.68	909.00	3.04%	0.45	12	199.4	6.23	4.02	34.1%	7.0	903.58	903.75
MH 16-007	MH 16-006	0.27	1.37	2.12	910.92	903.05	917.50	2.05%	0.51	12	384.0	5.11	3.30	41.6%	6.1	911.72	911.92
MH 16-008	MH 16-007	0.00	1.10	1.71	922.97	911.02	931.00	3.98%	0.38	12	300.0	7.12	4.59	24.0%	7.4	923.77	923.97
MH 16-009	MH 16-008	0.00	1.10	1.71	926.78	923.07	935.00	0.97%	0.57	12	381.0	3.52	2.27	48.4%	4.4	927.50	927.78
MH 16-010	MH 16-009	0.31	1.10	1.71	931.85	926.98	940.50	1.28%	0.52	12	380.3	4.04	2.61	42.2%	4.8	932.55	932.85
MH 16-011	MH 16-010	0.79	0.79	1.23	940.00	931.95	949.29	2.67%	0.32	12	301.0	5.84	3.77	21.0%	5.5	940.56	941.00

Table S3 - South Sanitary Sewer Flow - Ultimate Basin Build-Out

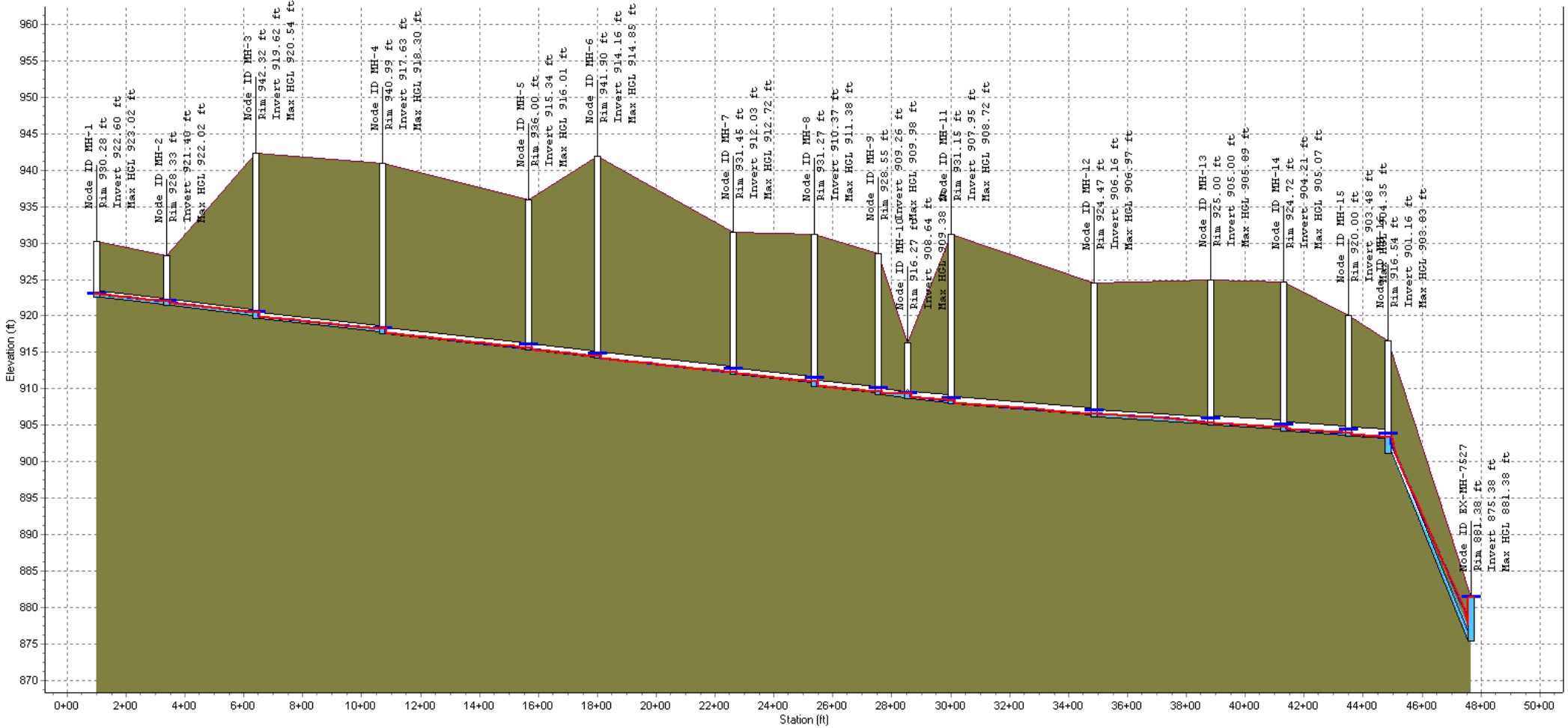
US MH	DS MH	Design Flow Rate (MGD)	Cumulative Design Flow Rate (MGD)	Cumulative Design Flow Rate (cfs)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Depth of Flow (ft)	Pipe Dia (inches)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (MGD)	Percent Pipe Capacity	Velocity (fps)	HGL Elev. At USMH	Crown of US Pipe
MH 16-005	EFHB		1.87	2.90	903.00	901.80	908.00	2.40%	0.51	16	50.00	11.11	7.17	26.1%	6.5	903.83	904.33
MH 16-005	LS Road PS	2.35	2.52	3.91	894.18	894.18	908.00	0.00%		20	35.00					903.83	895.85
MH 16-006	MH 16-005	0.00	2.04	3.16	902.75	896.68	909.00	3.04%	0.56	12	199.4	6.23	4.02	50.7%	7.7	905.26	903.75
MH 16-007	MH 16-006	0.85	2.04	3.16	910.92	903.05	917.50	2.05%	0.64	12	384.0	5.11	3.30	61.8%	6.6	911.89	911.92
MH 16-008	MH 16-007	0.00	1.19	1.84	922.97	911.02	931.00	3.98%	0.39	12	300.0	7.12	4.59	25.9%	7.5	923.80	923.97
MH 16-009	MH 16-008	0.00	1.19	1.84	926.78	923.07	935.00	0.97%	0.59	12	381.0	3.52	2.27	52.4%	4.4	927.52	927.78
MH 16-010	MH 16-009	0.31	1.19	1.84	931.85	926.98	940.50	1.28%	0.54	12	380.3	4.04	2.61	45.7%	4.9	932.58	932.85
MH 16-011	MH 16-010	0.88	0.88	1.36	940.00	931.95	949.29	2.67%	0.34	12	301.0	5.84	3.77	23.4%	5.7	940.59	941.00

APPENDIX G

Discovery Park South Civil 3D HGL Calculations

Profile Plot

Discovery Park Sanitary Sewer

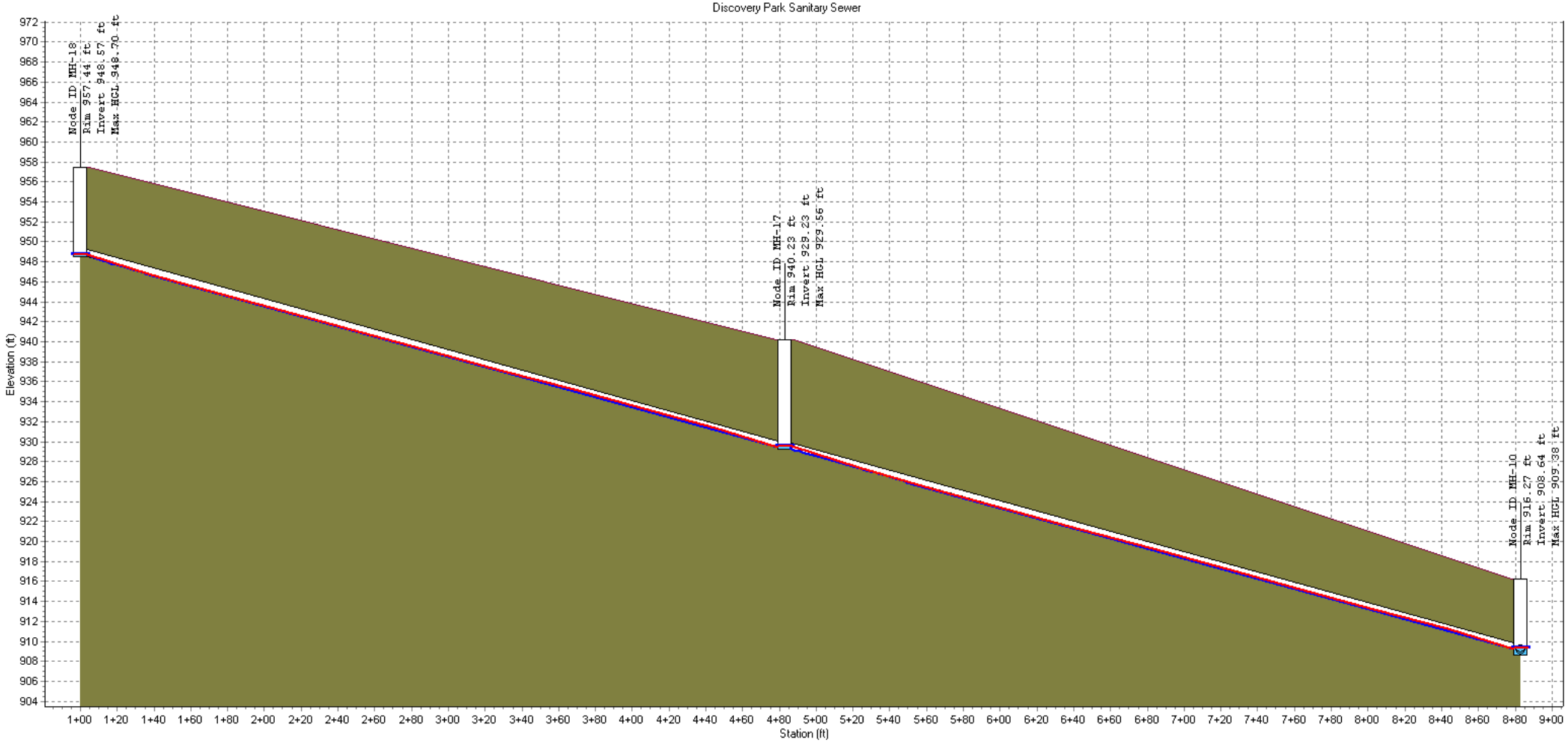


Node ID:	MH-1	MH-2	MH-3	MH-4	MH-5	MH-6	MH-7	MH-8	MH-9	MH-10	MH-11	MH-12	MH-13	MH-14	MH-15	MH-16	EX-MH-7527
Rim (ft):	930.28	928.33	942.32	940.99	936.00	941.90	931.45	931.27	928.55	916.27	931.15	924.47	925.00	924.72	920.00	916.54	881.38
Invert (ft):	922.60	921.40	919.62	917.63	915.34	914.16	912.03	910.37	909.26	908.64	907.95	906.16	905.00	904.21	903.48	901.16	875.38
Min Pipe Cover (ft):	6.85	5.90	21.36	22.33	19.63	26.70	18.38	19.57	18.25	6.37	22.00	17.11	18.75	19.07	15.07	12.13	4.75
Max HGL (ft):	923.02	922.02	920.54	918.30	916.01	914.85	912.72	911.38	909.98	909.38	908.72	906.97	905.89	905.07	904.35	903.83	881.38

Link ID:	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16
Length (ft):	236.50	305.63	428.24	497.45	232.98	459.37	276.31	216.56	100.19	149.83	482.11	398.75	247.35	220.25	133.29	282.09
Dia (in):	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	12.00	12.00	12.00	15.00	15.00	15.00	15.00
Slope (ft/ft):	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0033	0.0033	0.0024	0.0024	0.0024	0.0024	0.0914
Up Invert (ft):	922.60	921.40	919.62	917.63	915.34	914.16	912.03	910.37	909.26	908.64	907.95	906.16	905.00	904.21	903.48	901.16
Dn Invert (ft):	921.60	920.12	917.83	915.54	914.36	912.23	910.87	909.46	908.84	908.15	906.36	905.20	904.41	903.68	903.16	875.38
Max Q (cfs):	0.77	0.77	0.95	0.95	1.01	1.01	1.08	1.08	1.08	1.39	1.53	1.53	1.91	1.91	1.91	1.91
Max Vel (ft/s):	2.83	2.82	2.96	2.97	3.01	3.01	3.05	3.05	3.05	2.98	3.04	2.68	2.87	2.87	2.87	10.71
Max Depth (ft):	0.42	0.42	0.47	0.47	0.49	0.49	0.52	0.52	0.52	0.57	0.61	0.68	0.67	0.67	0.67	0.25

Profile Plot

Discovery Park Sanitary Sewer

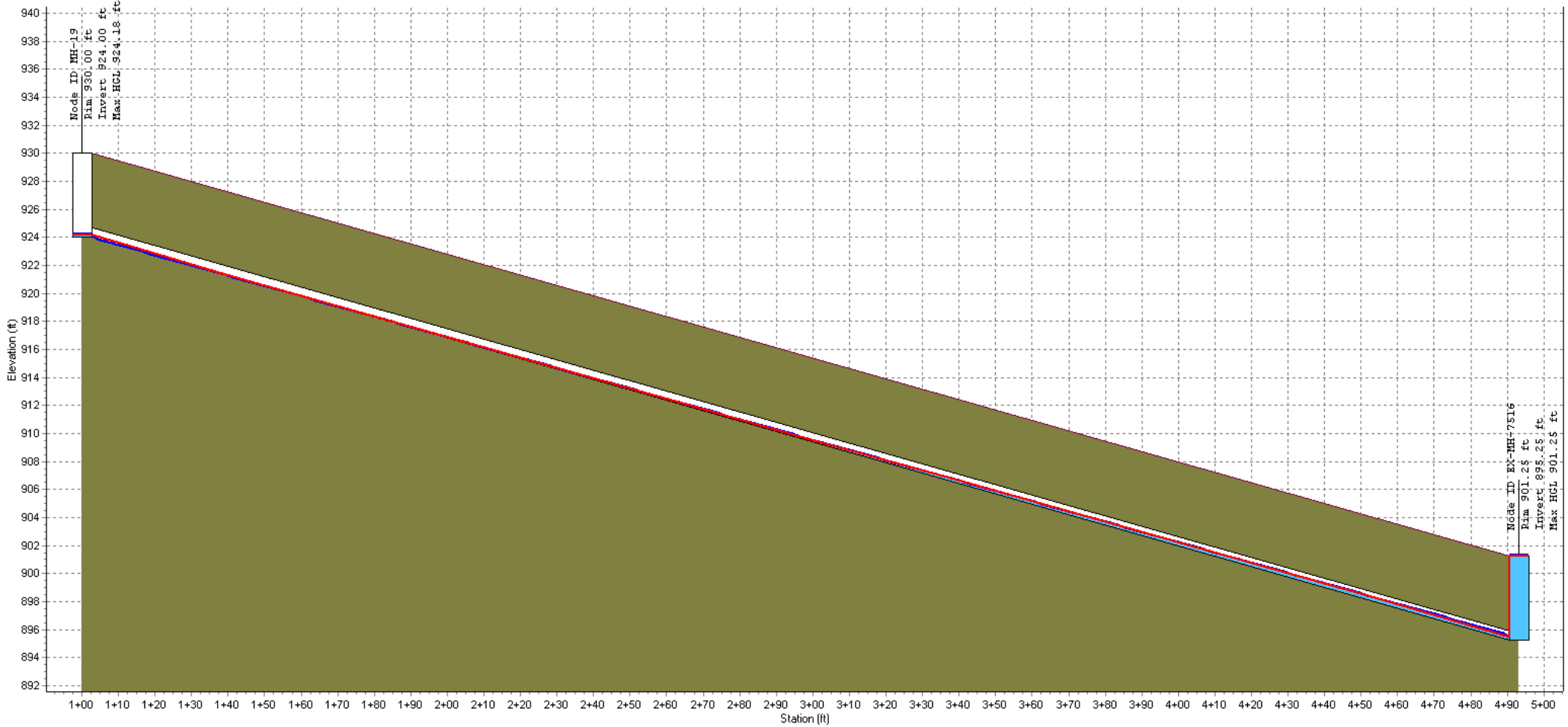


Node ID:	MH-18	MH-17	MH-10
Rim (ft):	957.44	940.23	916.27
Invert (ft):	948.57	929.23	908.64
Min Pipe Cover (ft):	8.20	10.13	6.37
Max HGL (ft):	948.70	929.56	909.38

Link ID:	P-17	P-18
Length (ft):	383.11	400.00
Dia (in):	8.00	8.00
Slope (ft/ft):	0.0500	0.0500
Up Invert (ft):	948.57	929.23
Dn Invert (ft):	929.43	909.23
Max Q (cfs):	0.25	0.31
Max Vel (ft/s):	5.12	5.45
Max Depth (ft):	0.13	0.15

Profile Plot

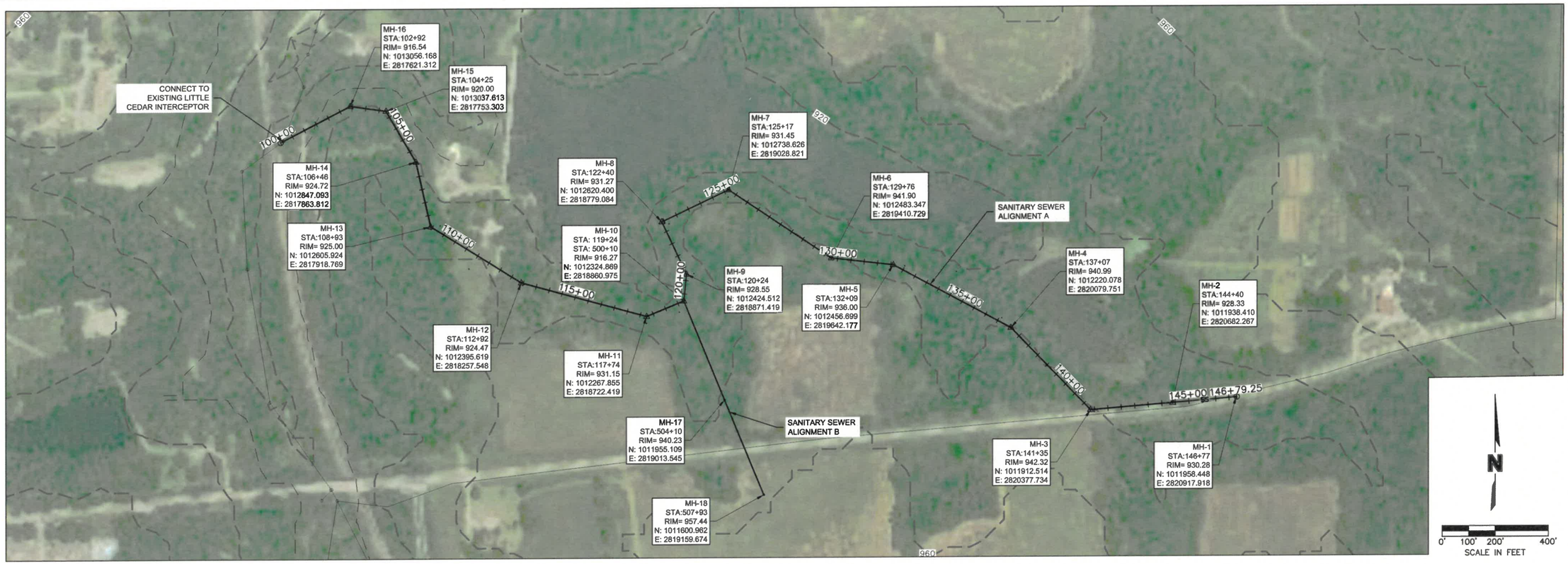
Discovery Park Sanitary Sewer



Node ID:	MH-19		EX-MH-7516
Rim (ft):	930.00		901.25
Invert (ft):	924.00		895.25
Min Pipe Cover (ft):	5.33		5.33
Max HGL (ft):	924.18		901.25
Link ID:		P-19	
Length (ft):		393.09	
Dia (in):		8.00	
Slope (ft/ft):		0.0731	
Up Invert (ft):		924.00	
Dn Invert (ft):		895.25	
Max Q (cfs):		0.59	
Max Vel (ft/s):		7.51	
Max Depth (ft):		0.18	

APPENDIX H

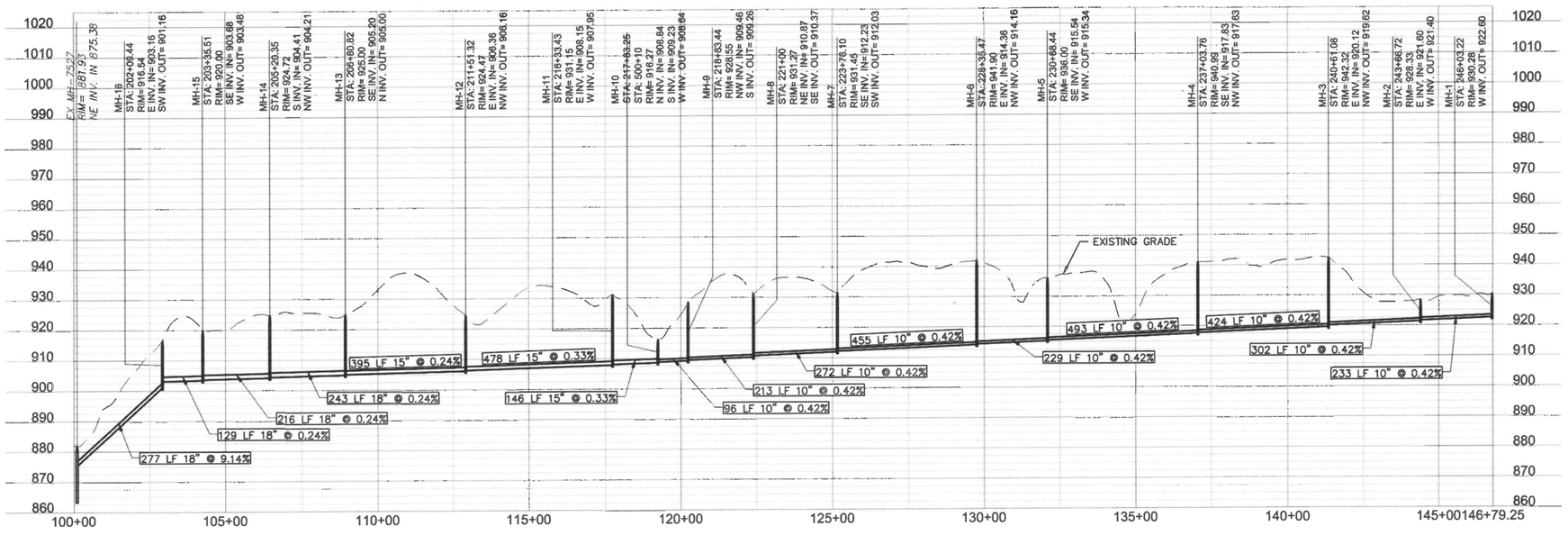
Discovery Park South Sanitary Sewer Layout and Design



NOTES

1. EXISTING GROUND ELEVATIONS WERE TAKEN FROM GIS DATA.
2. THIS EXHIBIT IS INTENDED TO SHOW PRELIMINARY SIZING AND APPROXIMATE ALIGNMENT LOCATION. FURTHER DESIGN IS NEEDED IF THIS OPTION IS TO BE PURSUED.

PROPOSED SANITARY SEWER ALIGNMENT A (100+00 - 146+80)



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REVISIONS

PROPOSED GRAVITY SEWER SIZING PLAN & PROFILE

PROPOSED GRAVITY SEWER DISCOVERY PARK

LEE'S SUMMIT, MISSOURI

2022

drawn by: KTM
checked by:
approved by: JBM
QA/QC by: JPH
project no.:
drawing no.:
date: 05/15/2022

EXHIBIT
6A

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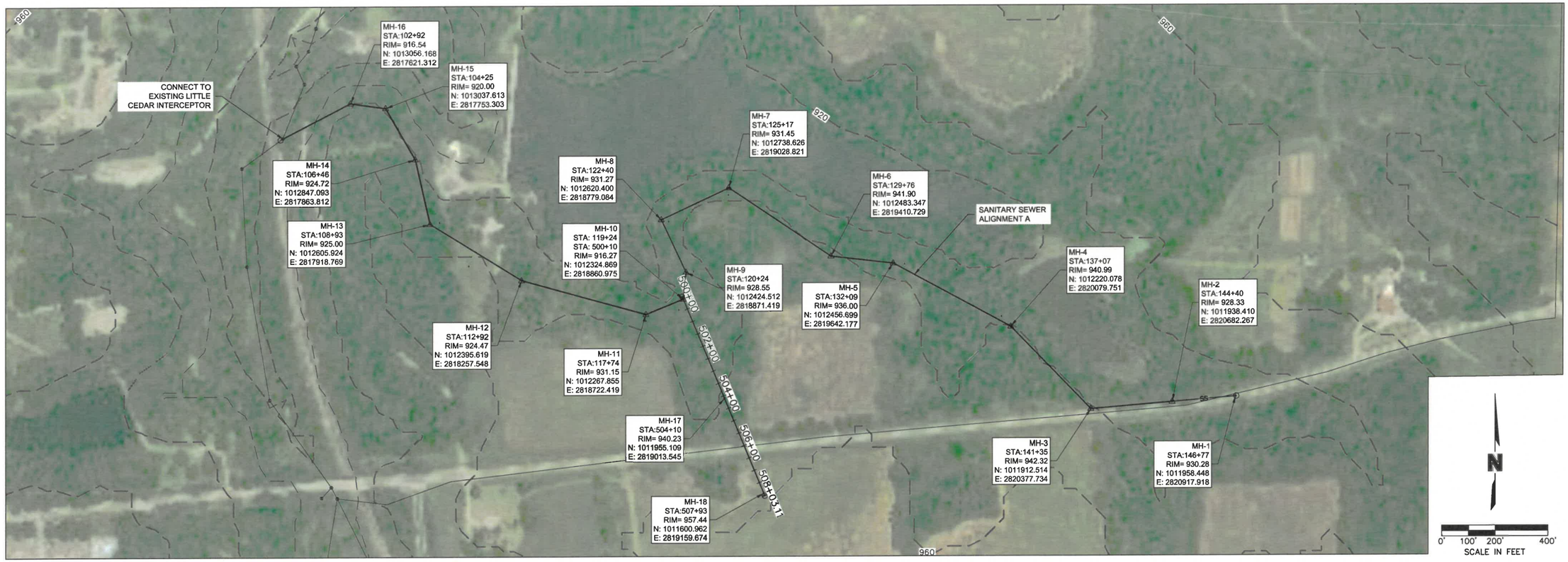

NOTES

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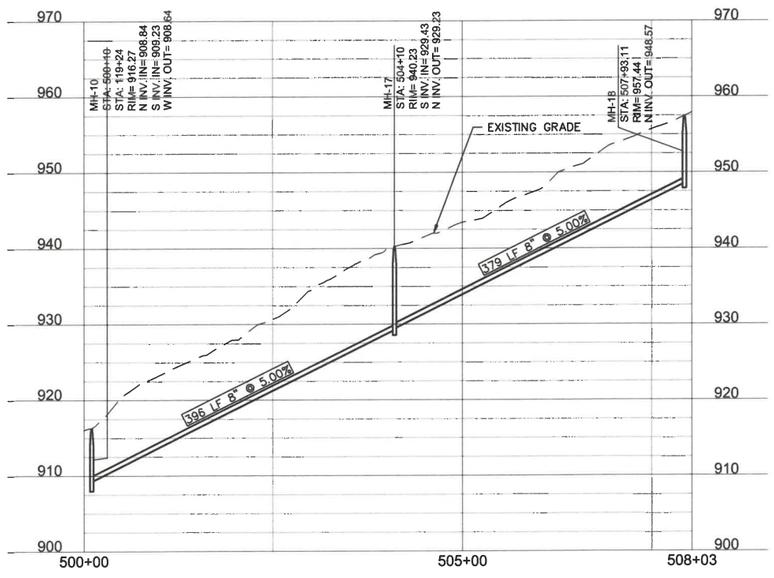
PROPOSED SANITARY SEWER ALIGNMENT B (500+00 - 508+03)



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PROPOSED GRAVITY SEWER
SIZING PLAN & PROFILE

PROPOSED GRAVITY SEWER
DISCOVERY PARK

LEE'S SUMMIT, MISSOURI

2022

drawn by: KTM
checked by:
approved by: JBM
QA/QC by: JPH
project no.:
drawing no.:
date: 05/15/2022

EXHIBIT
6B

DWG: F:\2021\04501-05000\021-04643-A\40-Design\Exhibits\Exhibits for Report\P_SSAN_A2104643.dwg USER: cwynd
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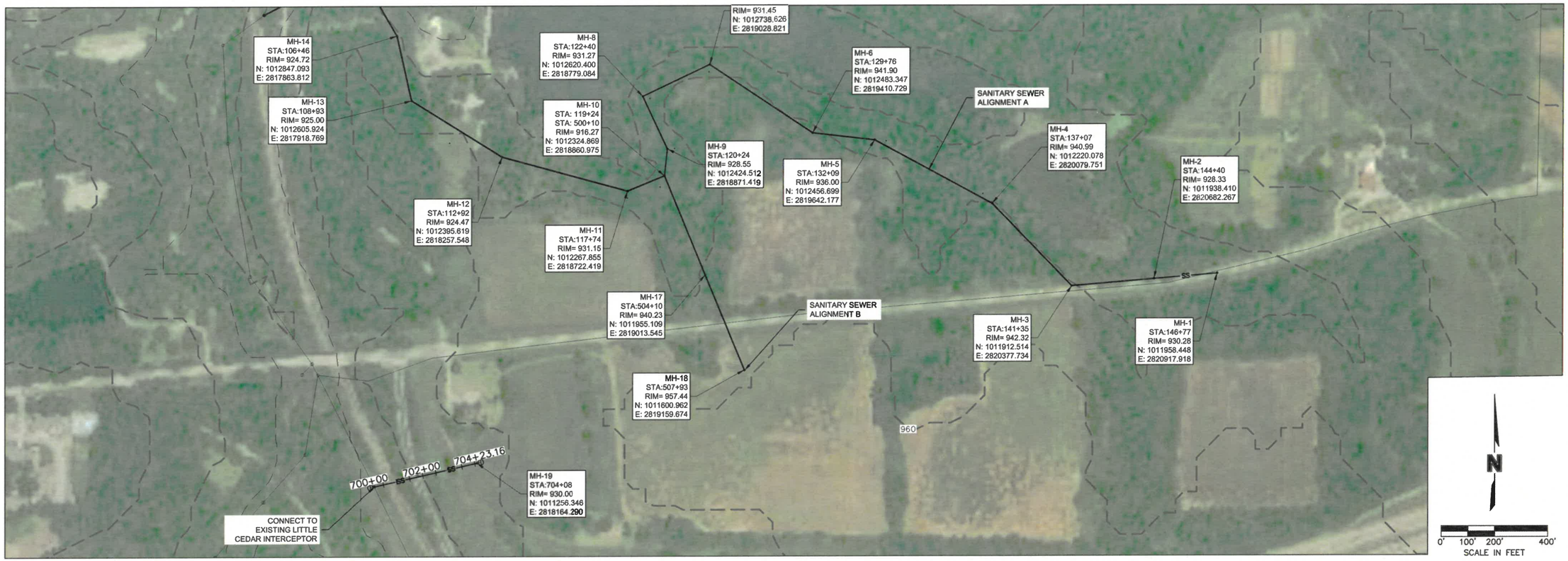
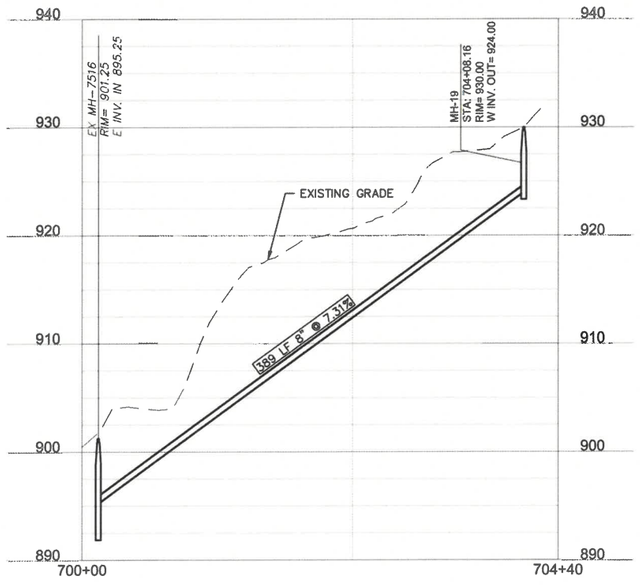


PROPOSED SANITARY SEWER ALIGNMENT C (700+0 - 704+40)



NOTES
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LEE'S SUMMIT, MISSOURI

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project no.:
drawing no.:
date: 05/15/2022

EXHIBIT
6C

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SANITARY SEWER SYSTEM CAPACITY ANALYSIS: DISCOVERY PARK

Lee's Summit, Missouri - 2023

May 2023

Olsson Project No. A21-04643