March 20, 2020

Mr. Judd Claussen, P.E.
Phelps Engineering, Inc.
1270 N Winchester
Olathe, KS 66061

Re: City of Lee's Summit, MO
Lee's Summit Apartments Update

Dear Mr. Claussen:

An analysis was completed to determine the effect of the proposed development on the existing sanitary sewer system. The proposed development consists of approximately 3.5 acres where the existing Lee's Summit United Methodist Church currently resides, near the intersection of 2nd Street and Douglas Street. The original analysis was summarized in a December 21, 2018 letter. A subsequent update was summarized in a January 7, 2020 letter. This letter provides a comprehensive summary of the full analysis.

The proposed development map for the original December 2018 analysis was based upon an apartment complex with a total of 278 units, broken down as follows:

- 3 - Studio Units
- 170 - One Bedroom Units
- 105 - Two Bedroom Units

The projected sanitary sewer flows generated by the proposed development were calculated utilizing the criteria in the City of Lee's Summit Design and Construction Manual. The peak wastewater flows consist of three components: Peak Base Flow, Peak Infiltration, and Peak Inflow. The projected flow is 191,200 gpd.

Subsequent to the original analysis, the layout was revised. The current plans for the development indicates the following breakdown of units:

- 212 – One Bedroom Units
- 114 – Two Bedroom Units

The revised projected sanitary sewer flows are calculated below:

Projected Flow Calculations:

Peak Base Flow:
= 300 gpd * EDU
= 300 gpd * [(1 * 212 units) + (2 * 114 units)]
= 192,000 gpd

Peak Infiltration:
= 500 gpd per area (acre)
= 500 gpd * 3.5 acres
= 1,725 gpd

Peak Inflow:
Q = kiA
Where: i = 5.57 iph (rain intensity chart LSD&C:
$T_c = 18.56*A^{0.2524}$, T_c = 25.4 min)
k = 0.006
A = 3.5 acres

Q = (0.006 * 5.57 * 3.5 acres)
= 0.115 cfs
= 74,528 gpd

Total Flow= Peak Base Flow + Peak Infiltration + Peak Inflow
= 192,000 gpd +1,725 gpd + 74,528 gpd
= 268,250 gpd

The original analysis was revised to utilize the revised flow projections.

The proposed site is located at the top of the West Prairie Lee Watershed, east of the Cedar Creek Watershed. Currently, the flow is conveyed west via interceptor to the Tudor Road Pump Station. This route has historically experienced surcharging and backups/overflows. Therefore, due to its proximity to the Cedar Creek Watershed, the evaluation was expanded to analyze the potential for routing the proposed flow west to the Cedar Creek Watershed. Figure 1 indicates the proposed development as well as the two proposed routes.

Alternative 1 - Route 1 through West Prairie Lee Watershed

An analysis was completed to determine the effect of the projected flow from the proposed development on the existing sanitary sewer system. It was assumed that the flow would enter the collection system at Manhole 30-239. The interceptor was evaluated from the point of entry to the discharge at the Tudor Road Pump Station. The extents of the analysis are indicated on the attached Figure 2. The route includes 24-inch parallel pipes that were installed as part of the West Prairie Lee Relief Sewer project. The 2007 Master Plan recommended improvements at the Tudor Road Pump Station to increase the capacity of the Pump Station to 24 MGD. The Master Plan should be referenced for future planning of these facilities.

Flows were projected for the existing condition using the City of Lee's Summit Design Criteria with the revised k factors for the West Prairie Lee Watershed established in the 2012 Wastewater Master Plan Update.

The focus of this analysis is to identify the impact of the additional flow from the proposed development on the hydraulic grade within the conveyance system. In other words, to determine if the system has the capacity required to adequately convey the projected flow without causing significant negative impacts to downstream facilities, such as the West Prairie Lee Interceptor. The initial analysis indicated a number of segments could be considered as overcapacity.

Table 1 below compares the hydraulic grade line under existing conditions, which is the baseline, to the hydraulic grade line of existing conditions plus the proposed development. A positive surcharge depth versus the manhole top indicates the hydraulic grade line is above the manhole rim elevation.

Table 1 - Existing Condition versus Existing Condition plus New Development

			Existing Condition		Existing Condition Plus New Development	
Upstream ID	Downstream ID	Manhole Depth (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)
25-216	25-071	10.65	30	-8.15	30	-7.86
25-215	25-216	12.16	30	-10.86	30	-10.54
25-214	25-215	12.01	30	-12.01	30	-12.01
25-363	25-214	14.66	30	-14.66	30	-14.66
25-364	25-363	9.48	30	-9.48	30	-9.48
25-365	25-364	13.73	30	-13.73	30	-13.73
25-366	25-365	19.19	30	-19.19	30	-19.19
25-367	25-366	14.81	30	-14.81	30	-14.81
25-211	25-367	11.73	30	-11.73	30	-11.73
25-244	25-211	12.68	30	-12.68	30	-12.68
25-210	25-244	10.98	30	-10.98	30	-10.98
25-209	25-210	11.85	30	-11.85	30	-11.85
25-208	25-209	14.12	30	-14.12	30	-14.12
25-001V	25-208	14.73	30	-14.73	30	-14.73
25-207	25-001V	16.3	30	-16.30	30	-16.30
25-206	25-207	20.26	30	-20.26	30	-20.26
25-205	25-206	17	30	-17.00	30	-17.00
25-285	25-205	11.58	30	-11.58	30	-11.58
25-287	25-285	7.99	18	-7.80	18	-7.63
25-288	25-287	8.72	18	-6.32	18	-5.86
25-289	25-288	9.55	18	-5.56	18	-4.82
25-290	25-289	9.4	18	-3.88	18	-2.87
25-291	25-290	9.28	18	-3.02	18	-1.85
25-292	25-291	8.15	18	-1.39	18	-0.15
25-293	25-292	6.91	18	1.51	18	2.96
32-418	25-293	9.64	18	0.79	18	2.46
32-419	32-418	9.28	18	0.02	18	1.74
32-420	32-419	13.95	18	-1.44	18	0.54
32-421	32-420	9.77	18	4.02	18	6.26
32-422	32-421	10.68	18	3.03	18	5.38
32-423	32-422	9.41	18	3.87	18	6.33
32-424	32-423	11.46	18	3.67	18	6.24
31-377	32-424	11.09	18	0.81	18	3.45
31-376	31-377	18.16	18	-6.59	18	-3.89
31-375	31-376	14.33	18	-3.99	18	-1.27
31-374	31-375	10.45	18	1.74	18	4.65
31-088	31-374	12.95	18	-1.04	18	1.89
31-089	31-088	16.58	15	-3.99	15	-0.89
31-090	31-089	16.91	15	-4.57	15	-1.27
31-091	31-090	10.81	15	2.12	15	5.57
31-115	31-091	11	15	2.15	15	5.68
31-396	31-115	6.78	15	3.05	15	6.60
31-114	31-396	5.93	15	3.44	15	7.18
31-117	31-114	7.5	15	0.01	15	3.94
31-379	31-117	9.24	15	-1.37	15	2.69
31-133	31-379	7.55	15	-1.85	15	2.28

			Existing Condition		Existing Condition Plus New Development	
Upstream ID	Downstream ID	Manhole Depth (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)
31-163	31-133	7.7	15	-2.78	15	1.50
31-169	31-163	14.75	15	-10.12	15	-5.75
31-095	31-169	12.8	15	-8.28	15	-3.64
31-170	31-095	11.6	15	-7.91	15	-3.22
31-204	31-170	10.15	15	-9.41	15	-4.65
31-203	31-204	11	15	-11.00	15	-6.93
31-202	31-203	9.96	15	-9.96	15	-6.43
31-201	31-202	9.9	15	-9.07	15	-5.31
31-197	31-201	9.9	15	-8.99	15	-5.16
31-196	31-197	9.72	15	-9.63	15	-5.77
31-195	31-196	11.3	15	-10.52	15	-6.49
31-194	31-195	10.09	15	-10.09	15	-9.00
31-190	31-194	8.2	15	-8.20	15	-7.30
31-212	31-190	11.74	15	-11.72	15	-10.76
31-213	31-212	8.36	15	-8.36	15	-7.70
31-214	31-213	8.25	15	-8.25	15	-7.57
31-215	31-214	8.11	15	-8.11	15	-7.68
31-216	31-215	9.14	15	-9.14	15	-8.92
31-217	31-216	10.18	15	-10.18	15	-9.90
31-187	31-217	9.34	15	-9.34	15	-9.34
31-414	31-187	5.74	12	-5.74	12	-5.74
31-220	31-414	7.68	12	-6.41	12	-6.11
31-234	31-220	6.57	12	-5.93	12	-5.45
31-253	31-234	8.02	12	-8.02	12	-8.02
31-254	31-253	6.75	12	-6.75	12	-6.75
31-388	31-254	12.25	12	-12.25	12	-12.25
31-270	31-388	12.22	12	-12.22	12	-12.22
31-300	31-270	5.74	12	-5.74	12	-5.74
31-397	31-300	4.9	12	-4.90	12	-4.90
31-224	31-397	9.37	12	-9.37	12	-9.37
31-410	31-224	7.9	12	-7.90	12	-7.90
31-301	31-410	4.16	8	-4.16	8	-4.16
30-271	31-301	12.33	12	-11.85	12	-11.79
30-272	30-271	13.09	15	-12.83	15	-12.76
30-274	30-272	14.3	12	-14.30	12	-14.30
30-273	30-274	8.87	8	-8.87	8	-8.87
30-239	30-273	9.04	8	-9.04	8	-9.04
30-195	30-239	13.25	8	-13.25	8	-13.25

Surcharge increase greater than 1 foot from existing condition

Table 2 below summarizes the segments that were indicated as overcapacity, or segments that have insufficient capacity to accommodate the projected flow. If the results indicate that there is an increase of surcharging in excess of one foot between the existing condition and existing conditions plus proposed development, it has been highlighted below.

Table 2 – Overcapacity Segments

			Existing Flows		**Existing Flows Plus New Development**	
Upstream ID	Downstream ID	Manhole Depth (ft)	Existing Diameter (in)	Surcharge Depth vs Manhole Top (ft)	Existing Diameter (in)	Surcharge Depth vs Manhole Top (ft)
25-290	25-289	9.40	18	-3.88	18	-2.87
25-291	25-290	9.28	18	-3.02	18	-1.85
25-292	25-291	8.15	18	-1.39	18	-0.15
25-293	25-292	6.91	18	1.51	18	2.96
32-418	25-293	9.64	18	0.79	18	2.46
32-419	32-418	9.28	18	0.02	18	1.74
32-420	32-419	13.95	18	-1.44	18	0.54
32-421	32-420	9.77	18	4.02	18	6.26
32-422	32-421	10.68	18	3.03	18	5.38
32-423	32-422	9.41	18	3.87	18	6.33
32-424	32-423	11.46	18	3.67	18	6.24
31-377	32-424	11.09	18	0.81	18	3.45
31-376	31-377	18.16	18	-6.59	18	-3.89
31-375	31-376	14.33	18	-3.99	18	-1.27
31-374	31-375	10.45	18	1.74	18	4.65
31-088	31-374	12.95	18	-1.04	18	1.89
31-089	31-088	16.58	15	-3.99	15	-0.89
31-090	31-089	16.91	15	-4.57	15	-1.27
31-091	31-090	10.81	15	2.12	15	5.57
31-115	31-091	11.00	15	2.15	15	5.68
31-396	31-115	6.78	15	3.05	15	6.60
31-114	31-396	5.93	15	3.44	15	7.18
31-117	31-114	7.50	15	0.01	15	3.94
31-379	31-117	9.24	15	-1.37	15	2.69
31-133	31-379	7.55	15	-1.85	15	2.28
31-163	31-133	7.70	15	-2.78	15	1.50
31-169	31-163	14.75	15	-10.12	15	-5.75

31-095	31-169	12.80	15	-8.28	15	-3.64
31-170	31-095	11.60	15	-7.91	15	-3.22
31-204	31-170	10.15	15	-9.41	15	-4.65
31-203	31-204	11.00	15	-11.00	15	-6.93
31-202	31-203	9.96	15	-9.96	15	-6.43
31-201	31-202	9.90	15	-9.07	15	-5.31
31-197	31-201	9.90	15	-8.99	15	-5.16
31-196	31-197	9.72	15	-9.63	15	-5.77
31-195	31-196	11.30	15	-10.52	15	-6.49
31-194	31-195	10.09	15	-10.09	15	-9.00

After completion of the initial analysis, the City provided flow monitoring data collected in 2016 for the study area. The flow data used to calculate the revised k's for the 2012 update was over 15 years old. The more recent flow data could be used to calculate revised k's that accurately reflect current conditions. As pipe ages and deteriorates, k values increase.

Flow data was collected at Manhole 31-089 during May 2016 through July 2016. In addition, the City installed a flow meter in Manhole 31-089 this fall to collect additional flow. The data was collected from October through December of 2018. Both sets of data were evaluated to calculate revised k factors to compare to the previous 2012 evaluation. Rain data was also collected for the same time period to establish the relationship between precipitation and sewer system flows.

In analyzing the fall 2018 data, two rain events were identified. The first was on November 4. However, this event was short in duration and low in intensity. The second event took place on December 1. Surcharging occurred during the recording of this event, rendering the data unusable. Therefore, the evaluation will focus on the flow rate data collected in 2016. Figure 3 illustrates the flow and rain hydrograph

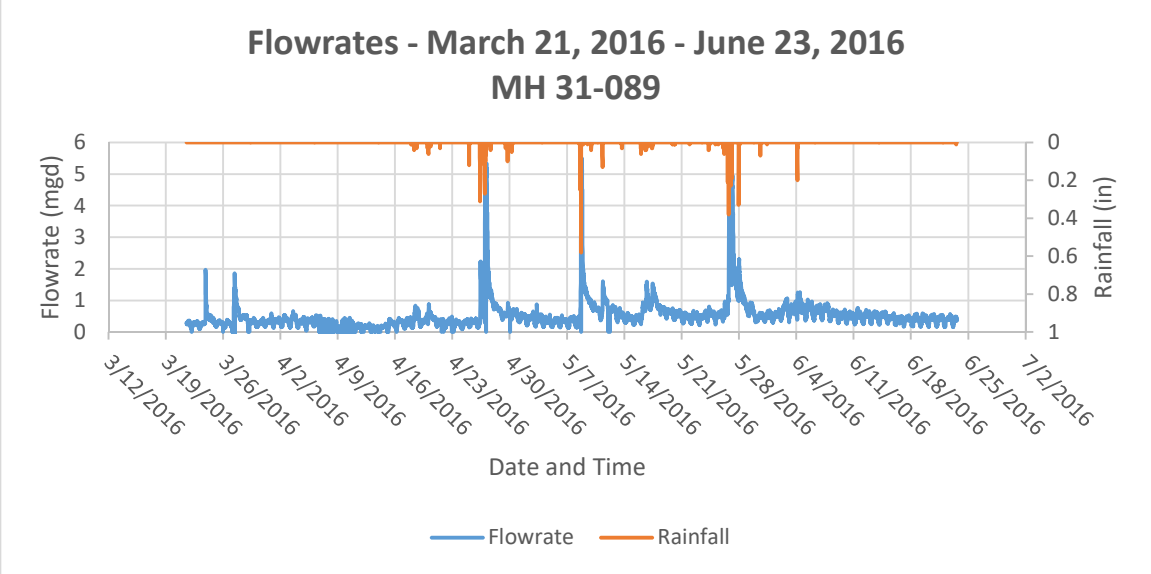


Figure 3 – Flow and Rain Hydrograph

The rainfall data was analyzed to determine the measured rainfall intensity-duration relationship. There were a number of rainfall events recorded, however, most of them were short in duration and low on depth. Three events were identified for further analysis. Each of these events equated to a less than one year storm. The Lee's Summit Design Criteria is based upon a 50-year storm.

The flow meter recorded data was analyzed to define the average daily dry weather flow, infiltration, and inflow components of the total flow. This information was used to recalculate the k coefficient for the study area, as shown in Table 3 below. At least three storms were evaluated and an average inflow coefficient value was used.

Table 3 – Inflow Coefficient Calculation

Storm Date	Delta TC (min)	Rain Intensity (in/hr)	Peak Flow Rate (mgd)	ADDF	Peak Inflow (mgd)	Peak Inflow (cfs)	Inflow Coefficient k
4/26/16	94	0.44	5.34	0.34	4.77	8.86	0.0178
5/8/16	94	0.79	5.50	0.34	4.99	9.27	0.0104
5/27/16	94	0.47	5.21	0.34	4.80	8.92	0.0167

A revised k coefficient of 0.015 is an average of the storm events. This is an increase from the revised k value utilized in the 2012 Update, which averaged between 0.0064 and 0.0012 for the flow monitoring area. The 2012 rev k values were utilized for the area downstream of the flow monitoring location.

Table 4, below, compares the surcharge depth from the manhole top calculated using the revised k coefficient utilizing actual rain and flow data for both existing condition and existing condition plus the projected additional flow from the development. Further evaluation was completed on the overcapacity segments to review the hydraulic grade, or surcharge conditions. Upsizing or paralleling certain segments will allow the system's hydraulic grade to be within the system. If this route is to be used, tt is recommended that the West Parallel Relief Sewer project be extended upstream with parallel pipes installed from Manhole 31-090 to Manhole 31-220, approximately 5,100 linear feet of pipe. Segments identified for improvement have been indicated in blue.

Table 4 - Existing Condition versus Existing Condition plus New Development with Revised k Values

			Existing Condition		Existing Condition Plus New Development		Proposed Improvements	
Upstream ID	Downstream ID	Manhole Depth (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Revised Diameter	Surcharge Depth vs Manhole Top (ft)
25-216	25-071	10.65	30	-8.07	30	-7.55	30	-7.55
25-215	25-216	12.16	30	-10.20	30	-9.66	30	-9.66
25-214	25-215	12.01	30	-11.91	30	-11.34	30	-11.34
25-363	25-214	14.66	30	-14.65	30	-14.07	30	-14.07
25-364	25-363	9.48	30	-9.48	30	-9.48	30	-9.48
25-365	25-364	13.73	30	-13.73	30	-13.73	30	-13.73
25-366	25-365	19.19	30	-19.19	30	-19.19	30	-19.19
25-367	25-366	14.81	30	-14.81	30	-14.81	30	-14.81
25-211	25-367	11.73	30	-11.73	30	-11.73	30	-11.73
25-244	25-211	12.68	30	-12.68	30	-12.68	30	-12.68
25-210	25-244	10.98	30	-10.98	30	-10.98	30	-10.98
25-209	25-210	11.85	30	-11.85	30	-11.85	30	-11.85
25-208	25-209	14.12	30	-14.12	30	-14.12	30	-14.12
25-001V	25-208	14.73	30	-14.73	30	-14.73	30	-14.73
25-207	25-001V	16.30	30	-16.20	30	-16.18	30	-16.18
25-206	25-207	20.26	30	-20.26	30	-20.26	30	-20.26
25-205	25-206	17.00	30	-17.00	30	-17.00	30	-17.00
25-285	25-205	11.58	30	-11.58	30	-11.58	30	-11.58
25-287	25-285	7.99	18	-7.99	18	-7.99	18	-7.99
25-288	25-287	8.72	18	-7.87	18	-7.77	18	-7.77
25-289	25-288	9.55	18	-8.48	18	-8.29	18	-8.29
25-290	25-289	9.40	18	-8.19	18	-7.90	18	-7.90
25-291	25-290	9.28	18	-8.08	18	-7.74	18	-7.74
25-292	25-291	8.15	18	-6.81	18	-6.45	18	-6.45
25-293	25-292	6.91	18	-4.81	18	-4.38	18	-4.38
32-418	25-293	9.64	18	-6.49	18	-5.98	18	-5.98
32-419	32-418	9.28	18	-7.48	18	-6.95	18	-6.95
32-420	32-419	13.95	18	-10.25	18	-9.64	18	-9.64
32-421	32-420	9.77	18	-6.04	18	-5.34	18	-5.34
32-422	32-421	10.68	18	-7.32	18	-6.58	18	-6.58
32-423	32-422	9.41	18	-6.76	18	-5.98	18	-5.98
32-424	32-423	11.46	18	-7.27	18	-6.45	18	-6.45
31-377	32-424	11.09	18	-10.30	18	-9.46	18	-9.46
31-376	31-377	18.16	18	-17.86	18	-16.99	18	-16.99
31-375	31-376	14.33	18	-14.33	18	-14.33	18	-14.33
31-374	31-375	10.45	18	-9.09	18	-9.02	18	-9.02
31-088	31-374	12.95	18	-11.86	18	-11.79	18	-11.79
31-089	31-088	16.58	15	-14.79	15	-14.64	15	-14.64
31-090	31-089	16.91	15	-4.61	15	-3.95	15	-15.12
31-091	31-090	10.81	15	9.26	15	10.26	15	-8.34
31-115	31-091	11.00	15	14.64	15	15.89	15	-8.03
31-396	31-115	6.78	15	16.52	15	17.82	15	-6.78
31-114	31-396	5.93	15	31.07	15	33.00	15	-5.19
31-117	31-114	7.50	15	41.23	15	43.78	15	-7.50
31-379	31-117	9.24	15	47.93	15	50.86	15	-8.21
31-133	31-379	7.55	15	52.57	15	55.74	15	-7.55
31-163	31-133	7.70	15	62.21	15	65.88	15	-7.61
31-169	31-163	14.75	15	61.43	15	65.40	15	-14.40
31-095	31-169	12.80	15	79.86	15	84.65	15	-11.32
31-170	31-095	11.60	15	83.17	15	88.12	15	-10.77
31-204	31-170	10.15	15	84.94	15	90.06	15	-10.15
31-203	31-204	11.00	15	84.79	15	90.04	15	-11.00
31-202	31-203	9.96	15	91.43	15	97.04	15	-9.96
31-201	31-202	9.90	15	103.50	15	109.79	15	-8.39
31-197	31-201	9.90	15	106.15	15	112.61	15	-8.22
31-196	31-197	9.72	15	106.85	15	113.40	15	-8.81
31-195	31-196	11.30	15	112.12	15	119.11	15	-9.45
31-194	31-195	10.09	15	114.76	15	122.13	15	-10.09
31-190	31-194	8.20	15	122.38	15	130.17	15	-8.20
31-212	31-190	11.74	15	121.19	15	129.15	15	-11.60
31-213	31-212	8.36	15	126.53	15	134.66	15	-8.36
31-214	31-213	8.25	15	128.82	15	137.11	15	-8.17

			Existing Condition		Existing Condition Plus New Development		Proposed Improvements	
Upstream ID	Downstream ID	Manhole Depth (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Revised Diameter	Surcharge Depth vs Manhole Top (ft)
31-215	31-214	8.11	15	129.90	15	138.28	15	-8.11
31-216	31-215	9.14	15	130.89	15	139.43	15	-9.14
31-217	31-216	10.18	15	132.84	15	141.62	15	-10.02
31-187	31-217	9.34	15	132.73	15	141.58	15	-9.34
31-414	31-187	5.74	12	133.90	12	143.82	12	-5.74
31-220	31-414	7.68	12	136.97	12	147.67	12	-6.17
31-234	31-220	6.57	12	139.60	12	150.78	12	-3.06
31-253	31-234	8.02	12	137.46	12	149.22	12	-4.61
31-254	31-253	6.75	12	136.56	12	148.62	12	-5.21
31-388	31-254	12.25	12	128.51	12	140.89	12	-12.25
31-270	31-388	12.22	12	128.40	12	140.82	12	-12.22
31-300	31-270	5.74	12	134.54	12	147.45	12	-5.59
31-397	31-300	4.90	12	134.85	12	147.77	12	-4.90
31-224	31-397	9.37	12	127.95	12	140.96	12	-9.37
31-410	31-224	7.90	12	128.39	12	141.59	12	-7.90
31-301	31-410	4.16	8	129.06	8	142.79	8	-4.16
30-271	31-301	12.33	12	121.62	12	135.50	12	-11.45
30-272	30-271	13.09	15	120.67	15	134.55	15	-12.39
30-274	30-272	14.30	12	115.82	12	129.83	12	-14.30
30-273	30-274	8.87	8	119.31	8	134.23	8	-8.87
30-239	30-273	9.04	8	115.21	8	130.61	8	-9.04
30-195	30-239	13.25	8	105.23	8	121.07	8	-13.25

Surcharge increase greater than 1 foot from existing condition

Alternative 2 - Route 2 through Cedar Creek Watershed

Due to the past history of surcharging within the West Prairie Lee Interceptor and the results of the analysis above, an alternative route was evaluated. As stated earlier, the proposed development is located at the top of the West Prairie Lee Watershed. To the west of the proposed development is the Cedar Creek Watershed. The City has recently completed capacity improvement projects to the Cedar Creek Interceptor and is currently undergoing a study to identify future capacity improvements with the Downtown Interceptor project.

The site was evaluated to determine if the elevations would accommodate the sanitary sewer flow from the proposed development being conveyed to the Cedar Creek Watershed collection system. Two potential tie-in points were located. Flow can be conveyed through a new line to the north, indicated by the blue line on the figure below, where it can tie in to the existing sewer at the location indicated at approximately elevation 1023 ft. Flow could also be conveyed to the west, indicated in orange on the figure below, and tie into the existing line at the location indicated at approximately elevation 1020. The sewer line to the north will require deep excavation of between 20-25 feet and a potential sewer depth in excess of the City's design standards. The proposed sewer line to the west would require boring under the existing railroad. Preliminary cost estimates have been prepared for the two routes and are attached.

Figure 4 – Proposed Routing to Cedar Creek Watershed

An evaluation was completed in the Cedar Creek Watershed, the Downtown Interceptor Study, to model the existing system and provide recommendations for capacity improvements. The Downtown Sewer Study should be referenced for future planning of these facilities. The study did take into account the proposed development of the Lee's Summit Apartment. Proposed improvements for the Downtown Interceptor are currently under design. The attached Figure 5 indicates the extents of the Downtown Sewer Study in conjunction with the proposed development. For the purpose of this evaluation, the segments upstream of the Downtown Interceptor, Segments 30-192 through 30-187, were analyzed to determine the effect of the projected flow from the proposed development on the existing sanitary sewer system. The proposed improvements for the Downtown Interceptor project should mitigate the HGL downstream of Segment 30-187.

The results of the analysis for segments 30-192 through 30-187 are included in Table 5 below. The results indicate the projected flows from the proposed development cause some surcharging but it is contained within the system. The highlighted cells indicate segments which experience an increase in the hydraulic grade line of greater than one foot. It should be noted that actual surveyed data was used for segments MH 30-186 through MH 30-190 in lieu of the City's GIS data.

Table 5 – Existing Condition versus Existing Condition plus New Development

			Existing Condition		Existing Condition Plus New Development	
Upstream ID	Downstream ID	Manhole Depth (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)
30-188	30-187	8.53	8	-5.63	8	-5.05
30-189	30-188	8.30	8	-5.68	8	-4.55
30-347	30-189	7.50	8	-5.48	8	-3.40
30-190	30-347	6.37	8	-5.71	8	-3.31
30-191	30-190	7.50	8	-6.72	8	-3.68
30-221	30-191	6.76	8	-6.76	8	-6.76
30-226	30-221	6.30	8	-6.30	8	-6.30
30-238	30-226	7.50	8	-7.50	8	-7.50
30-241	30-238	7.40	8	-7.40	8	-7.40
30-240	30-241	14.12	8	-14.12	8	-14.12
30-225	30-240	10.92	8	-10.92	8	-10.92
30-196	30-225	6.20	8	-6.20	8	-5.91
30-192	30-196	5.40	8	-5.40	8	-5.29

Alternative 3 – Route Flows between the Two Watersheds

A third alternative was evaluated which would split flows between the two watersheds. This alternative assumes that the southern portion of the property, approximately the southern two acres, will be conveyed to the West Prairie Lee Watershed utilizing the existing collection system, while the northern portion of the property will be conveyed through a new line to the Cedar Creek Watershed. In addition, the property to the north, the First Baptist Church of Lee's Summit, will also be conveyed to the Cedar Creek Watershed. The premise of this alternative is to maintain a net zero change in flow currently conveyed through the West Prairie Lee Interceptor by offloading the existing West Prairie Lee Watershed of the sanitary sewer flows from both the First Baptist Church and the United Methodist Church and conveying an equivalent amount from the proposed development.

Dry weather flows were obtained from the City for the two churches from their current water usage. Each church has an average dry weather flow of approximately 167 gpd.

Wet weather flows were calculated to determine the current projected flow contributed by the sites. The calculations were completed utilizing the City's design criteria.

The projected flow for the First Baptist Church of Lee's Summit is:

Peak Base Flow
= 167 gpd

Peak Infiltration:
= 250 gpd per area (acre)
= 250 gpd * 3.1 acres
= 780 gpd

Peak Inflow:
Q = kiA
Where: i = 5.62 iph (rain intensity chart LSD&C: $T_c = 18.56*A^{0.2524}$, T_c = 24.7 min)
k = 0.003
A = 3.1 acres

Q = (0.003 * 5.62 * 3.1 acres)
= 0.05 cfs
= 33,996 gpd

Total Flow= Peak Base Flow + Peak Infiltration + Peak Inflow
= 167 gpd +780 gpd + 33,996 gpd
= 34,900 gpd

The projected flow for the United Methodist Church of Lee's Summit is:

Peak Base Flow
= 167 gpd

Peak Infiltration:
= 250 gpd per area (acre)
= 250 gpd * 3.5 acres
= 863 gpd

Peak Inflow:
Q = kiA

Where: i = 5.57 iph (rain intensity chart LSD&C: $T_c = 18.56*A^{0.2524}$, T_c = 25.4 min)
k = 0.003
A = 3.5 acres

Q = (0.003 * 5.57 * 3.5 acres)
= 0.06 cfs
= 37,264 gpd

Total Flow= Peak Base Flow + Peak Infiltration + Peak Inflow
= 167 gpd +863 gpd + 37,264 gpd
= 38,300 gpd

Total flow between the two properties is 73,200 gpd. This equates to approximately 55 units that can be conveyed to the West Prairie Lee Watershed.

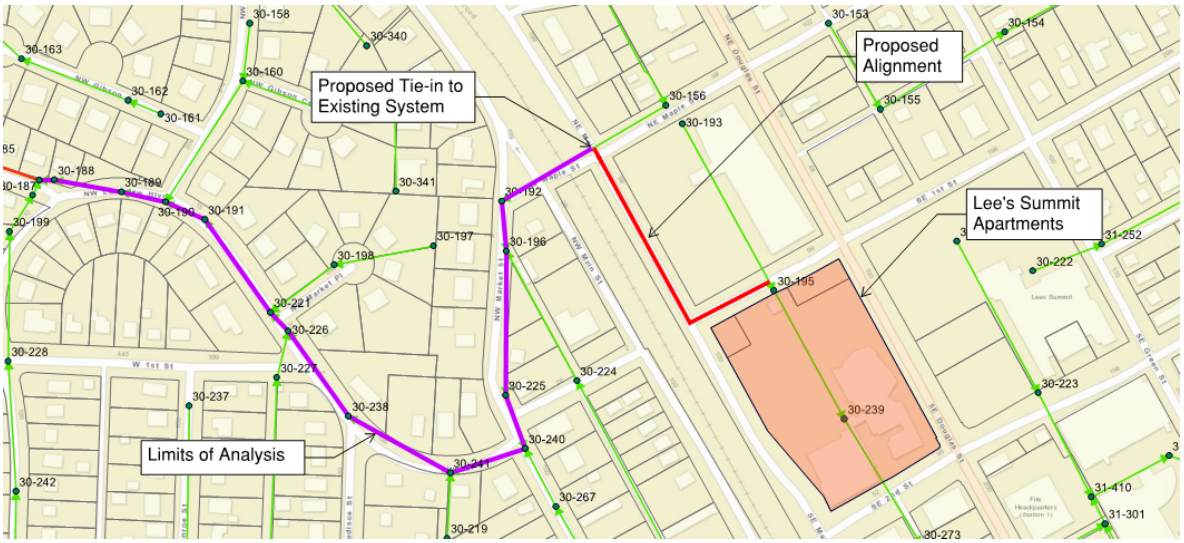
Alternative 3 eliminates the extensive downstream improvements required to the West Prairie Lee Interceptor to mitigate the impact from the proposed development. Additionally, it does not require the on site improvements to the southern portion of the proposed site that would be required for Alternative 2.

An analysis was completed for both watersheds to determine the impact of the proposed development on existing infrastructure.

Cedar Creek Watershed
It was previously discussed that there were two potential tie-in points in the Cedar Creek Watershed. Flow can be conveyed through a new line to the north or it could also be conveyed to the west. During the preliminary design phase, it was determined that the optimal route would be the northern route.

The northern portion will be conveyed through a new 8" sanitary sewer pipe that will be connected between Manholes 30-156 and Manhole 30-192. This alignment is indicated in Figure 6 below:

Figure 6 – Proposed Routing to Cedar Creek Watershed



Flow projections were completed to determine the flow contribution from the proposed development. It is proposed that 178 one bedroom units and 95 two bedroom units will be conveyed north to the Cedar Creek Watershed. Flow projections are indicated below:

Peak Base Flow:

= 300 gpd * EDU
= 300 gpd * [(1 * 178 units) + (2 * 95 units)]
= 110,400 gpd

Peak Infiltration:

= 500 gpd per area (acre)
= 500 gpd * 1.5 acres
= 750 gpd

Peak Inflow:

Q = kiA
Where: i = 6.19 iph (rain intensity chart LSD&C:
$T_c = 18.56*A^{0.2524}$, T_c = 20.6 min)
k = 0.006
A = 1.5 acres

Q = (0.006 * 6.19 * 1.5 acres)
= 0.05 cfs
= 36,000 gpd

Total Flow= Peak Base Flow + Peak Infiltration + Peak Inflow
= 110,400 gpd +750 gpd + 36,000 gpd
= 147,200 gpd

Including the First Baptist Church of Lee's Summit, the total flow to be conveyed to the Cedar Creek Watershed is 182,100 gpd.

The analysis discussed above was completed for the revised flow of 182,100 gpd. The results are indicated in Table 6 below, which provides a comparison of the hydraulic grade lines for existing conditions, which is the baseline, and existing conditions plus the proposed development. A positive surcharge depth versus the manhole top indicates the hydraulic grade line is above the manhole rim elevation. The highlighted cells indicate segments which saw an increase in the hydraulic grade line of greater than one foot.

Table 6 – Existing Condition versus Existing Condition plus New Development

			Existing Condition		**Existing Condition Plus New Development**		**Proposed Improvements**	
Upstream ID	Downstream ID	Manhole Depth (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)	Existing Diameter	Surcharge Depth vs Manhole Top (ft)
30-188	30-187	8.53	8	-5.63	8	-5.18	10	-7.34
30-347	30-188	8.25	8	-5.68	8	-4.80	8	-6.96
30-189	30-347	7.50	8	-5.48	8	-3.86	8	-6.02
30-190	30-189	6.37	8	-5.71	8	-3.85	8	-6.01
30-191	30-190	7.50	8	-6.72	8	-4.36	8	-6.52
30-221	30-191	6.76	8	-6.76	8	-6.76	8	-6.76
30-226	30-221	6.30	8	-6.30	8	-6.30	8	-6.30
30-238	30-226	7.50	8	-7.50	8	-7.50	8	-7.50
30-241	30-238	7.40	8	-7.40	8	-7.40	8	-7.40
30-240	30-241	14.12	8	-14.12	8	-14.12	8	-14.12
30-225	30-240	10.92	8	-10.92	8	-10.92	8	-10.92
30-196	30-225	6.20	8	-6.20	8	-6.05	8	-6.05
30-192	30-196	5.40	8	-5.40	8	-5.40	8	-5.40

As can be seen above, it is proposed to replace segment 30-188 to 30-187 with a 10-inch diameter pipe. This will bring the hydraulic grade line below the hydraulic grade line under existing conditions, thereby mitigating the impacts of the proposed development.

West Prairie Lee Watershed

It was assumed that the flow would enter the existing West Prairie Lee Watershed collection system at Manhole 30-239. The interceptor was evaluated from the point of entry to the discharge at the Tudor Road Pump Station. The extents of the analysis are indicated on the attached Figure 2. The route includes 24-inch parallel pipes that were installed as part of the West Prairie Lee Relief Sewer project.

Flows were projected for the existing condition using the City of Lee's Summit Design Criteria with the revised k factors for the South Prairie Lee Watershed established in the 2012 Wastewater Master Plan Update and the revised k factors established above.

34 one bedroom units and 19 two bedroom units will be conveyed south to the West Prairie Lee Watershed. Flow projections are indicated below:

Peak Base Flow:

= 300 gpd * EDU
= 300 gpd * [(1 * 34 units) + (2 * 19 units)]
= 21,600 gpd

Peak Infiltration:

= 500 gpd per area (acre)
= 500 gpd * 2.0 acres
= 1,000 gpd

Peak Inflow:

Q = kiA
Where: i = 6.19 iph (rain intensity chart LSD&C:
$T_c = 18.56*A^{0.2524}$, T_c = 22.1 min)
k = 0.006
A = 2.0 acres

Q = (0.006 * 6.00 * 2.0 acres)
= .07 cfs
= 46,500 gpd

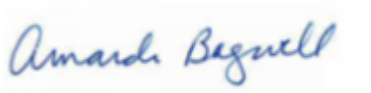
Total Flow= Peak Base Flow + Peak Infiltration + Peak Inflow

= 21,600 gpd +1,000 gpd + 46,500 gpd
= 69,100 gpd

As stated above, the First Baptist Church of Lee's Summit will be conveyed to the north with the installation of the proposed sewer line and the proposed development will eliminate the United Methodist Church. The projected flow for the two properties is approximately 73,200 gpd. This flow can be offset against the flow projections for the proposed development. The total flow to be conveyed to the West Prairie Lee Watershed is less than what is currently being conveyed. Therefore, no additional analysis was completed for the West Prairie Lee Watershed existing collection system.

If you have any questions, please feel free to contact me at 816-347-1164.

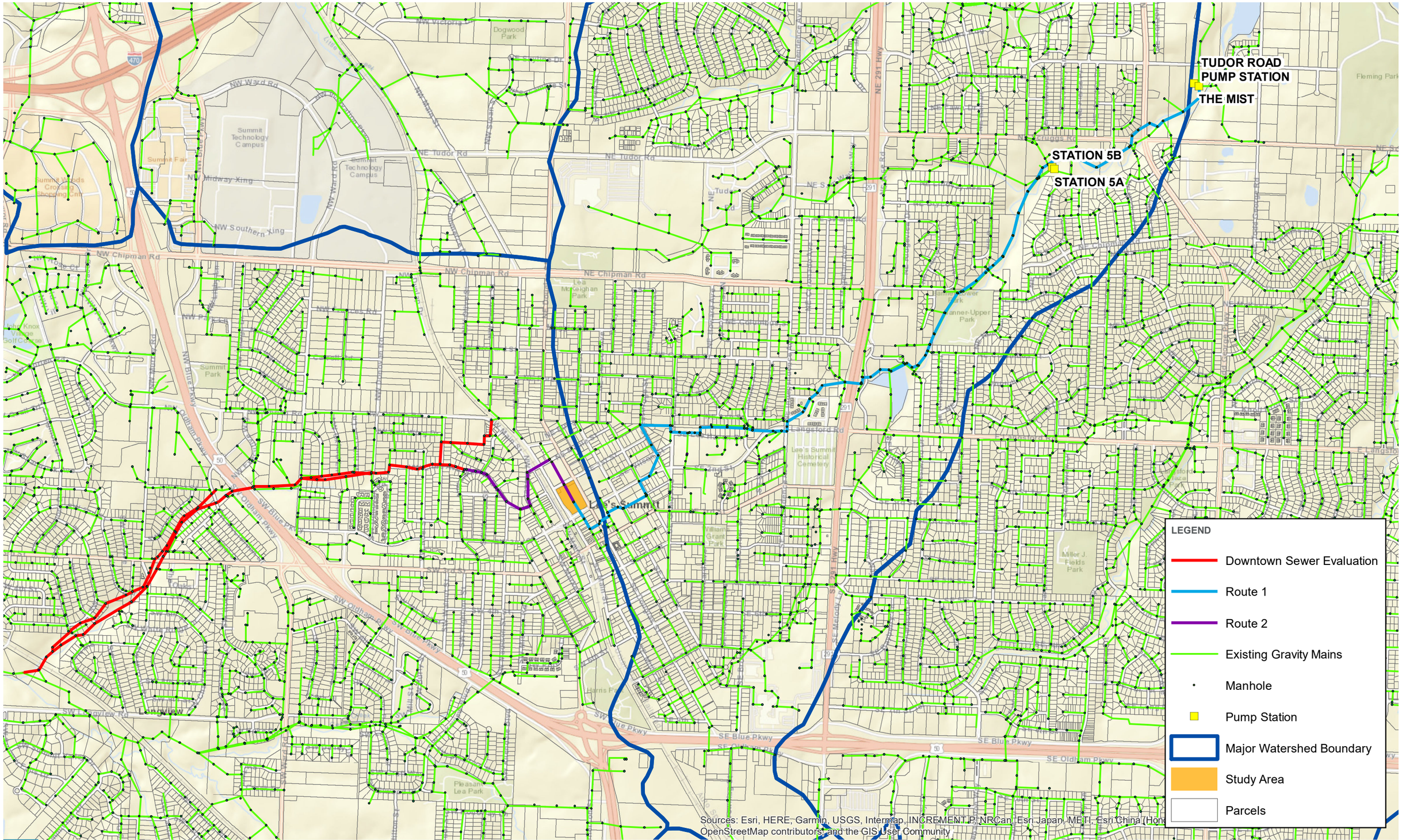
Sincerely,



Amanda Bagwell, P.E.
Project Manager

enclosure

CC: Doug Ubben, Jr, Phelps Engineering, Inc.
Mitch Wiebelhaus, HDR

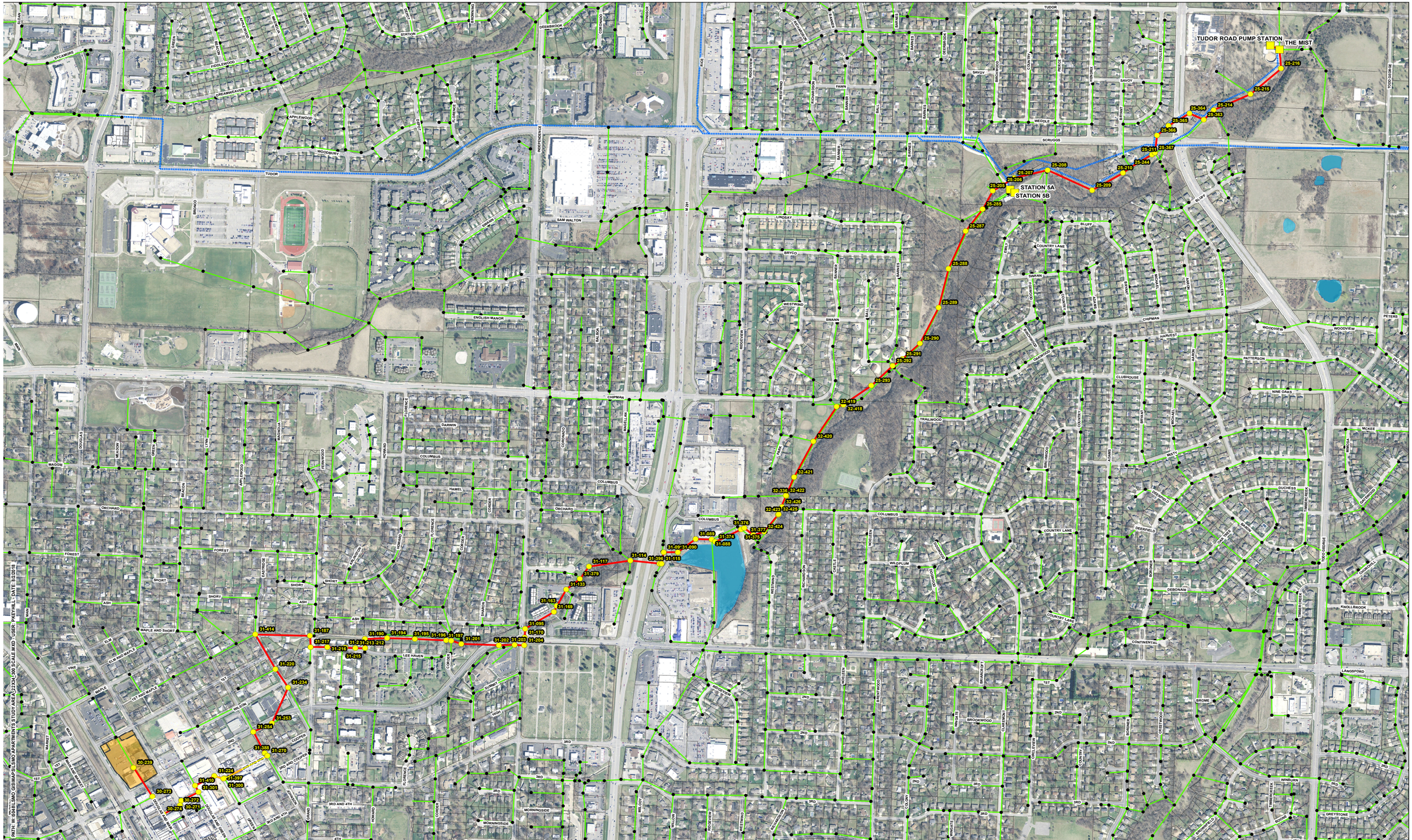


CITY OF LEE'S SUMMIT, MO

LEE'S SUMMIT APARTMENTS

FIGURE 1

PATH: - USER: TGRAHAM - DATE: 12/21/2018

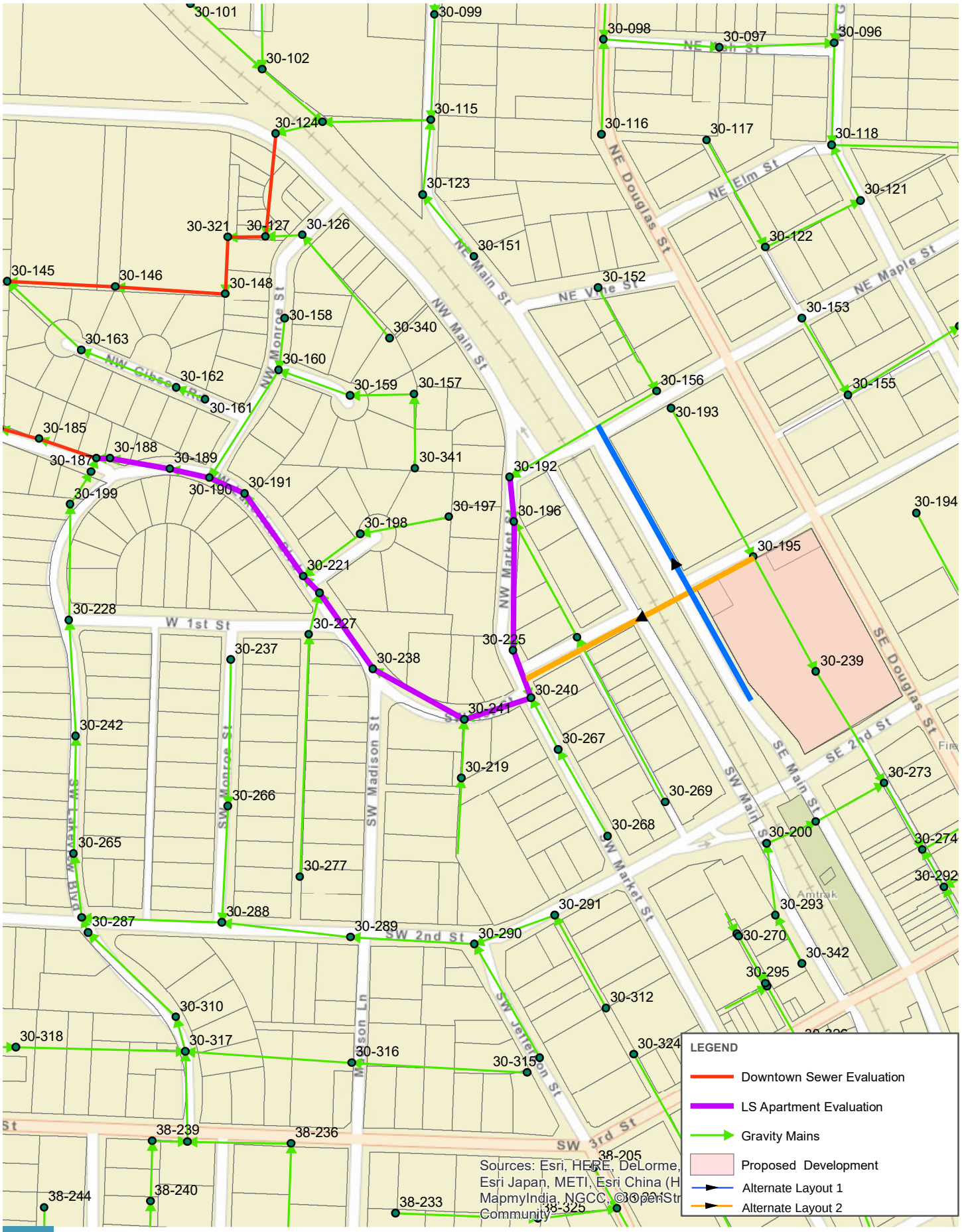


HDR

LEE'S SUMMIT APARTMENTS

FIGURE 2

PATH: - USER: TGRAHAM - DATE: 12/21/2018



CITY OF LEE'S SUMMIT, MO

LEE'S SUMMIT APARTMENTS

FIGURE 5

ENGINEER'S PRELIMINARY COST ESTIMATE OF PROBABLE CONSTRUCTION COSTS
LEE'S SUMMIT APARTMENTS - ROUTE 2
LEE'S SUMMIT, MO

December 19, 2018

Item No.	Description	Quantity	Unit	Unit Price $	Price $
1.	Mobilization (3% max of total bid)	1	LS	$7,500.00	$7,500.00
2.	Demolition, Clearing & Grubbing	1	LS	$5,000.00	$5,000.00
3.	8" Sanitary Sewer (PVC SDR-26)	575	LF	$158.00	$90,850.00
4.	Railroad Boring with Casing and Carrier Pipe	100	LF	$850.00	$85,000.00
5.	4' Dia. Manhole (8'-12' Depth)	1	EA	$4,800.00	$4,800.00
6.	Bypass Pumping	1	LS	$10,000.00	$10,000.00
7.	Street Repair	1	LS	$24,000.00	$24,000.00
8.	Erosion Control	1	LS	$5,000.00	$5,000.00
				SUBTOTAL:	**$232,150.00**
				CONTINGENCY (15%):	$34,900.00
				TOTAL CONSTRUCTION:	**$268,000.00**
				Legal, Easements, Engineering, Inspection (20%):	$53,600.00
				PROJECT TOTAL:	**$321,000.00**

ENGINEER'S PRELIMINARY COST ESTIMATE OF PROBABLE CONSTRUCTION COSTS
LEE'S SUMMIT APARTMENTS - ROUTE 1
LEE'S SUMMIT, MO

December 19, 2018

Item No.	Description	Quantity	Unit	Unit Price $	Price $
1.	Mobilization (3% max of total bid)	1	LS	$6,000.00	$6,000.00
2.	Demolition, Clearing & Grubbing	1	LS	$5,000.00	$5,000.00
3.	8" Sanitary Sewer (PVC SDR-26)	720	LF	$190.00	$136,800.00
4.	4' Dia. Manhole (12'-18' Depth)	3	EA	$5,500.00	$16,500.00
5.	Sod	100	SY	$5.00	$500.00
6.	Bypass Pumping	1	LS	$5,000.00	$5,000.00
7.	Street Repair	1	LS	$20,000.00	$20,000.00
8.	Erosion Control	1	LS	$5,000.00	$5,000.00
				SUBTOTAL:	**$194,800.00**
				CONTINGENCY (15%):	$29,300.00
				TOTAL CONSTRUCTION:	**$225,000.00**
				Legal, Easements, Engineering, Inspection (20%):	$45,000.00
				PROJECT TOTAL:	**$270,000.00**

*Outside of City standard sewer depth