Parkview Drainage Study

City of Franklin, Tennessee

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Appendices

1. Introduction

This project addresses localized flooding and ponding in the City of Franklin, Tennessee. As illustrated in Figure 1, the area of interest extends the entire length of Parkview Drive and along Evans Street between East Fowlkes and South Margin Streets.

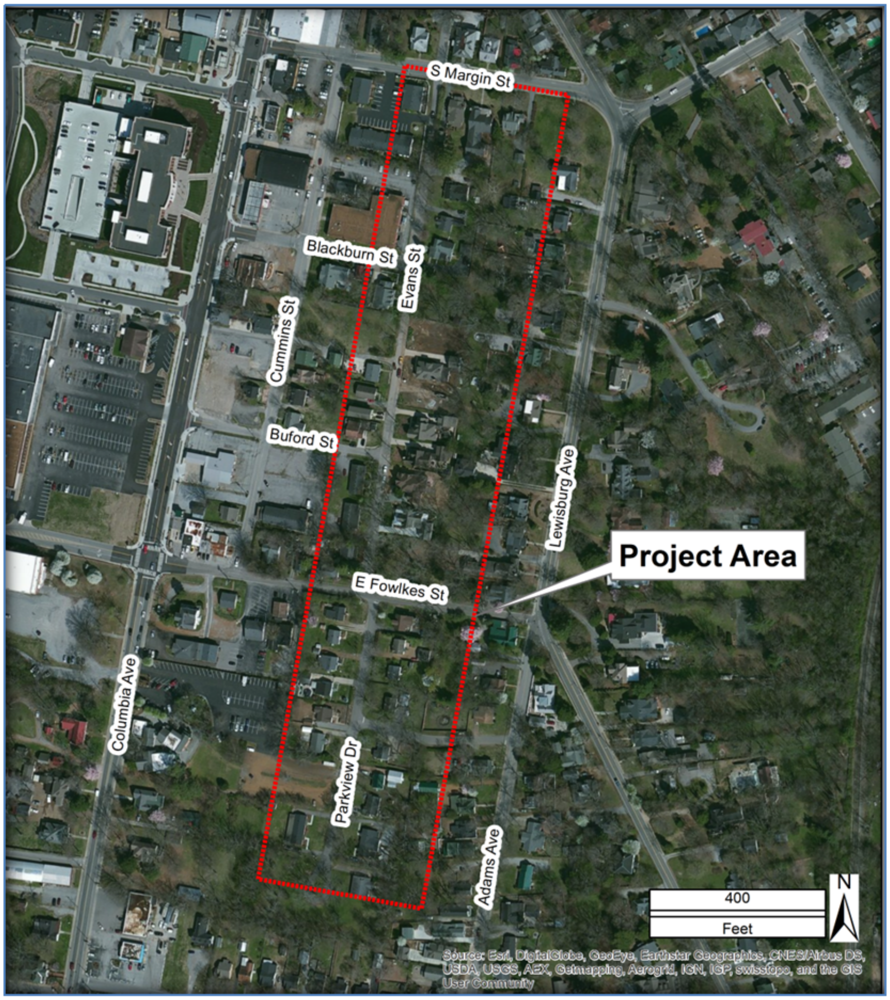

Figure 1: Parkview Drainage Study Project Area

The existing stormwater system mainly consists of a series of intermittent roadside ditches and culverts. Additionally, a 30-inch corrugated metal pipe (CMP) has been installed at the north end of Evans Street to help convey flow to the stormwater system to the north. When the existing stormwater system was originally designed, the drainage area consisted of low-density, single-family residences. Since the original design, however, the housing density has increased, so the infiltration of rainfall has decreased, causing more runoff. New development has also replaced areas that were previously used as natural storage areas, resulting in higher peak stormwater flows. The increased runoff and higher peak storm flows have created the need for an improved stormwater conveyance system.

An initial drainage study was performed in 1995 for the City of Franklin to identify alternatives and opinions of probable costs to alleviate flooding in the Parkview area. The initial drainage study is included as Appendix A to this report. The study recommended two primary alternatives: (1) construct a new piped stormwater system that would extend along Parkview Avenue and Evans Street and connect to Columbia Avenue, or (2) construct a new piped stormwater system that would extend from the Parkview area directly to the Harpeth River. In an effort to further reduce peak flows, the report also recommended utilizing a vacant lot as a detention area.

The purpose of this report is to further evaluate the recommended alternatives, based on updated land use and current storm sewer layouts. To characterize the nature of the runoff, a stormwater model was developed to estimate the infiltration and runoff caused by rain events, given the land use and soil types of the drainage area. The model was also used to estimate the hydraulic conveyance capacity of a proposed dedicated stormwater system. This report summarizes the methodology, analysis, and alternatives for mitigating the flooding problem in the Parkview Drainage Study area.

2. Methodology

The following subsections summarize the project data, including field reconnaissance, and the model development process.

2.1. Project Data

The following data were used for the drainage study from the sources indicated:

- 1995 Drainage Study for Parkview Avenue (Smith Seckman Reid, Inc) – City of Franklin
- Inventory Geodatabase – City of Franklin
- Topography – 2-ft Contours – City of Franklin
- Aerial Photography – ESRI GIS Server
- Web Soil Survey (Appendix B) – Natural Resources Conservation Service (NRCS)
- Limited BWSC Field Survey (July 20, 2015)

2.1.1 Client Meeting and Site Visit

A kickoff meeting was conducted on June 3, 2015, with Paul Holzen, Director of Engineering for the City of Franklin. The recommendations made during the 1995 drainage study were discussed. As mentioned above, two basic alternatives were recommended: (1) construct a new storm sewer system to connect to the existing storm sewer system on Columbia Avenue, and (2) construct a new storm sewer system that connects to the Harpeth River. Also recommended was the additional option to use a vacant lot in the Parkview area to construct underground detention in conjunction with either new storm sewer system. During discussions with Mr. Holzen, it was decided to review the possibility of connecting a new storm sewer to Columbia Avenue. It was also revealed that the vacant lot was no longer available for detention, but the potential of constructing a detention pond at the downstream end of the storm sewer route to the Harpeth River would be evaluated.

A site visit was made to the area of interest on June 16, 2015, specifically to confirm the drainage boundaries and to investigate the condition of the existing stormwater system infrastructure. A general lack of a continuous stormwater conveyance system was observed. Some roadside ditches and culverts exist on Parkview Avenue but are not continuous and would allow runoff to pond. A piped stormwater system consisting of corrugated metal pipe exists in portions of Evans Street, but there are very few inlets. The inlets that do exist are typically located in areas that do not allow ponding water to enter the system efficiently. Additionally, a majority of the drainage from Parkview Avenue flows along an existing ditch located to the east of Evans Street, but no outfall point could be determined, suggesting that runoff would likely pond in the area. Residents along Evans Street confirmed this and reported that ponding occurs in Evans Street, indicating that the storm sewer system there is also insufficient. Figure 2 presents observations from the site visit.

Figure 2: Parkview Site Visit Observations

2.1.2 Alternative Screening

Before beginning detailed stormwater system simulations, multiple alternatives were screened using existing GIS data and record drawings to reduce the number of simulations required. The following represents the results of the screening:

1. Route to the Columbia Avenue Storm Sewer System: It was determined from record drawings that two 24” pipes exist in Columbia Avenue. However, the record drawings show that the pipes were installed with minimum cover, suggesting that their inverts are approximately four feet below the ground. Based on model results, a 54” pipe was estimated as the size required to adequately convey discharge away from the Parkview area and would be too large to connect to the existing 24” pipes. Based on this screening, the Columbia Avenue alternative was abandoned.

2. Route to the Harpeth River: Two streets were evaluated as potential routes for a new storm sewer system to connect to the Harpeth River: South Margin and Church Streets. Existing ground profiles of both streets, based on the City of Franklin's contour information, indicate that the South Margin Street route would require less excavation to construct a new storm sewer, so it was selected for the simulation analysis. This route was modeled with a proposed natural channel located in the floodplain of the Harpeth River. During the design phase water quality features will be evaluated. However, property acquisition may limit the size of water quality features that can be implemented.

2.2. Model Development

The following subsections outline the process for developing the stormwater model used to analyze the Parkview area flooding alternatives. The stormwater model was developed using InfoSWMM (Innovyze v13.0), a GIS-based stormwater management modeling software that has the ability to incorporate GIS layers, as well as perform both hydrologic and hydraulic calculations. Infiltration and runoff calculations were made using the NRCS (formerly SCS) curve number and unit hydrograph methodology, which uses land use data, soil data, and time of concentration calculations to estimate the stormwater runoff hydrographs for individual drainage areas.

2.2.1 Drainage Areas

The project's drainage area was subdivided into 29 subbasins as illustrated in Figure 3. Additionally, the subbasin areas are presented in Table 1.

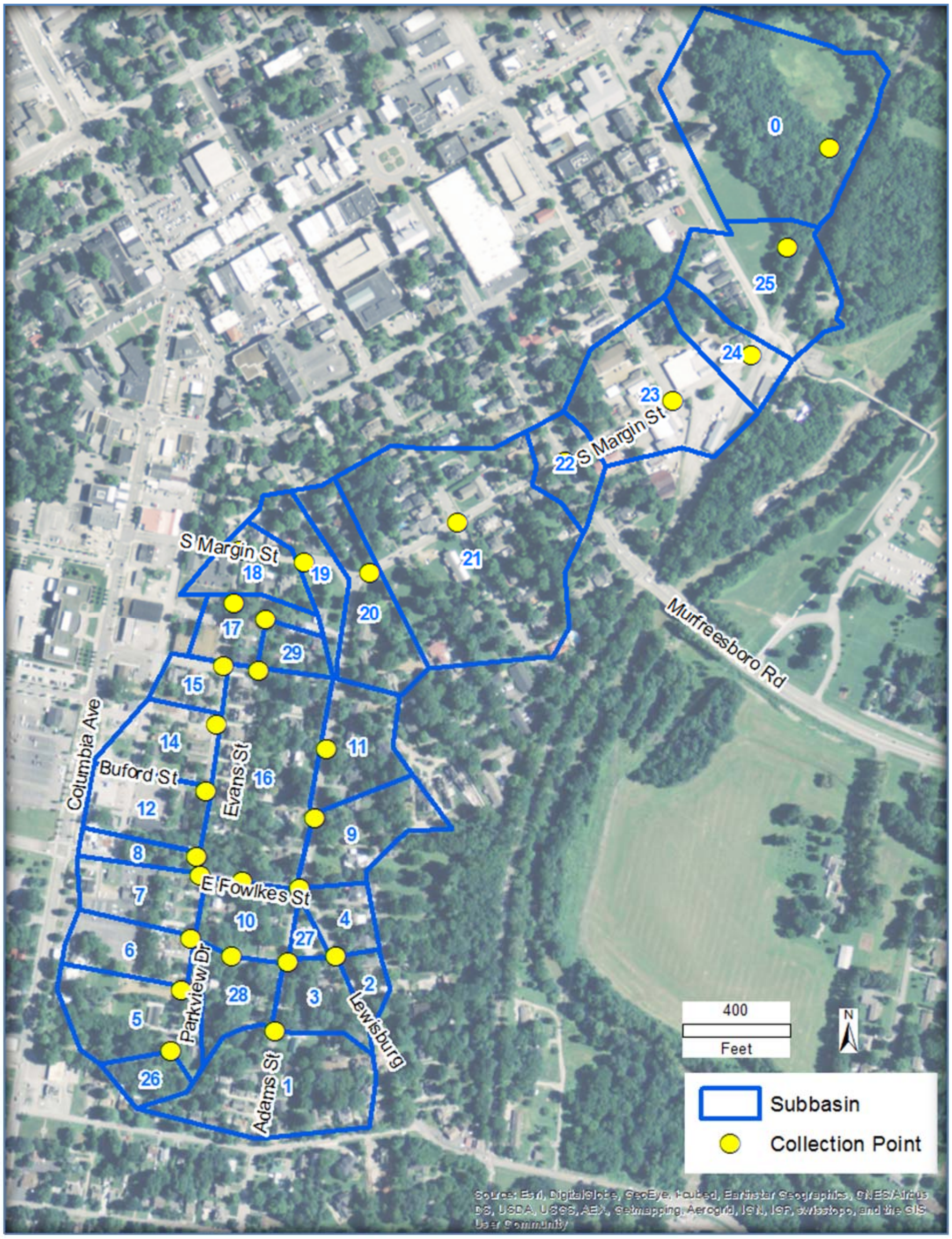

Figure 3: Subbasin Overview

Table 1: Subbasin Area Summary

Subbasin ID	Area (Acres)		Subbasin ID	Area (Acres)
0	10.54		16	6.93
1	5.67		17	1.80
2	0.76		18	1.95
3	1.88		19	1.91
4	1.35		20	3.54
5	3.52		21	12.55
6	2.13		22	1.76
7	2.26		23	5.94
8	0.96		24	2.05
9	2.85		25	4.84
10	2.17		26	1.01
11	2.71		27	0.42
12	2.51		28	2.09
14	2.28		29	0.93
15	1.07			

2.2.2 Runoff Characteristics

The initial phase of stormwater model development was to characterize the soil types and land use of each subbasin to develop the runoff flows that contribute to the stormwater system. Hydrologic soil groups determined for the drainage basin are based on the NRCS Web Soil Survey and are presented in Figure 4.

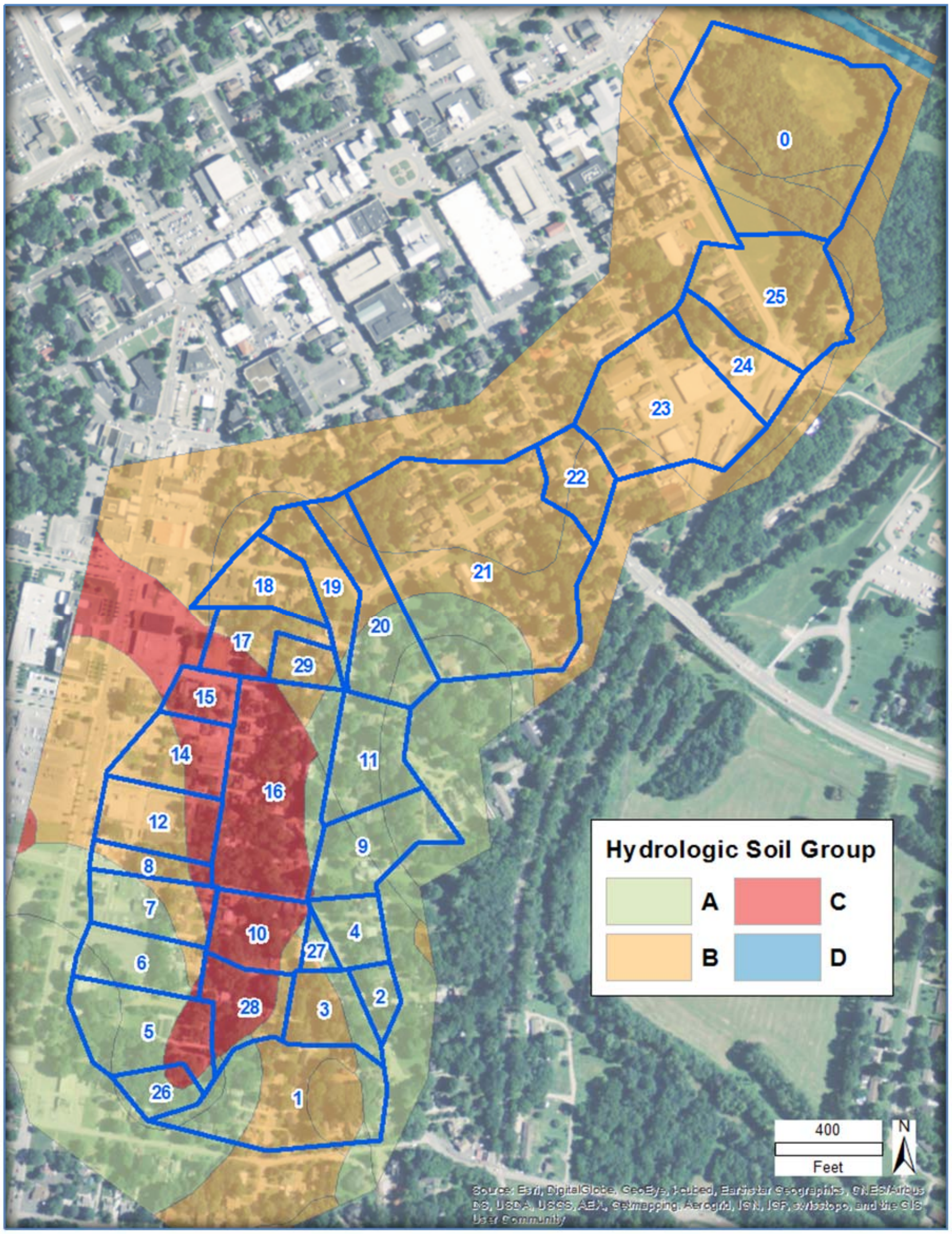

Figure 4: Hydrologic Soil Groups

The City's GIS layers and existing aerial photography were used to estimate the land use of the drainage basin as shown in Figure 5. Upon review, it was determined that the land use for the drainage basin could be described as 39.1% impervious area and 61.9% lawn area. There are minimal non-lawn forested areas in the project drainage area.

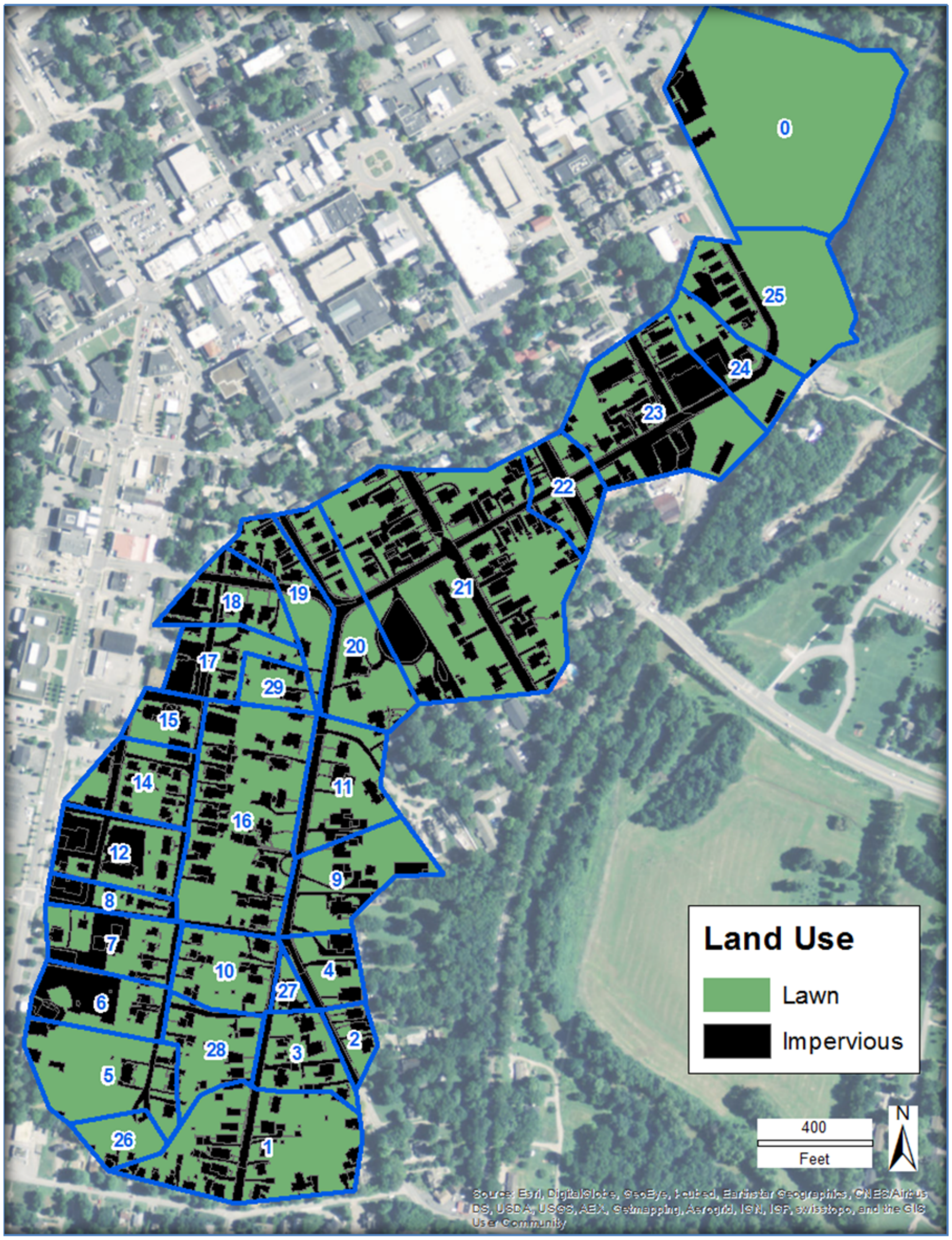

Figure 5: Land Use Overview

Using the GIS tools, the soil groups, land use, and subbasins were merged to develop composite curve numbers for each subbasin. The composite curve numbers are presented in Table 2.

Table 2: Subbasin Curve Number Summary

Subbasin ID	NRCS Weighted Curve Number	Subbasin ID	NRCS Weighted Curve Number
0	63	16	78
1	67	17	82
2	72	18	84
3	74	19	76
4	70	20	71
5	56	21	81
6	83	22	85
7	87	23	84
8	87	24	75
9	60	25	68
10	80	26	51
11	65	27	75
12	88	28	78
14	84	29	70
15	87		

2.2.3 Times of Concentration

After the individual subbasins were delineated and the composite curve numbers were calculated, the times of concentration were computed using standard NRCS methods (TR-55) and the applicable base data (aerial photography, City contours). The times of concentration typically consisted of three components: sheet flow, shallow concentrated flow, and channel flow. The sheet flow was limited to 100 feet and was computed using the kinematic wave equation. The Manning's n overflow coefficient used for each flow path was 0.24. While digital contour data was used to estimate slopes, several flow paths had slopes of less than 1%. To prevent overestimation of the time of concentrations, the slopes were limited to 1% for sheet flow and 0.5% for shallow concentrated flow. Aerial photography was used to determine if shallow concentrated flow paths were paved or unpaved, and the times of concentration for each shallow concentrated flow were computed accordingly. Finally, times of concentration for the channel flow components were computed using the Manning's equation by assuming a 1-foot depth of flow in a channel with 3:1 side slopes. Following the computation of the individual components, the times of concentration were summed to produce a total time of concentration for each subbasin, as presented in Table 3.

Table 3: Subbasin Times of Concentrations

Subbasin ID	Time of Concentration (min)		Subbasin ID	Time of Concentration (min)
0	16		16	13
1	15		17	14
2	18		18	12
3	13		19	15
4	8		20	10
5	11		21	8
6	8		22	18
7	8		23	18
8	15		24	21
9	19		25	19
10	17		26	7
11	10		27	11
12	11		28	8
14	20		29	10
15	18			

2.2.4 Storm Sewer System

Through discussions with City of Franklin staff and further revisions of alternatives, a final storm sewer route that extended north along Parkview Drive, then Evans Street, and then northeast along South Margin Street to the Harpeth River was selected for evaluation. The proposed route is presented in Figure 6.

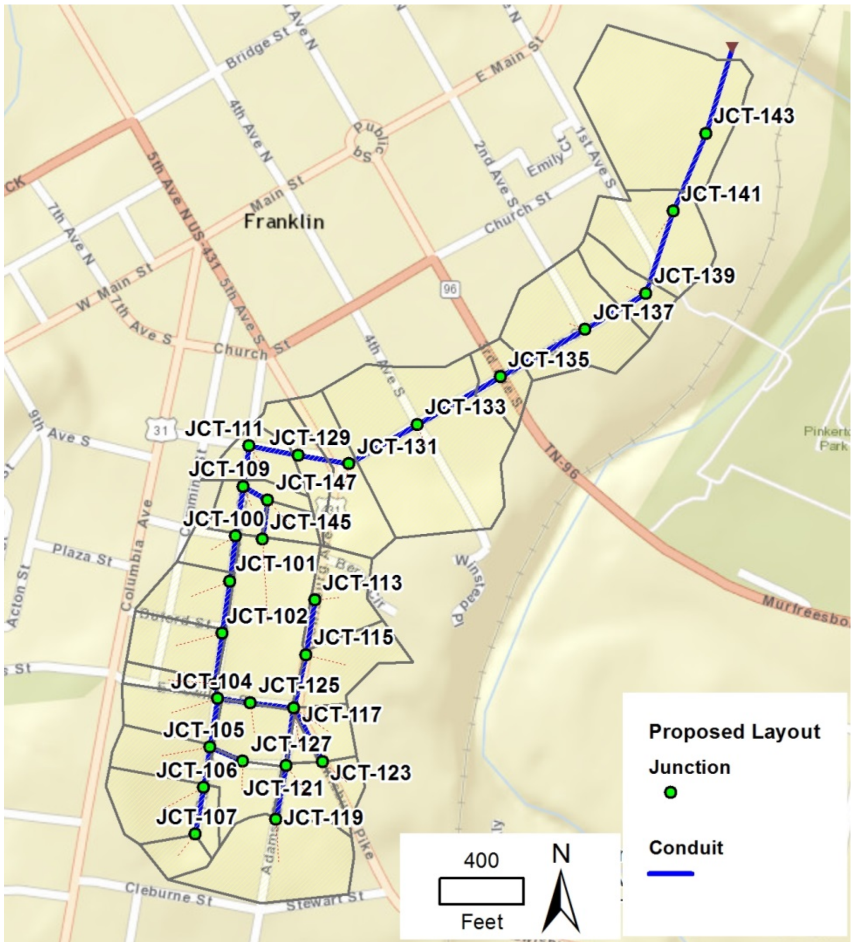

Figure 6: Proposed Storm Sewer Layout

The proposed route was configured in the InfoSWMM model, using a series of junctions (manholes) and conduits (pipes). Based on discussions with the City of Franklin, a 10-year, 24-hour storm, which has a rainfall depth of 5.13 inches (Appendix B), was used as the design rainfall event. Simulations were performed for the 5-year (4.48 inches) and 2-year (3.68 inches), 24-hour rainfall events to demonstrate performance of the 10-year design during smaller storm events. Using these rainfall amounts, the NRCS curve numbers, and times of concentration, runoff hydrographs were computed for each subbasin and directed to the nearest junction. Junction losses were estimated using the values in Table 4.

Table 4: Junction Losses

Junction Description	Headloss Coefficient
Sewer trunkline with no bend at manhole	0.5
Sewer trunkline with 45° bend at manhole	0.6
Sewer trunkline with 90° bend at manhole	0.8
Large lateral at 90° to sewer trunkline manhole	0.7
Small lateral at 90° to sewer trunkline manhole	0.6
Two sewer lines entering manhole with angle < 90° between two inlet lines	0.8
Two sewer lines entering manhole with angle ≥ 90° between two inlet lines	0.9
Three or more sewer lines entering manhole	1.0

For the proposed storm sewer design, pipe sizes and inverts were adjusted iteratively so that the hydraulic grade line (HGL) remained below the rim of the junctions and to ensure that the conduits had a minimum of 2 feet of cover.

Alternatively, a separate storm sewer simulation and design was performed, using a 5-year, 24-hour storm with a rainfall depth of 4.48 inches, to provide a secondary, lower-cost choice, but with a lower level of service.

3. Results

The stormwater model was used to simulate the various storm events. Peak HGL results for the design storm (10-year, 24-hour) event are presented in Appendix C. The smaller 2-year and 5-year, 24-hour storms were also simulated. Maximum discharge results occurring at the subbasins and junctions are presented in Tables 5 and 6, respectively. Maximum discharge results for subbasins are shown in Figure 7. Maximum discharge results for conduits are shown in Figure 8.

Table 5: Project Drainage Subbasin Results Summary

Subbasin	Peak Flow (cfs)			Subbasin	Peak Flow (cfs)		
	2-year	5-year	10-year		2-year	5-year	10-year
SUB_0	8.38	14.89	20.86	SUB_23	15.54	20.75	25.05
SUB_1	6.60	10.70	14.36	SUB_24	3.23	4.69	5.93
SUB_10	4.95	6.85	8.43	SUB_25	5.26	8.39	11.16
SUB_11	2.69	4.53	6.21	SUB_26	0.14	0.57	1.13
SUB_12	10.58	13.70	16.25	SUB_27	0.97	1.41	1.78
SUB_14	5.59	7.47	9.02	SUB_28	6.59	9.29	11.56
SUB_15	3.12	4.07	4.85	SUB_29	1.69	2.61	3.41
SUB_16	16.93	23.79	29.57	SUB_3	3.75	5.49	6.98
SUB_17	5.06	6.87	8.38	SUB_4	2.73	4.19	5.48
SUB_18	6.48	8.65	10.44	SUB_5	1.37	3.32	5.31
SUB_19	3.89	5.58	7.02	SUB_6	8.37	11.27	13.68
SUB_2	1.07	1.61	2.08	SUB_7	10.37	13.54	16.12
SUB_20	6.84	10.40	13.49	SUB_8	3.12	4.07	4.85
SUB_21	45.35	62.16	76.15	SUB_9	1.47	2.88	4.20
SUB_22	4.77	6.32	7.59				

[1] Subbasin IDs are shown in Figure 7

Table 6: Project Drainage Junction Results Summary

Node	Peak Flow (cfs)			Node	Peak Flow (cfs)		
	2-year	5-year	10-year		2-year	5-year	10-year
JCT-100	62.24	89.36	109.07	JCT-123	1.07	1.61	2.08
JCT-101	59.37	85.72	104.29	JCT-125	22.33	34.96	47.33
JCT-102	54.53	80.14	97.99	JCT-127	6.59	9.29	11.56
JCT-103	44.67	66.99	84.87	JCT-129	95.22	135.15	161.91
JCT-104	41.67	63.11	80.41	JCT-131	100.50	143.18	171.99
JCT-105	15.71	23.48	30.49	JCT-133	128.15	181.68	220.40
JCT-106	1.51	3.87	6.32	JCT-135	132.79	187.23	223.65
JCT-107	0.14	0.57	1.13	JCT-137	148.02	207.69	247.09
JCT-109	85.47	121.99	149.58	JCT-139	150.92	210.69	251.82
JCT-111	91.50	130.09	155.13	JCT-141	155.52	218.40	262.68
JCT-113	2.69	4.53	6.21	JCT-143	174.76	218.30	262.65
JCT-115	4.06	7.30	10.25	JCT-145	16.93	23.79	29.57
JCT-117	17.45	28.18	37.24	JCT-147	18.45	26.11	32.83
JCT-119	6.60	10.70	14.36	OFALL-14	174.76	220.12	263.10
JCT-121	10.20	16.02	21.13				

[1] Junction IDs are shown in Figure 8

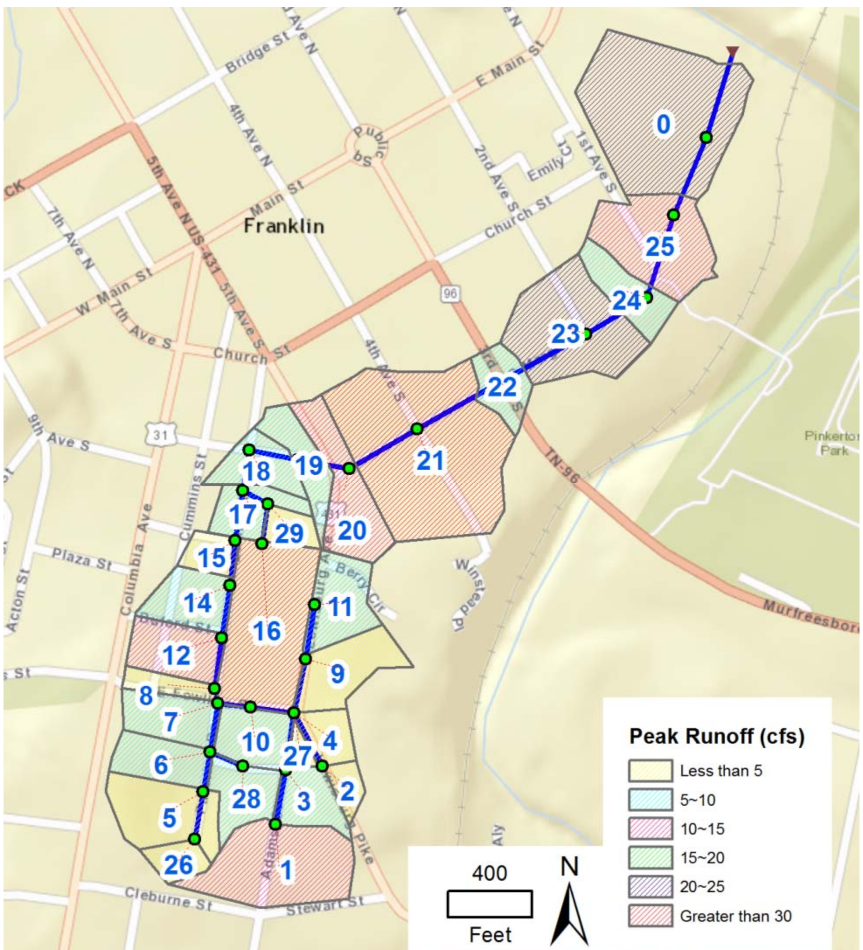

Figure 7: Subbasins Maximum Discharge

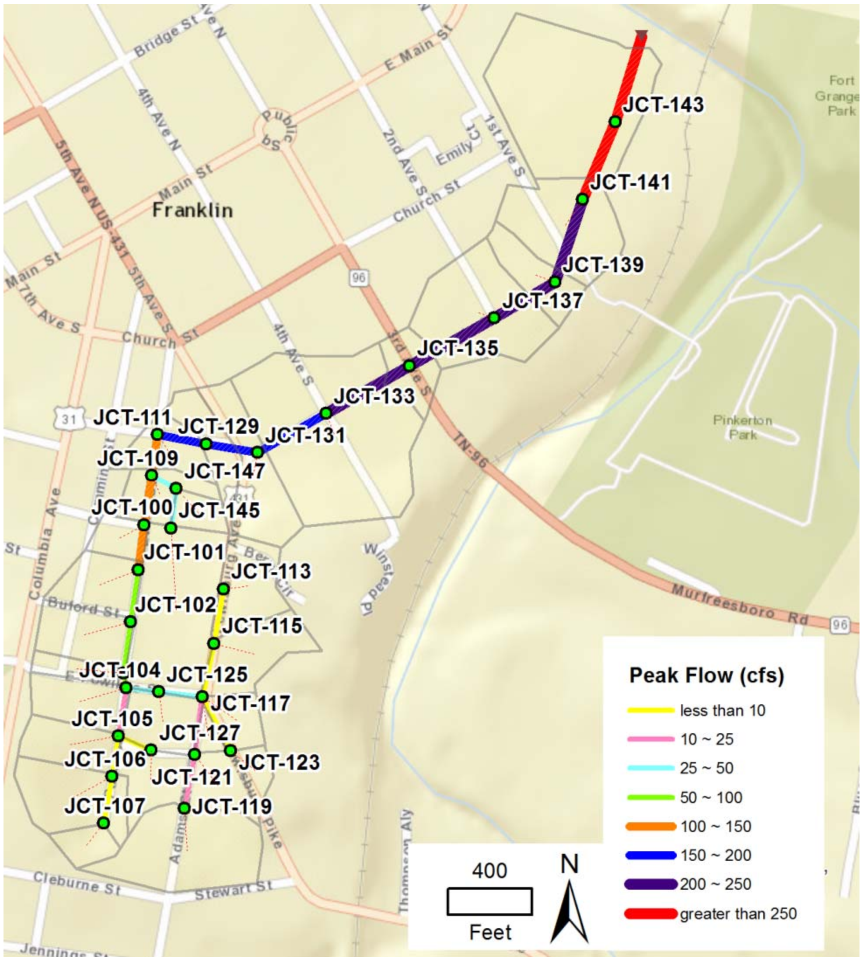

Figure 8: Conduits Maximum Discharge

As a supplementary alternative, a natural channel was added at the downstream end of the drainage basin, to provide a natural transition before discharging to the Harpeth River. The stream segment will convey the proposed storm sewer discharge through approximately 50-feet of armored transition to dissipate energy, and 350-feet of meanders, before entering the Harpeth River. Figure 9 shows the approximate location of the natural stream segment and a typical cross-section. During the design phase water quality features will be evaluated. However, property acquisition may limit the size of water quality features that can be implemented.

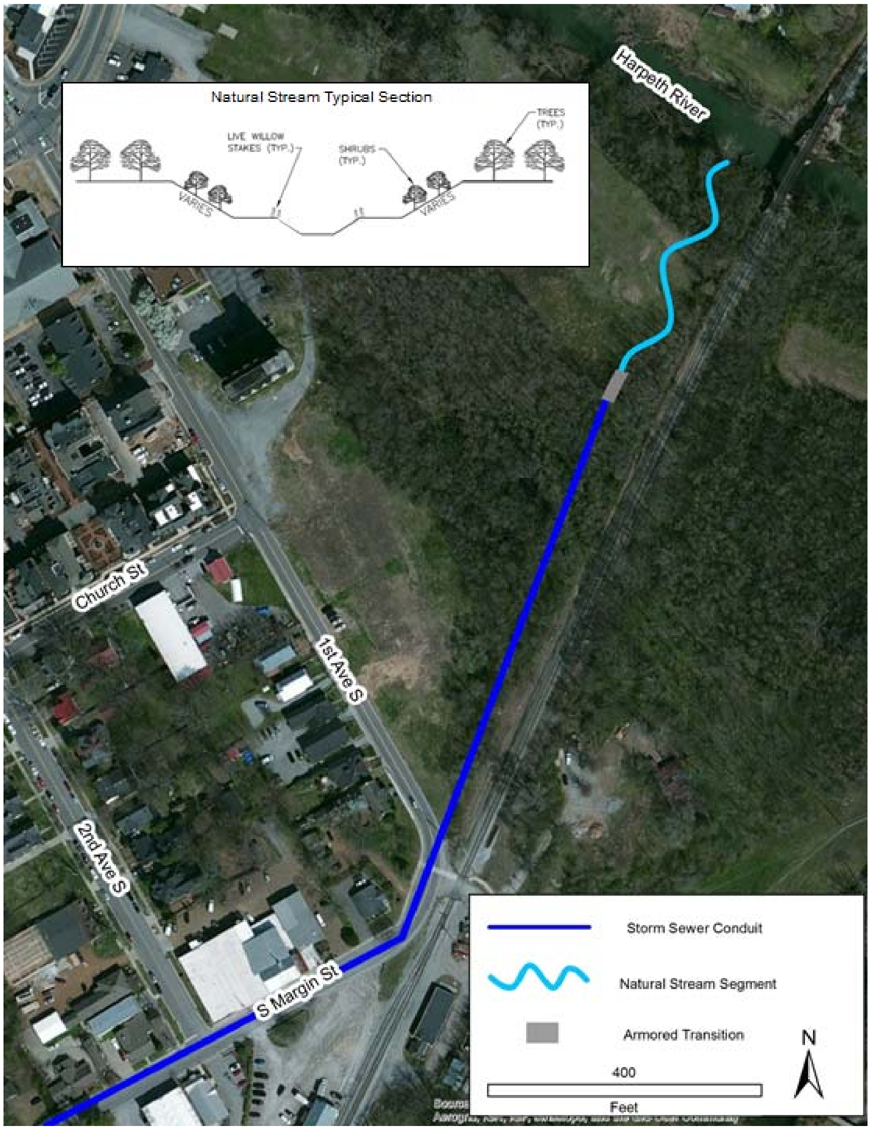

Figure 9: Proposed Natural Channel

Finally, in order to provide the City of Franklin with an estimate of how cost would vary according to the level of service provided by the proposed storm sewer system, a storm sewer system was designed to a 5-year, 24-hour storm following the proposed alignment.

3.1 Solution Alternatives

This section presents three improvement alternative summaries that include a description of the alternative and a conceptual project budget. The solution alternatives and related cost assumptions are presented at the conceptual level for planning purposes. The TDOT Average Unit Prices for 2014 and vendor prices were used for developing the budget concepts. The geotechnical allowance is assumed to be the same for each alternative for the purpose of comparison. Opinions of cost will be further developed during the design process.

Alternative 1 – Storm Sewer System Designed to the 10-Year, 24-Hour Event

This alternative includes installing a new storm sewer system from the Parkview Avenue Area to the Harpeth River (Figure 6). The system was designed for the storm sewer system to contain the peak flows during the 10-year, 24-hour design storm event.

Description	QTY	UNIT	$ / UNIT	TOTAL
18" RCP, Class III	2197	LF	$ 45	$ 98,865.00
24" RCP, Class III	169	LF	$ 72	$ 12,168
30" RCP, Class III	1098	LF	$ 96	$ 105,408
36" RCP, Class III	210	LF	$ 123.75	$ 25,988
42" RCP, Class III	157	LF	$ 180	$ 28,260
48" RCP, Class III	785	LF	$ 250	$ 196,250
54" RCP, Class III	437	LF	$ 300	$ 131,100
60" RCP, Class III	860	LF	$ 350	$ 301,000
66" RCP, Class III	922	LF	$ 390	$ 359,580
84" RCP, Class III	1579	LF	$ 700	$ 1,105,300
Catch Basins, 0-4'	16	EA	$ 3,000	$ 48,000
Catch Basins, 4-8'	16	EA	$ 3,600	$ 57,600
Catch Basins, 8-12'	16	EA	$ 5,000	$ 80,000
Manhole, Dia. 48", 0-4', BASE	5	EA	$ 3,200	$ 16,000
Manhole, Dia. 48", 4-8'	5	EA	$ 3,500	$ 17,500
Manhole, Dia. 60", 0-4', BASE	1	EA	$ 4,000	$ 4,000
Manhole, Dia. 60", 4-8'	1	EA	$ 4,800	$ 4,800
Manhole, Dia. 72", 4-8'	4	EA	$ 8,000	$ 32,000
Manhole, Dia. 72", 8-12'	2	EA	$ 10,500	$ 21,000
Manhole, Dia. 84", 0-4', BASE	2	EA	$ 9,000	$ 18,000
Manhole, Dia. 84", 4-8'	3	EA	$ 13,000	$ 39,000
Manhole, Dia. 120", 4-8'	4	EA	$ 20,000	$ 80,000
Manhole, Dia. 120", 8-12'	7	EA	$ 25,000	$ 175,000
Manhole, Dia. 120", 12-16'	4	EA	$ 30,000	$ 120,000
Class "C" Riprap	725	TON	$ 35	$ 25,376
84" Headwall	1	EA	$ 10,000	$ 10,000
Additional Excavation	7032	CY	$ 15	$ 105,480
Basestone	2653	TON	$ 22	$ 58,373
Pavement (Binder)	1056	TON	$ 82	$ 86,615
Pavement (Surface)	1118	TON	$ 100	$ 111,784
Brick Sidewalk with Concrete Base & Asphalt Setting Bed	1400	SY	$ 200	$ 280,000
Brick Handicap Ramp	2700	SF	$ 38	$ 102,600
Concrete Curb and Gutter	885	CY	$ 230	$ 203,550
Cold Planing Bituminous Pavemet	7336	SY	$ 4.50	$ 33,012
Traffic Control	1	LS	$ 50,000	$ 50,000
Plastic Pavement Marking (Stop Line)	200	LF	$ 12	$ 2,400
Plastic Pavement Marking (Turn Lane Arrow)	4	EA	$ 140	$ 560
Plastic Pavement Marking (Longitudinal Cross Walk)	2588	LF	$ 30	$ 77,640
Plastic Pavement Marking (Straight - Turn Arrow)	4	EA	$ 360	$ 1,440
Plastic Pavement Marking (4" Line)	3	LM	$ 2,000	$ 6,000
Mobilization	1	LS	$ 100,000	$ 100,000
EPSC	1	LS	$ 50,000	$ 50,000
Seeding	2	ACRE	$ 1,000	$ 2,000
Install 12-inch DIP Class 350 Waterline	6008	LF	$ 140	$ 841,120
Compact DI Fittings	5000	LBS	$ 8	$ 40,000
Disconnect/Reconnect Water Service	130	EA	$ 155	$ 20,150
Install 12" Gravity Sewer	1000	LF	$ 105	$ 105,000
Install New 4' Dia Manhole up to 6'	26	EA	$ 4,500	$ 117,000
Install 8" SDR-35 PVC Gravity Sewer	5000	LF	$ 100	$ 500,000
Lateral Service Connection	105	EA	$ 1,500	$ 157,500
Right of Way	1	ACRE	$ 150,000	$ 150,000
Geotechnical Allowance	1	LS	$ 50,000	$ 50,000
SUBTOTAL				$ 6,364,419
Survey and Design			10.0%	$ 636,442
Construction Administration Services			5.0%	$ 318,221
Contingency			20.0%	$ 1,272,884
TOTAL				**$8.6 Million**

Alternative 2 – Storm Sewer System Designed to the 10-Year, 24-Hour Event with Added Natural Channel

This alternative includes installing a new storm sewer system from the Parkview Avenue Area to the Harpeth River (Figure 6). The system was designed for the storm sewer system to contain the peak flows during the 10-year, 24-hour design storm event. Additionally, the storm sewer system would discharge into a natural channel before entering the Harpeth River.

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Manhole, Dia. 48", 4-8'	5	EA	$ 3,500	$ 17,500
Manhole, Dia. 60", 0-4', BASE	1	EA	$ 4,000	$ 4,000
Manhole, Dia. 60", 4-8'	1	EA	$ 4,800	$ 4,800
Manhole, Dia. 72", 4-8'	4	EA	$ 8,000	$ 32,000
Manhole, Dia. 72", 8-12'	2	EA	$ 10,500	$ 21,000
Manhole, Dia. 84", 0-4', BASE	2	EA	$ 9,000	$ 18,000
Manhole, Dia. 84", 4-8'	3	EA	$ 13,000	$ 39,000
Manhole, Dia. 120", 4-8'	4	EA	$ 20,000	$ 80,000
Manhole, Dia. 120", 8-12'	7	EA	$ 25,000	$ 175,000
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Mobilization	1	LS	$ 100,000	$ 100,000
EPSC	1	LS	$ 50,000	$ 50,000
Seeding	5	$ / acre	$ 1,000	$ 5,000
Install 12-inch DIP Class 350 Waterline	6008	LF	$ 140	$ 841,120
Compact DI Fittings	5000	LBS	$ 8	$ 40,000
Disconnect/Reconnect Water Service	130	EA	$ 155	$ 20,150
Install 12" Gravity Sewer	1000	LF	$ 105	$ 105,000
Install New 4' Dia Manhole up to 6'	26	EA	$ 4,500	$ 117,000
Install 8" SDR-35 PVC Gravity Sewer	5000	LF	$ 100	$ 500,000
Lateral Service Connection	105	EA	$ 1,500	$ 157,500
Natural Channel	350	LF	$ 350	$ 122,500
Right of Way	1.5	ACRE	$ 150,000	$ 225,000
Geotechnical Allowance	1	LS	$ 50,000	$ 50,000
SUBTOTAL				$ 6,329,543
Survey and Design			10.0%	$ 632,954
Construction Administration Services			5.0%	$ 316,477
Contingency			20.0%	$ 1,265,909
TOTAL				**$ 8.6 Million**

Alternative 3 – Storm Sewer System Designed to the 5-Year, 24-Hour Event

This alternative includes installing a new storm sewer system from the Parkview Avenue Area to the Harpeth River (Figure 6). The system was designed for the storm sewer system to contain the peak flows during the 5-year, 24-hour design storm event.

Description	QTY	UNIT	$ / UNIT	TOTAL
18" RCP, Class III	2197	LF	$ 45	$ 98,865
24" RCP, Class III	431	LF	$ 72	$ 31,032
30" RCP, Class III	1047	LF	$ 96	$ 100,512
36" RCP, Class III	229	LF	$ 123.75	$ 28,338.75
42" RCP, Class III	497	LF	$ 180	$ 89,443.80
48" RCP, Class III	653	LF	$ 250	$ 163,361.75
54" RCP, Class III	860	LF	$ 300	$ 258,019.20
60" RCP, Class III	922	LF	$ 350	$ 322,731.15
66" RCP, Class III	1579	LF	$ 390	$ 615,729.66
Catch Basins, 0-4'	16	EA	$ 3,000	$ 48,000
Catch Basins, 4-8'	16	EA	$ 3,600	$ 57,600
Catch Basins, 8-12'	16	EA	$ 5,000	$ 80,000
Manhole, Dia. 48", 0-4', BASE	7	EA	$ 3,200	$ 22,400
Manhole, Dia. 48", 4-8'	6	EA	$ 3,500	$ 21,000
Manhole, Dia. 60", 4-8'	1	EA	$ 4,000	$ 4,000
Manhole, Dia. 60", 8-12'	1	EA	$ 4,800	$ 4,800
Manhole, Dia. 72", 4-8'	6	EA	$ 8,000	$ 48,000
Manhole, Dia. 84", 4-8'	3	EA	$ 13,000	$ 39,000
Manhole, Dia. 84", 8-12'	4	EA	$ 17,000	$ 68,000
Manhole, Dia. 120", 4-8'	2	EA	$ 20,000	$ 40,000
Manhole, Dia. 120", 8-12'	4	EA	$ 25,000	$ 100,000
Manhole, Dia. 120", 12-16'	4	EA	$ 30,000	$ 120,000
Class "C" Riprap	725	TON	$ 35	$ 25,376.04
66" Headwall	1	EA	$ 8,000	$ 8,000
Additional Excavation	5869	CY	$ 15	$ 88,035
Basestone	2396	TON	$ 22	$ 52,709.80
Pavement (Binder)	954	TON	$ 82	$ 78,209.74
Pavement (Surface)	1118	TON	$ 100	$ 111,784.36
Brick Sidewalk with Concrete Base & Asphalt Setting Bed	1400	SY	$ 200	$ 280,000
Brick Handicap Ramp	2700	SF	$ 38	$ 102,600
Concrete Curb and Gutter	885	CY	$ 230	$ 203,550
Cold Planing Bituminous Pavemet	7336	SY	$ 4.50	$ 33,012
Traffic Control	1	LS	$ 50,000	$ 50,000
Plastic Pavement Marking (Stop Line)	200	LF	$ 12	$ 2,400
Plastic Pavement Marking (Turn Lane Arrow)	4	EA	$ 140	$ 560
Plastic Pavement Marking (Longitudinal Cross Walk)	2588	LF	$ 30	$ 77,640
Plastic Pavement Marking (Straight - Turn Arrow)	4	EA	$ 360	$ 1,440
Plastic Pavement Marking (4" Line)	3	LM	$ 2,000	$ 6,000
Mobilization	1	LS	$ 100,000	$ 100,000
EPSC	1	LS	$ 50,000	$ 50,000
Seeding	2	$ / acre	$ 1,000	$ 2,000
Install 12-inch DIP Class 350 Waterline	6008	LF	$ 140	$ 841,120
Compact DI Fittings	5000	LBS	$ 8	$ 40,000
Disconnect/Reconnect Water Service	130	EA	$ 155	$ 20,150
Install 12" Gravity Sewer	1000	LF	$ 105	$ 105,000
Install New 4' Dia Manhole up to 6'	26	EA	$ 4,500	$ 117,000
Install 8" SDR-35 PVC Gravity Sewer	5000	LF	$ 100	$ 500,000
Lateral Service Connection	105	EA	$ 1,500	$ 157,500
Right of Way	1	ACRE	$ 150,000	$ 150,000
Geotechnical Allowance	1	LS	$ 50,000	$ 50,000
SUBTOTAL				$ 5,614,920.25
Survey and Design			10.0%	$ 561,492.03
Construction Administration Services			5.0%	$ 280,746.01
Contingency			20.0%	$ 1,122,984.05
TOTAL				**$7.6 Million**

Appendix A

Previous Drainage Study

LHW

Smith Seckman Reid, Inc.
CONSULTING
ENGINEERS

May 2, 1995

Mr. Dave Parker
City Engineer
City of Franklin
City Hall, Box 305
Franklin, TN 37064

RE: **Parkview Drainage Improvements**
SSR #95-41-002.0

Dear Dave:

Pursuant to your request, we have investigated the hydrology and hydraulics involved with the installation of a storm sewer system to serve the Parkview area. As you are aware, the preliminary design of the storm sewer system was to begin along Evans Avenue and extending north along Evans Avenue to a point where the natural drainage way crosses under Evans Avenue and then crosses Parkview and Fowlkes Streets. The drainage way then travels back to Evans Avenue at approximately the intersection of Evans Avenue and Buford Street. The system would then continue to extend northward along Evans Avenue to a point just east of the South Central Bell parking lot. The system would then traverse through the South Central Bell parking lot to the west side of Cummings Street. The system would then traverse north along the west side of Cummings Street to a point on the northeast side of the Handy Hardware parking lot. It would then traverse westward through the Handy Hardware parking lot and connect to the existing storm sewer system in Columbia Avenue. Please refer to the exhibit attached.

There is very little storm sewer systems in place in these areas at this time. The majority of the system in the southern portion of the project is culverts under driveways, roadways, etc. In the northern portion a more formal storm sewer system exists. This system is old and generally is of varying sizes and types of pipes. The storm sewer system in Columbia Avenue was constructed in the early 80's as a part of a Tennessee Department of Transportation (TDOT) project.

The drainage basin for this project is approximately 50 acres. The terrain is fairly gentle and has some slopes approaching 6 to 7 percent. The majority of the drainage basin is residential with lots ranging from one quarter acre to one acre in size. The majority of the drainage basin is developed. Typically, surface runoff is collected at roadside ditches and then is transferred to downstream drainage ways and/or pipes. Based upon our calculations, the flow two-year storm event is approximately 120 cfs

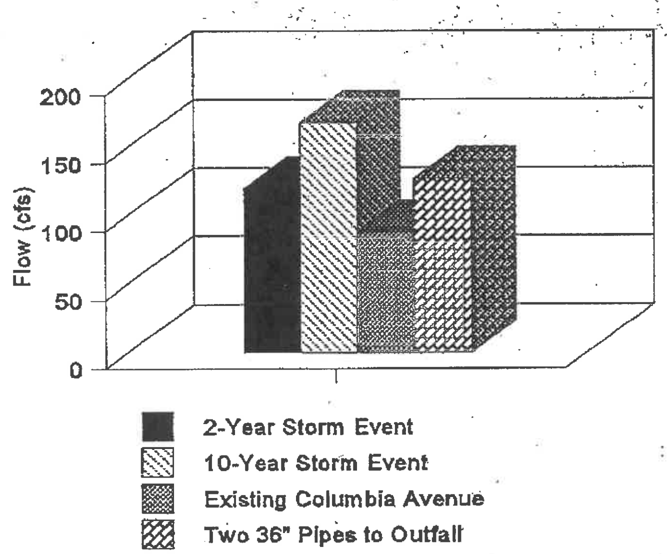
3519 West End Avenue, Suite 700 • Nashville, TN 37203 • (615) 383-1113 • FAX: (615) 386-8469

at Columbia Avenue and the flow for the ten-year storm event is approximately 168 cfs at Columbia Avenue.

This project has been considered due to localized flooding and/or ponding in some of the areas of the drainage basin. This appears to be more of a problem in the southern end along Evans Street and the natural drainage way to the east of Evans Street. The localized ponding and/or flooding is currently acting as a natural detention basin thereby reducing the flow downstream.

At the proposed point of connection (in front of Franklin Plumbing), there is a 36" x 20" box culvert and two 18" pipes which can transfer the existing flow across Columbia Avenue to a catch basin. The outlet of this catch basin is two 36" pipes continuing westward to a natural drainage way. There have been reports that this downstream drainage way currently also has localized flooding problems.

Based upon our investigation, the allowable capacity in the two 36" pipes is approximately 127 cfs (for both pipes). The existing 36" x 20" box culvert will handle approximately 40 cfs and the two 18" pipes will handle approximately 12 cfs each. There are additional 18" pipes available at South Margin Street and on the western side of Columbia Avenue. Under the current situations, the maximum that could be discharged from the Parkview drainage area under Columbia Avenue is 48 cfs for the 18" pipes (4 each at 12 cfs each) and 40 cfs for the 36" x 20" box from Cummings Street to Columbia Avenue for a grand total of 88 cfs.



Based upon the above graph, it becomes evident that the existing drainage ways under Columbia Avenue can not pass the 2- or 10-year storm events. After performing the investigation and finding that the critical section is under Columbia Avenue, we investigated the following options. Option 1 is to install a storm sewer system which would encompass the entire Parkview drainage area as described and install a new pipe under Columbia Avenue. Option 2 would be to install the drainage system as described to the point of the intersection of Buford Street and Evans Avenue, thereby reducing the discharge under Columbia Avenue to the existing drainage way capacity (88 cfs). Option 3 is to construct a detention basin just north of the intersection of East Fowlkes Street and the natural drainage way. Option 4 would be to install a storm water pumping station near the Buford Street and Evans Avenue intersection. Option 5 would be to install the Option 1 improvements and construct an outfall pipe down Church or South Margin Streets to the Harpeth River. A planimetric representation of the options is attached. A brief discussion of the options, including their advantages and disadvantages is as follows:

Option 1

This option is the construction of a new storm sewer system for the entire drainage basin and the installation of a new 54" reinforced concrete pipe under Columbia Avenue. This storm system would follow the path previously described and would alleviate localized flooding and/or ponding on the southern end during the design rainfall events. We would recommend that the 10-year storm be designed in this case. There are some disadvantages in using this option. We have previously indicated there is localized flooding downstream of the Parkview project. Once the new storm sewer system improvements are installed, this problem will only grow in magnitude. The scope of this project at this time does not allow for investigation of downstream drainage ways; therefore, they have not been investigated.

Option 2

Option 2 is the installation of a storm sewer system to a point near the intersection of Buford Street and Evans Avenue. This system would connect to the existing 18" RCP and 36" x 20" box culverts under Columbia Avenue. Again, we would recommend that this storm sewer system be designed as a 10-year system to allow the pipes to be utilized in the future. The connections to the 5 drainage ways under Columbia Avenue would be accomplished through flow splitting devices which will allow only a certain portion to be discharged at each connection point; thereby, spreading out the flows to allow multiple connection points. This alleviates the need for the construction of a new pipe under Columbia Avenue. We believe this to be only a short-term solution until planning and the accumulation of funds can be accomplished to construct/improve the necessary drainage ways downstream of Columbia Avenue. On the southern end where the localized ponding/flooding is occurring, no improvements other than some minor ditch repairs would be constructed. As previously stated, the existing drainage ways act as a natural detention basin. Therefore, the peak flows are attenuated by the localized ponding/flooding. In doing so, the peak discharge is therefore reduced and the downstream drainage ways are not impacted as greatly. While this is not desirable for the residents in this area, it alleviates downstream problems. The improvements in the southern Parkview area could be constructed at a later date when the downstream drainage ways have been improved to provide the capacity for these additional flows.

Option 3

This option entails construction of a detention basin somewhere within the drainage basin. Assuming that the goal of the detention basin is to reduce the flows to allow connection to the existing drainage ways under Columbia Avenue (capacity of 88 cfs), the size of the detention basin for a 2-year storm event would be approximately 1 acre-feet and for a 10-year storm event would be approximately 2.25 acre-feet. The sizes of these detention basins have been calculated based upon containing the first 20 minutes of the difference between the allowable discharge rate (under Columbia Avenue) and the peak discharge for the design storm.

After preliminarily sizing the detention basin, the next step was to determine where to locate this structure. With the Parkview drainage area being densely populated with houses, there is only one area of sufficient size that could be utilized as a detention basin. This area is located immediately upstream (south) of the intersection of Buford Street and Evans Avenue. The physical characteristics of the detention basin can vary. In general, should the detention basin be 1 foot deep, then the surface area of the detention basin would be as indicated, i.e. for a 2-year storm event the surface area would be 1 acre and for a 10-year storm event the service area would be 2.25 acres. Should the detention basin be 2 feet in depth, then the depths for 2-year and 10-year storm events would be .5 acre and 1.625 acres respectively. This method can be used for any depth desired. In the investigation for the location of the detention basin, an area is needed that has sufficient change in elevation to allow the detention basin to have a reasonable depth so as to reduce the surface area. In further investigating the proposed site, it was determined that, on this property alone, the difference in elevation was approximately one foot. Based upon this, there is not sufficient area to accommodate the required detention basin for either storm event. A two foot elevation drop could be attained if the detention basin extended under Park Avenue. However, there are significant problems with existing garages, structures, and other items within the necessary detention area which would have to be relocated. Due to the problems with location of a detention basin of the size and depth necessary, and the questionable value of a detention basin only storing the first 20 minutes of a storm, this option was eliminated from further consideration.

Option 4

This option is construction of a storm water pumping station very near the location of the intersection of Buford Street and Evans Avenue. This storm water pumping station would be designed to handle only the flow necessary to allow the design storm discharge to be transported under Columbia Avenue through the existing pipes. The approximate flows as indicated in Option 3 above are the same. To be more specific, the pumping station would be necessary to pump 32 cfs for the 2-year storm event and 80 cfs for the 10-year storm event. This equates to 14,400 gpm for the 2-year storm event and 36,000 gpm for the 10-year storm event. Due to these very large flows and the budget of this project, again, we have not chosen to move forward with any further investigations into this option.

Option 5

Option 5 is to divert the flows from the Parkview area away from the natural pattern of flowing under Columbia Avenue by installing a storm sewer system which would transfer the flows down Church Street or South Margin Street and, ultimately, to the Harpeth River. There is an existing pipe in Church Street which we understand to be at or near capacity. With the installation of an additional pipe down Church Street, there are two alternatives available. First, is to merely parallel the two pipes. Second, is to construct one large pipe and combine the flows.

A detailed investigation of this option has not been accomplished; however, for the purposes of this report, it is assumed that the elevation of the existing 30" pipe would be too shallow for combining with the Parkview drainage system. Therefore, we have assumed that the pipes must be paralleled and that the Parkview drainage system outfall pipe would be deeper than that of the existing storm and sanitary sewers in Church or South Margin. Additional investigation would be necessary to determine the exact cost of this option. Based upon the assumptions listed above, a cost estimate is included for this option. Also, additional investigation would be required to determine feasibility based upon existing utilities and other unknown factors.

The advantages of this option are that the Parkview storm water flows are transferred directly to the Harpeth River; thereby, alleviating some downstream drainage way ponding/flooding west of Columbia Avenue as a result of the Parkview stormwater flows.

Based upon our investigation, there are three options which we consider to be feasible, Options 1, 2 and 5. Our first recommendation would be to investigate Option 5 further so as to understand all of the constraints involved with the installation of the outfall line down Church or South Margin Streets. We recommend this because this option may alleviate some problems of the downstream drainage ways. If after further investigation this option is not chosen, then we would recommend that Options 1 and 2 be chosen. These are listed in order of preference. We feel that the construction of the total drainage way improvements are a long-term solution and provide the desired result of reducing localized ponding/flooding in the Parkview area. This is not to say that this could not occur in phases where Option 2 could be constructed first, improvements to the downstream drainage ways be investigated, planned and budgeted for and then the remainder of the system be installed.

We trust this fully explains the situation. In accordance with your request, we will be prepared to present this to the Public Transportation Committee on Wednesday, May 10 at 6:00 p.m. Should you have any questions or comments before that time, we would be happy to respond to them.

Sincerely,

SMITH SECKMAN REID, INC.

Holman Waters

L. Holman Waters, Jr., P.E.

Enclosures

LHW/cg
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cc: SCL, JMW

OPINION OF PROBABLE COST
Parkview Drainage Improvements - Option I
New Storm System Under Columbia Pike - 10-Year Storm Event

1.	18" RCP - 450 LF @ 30/LF	$13,500.00
2.	24" RCP - 50 LF @ 34/LF	1,700.00
3.	24" CMP - 200 LF @ 30/LF	6,000.00
4.	30" CMP - 75 LF @ 40/LF	3,000.00
5.	36" RCP - 25 LF @ 57.5/LF	1,437.50
6.	36" CMP - 370 LF @ 47/LF	17,390.00
7.	42" RCP - 40 LF @ 73.5/LF	2,940.00
8.	42" CMP - 300 LF @ 57/LF	17,100.00
9.	48" RCP - 750 LF @ 90/LF	67,500.00
10.	54" RCP - 930 LF @ 110/LF	102,300.00
11.	Catchbasins w/Inlets - 40 EA @ 1200/EA	48,000.00
12.	Tunnel Columbia Avenue - 60 LF @ 500/LF	30,000.00
13.	Pavement Removal & Replacement - 1700 Sq. Yds. @ 30/Yds.	51,000.00
14.	Driveway Crossings - 8 EA @ 400 EA	3,200.00
15.	Property Restoration - Lump Sum	40,000.00
16.	Ditch Improvements - 700 LF @ 10/LF	7,000.00
		$412,067.50
	Plus 10% Contingencies	41,206.75
	Grand Total	$453,274.25

OPINION OF PROBABLE COST
Parkview Drainage Improvements - Option I
New Storm System Under Columbia Pike - 2-Year Storm Event

1.	18" RCP - 450 LF @ 30/LF	$13,500.00
2.	18" RCP - 130 LF @ 22/LF	2,860.00
3.	24" CMP - 70 LF @ 30/LF	2,100.00
4.	30" CMP - 30 LF @ 50/LF	1,500.00
5.	30" RCP - 215 LF @ 40/LF	8,600.00
6.	36" RCP - 25 LF @ 57.5/LF	1,437.50
7.	36" CMP - 370 LF @ 47/LF	17,390.00
8.	42" RCP - 370 LF @ 73.5/LF	27,195.00
9.	42" CMP - 45 LF @ 57/LF	2,565.00
10.	48" RCP - 1,200 LF @ 90/LF	108,000.00
11.	Catchbasins w/Inlets - 40 EA @ 1200/EA	48,000.00
12.	Tunnel Columbia Avenue - 60 LF @ 500/LF	30,000.00
13.	Pavement Removal & Replacement - 1700 Sq. Yds. @ 30/Yds.	51,000.00
14.	Driveway Crossings - 8 EA @ 400 EA	3,200.00
15.	Property Restoration - Lump Sum	40,000.00
16.	Ditch Improvements - 700 LF @ 10/LF	7,000.00
		$364,347.50
	Plus 10% Contingencies	36,434.75
	Grand Total	$400,782.25

OPINION OF PROBABLE COST

Parkview Drainage Improvements - Option II
Utilize Existing System under Columbia Pike
Install Partial Improvements in Parkview Area - 10-Year Storm Event

1.	18" RCP - 540 LF @ 30/LF	$ 16,200.00
2.	48" RCP - 440 LF @ 90/LF	39,600.00
3.	54" RCP - 1200 LF @ 110/LF	132,000.00
5.	Catch Basins w/Inlets - 20 @ 1200	24,000.00
6.	Flow Splitting Junction Boxes - 4 @ 8000	32,000.00
7.	Connect to Existing Catch Basins - 4 EA @ 800	3,200.00
8.	Pavement Removal & Replacement - 1800 Sq. Yds. @ 30	54,000.00
9.	Driveway Crossings - 6 EA @ 400	2,400.00
10.	Property Restoration	30,000.00
11.	Ditch Improvements - 700 LF @ 10/LF	7,000.00
		$340,400.00
	Plus 10% Contingencies	34,040.00
	Grand Total	$374,440.00

OPINION OF PROBABLE COST
Parkview Drainage Improvements - Option II
Utilize Existing System under Columbia Pike
Install Partial Improvements in Parkview Area - 2-Year Storm Event

---

1.	18" RCP - 540 LF @ 30/LF	$16,200.00
2.	42" RCP - 440 LF @ 73.5/LF	32,340.00
3.	42" CMP - 45 LF @ 57/LF	2,565.00
4.	48" RCP - 1200 LF @ 84/LF	100,800.00
5.	Catch Basins w/Inlets - 20 @ 1200	24,000.00
6.	Flow Splitting Junction Boxes - 4 @ 8000	32,000.00
7.	Connect to Existing Catch Basins - 4 EA @ 800	3,200.00
8.	Pavement Removal & Replacement - 1800 Sq. Yds. @ 30	54,000.00
9.	Driveway Crossings - 6 EA @ 400	2,400.00
10.	Property Restoration	30,000.00
11.	Ditch Improvements - 700 LF @ 10/LF	7,000.00
		$311,705.00
	Plus 10% Contingencies	31,170.50
	Grand Total	$342.875.50

OPINION OF PROBABLE COST
Parkview Drainage Improvements - Option V
New Storm System - Church Street to Harpeth River - 10-Year Storm Event

---

1.	18" RCP - 450 LF @ 30/LF	$13,500.00
2.	24" RCP - 50 LF @ 34/LF	1,700.00
3.	24" CMP - 200 LF @ 30/LF	6,000.00
4.	30" CMP - 75 LF @ 40/LF	3,000.00
5.	36" RCP - 25 LF @ 57.5/LF	1,437.50
6.	36" CMP - 370 LF @ 47/LF	17,390.00
7.	42" RCP - 40 LF @ 73.5/LF	2,940.00
8.	42" CMP - 300 LF @ 57/LF	17,100.00
9.	48" RCP - 750 LF @ 90/LF	67,500.00
10.	54" RCP - 4330 LF @ 110/LF	476,300.00
11.	Catchbasins w/Inlets - 40 EA @ 1200/EA	48,000.00
12.	Pavement Removal & Replacement - 1700 Sq. Yds. @ 30/Yds.	51,000.00
13.	Driveway Crossings - 8 EA @ 400 EA	3,200.00
14.	Property Restoration - Lump Sum	40,000.00
15.	Ditch Improvements - 700 LF @ 10/LF	7,000.00
		$756,067.50
	Plus 10% Contingencies	75,606.75
	Grand Total	$831,674.25


431
OPTION 5
OPTION 1 & 2
OPTION 4
OPTION 3
NASHVILLE
96
FRANKL
(BM 648 Nas
(647)

SCALE: 1" = 500'

Appendix B

Point Precipitation Frequency Estimates

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NOAA's National Weather Service
Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)

Home | Site Map | News | Organization | Search | NWS | All NOAA | Go

General Info
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- FAQ
- Glossary

Precipitation Frequency (PF)
- PF Data Server
- PF in GIS Format
- PF Maps
- Temporal Distr.
- Time Series Data
- PFDS Perform.
- PF Documents

Probable Maximum Precipitation (PMP)
- PMP Documents

Miscellaneous
- Publications
- AEP Storm Analysis
- Record Precipitation

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USA.gov

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: TN

DATA DESCRIPTION

Data type: precipitation depth **Units:** english **Time series type:** partial duration

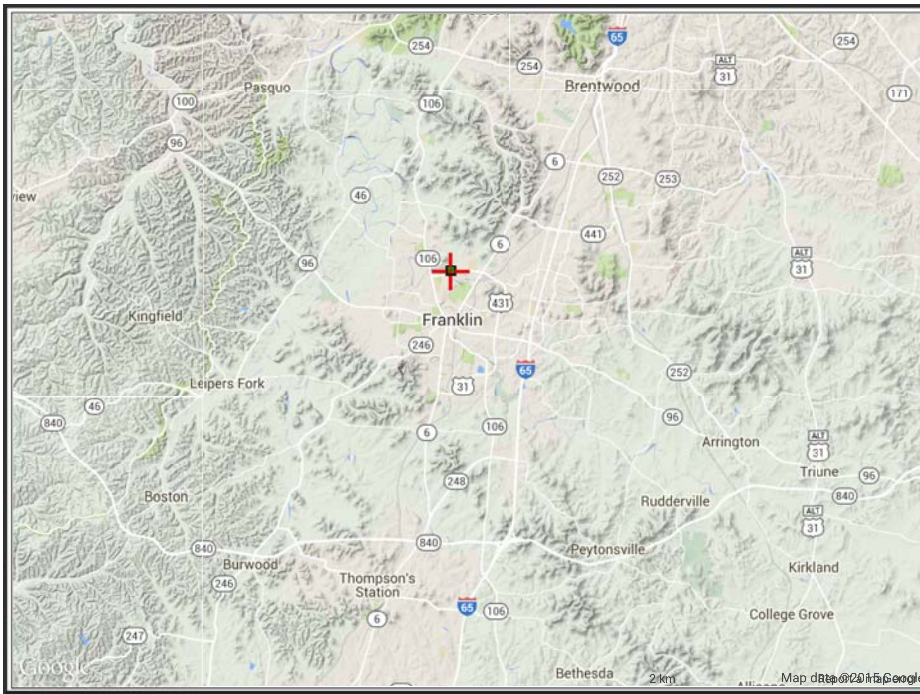
SELECT LOCATION

1. Manually:

a) **Enter location** (decimal degrees, use "-" for S and W): latitude: longitude: submit

b) **Select station** (click here for a list of stations used in frequency analysis for TN): select station

2. Use map:



a) Select location
(move crosshair or double click)
b) Click on station icon
(☑ show stations on map)

LOCATION INFORMATION:
Name: Franklin, Tennessee, US*
Latitude: 35.9475°
Longitude: -86.8703°
Elevation: 617 ft*

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 2, Version 3

PF tabular | PF graphical | Supplementary information | Print Page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.398 (0.369-0.432)	0.468 (0.434-0.509)	0.541 (0.500-0.589)	0.601 (0.555-0.653)	0.678 (0.621-0.737)	0.737 (0.671-0.800)	0.796 (0.720-0.865)	0.854 (0.766-0.930)	0.931 (0.824-1.02)	0.992 (0.869-1.09)
10-min	0.635 (0.589-0.690)	0.749 (0.694-0.815)	0.867 (0.801-0.944)	0.961 (0.887-1.05)	1.08 (0.990-1.17)	1.17 (1.07-1.27)	1.27 (1.14-1.38)	1.35 (1.22-1.48)	1.47 (1.30-1.61)	1.56 (1.37-1.71)
15-min	0.794 (0.737-0.862)	0.941 (0.872-1.02)	1.10 (1.01-1.19)	1.22 (1.12-1.32)	1.37 (1.26-1.49)	1.49 (1.35-1.61)	1.60 (1.45-1.74)	1.71 (1.53-1.86)	1.85 (1.64-2.02)	1.96 (1.72-2.15)
30-min	1.09 (1.01-1.18)	1.30 (1.20-1.42)	1.56 (1.44-1.70)	1.76 (1.63-1.92)	2.03 (1.86-2.21)	2.24 (2.04-2.43)	2.45 (2.21-2.66)	2.66 (2.39-2.90)	2.95 (2.61-3.22)	3.17 (2.78-3.48)
60-min	1.36 (1.26-1.47)	1.63 (1.51-1.78)	2.00 (1.85-2.17)	2.29 (2.12-2.49)	2.70 (2.48-2.94)	3.03 (2.76-3.29)	3.37 (3.05-3.67)	3.73 (3.35-4.06)	4.23 (3.75-4.62)	4.63 (4.06-5.08)
2-hr	1.59 (1.47-1.73)	1.91 (1.76-2.08)	2.33 (2.15-2.53)	2.67 (2.46-2.91)	3.15 (2.88-3.42)	3.54 (3.21-3.85)	3.94 (3.55-4.29)	4.37 (3.91-4.76)	4.97 (4.38-5.43)	5.46 (4.76-5.99)
3-hr	1.73 (1.60-1.89)	2.07 (1.91-2.26)	2.52 (2.33-2.75)	2.90 (2.66-3.16)	3.41 (3.12-3.71)	3.84 (3.48-4.18)	4.28 (3.86-4.66)	4.75 (4.24-5.18)	5.41 (4.76-5.91)	5.94 (5.17-6.51)
6-hr	2.12 (1.95-2.32)	2.53 (2.33-2.77)	3.07 (2.82-3.37)	3.52 (3.23-3.86)	4.16 (3.78-4.56)	4.69 (4.23-5.13)	5.24 (4.69-5.74)	5.83 (5.17-6.40)	6.66 (5.82-7.33)	7.34 (6.34-8.10)
12-hr	2.53 (2.34-2.76)	3.02 (2.79-3.29)	3.67 (3.38-4.00)	4.20 (3.86-4.58)	4.95 (4.52-5.40)	5.57 (5.05-6.06)	6.22 (5.59-6.77)	6.91 (6.16-7.53)	7.87 (6.91-8.60)	8.64 (7.51-9.49)
24-hr	3.08 (2.89-3.30)	3.68 (3.45-3.95)	4.48 (4.20-4.80)	5.13 (4.80-5.49)	6.03 (5.62-6.46)	6.76 (6.28-7.23)	7.52 (6.95-8.04)	8.30 (7.64-8.87)	9.39 (8.58-10.0)	10.3 (9.31-11.0)
2-day	3.65 (3.43-3.89)	4.36 (4.10-4.65)	5.32 (5.01-5.69)	6.11 (5.75-6.52)	7.22 (6.76-7.69)	8.11 (7.57-8.64)	9.06 (8.41-9.64)	10.0 (9.27-10.7)	11.4 (10.5-12.2)	12.5 (11.4-13.4)

3-day	**3.88** (3.65-4.13)	**4.63** (4.37-4.94)	**5.65** (5.32-6.01)	**6.46** (6.08-6.87)	**7.59** (7.12-8.07)	**8.50** (7.95-9.03)	**9.45** (8.79-10.0)	**10.4** (9.65-11.1)	**11.8** (10.8-12.5)	**12.9** (11.7-13.7)
4-day	**4.11** (3.88-4.37)	**4.91** (4.64-5.22)	**5.97** (5.64-6.34)	**6.81** (6.42-7.23)	**7.96** (7.48-8.44)	**8.89** (8.33-9.41)	**9.83** (9.16-10.4)	**10.8** (10.0-11.4)	**12.1** (11.2-12.9)	**13.2** (12.1-14.0)
7-day	**4.86** (4.61-5.15)	**5.80** (5.50-6.14)	**7.05** (6.67-7.46)	**8.05** (7.61-8.51)	**9.44** (8.89-9.97)	**10.6** (9.90-11.1)	**11.7** (10.9-12.4)	**12.9** (12.0-13.7)	**14.6** (13.4-15.5)	**15.9** (14.6-16.9)
10-day	**5.56** (5.28-5.86)	**6.61** (6.29-6.97)	**7.96** (7.56-8.38)	**9.01** (8.55-9.49)	**10.4** (9.89-11.0)	**11.6** (10.9-12.2)	**12.7** (12.0-13.4)	**13.9** (13.0-14.7)	**15.5** (14.4-16.4)	**16.7** (15.4-17.7)
20-day	**7.57** (7.22-7.95)	**8.96** (8.55-9.41)	**10.6** (10.1-11.1)	**11.8** (11.2-12.3)	**13.3** (12.7-14.0)	**14.5** (13.8-15.2)	**15.7** (14.8-16.4)	**16.8** (15.8-17.6)	**18.2** (17.1-19.2)	**19.3** (18.0-20.4)
30-day	**9.29** (8.88-9.71)	**10.9** (10.5-11.4)	**12.7** (12.2-13.3)	**14.1** (13.5-14.7)	**15.9** (15.1-16.6)	**17.2** (16.3-18.0)	**18.5** (17.5-19.3)	**19.7** (18.7-20.7)	**21.4** (20.1-22.4)	**22.6** (21.2-23.7)
45-day	**11.7** (11.2-12.2)	**13.7** (13.1-14.3)	**15.8** (15.1-16.4)	**17.3** (16.5-18.0)	**19.3** (18.4-20.1)	**20.7** (19.8-21.6)	**22.1** (21.1-23.1)	**23.5** (22.3-24.5)	**25.2** (23.8-26.4)	**26.4** (24.9-27.7)
60-day	**14.1** (13.5-14.7)	**16.5** (15.8-17.2)	**18.9** (18.1-19.7)	**20.6** (19.7-21.5)	**22.8** (21.8-23.8)	**24.3** (23.2-25.4)	**25.8** (24.6-27.0)	**27.1** (25.8-28.4)	**28.8** (27.3-30.2)	**30.0** (28.4-31.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in csv format: precipitation frequency estimates Submit

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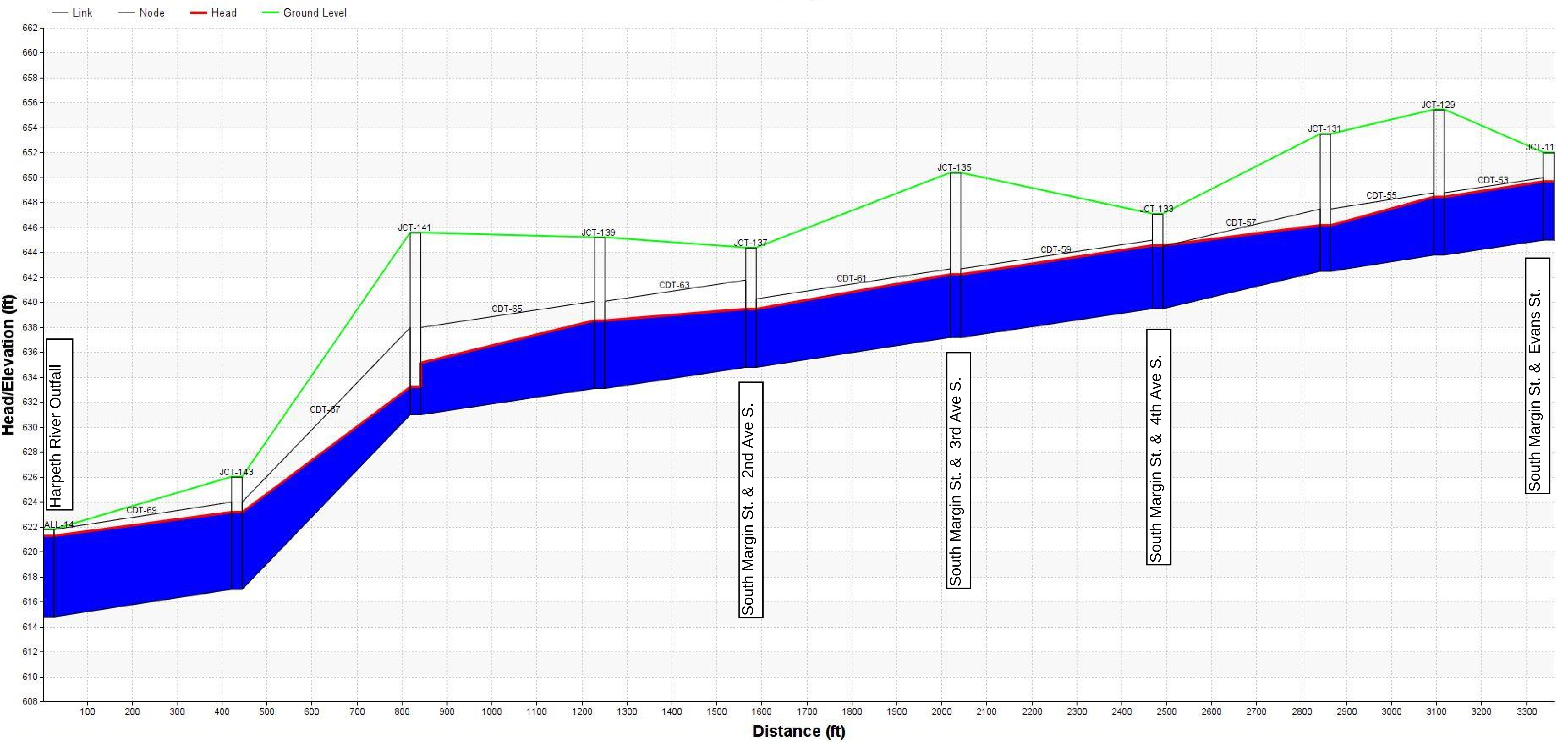
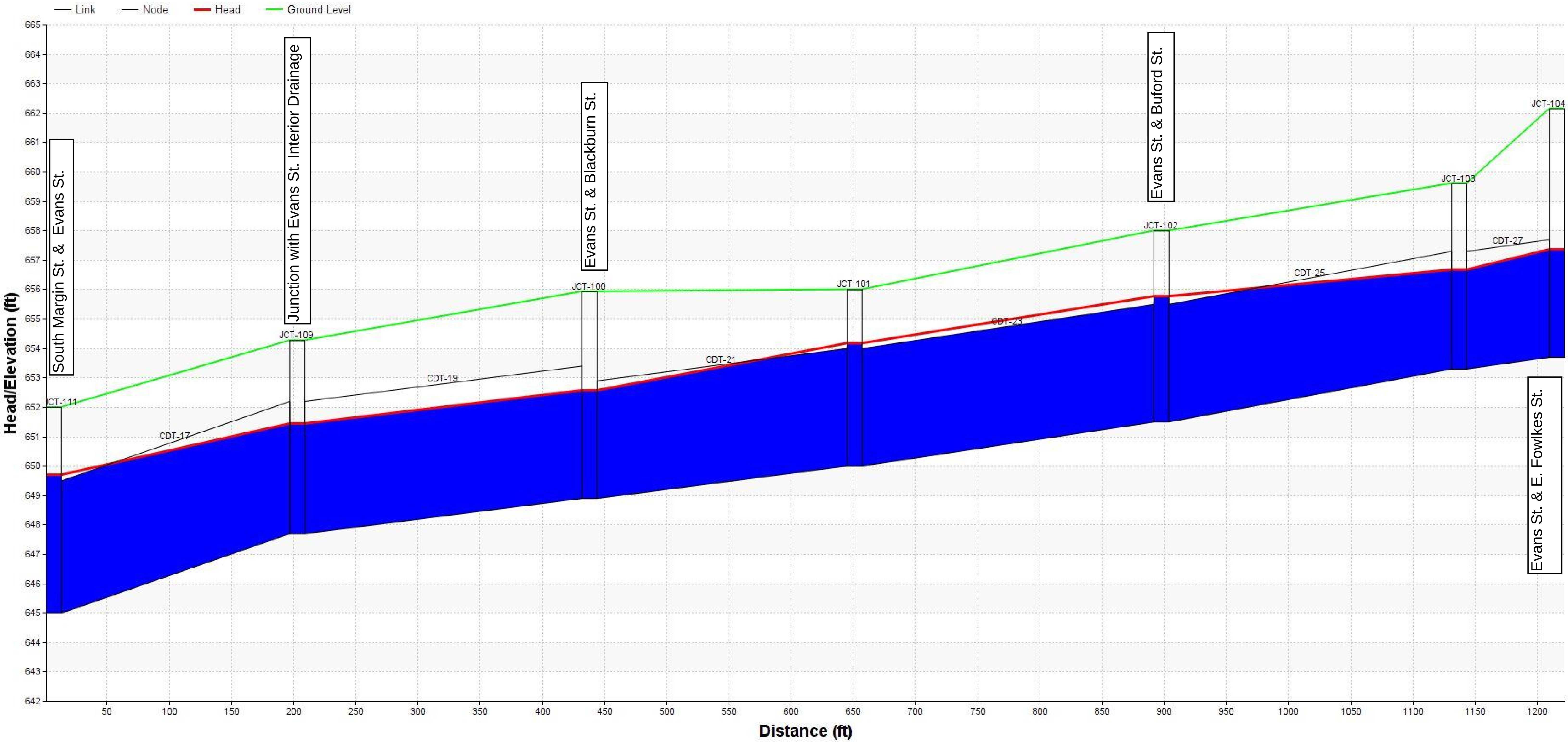
Appendix C

10-Year Storm Sewer Simulation Results

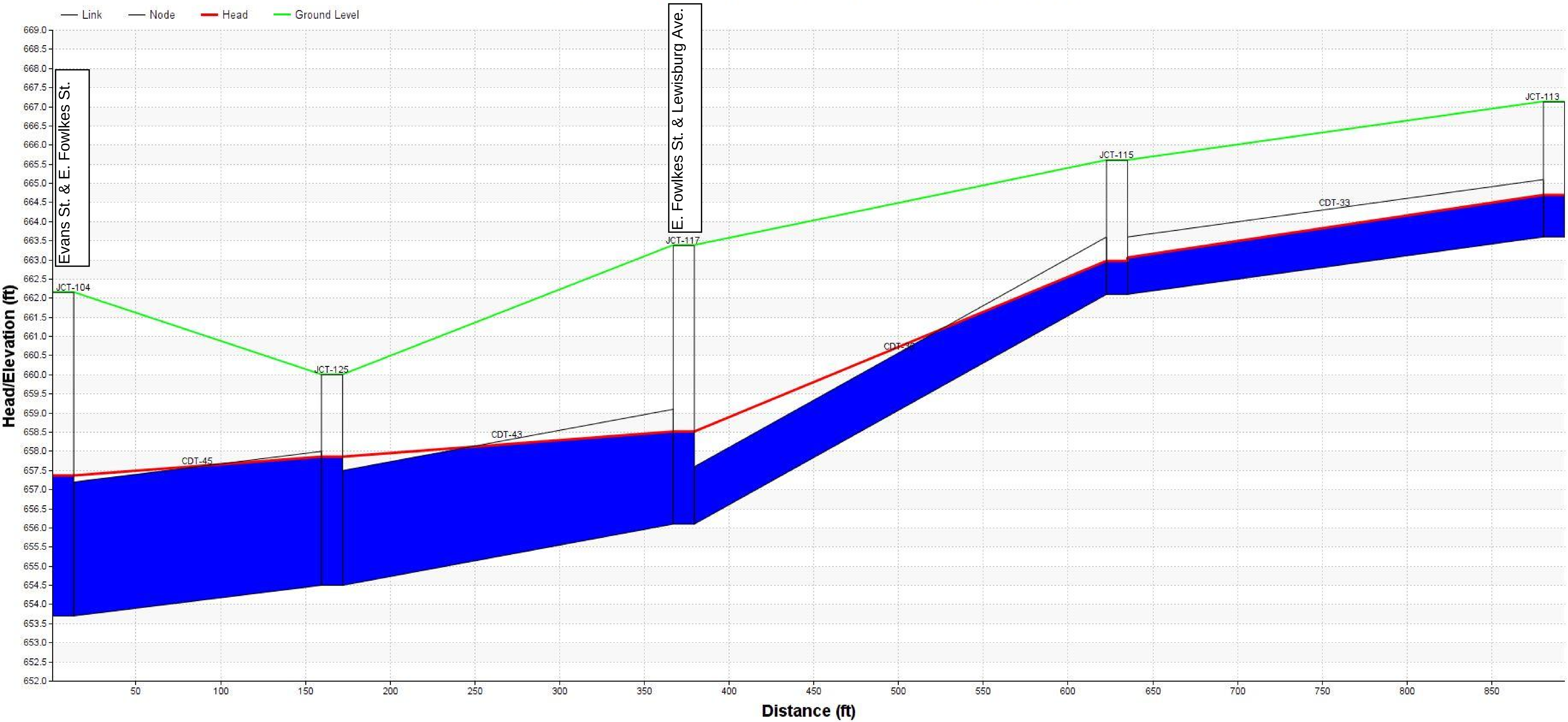
South Margin Street



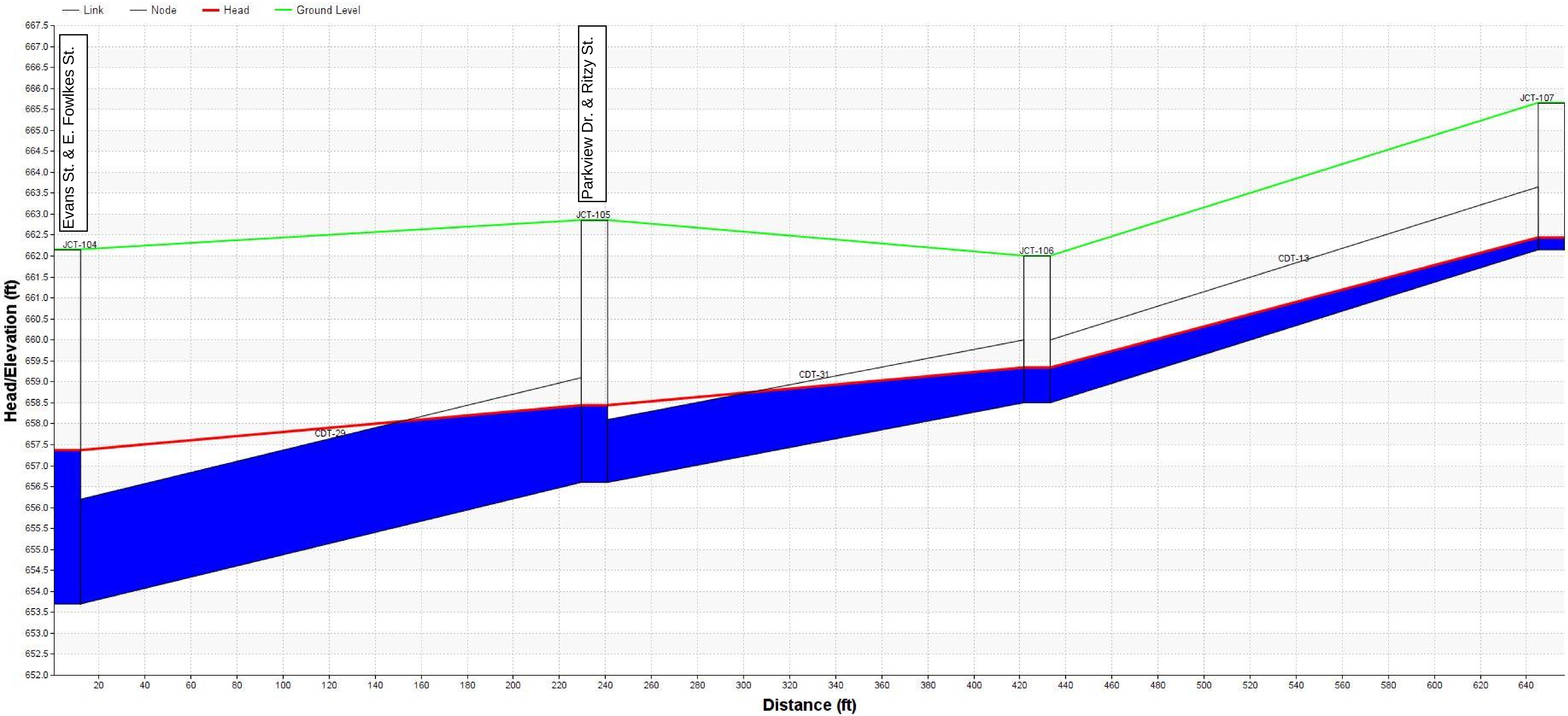
Evans Street



Lewisburg Avenue to East Fowlkes Street



Parkview Drive



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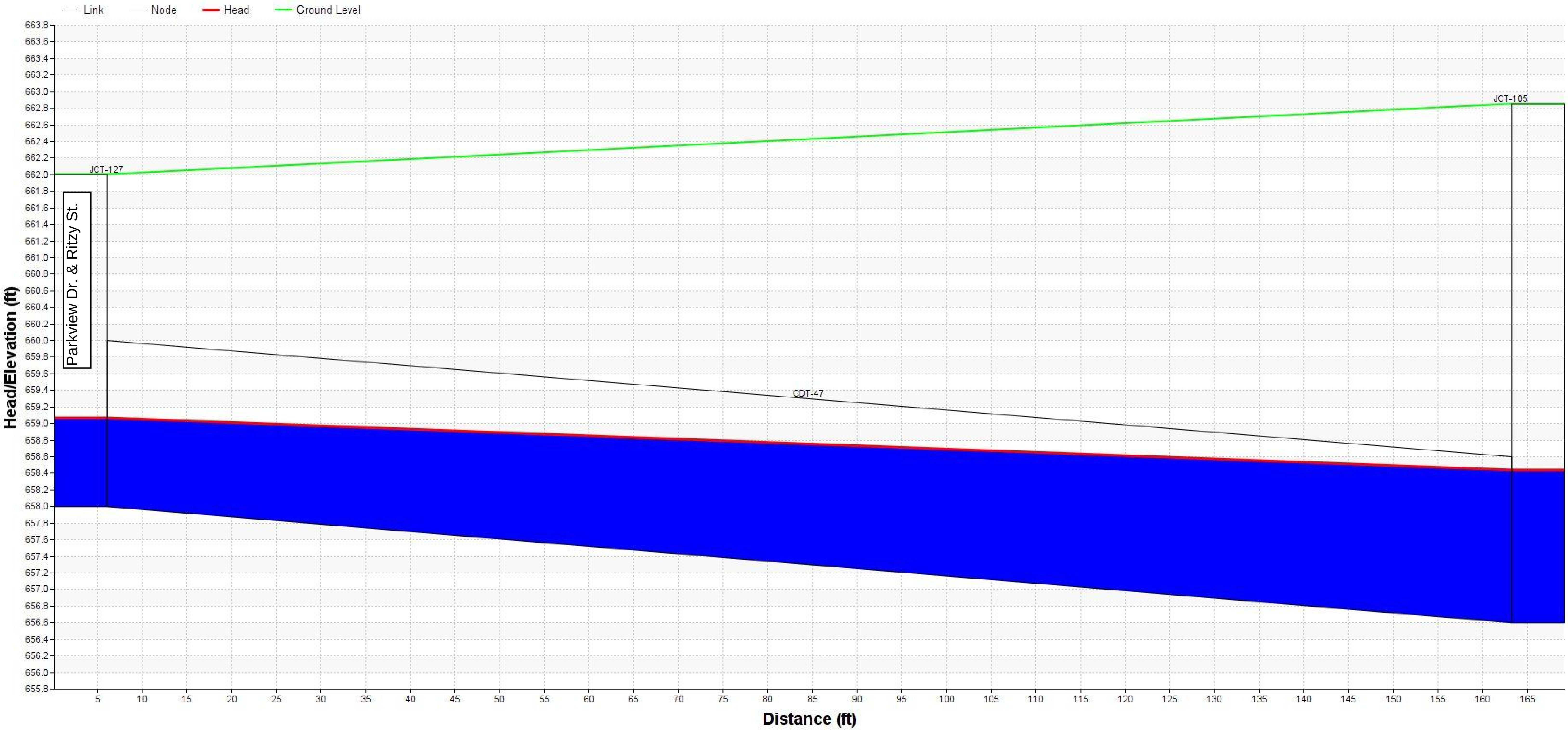
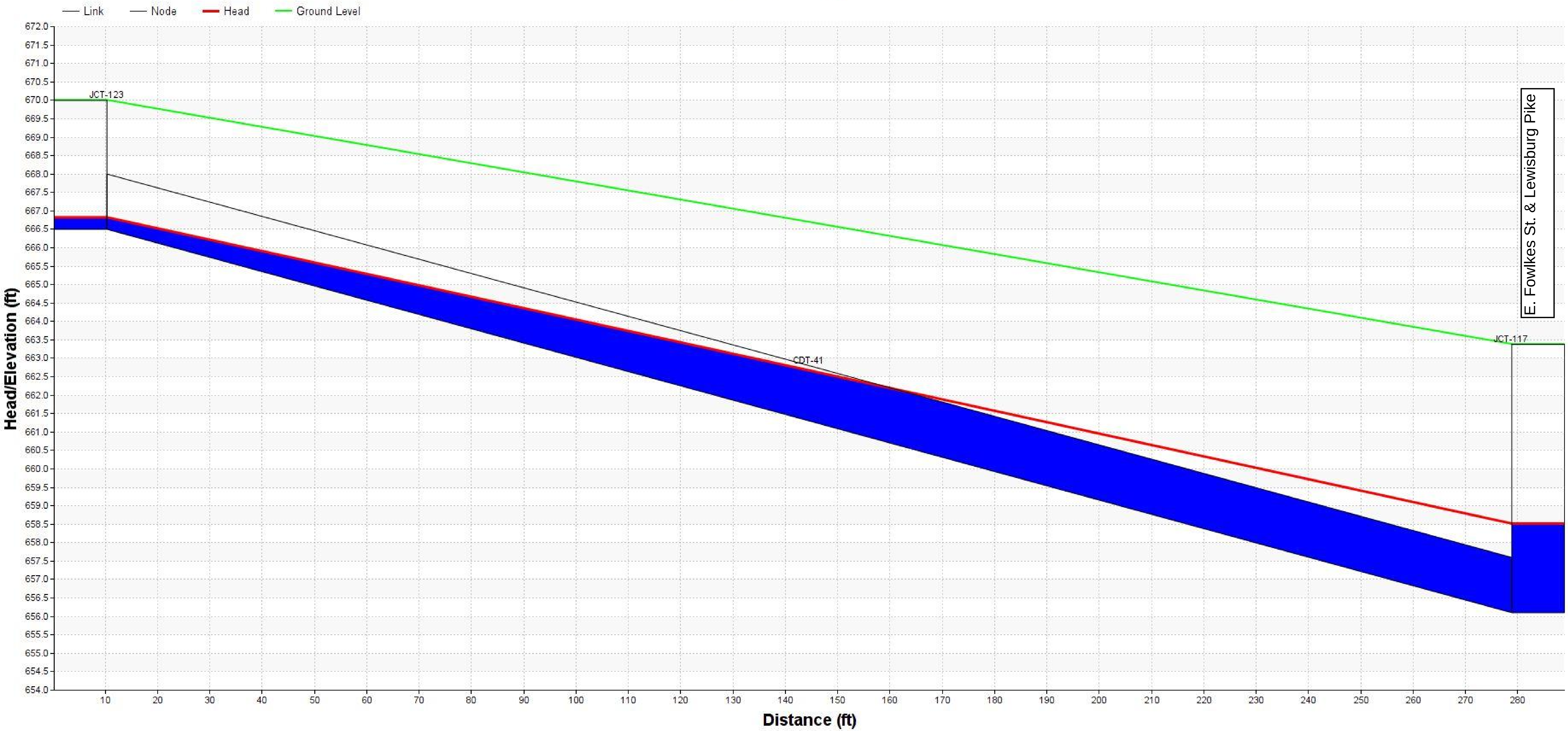
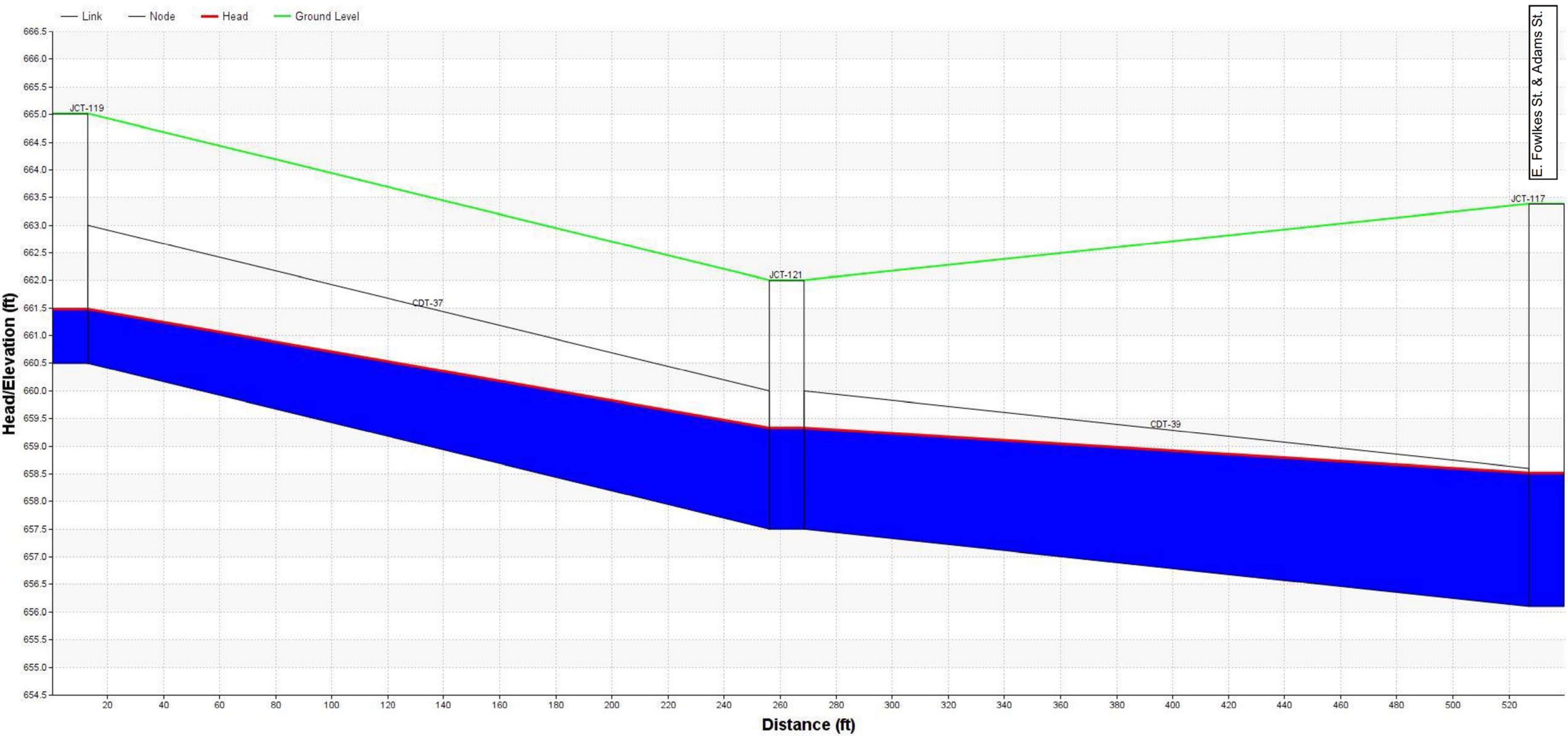
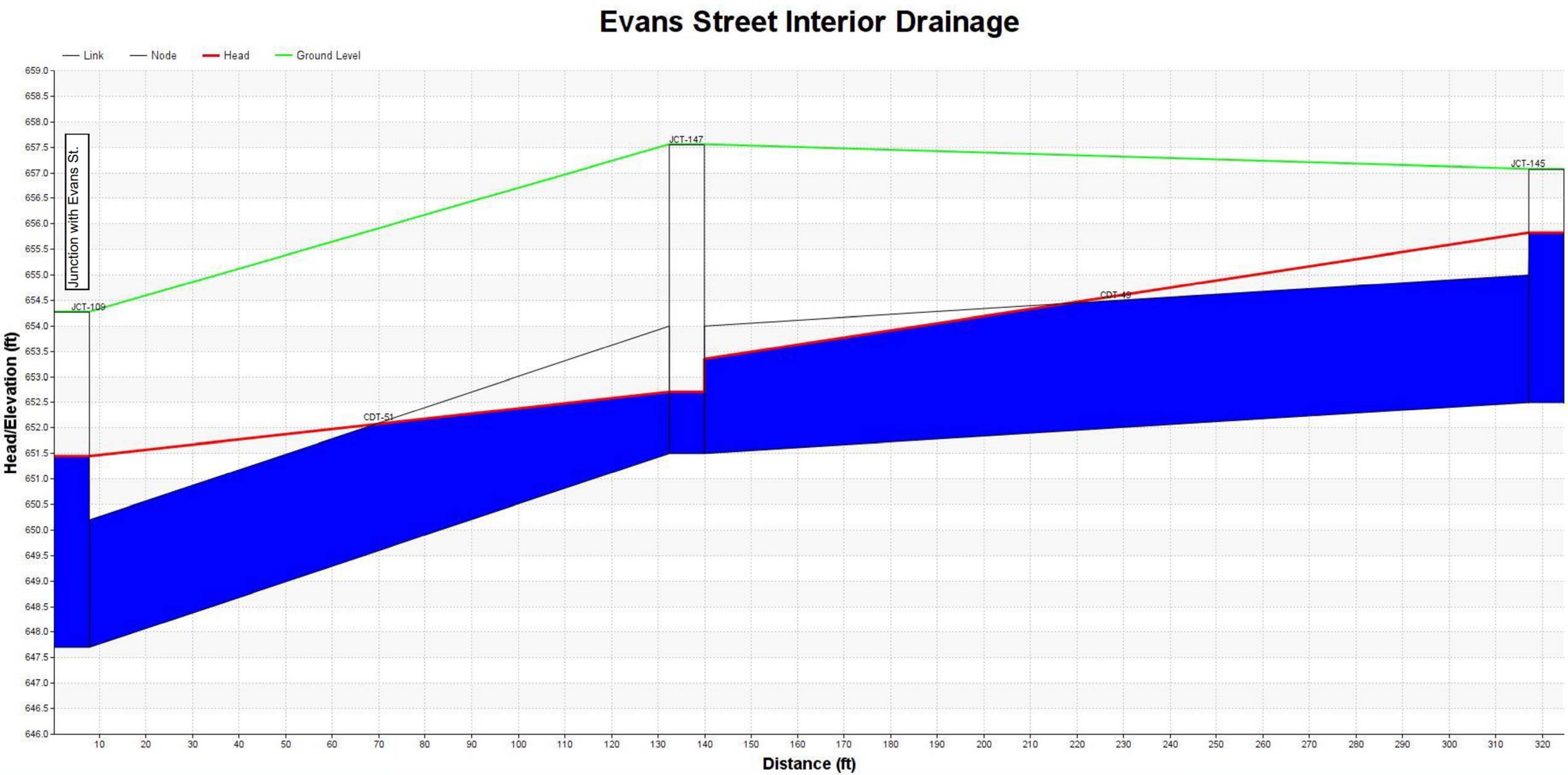


Lewisburg Pike



Adams Street




Evans Street Interior Drainage
Link
Node
Head
Ground Level
Junction with Evans St.
JCT-109
CDT-51
JCT-147
CDT-49
JCT-145
Head/Elevation (ft)
Distance (ft)