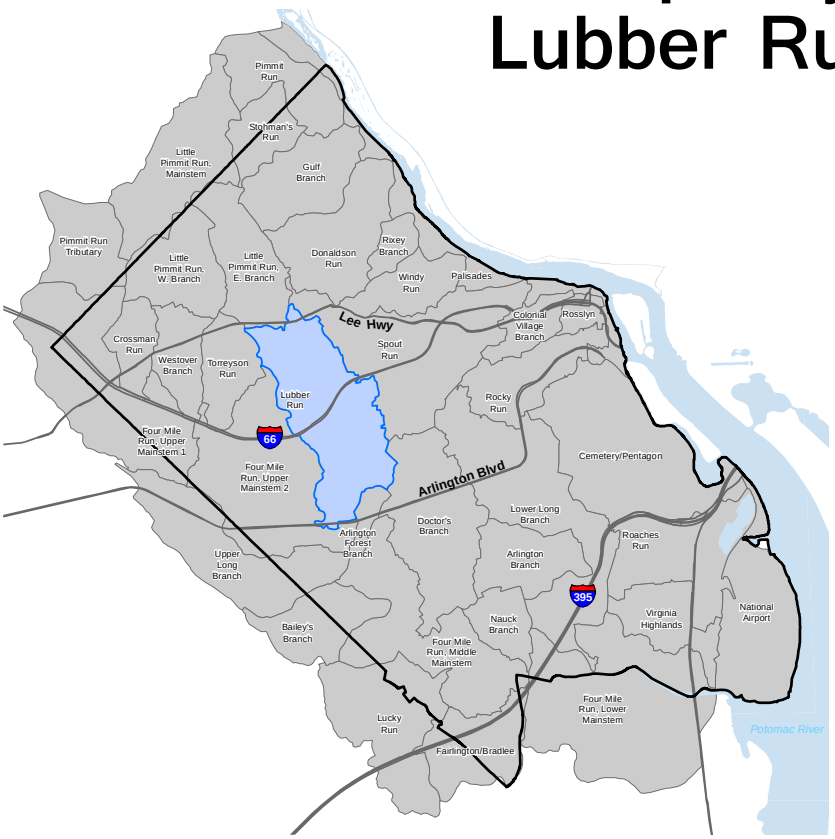
Stormwater Capacity Analysis for Lubber Run Watershed



Prepared for

Arlington County, Virginia

January 23, 2013

CH2MHILL®

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Chantilly, VA 20151

Stormwater Capacity Analysis for Lubber Run Watershed: Contents

This capacity analysis comprises the material below. Earlier technical memorandums—on GIS data gaps and stormwater capacity, for example—were presented as appendixes to subsequent memorandums; the outline below shows the relationship among the watershed-specific memorandums.

Design Iterations

Stormwater Capacity Analysis for Lubber Run Watershed: Design Iterations, Arlington County, Virginia

PREPARED FOR: Arlington County, Virginia

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DATE: January 23, 2013

PROJECT NUMBER: 240033.T5.LR.04.01

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Appendixes

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Executive Summary

The purpose of this project is to provide a program that will analyze storm sewer capacity issues, identify problem areas, develop and prioritize solutions, and provide support for public outreach and education. The project is being implemented in phases by watershed.

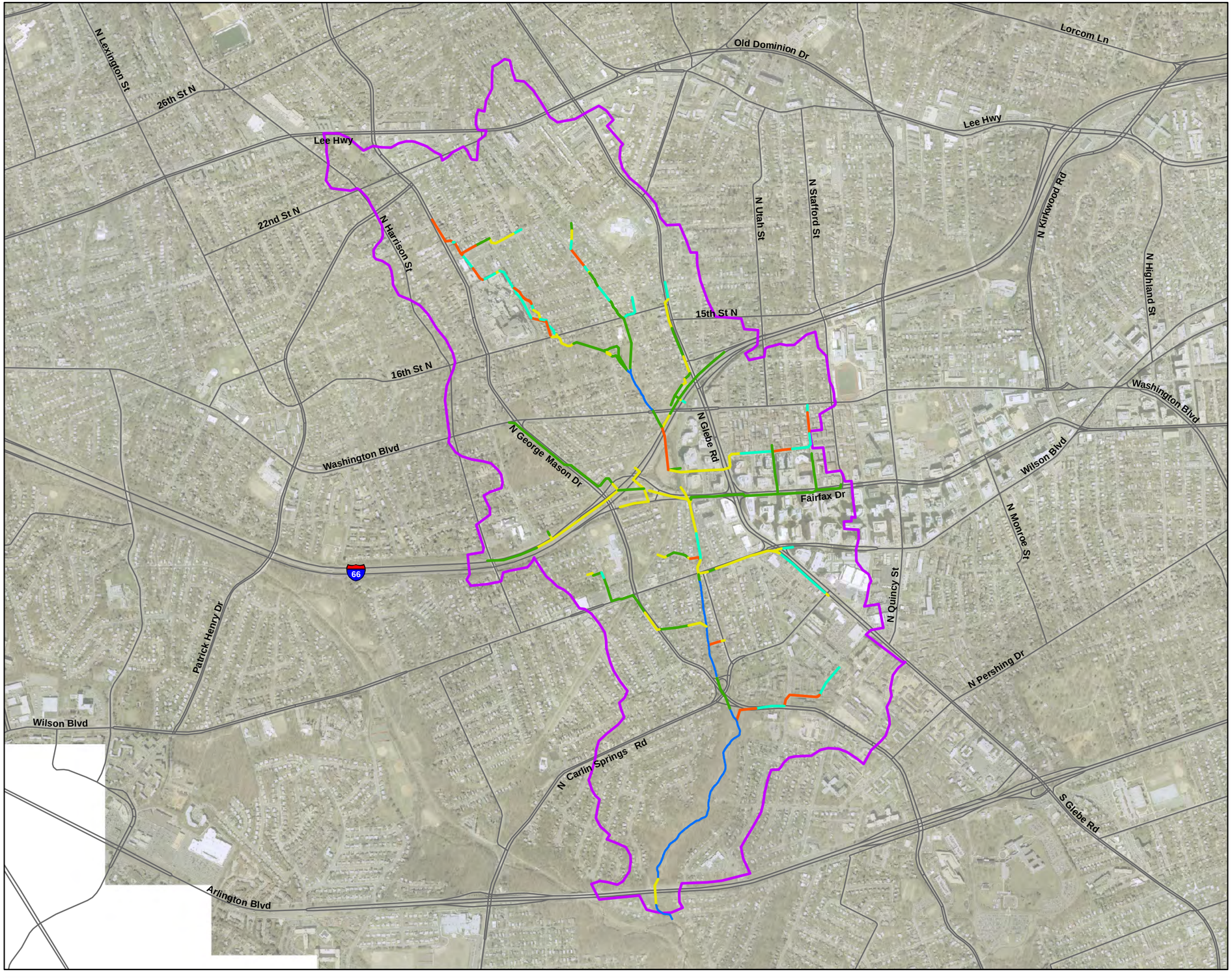
This technical memorandum (TM) focuses on the development of design solutions for the Lubber Run watershed. It summarizes the County's existing storm sewer system and the hydraulic model developed in Task 2, and describes the technical approach to and results from the design iteration model runs.

The hydraulic model developed in Task 2 of this project predicts that approximately 59 percent of the Lubber Run watershed system is experiencing capacity limitations during the June 2006 storm event, and approximately 90 percent is experiencing capacity limitations during the 10-year, 24-hour (10yr-24hr) SCS Type II storm. Plan views of the conduits experiencing capacity limitations are provided in **Figure 1** and Figure **2**.

The objective of this portion of the study is to identify design solutions to eliminate flooding in the model for these two storm events. This is accomplished by iteratively adjusting the capacity of the system as needed, including adding additional barrels of the same diameters alongside existing pipes, adding parallel pipe systems of differing sizes, increasing existing pipe diameters, and then running the hydraulic model. When a parallel pipe is added, all hydraulic parameters except for size match the existing pipe.

The solution identified to eliminate flooding during the June 2006 event requires adding additional capacity to 5,565 linear feet (LF) of pipe in Lubber Run. This equates to approximately 14 percent of the modeled system. The changes required to eliminate flooding during the 10yr-24hr SCS Type II storm are more extensive. The final solution identified during the 10yr-24hr SCS Type II storm requires changes to approximately 18,494 LF of pipe. These changes affect approximately 45 percent of the modeled system in Lubber Run.

The hydraulic modeling results presented in this TM should be reviewed with the understanding that flooding was alleviated by adding conveyance capacity as described above (see **Figure 5** and **Figure 19**) and that the results presented are from a modeling perspective only. While flooding was eliminated from the model, practically, the risk of flooding is never completely eliminated. All of the assumptions should be verified and adjusted as necessary during the design phase. All other parameters (e.g., slope, inverts, losses, and storage nodes) were left unaltered from the hydraulic model developed in Task 2, except as described in Section 2.3



VICINITY MAP

Legend

- Flooded
- Insufficient Freeboard
- Surcharged
- Sufficient Conveyance Capacity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 1
June 2006 Storm
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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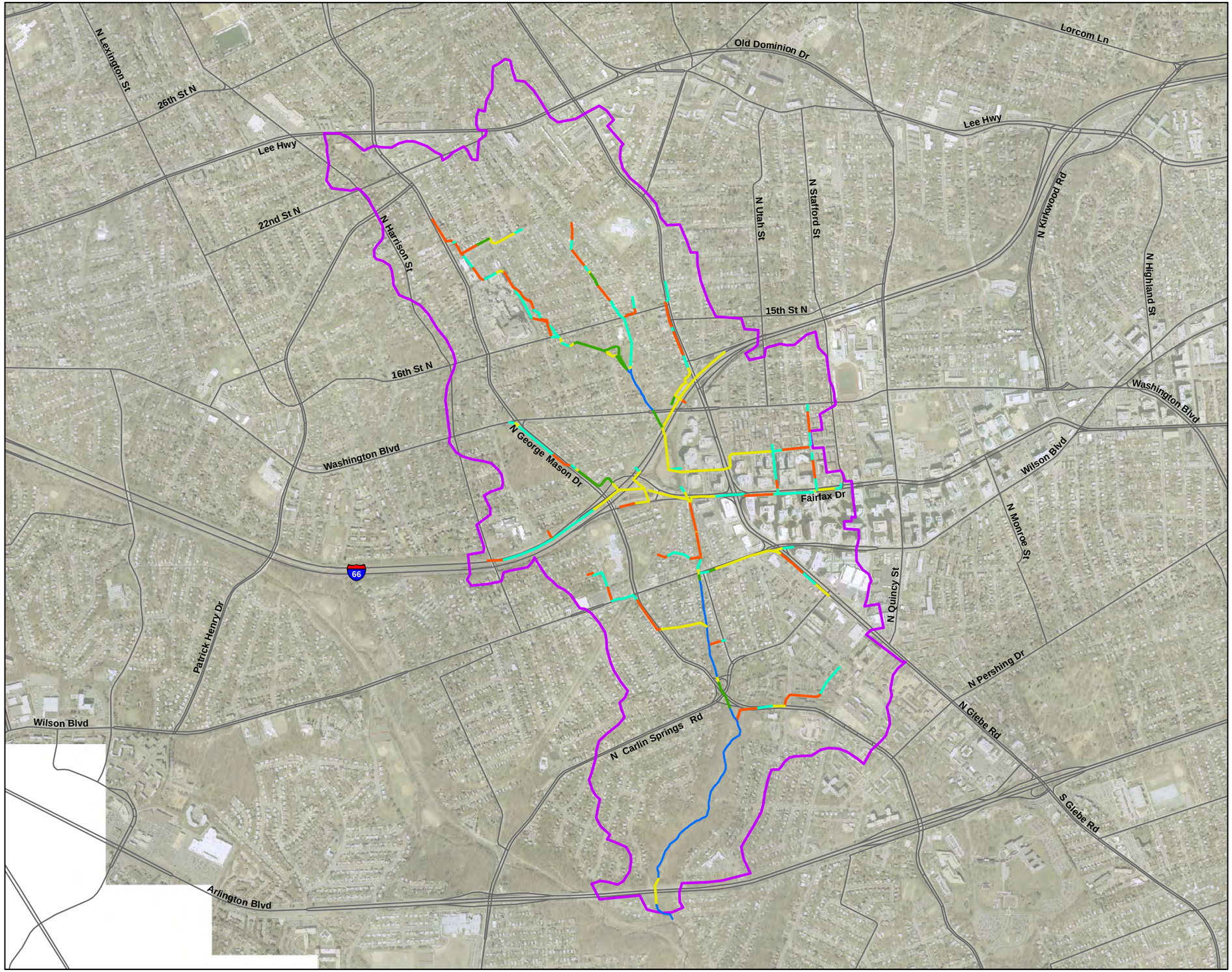

VICINITY MAP

Legend

- Flooded
- Insufficient Freeboard
- Surcharged
- Sufficient Conveyance Capcity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 2
10-yr 24-hr Storm
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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1 Introduction and Project Objectives

The work described in this TM is one of the elements of a storm sewer capacity analysis project. In discussions with representatives from Arlington County, it is understood that the County is undertaking a larger effort to update and combine the 1996 Storm Water Master Plan and the 2001 Watershed Management Plan. This TM addresses the final task (Task 4) of suggesting design solutions to the capacity problems previously identified in the modeling in Task 2 of the overall project.

2 Background

2.1 Existing System Versus Modeled System

The stormwater collection system elements include the following:

- Closed conduits, such as gravity sewers and culverts
- Stream channel segments
- Drainage inlets and junctions, such as roadside curb inlets, manholes, catchbasins, and yard and grate inlets

Elements of the ArcGIS existing stormwater collection system and the corresponding stormwater model developed for the Lubber Run watershed are summarized in **Table 1**. The modeling effort includes the storm sewer network of pipes 36 inches in diameter and larger. The table reflects updated GIS information provided by the County in March 2012. This is discussed in greater detail in Section 2.2.

TABLE 1
Comparison of Existing Lubber Run Stormwater System and Modeled System

Stormwater System Element	Existing	Modeled
Drainage area (acres)	1,015	1,029
Number of conveyance segments in stormwater system[a]	1,968	331
Total length of conveyance segments in stormwater system (linear feet)[b]	141,706	40,666
Size range (inches)[c]	4–96	36–96
Number of circular pipe segments	1,840	252
Number of noncircular pipe segments	61	56
Length of stream channel segments (linear feet)	9117	5,505
Length of ditch segments (linear feet)	778	0

TABLE 1 (CONTINUED)
Comparison of Existing Lubber Run Stormwater System and Modeled System

Stormwater System Element	Existing	Modeled
Total inlets/junctions/end points (model nodes)	1983	327
Catchbasins	800	50
Manholes	652	179
Yard inlets	44	6
Grate inlets	248	26
End walls	52	8
Junction chambers	69	54
Detention outlets	64	2
Best management practices (BMPs)	0	0
Unknown types of nodes	54	0
"Dummy"	0	2

[a] Segments include circular pipes, box culverts, elliptical pipes, ditches, and streams.
[b] Includes streams and ditches.
[c] Modeling scope is limited to stormwater conveyance system pipes 36 inches in diameter and larger. Smaller-diameter pipes are included only if they convey flows from pipes 36 inches in diameter and larger.

Figure 3 shows the existing stormwater collection system in the Lubber Run watershed; **Figure 4** shows the modeled system.

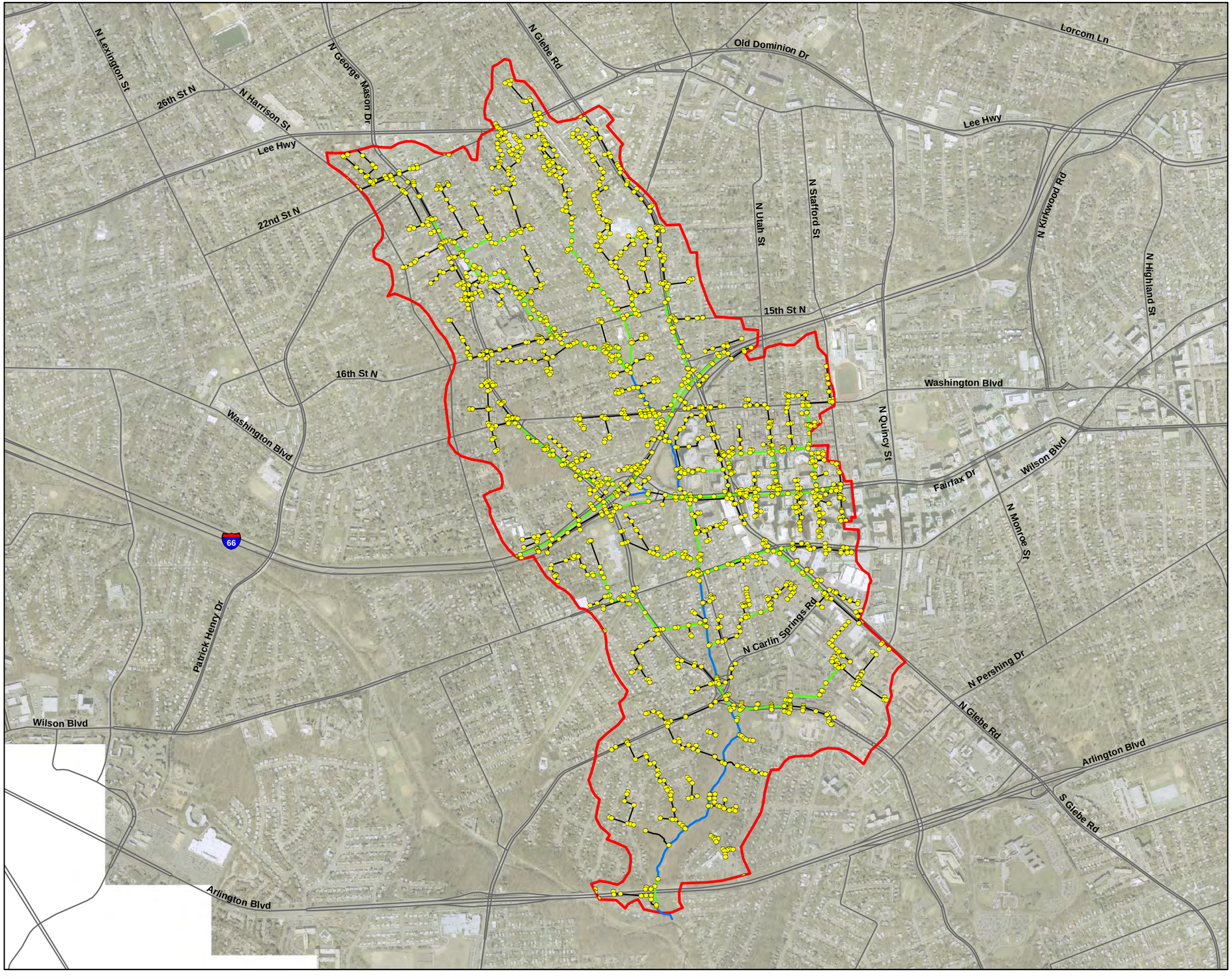
2.2 Data Sources and Review

Arlington County provided storm drainage network data in ESRI ArcGIS format, as-built drawings, and initial base layers (GIS shapefiles); the final ArcGIS PGDB (personal geodatabase) was delivered to CH2M HILL in November 2010.

The final data for the Lubber Run watershed model were evaluated for quality. CH2M HILL found 193 nodes and 196 links with data gaps or anomalies. A data gaps TM detailing the suggested assumptions to fill in the gaps was prepared for the County in November 2010 and is included as an appendix to the Task 2 TM (which is itself included as **Appendix A** here).

Updated GIS information was provided by the County in March 2012. This information was incorporated into the design solutions modeling effort where appropriate and as documented in **Appendix B**. Information for new conduits less than 36 inches in diameter was used to add additional storage to storage nodes.

Updated contour data were provided by the County in September 2012. An analysis was conducted to determine the differences between the rim elevations originally used in the model and new rim elevations based on the newly provided contour data. Rim elevations that differed by more than 2 feet were reviewed and revised as appropriate. This information is documented in **Appendix B.**



VICINITY MAP

Legend

- Stormwater Junctions
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"
- Streams
- Roads
- Original Watershed Boundary

N

0 700 1,400
Feet

FIGURE 3
Existing Stormwater Collection System
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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\\ORION\PROJ\ARLINGTONVACOUNTYOF\392309STORMWATERCAP\WSLUBBERRUN\WORKINGGIS\LAYOUT\DESIGN_ITERATIONS\FIGURE3_EXISTING_STORMWATER_COLLECTION_SYSTEM.MXD FCAIN 12/19/2012 9:21:40 AM

VICINITY MAP

Legend

- Modeled Stormwater Junctions
- Modeled Stormwater Mains ≥ 36"
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 4
Modeled Stormwater Collection System
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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2.3 Hydrologic and Hydraulic Modeling

The hydrologic modeling task includes several steps: defining subwatershed boundaries, identifying hydrologic node connections, estimating hydrologic parameters for each subwatershed, and identifying rainfall distributions to analyze. ArcHydro Tools 9.2 and HEC-GeoHMS were used to delineate the subwatersheds and determine hydrologic parameters. The County chose two events for these modeling activities: the June 2006 storm event and the 10yr-24hr SCS Type II distribution.

The hydraulic modeling task includes three steps: (1) importing the stormwater network and physical data into PCSWMM version 2011, the stormwater management model selected for this project; (2) defining the boundary conditions for each hydrologic scenario; and (3) evaluating the hydraulic performance of the stormwater drainage system for the two storm event scenarios. **Figure 1** and **Figure 2** identify the areas from the Task 2 capacity analysis TM (**Appendix A**) where there was flooding in the June 2006 storm and the SCS Type II 10yr-24hr storm, respectively.

3 Technical Approach

The model developed during Task 2 using the methodology described in Section 2.3 served as the basis for the iterative design modeling described in this TM. Design iterations were run for the June 2006 and the 10yr-24hr SCS Type II storms. The goal of Task 4 is to eliminate all flooding and rim conditions in the existing conditions model, but not necessarily insufficient freeboard (less than 1 foot of separation between the ground elevation and the hydraulic grade line, or HGL) or surcharge conditions. The general objective is to strategically add additional barrels or parallel pipes to the existing system. For convention, adding an additional barrel is adding an identical conduit (identical for every parameter: diameter, slope, etc.); adding a parallel pipe is adding a conduit that differs from the existing system, typically by having a different size or other parameter, such as slope. The following approach was used to optimize the capacity needed to eliminate system flooding:

1. Start with the base model that includes storage in the most-upstream nodes as developed in the Task 2 capacity analysis. It is assumed that capacity issues in the minor systems will be addressed and that the flows entering the modeled system should remain as currently modeled.
2. Add pipe barrels (identical conduits). For reconstructing existing sewer systems, it is often easier to expand a system either vertically or horizontally. Arlington County has requested that we first consider horizontal expansion by adding an additional barrel or parallel pipe to increase conveyance of the existing system. Pipe barrels were added according to the following:
   - Connect additional barrels to existing manhole structures. Start with an equivalent diameter in the flooded area. Match existing inverts to ensure hydraulic continuity at the downstream end of each modified section. If multiple barrels already exist, the lowest invert should be used for any added barrels.
   - If too little or too much capacity is provided by the additional barrel, change the additional barrel to a parallel conduit and increase or decrease the diameter as

needed. Avoid altering the existing system. If the diameter of the parallel conduit required is 12 inches or smaller, then increasing the existing system diameter may be considered instead.

- Do not add additional model nodes unless absolutely necessary.

3. Begin adding pipe barrels/parallel conduits immediately downstream of a flooded node or conduit and work upstream. Try not to exceed the diameter of the most downstream conduit. Try to minimize diameter changes and work only as far upstream as needed for the flooded segment.
4. Do not be concerned about minimum cover beyond a minimum of at least 3 inches. However, do check pipe daylighting; make a round pipe rectangular as needed. As pipe size is increased, examine any downstream stream cross sections to ensure no flow is lost; if it is, consider extending the cross-section geometry based on contours.

4 Results

4.1 PCSWMM Terminology

PCSWMM displays some information on its profile graphics depending how much space is available on the profile. For example, the date and time will not always appear on longer lengths of network because there is more information that is needed to be displayed. The following list is terminology that PCSWMM uses to label the profiles seen below:

- Number displayed at the top of the figure: conduit identification number (Conduit ID)
- Number displayed at the bottom of the figure: junction identification number (Junction ID)
- Red dot at junction rim: signifies flooding at a node in the existing model.
- Number directly below pipe segments: diameter in feet followed by number of barrels in parentheses
- Vertical axis provided in feet based on NAVD88 datum
- Horizontal axis provided in feet
- Index map: blue highlighted pipe segment on index map is displayed in profile view

Sewer system profiles were generated as a result of the iterative modeling and include profiles of the existing system, the final model design solution, and in some cases a final model design parallel solution. **Table 2** and **Table 3** provide the final model flow rates. These flow rates sum the final and parallel systems.

The pipe flow depth information provided in **Table 2** and **Table 3** represents maximum flow depths reported by the model. The corresponding figures are graphical representations of approximate flow depths; therefore, refer to the tables for the most precise information.

4.2 June 2006 Event

For the June 2006 event, capacity was added to 52 conduits (5,565 LF of pipe in total). This equates to 14 percent of the modeled pipe network in Lubber Run.

Changes to diameter and the existing and resulting flows are summarized in **Table 2**. A map showing the June 2006 storm upgrade locations throughout the watershed is included in **Figure 5.** Profiles showing the existing conditions and final results are shown in **Figure 6** through **Figure 18**. Profiles were displayed only for segments of the stormwater network where any of the following conditions were met:

- Pipe size was increased
- An identical barrel was added to the system
- An additional pipe was added to the system

The existing model profile depicts the peak water surface elevation with solid blue fill and peak HGL with a dark blue line. The HGL represents the sum of the pressure head and the elevation head along the profile. Flooded nodes in the existing conditions model are annotated with a red dot behind the junction rim. The final profile also displays the existing system HGL with a dark green line for reference.

TABLE 2
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
Upper Area—North of I-66																	
N. George Mason Dr., between 20th St. N. and 19th St. N. (Figure 6, profile continues on Figure 7)																	
5627	5955	6132	185.0	3.5	3.5	1	1			9.6	9.6	3.1	5.4	2.5	3.1	90.6	90.5
5666	6132	6286	178.1	3.5	3.5	1	1	LR5	1.5	9.6	11.4	5.4	8.2	3.1	6.8	85.5	91.7
5665	6286	6273	72.8	3.5	3.5	1	1			9.6	9.6	8.2	6.1	6.8	4.4	106.3	106.4
5672	6273	6302	41.4	3.5	3.5	1	1			9.6	9.6	6.1	8.0	4.4	4.7	89.0	106.4
6543	6302	6308	23.4	3.5	3.5	1	1			9.6	9.6	8.0	7.1	4.7	3.0	114.2	133.7
6542	6308	6434	178.6	3.5	3.5	1	1	LR1	2.5	9.6	14.5	7.1	8.1	3.0	3.4	113.8	133.1
5727	6434	6460	28.8	3.5	3.5	1	2			9.6	19.2	8.1	8.7	3.4	3.8	117.5	138.3
19th St N., between N. Columbus St. and N. George Mason Dr.																	
5623	6104	6122	30.9	3	3	1	1			7.1	7.1	4.6	3.3	4.6	3.3	49.4	49.4
5640	6122	6180	96.2	3	3	1	1			7.1	7.1	3.3	4.1	3.3	4.1	49.4	49.4
5646	6180	6194	24.7	3	3	1	1			7.1	7.1	4.1	3.9	4.1	3.9	49.4	49.4
5659	6194	6257	130.5	3	3	1	1			7.1	7.1	3.9	3.6	3.9	3.6	49.4	49.4
5678	6257	6313	131.8	3	3	1	1			7.1	7.1	3.6	3.7	3.6	3.7	49.4	49.4
5679	6313	6309	57.3	3	3	1	1			7.1	7.1	3.7	3.2	3.7	3.2	49.4	49.4
5675	6309	6250	69.7	3	3	1	1			7.1	7.1	3.2	2.7	3.2	2.7	49.4	49.4
5689	6250	6341	220.9	3.5	3.5	1	1			9.6	9.6	2.7	2.0	2.7	1.6	80.4	80.4
5716	6341	6423	207.0	3.5	3.5	1	1			9.6	9.6	2.0	7.4	1.6	3.7	80.4	80.4
5726	6423	6460	32.3	3.5	3.5	1	1			9.6	9.6	7.4	8.7	3.7	3.8	77.6	80.4
N. George Mason Dr., between 19th St. N. and 17th Rd. N. (Figure 7, profile continues on Figure 8 West Branch and Figure 9 East Branch)																	
5745	6460	6544	105.7	5	5	1	1			19.6	19.6	8.7	12.3	3.8	5.1	178.0	216.8
5768	6544	6676	135.0	5	5	1	1			19.6	19.6	12.3	12.2	5.1	3.7	178.0	215.7
5819	6676	6834	185.0	5	5	1	2			19.6	39.3	12.2	11.2	3.7	5.0	185.2	222.8
5830	6834	6862	42.0	5	5	1	2			19.6	39.3	11.2	11.7	5.0	5.1	206.8	269.1
24274	6862	24171	31.2	5	5	1	2			19.6	39.3	11.7	10.5	5.1	4.3	206.8	269.1
24275	24171	24161	127.0	5	5	1	2			19.6	39.3	10.5	10.4	4.3	3.9	206.7	268.5
24273	24161	6710	108.0	5	5	1	2			19.6	39.3	10.4	12.5	3.9	4.5	206.7	266.6

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
5786	6710	6727	55.6	5.5	5.5	1	2			23.8	47.5	12.5	12.5	4.5	4.3	206.4	264.5
5887	6727	7005	263.0	5.5	5.5	1	2			23.8	47.5	12.5	7.4	4.3	6.0	200.2	263.9
5891	7005	7014	16.2	5.5	5.5	1	2			23.8	47.5	7.4	6.7	6.0	6.0	223.7	275.8
West Branch along N. Edison St., between 17th Rd. N. and 16th St. N. (Figure 8, profile continues on Figure 10)																	
5912	7014	7076	82.2	4.5	4.5	1	1			15.9	15.9	6.7	6.6	6.0	5.3	167.1	161.0
5946	7076	7153	79.3	4.5	4.5	1	1			15.9	15.9	6.6	6.5	5.3	4.5	167.0	161.0
5991	7153	7269	116.5	4.5	4.5	1	1			15.9	15.9	6.5	9.0	4.5	3.2	164.9	160.3
6043	7269	7423	211.9	4.5	4.5	1	1			15.9	15.9	9.0	15.4	3.2	5.2	150.5	160.4
24258	7423	24162	182.0	4.5	4.5	1	1			15.9	15.9	15.4	7.7	5.2	5.4	172.4	176.0
24259	24162	7494	182.0	4.5	4.5	1	1			15.9	15.9	7.7	6.9	5.4	3.5	163.9	176.2
7789	7494	7674	216.0	4.5	4.5	1	2			15.9	31.8	6.9	6.7	3.5	3.7	138.0	175.3
16825	7674	7696	32.0	4.5	4.5	1	2			15.9	31.8	6.7	6.4	3.7	3.6	138.0	174.9
16827	7696	7695	75.0	4.5	4.5	1	2			15.9	31.8	6.4	6.0	3.6	4.1	167.4	212.3
East Branch along N. Edison St., between 17th Rd. N. and 16th St. N. (Figure 9, profile continues on Figure 10)																	
5892	7014	7015	8.0	3.5	3.5	1	1			9.6	9.6	6.7	7.0	6.0	5.5	74.7	115.9
5906	7015	7061	88.7	3.5	3.5	1	2			9.6	19.2	7.0	6.3	5.5	5.2	62.9	115.9
5939	7061	7131	61.5	3.5	3.5	1	2			9.6	19.2	6.3	6.2	5.2	5.5	56.9	115.9
6568	7131	7232	161.7	3.5	3.5	1	2			9.6	19.2	6.2	6.0	5.5	5.7	75.1	140.2
5983	7232	7255	22.5	3.5	3.5	1	2			9.6	19.2	6.0	5.7	5.7	5.2	70.9	140.2
6027	7255	7345	91.0	3.5	3.5	1	2			9.6	19.2	5.7	6.1	5.2	5.1	75.3	145.9
6032	7345	7369	86.2	3.5	3.5	1	2			9.6	19.2	6.1	6.2	5.1	5.0	75.3	145.9
6055	7369	7458	93.0	3.5	3.5	1	2			9.6	19.2	6.2	6.7	5.0	4.9	75.3	145.9
6059	7458	7469	88.0	3.5	3.5	1	2			9.6	19.2	6.7	5.9	4.9	3.0	75.3	145.9
20620	7469	7536	73.0	3.5	3.5	1	2			9.6	19.2	5.9	6.3	3.0	3.1	85.0	156.4
20621	7536	7664	187.0	3.5	3.5	1	2			9.6	19.2	6.3	5.3	3.1	3.7	85.2	156.1
7788	7664	7695	37.9	4×7	4×7	1	1			28.0	28.0	5.3	6.0	3.7	4.1	87.1	155.8

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
Southeast of N. Edison St., between 16th St. N. and 15th St. N. (Figure 10)																	
7798	7695	7724	43.3	4.83×7.58 [a]	4.83×7.58 [a]	1	2			28.8	57.6	6.0	5.4	4.1	3.9	249.0	367.6
7799	7724	7785	66.5	4.83×7.58 [a]	4.83×7.58 [a]	1	2			28.8	57.6	5.4	5.3	3.9	4.3	262.4	377.5
7800	7785	7840	92.8	4.83×7.58 [a]	4.83×7.58 [a]	1	2			28.8	57.6	5.3	5.0	4.3	4.8	262.8	375.3
7801	7840	7834	48.0	4.83×7.58 [a]	4.83×7.58 [a]	1	2			28.8	57.6	5.0	5.1	4.8	5.6	282.6	390.5
7803	7834	7795	53.0	4.83×7.58 [a]	4.83×7.58 [a]	1	2			28.8	57.6	5.1	4.3	5.6	5.5	282.5	389.3
7804	7795	7769	57.0	4.83×7.58 [a]	4.83×7.58 [a]	1	2			28.8	57.6	4.3	3.4	5.5	5.5	282.5	388.8
7805	7769	7874	253.0	5.25×8.17 [a]	5.25×8.17 [a]	1	1			33.7	33.7	3.4	3.3	5.5	5.4	282.4	388.6
7808	7874	7931	118.0	5.25×8.17 [a]	5.25×8.17 [a]	1	1			33.7	33.7	3.3	3.4	5.4	5.4	284.8	388.7
West Branch Southeast of N. Buchanan St., between 15th St. N. and 14th St. N.																	
7758	7931	7957	77.0	5.25×8.17 [a]	5.25×8.17 [a]	1	1			33.7	33.7	3.4	3.5	5.4	5.6	231.1	290.6
20622	7957	7994	62.0	4×6.33 [a]	4×6.33 [a]	1	1			19.9	19.9	3.5	5.8	5.6	7.6	55.5	100.1
20623	7957	7994	70.3	4.5×6 [a]	4.5×6[a]	1	1			21.2	21.2	3.5	5.8	5.6	7.6	193.5	192.3
7760	7994	8028	28.0	6	6	1	1			28.3	28.3	5.8	5.6	7.6	7.2	227.9	290.7
7761	8028	8005	55.0	6	6	1	1			28.3	28.3	5.6	4.5	7.2	5.8	227.9	290.6
7762	8005	8095	105.0	6	6	1	1			28.3	28.3	4.5	3.7	5.8	4.3	227.9	290.7
20625	8095	8195	141.0	6	6	1	1			28.3	28.3	3.7	4.0	4.3	4.3	227.8	290.7
East Branch Southeast of N. Buchanan St., between 15th St. N. and 14th St. N.																	
16832	7931	7918	45.0	4.5	4.5	1	1			15.9	15.9	3.4	3.1	5.4	4.8	67.2	108.8
16831	7918	7910	43.2	4.5	4.5	1	1			15.9	15.9	3.1	2.9	4.8	4.5	67.2	108.8
16830	7910	7883	38.0	4.5	4.5	1	1			15.9	15.9	2.9	2.8	4.5	4.3	67.2	108.8
7763	7883	7844	96.4	4.5	4.5	1	1			15.9	15.9	2.8	3.1	4.3	4.4	74.3	113.5
7764	7844	7878	35.0	4.5	4.5	1	1			15.9	15.9	3.1	2.7	4.4	3.8	76.2	114.6
7765	7878	8007	113.0	4.5	4.5	1	1			15.9	15.9	2.7	2.3	3.8	3.1	76.2	114.6
20626	8007	8195	224.0	4.5	4.5	1	1			15.9	15.9	2.3	4.0	3.1	4.3	76.3	114.5
N. Cameron St., between 20th St. N. and 18th St. N. (Figure 11)																	
5622	6022	6121	103.0	3	3	1	1			7.1	7.1	2.5	2.4	2.5	2.2	70.1	70.2
5664	6121	6278	149.9	3	3	1	1			7.1	7.1	2.4	6.3	2.2	2.4	68.9	70.1
5698	6278	6372	114.5	3	3	1	1			7.1	7.1	6.3	8.8	2.4	2.8	68.9	70.0

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
5744	6372	6539	202.6	3.5	3.5	1	1			9.6	9.6	8.8	5.6	2.8	2.8	68.9	69.4
5761	6539	6637	115.0	3.5	3.5	1	2			9.6	19.2	5.6	5.3	2.8	4.2	92.0	93.5
5776	6637	6692	40.0	3.5	3.5	1	2			9.6	19.2	5.3	4.8	4.2	4.9	92.0	93.6
5785	6692	6721	60.0	3.5	3.5	1	1			9.6	9.6	4.8	4.0	4.9	4.1	92.0	93.5
5797	6721	6741	21.0	3.5	3.5	1	1			9.6	9.6	4.0	3.0	4.1	3.0	92.0	93.6
5806	6741	6777	42.2	3.5	3.5	1	1			9.6	9.6	3.0	2.3	3.0	2.2	92.0	93.6
6576	6777	6973	213.0	4	4	1	1			12.6	12.6	2.3	2.9	2.2	2.8	93.1	93.7
24246	6973	24153	170.0	4	4	1	1			12.6	12.6	2.9	3.3	2.8	3.2	113.6	111.4
24247	24153	7198	170.0	4	4	1	1			12.6	12.6	3.3	3.7	3.2	3.7	113.0	111.3
6582	7198	7245	56.0	4	4	1	1			12.6	12.6	3.7	3.4	3.7	3.4	112.5	111.3
6579	7245	7338	109.3	4	4	1	1			12.6	12.6	3.4	3.0	3.4	3.0	112.6	111.3
20422	7338	7445	178.4	4	4	1	1			12.6	12.6	3.0	3.8	3.0	3.8	128.6	126.5
N. Abingdon St., between 16th Rd. N. and 16th St. N. (Figure 12)																	
24260	7147	7333	168.0	3.5	3.5	1	1			9.6	9.6	2.7	6.7	2.4	2.5	79.4	79.2
24256	7333	7394	155.0	3	3	1	1			7.1	7.1	6.7	5.3	2.5	3.1	76.9	78.2
24305	7394	24160	52.0	3	3	1	2			7.1	14.1	5.3	4.2	3.1	4.2	76.9	78.3
24306	24160	7445	15.0	3	3	1	1			7.1	7.1	4.2	3.8	4.2	3.8	76.9	78.3
20424	7445	7778	340.0	5	5	1	1			19.6	19.6	3.8	3.7	3.8	3.7	216.7	216.3
7768	7778	8143	339.2	5	5	1	1			19.6	19.6	3.7	4.8	3.7	4.8	227.5	227.2
7769	8143	8156	15.0	5	5	1	1			19.6	19.6	4.8	3.2	4.8	3.4	237.2	236.7
Stream between 14th St. N. and Washington Blvd.																	
21835	8156	8229	73.2	Stream	Stream	1	1									237.6	235.4
20628	8195	8229	66.1	Stream	Stream	1	1									325.0	427.5
20649	8229	8423	233.3	Stream	Stream	1	1									561.2	646.4
8058	8423	8529	136.5	Stream	Stream	1	1									583.6	671.6
8060	8529	8646	121.5	Stream	Stream	1	1									677.3	787.6
8061	8646	8746	127.6	Stream	Stream	1	1									606.4	684.4

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
N. Glebe Rd., between 16th St. N. and I-66																	
3009	6907	7023	97.8	3	3	1	1			7.1	7.1	2.3	6.1	2.3	6.0	49.3	49.6
3084	7023	7181	147.7	3	3	1	1			7.1	7.1	6.1	4.0	6.0	3.5	49.0	48.6
3108	7181	7233	69.0	3	3	1	1			7.1	7.1	4.0	1.9	3.5	1.9	49.0	48.6
3225	7233	7480	243.0	3	3	1	1			7.1	7.1	1.9	4.2	1.9	2.6	49.0	48.7
20414	7480	7588	112.9	3	3	1	1			7.1	7.1	4.2	2.8	2.6	2.7	75.2	73.9
7826	7588	7635	52.0	3	3	1	1			7.1	7.1	2.8	1.9	2.7	1.8	74.6	73.9
7827	7635	7861	228.3	3	3	1	1			7.1	7.1	1.9	2.7	1.8	2.7	74.5	74.1
7829	7861	8025	135.3	3	3	1	1			7.1	7.1	2.7	2.1	2.7	2.1	85.7	85.3
7832	8025	8172	189.2	3	3	1	1			7.1	7.1	2.1	3.8	2.1	3.6	85.8	85.4
7833	8172	8232	67.8	3	3	1	1			7.1	7.1	3.8	3.4	3.6	3.4	95.5	95.0
7837	8232	8260	42.1	3.5	3.5	1	1			9.6	9.6	3.4	3.2	3.4	3.2	95.4	94.9
7838	8260	8308	71.8	3.5	3.5	1	1			9.6	9.6	3.2	3.8	3.2	3.8	95.4	94.9
7839	8308	8360	49.6	3.5	3.5	1	1			9.6	9.6	3.8	3.5	3.8	3.5	95.2	94.8
7840	8360	8386	63.7	3.5	3.5	1	1			9.6	9.6	3.5	2.9	3.5	2.6	95.1	94.5
8063	8386	8526	179.8	3.5	3.5	1	1			9.6	9.6	2.9	2.2	2.6	2.0	95.0	94.7
7998	8526	8569	74.8	5	5	1	1			19.6	19.6	2.2	4.8	2.0	5.3	103.7	103.4
62 ft North of Intersection of Washington Blvd. and I-66																	
16884	8667	8526	147.8	3.5	3.5	1	1			9.6	9.6	0.6	2.2	0.6	2.0	10.2	10.2
Along I-66, Approximately 100 ft Northeast of Washington Blvd.																	
8012	8635	8628	9.2	3.5	3.5	1	1			9.6	9.6	3.4	4.5	3.8	5.0	23.6	23.7
8013	8628	8588	65.5	3.5	3.5	1	1			9.6	9.6	4.5	4.6	5.0	5.1	23.4	23.4
8014	8588	8569	26.6	3.5	3.5	1	1			9.6	9.6	4.6	4.8	5.1	5.3	23.2	23.3
Along I-66, Northeast of Beaver Pond																	
7849	7955	8024	92.7	5	5	1	1			19.6	19.6	4.1	4.2	4.6	4.7	31.3	31.4
7851	8024	8102	139.6	5	5	1	1			19.6	19.6	4.2	4.3	4.7	4.8	29.3	29.4
7864	8102	8250	257.4	5	5	1	1			19.6	19.6	4.3	4.5	4.8	5.0	28.7	26.0
7862	8250	8414	227.5	5	5	1	1			19.6	19.6	4.5	4.7	5.0	5.1	32.8	32.3
8064	8414	8569	202.9	5	5	1	1			19.6	19.6	4.7	4.8	5.1	5.3	30.9	30.7

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
7997	8569	8792	251.7	5×6	5×6	2	2			60.0	60.0	4.8	4.9	5.3	5.3	153.4	153.3
16883	8792	9021	237.1	5×6	5×6	2	2			60.0	60.0	4.9	5.2	5.3	5.5	149.5	145.8
N. George Mason Dr., between Washington Blvd. and I-66																	
7941	8915	8922	68.0	3.5	3.5	1	1			9.6	9.6	2.4	2.7	2.4	2.7	74.9	74.9
7954	8922	8995	94.0	3.5	3.5	1	1			9.6	9.6	2.7	1.9	2.7	1.9	74.7	74.7
7994	8995	9184	314.0	3.5	3.5	1	1			9.6	9.6	1.9	2.0	1.9	2.0	74.3	74.3
7988	9184	9348	300.0	3.5	3.5	1	1			9.6	9.6	2.0	2.3	2.0	2.3	74.4	74.4
8220	9348	9455	223.0	3.5	3.5	1	1			9.6	9.6	2.3	3.9	2.3	3.9	86.8	86.8
8162	9455	9464	84.0	4	4	1	1			12.6	12.6	3.9	3.4	3.9	3.4	91.9	91.9
8163	9464	9508	68.0	4	4	1	1			12.6	12.6	3.4	3.0	3.4	3.0	99.7	99.7
24262	9508	24163	52.0	4	4	1	1			12.6	12.6	3.0	2.8	3.0	2.8	109.9	109.9
24263	24163	9614	125.0	4	4	1	1			12.6	12.6	2.8	2.5	2.8	2.5	109.9	109.9
8168	9614	9758	236.2	5	5	1	1			19.6	19.6	2.5	2.6	2.5	2.6	110.1	110.1
16933	9758	9744	42.5	5	5	1	1			19.6	19.6	2.6	2.5	2.6	2.5	110.1	110.1
8219	9744	9711	42.5	5	5	1	1			19.6	19.6	2.5	2.6	2.5	2.6	110.1	110.1
8179	9711	9655	73.7	5	5	1	1			19.6	19.6	2.6	2.9	2.6	2.9	110.1	110.1
8180	9655	9651	41.2	5	5	1	1			19.6	19.6	2.9	3.1	2.9	3.1	110.1	110.1
8181	9651	9725	85.6	5	5	1	1			19.6	19.6	3.1	5.7	3.1	5.6	110.1	110.1
8182	9725	9825	118.8	4.42×6.92[a]	4.42×6.92[a]	1	1			24.0	24.0	5.7	5.6	5.6	5.6	126.9	126.9
West Branch along I-66, between N. Harrison St. and VDOT Pond																	
8487	10771	10762	227.3	3	3	1	1			7.1	7.1	2.5	2.2	2.5	2.2	24.0	24.0
8488	10762	10687	246.6	3	3	1	1			7.1	7.1	2.2	2.1	2.2	2.1	23.9	23.9
8548	10687	10574	247.2	3	3	1	1			7.1	7.1	2.1	2.3	2.1	2.4	23.5	23.5
8546	10574	10480	247.4	3	3	1	1			7.1	7.1	2.3	3.6	2.4	3.6	24.7	24.7
24267	10480	10289	457.6	4.5	4.5	1	1			15.9	15.9	3.6	4.7	3.6	4.7	64.4	64.4
8201	10289	10101	264.5	4.42×6.92[a]	4.42×6.92[a]	1	1			24.0	24.0	4.7	5.1	4.7	5.1	89.4	89.3
8202	10101	10024	167.2	4.42×6.92[a]	4.42×6.92[a]	1	1			24.0	24.0	5.1	5.5	5.1	5.5	83.5	83.6
8205	10024	9862	209.1	4.42×6.92[a]	4.42×6.92[a]	1	1			24.0	24.0	5.5	5.7	5.5	5.6	83.5	83.6

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8206	9862	9825	39.1	4.42×6.92[a]	4.42×6.92[a]	1	1			24.0	24.0	5.7	5.6	5.6	5.6	92.4	92.4
8183	9825	VDOTPond	138.8	6×8	6×8	2	2			96.0	96.0	5.6	7.6	5.6	7.6	216.1	216.5
West Branch along I-66, 200 ft East of N. Frederick St.																	
8550	10421	10448	55.3	3	3	1	1			7.1	7.1	2.3	3.6	2.3	3.6	46.2	46.2
8542	10448	10480	61.4	3.5	3.5	1	1			9.6	9.6	3.6	3.6	3.6	3.6	46.1	46.1
Middle Area—between I-66 and N. Carlin Springs Rd.																	
Box Culvert Discharging to the Beaver Pond																	
16865	8746	8787	85.0	6×10	6×10	3	3			180.0	180.0	2.0	2.0	2.3	2.3	591.8	677.7
16876	8787	8823	45.0	6×10	6×10	3	3			180.0	180.0	2.0	2.0	2.3	2.3	622.2	711.2
16877	8823	8900	92.2	6×10	6×10	3	3			180.0	180.0	2.0	3.3	2.3	3.6	621.9	711.4
16858	8900	8979	66.8	6×10	6×10	3	3			180.0	180.0	3.3	4.8	3.6	4.9	689.7	713.3
16856	8979	9021	37.0	6×10	6×10	3	3			180.0	180.0	4.8	5.2	4.9	5.5	767.8	742.9
8062	9021	DummyNode2	40.0	6×10	6×10	3	3			180.0	180.0	5.2	11.0	5.5	7.2	901.4	903.8
8062_2	DummyNode2	BeaverPond	75.2	4.87×10 [b]	4.87×10 [b]	3	3			146.1	146.1	11.0	5.7	7.2	5.9	810.6	852.5
Pipe Discharging to Beaver Pond, Coming from East																	
8235	9509	BeaverPond	32.0	3	3	1	1			7.1	7.1	2.1	5.7	2.1	5.9	38.6	38.6
N. Stuart St., between Washington Blvd. and 11th St.; 11th St. N. between N. Stuart St. and N. Utah St. (Figure 13, profile continues on Figure 14)																	
8118	8669	8767	99.6	3	3	1	1			7.1	7.1	3.8	6.7	2.5	3.0	26.6	26.1
8120	8767	8964	185.6	3	3	1	2			7.1	14.1	6.7	5.8	3.0	3.8	26.6	26.0
24276	8964	24172	60.0	3	3	1	2			7.1	14.1	5.8	7.1	3.8	4.4	26.3	26.0
24277	24172	9223	60.0	3	3	1	2			7.1	14.1	7.1	7.2	4.4	5.0	25.2	26.0
8102	9223	9260	56.6	4	4	1	2			12.6	25.1	7.2	7.9	5.0	5.2	25.2	25.8
16919	9260	9287	225.1	4	4	1	2			12.6	25.1	7.9	8.4	5.2	6.1	33.0	36.3
16918	9287	9298	136.0	4.5	4.5	1	2			15.9	31.8	8.4	8.9	6.1	8.9	67.6	70.1
16917	9298	9311	148.9	4.5	4.5	1	2			15.9	31.8	8.9	7.6	8.9	7.5	65.8	66.0
11 St. N., between N. Utah St. and Beaver Pond (Figure 14)																	
16920	9311	9326	317.6	5	5	1	2			19.6	39.3	7.6	19.5	7.5	8.6	88.4	88.4
8142	9326	9336	131.1	5	5	1	1			19.6	19.6	19.5	12.7	8.6	9.7	78.6	79.3

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8137	9336	9339	129.4	5	5	1	1			19.6	19.6	12.7	11.2	9.7	10.1	78.6	79.3
8038	9339	9363	48.0	5.5	5.5	1	1			23.8	23.8	11.2	11.3	10.1	10.4	78.6	79.3
8309	9363	9478	139.1	5.5	5.5	1	1			23.8	23.8	11.3	12.0	10.4	10.5	95.0	91.5
8289	9478	9497	26.1	5.5	5.5	1	1			23.8	23.8	12.0	12.0	10.5	10.3	95.0	91.6
8250	9497	9524	89.1	5.5	5.5	1	1			23.8	23.8	12.0	12.0	10.3	10.3	99.8	95.2
24302	9524	DummyNode	208.0	5.5	5.5	1	1			23.8	23.8	12.0	11.7	10.3	10.3	115.7	107.2
24302_2	DummyNode	9543	75.0	5.23 [b]	5.23 [b]	1	1			21.5	21.5	11.7	11.2	10.3	10.1	115.7	107.2
8242	9543	9552	157.6	4.93 [b]	4.93 [b]	1	1			19.1	19.1	11.2	9.8	10.1	9.6	115.7	107.2
8243	9552	9555	110.2	4.5 [b]	4.5 [b]	1	1			15.9	15.9	9.8	8.8	9.6	9.1	115.7	107.2
8245	9555	9561	49.9	3.99 [b]	3.99 [b]	1	1			12.5	12.5	8.8	8.1	9.1	8.4	115.7	107.2
8246	9561	BeaverPond	75.0	3.79 [b]	3.79 [b]	1	1			11.3	11.3	8.1	5.7	8.4	5.9	115.7	107.2
N. Stuart, between 11 St. N. and Fairfax Dr.																	
24292	24183	24174	185.0	3	3	1	1			7.1	7.1	1.0	1.5	1.0	1.5	17.6	17.6
24280	24174	9404	50.0	3	3	1	1			7.1	7.1	1.5	1.8	1.5	1.8	17.6	17.6
8423	9404	9596	185.1	3	3	1	1			7.1	7.1	1.8	1.9	1.8	1.9	17.2	17.2
8420	9596	9644	50.0	3	3	1	1			7.1	7.1	1.9	2.0	1.9	2.0	16.7	16.7
8318	9644	9734	101.3	3	3	1	1			7.1	7.1	2.0	2.1	2.0	2.1	16.6	16.6
8412	9734	9820	78.2	3.5	3.5	1	1			9.6	9.6	2.1	2.9	2.1	2.9	17.0	17.0
Fairfax Dr., between N. Stafford St. and N. Utah St.																	
8425	9731	9788	53.1	3	3	1	1			7.1	7.1	2.1	2.1	2.1	2.1	5.7	5.7
8426	9788	9797	59.1	3.5	3.5	1	1			9.6	9.6	2.1	2.4	2.1	2.4	5.4	5.4
24281	9797	24175	75.0	3.5	3.5	1	1			9.6	9.6	2.4	2.5	2.4	2.5	21.2	21.2
24282	24175	9809	110.0	3.5	3.5	1	1			9.6	9.6	2.5	2.7	2.5	2.7	20.5	20.5
8330	9809	9820	87.4	3.5	3.5	1	1			9.6	9.6	2.7	2.9	2.7	2.9	19.9	19.9
8335	9820	9856	59.5	4.5	4.5	1	1			15.9	15.9	2.9	2.8	2.9	2.8	35.6	35.6
8434	9856	9860	221.1	4.5	4.5	1	1			15.9	15.9	2.8	3.5	2.8	3.4	64.9	64.9
8435	9860	9871	135.5	5	5	1	1			19.6	19.6	3.5	4.0	3.4	3.8	89.2	89.2
8373	9871	9878	143.5	5	5	1	1			19.6	19.6	4.0	4.7	3.8	4.4	87.8	87.9

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
N. Utah St., between 11th St. N. and Fairfax Dr.																	
8076	9234	9311	75.0	3	3	1	1			7.1	7.1	1.8	7.6	1.8	7.5	41.1	41.1
8419	9311	9463	196.1	3	3	1	1			7.1	7.1	7.6	1.3	7.5	1.2	23.9	21.9
8397	9463	9568	106.1	3	3	1	1			7.1	7.1	1.3	1.7	1.2	1.6	24.0	22.0
8398	9568	9574	7.1	3	3	1	1			7.1	7.1	1.7	1.6	1.6	1.5	23.9	21.9
8399	9574	9693	111.8	3	3	1	1			7.1	7.1	1.6	1.6	1.5	1.5	23.9	21.9
8400	9693	9757	78.9	3	3	1	1			7.1	7.1	1.6	1.5	1.5	1.4	24.0	22.0
8401	9757	9813	48.7	3	3	1	1			7.1	7.1	1.5	1.7	1.4	1.6	24.0	22.1
8402	9813	9878	61.9	3	3	1	1			7.1	7.1	1.7	4.7	1.6	4.4	32.9	30.7
Fairfax Dr., between N. Utah St. and N. Woodrow St.																	
8374	9878	9884	80.7	6	6	1	1			28.3	28.3	4.7	4.7	4.4	4.5	111.6	101.9
8375	9884	9901	244.1	6	6	1	1			28.3	28.3	4.7	4.9	4.5	4.7	111.6	100.9
8376	9901	9910	148.4	6	6	1	1			28.3	28.3	4.9	5.0	4.7	4.9	124.5	116.7
8387	9910	9877	35.8	6	6	1	1			28.3	28.3	5.0	4.7	4.9	4.6	124.0	116.4
8388	9877	9889	45.3	6	6	1	1			28.3	28.3	4.7	4.3	4.6	4.2	124.0	116.4
8440	9889	9896	150.6	6	6	1	1			28.3	28.3	4.3	4.2	4.2	4.1	144.0	138.4
16586	9896	9925	218.0	6	6	1	1			28.3	28.3	4.2	4.4	4.1	4.3	146.2	140.7
8263	9925	9926	197.8	6	6	1	1			28.3	28.3	4.4	3.5	4.3	3.4	145.7	140.4
8264	9926	9940	129.7	6	6	1	1			28.3	28.3	3.5	4.4	3.4	3.9	145.1	140.3
8265	9940	9977	32.0	6	6	1	1			28.3	28.3	4.4	4.1	3.9	3.1	144.7	140.2
8262	9977	10046	67.1	6	6	1	1			28.3	28.3	4.1	6.3	3.1	5.4	166.8	164.0
Fairfax Dr., between N. George Mason Dr. and VDOT Pond																	
8197	10077	10036	182.6	3	3	1	1			7.1	7.1	5.1	5.6	4.8	5.6	16.5	16.5
8305	10036	10013	206.8	3	3	1	1			7.1	7.1	5.6	6.4	5.6	6.4	16.5	16.5
8224	10013	VDOTPond	109.4	3	3	1	1			7.1	7.1	6.4	7.6	6.4	7.6	16.5	16.5
Pipe Discharging to VDOT Pond, Coming from the East																	
8291	9507	9545	50.2	3	3	1	1			7.1	7.1	3.6	4.4	3.6	4.4	16.9	16.9
8295	9545	9556	23.9	3	3	1	1			7.1	7.1	4.4	4.9	4.4	4.9	16.2	16.2

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8302	9556	9696	160.7	3	3	1	1			7.1	7.1	4.9	6.0	4.9	6.0	15.5	15.5
16937	9696	VDOTPond	96.5	3	3	1	1			7.1	7.1	6.0	7.6	6.0	7.6	15.5	15.5
Pipes out of VDOT Pond, between I-66 and Fairfax Dr.																	
16948	9851	9897	240.0	6×8	6×8	2	2			96.0	96.0	5.9	6.5	5.6	6.3	230.1	238.2
8226	9897	9930	136.3	6×8	6×8	2	2			96.0	96.0	6.5	6.9	6.3	6.7	234.4	242.5
8227	9930	9938	18.8	6×8	6×8	2	2			96.0	96.0	6.9	6.9	6.7	6.7	234.3	242.5
8228	9938	9961	80.6	6×8	6×8	2	2			96.0	96.0	6.9	7.1	6.7	6.9	234.3	242.5
8229	9961	9978	92.8	6×8	6×8	2	2			96.0	96.0	7.1	7.4	6.9	7.1	236.2	244.3
Downstream from the VDOT and Beaver Ponds, between Fairfax Dr. and Wilson Blvd. (Figure 15)																	
21780	9799	9864	86.6	6×10	6×10	3	3			180.0	180.0	7.5	7.5	7.5	7.4	838.4	936.8
21781	9864	9978	101.5	6×10	6×10	2	2			120.0	120.0	7.5	7.4	7.4	7.1	838.5	936.8
24298	9978	24187	16.6	6×10	6×10	2	2			120.0	120.0	7.4	6.3	7.1	5.6	1056.2	1168.2
24299	24187	10046	51.2	6×10	6×10	2	2			120.0	120.0	6.3	6.3	5.6	5.4	1057.7	1168.3
8231	10046	10173	175.0	6×10	6×10	2	2			120.0	120.0	6.3	6.4	5.4	5.0	1171.0	1296.4
8591	10173	10428	261.2	6×10	6×10	2	2			120.0	120.0	6.4	7.6	5.0	5.9	1171.3	1296.5
8593	10428	10437	9.0	6×10	6×10	2	2			120.0	120.0	7.6	7.2	5.9	5.2	1173.6	1296.9
8594	10437	10683	303.3	6×10	6×10	2	2			120.0	120.0	7.2	8.5	5.2	6.5	1190.0	1316.4
8569	10683	10761	78.5	6×10	6×10	2	2			120.0	120.0	8.5	8.5	6.5	6.3	1193.2	1319.6
8570	10761	10907	152.9	6×10	6×10	2	**3**			120.0	180.0	8.5	8.0	6.3	6.6	1153.0	1364.6
8571	10907	10927	15.0	6×10	6×10	2	**3**			120.0	180.0	8.0	7.7	6.6	6.4	1153.3	1364.6
24307	10927	24177	40.0	6×10	6×10	2	**3**			120.0	180.0	7.7	7.5	6.4	6.5	1153.3	1364.7
24308	24177	10969	8.0	6×10	6×10	2	**3**			120.0	180.0	7.5	5.3	6.5	5.0	1255.4	1464.3
16979	10969	11043	90.3	6×10	6×10	2	**3**			120.0	180.0	5.3	4.0	5.0	4.4	1254.5	1464.3
8th Rd. N., between N. Buchanan St. and N. Woodrow St.																	
8555	10686	10726	104.2	3	3	1	1			7.1	7.1	1.6	3.1	1.6	3.1	38.6	38.6
8556	10726	10701	52.0	3	3	1	1			7.1	7.1	3.1	2.5	3.1	2.5	38.6	38.6
8557	10701	10672	51.6	3	3	1	1			7.1	7.1	2.5	2.7	2.5	2.7	38.5	38.5
8558	10672	10648	47.8	3	3	1	1			7.1	7.1	2.7	2.4	2.7	2.4	38.5	38.5

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8559	10648	10678	138.0	3	3	1	1			7.1	7.1	2.4	2.7	2.4	2.6	38.3	38.3
8560	10678	10695	50.0	3	3	1	1			7.1	7.1	2.7	2.6	2.6	2.4	38.1	38.1
8563	10695	10733	50.0	3	3	1	1			7.1	7.1	2.6	2.7	2.4	2.5	38.1	38.1
8565	10733	10746	36.0	3	3	1	1			7.1	7.1	2.7	4.0	2.5	3.9	38.1	38.2
8566	10746	10722	102.0	3	3	1	1			7.1	7.1	4.0	4.8	3.9	4.7	38.1	38.2
8567	10722	10761	49.5	3	3	1	1			7.1	7.1	4.8	8.5	4.7	6.3	62.2	62.6
N. Glebe Rd., between N. Carlin Springs Rd. and Wilson Blvd. (Figure 16)																	
16982	11188	11143	68.8	3	3	1	1			7.1	7.1	3.5	3.6	2.5	2.0	38.3	39.1
16983	11143	11075	155.0	3	3	1	1			7.1	7.1	3.6	9.1	2.0	5.1	38.6	39.0
8652	11075	11062	31.0	3	3	1	1			7.1	7.1	9.1	9.5	5.1	5.2	36.1	38.3
8653	11062	10940	231.0	3	3	1	1			7.1	7.1	9.5	7.3	5.2	3.7	34.8	37.7
8654	10940	10806	182.0	3.5	3.5	1	1			9.6	9.6	7.3	7.3	3.7	4.4	50.8	56.1
8655	10806	10665	230.0	3.5	3.5	1	1	LR4	4.5	9.6	25.5	7.3	7.4	4.4	6.2	49.2	56.5
8656	10665	10618	91.4	3.5	3.5	1	1			9.6	9.6	7.4	8.4	6.2	6.5	49.2	46.1
Wilson Blvd., between N. Glebe Rd. and N. Abingdon St.																	
8639	10566	10583	161.7	3	3	1	1			7.1	7.1	5.9	6.5	5.2	5.9	40.5	37.6
8640	10583	10618	118.2	3	3	1	1			7.1	7.1	6.5	8.4	5.9	6.5	40.5	37.6
8657	10618	10614	100.0	3.5	3.5	1	1			9.6	9.6	8.4	9.2	6.5	8.2	95.7	93.6
8658	10614	10679	158.0	4	4	1	1			12.6	12.6	9.2	9.4	8.2	7.8	95.7	93.6
8659	10679	10696	67.2	4	4	1	1			12.6	12.6	9.4	9.0	7.8	7.6	113.7	110.6
8660	10696	10744	132.0	4	4	1	1			12.6	12.6	9.0	8.9	7.6	7.9	113.7	110.6
8672	10744	10824	233.0	4	4	1	1			12.6	12.6	8.9	6.4	7.9	5.1	113.7	110.6
8578	10824	10879	173.0	4	4	1	1			12.6	12.6	6.4	2.3	5.1	2.2	128.6	124.2
24313	10879	24190	125.0	4	4	1	1			12.6	12.6	2.3	2.4	2.2	2.2	128.6	124.0
24314	24190	24176	122.0	4	4	1	1			12.6	12.6	2.4	5.2	2.2	4.2	128.9	124.2
24285	24176	24177	5.0	4	4	1	1			12.6	12.6	5.2	7.5	4.2	6.5	128.2	123.8

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
N. George Mason Dr., between 8th Rd. N. and Stream; Immediately Upstream of 7th St. N.																	
8507	10974	10951	84.0	3	3	1	1			7.1	7.1	3.4	3.3	3.4	3.3	29.9	29.9
8508	10951	10990	40.0	3	3	1	1			7.1	7.1	3.3	2.8	3.3	2.8	30.0	30.0
8509	10990	10943	125.0	3	3	1	1			7.1	7.1	2.8	2.1	2.8	2.1	29.6	29.6
8512	10943	11014	86.0	3.5	3.5	1	1			9.6	9.6	2.1	1.8	2.1	1.8	29.3	29.3
24271	11014	24169	142.0	3.5	3.5	1	1			9.6	9.6	1.8	2.2	1.8	2.2	29.1	29.1
24272	24169	11179	108.0	3.5	3.5	1	1			9.6	9.6	2.2	2.4	2.2	2.4	29.6	29.6
8514	11179	11241	88.6	4	4	1	1			12.6	12.6	2.4	2.9	2.4	2.9	52.2	52.2
8517	11241	11221	107.0	4	4	1	1			12.6	12.6	2.9	3.0	2.9	3.0	51.8	51.8
8518	11221	11225	39.0	4	4	1	1			12.6	12.6	3.0	2.7	3.0	2.7	51.5	51.5
8519	11225	11182	157.0	4	4	1	1			12.6	12.6	2.7	2.8	2.7	2.8	51.7	51.7
24309	11182	24188	97.4	4	4	1	1			12.6	12.6	2.8	2.3	2.8	2.3	75.0	75.0
24310	24188	11357	205.8	4	4	1	1			12.6	12.6	2.3	2.9	2.3	2.9	74.7	74.7
17327	11357	11521	298.7	4	4	1	1			12.6	12.6	2.9	5.3	2.9	5.3	74.8	74.8
24283	11521	11517	29.8	4	4	1	1			12.6	12.6	5.3	3.5	5.3	3.5	114.4	114.4
24311	11517	24189	54.8	4	4	1	1			12.6	12.6	3.5	2.8	3.5	2.8	114.4	114.4
24312	24189	11502	170.3	4	4	1	1			12.6	12.6	2.8	3.6	2.8	3.6	114.4	114.4
17315	11502	11495	40.9	4	4	1	1			12.6	12.6	3.6	2.5	3.6	2.5	114.4	114.4
17316	11495	11476	154.1	4	4	1	1			12.6	12.6	2.5	2.3	2.5	2.3	114.4	114.4
17317	11476	11449	169.9	4	4	1	1			12.6	12.6	2.3	5.7	2.3	6.0	114.4	114.4
17318	11449	11483	81.2	4.5	4.5	1	1			15.9	15.9	5.7	4.6	6.0	4.9	133.2	133.2
430 ft North of N. George Mason Dr. and N. Carlin Springs Rd. (Figure 17)																	
17329	11622	11628	41.0	3	3	1	1			7.1	7.1	7.1	5.4	5.2	3.3	90.1	90.1
20817	11628	11643	55.0	3	3	1	1			7.1	7.1	5.4	3.6	3.3	1.9	90.1	90.1
20818	11643	11671	122.5	3×4.83 [a]	3×4.83 [a]	1	1			11.6	11.6	3.6	4.3	1.9	2.4	86.3	90.1
20819	11671	11684	17.0	3	3	1	**2**			7.1	14.1	4.3	4.6	2.4	4.9	76.0	90.0
Stream between Wilson Blvd. and N. Carlin Springs Rd.																	
10111	11043	11254	316.3	Stream	Stream	1	1									1254.5	1464.4

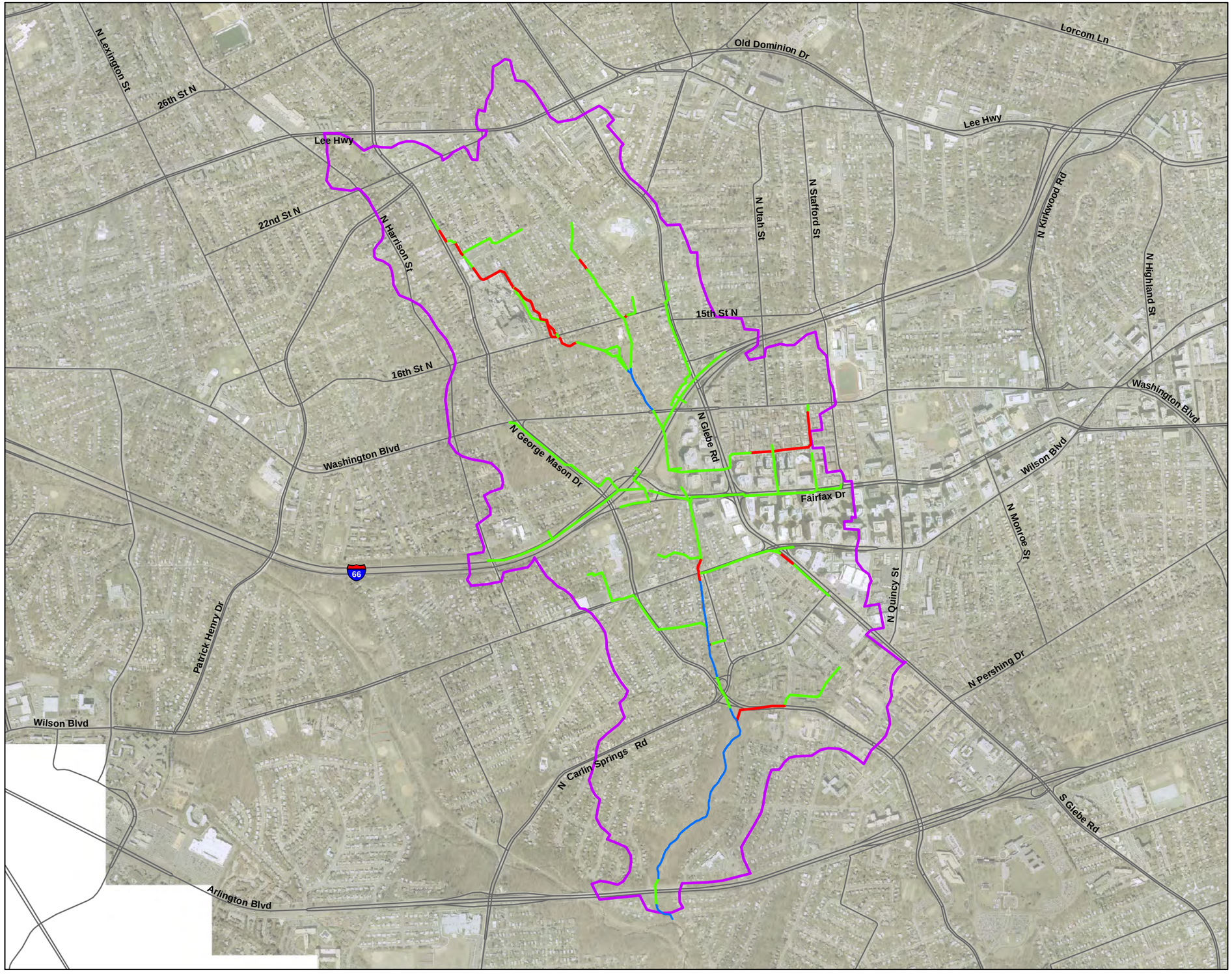
TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
20822	11254	11427	255.5	Stream	Stream	1	1									1260.9	1470.4
20823	11427	11483	85.0	Stream	Stream	1	1									1269.9	1478.9
20820	11483	11684	275.4	Stream	Stream	1	1									1390.5	1593.8
10229	11684	11987	466.0	Stream	Stream	1	1									1464.2	1661.0
Box Culvert between N. Carlin Springs Rd. and 4th Rd. N.																	
17366	11987	11996	17.0	8×10	8×10	2	2			160.0	160.0	8.7	7.9	9.7	8.6	1461.5	1654.4
17367	11996	12009	18.9	8×10	8×10	2	2			160.0	160.0	7.9	7.5	8.6	8.2	1461.5	1654.4
17368	12009	12042	35.0	8×10	8×10	2	2			160.0	160.0	7.5	7.0	8.2	7.7	1467.3	1659.8
10198	12042	12071	37.0	8×10	8×10	2	2			160.0	160.0	7.0	6.5	7.7	7.1	1490.7	1681.4
10199	12071	12208	199.3	8×10	8×10	2	2			160.0	160.0	6.5	6.6	7.1	7.1	1498.9	1688.8
10200	12208	12238	45.7	8×10	8×10	2	2			160.0	160.0	6.6	5.9	7.1	6.4	1504.7	1694.0
10201	12238	12333	132.3	8×10	8×10	2	2			160.0	160.0	5.9	3.5	6.4	3.7	1527.3	1715.0
South Area—South of N. Carlin Springs Rd.																	
N. George Mason Dr., between N. Thomas St. and Stream (Figure 18)																	
17347	11887	11890	6.0	3	3	1	1			7.1	7.1	5.1	3.7	4.6	2.8	63.0	64.1
24315	11890	12057	283.7	3	3	1	1			7.1	7.1	3.7	7.0	2.8	4.7	62.3	62.9
24317	12057	24191	122.5	3	3	1	1			7.1	7.1	7.0	6.8	4.7	4.3	61.4	62.9
24318	24191	12194	69.7	3	3	1	1			7.1	7.1	6.8	6.5	4.3	2.8	61.4	62.9
10234	12194	12193	432.6	3	3	1	1			7.1	7.1	6.5	8.5	2.8	7.5	64.9	64.9
10236	12193	12242	91.8	3.5	3.5	1	1			9.6	9.6	8.5	8.1	7.5	6.7	91.1	97.6
10237	12242	12293	84.0	3.5	3.5	1	1			9.6	9.6	8.1	12.8	6.7	8.0	103.7	112.3
10245	12293	12295	179.8	3.5	3.5	1	1	LR2	1.5	9.6	11.4	12.8	14.4	8.0	3.0	150.7	165.3
10246	12295	12334	223.0	3.5	3.5	1	1	LR3	1.5	9.6	11.4	14.4	13.9	3.0	2.3	150.7	162.7
10247	12334	12354	231.0	3.5	3.5	1	2			9.6	19.2	13.9	4.6	2.3	2.9	150.7	163.5
10274	12354	12485	131.0	3.5	3.5	1	2			9.6	19.2	4.6	4.8	2.9	5.1	117.2	185.9
Between N. George Mason Dr. and Outfall																	
10230	12333	12362	34.7	Stream	Stream	1	1									1527.4	1715.1
10231	12362	12485	166.8	Stream	Stream	1	1									1527.5	1715.5
10344	12485	12622	213.7	Stream	Stream	1	1									1644.6	1863.9

TABLE 2 (CONTINUED)
June 2006 Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
10348	12622	12885	509.2	Stream	Stream	1	1									1666.7	1885.8
17391	12885	13251	508.6	Stream	Stream	1	1									1704.7	1921.5
17392	13251	13298	54.5	Stream	Stream	1	1									1704.8	1921.6
20855	13298	13397	110.5	Stream	Stream	1	1									1726.0	1941.9
20856	13397	13762	496.4	Stream	Stream	1	1									1744.3	1959.9
10402	13762	14008	336.3	Stream	Stream	1	1									7659.0	11191.2
10403	14008	14405	528.9	Stream	Stream	1	1									11343.9	15492.0
21160	14405	14510	110.0	7×12[a]	7×12[a]	1	1			78.0	78.0	24.3	17.6	27.1	19.2	1571.3	1674.6
18030	14510	14737	252.5	7×12[a]	7×12[a]	1	1			78.0	78.0	17.6	9.4	19.2	9.4	1579.8	1688.4
18035	14737	14764	37.6	Stream	Stream	1	1									1566.6	1671.1
18036	14764	14919	351.6	Stream	Stream	1	1									1695.4	1770.7

US, upstream; DS, downstream. Note that cross-sectional area and HGL are not calculated for natural stream sections. The existing and final HGL data represent maximum node depths.
[a] Irregularly shaped pipe, such as arch, elliptical.
[b] Pipes modified in Task 2 to model the impact of sedimentation.



VICINITY MAP

Legend

- Modeled Stormwater Mains with Recommended Additional Capacity
- Modeled Stormwater Mains with Sufficient Existing Capacity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 5
Recommended Additional Capacity for the June 2006 Storm
Lubber Run Watershed
Arlington County Storm Capacity Analysis

CH2MHILL

FIGURE 6 - Lubber Run
N. George Mason Dr., between 20th St. N. and 19th St. N. for the June 2006 Storm Event

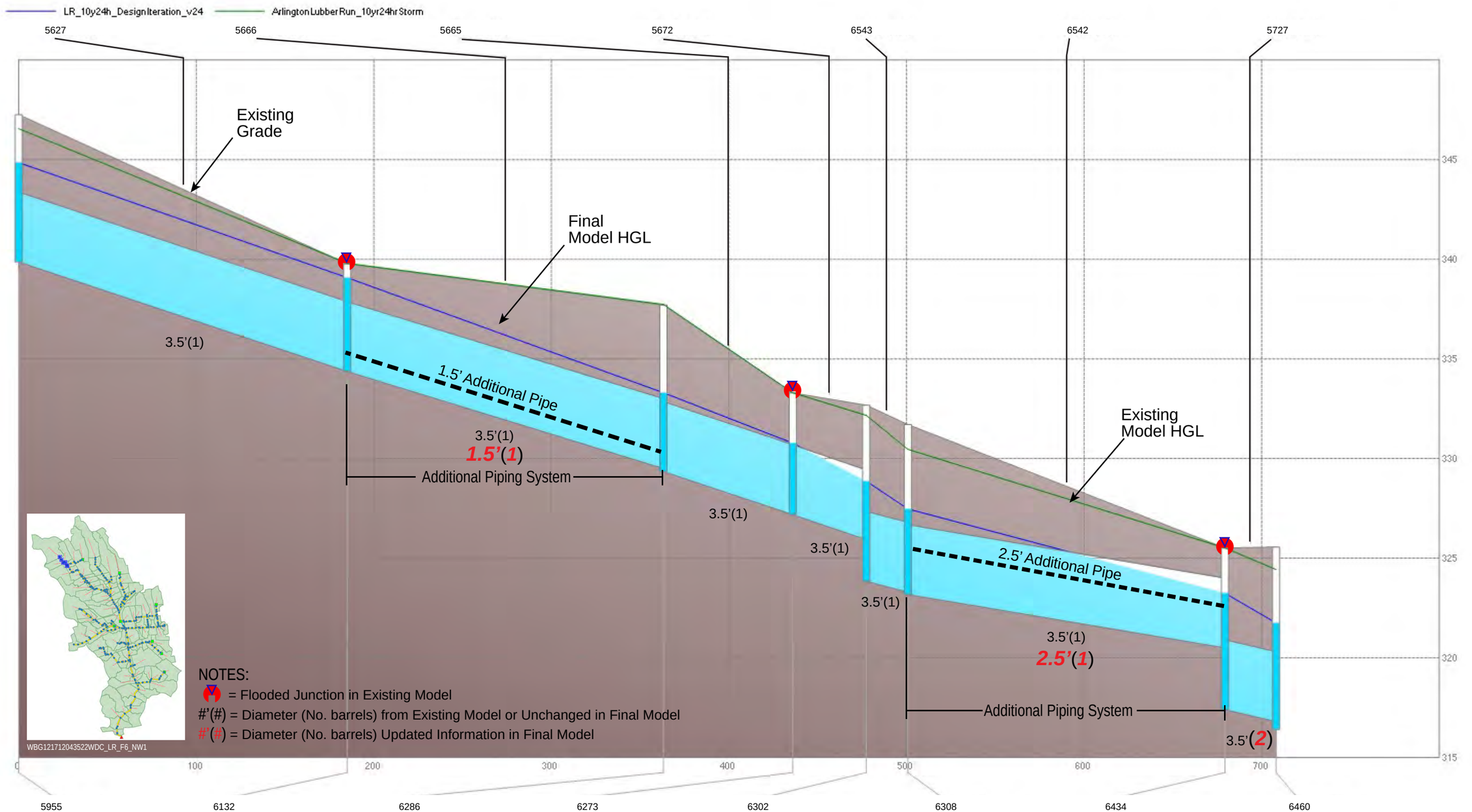


FIGURE 7 - Lubber Run
N. George Mason Dr., between 19th St. N. and 17th Rd. N. for the June 2006 Storm Event

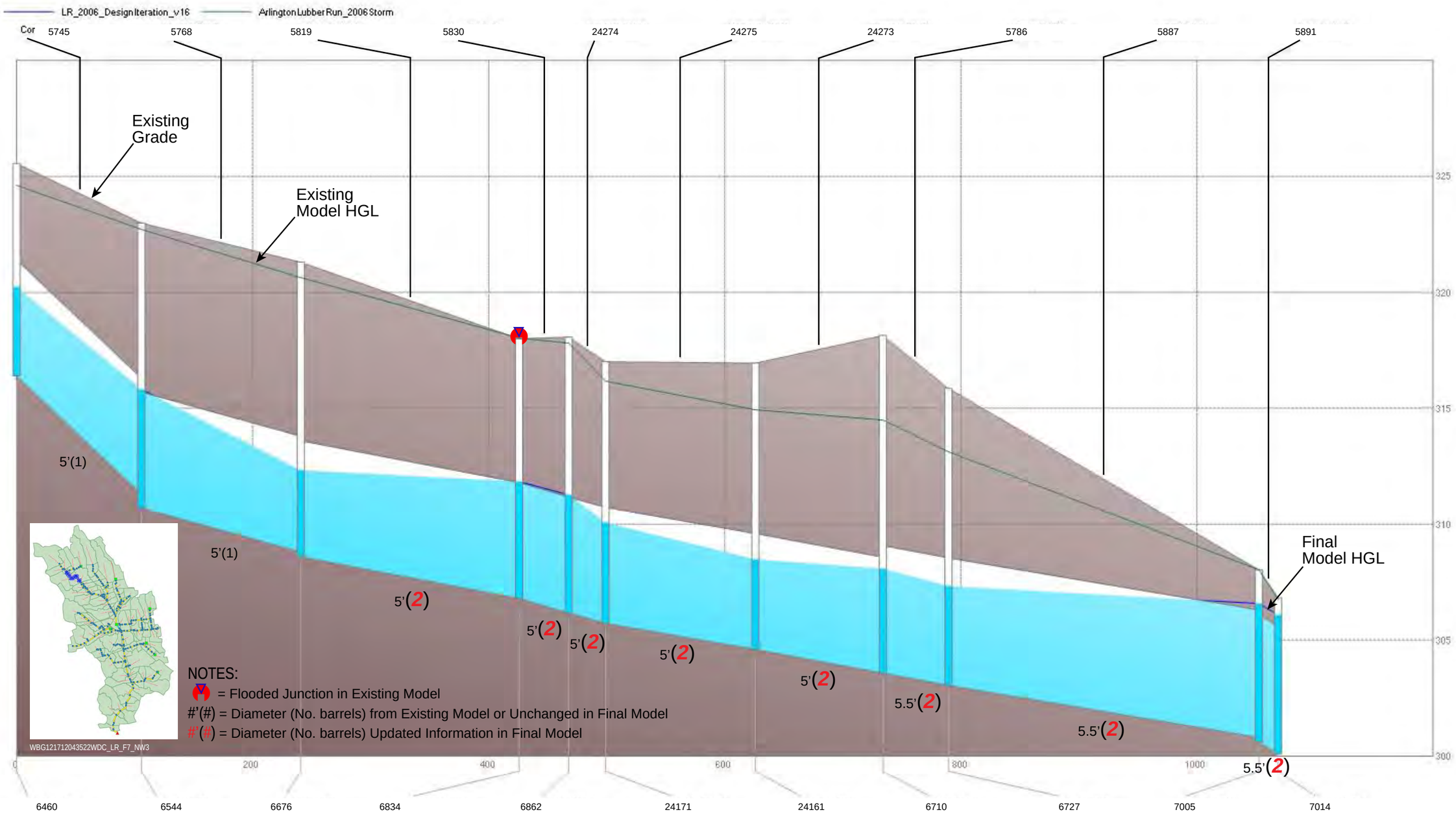


FIGURE 8 - Lubber Run
West Branch along N. Edison St., between 17th Rd. N. and 16th St. N. for the June 2006 Storm Event

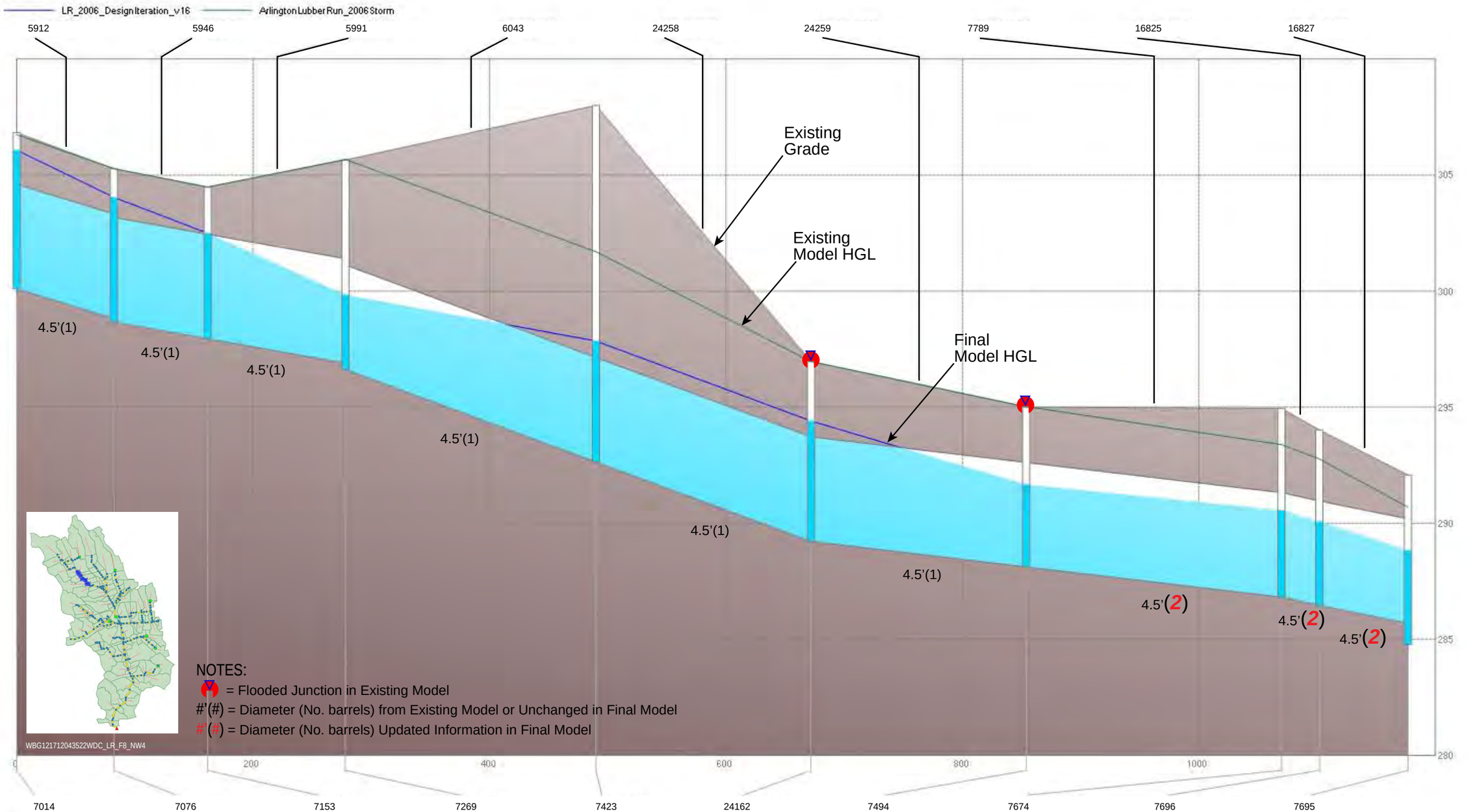


FIGURE 9 - Lubber Run
East Branch along N. Edison St., between 17th Rd. N. and 16th St. N. for the June 2006 Storm Event

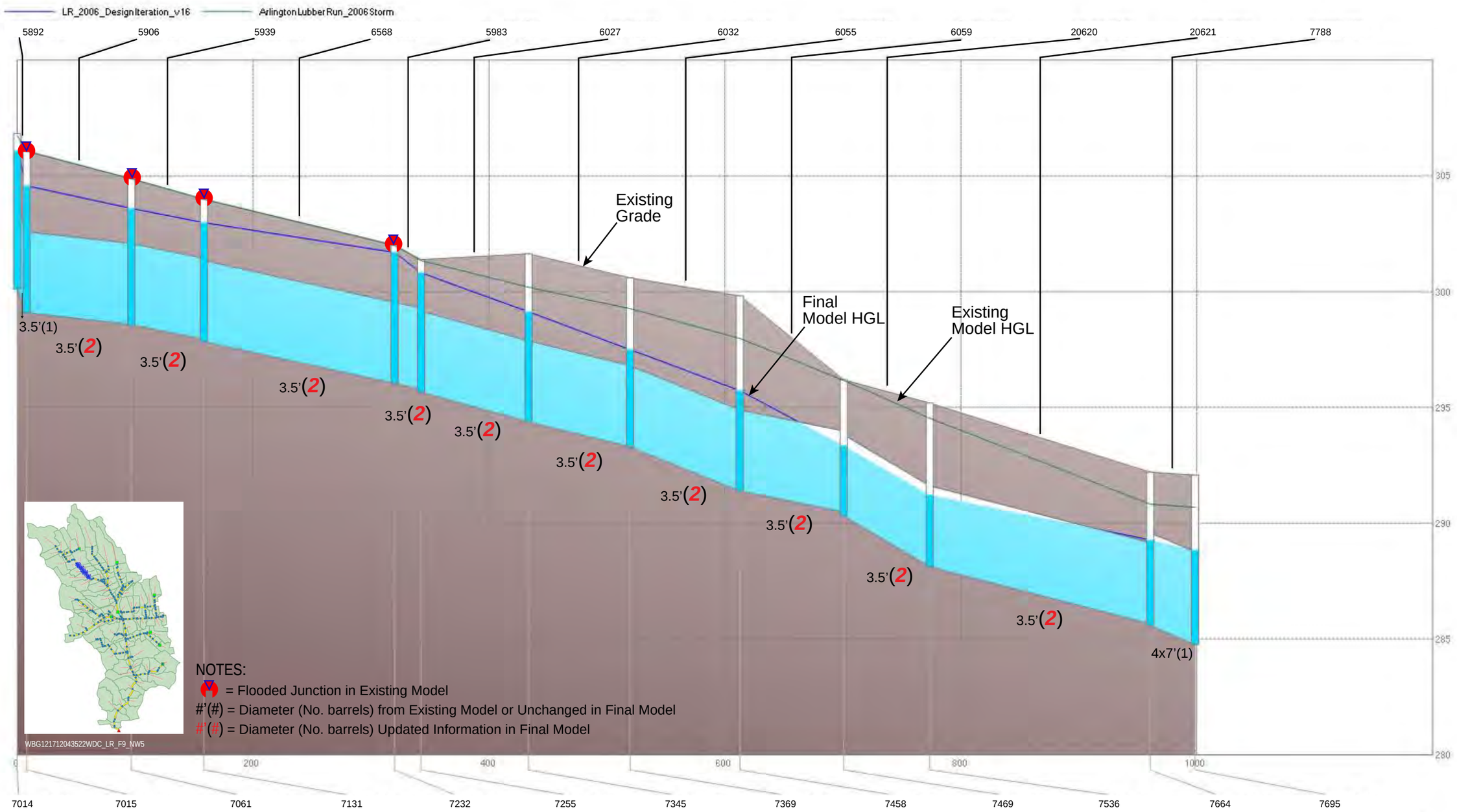


FIGURE 10 - Lubber Run
Southeast of N. Edison St., between 16th St. N. and 15th St. N. for the June 2006 Storm Event

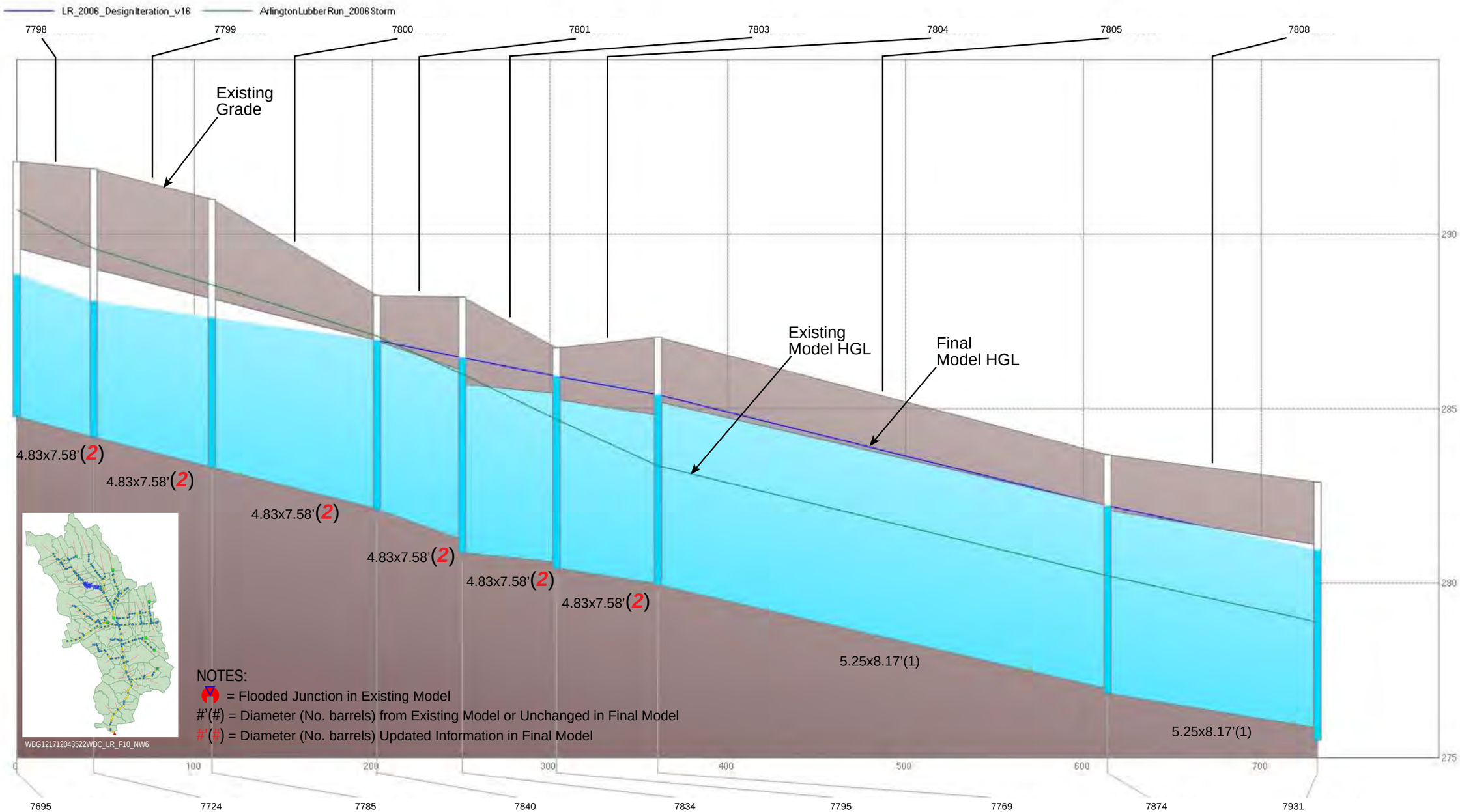


FIGURE 11 - Lubber Run
N. Cameron St., between 20th St. N. and 18th St. N. for the June 2006 Storm Event

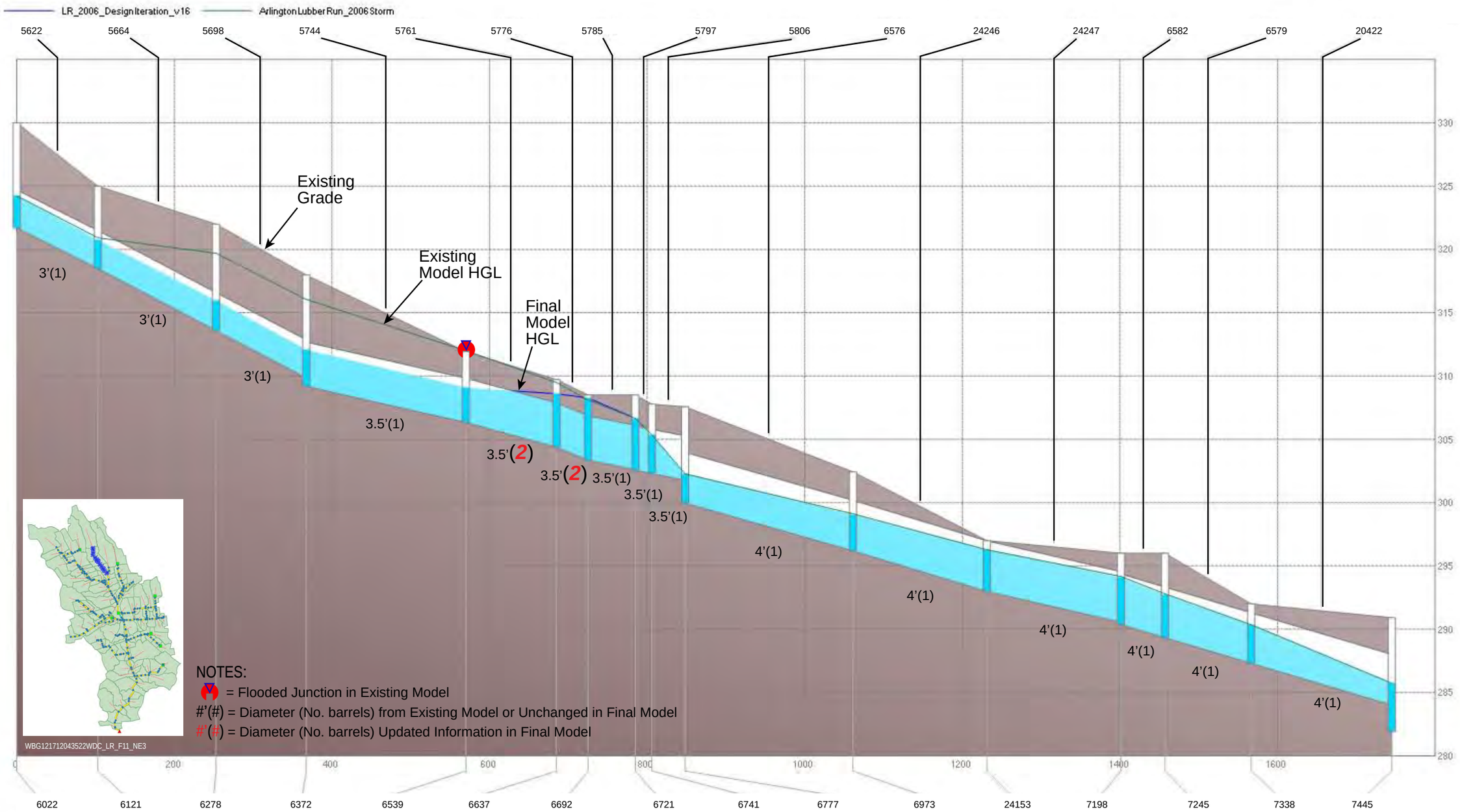


FIGURE 12 - Lubber Run
N. Abingdon St., between 16th Rd. N. and 16th St. N. for the June 2006 Storm Event

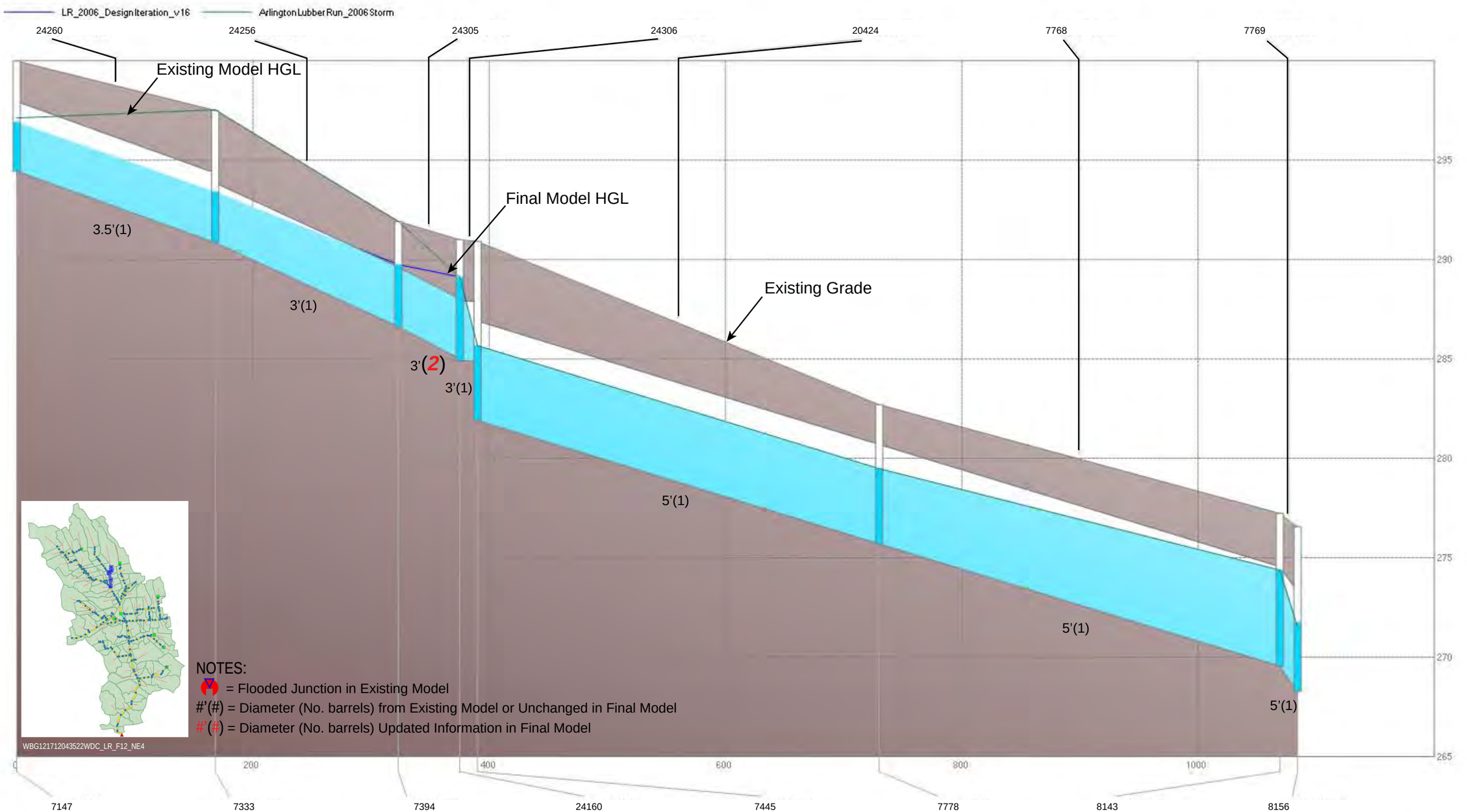


FIGURE 13 - Lubber Run
N. Stuart St., between Washington Blvd. and 11th St.; 11th St. N. between N. Stuart St. and N. Utah St. for the June 2006 Storm Event

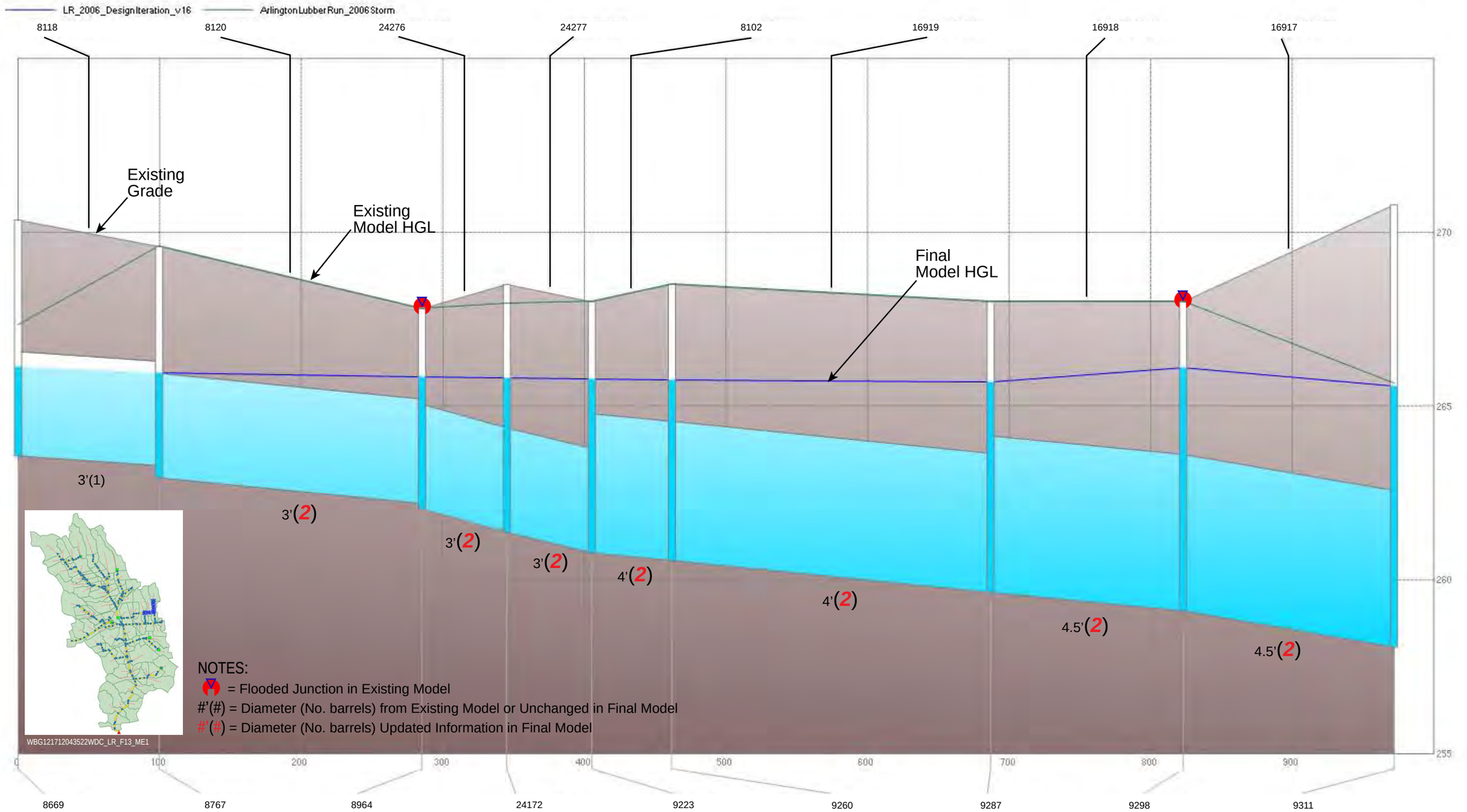


FIGURE 14 - Lubber Run
11 St. N., between N. Utah St. and Beaver Pond for the June 2006 Storm Event

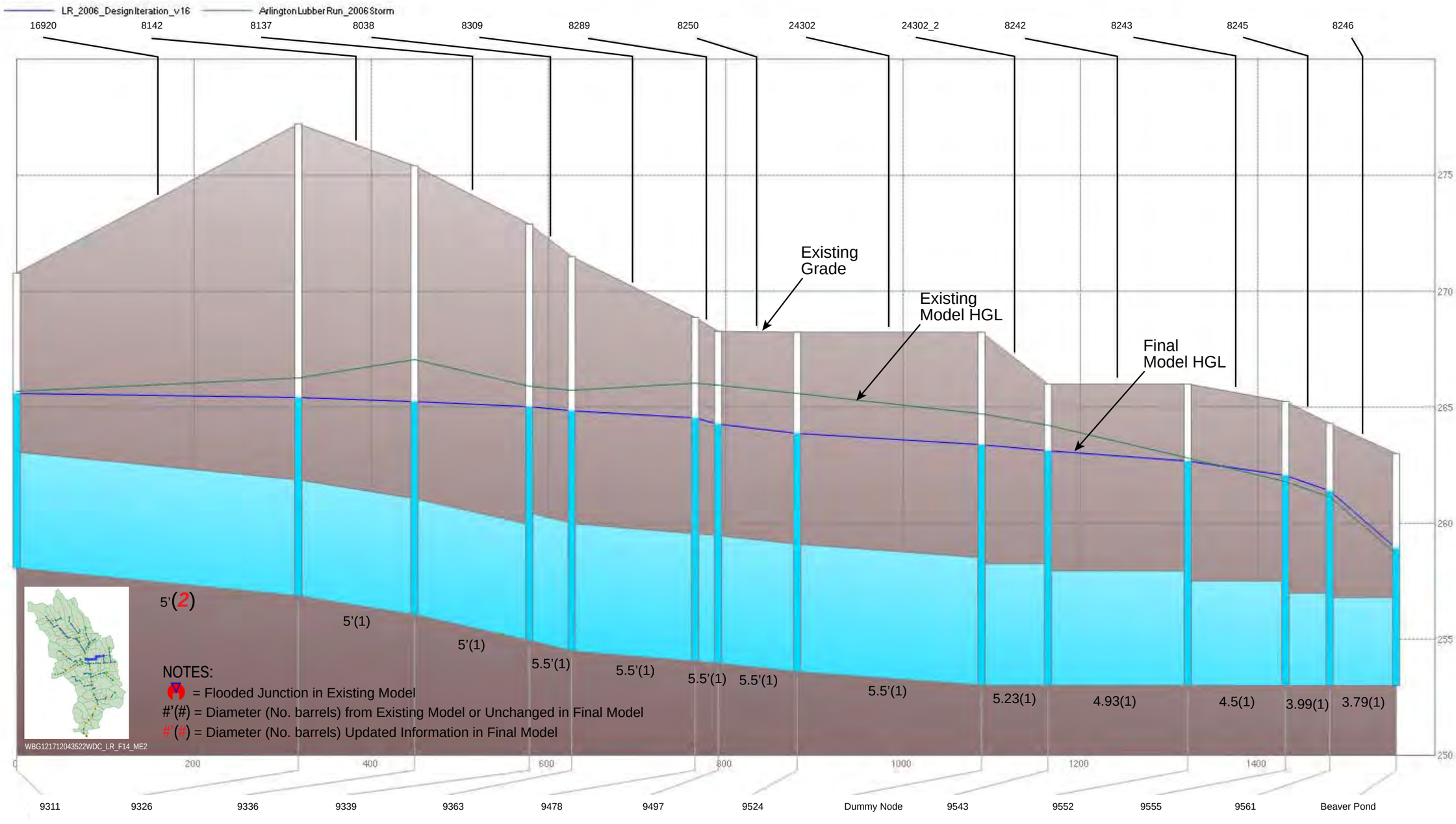


FIGURE 15 - Lubber Run
Downstream from the VDOT and Beaver Ponds, between Fairfax Dr. and Wilson Blvd. for the June 2006 Storm Event

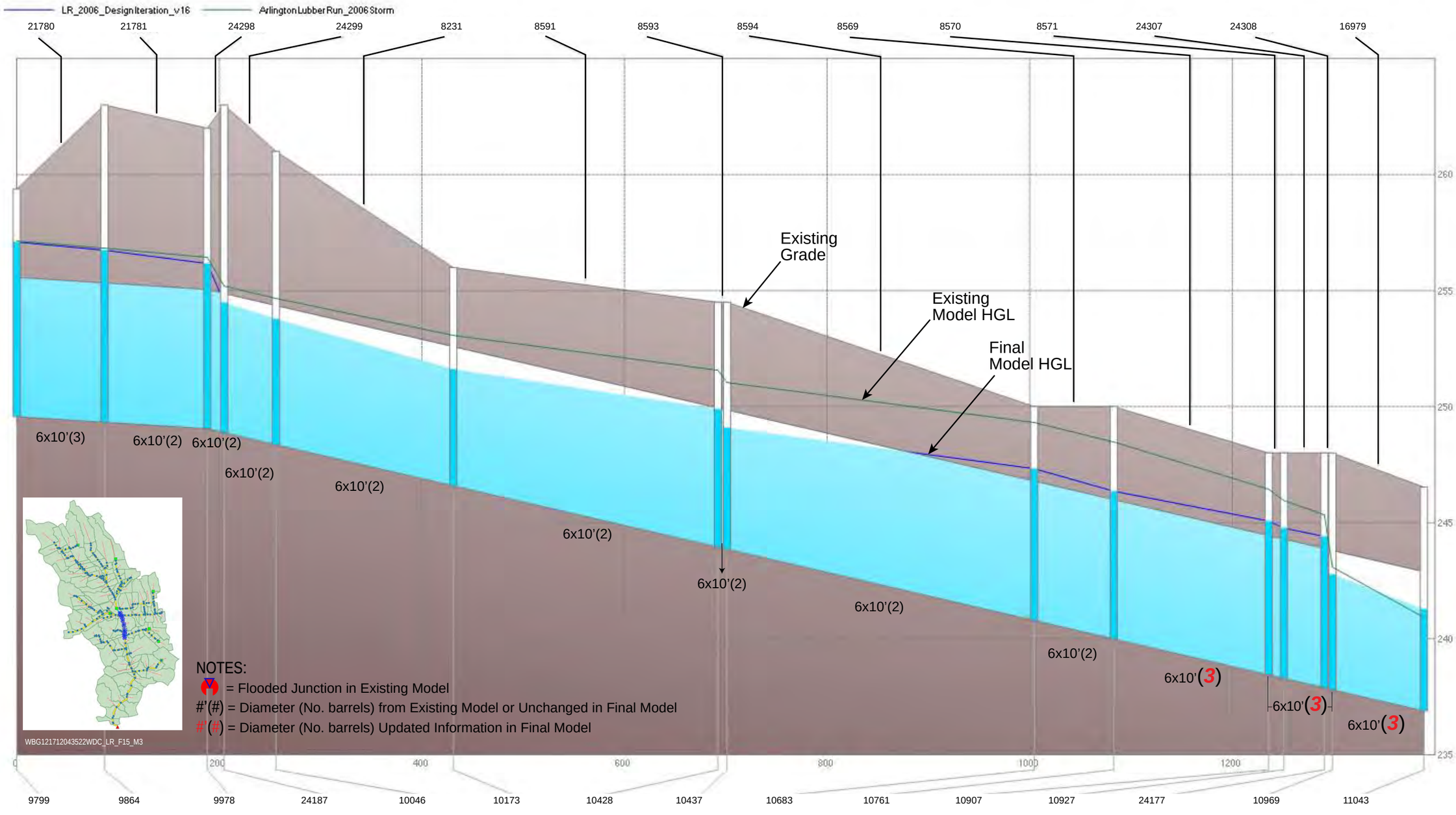


FIGURE 16 - Lubber Run
N. Glebe Rd., between N. Carlin Springs Rd. and Wilson Blvd. for the June 2006 Storm Event

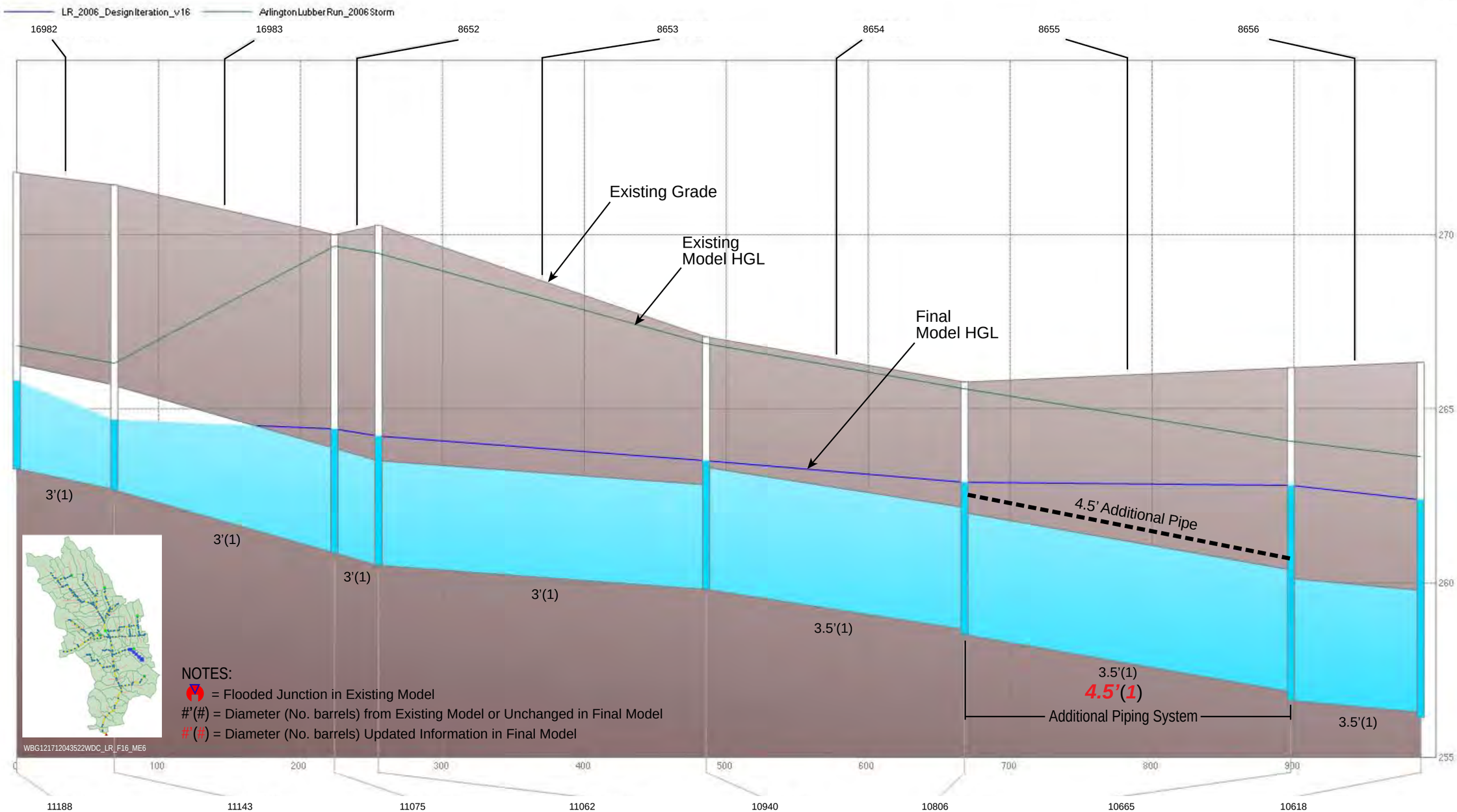


FIGURE 17 - Lubber Run
430 ft North of N. George Mason Dr. and N. Carlin Springs Rd. for the June 2006 Storm Event

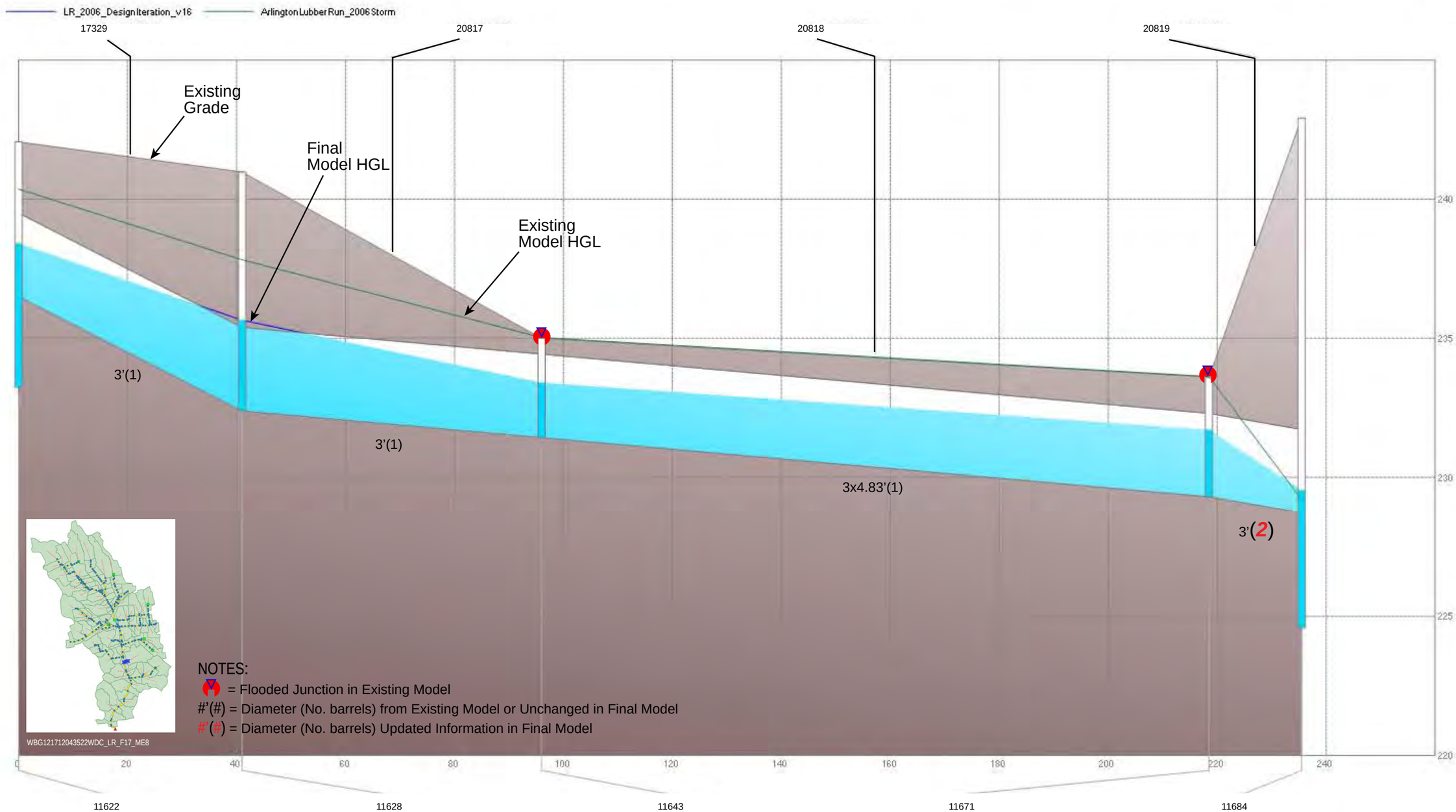
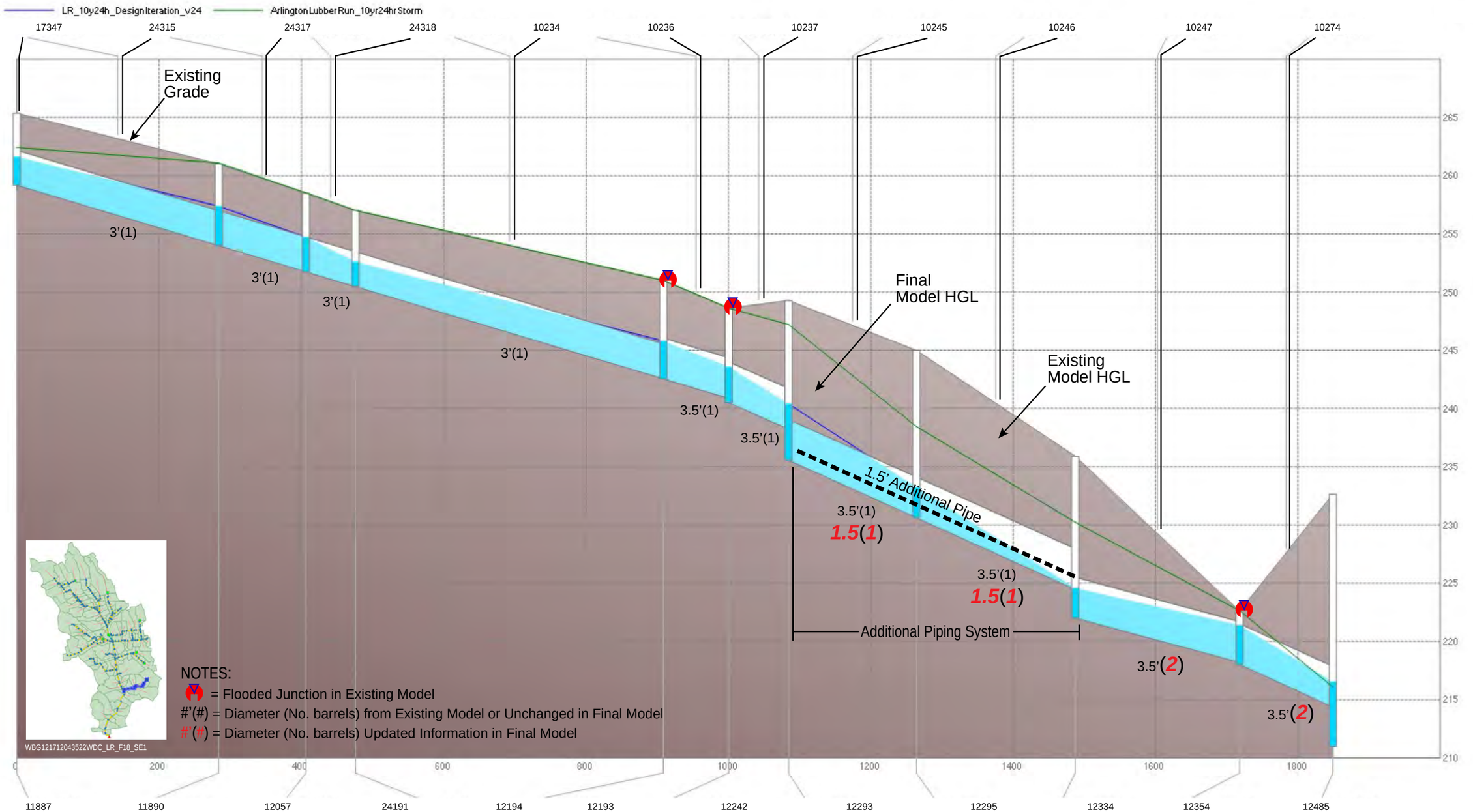


FIGURE 18 - Lubber Run
N. George Mason Dr., between N. Thomas St. and Stream for the June 2006 Storm Event



4.3 10yr-24hr SCS Type II Storm

For the 10yr-24hr SCS Type II storm, capacity was added to 162 conduits (18,494 LF of pipe in total). This equates to 45 percent of the modeled pipe network in Lubber Run.

Changes to diameter and the existing and resulting flows are summarized in **Table 3**. A map showing the 10yr-24hr storm upgrade locations throughout the watershed is included in **Figure 19.** Profiles showing the existing conditions and final results are shown in **Figure 20** through **Figure 44**. Profiles were displayed only for segments of the stormwater network where any of the following conditions were met:

- Pipe size was increased
- An identical barrel was added to the system
- An additional pipe was added to the system

The existing model profile depicts the peak water surface elevation with solid blue fill and peak HGL with a dark blue line. The HGL represents the sum of the pressure head and the elevation head along the profile. Flooded nodes in the existing conditions model are annotated with a red dot behind the junction rim. The final profile displays the existing system HGL with a dark green line for reference.

TABLE 3
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
Upper Area—North of I-66																	
N. George Mason Dr., between 20th St. N. and 19th St. N. (Figure 20, profile continues on Figure 22)																	
5627	5955	6132	185.0	3.5	3.5	1	1			9.6	9.6	3.1	5.4	4.9	4.8	129.1	129.6
5666	6132	6286	178.1	3.5	3.5	1	1			9.6	9.6	5.4	8.2	4.8	3.9	87.9	130.8
5665	6286	6273	72.8	3.5	3.5	1	**2**			9.6	19.2	8.2	6.1	3.9	3.6	108.2	163.7
5672	6273	6302	41.4	3.5	3.5	1	**2**			9.6	19.2	6.1	8.0	3.6	5.0	89.7	163.1
6543	6302	6308	23.4	3.5	3.5	1	**2**			9.6	19.2	8.0	7.1	5.0	4.3	114.9	208.7
6542	6308	6434	178.6	3.5	3.5	1	**2**			9.6	19.2	7.1	8.1	4.3	5.8	114.9	208.8
5727	6434	6460	28.8	3.5	3.5	1	**2**			9.6	19.2	8.1	8.7	5.8	5.3	118.3	216.2
19th St N., between N. Columbus St. and N. George Mason Dr. (Figure 21)																	
5623	6104	6122	30.9	3	3	1	1			7.1	7.1	4.6	3.3	4.7	3.4	49.7	49.7
5640	6122	6180	96.2	3	3	1	1			7.1	7.1	3.3	4.1	3.4	4.2	49.7	49.7
5646	6180	6194	24.7	3	3	1	1			7.1	7.1	4.1	3.9	4.2	4.0	49.7	49.7
5659	6194	6257	130.5	3	3	1	1			7.1	7.1	3.9	3.6	4.0	3.7	49.7	49.7
5678	6257	6313	131.8	3	3	1	1			7.1	7.1	3.6	3.7	3.7	3.9	49.7	49.7
5679	6313	6309	57.3	3	3	1	1			7.1	7.1	3.7	3.2	3.9	3.5	49.7	49.7
5675	6309	6250	69.7	3	3	1	1			7.1	7.1	3.2	2.7	3.5	3.2	49.7	49.7
5689	6250	6341	220.9	3.5	3.5	1	1			9.6	9.6	2.7	2.0	3.2	1.6	96.2	96.3
5716	6341	6423	207.0	3.5	3.5	1	1	**LR3**	**1.5**	9.6	11.4	2.0	7.4	1.6	5.0	96.4	99.6
5726	6423	6460	32.3	3.5	3.5	1	1	**LR4**	**1.5**	9.6	11.4	7.4	8.7	5.0	5.3	77.7	102.1
N. George Mason Dr., between 19th St. N. and 17th Rd. N. (Figure 22, profile continues on Figure 23 West Branch and Figure 24 East Branch)																	
5745	6460	6544	105.7	5	5	1	**2**			19.6	39.3	8.7	12.3	5.3	9.7	178.2	319.1
5768	6544	6676	135.0	5	5	1	**2**			19.6	39.3	12.3	12.2	9.7	9.9	178.2	319.1
5819	6676	6834	185.0	5	5	1	**2**			19.6	39.3	12.2	11.2	9.9	10.2	193.1	333.7
5830	6834	6862	42.0	5	5	1	1	**LR8**	**5.5**	19.6	43.4	11.2	11.7	10.2	9.7	200.7	421.1
24274	6862	24171	31.2	5	5	1	1	**LR5**	**5.5**	19.6	43.4	11.7	10.5	9.7	8.2	200.7	421.1
24275	24171	24161	127.0	5	5	1	1	**LR7**	**5.5**	19.6	43.4	10.5	10.4	8.2	6.9	200.7	421.1
24273	24161	6710	108.0	5	5	1	1	**LR6**	**5.5**	19.6	43.4	10.4	12.5	6.9	6.9	200.7	421.2

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
5786	6710	6727	55.6	5.5	5.5	1	2			23.8	47.5	12.5	12.5	6.9	6.1	200.7	421.2
5887	6727	7005	263.0	5.5	5.5	1	2			23.8	47.5	12.5	7.4	6.1	5.9	200.7	422.4
5891	7005	7014	16.2	5.5	5.5	1	2			23.8	47.5	7.4	6.7	5.9	4.9	222.3	457.5
West Branch along N. Edison St., between 17th Rd. N. and 16th St. N. (Figure 23, profile continues on Figure 25)																	
5912	7014	7076	82.2	4.5	4.5	1	2			15.9	31.8	6.7	6.6	4.9	4.6	159.7	292.6
5946	7076	7153	79.3	4.5	4.5	1	2			15.9	31.8	6.6	6.5	4.6	3.9	160.7	292.3
5991	7153	7269	116.5	4.5	4.5	1	2			15.9	31.8	6.5	9.0	3.9	2.8	158.6	290.0
6043	7269	7423	211.9	4.5	4.5	1	2			15.9	31.8	9.0	15.4	2.8	3.7	150.9	290.5
24258	7423	24162	182.0	4.5	4.5	1	2			15.9	31.8	15.4	7.7	3.7	4.7	180.2	314.3
24259	24162	7494	182.0	4.5	4.5	1	2	LR1	5×7	15.9	66.8	7.7	6.9	4.7	5.6	163.9	324.5
7789	7494	7674	216.0	4.5	4.5	1	1	LR26	5×7	15.9	50.9	6.9	6.7	5.6	5.8	137.6	301.2
16825	7674	7696	32.0	4.5	4.5	1	1	LR24	5×7	15.9	50.9	6.7	6.4	5.8	5.8	137.6	301.5
16827	7696	7695	75.0	4.5	4.5	1	1	LR25	5×7	15.9	50.9	6.4	6.0	5.8	6.5	166.8	368.1
East Branch along N. Edison St., between 17th Rd. N. and 16th St. N. (Figure 24, profile continues on Figure 25)																	
5892	7014	7015	8.0	3.5	3.5	1	1	LR33	5	9.6	29.3	6.7	7.0	4.9	5.5	75.5	168.1
5906	7015	7061	88.7	3.5	3.5	1	1	LR34	5	9.6	29.3	7.0	6.3	5.5	5.3	62.9	165.4
5939	7061	7131	61.5	3.5	3.5	1	1	LR32	5	9.6	29.3	6.3	6.2	5.3	5.3	56.9	168.4
6568	7131	7232	161.7	3.5	3.5	1	1	LR29	5	9.6	29.3	6.2	6.0	5.3	5.5	75.1	217.8
5983	7232	7255	22.5	3.5	3.5	1	1	LR35	5	9.6	29.3	6.0	5.7	5.5	4.9	71.2	220.8
6027	7255	7345	91.0	3.5	3.5	1	1	LR30	5	9.6	29.3	5.7	6.1	4.9	5.0	74.4	230.2
6032	7345	7369	86.2	3.5	3.5	1	1	LR31	5	9.6	29.3	6.1	6.2	5.0	4.9	74.4	227.6
6055	7369	7458	93.0	3.5	3.5	1	1	LR36	5	9.6	29.3	6.2	6.7	4.9	5.2	74.4	225.8
6059	7458	7469	88.0	3.5	3.5	1	1	LR37	5	9.6	29.3	6.7	5.9	5.2	4.0	74.4	226.0
20620	7469	7536	73.0	3.5	3.5	1	1	LR27	5	9.6	29.3	5.9	6.3	4.0	3.9	84.6	247.0
20621	7536	7664	187.0	3.5	3.5	1	1	LR28	6×6	9.6	45.6	6.3	5.3	3.9	5.9	84.6	262.7
7788	7664	7695	37.9	4×7	4×7	1	1	LR38	6×6	28.0	64.0	5.3	6.0	5.9	6.5	86.2	243.2

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
Southeast of N. Edison St., between 16th St. N. and 15th St. N. (Figure 25, profile continues on Figure 26)																	
7798	7695	7724	43.3	4.83×7.58[a]	4.83×7.58[a]	1	1	LR39	6×7	28.8	70.8	6.0	5.4	6.5	6.0	249.1	606.8
7799	7724	7785	66.5	4.83×7.58[a]	4.83×7.58[a]	1	1	LR40	6×7	28.8	70.8	5.4	5.3	6.0	5.9	269.6	624.4
7800	7785	7840	92.8	4.83×7.58[a]	4.83×7.58[a]	1	1	LR41	6×7	28.8	70.8	5.3	5.0	5.9	5.7	269.6	624.3
7801	7840	7834	48.0	4.83×7.58[a]	4.83×7.58[a]	1	1	LR42	6×8	28.8	76.8	5.0	5.1	5.7	6.1	309.4	660.7
7803	7834	7795	53.0	4.83×7.58[a]	4.83×7.58[a]	1	1	LR43	6×8	28.8	76.8	5.1	4.3	6.1	5.6	309.4	661.0
7804	7795	7769	57.0	4.83×7.58[a]	4.83×7.58[a]	1	1	LR44	6×8	28.8	76.8	4.3	3.4	5.6	5.1	309.3	660.7
7805	7769	7874	253.0	5.25×8.17[a]	5.25×8.17[a]	1	1	LR45	5×5	33.7	58.7	3.4	3.3	5.1	5.1	309.0	660.5
7808	7874	7931	118.0	5.25×8.17[a]	5.25×8.17[a]	1	1	LR46	5×5	33.7	58.7	3.3	3.4	5.1	5.1	309.1	655.6
West Branch Southeast of N. Buchanan St., between 15th St. N. and 14th St. N. (Figure 26)																	
7758	7931	7957	77.0	5.25×8.17[a]	5.25×8.17[a]	1	1	LR104	5×5	33.7	58.7	3.4	3.5	5.1	5.0	252.0	575.1
20622	7957	7994	62.0	4×6.33[a]	4×6.33[a]	1	1	LR94	5×5	19.9	44.9	3.5	5.8	5.0	6.6	83.6	290.7
20623	7957	7994	70.3	4.5×6[a]	4.5×6[a]	1	1			21.2	21.2	3.5	5.8	5.0	6.6	192.3	280.0
7760	7994	8028	28.0	6	6	1	1	LR105	6×6	28.3	64.3	5.8	5.6	6.6	6.5	251.7	568.9
7761	8028	8005	55.0	6	6	1	1	LR106	6×8	28.3	76.3	5.6	4.5	6.5	6.0	251.7	569.1
7762	8005	8095	105.0	6	6	1	1	LR107	6	28.3	56.5	4.5	3.7	6.0	4.6	251.7	568.9
20625	8095	8195	141.0	6	6	1	1	LR95	6	28.3	56.5	3.7	4.0	4.6	5.6	251.9	569.1
East Branch Southeast of N. Buchanan St., between 15th St. N. and 14th St. N.																	
16832	7931	7918	45.0	4.5	4.5	1	1			15.9	15.9	3.4	3.1	5.1	4.6	81.8	101.8
16831	7918	7910	43.2	4.5	4.5	1	1			15.9	15.9	3.1	2.9	4.6	4.4	81.8	101.8
16830	7910	7883	38.0	4.5	4.5	1	1			15.9	15.9	2.9	2.8	4.4	4.3	81.9	101.9
7763	7883	7844	96.4	4.5	4.5	1	1			15.9	15.9	2.8	3.1	4.3	4.5	94.1	110.6
7764	7844	7878	35.0	4.5	4.5	1	1			15.9	15.9	3.1	2.7	4.5	3.9	97.1	112.8
7765	7878	8007	113.0	4.5	4.5	1	1			15.9	15.9	2.7	2.3	3.9	3.4	97.0	112.8
20626	8007	8195	224.0	4.5	4.5	1	1			15.9	15.9	2.3	4.0	3.4	5.6	96.9	112.8
N. Cameron St., between 20th St. N. and 18th St. N. (Figure 27)																	
5622	6022	6121	103.0	3	3	1	1			7.1	7.1	2.5	2.4	7.2	5.7	92.3	90.7
5664	6121	6278	149.9	3	3	1	1			7.1	7.1	2.4	6.3	5.7	4.9	85.0	90.7
5698	6278	6372	114.5	3	3	1	1			7.1	7.1	6.3	8.8	4.9	4.2	85.0	90.7

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
5744	6372	6539	202.6	3.5	3.5	1	1			9.6	9.6	8.8	5.6	4.2	2.7	85.0	90.7
5761	6539	6637	115.0	3.5	3.5	1	2			9.6	19.2	5.6	5.3	2.7	2.8	92.0	135.4
5776	6637	6692	40.0	3.5	3.5	1	2			9.6	19.2	5.3	4.8	2.8	3.1	92.0	135.1
5785	6692	6721	60.0	3.5	3.5	1	2			9.6	19.2	4.8	4.0	3.1	2.9	92.0	135.0
5797	6721	6741	21.0	3.5	3.5	1	2			9.6	19.2	4.0	3.0	2.9	2.4	92.0	135.0
5806	6741	6777	42.2	3.5	3.5	1	2			9.6	19.2	3.0	2.3	2.4	2.2	92.2	135.0
6576	6777	6973	213.0	4	4	1	1	LR12	2.5	12.6	17.5	2.3	2.9	2.2	3.2	93.2	135.7
24246	6973	24153	170.0	4	4	1	1	LR10	2.5	12.6	17.5	2.9	3.3	3.2	3.8	127.1	171.7
24247	24153	7198	170.0	4	4	1	1	LR125	2.5	12.6	17.5	3.3	3.7	3.8	4.0	121.5	168.1
6582	7198	7245	56.0	4	4	1	1	LR123	2.5	12.6	17.5	3.7	3.4	4.0	3.5	121.5	166.0
6579	7245	7338	109.3	4	4	1	1	LR13	2.5	12.6	17.5	3.4	3.0	3.5	2.6	121.7	166.2
20422	7338	7445	178.4	4	4	1	1	LR11	3.5	12.6	22.2	3.0	3.8	2.6	5.1	150.5	192.4
N. Abingdon St., between 16th Rd. N. and 16th St. N. (Figure 28)																	
24260	7147	7333	168.0	3.5	3.5	1	1			9.6	9.6	2.7	6.7	3.4	2.4	90.0	113.8
24256	7333	7394	155.0	3	3	1	1	LR16	2.5	7.1	12.0	6.7	5.3	2.4	3.7	90.0	114.1
24305	7394	24160	52.0	3	3	1	1	LR15	2.5	7.1	12.0	5.3	4.2	3.7	3.6	81.8	113.8
24306	24160	7445	15.0	3	3	1	1	LR14	2.5	7.1	12.0	4.2	3.8	3.6	5.1	81.9	113.8
20424	7445	7778	340.0	5	5	1	1	LR17	3	19.6	26.7	3.8	3.7	5.1	5.6	250.2	328.4
7768	7778	8143	339.2	5	5	1	1	LR18	3	19.6	26.7	3.7	4.8	5.6	5.8	270.5	339.6
7769	8143	8156	15.0	5	5	1	1	LR19	3.5	19.6	29.3	4.8	3.2	5.8	4.7	291.6	355.4
Stream between 14th St. N. and Washington Blvd.																	
21835	8156	8229	73.2	Stream	Stream	1	1									291.4	356.0
20628	8195	8229	66.1	Stream	Stream	1	1									390.6	719.3
20649	8229	8423	233.3	Stream	Stream	1	1									680.9	1070.5
8058	8423	8529	136.5	Stream	Stream	1	1									722.4	1106.7
8060	8529	8646	121.5	Stream	Stream	1	1									849.4	1289.4
8061	8646	8746	127.6	Stream	Stream	1	1									743.7	1120.5

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
N. Glebe Rd., between 16th St. N. and I-66 (Figure 29)																	
3009	6907	7023	97.8	3	3	1	1			7.1	7.1	2.3	6.1	3.8	4.0	59.9	66.1
3084	7023	7181	147.7	3	3	1	1	LR52	1.5	7.1	8.8	6.1	4.0	4.0	3.5	59.9	66.1
3108	7181	7233	69.0	3	3	1	1	LR53	1.5	7.1	8.8	4.0	1.9	3.5	1.7	59.9	66.1
3225	7233	7480	243.0	3	3	1	1	LR56	2	7.1	10.2	1.9	4.2	1.7	2.8	60.9	66.6
20414	7480	7588	112.9	3	3	1	1	LR55	2	7.1	10.2	4.2	2.8	2.8	2.7	86.3	107.5
7826	7588	7635	52.0	3	3	1	1	LR57	2	7.1	10.2	2.8	1.9	2.7	1.7	86.3	107.0
7827	7635	7861	228.3	3	3	1	1	LR58	2	7.1	10.2	1.9	2.7	1.7	3.6	88.6	108.2
7829	7861	8025	135.3	3	3	1	1	LR59	2	7.1	10.2	2.7	2.1	3.6	2.6	102.9	125.7
7832	8025	8172	189.2	3	3	1	1	LR60	2	7.1	10.2	2.1	3.8	2.6	4.7	102.9	131.0
7833	8172	8232	67.8	3	3	1	1	LR61	2	7.1	10.2	3.8	3.4	4.7	4.2	120.9	141.9
7837	8232	8260	42.1	3.5	3.5	1	1	LR62	2	9.6	12.8	3.4	3.2	4.2	4.0	120.9	141.9
7838	8260	8308	71.8	3.5	3.5	1	1	LR63	2	9.6	12.8	3.2	3.8	4.0	5.6	120.8	141.9
7839	8308	8360	49.6	3.5	3.5	1	1	LR64	2	9.6	12.8	3.8	3.5	5.6	4.8	120.8	141.7
7840	8360	8386	63.7	3.5	3.5	1	1	LR65	2	9.6	12.8	3.5	2.9	4.8	3.6	120.8	141.7
8063	8386	8526	179.8	3.5	3.5	1	1	LR66	2	9.6	12.8	2.9	2.2	3.6	3.5	120.8	141.1
7998	8526	8569	74.8	5	5	1	1			19.6	19.6	2.2	4.8	3.5	7.5	139.2	155.5
62 ft North of Intersection of Washington Blvd. and I-66																	
16884	8667	8526	147.8	3.5	3.5	1	1			9.6	9.6	0.6	2.2	0.8	3.5	17.9	17.9
Along I-66, Approximately 100 ft Northeast of Washington Blvd.																	
8012	8635	8628	9.2	3.5	3.5	1	1			9.6	9.6	3.4	4.5	6.4	7.4	36.7	36.7
8013	8628	8588	65.5	3.5	3.5	1	1			9.6	9.6	4.5	4.6	7.4	7.4	35.3	36.6
8014	8588	8569	26.6	3.5	3.5	1	1			9.6	9.6	4.6	4.8	7.4	7.5	35.3	36.7
Along I-66, Northeast of Beaver Pond																	
7849	7955	8024	92.7	5	5	1	1			19.6	19.6	8.0	7.7	11.5	10.9	51.8	51.8
7851	8024	8102	139.6	5	5	1	1			19.6	19.6	7.7	7.7	10.9	11.0	51.8	51.8
7864	8102	8250	257.4	5	5	1	1			19.6	19.6	7.7	8.2	11.0	11.2	52.1	52.2
7862	8250	8414	227.5	5	5	1	1			19.6	19.6	8.2	6.1	11.2	11.1	68.6	68.5
8064	8414	8569	202.9	5	5	1	1			19.6	19.6	6.1	5.8	11.1	7.5	69.2	69.3

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
7997	8569	8792	251.7	5×6	5×6	2	2			60.0	60.0	5.8	5.8	7.5	7.3	249.0	265.3
16883	8792	9021	237.1	5×6	5×6	2	2			60.0	60.0	5.8	5.9	7.3	7.4	242.1	265.4
N. George Mason Dr., between Washington Blvd. and I-66 (Figure 30)																	
7941	8915	8922	68.0	3.5	3.5	1	1			9.6	9.6	2.4	2.7	5.3	5.0	115.1	117.8
7954	8922	8995	94.0	3.5	3.5	1	1			9.6	9.6	2.7	1.9	5.0	2.7	115.1	117.8
7994	8995	9184	314.0	3.5	3.5	1	1			9.6	9.6	1.9	2.0	2.7	2.9	112.1	118.0
7988	9184	9348	300.0	3.5	3.5	1	1			9.6	9.6	2.0	2.3	2.9	2.0	111.5	117.6
8220	9348	9455	223.0	3.5	3.5	1	2			9.6	19.2	2.3	3.9	2.0	4.0	137.2	141.9
8162	9455	9464	84.0	4	4	1	2			12.6	25.1	3.9	3.4	4.0	4.2	116.4	152.4
8163	9464	9508	68.0	4	4	1	2			12.6	25.1	3.4	3.0	4.2	4.7	126.4	166.3
24262	9508	24163	52.0	4	4	1	2			12.6	25.1	3.0	2.8	4.7	5.4	143.5	181.8
24263	24163	9614	125.0	4	4	1	1			12.6	12.6	2.8	2.5	5.4	3.5	143.4	181.8
8168	9614	9758	236.2	5	5	1	1			19.6	19.6	2.5	2.6	3.5	3.7	143.4	181.8
16933	9758	9744	42.5	5	5	1	1			19.6	19.6	2.6	2.5	3.7	3.8	143.4	181.8
8219	9744	9711	42.5	5	5	1	1			19.6	19.6	2.5	2.6	3.8	4.1	143.4	181.8
8179	9711	9655	73.7	5	5	1	1			19.6	19.6	2.6	2.9	4.1	4.5	143.4	181.8
8180	9655	9651	41.2	5	5	1	1			19.6	19.6	2.9	3.1	4.5	4.4	143.4	181.8
8181	9651	9725	85.6	5	5	1	1			19.6	19.6	3.1	5.7	4.4	7.6	143.4	181.8
8182	9725	9825	118.8	4.42×6.92[a]	4.42×6.92[a]	1	1			24.0	24.0	5.7	5.6	7.6	6.9	180.4	212.1
West Branch along I-66, between N. Harrison St. and VDOT Pond (Figure 31)																	
8487	10771	10762	227.3	3	3	1	1			7.1	7.1	2.5	2.2	5.0	4.1	38.4	40.5
8488	10762	10687	246.6	3	3	1	1			7.1	7.1	2.2	2.1	4.1	3.3	38.4	40.5
8548	10687	10574	247.2	3	3	1	1			7.1	7.1	2.1	2.3	3.3	2.8	38.4	40.7
8546	10574	10480	247.4	3	3	1	2			7.1	14.1	2.3	3.6	2.8	4.2	38.4	40.2
24267	10480	10289	457.6	4.5	4.5	1	2			15.9	31.8	3.6	4.7	4.2	5.6	101.9	104.2
8201	10289	10101	264.5	4.42×6.92[a]	4.42×6.92[a]	1	2			24.0	48.0	4.7	5.1	5.6	6.1	156.9	153.4
8202	10101	10024	167.2	4.42×6.92[a]	4.42×6.92[a]	1	2			24.0	48.0	5.1	5.5	6.1	6.6	156.9	153.5
8205	10024	9862	209.1	4.42×6.92[a]	4.42×6.92[a]	1	2			24.0	48.0	5.5	5.7	6.6	6.9	156.9	153.5

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8206	9862	9825	39.1	4.42×6.92[a]	4.42×6.92[a]	1	2			24.0	48.0	5.7	5.6	6.9	6.9	176.3	170.9
8183	9825	VDOTPond	138.8	6×8	6×8	2	2			96.0	96.0	5.6	7.6	6.9	8.9	357.6	379.6
West Branch along I-66, 200 ft East of N. Frederick St. (Figure 32)																	
8550	10421	10448	55.3	3	3	1	1			7.1	7.1	2.3	3.6	4.0	4.0	75.9	75.9
8542	10448	10480	61.4	3.5	3.5	1	2			9.6	19.2	3.6	3.6	4.0	4.2	71.3	75.1
Middle Area—between I-66 and N. Carlin Springs Rd.																	
Box Culvert Discharging to the Beaver Pond																	
16865	8746	8787	85.0	6×10	6×10	3	3			180.0	180.0	2.0	2.0	3.7	3.9	737.7	1117.1
16876	8787	8823	45.0	6×10	6×10	3	3			180.0	180.0	2.0	2.0	3.9	4.3	796.5	1164.6
16877	8823	8900	92.2	6×10	6×10	3	3			180.0	180.0	2.0	3.3	4.3	6.0	796.4	1158.2
16858	8900	8979	66.8	6×10	6×10	3	3			180.0	180.0	3.3	4.8	6.0	7.0	795.0	1153.0
16856	8979	9021	37.0	6×10	6×10	3	3			180.0	180.0	4.8	5.2	7.0	7.4	794.4	1153.2
8062	9021	DummyNode2	40.0	6×10	6×10	3	3			180.0	180.0	5.2	11.0	7.4	8.0	1039.1	1390.7
8062_2	DummyNode2	BeaverPond	75.2	4.87×10 [b]	4.87×10[b]	3	3			146.1	146.1	11.0	5.7	8.0	7.3	1029.8	1390.7
Pipe Discharging to Beaver Pond, Coming from East																	
8235	9509	BeaverPond	32.0	3	3	1	1			7.1	7.1	2.1	5.7	3.0	7.3	58.6	58.5
N. Stuart St., between Washington Blvd. and 11th St.; 11th St. N. between N. Stuart St. and N. Utah St. (Figure 33, profile continues on Figure 34)																	
8118	8669	8767	99.6	3	3	1	1	LR9	3	7.1	14.1	3.8	6.7	2.5	3.0	43.3	43.4
8120	8767	8964	185.6	3	3	1	1	LR78	3	7.1	14.1	6.7	5.8	3.0	3.7	43.3	42.8
24276	8964	24172	60.0	3	3	1	1	LR68	4	7.1	19.6	5.8	7.1	3.7	4.4	28.0	47.2
24277	24172	9223	60.0	3	3	1	1	LR69	4.5	7.1	23.0	7.1	7.2	4.4	5.0	28.0	48.5
8102	9223	9260	56.6	4	4	1	1	LR70	5	12.6	32.2	7.2	7.9	5.0	5.3	28.0	45.2
16919	9260	9287	225.1	4	4	1	1	LR75	5	12.6	32.2	7.9	8.4	5.3	6.1	35.9	59.9
16918	9287	9298	136.0	4.5	4.5	1	1	LR72	5	15.9	35.5	8.4	8.9	6.1	6.4	81.2	107.6
16917	9298	9311	148.9	4.5	4.5	1	1	LR71	5	15.9	35.5	8.9	7.6	6.4	7.3	81.2	104.8
11 St. N., between N. Utah St. and Beaver Pond (Figure 34)																	
16920	9311	9326	317.6	5	5	1	1	LR76	5	19.6	39.3	7.6	19.5	7.3	8.0	76.8	142.1
8142	9326	9336	131.1	5	5	1	1	LR80	5	19.6	39.3	19.5	12.7	8.0	8.7	76.8	142.1

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8137	9336	9339	129.4	5	5	1	1	LR79	5	19.6	39.3	12.7	11.2	8.7	9.6	76.8	142.1
8038	9339	9363	48.0	5.5	5.5	1	1	LR73	5	23.8	43.4	11.2	11.3	9.6	9.9	76.8	142.2
8309	9363	9478	139.1	5.5	5.5	1	1	LR74	5	23.8	43.4	11.3	12.0	9.9	10.0	99.9	165.3
8289	9478	9497	26.1	5.5	5.5	1	1	LR86	5	23.8	43.4	12.0	12.0	10.0	9.9	99.9	165.4
8250	9497	9524	89.1	5.5	5.5	1	1	LR85	5	23.8	43.4	12.0	12.0	9.9	9.9	109.4	173.0
24302	9524	DummyNode	208.0	5.5	5.5	1	1	LR87	5	23.8	43.4	12.0	11.7	9.9	10.0	134.9	196.8
24302_2	DummyNode	9543	75.0	5.23[b]	5.23[b]	1	1	LR67	5.23	21.5	43.0	11.7	11.2	10.0	9.8	134.9	196.8
8242	9543	9552	157.6	4.93[b]	4.93[b]	1	1	LR81	4.93	19.1	38.2	11.2	9.8	9.8	9.4	135.0	196.8
8243	9552	9555	110.2	4.5[b]	4.5[b]	1	1	LR82	4.5	15.9	31.8	9.8	8.8	9.4	9.0	135.0	196.8
8245	9555	9561	49.9	3.99[b]	3.99[b]	1	1	LR83	3.99	12.5	25.0	8.8	8.1	9.0	8.5	135.0	196.9
8246	9561	BeaverPond	75.0	3.79[b]	3.79[b]	1	1	LR84	3.79	11.3	22.6	8.1	5.7	8.5	7.3	135.0	196.8
N. Stuart, between 11 St. N. and Fairfax Dr. (Figure 35)																	
24292	24183	24174	185.0	3	3	1	1			7.1	7.1	1.0	1.5	1.3	2.9	28.5	26.9
24280	24174	9404	50.0	3	3	1	2			7.1	14.1	1.5	1.8	2.9	3.3	28.6	25.7
8423	9404	9596	185.1	3	3	1	2			7.1	14.1	1.8	1.9	3.3	3.6	28.6	24.0
8420	9596	9644	50.0	3	3	1	2			7.1	14.1	1.9	2.0	3.6	3.8	22.4	23.9
8318	9644	9734	101.3	3	3	1	2			7.1	14.1	2.0	2.1	3.8	4.0	22.4	25.1
8412	9734	9820	78.2	3.5	3.5	1	2			9.6	19.2	2.1	2.9	4.0	4.9	22.4	27.7
Fairfax Dr., between N. Stafford St. and N. Utah St. (Figure 36, profile continues on Figure 37)																	
8425	9731	9788	53.1	3	3	1	1			7.1	7.1	2.1	2.1	4.1	4.1	25.1	9.5
8426	9788	9797	59.1	3.5	3.5	1	1			9.6	9.6	2.1	2.4	4.1	4.4	25.1	9.6
24281	9797	24175	75.0	3.5	3.5	1	1			9.6	9.6	2.4	2.5	4.4	4.5	40.4	27.9
24282	24175	9809	110.0	3.5	3.5	1	1			9.6	9.6	2.5	2.7	4.5	4.7	40.4	26.6
8330	9809	9820	87.4	3.5	3.5	1	1			9.6	9.6	2.7	2.9	4.7	4.9	40.5	25.0
8335	9820	9856	59.5	4.5	4.5	1	1			15.9	15.9	2.9	2.8	4.9	4.9	41.6	49.6
8434	9856	9860	221.1	4.5	4.5	1	2			15.9	31.8	2.8	3.5	4.9	5.8	70.3	88.8
8435	9860	9871	135.5	5	5	1	2			19.6	39.3	3.5	4.0	5.8	6.4	108.1	122.0
8373	9871	9878	143.5	5	5	1	1			19.6	19.6	4.0	4.7	6.4	6.7	108.1	122.0

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
N. Utah St., between 11th St. N. and Fairfax Dr.																	
8076	9234	9311	75.0	3	3	1	1			7.1	7.1	1.8	7.6	2.7	7.3	67.1	67.0
8419	9311	9463	196.1	3	3	1	1			7.1	7.1	7.6	1.3	7.3	1.1	55.9	17.7
8397	9463	9568	106.1	3	3	1	1			7.1	7.1	1.3	1.7	1.1	1.5	52.1	17.7
8398	9568	9574	7.1	3	3	1	1			7.1	7.1	1.7	1.6	1.5	1.5	52.0	17.7
8399	9574	9693	111.8	3	3	1	1			7.1	7.1	1.6	1.6	1.5	2.0	52.2	17.9
8400	9693	9757	78.9	3	3	1	1			7.1	7.1	1.6	1.5	2.0	2.5	49.2	20.6
8401	9757	9813	48.7	3	3	1	1			7.1	7.1	1.5	1.7	2.5	3.3	49.4	22.8
8402	9813	9878	61.9	3	3	1	1			7.1	7.1	1.7	4.7	3.3	6.7	72.0	36.2
Fairfax Dr., between N. Utah St. and N. Woodrow St. (Figure 37)																	
8374	9878	9884	80.7	6	6	1	1			28.3	28.3	4.7	4.7	6.7	6.7	153.2	146.7
8375	9884	9901	244.1	6	6	1	1			28.3	28.3	4.7	4.9	6.7	6.6	153.2	146.6
8376	9901	9910	148.4	6	6	1	**2**			28.3	56.5	4.9	5.0	6.6	6.9	182.2	168.5
8387	9910	9877	35.8	6	6	1	1			28.3	28.3	5.0	4.7	6.9	6.4	182.1	168.5
8388	9877	9889	45.3	6	6	1	1			28.3	28.3	4.7	4.3	6.4	6.0	182.2	168.6
8440	9889	9896	150.6	6	6	1	1			28.3	28.3	4.3	4.2	6.0	5.9	219.5	199.4
16586	9896	9925	218.0	6	6	1	1			28.3	28.3	4.2	4.4	5.9	5.9	226.5	202.6
8263	9925	9926	197.8	6	6	1	1			28.3	28.3	4.4	3.5	5.9	5.2	225.8	202.1
8264	9926	9940	129.7	6	6	1	1			28.3	28.3	3.5	4.4	5.2	5.8	222.4	200.9
8265	9940	9977	32.0	6	6	1	1			28.3	28.3	4.4	4.1	5.8	5.0	221.9	200.6
8262	9977	10046	67.1	6	6	1	1			28.3	28.3	4.1	6.3	5.0	6.4	265.9	237.4
Fairfax Dr., between N. George Mason Dr. and VDOT Pond																	
8197	10077	10036	182.6	3	3	1	1			7.1	7.1	5.1	5.6	6.4	7.2	26.2	25.6
8305	10036	10013	206.8	3	3	1	1			7.1	7.1	5.6	6.4	7.2	7.7	26.2	25.6
8224	10013	VDOTPond	109.4	3	3	1	1			7.1	7.1	6.4	7.6	7.7	8.9	26.2	25.6
Pipe Discharging to VDOT Pond, Coming from the East																	
8291	9507	9545	50.2	3	3	1	1			7.1	7.1	3.6	4.4	5.7	6.2	28.9	28.9
8295	9545	9556	23.9	3	3	1	1			7.1	7.1	4.4	4.9	6.2	6.5	28.9	28.9

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8302	9556	9696	160.7	3	3	1	1			7.1	7.1	4.9	6.0	6.5	7.2	28.9	28.9
16937	9696	VDOTPond	96.5	3	3	1	1			7.1	7.1	6.0	7.6	7.2	8.9	28.9	28.9
Pipes out of VDOT Pond, between I-66 and Fairfax Dr.																	
16948	9851	9897	240.0	6×8	6×8	2	2			96.0	96.0	5.9	6.5	7.4	8.0	306.9	351.9
8226	9897	9930	136.3	6×8	6×8	2	2			96.0	96.0	6.5	6.9	8.0	8.3	299.0	361.4
8227	9930	9938	18.8	6×8	6×8	2	2			96.0	96.0	6.9	6.9	8.3	8.3	298.3	361.9
8228	9938	9961	80.6	6×8	6×8	2	2			96.0	96.0	6.9	7.1	8.3	8.5	299.6	361.5
8229	9961	9978	92.8	6×8	6×8	2	2			96.0	96.0	7.1	7.4	8.5	8.7	306.4	365.8
Downstream from the VDOT and Beaver Ponds, between Fairfax Dr. and Wilson Blvd. (Figure 38)																	
21780	9799	9864	86.6	6×10	6×10	3	3			180.0	180.0	7.5	7.5	9.4	9.1	905.8	1141.4
21781	9864	9978	101.5	6×10	6×10	2	2			120.0	120.0	7.5	7.4	9.1	8.7	905.7	1141.4
24298	9978	24187	16.6	6×10	6×10	2	2			120.0	120.0	7.4	6.3	8.7	6.8	1142.8	1397.3
24299	24187	10046	51.2	6×10	6×10	2	2			120.0	120.0	6.3	6.3	6.8	6.4	1142.4	1397.4
8231	10046	10173	175.0	6×10	6×10	2	2			120.0	120.0	6.3	6.4	6.4	5.3	1243.5	1529.6
8591	10173	10428	261.2	6×10	6×10	2	2			120.0	120.0	6.4	7.6	5.3	5.4	1243.6	1530.7
8593	10428	10437	9.0	6×10	6×10	2	2	LR114	8×10	120.0	200.0	7.6	7.2	5.4	4.9	1243.6	1532.3
8594	10437	10683	303.3	6×10	6×10	2	2	LR115	8×10	120.0	200.0	7.2	8.5	4.9	7.3	1273.3	1570.9
8569	10683	10761	78.5	6×10	6×10	2	2	LR111	8×10	120.0	200.0	8.5	8.5	7.3	7.6	1261.3	1569.2
8570	10761	10907	152.9	6×10	6×10	2	2	LR112	8×10	120.0	200.0	8.5	8.0	7.6	7.7	1205.1	1636.1
8571	10907	10927	15.0	6×10	6×10	2	2	LR113	8×10	120.0	200.0	8.0	7.7	7.7	7.5	1205.4	1636.9
24307	10927	24177	40.0	6×10	6×10	2	2	LR108	8×10	120.0	200.0	7.7	7.5	7.5	7.5	1205.4	1637.2
24308	24177	10969	8.0	6×10	6×10	2	2	LR109	8×10	120.0	200.0	7.5	5.3	7.5	5.7	1351.2	1784.3
16979	10969	11043	90.3	6×10	6×10	2	2	LR110	8×10	120.0	200.0	5.3	4.0	5.7	4.9	1350.3	1784.4
8th Rd. N., between N. Buchanan St. and N. Woodrow St. (Figure 39)																	
8555	10686	10726	104.2	3	3	1	1	LR88	2	7.1	10.2	1.6	3.1	2.3	3.6	64.9	65.1
8556	10726	10701	52.0	3	3	1	1	LR89	2	7.1	10.2	3.1	2.5	3.6	2.8	46.5	63.1
8557	10701	10672	51.6	3	3	1	1	LR90	2	7.1	10.2	2.5	2.7	2.8	3.1	46.6	63.3
8558	10672	10648	47.8	3	3	1	1	LR91	2	7.1	10.2	2.7	2.4	3.1	2.8	45.5	62.9

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
8559	10648	10678	138.0	3	3	1	1	LR92	2	7.1	10.2	2.4	2.7	2.8	2.4	45.5	62.6
8560	10678	10695	50.0	3	3	1	1	LR93	2	7.1	10.2	2.7	2.6	2.4	1.9	45.5	62.6
8563	10695	10733	50.0	3	3	1	1	LR22	2.5	7.1	12.0	2.6	2.7	1.9	1.7	45.5	62.5
8565	10733	10746	36.0	3	3	1	1	LR23	3	7.1	14.1	2.7	4.0	1.7	3.3	45.5	62.2
8566	10746	10722	102.0	3	3	1	1	LR47	4×8	7.1	39.1	4.0	4.8	3.3	4.8	45.5	63.2
8567	10722	10761	49.5	3	3	1	1	LR48	4×8	7.1	39.1	4.8	8.5	4.8	7.6	77.3	104.4
N. Glebe Rd., between N. Carlin Springs Rd. and Wilson Blvd. (Figure 40)																	
16982	11188	11143	68.8	3	3	1	1			7.1	7.1	3.5	3.6	3.6	3.0	44.1	54.6
16983	11143	11075	155.0	3	3	1	1			7.1	7.1	3.6	9.1	3.0	3.6	44.1	54.0
8652	11075	11062	31.0	3	3	1	1			7.1	7.1	9.1	9.5	3.6	3.7	44.1	53.8
8653	11062	10940	231.0	3	3	1	1	LR49	3.5	7.1	16.7	9.5	7.3	3.7	4.9	44.1	52.9
8654	10940	10806	182.0	3.5	3.5	1	1	LR50	3.5	9.6	19.2	7.3	7.3	4.9	6.3	66.4	75.5
8655	10806	10665	230.0	3.5	3.5	1	1	LR51	4	9.6	22.2	7.3	7.4	6.3	9.2	66.4	72.3
8656	10665	10618	91.4	3.5	3.5	1	1	LR54	4	9.6	22.2	7.4	8.4	9.2	8.2	66.4	72.3
Wilson Blvd., between N. Glebe Rd. and N. Abingdon St. (Figure 41)																	
8639	10566	10583	161.7	3	3	1	1			7.1	7.1	5.9	6.5	5.5	7.2	51.4	53.8
8640	10583	10618	118.2	3	3	1	1			7.1	7.1	6.5	8.4	7.2	8.2	51.4	53.7
8657	10618	10614	100.0	3.5	3.5	1	1	LR77	4	9.6	22.2	8.4	9.2	8.2	10.7	101.2	108.2
8658	10614	10679	158.0	4	4	1	1			12.6	12.6	9.2	9.4	10.7	10.8	101.2	108.2
8659	10679	10696	67.2	4	4	1	1			12.6	12.6	9.4	9.0	10.8	10.4	119.5	125.0
8660	10696	10744	132.0	4	4	1	1			12.6	12.6	9.0	8.9	10.4	10.8	119.5	125.0
8672	10744	10824	233.0	4	4	1	1			12.6	12.6	8.9	6.4	10.8	6.9	119.5	125.0
8578	10824	10879	173.0	4	4	1	1			12.6	12.6	6.4	2.3	6.9	2.5	140.5	143.4
24313	10879	24190	125.0	4	4	1	1			12.6	12.6	2.3	2.4	2.5	3.4	140.1	143.1
24314	24190	24176	122.0	4	4	1	1			12.6	12.6	2.4	5.2	3.4	6.0	139.0	141.8
24285	24176	24177	5.0	4	4	1	1			12.6	12.6	5.2	7.5	6.0	7.5	139.0	141.7

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
N. George Mason Dr., between 8th Rd. N. and Stream; Immediately Upstream of 7th St. N. (Figure 42)																	
8507	10974	10951	84.0	3	3	1	1			7.1	7.1	3.4	3.3	5.2	4.6	40.6	38.7
8508	10951	10990	40.0	3	3	1	1			7.1	7.1	3.3	2.8	4.6	3.7	40.6	38.7
8509	10990	10943	125.0	3	3	1	1			7.1	7.1	2.8	2.1	3.7	2.8	40.6	38.7
8512	10943	11014	86.0	3.5	3.5	1	1			9.6	9.6	2.1	1.8	2.8	2.7	41.6	38.8
24271	11014	24169	142.0	3.5	3.5	1	1			9.6	9.6	1.8	2.2	2.7	3.4	44.7	40.0
24272	24169	11179	108.0	3.5	3.5	1	1			9.6	9.6	2.2	2.4	3.4	3.6	46.6	41.5
8514	11179	11241	88.6	4	4	1	1			12.6	12.6	2.4	2.9	3.6	4.1	64.7	68.0
8517	11241	11221	107.0	4	4	1	1			12.6	12.6	2.9	3.0	4.1	4.1	64.8	68.2
8518	11221	11225	39.0	4	4	1	1			12.6	12.6	3.0	2.7	4.1	3.8	65.5	68.4
8519	11225	11182	157.0	4	4	1	1			12.6	12.6	2.7	2.8	3.8	3.9	66.9	68.7
24309	11182	24188	97.4	4	4	1	1			12.6	12.6	2.8	2.3	3.9	2.9	95.9	104.8
24310	24188	11357	205.8	4	4	1	1			12.6	12.6	2.3	2.9	2.9	4.2	95.9	104.9
17327	11357	11521	298.7	4	4	1	1	LR96	2	12.6	15.7	2.9	5.3	4.2	5.8	91.2	106.6
24283	11521	11517	29.8	4	4	1	1	LR99	2.5	12.6	17.5	5.3	3.5	5.8	4.1	155.3	176.9
24311	11517	24189	54.8	4	4	1	1	LR98	2.5	12.6	17.5	3.5	2.8	4.1	3.1	155.3	176.0
24312	24189	11502	170.3	4	4	1	1	LR97	2.5	12.6	17.5	2.8	3.6	3.1	3.8	155.3	178.1
17315	11502	11495	40.9	4	4	1	1	LR100	2.5	12.6	17.5	3.6	2.5	3.8	2.6	155.3	175.6
17316	11495	11476	154.1	4	4	1	1	LR101	2.5	12.6	17.5	2.5	2.3	2.6	3.3	155.3	178.5
17317	11476	11449	169.9	4	4	1	1	LR102	2.5	12.6	17.5	2.3	5.7	3.3	7.6	155.3	181.5
17318	11449	11483	81.2	4.5	4.5	1	1	LR103	2.5	15.9	20.8	5.7	4.6	7.6	5.6	191.9	208.1
430 ft North of N. George Mason Dr. and N. Carlin Springs Rd. (Figure 43)																	
17329	11622	11628	41.0	3	3	1	1			7.1	7.1	7.1	5.4	6.5	4.8	99.4	114.1
20817	11628	11643	55.0	3	3	1	1			7.1	7.1	5.4	3.6	4.8	2.5	99.4	114.1
20818	11643	11671	122.5	3×4.83[a]	3×4.83[a]	1	1			11.6	11.6	3.6	4.3	2.5	2.9	86.3	114.1
20819	11671	11684	17.0	3	3	1	2			7.1	14.1	4.3	4.6	2.9	5.6	76.0	114.1
Stream between Wilson Blvd. and N. Carlin Springs Rd.																	
10111	11043	11254	316.3	Stream	Stream	1	1									1351.2	1785.1

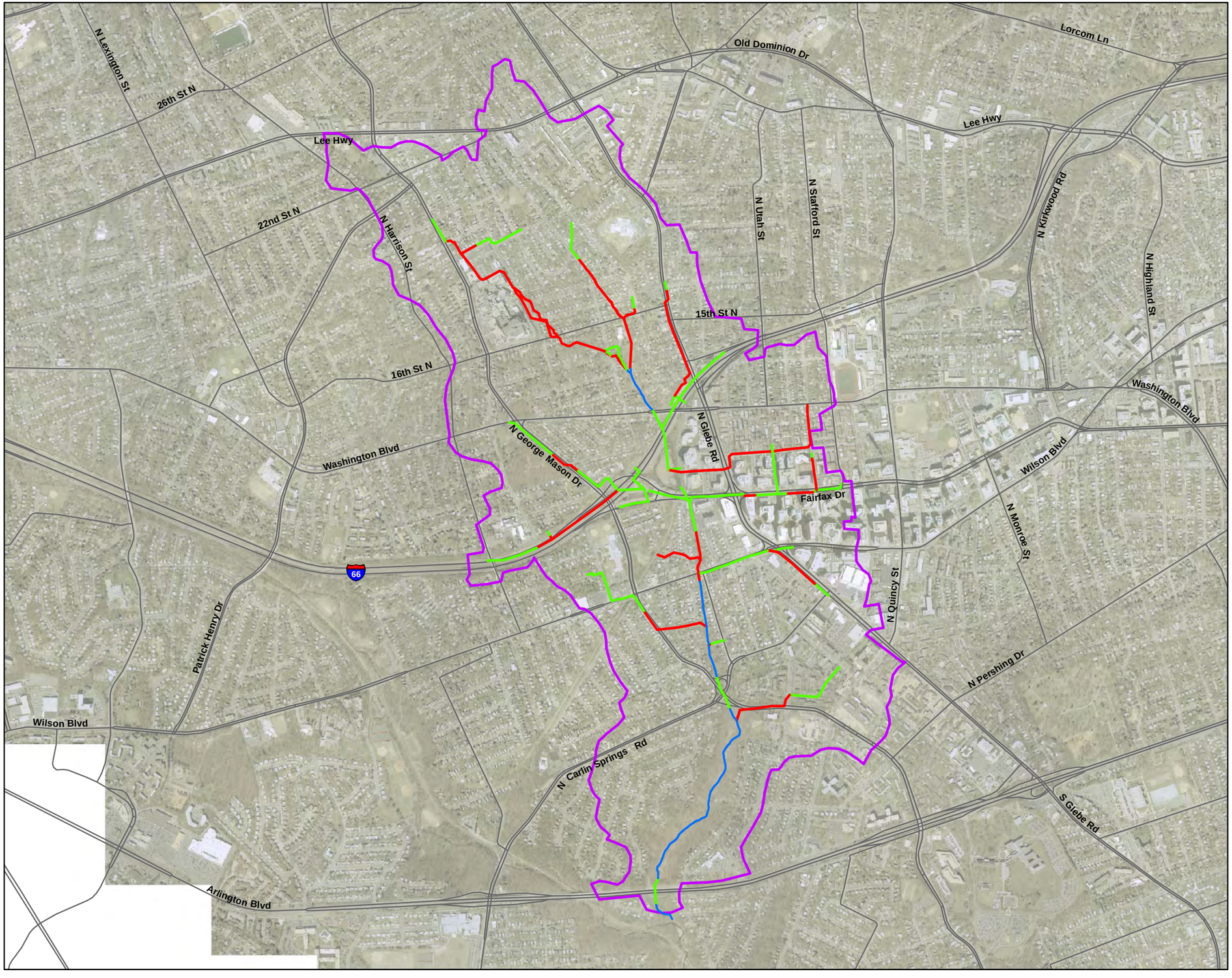
TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
20822	11254	11427	255.5	Stream	Stream	1	1									1365.9	1793.8
20823	11427	11483	85.0	Stream	Stream	1	1									1383.9	1806.7
20820	11483	11684	275.4	Stream	Stream	1	1									1575.1	1996.0
10229	11684	11987	466.0	Stream	Stream	1	1									1654.2	2111.6
Box Culvert between N. Carlin Springs Rd. and 4th Rd. N.																	
17366	11987	11996	17.0	8×10	8×10	2	2			160.0	160.0	8.7	7.9	12.5	10.9	1647.9	2017.6
17367	11996	12009	18.9	8×10	8×10	2	2			160.0	160.0	7.9	7.5	10.9	10.2	1648.2	2017.6
17368	12009	12042	35.0	8×10	8×10	2	2			160.0	160.0	7.5	7.0	10.2	9.5	1657.2	2023.8
10198	12042	12071	37.0	8×10	8×10	2	2			160.0	160.0	7.0	6.5	9.5	8.7	1690.1	2044.7
10199	12071	12208	199.3	8×10	8×10	2	2			160.0	160.0	6.5	6.6	8.7	8.2	1703.1	2052.1
10200	12208	12238	45.7	8×10	8×10	2	2			160.0	160.0	6.6	5.9	8.2	7.3	1714.3	2057.4
10201	12238	12333	132.3	8×10	8×10	2	2			160.0	160.0	5.9	3.5	7.3	4.1	1749.7	2078.2
South Area—South of N. Carlin Springs Rd.																	
N. George Mason Dr., between N. Thomas St. and Stream (Figure 44)																	
17347	11887	11890	6.0	3	3	1	1			7.1	7.1	5.1	3.7	4.3	2.4	61.1	62.6
24315	11890	12057	283.7	3	3	1	1			7.1	7.1	3.7	7.0	2.4	3.3	61.8	62.5
24317	12057	24191	122.5	3	3	1	1			7.1	7.1	7.0	6.8	3.3	2.9	61.8	62.5
24318	24191	12194	69.7	3	3	1	1			7.1	7.1	6.8	6.5	2.9	2.1	62.1	62.5
10234	12194	12193	432.6	3	3	1	1			7.1	7.1	6.5	8.5	2.1	3.2	66.2	62.4
10236	12193	12242	91.8	3.5	3.5	1	1	LR120	2.5	9.6	14.5	8.5	8.1	3.2	3.1	89.6	113.3
10237	12242	12293	84.0	3.5	3.5	1	1	LR121	2.5	9.6	14.5	8.1	12.8	3.1	4.8	101.0	139.6
10245	12293	12295	179.8	3.5	3.5	1	1	LR122	3	9.6	16.7	12.8	14.4	4.8	2.6	155.2	222.0
10246	12295	12334	223.0	3.5	3.5	1	1	LR20	3	9.6	16.7	14.4	13.9	2.6	2.6	155.2	221.8
10247	12334	12354	231.0	3.5	3.5	1	1	LR21	4×4	9.6	25.6	13.9	4.6	2.6	3.3	155.2	222.2
10274	12354	12485	131.0	3.5	3.5	1	1	LR2	4×4	9.6	25.6	4.6	4.8	3.3	5.6	117.2	260.6
Between N. George Mason Dr. and Outfall																	
10230	12333	12362	34.7	Stream	Stream	1	1									1749.8	2078.2
10231	12362	12485	166.8	Stream	Stream	1	1									1750.4	2078.6
10344	12485	12622	213.7	Stream	Stream	1	1									1866.8	2237.1

TABLE 3 (CONTINUED)
10yr-24hr Storm Event: Final Iteration Results Summary

	Node ID			Size (Diameter or H × W) (ft)		No. of Barrels		Additional Pipe		Equivalent Cross-Sectional Area (ft^2)		Existing HGL		Final HGL		Flow (cfs)	
Conduit ID	US	DS	Length (ft)	Existing	Final	Existing	Final	Model ID	Diameter (ft)	Existing	Final	US (ft)	DS (ft)	US (ft)	DS (ft)	Existing	Final
10348	12622	12885	509.2	Stream	Stream	1	1									1903.6	2261.2
17391	12885	13251	508.6	Stream	Stream	1	1									1961.7	2300.0
17392	13251	13298	54.5	Stream	Stream	1	1									1963.2	2300.3
20855	13298	13397	110.5	Stream	Stream	1	1									2000.8	2324.8
20856	13397	13762	496.4	Stream	Stream	1	1									2033.3	2344.5
10402	13762	14008	336.3	Stream	Stream	1	1									3014.3	7249.6
10403	14008	14405	528.9	Stream	Stream	1	1									4992.5	10468.8
21160	14405	14510	110.0	7×12[a]	7×12[a]	1	1			78.0	78.0	24.3	17.6	23.6	16.6	1447.6	1608.0
18030	14510	14737	252.5	7×12[a]	7×12[a]	1	1			78.0	78.0	17.6	9.4	16.6	8.0	1453.3	1614.2
18035	14737	14764	37.6	Stream	Stream	1	1									1450.8	1614.7
18036	14764	14919	351.6	Stream	Stream	1	1									1577.9	1756.5

US, upstream; DS, downstream. Note that cross-sectional area and HGL are not calculated for natural stream sections. The existing and final HGL data represent maximum node depths.
[a] Irregularly shaped pipe, such as arch, elliptical.
[b] Pipes modified in Task 2 to model the impact of sedimentation.



VICINITY MAP

Legend

- Modeled Stormwater Mains with Recommended Additional Capacity
- Modeled Stormwater Mains with Sufficient Existing Capacity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 19
Recommended Additional Capacity for the 10-yr, 24-hr Storm
Lubber Run Watershed
Arlington County Storm Capacity Analysis

CH2MHILL

FIGURE 20 - Lubber Run
N. George Mason Dr., between 20th St. N. and 19th St. N. for the 10yr-24hr Storm Event

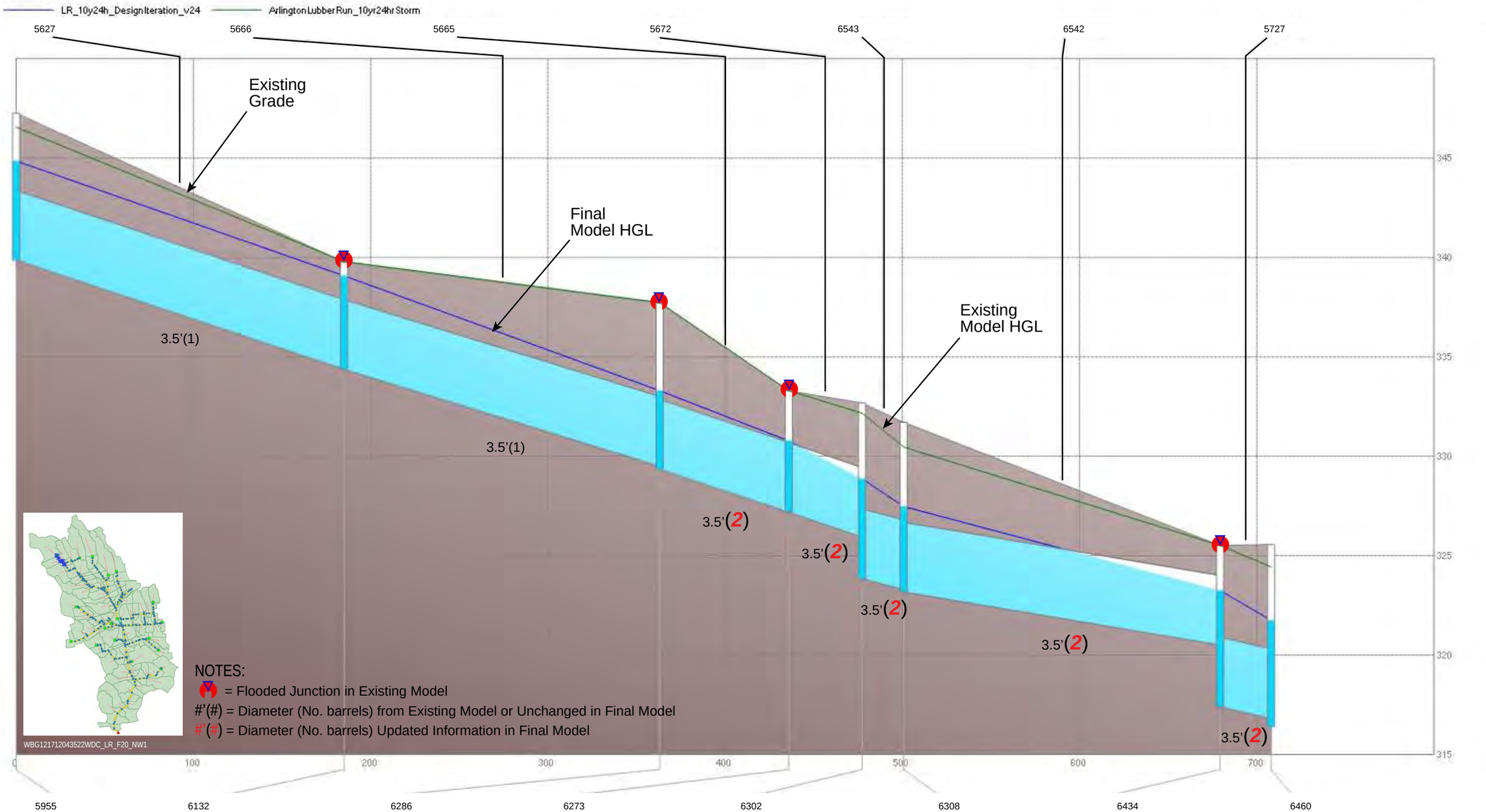


FIGURE 21 - Lubber Run
19th St. N., between N. Columbus St. and N. George Mason Dr. for the 10yr-24hr Storm Event

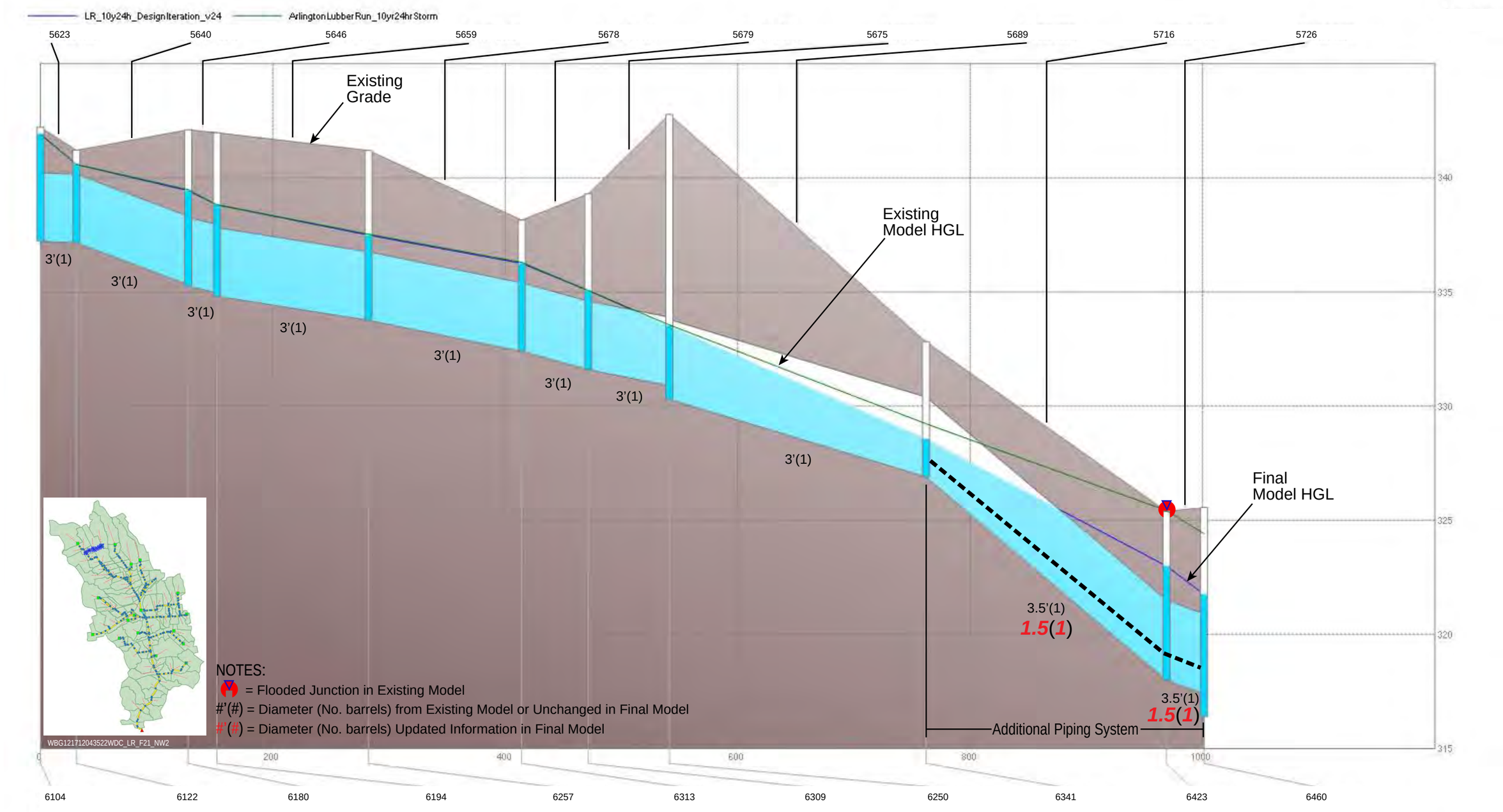


FIGURE 22 - Lubber Run
N. George Mason Dr., between 19th St. N. and 17th Rd. N. for the 10yr-24hr Storm Event

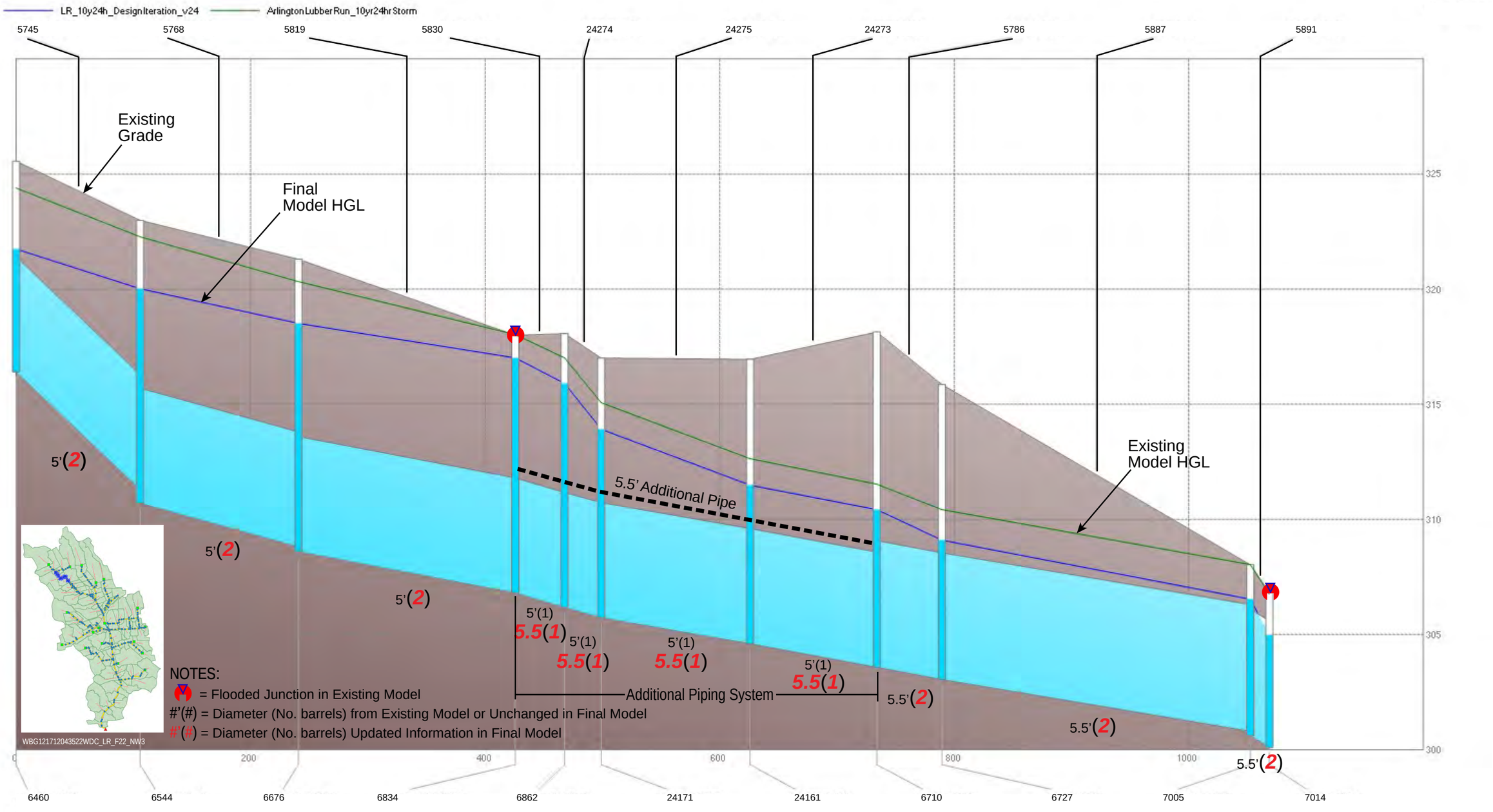


FIGURE 23 - Lubber Run
West Branch along N. Edison St., between 17th Rd. N. and 16th St. N. for the 10yr-24hr Storm Event

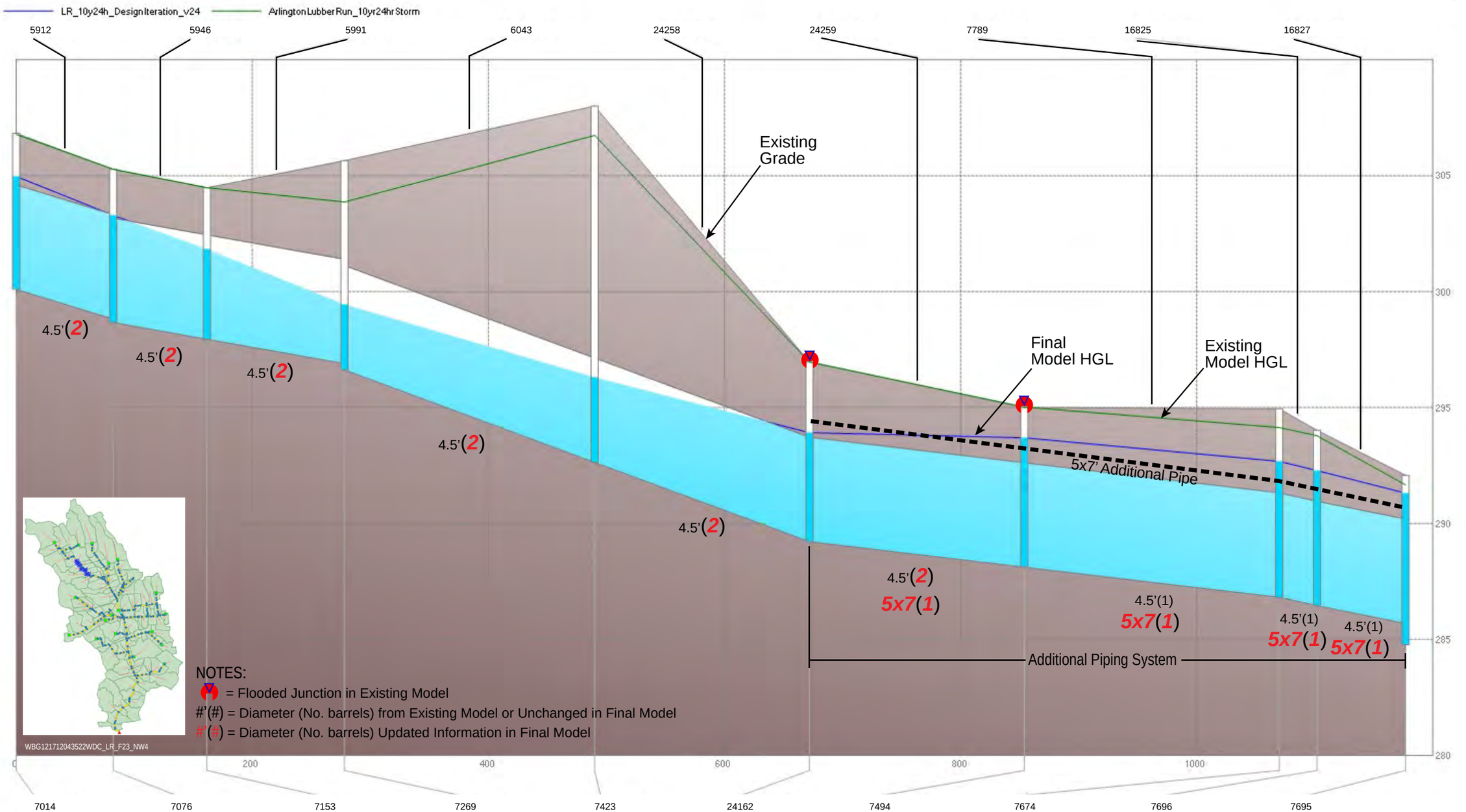


FIGURE 24 - Lubber Run
East Branch along N. Edison St., between 17th Rd. N. and 16th St. N. for the 10yr-24hr Storm Event

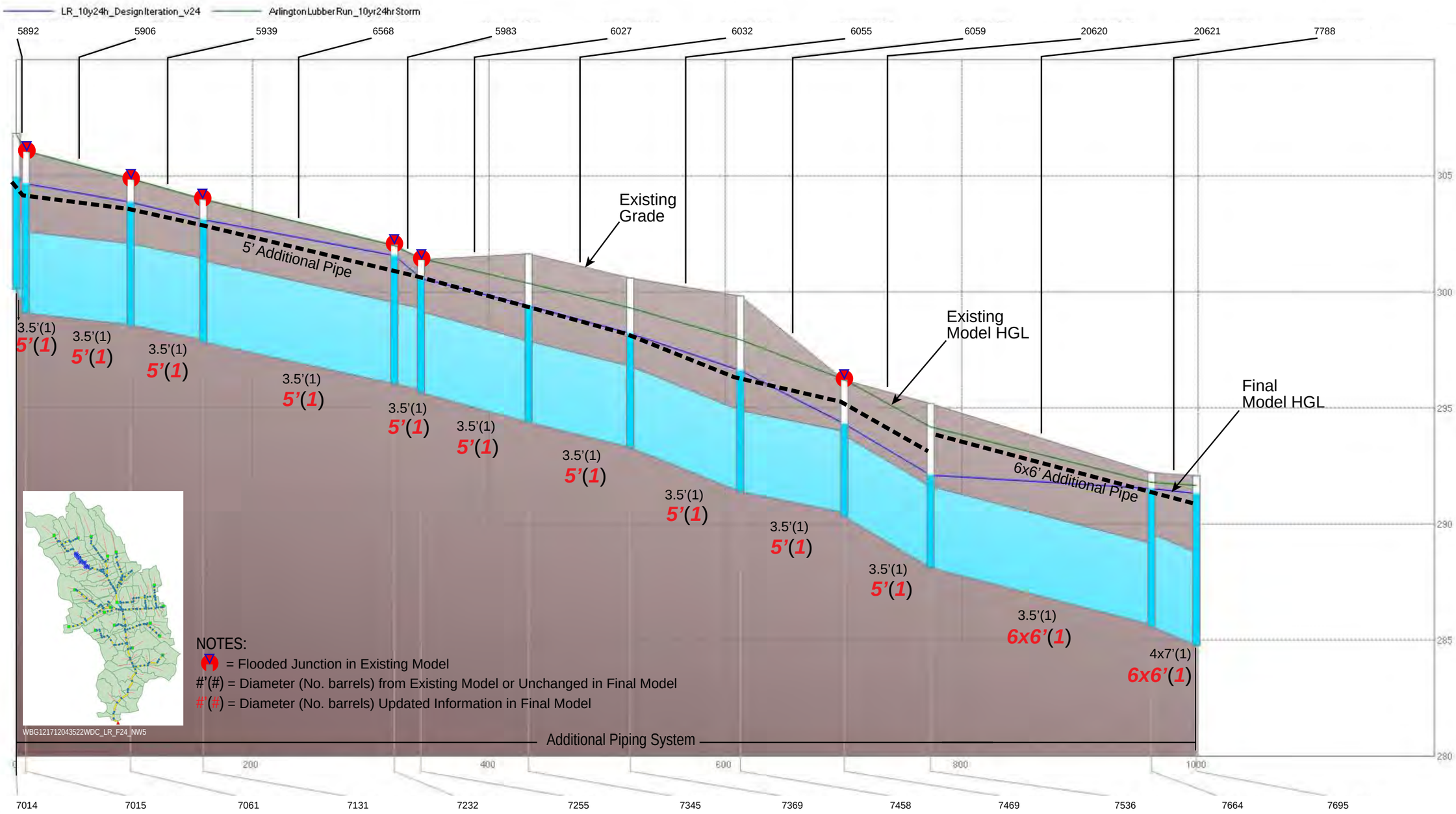


FIGURE 25 - Lubber Run
Southeast of N. Edison St., between 16th St. N. and 15th St. N. for the 10yr-24hr Storm Event

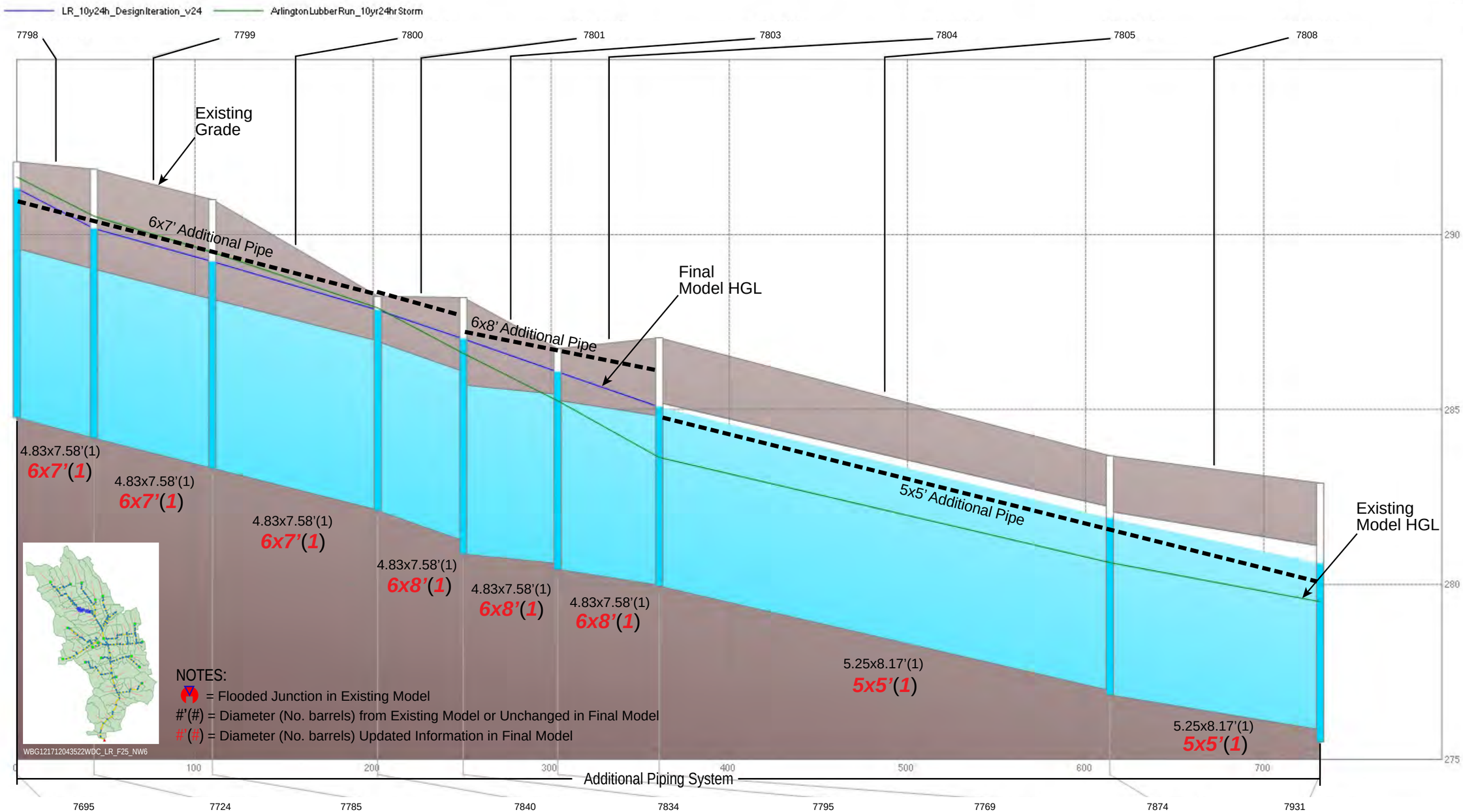


FIGURE 26 - Lubber Run
West Branch Southeast of N. Buchanan St., between 15th St. N. and 14th St. N. for the 10yr-24hr Storm Event

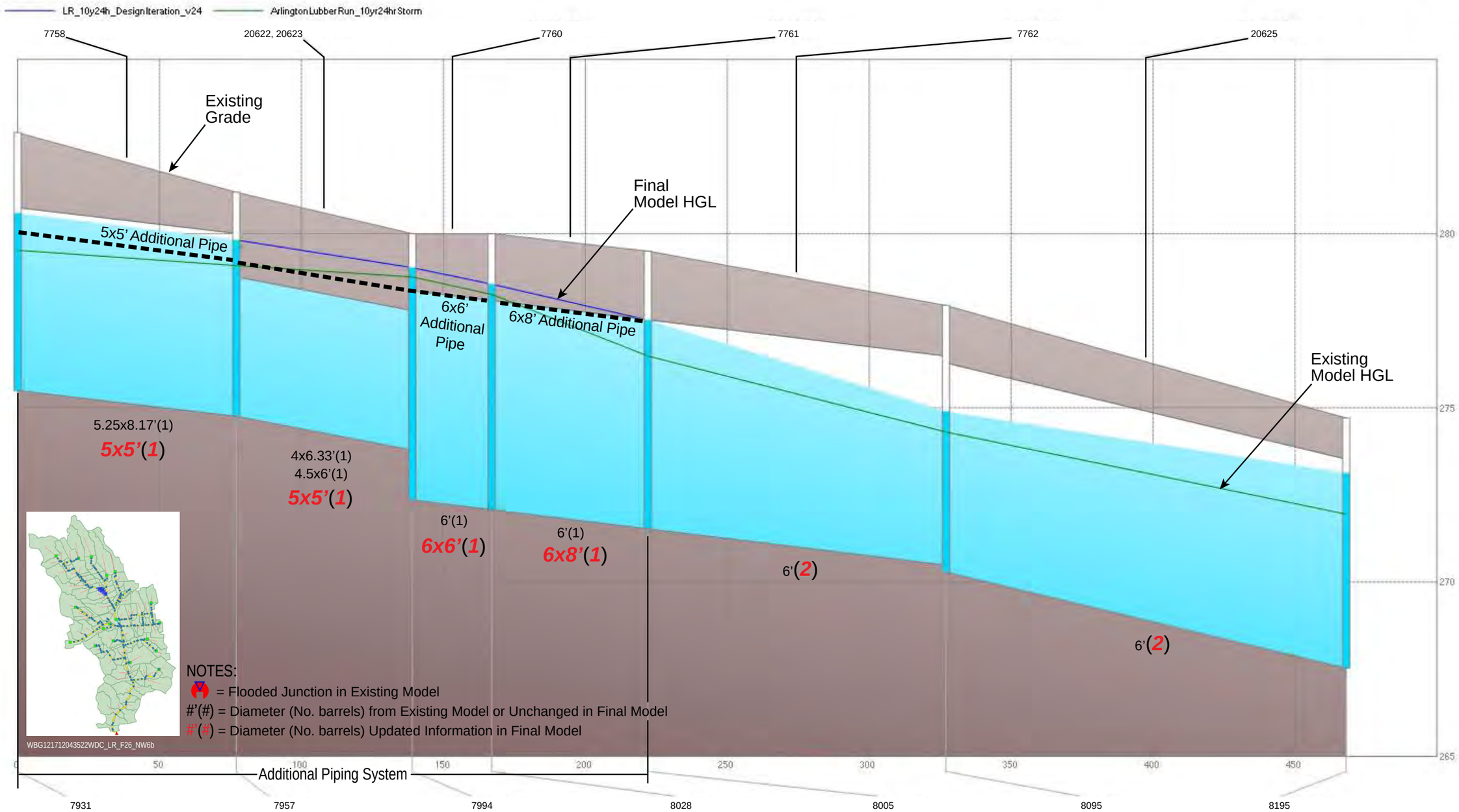


FIGURE 27 - Lubber Run
N. Cameron St., between 20th St. N. and 18th St. N. for the 10yr-24hr Storm Event

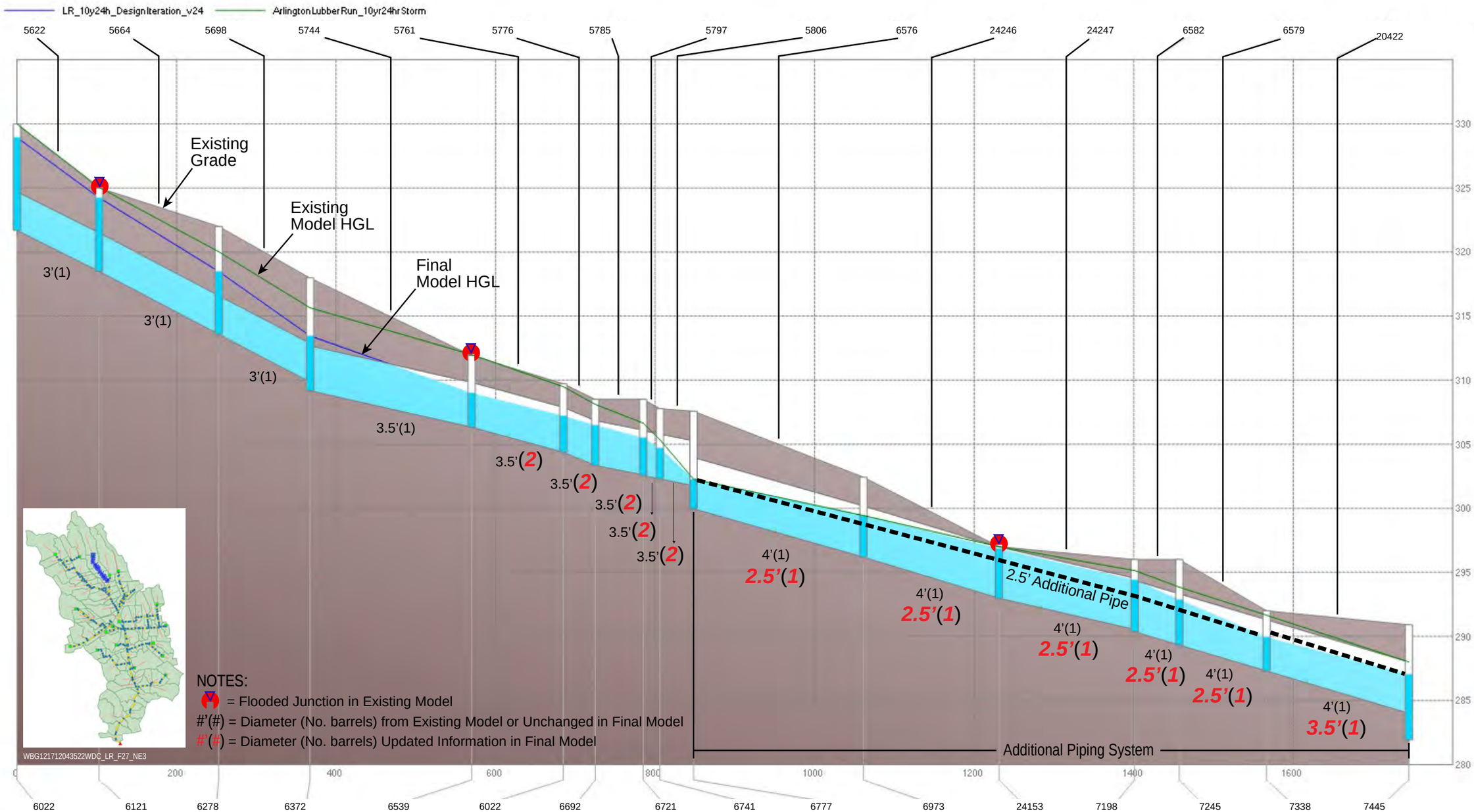


FIGURE 28 - Lubber Run
N. Abingdon St., between 16th Rd. N. and 16th St. N. for the 10yr-24hr Storm Event

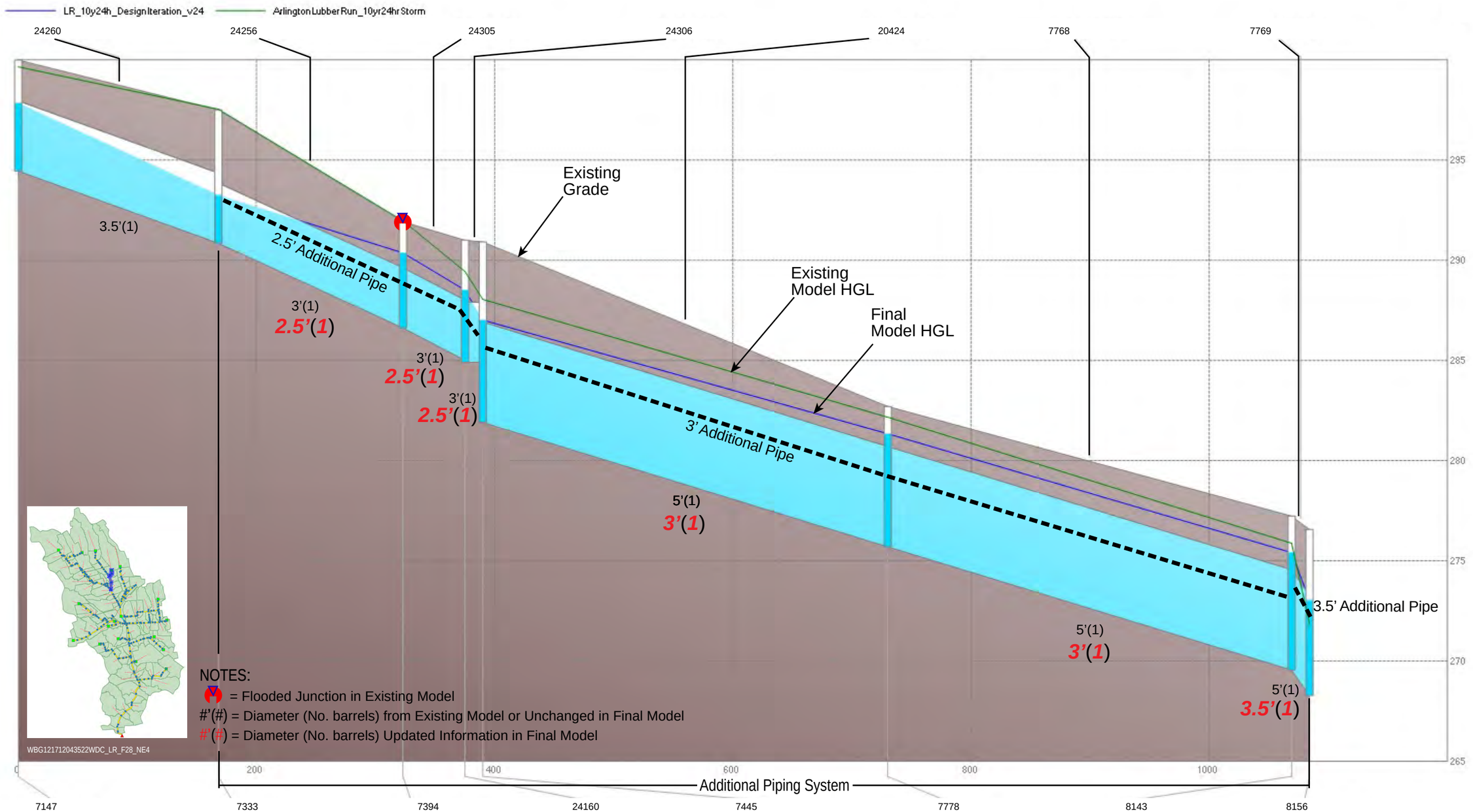


FIGURE 29 - Lubber Run
N. Glebe Rd., between 16th St. N. and I-66 for the 10yr-24hr Storm Event

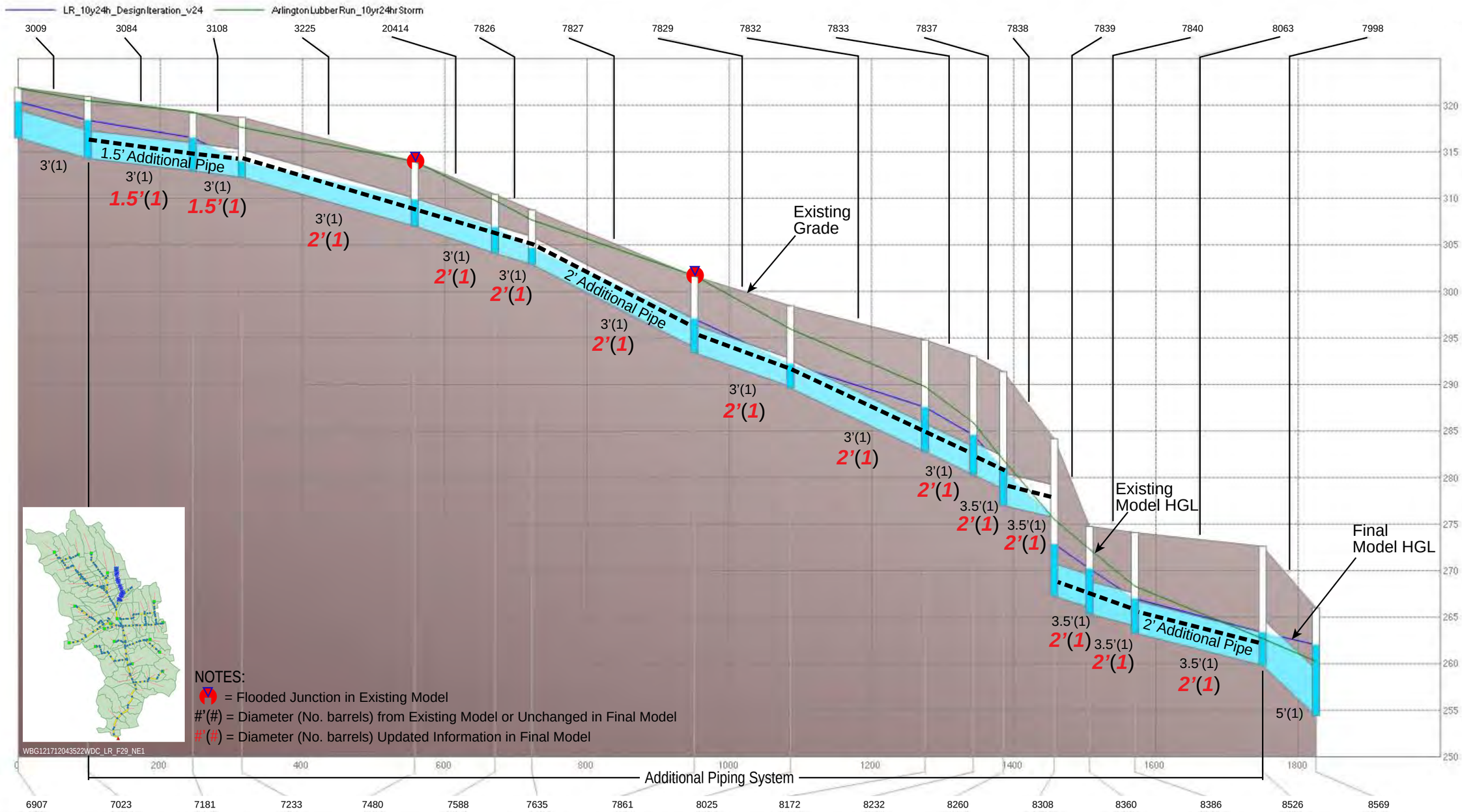


FIGURE 30 - Lubber Run
N. George Mason Dr., between Washington Blvd. and I-66 for the 10yr-24hr Storm Event

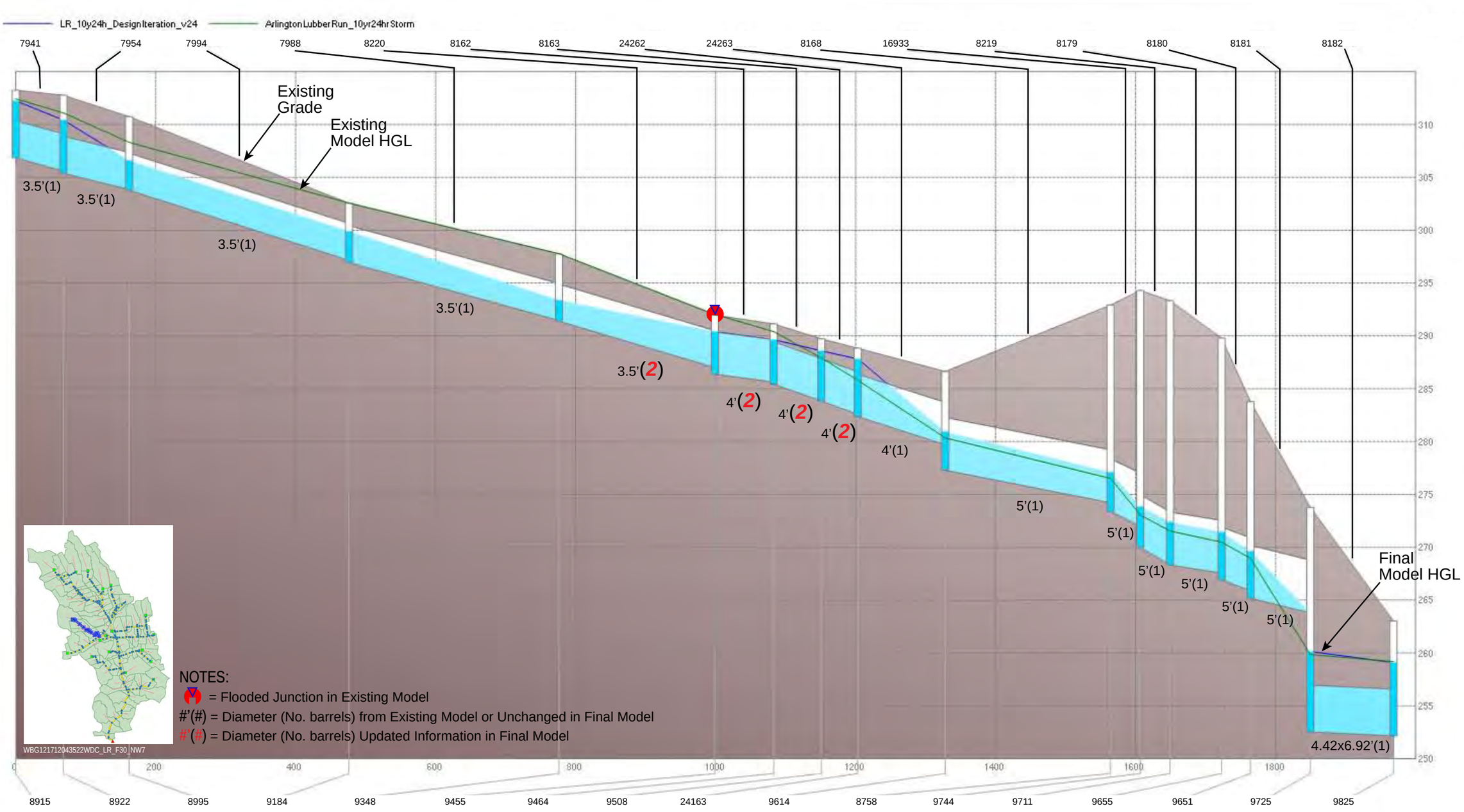


FIGURE 31 - Lubber Run
West Branch along I-66, between N. Harrison St. and VDOT Pond for the 10yr-24hr Storm Event

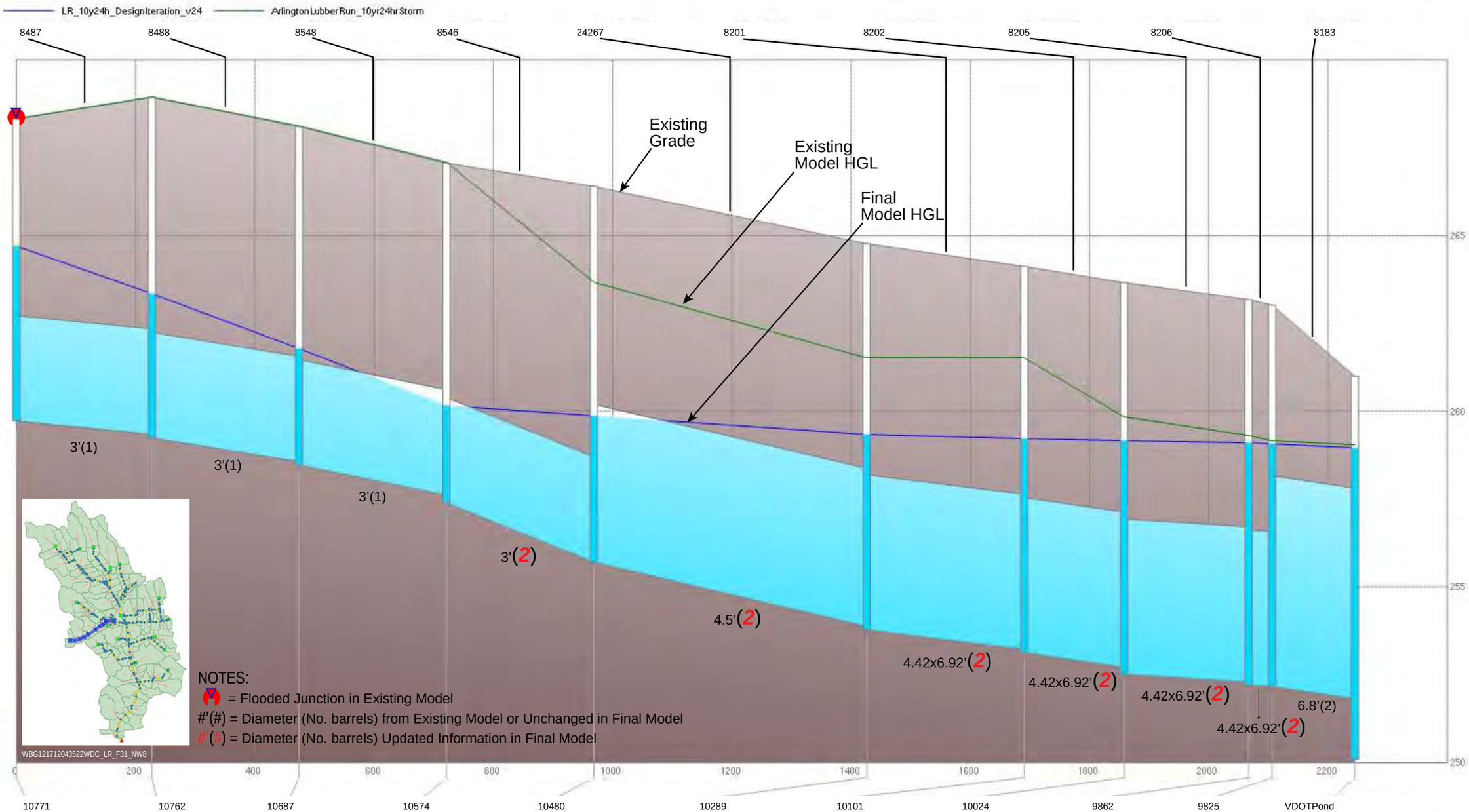


FIGURE 32 - Lubber Run
West Branch along I-66, 200 ft East of N. Frederick St. for the 10yr-24hr Storm Event

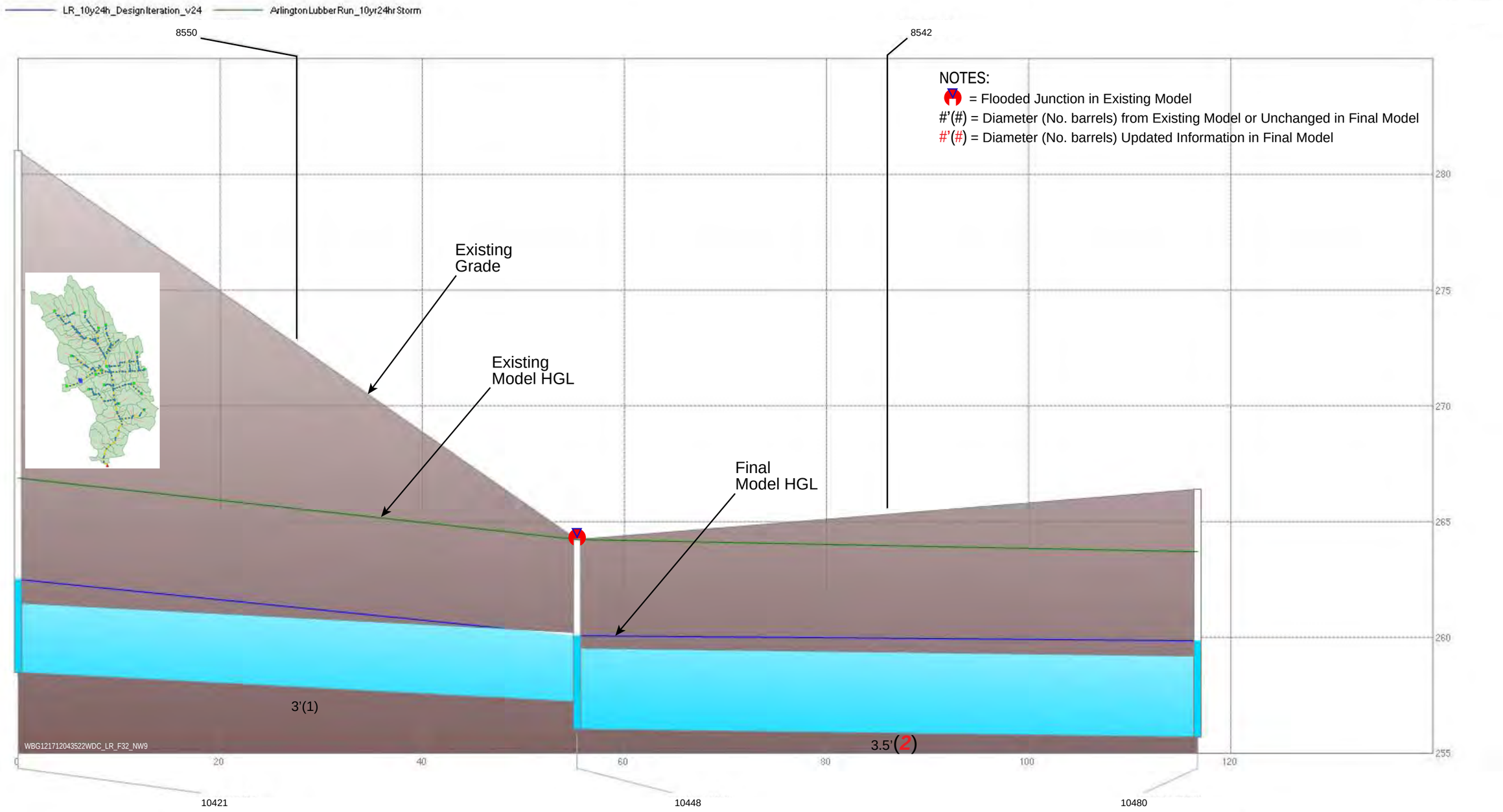


FIGURE 33 - Lubber Run
N. Stuart St., between Washington Blvd. and 11th St.; 11th St. N. between N. Stuart St. and N. Utah St. for the 10yr-24hr Storm Event

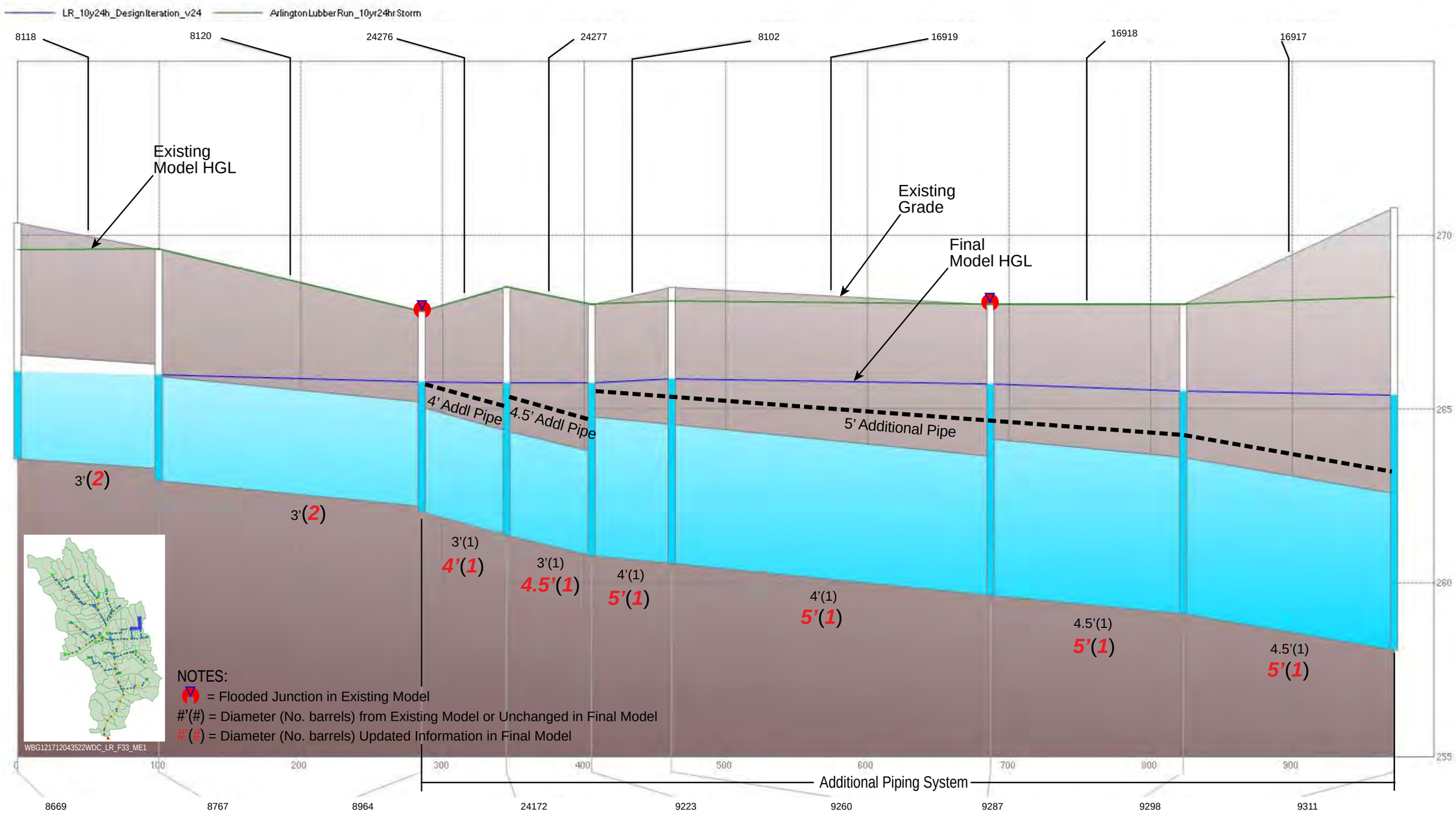


FIGURE 34 - Lubber Run
11th St. N., between N. Utah St. and Beaver Pond for the 10yr-24hr Storm Event

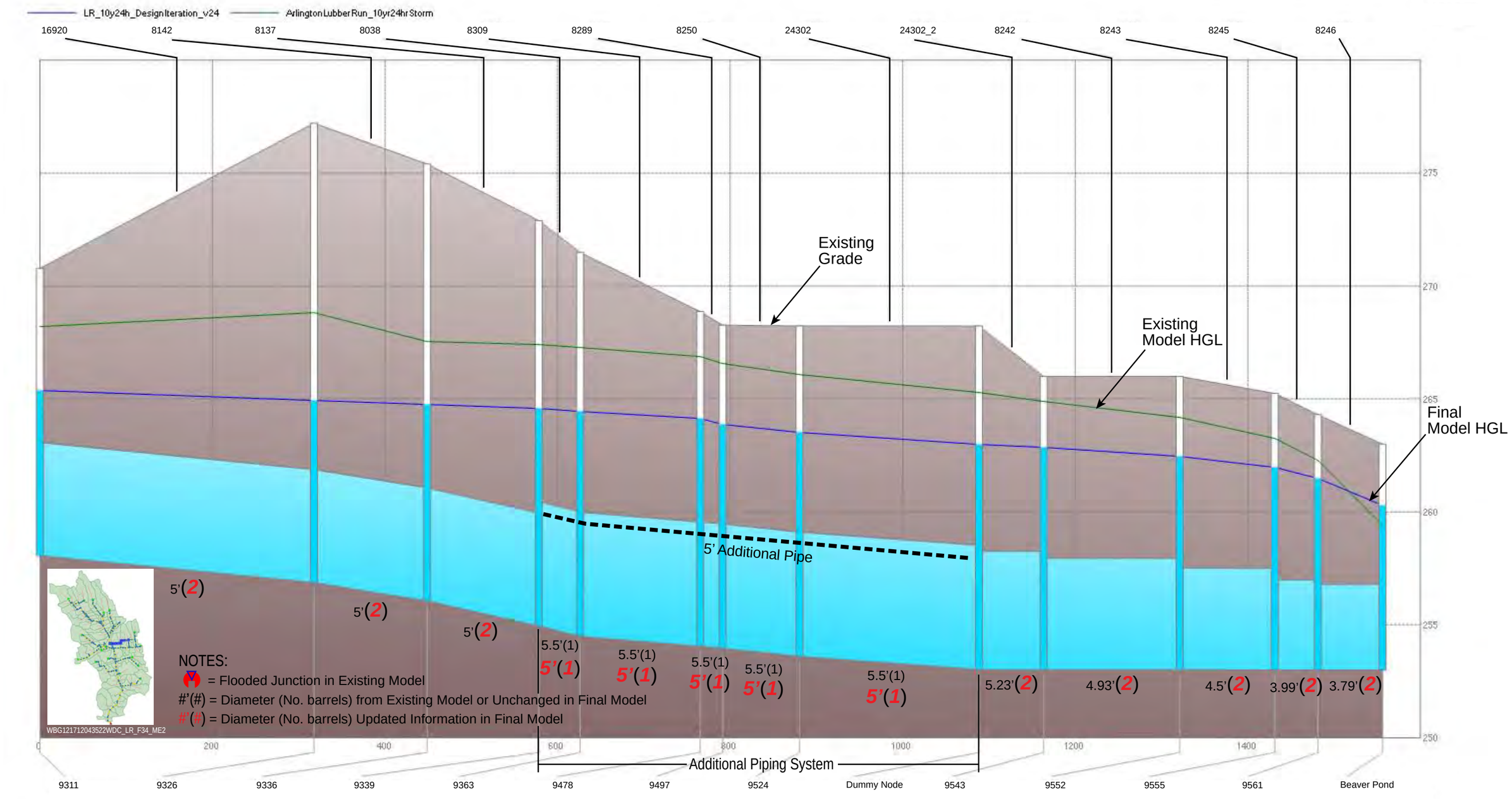


FIGURE 35 - Lubber Run
N. Stuart, between 11th St. N. and Fairfax Dr. for the 10yr-24hr Storm Event

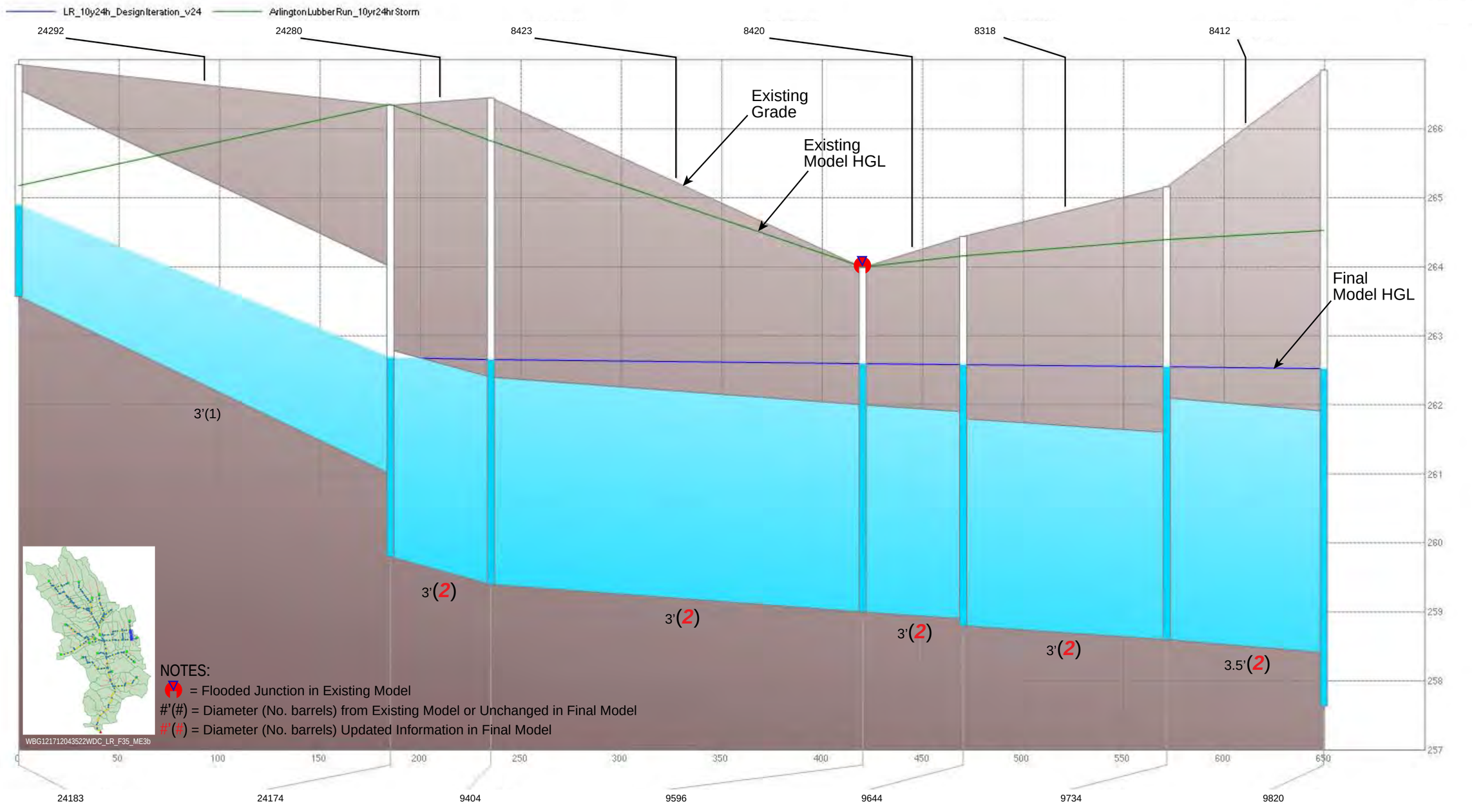


FIGURE 36 - Lubber Run
Fairfax Dr., between N. Stafford St. and N.Utah St. for the 10yr-24hr Storm Event

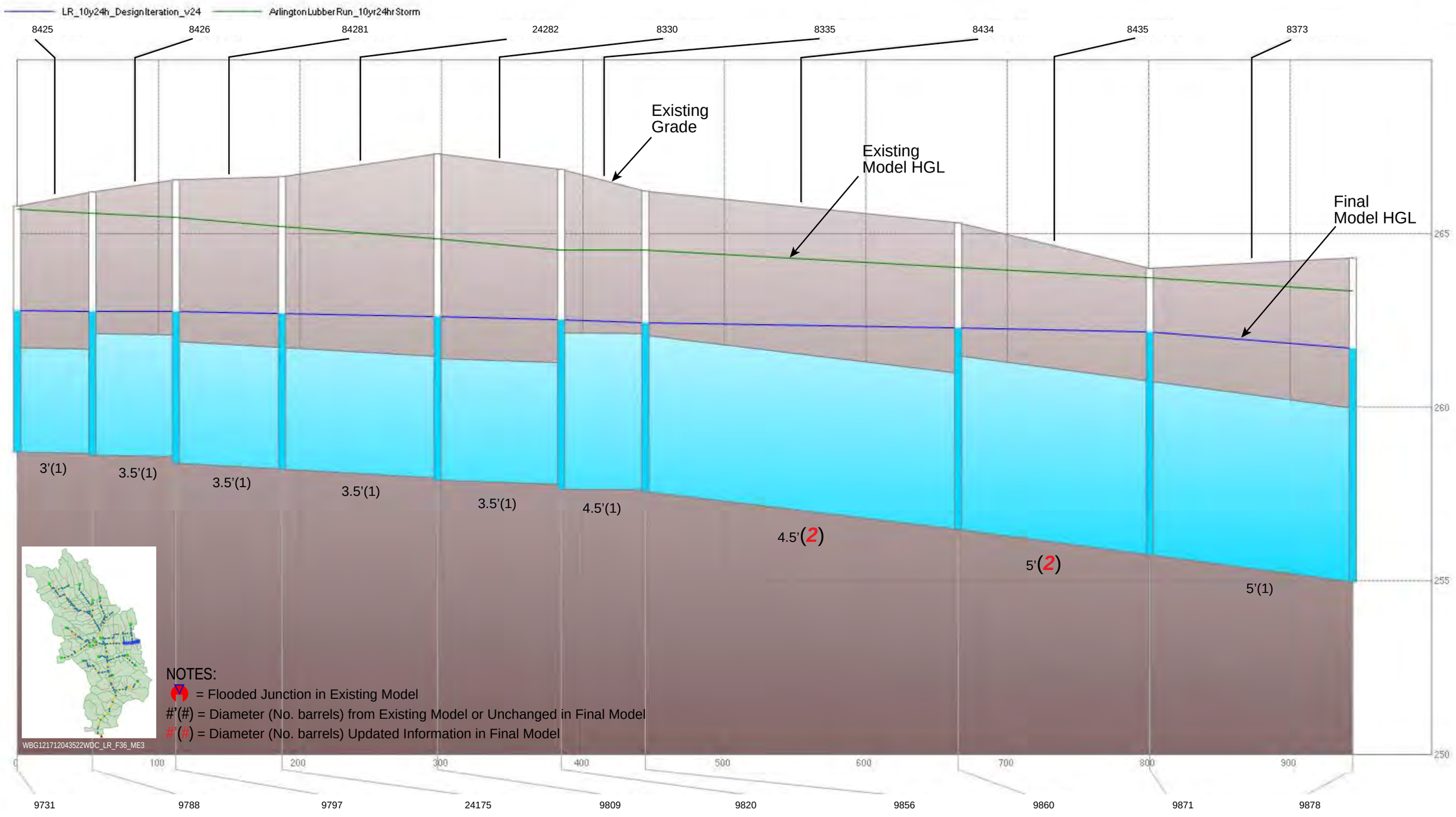


FIGURE 37 - Lubber Run
Fairfax Dr., between N. Utah St. and N. Woodrow St. for the 10yr-24hr Storm Event

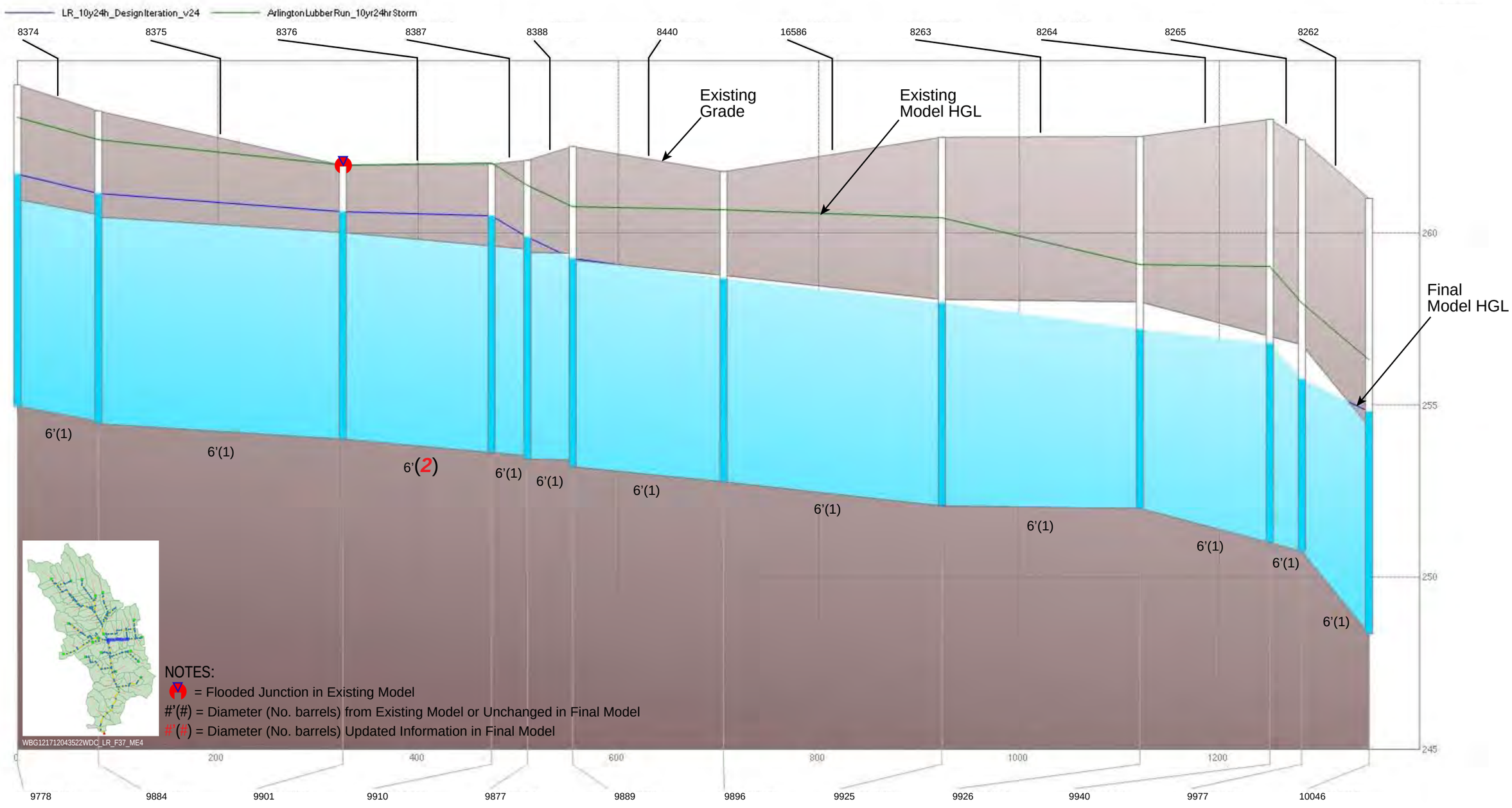


FIGURE 38 - Lubber Run
Downstream from the VDOT and Beaver Ponds, between Fairfax Dr. and Wilson Blvd. for the 10yr-24hr Storm Event

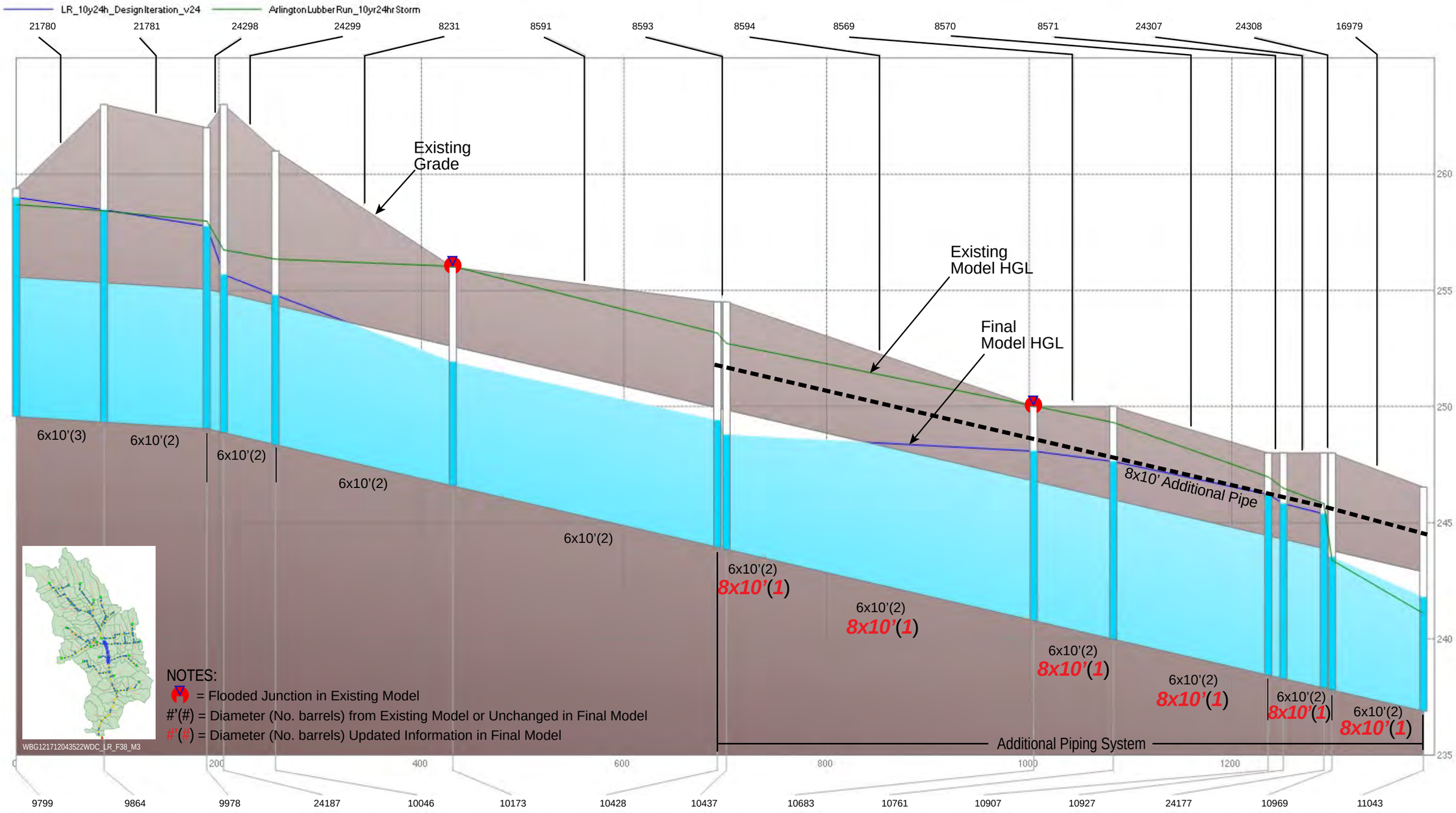


FIGURE 39 - Lubber Run
8th Rd. N., between N. Buchanan St. and N. Woodrow St. for the 10yr-24hr Storm Event

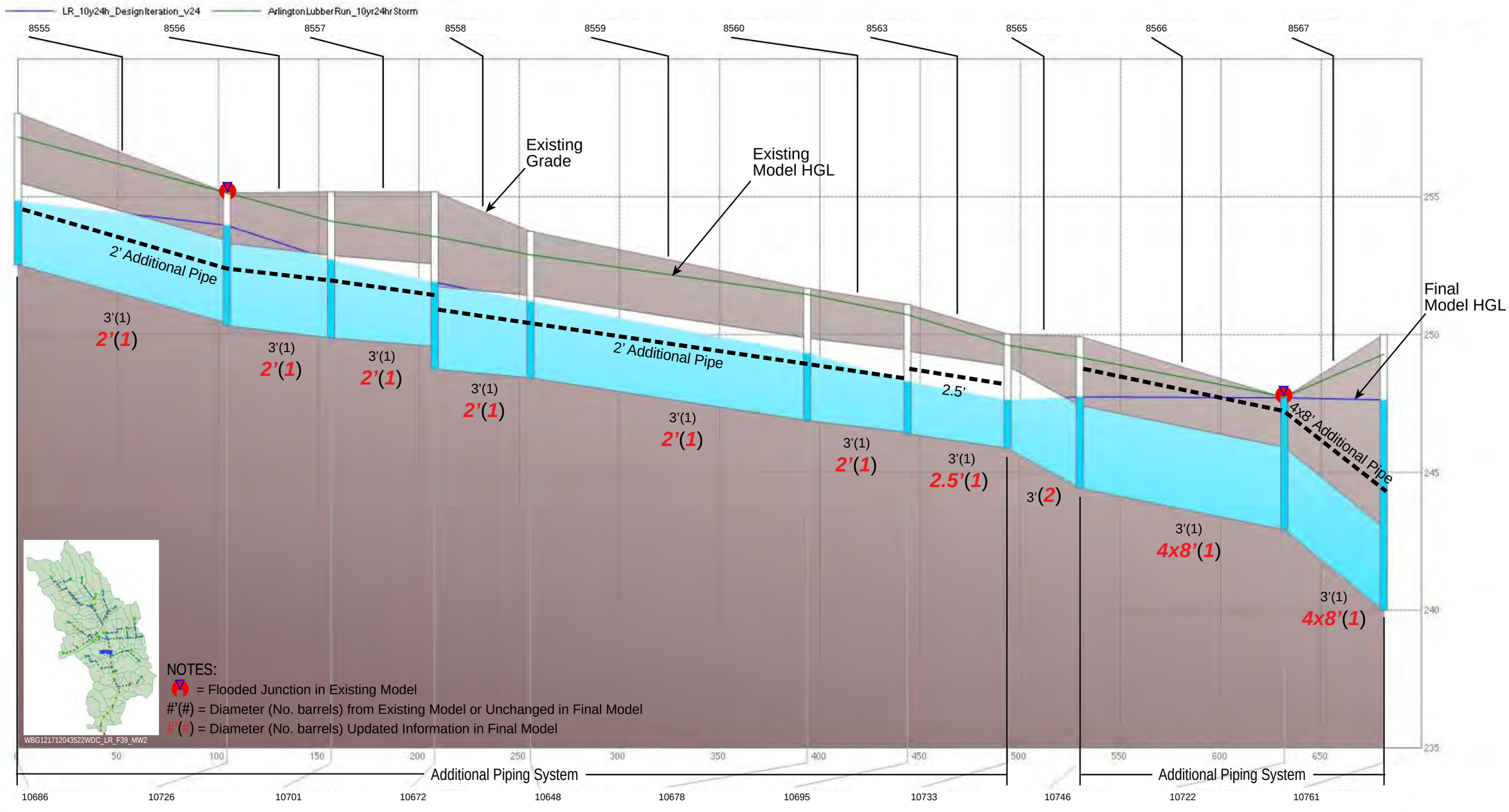


FIGURE 40 - Lubber Run
N. Glebe Rd., between N. Carlin Springs Rd. and Wilson Blvd. for the 10yr-24hr Storm Event

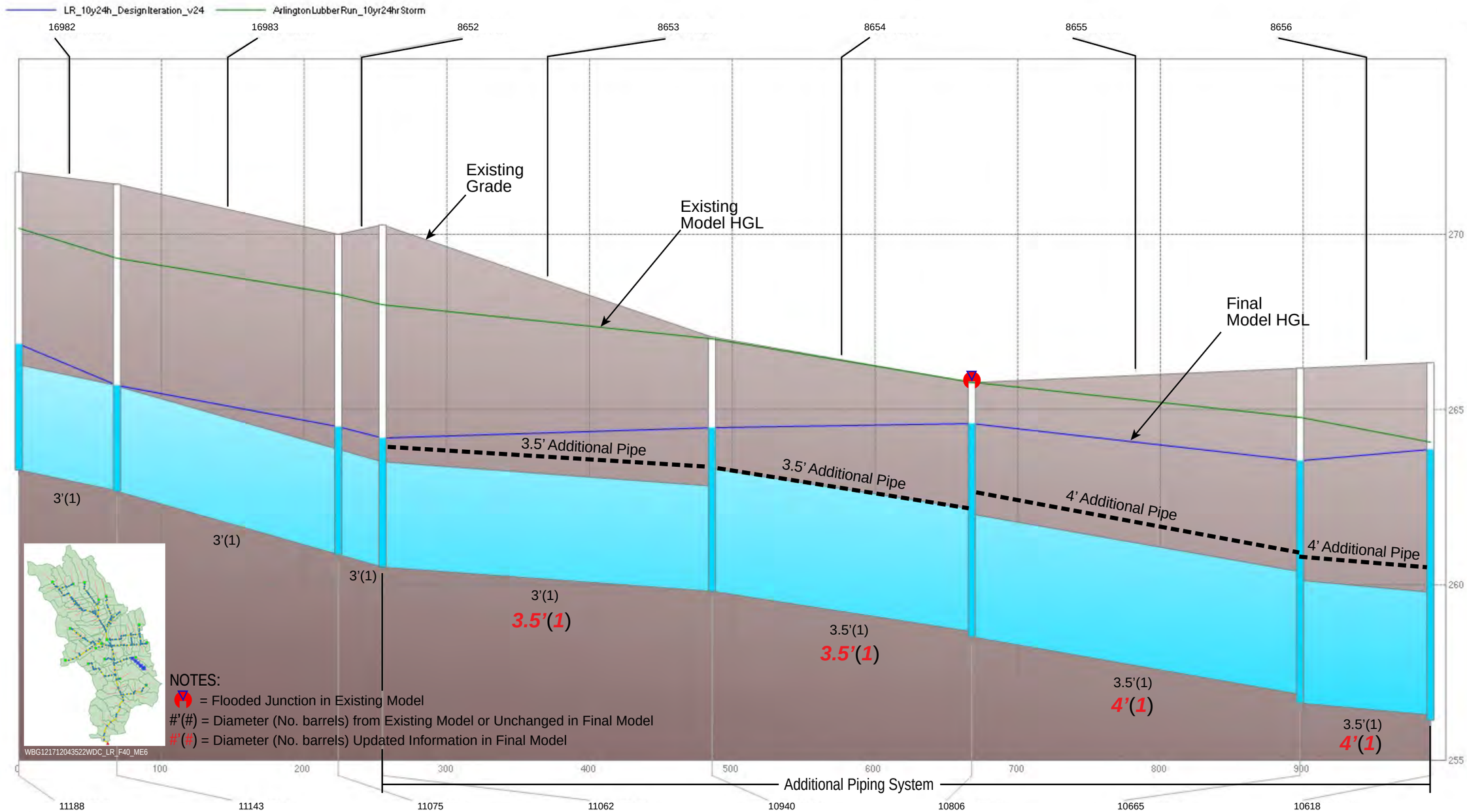


FIGURE 41 - Lubber Run
Wilson Blvd., between N. Glebe Rd. and N. Abingdon St. for the 10yr-24hr Storm Event

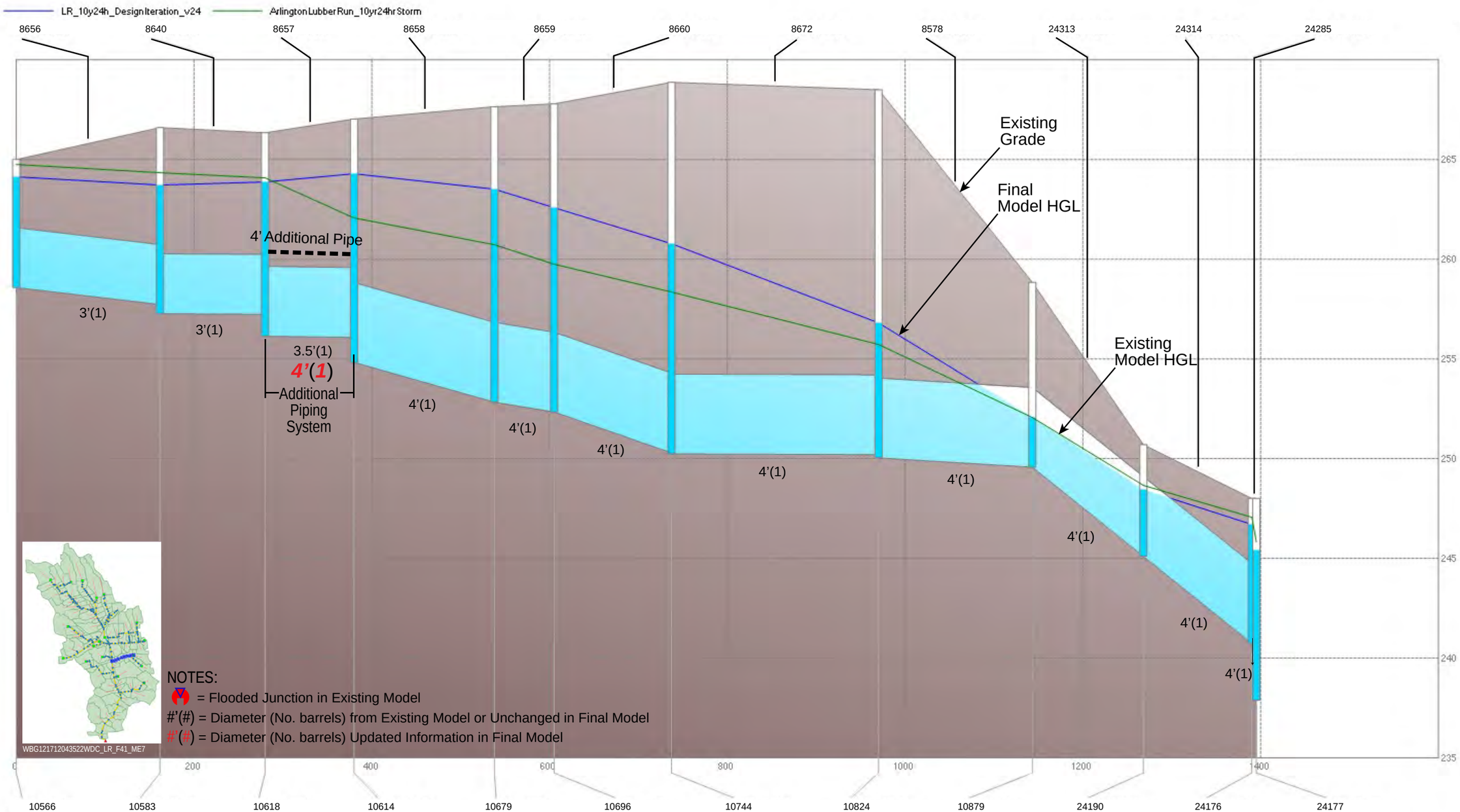


FIGURE 42 - Lubber Run

N. George Mason Dr., between 8th Rd. N. and Stream; Immediately Upstream of 7th St. N. for the 10yr-24hr Storm Event

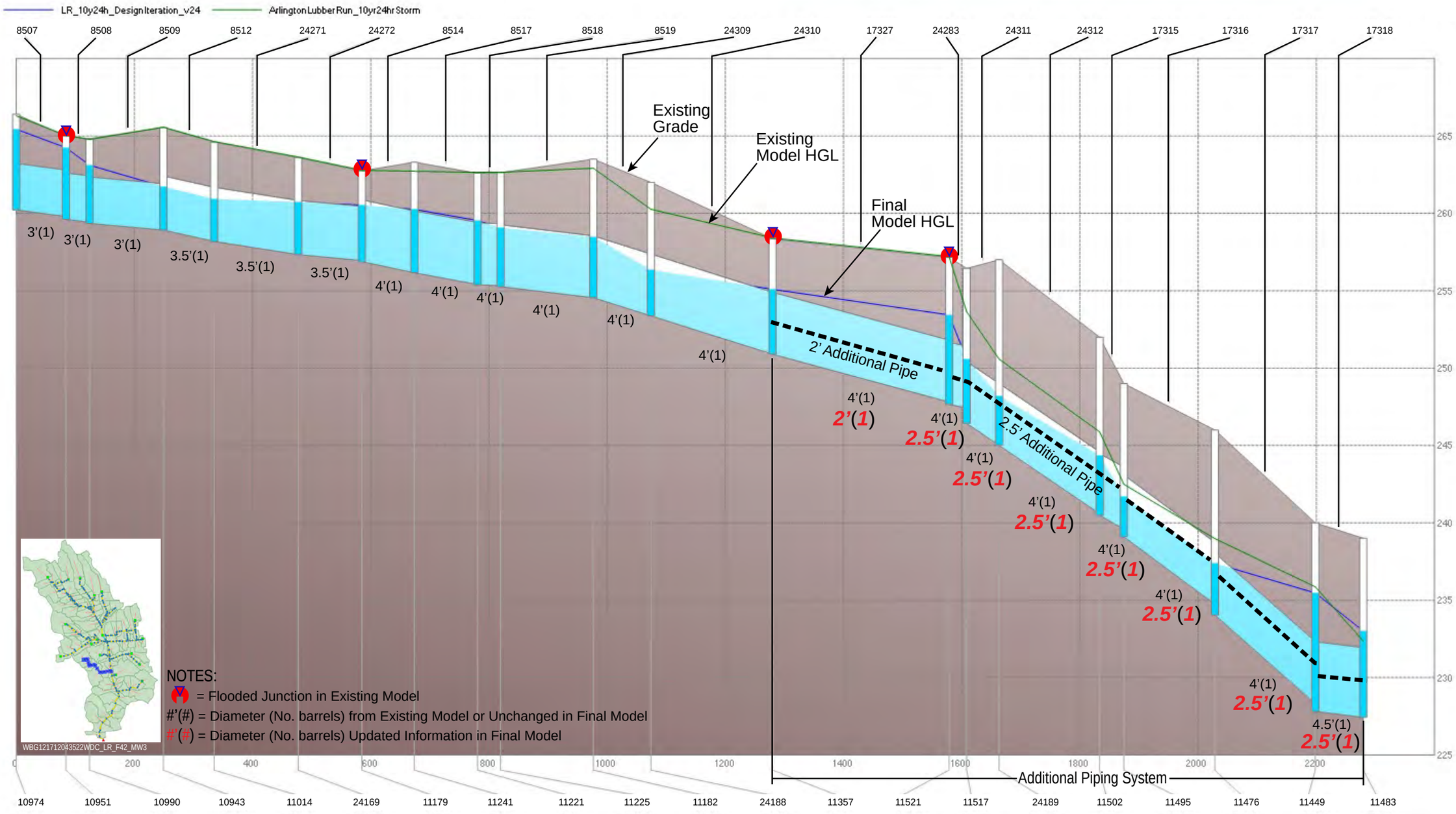


FIGURE 43 - Lubber Run
430 ft North of N. George Mason Dr. and N. Carlin Springs Rd. for the 10yr-24hr Storm Event

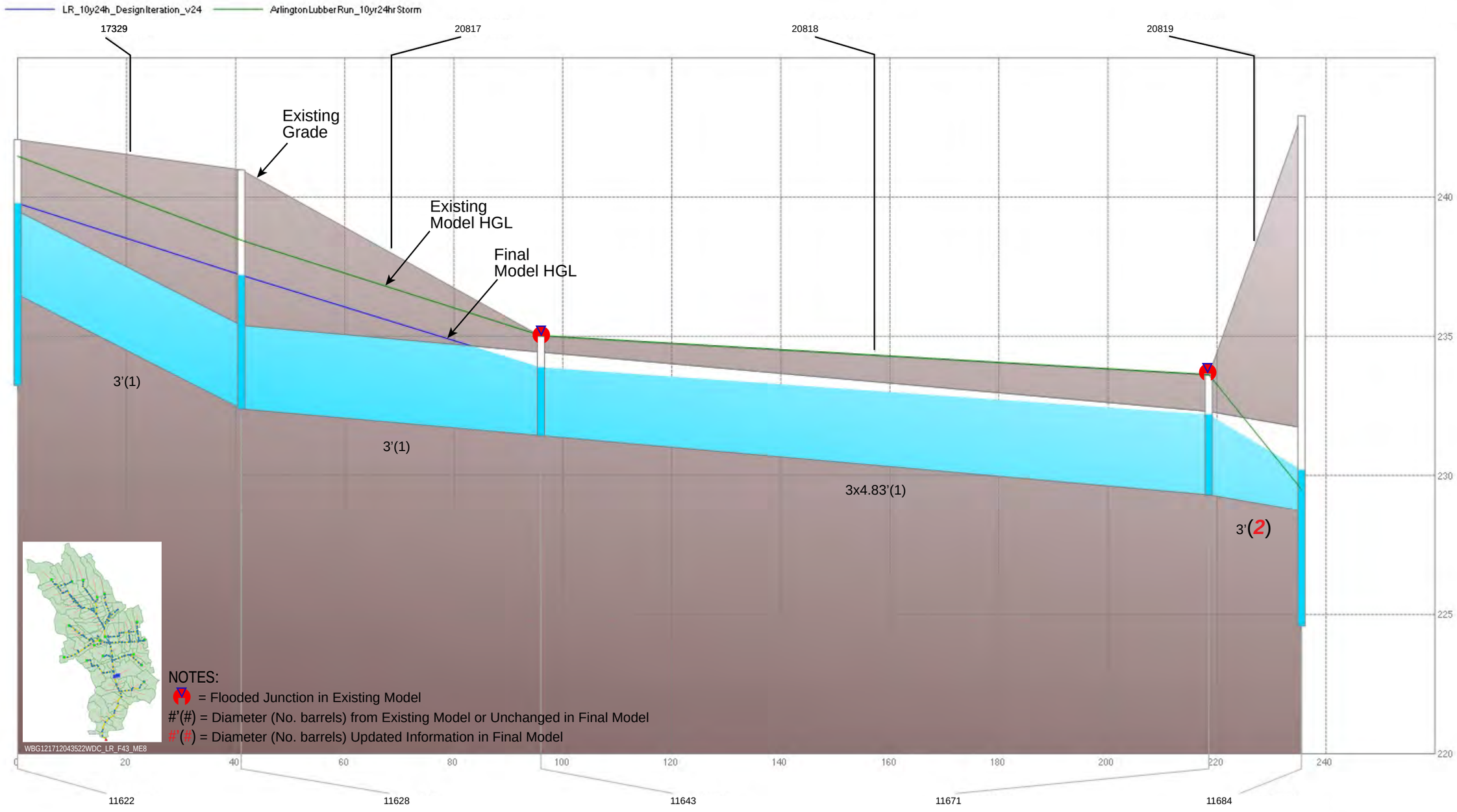
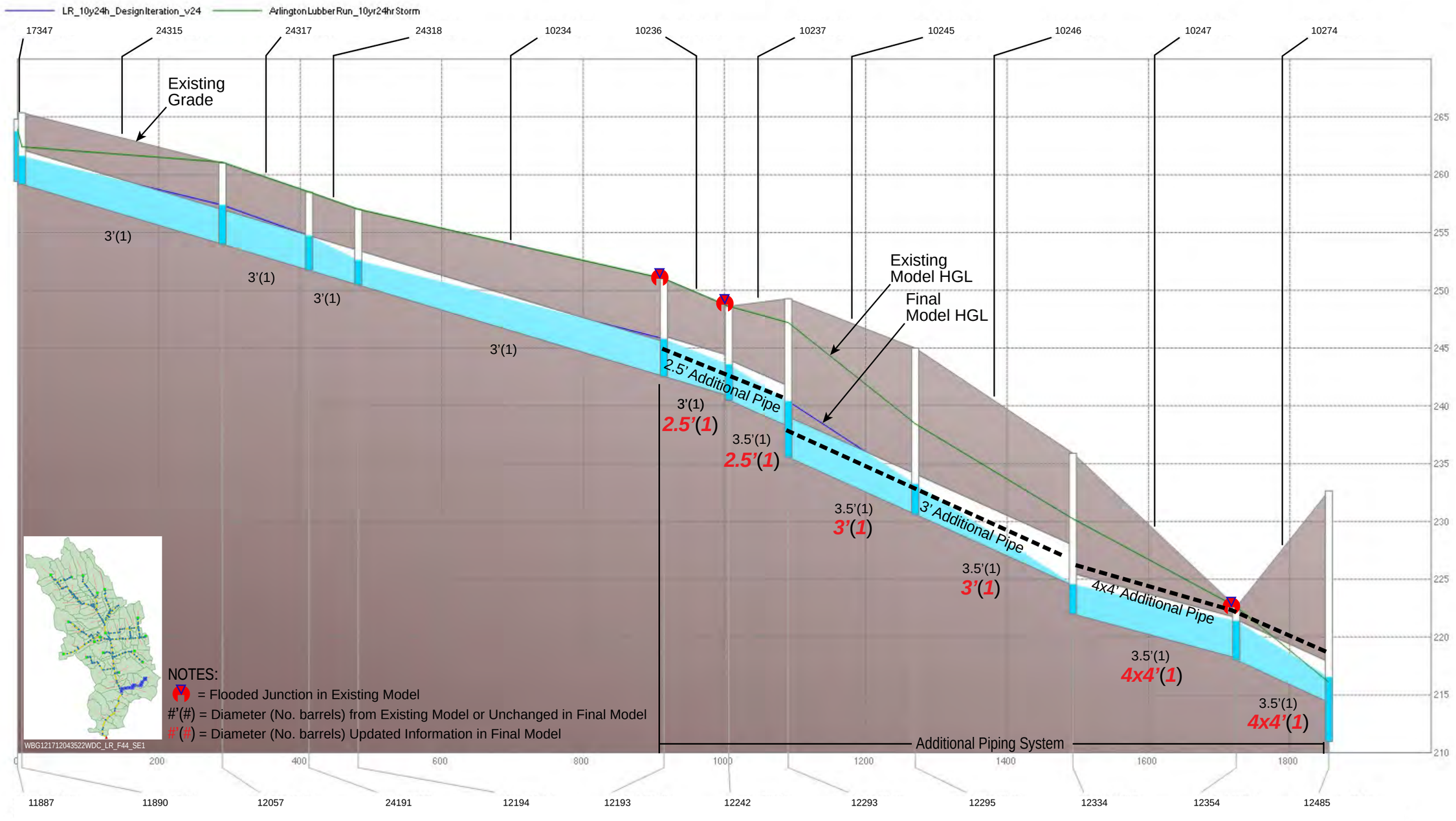


FIGURE 44 - Lubber Run

N. George Mason Dr., between N. Thomas St. and Stream for the 10yr-24hr Storm Event



5 Summary

The focus of this task was to develop solutions that eliminate flooding in the model during two selected storm events: the June 2006 storm event and the 10yr-24hr SCS Type II storm. Though specific model solutions were developed, the goal of the task was to understand what design capacity may be necessary to minimize the risk of flooding during similar rainfall events.

The hydraulic modeling results presented in this TM should be reviewed with the understanding that several assumptions were made to fill data gaps, primarily assumptions about pipe inverts, rim elevations, and inlet conditions. Additionally, when solutions were developed, the number of barrels and/or pipe sizes was the primary parameters adjusted. Implementation of these or similar solutions will not guarantee the elimination of flooding in the watershed.

Because of the assumptions applied to the model, it is important to note that all results are presented from a modeling perspective, not a design perspective. Assumptions should be verified and may need adjusting during the design stage of all improvement projects. Moreover, there are many factors related to scoping and implementing a project that will need to be taken into account with the model results when improvement projects are considered. Additionally, even after the completion of the improvement projects, the risk of flooding is never completely eliminated.

Results of the design iterations show that flooding in the model during the June 2006 storm event may be eliminated by adding capacity to about 14 percent of the modeled network. Eliminating flooding in the model during the 10yr-24hr SCS Type II storm requires changes throughout the network. The solution identified in this TM requires adding capacity to about 45 percent of the modeled pipe network.

Capacity Analysis

Appendix A
Stormwater Capacity Analysis for Lubber Run Watershed, Arlington County, Virginia

Stormwater Capacity Analysis for Lubber Run Watershed, Arlington County, Virginia

PREPARED FOR: Arlington County, Virginia

PREPARED BY: CH2M HILL

COPIES: Tara Ajello/CH2M HILL
Rita Fordiani/CH2M HILL

DATE: July 6, 2012

PROJECT NUMBER: 240033.LR.02.03

Contents

Appendixes

Tables

Figures

Executive Summary

Arlington County, Virginia, has initiated a project to analyze storm sewer capacity issues, identify problem areas, develop and prioritize solutions, and provide support for public outreach and education. The project is being implemented in phases by watershed.

The objective of this study is to identify areas in the stormwater collection system that do not have adequate capacity. Two rainfall events were modeled: (1) the June 25, 2006, storm event using rain gauge data from the Donaldson Run lift station and (2) a 10-year, 24-hour (10yr-24hr) storm based on the Soil Classification System (SCS) Type II distribution.

This technical memorandum (TM) focuses on the hydrologic and hydraulic analyses of the Lubber Run watershed using the model PCSWMM 2011. It summarizes the County's existing storm sewer system in the watershed, the model development steps, data sources and gaps, and model assumptions and results.

The total rainfall for the June 2006 storm event is higher than that for the 10yr-24hr SCS Type II storm. Consequently, the results of the hydrologic analysis show that the June 2006 storm event produces more stormwater runoff (16 million cubic feet) than the 10yr-24hr SCS Type II storm (12 million cubic feet).

However, since the peak rainfall intensity for the 10yr-24hr SCS Type II storm (6.74 in./hr) is higher than the June 2006 storm event's (4.80 in./hr), the 10yr-24hr SCS Type II storm results in the watershed's having more conveyance capacity limitations. **Table 1** shows the summary of the conveyance capacity limitations for each storm event.

The hydraulic modeling results presented in this TM should be reviewed with the understanding that several assumptions, primarily about pipe inverts, were made to fill data gaps. All assumptions should be verified when infrastructure is designed on the basis of this preliminary capacity modeling. This TM does not include an analysis of capacity upgrades to stormwater infrastructure designed to reduce the capacity limitations of the stormwater conveyance system.

1 Introduction and Project Objectives

The work described in this TM is one of the major elements of a storm sewer capacity analysis project. Based on discussions with Arlington County staff, it is understood that the County is undertaking a larger effort to update and combine the 1996 Stormwater Master Plan and the 2001 Watershed Management Plan. This TM is part of the project that focuses on the storm sewer capacity issues.

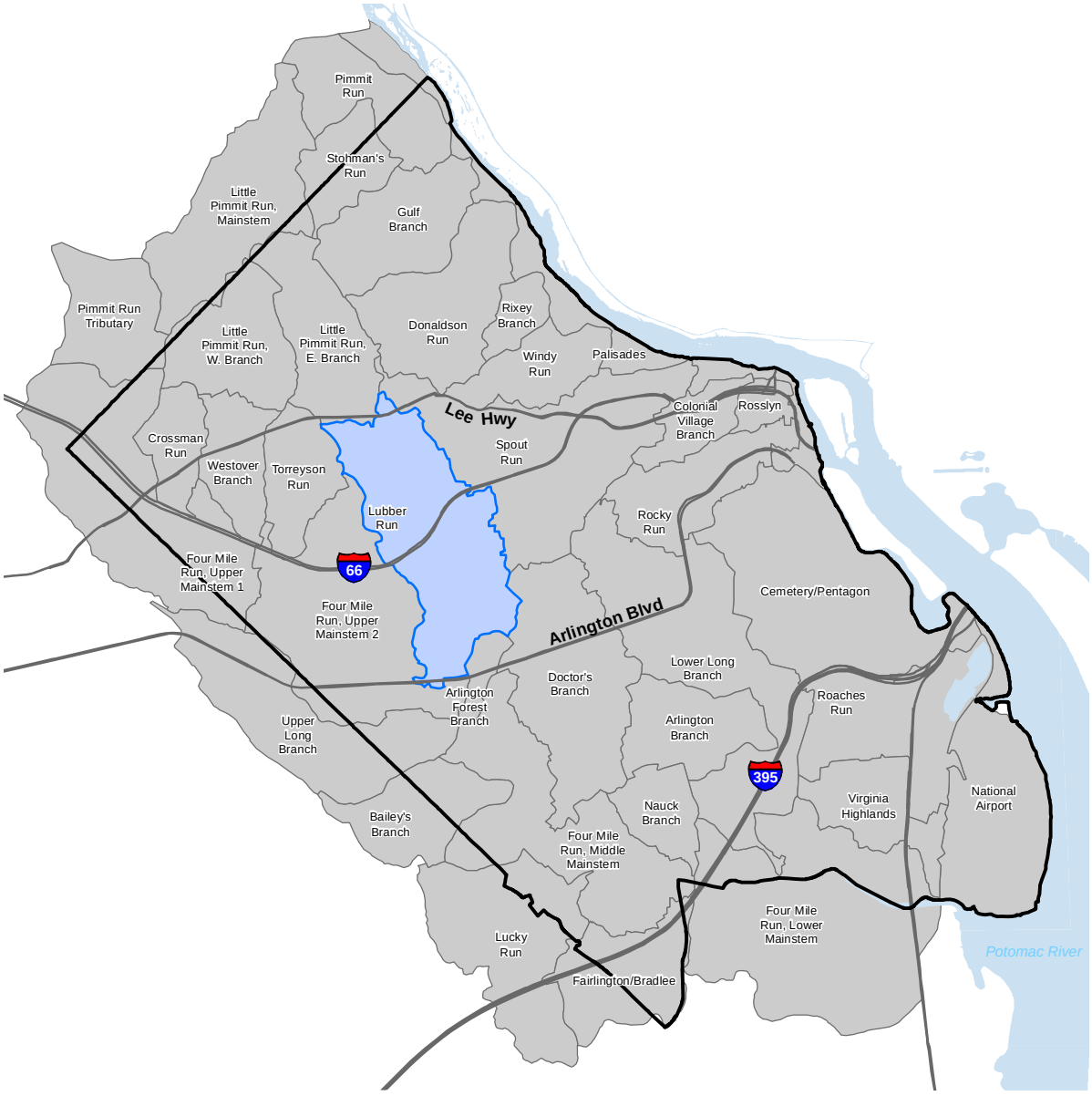
The purpose of this TM is to conduct a stormwater capacity analysis of the existing stormwater collection system for the Lubber Run watershed, and to identify areas of the stormwater collection system that may not have adequate capacity based on two storm events: the June 2006 and the 10yr-24hr SCS Type II. **Figure 1** shows the various drainage watersheds for Arlington County.

TABLE 1
Summary of Conveyance Capacity Limitations

Scenario (with Storage)	Modeled System (Linear Feet)[a]	HGL Flooding Ground Surface		HGL Within 1 Foot of Ground Surface		HGL Surcharging Pipe Crown		Capacity Limitations	
		Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System
June 2006 storm event	35,091	4,197	12	6,630	19	9,920	28	20,746	59
10yr-24hr SCS Type II storm	35,091	9,720	28	11,905	34	10,203	29	31,827	91

HGL, hydraulic grade line.
[a]The modeled system in this table includes the pipe network described in Table 2. It does not include natural stream channels.

FIGURE 1
Watersheds, Arlington County, Virginia (Lubber Run Highlighted)



2 Description of Existing Stormwater Collection System

2.1 Existing Versus Modeled Stormwater Collection System

The Lubber Run watershed is approximately 1,029 acres and is the seventh largest watershed in Arlington County. The zoning is predominantly residential; the remaining area consists of a mix of commercial, industrial, institutional, and highways.

In general, stormwater runoff is collected by storm sewers and flows south to Four Mile Run stream. The stream continues through Four Mile Run watershed.

The stormwater collection system elements include the following:

- Closed conduits, such as gravity sewers and culverts
- Stream channel segment and ditches
- Ponds
- Drainage inlets and junctions, such as roadside curb inlets, manholes, catchbasins, and yard and grate inlets

Elements of the ArcGIS existing stormwater collection system and the corresponding stormwater model developed for the Lubber Run watershed are summarized in **Table 2**. The modeling effort includes the storm sewer network of pipes 36 inches in diameter and larger.

TABLE 2
Comparison of Existing Lubber Run Stormwater System and Modeled System

Stormwater System Element	Existing	Modeled
Drainage area (acres)	1,015	1,029
Number of conveyance segments in stormwater system[a]	1,890	330
Total length of conveyance segments in stormwater system (linear feet)	142,128	40,596
Size range (in.)[b]	10–96	36–96
Number of circular pipe segments	1,765	252
Number of noncircular pipe segments	62	55
Length of stream channel segments (linear feet)	8,339	5,505
Length of ditch segments (linear feet)	778	0
Total inlets/junctions/end points (model nodes)[c]	1,895	327
Catchbasins	785	52
Manholes	618	176
Yard inlets	44	6
Grate inlets	215	27
End walls	52	9
Junction chambers	68	53
Detention outlets	54	2
Best management practices (BMPs)	1	0
Unknown types of nodes	58	0
"Dummy"	0	2

[a]Segments include circular pipes, box culverts, elliptical pipes, ditches, and streams.
[b]Modeling scope is limited to stormwater conveyance system pipes 36 inches in diameter and larger.
[c]Nodes include manholes, catchbasins, inlets, end walls, junctions, detention outlets, and "dummy" (see Section 4.4.3).

Observations

- Drainage area: The modeled drainage area is larger than the existing drainage area received initially from the County. This is because of adjustments made to the watershed boundary during this project as discussed in Section 2.3.
- Detention outlet: The County defines a detention outlet as an element connected to a detention pipe. These detention storage pipes are large-diameter pipes connected to downstream pipes typically having a diameter smaller (sometimes less than 36 inches) than that of the upstream pipe. In the Lubber Run watershed, 54 detention nodes were identified in the ArcGIS PGDB (personal geodatabase), but only two are included in the model: the Beaver Pond outlet and the VDOT Pond outlet.
- BMP and unknown types of nodes: The "BMP" and "unknown types of nodes" are not modeled because they are connected to pipes with a diameter less than 36 inches.
- The ArcGIS PGDB includes several links and nodes to represent the VDOT and Beaver Ponds but does not include the hydraulic control structures that are most important to the function and capacity of the stormwater system; therefore, on the basis of as-built drawings, the weirs and orifice in the VDOT Pond and the weir in the Beaver Pond are included in the Lubber Run PCSWMM. In addition, each pond is now represented by a single storage node instead of several links and nodes.

Figure 2 shows the existing stormwater collection system in the Lubber Run watershed; **Figure 3** shows the modeled system.

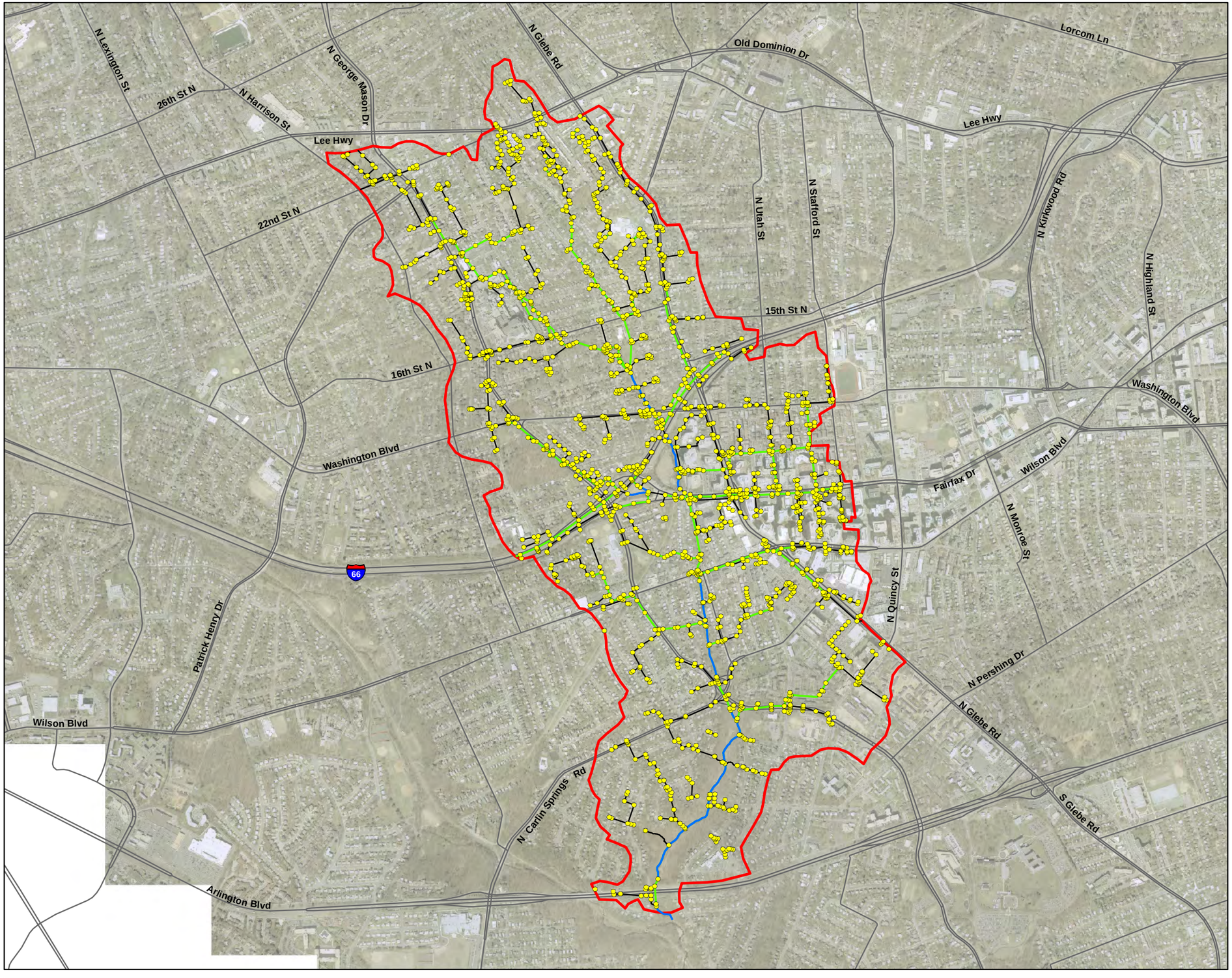
2.2 Data Sources

The storm drainage network data was provided by Arlington County in ESRI ArcGIS format for the entire County. The following documents were also provided by the County:

- As-built drawings
- Beaver Pond Land Surveying prepared by Rice Associates in December 2010
- I-66 Spot Improvement: SWM [stormwater management] Riser Structure modification prepared by HNTB Corporation in June 2009 [Sheet 2L(3)]
- I-66 Spot Improvement: SWM Pond Plan drawings prepared for VDOT by HNTB Corporation in June 2009 [Sheet 2L(1)]

Initial base layers (GIS shapefiles) were obtained from Arlington County in June 2010. CH2M HILL worked closely with the County from September to November to complete the storm sewer data gathering for the Lubber Run watershed. The final ArcGIS PGDB was delivered to CH2M HILL on November 15, 2010.

During a preliminary review of the ArcGIS PGDB, it was determined that there was a need to survey key stream cross sections. CH2M HILL staff met with County staff to examine this issue in more detail. Surveyed data were delivered to CH2M HILL in November 2010.



VICINITY MAP

Legend

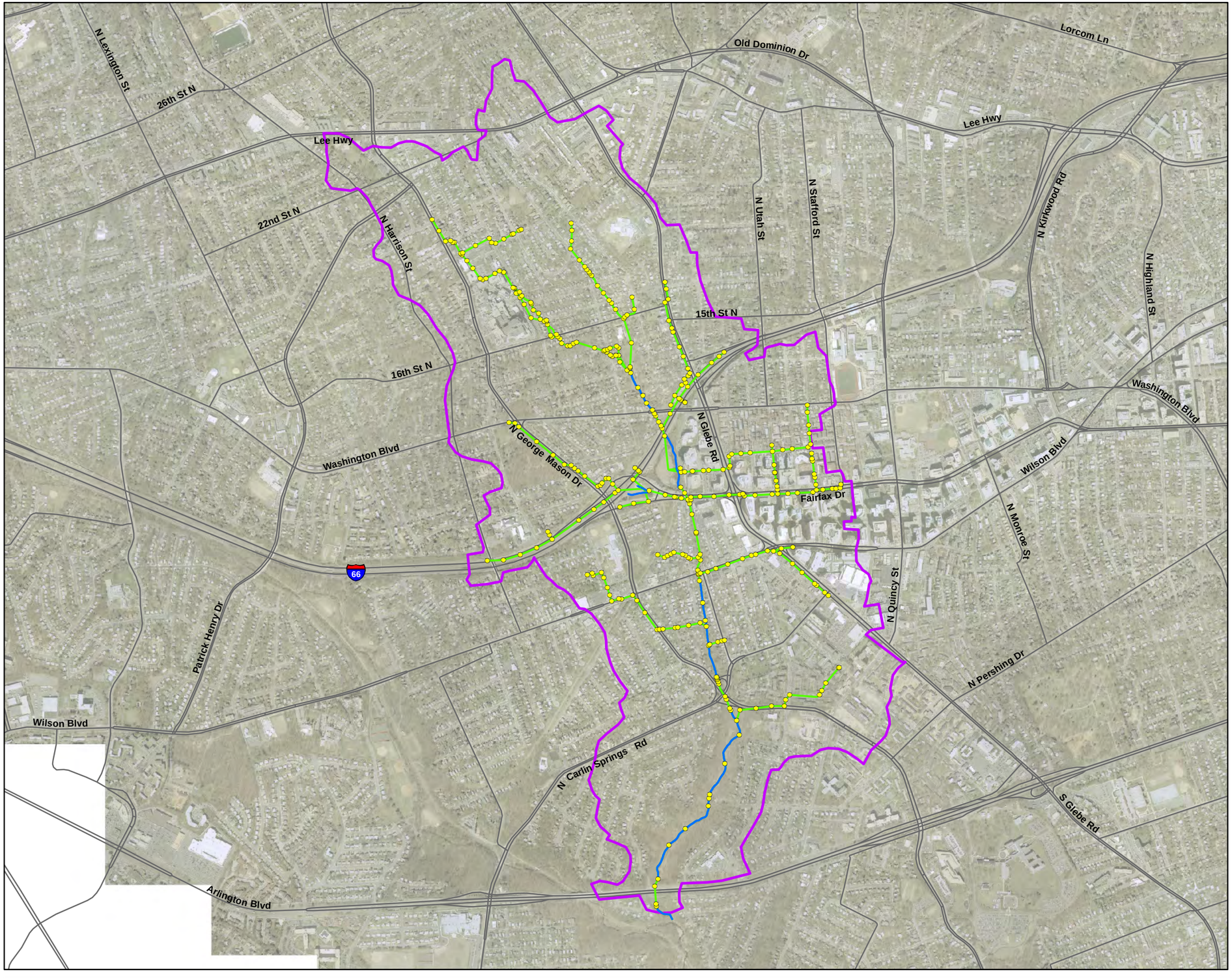
- Stormwater Junctions
- Stormwater Mains ≥ 36"
- Stormwater Mains < 36"
- Streams
- Roads
- Original Watershed Boundary

N

0 700 1,400
Feet

FIGURE 2
Existing Stormwater Collection System
Lubber Run Watershed
Arlington County Storm Capacity Analysis

CH2MHILL



VICINITY MAP

Legend

- Modeled Stormwater Junctions
- Modeled Stormwater Mains ≥ 36"
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 3
Modeled Stormwater Collection System
Lubber Run Watershed
Arlington County Storm Capacity Analysis

CH2MHILL

H:\ARLINGTONVACOUNTYOF\392309STORMWATERCAP\WSLUBBERRUN\WORKINGGIS\LAYOUT\SWCAPACITYTM\FINAL_FIGURES\11X17\FIGURE3_MODELED_COLLECTION_SYSTEM.MXD FCAIN 6/21/2012 3:13:17 PM

The final data for the Lubber Run watershed model were evaluated for quality. CH2M HILL found that 193 nodes and 196 links had missing data and/or anomalies. A data gaps TM detailing the suggested assumptions to fill in the gaps was prepared for the County in November 2010. (See **Appendix A**.) Three additional anomalies were encountered later: the rim elevation for nodes GIS ID 9507 and GIS ID 24153 were inconsistent with contour lines; therefore, values were modified to be consistent with the contour lines provided in the data. In the County ArcGIS PGDB, conduit GID 8108 is labeled as having a 36-inch diameter, but as-built 4630-145 shows this pipe as having a 15-inch diameter. The as-built information was used; therefore, this pipe was not modeled.

2.3 Watershed Boundary Anomalies

The Lubber Run watershed boundary was provided by the County. Anomalies were identified and the boundary was adjusted as needed based on topographic data, orthophotos, and the stormwater collection system connectivity. The details of these changes are described in the data gaps TM (**Appendix A**).

3 Technical Approach

This section describes the hydraulic evaluation of the Lubber Run stormwater system under various hydrologic scenarios. A dynamic stormwater model was developed as the evaluation tool using PCSWMM 2011.

3.1 Methodology

The hydrologic and hydraulic model involves the following steps:

- Hydrology
    1. Define the subwatershed boundaries
    2. Identify the hydrologic node connections
    3. Estimate the hydrologic parameters for each subwatershed
    4. Identify the rainfall distribution to analyze
- Hydraulics
    1. Import the stormwater network and physical data (inverts, ground elevation, pipe length, size, material)
    2. Define the boundary conditions for each hydrologic scenario
    3. Evaluate the hydraulic performance of the stormwater drainage system for two storm event scenarios

Arlington County provided the following required data:

- Arlington.mdb: geodatabase for stormwater collection system and watershed boundary shapefile
- 2009 data CD files: Arlington County's GIS data (shapefiles), such as topographic data, soil maps, cadastral data, and impervious information

- 2007 orthophotos
- 2006 rainfall event

The following sections describe the hydrologic and hydraulic modeling for the Lubber Run watershed.

3.2 Hydrologic Modeling

The hydrologic modeling consisted of two major components:

- Hydrologic parameters: delineation of subwatersheds and computation of hydrologic parameters such as drainage areas, basin slope, basin width, and percent impervious area for each subwatershed
- Rainfall: modeled the June 2006 storm event and the 10-yr 24-hr SCS Type II storm

Most hydrologic parameters were estimated using Arc Hydro Tools 9.3 and the ArcGIS version of HEC-GeoHMS. The Arc Hydro tools are a set of public domain utilities developed jointly by the Center for Research in Water Resources (http://www.crwr.utexas.edu) of the University of Texas at Austin, and the Environmental Systems Research Institute, Inc. These tools provide functionalities for terrain processing, watershed delineation, and attribute management. They operate on top of the Arc Hydro data model in the ArcGIS environments.

HEC-GeoHMS is geospatial hydrologic modeling software developed and maintained by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE). The model allows users to visualize spatial information, perform spatial analysis, delineate subwatersheds, and estimate subwatershed hydrologic parameters. The model uses the Digital Elevation Model (DEM) for the subject watershed to compute the hydrologic parameters. The "burning in" technique allows the user to impose the drainage system on the terrain to better produce the watershed boundaries.[1]

3.3 Subwatershed Delineation

The Arc Hydro tools were used to delineate the subwatersheds based on the DEM and stormwater network. Some of the automatically delineated subwatershed boundaries were adjusted before proceeding with the calculation of the hydrologic parameters. HEC-GeoHMS was used to compute the following hydrologic parameters: drainage areas, slope, and longest flow path. Width is calculated by dividing the area by the longest flow path.

3.4 Imperviousness

The percent imperviousness of each subwatershed was determined by overlaying the impervious coverage information with the delineated subwatersheds in ArcGIS. The impervious coverage is represented by buildings and paved features (e.g., driveways, handicap ramps, paved medians, sidewalks). It was assumed the impervious coverage is

[1] USACE, *User's Manual*, *Geospatial Hydrologic Modeling Extension HEC-GeoHMS*, Version 1.1, Hydrologic Engineering Center, 2003.

100 percent impervious. **Figure 4** shows the impervious areas used in the hydrology analysis. The following shapefiles were used for the impervious calculation:

- Building_arc.shp
- Driveway_poly
- Parkinglot_poly
- Road_poly_split
- Alley_Poly
- Handicapramp_poly
- PavedMedian_poly
- Sidewalk_poly

3.5 Hydrologic Parameter Summary

The schematic of the hydrologic model for the watershed is presented in **Figure 5**. The schematic model shows the basin ID, delineated boundaries, centroidal longest flow path, and drainage inlet for each subwatershed.

The hydrologic parameters for each subwatershed are presented in **Table 3**. The following are the major drainage characteristics for the watershed:

- Total drainage area is 1,029 acres.
- Lubber Run watershed is divided into 118 subwatersheds.
- 46.1 percent of the total drainage area is impervious (range across the subwatersheds of 0.5–96.4).
- Flows were introduced at 117 of 325 inlets (36 percent).
- Average basin area is 9 acres (range of 0.4–36).
- Average basin slope is 6.1 percent (range of 0.8–19.7).
- Average basin width is 869 feet (range of 74–2,539).

TABLE 3
Hydrologic Parameters

		Area				
Subwatershed	Inlet	Total (Acres)	Impervious (Acres)	Percent Impervious	Slope (%)	Width (ft)
W1110	6022	30	14	46.3	6.7	889
W1120	5955	36	15	42.4	5.8	1,838
W1130	6104	25	12	49.6	6.6	919
W1220	6434	1	0.7	49.8	5.7	794
W1270	7147	34	16	45.9	7.2	944
W1280	6973	7	3	41.9	6.1	816
W1290	7423	5	4	84.1	7.4	791
W1330	6907	20	11	54.6	6.0	637
W1340	8143	5	1	26.6	5.2	736
W1360	7955	9	4	40.9	14.4	1,489
W1380	7840	11	3	25.4	5.5	791
W1430	8423	12	4	36.8	4.1	560

TABLE 3 (CONTINUED)
Hydrologic Parameters

		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious**	**Slope (%)**	**Width (ft)**
W1440	8646	3	0.8	24.0	4.1	1,166
W1470	8669	11	5	40.5	2.6	861
W1540	24183	4	3	78.1	1.3	672
W1560	8915	28	12	43.2	4.4	2,157
W1600	9856	8	7	92.5	0.8	884
W1620	10077	7	2	32.9	9.3	574
W1690	10289	11	3	29.2	7.2	2,215
W1710	10566	11	11	96.4	0.9	1,216
W1720	10974	12	4	36.3	4.2	1,175
W1730	10824	4	3	83.5	2.0	575
W1750	10940	4	4	90.5	2.8	963
W1760	24177	6	4	62.6	5.1	730
W1780	11427	4	2	37.1	7.6	575
W1790	11182	7	4	66.0	2.4	1,027
W1840	11622	30	15	48.7	4.8	2,539
W1860	11449	8	3	39.4	5.9	785
W1870	11684	2	0.5	20.6	12.2	499
W1890	11521	20	7	36.9	3.1	1,812
W1930	12009	3	0.4	13.1	15.4	577
W1960	12042	12	5	46.0	3.6	804
W1970	12293	21	10	48.1	3.0	1,040
W1980	12193	13	7	56.2	3.9	1,280
W2010	12885	19	6	32.0	9.1	1,395
W2120	13762	32	12	36.6	7.5	1,305
W2150	14008	25	5	18.9	9.1	1,121
W2160	14510	13	3	24.5	17.4	2,128
W2240	6460	2	0.8	44.6	4.9	270
W2270	6302	11	5	43.8	5.0	630
W2340	6286	9	3	36.9	8.7	578
W2430	7131	12	5	41.7	5.9	1,119
W2440	7469	4	2	36.1	6.7	729
W2480	7255	2	1	42.7	6.7	378

TABLE 3 (CONTINUED)
Hydrologic Parameters

		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious**	**Slope (%)**	**Width (ft)**
W2490	7724	5	2	37.5	5.3	712
W2510	6539	9	4	39.5	7.8	1,298
W2590	7338	6	2	41.0	5.5	1,146
W2610	7445	4	2	43.7	5.3	920
W2620	7861	4	2	42.7	4.2	898
W2630	7480	9	4	47.7	4.3	890
W2640	9021	3	1	38.7	9.4	1,301
W2730	9234	15	8	53.0	3.6	833
W2800	8195	11	3	30.8	4.8	1,003
W2830	9363	5	4	72.6	3.5	717
W2890	9287	14	7	53.4	3.8	1,005
W2920	9260	3	2	57.3	2.4	493
W2990	9797	4	3	83.8	1.2	922
W3040	11254	3	1	37.8	7.4	688
W3120	9862	4	1	36.2	14.2	415
W3170	10686	15	5	33.7	3.9	1,917
W3180	9897	2	1	53.0	4.2	339
W3200	BeaverPond	8	0.04	0.5	9.1	737
W3230	VDOTPond	3	0.02	1.0	15.7	446
W3330	9961	0.9	0.2	26.9	3.9	301
W3420	9896	0.8	0.8	94.8	1.7	191
W3440	10618	4	4	95.9	1.1	479
W3490	11179	6	4	58.6	3.5	1,536
W3650	11887	21	13	63.7	3.2	1,736
W3660	11188	9	8	86.8	1.4	1,649
W3690	12242	6	3	48.5	4.1	576
W3700	12071	4	2	47.5	6.3	396
W3710	12208	3	1	42.7	9.3	450
W3720	12622	11	4	31.4	7.6	1,007
W3740	13298	11	2	17.2	13.2	1,704
W3750	13397	9	3	32.3	10.6	1,043
W3760	14764	7	3	41.1	15.6	615

TABLE 3 (CONTINUED)
Hydrologic Parameters

		Area				
Subwatershed	**Inlet**	**Total (Acres)**	**Impervious (Acres)**	**Percent Impervious**	**Slope (%)**	**Width (ft)**
W3770	12238	11	5	40.2	5.5	577
W3780	12354	9	4	40.0	8.1	967
W3800	7005	6	5	78.8	7.4	936
W3820	6676	3	2	68.9	5.2	293
W3830	6834	18	7	41.7	8.7	943
W3850	6834	2	1	54.1	4.1	621
W3860	7696	17	9	53.3	7.8	670
W3890	10421	15	7	49.6	6.7	1,164
W3900	10679	6	5	87.4	6.3	823
W4000	9977	8	6	81.3	2.0	554
W4010	10437	10	7	70.7	4.5	1,213
W4020	10683	2	0.2	11.5	4.5	604
W4040	10722	9	4	43.1	4.6	1,186
W4070	9524	5	4	86.2	3.3	366
W4090	9497	2	0.9	53.2	3.7	552
W4100	9889	6	5	87.7	2.1	622
W4170	9860	6	5	83.3	1.1	1,308
W4190	9901	5	4	89.6	2.0	1,084
W4200	9813	4	3	78.8	2.3	852
W4290	VDOTPond	0.4	0.3	70.0	19.7	74
W4300	9725	7	3	37.5	6.4	906
W4320	9507	5	1	29.7	9.8	1,323
W4390	8787	16	7	41.4	4.5	825
W4400	9348	7	1	18.5	4.2	863
W4410	9455	4	0.3	6.8	5.8	424
W4420	9464	4	1	30.5	4.6	348
W4430	9508	4	2	51.2	4.8	302
W4450	BeaverPond	2	1	56.0	7.8	200
W4460	9509	9	7	69.8	5.2	1,135
W4470	8635	6	4	70.7	8.3	403
W4480	8250	3	1	41.8	12.9	531
W4500	8569	1	1	57.3	9.7	378

TABLE 3 (CONTINUED)
Hydrologic Parameters

		Area				
Subwatershed	Inlet	Total (Acres)	Impervious (Acres)	Percent Impervious	Slope (%)	Width (ft)
W4520	8667	4	1	27.6	8.6	620
W4530	7883	2	1	46.3	5.1	339
W4540	7931	6	2	27.5	4.8	896
W4550	7844	0.5	0.3	55.5	4.5	212
W4560	7778	4	1	38.9	5.8	873
W4570	6250	13	5	37.3	8.2	809
W4630	9731	1	1	84.7	1.7	543
W4660	VDOTPond	1	0.3	25.5	10.9	469
W4780	8172	4	2	43.4	5.1	476
W4830	10771	10	3	32.0	5.3	896

3.6 Infiltration Parameters

Infiltration was modeled using the Green-Ampt method. To calculate the infiltration parameters, the digital soil maps were overlaid with the subwatersheds to assign respective soils map unit symbology (MUSYM). The MUSYM was then correlated with the Arlington County soil survey to determine the soil name and characteristics. It was determined that approximately 28 percent of the soil in Lubber Run is loam, 32 percent is sandy loam and 40 percent is silty loam. The infiltration parameters adopted for the three types of soil are listed in **Table 4**.

TABLE 4
Soil Infiltration Parameters

Soil Texture Class	Soil Map Units	Percent of Soil	Hydraulic Conductivity (in./hr)	Suction Head (in.)	Initial Deficit (in.)
Loam	12, 13	28	0.13	3.50	0.23
Sandy loam	4A–4C, 9C, 11B–11D, 15D, 16B	32	0.43	4.33	0.26
Silty loam	6B–6D, 7A-7D, 10B–10D	40	0.26	6.69	0.22

Source: Rawls, Walter J., Donald L. Brakensiek, and Norman Miller, “Green-Ampt Infiltration Parameters from Soils Data,” *Journal of Hydraulic Engineering*, vol. 109, no. 1, January 1983, pp. 62–70 (doi: http://dx.doi.org/10.1061/(ASCE)0733-9429(1983)109:1(62)).

The infiltration parameters of each subwatershed were determined by intersecting the soil map with the delineated subwatersheds in ArcGIS to calculate the area-weighted value. **Figure 6** shows the soil map for the Lubber Run watershed. **Appendix B** provides details on soil texture class and soil map units.

3.7 Surface Roughness and Depression Storage

Table 5 shows parameters used for pervious and impervious area in the model. Depression storage is set at zero to reduce the time for hydrologic flow to enter the hydraulic system.

TABLE 5
Surface Roughness and Depression Storage

	Areas	
Description	**Impervious**	**Pervious**
Manning's *n*	0.014	0.3
Depression storage	0	0

Source: James, W., *User's Guide to SWMM5*. 12th ed., CHI, 2008. p. 766.

3.8 Rainfall Distributions

Choosing the correct rainfall distribution as well as frequency and duration are important factors in the development of the hydrologic model and in the results of the hydraulic model. Arlington County proceeded with two storms of interest:

- June 2006 storm event based on the rain gauge data at the Donaldson Run lift station; total rainfall volume of 5.84 inches
- 10yr-24 storm based on SCS Type II distribution: the 10yr-24 hr storm volume was obtained from VDOT "Hydraulic Advisory 05-04.3," January 2008; total volume of 4.84 inches

The County has maintained a list and map of flooding complaints from the June 2006 storm, and this was used as anecdotal information for comparison purposes. Although not a true calibration, model results for the June 2006 storm event were compared to the flooding complaint map to see how the results align. (See Section 5.1.)

The 5-minute-duration hyetograph data for the two storms are provided in **Appendix C** and in **Figure 7**.

VICINITY MAP

Legend

- Alley
- Driveway
- Handicap Ramp
- Parking Lot
- Paved Median
- Road
- Sidewalk
- Building
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 4
Impervious Areas
Lubber Run Watershed
Arlington County Storm Capacity Analysis

CH2MHILL

VICINITY MAP

Legend

- Runoff Input Junction
- Centroidal Longest Flow Path
- Subwatershed
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400

Feet

FIGURE 5
Hydrologic Model Schematic
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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VICINITY MAP

Legend

Soil Type

- Loam
- Sandy loam
- Silty loam
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400

Feet

FIGURE 6
Soil Map
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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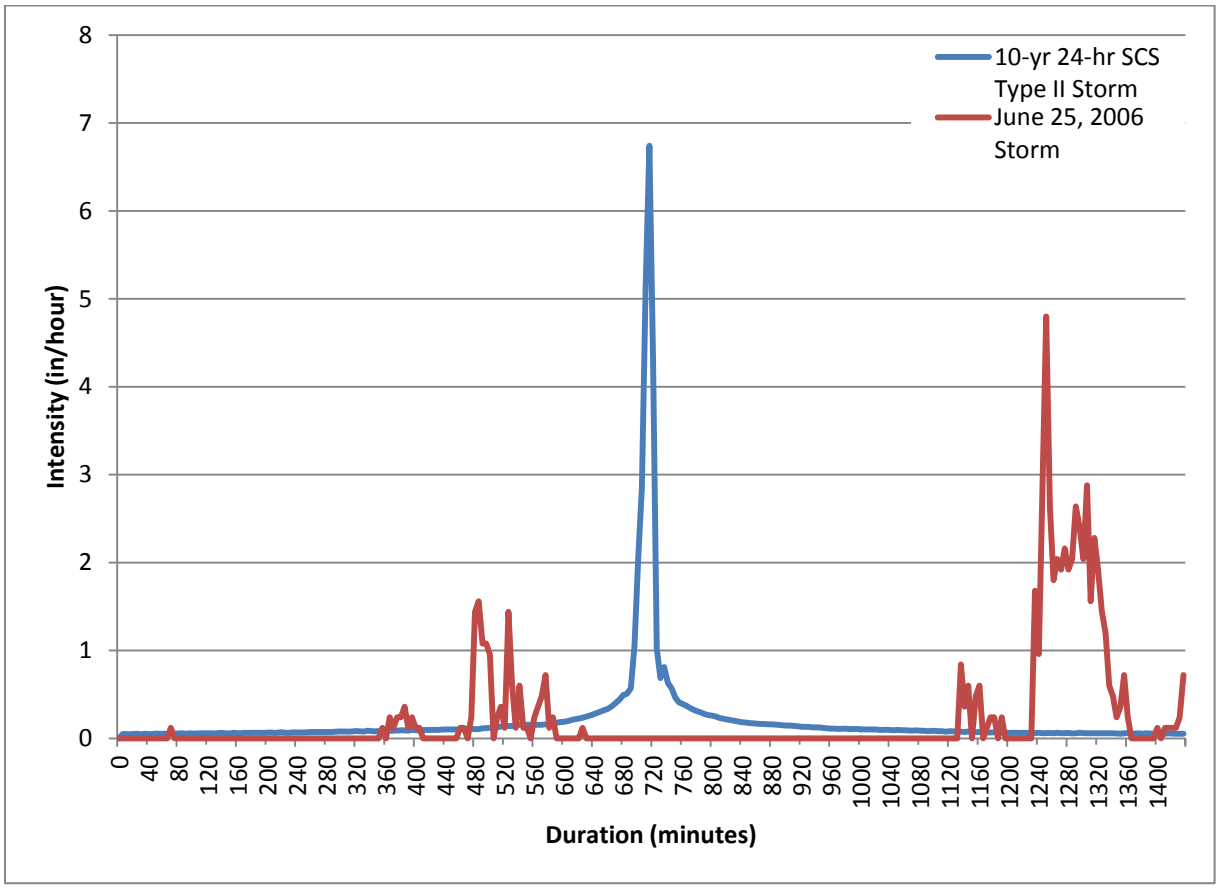
FIGURE 7
Storm Hyetographs



3.9 Simulation of Stormwater Runoff

The private domain software PCSWMM 2011 was used to simulate natural rainfall-runoff processes from the watershed. Hydrologic parameters such as area, slope, and width for 118 subwatersheds were estimated using Arc Hydro Tools 9.3 and ArcGIS version of HEC-GeoHMS, as described earlier. The percent imperviousness of each subwatershed was determined by overlaying the impervious coverage information with the delineated subwatersheds in ArcGIS. These hydrologic parameters, listed in **Table 3**, were used as input to the subwatersheds. The two hyetographs were also used as input to the subwatersheds of PCSWMM 2011. The U.S. Environmental Protection Agency (EPA) stormwater management model (SWMM) Runoff Non-linear Reservoir Method was used to simulate stormwater runoff from each subwatershed in response to each of the hyetographs. Groundwater and snow pack are not included in the hydrologic analysis.

For presentation purposes, the watershed was divided into three areas (see **Figure 8**):

- Upper area: north of I-66
- Middle area: between I-66 and N. Carlin Springs Rd.
- Lower area: south of N. Carlin Springs Rd.

VICINITY MAP

Legend

- Subwatershed
- Lower Area: South of N. Carlin Springs Rd
- Middle Area: Between I-66 and N. Carlin Springs Rd.
- Upper Area: North of I-66
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400

Feet

FIGURE 8
Subwatersheds
Lubber Run Watershed
Arlington County Storm Capacity Analysis

Figures 9, **10**, and **11** show the peak runoff at storm drain inlets for the two storm events. The peak runoff for the June 2006 storm is lower than the 10yr-24hr storm's, as expected. Caution should be taken when comparing the results in this figure because the runoff is related to the tributary area of each subwatershed, and the subwatersheds are not homogeneous in size.

FIGURE 9
Peak Runoff: Upper Area Subwatersheds (North of I-66)

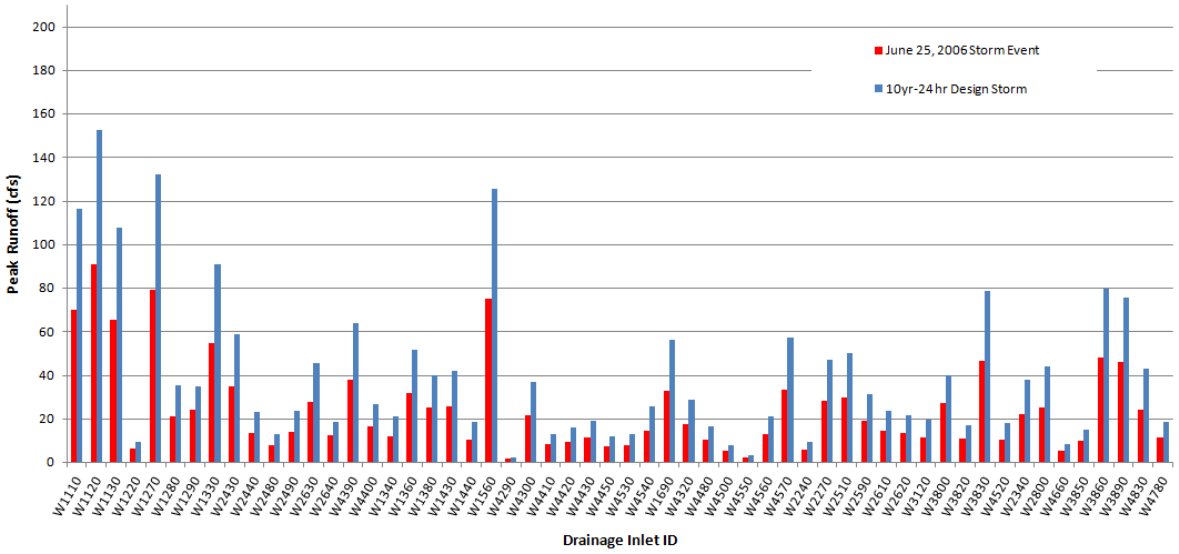


FIGURE 10
Peak Runoff: Middle Area Subwatersheds (Between I-66 and N. Carlin Springs Rd.)

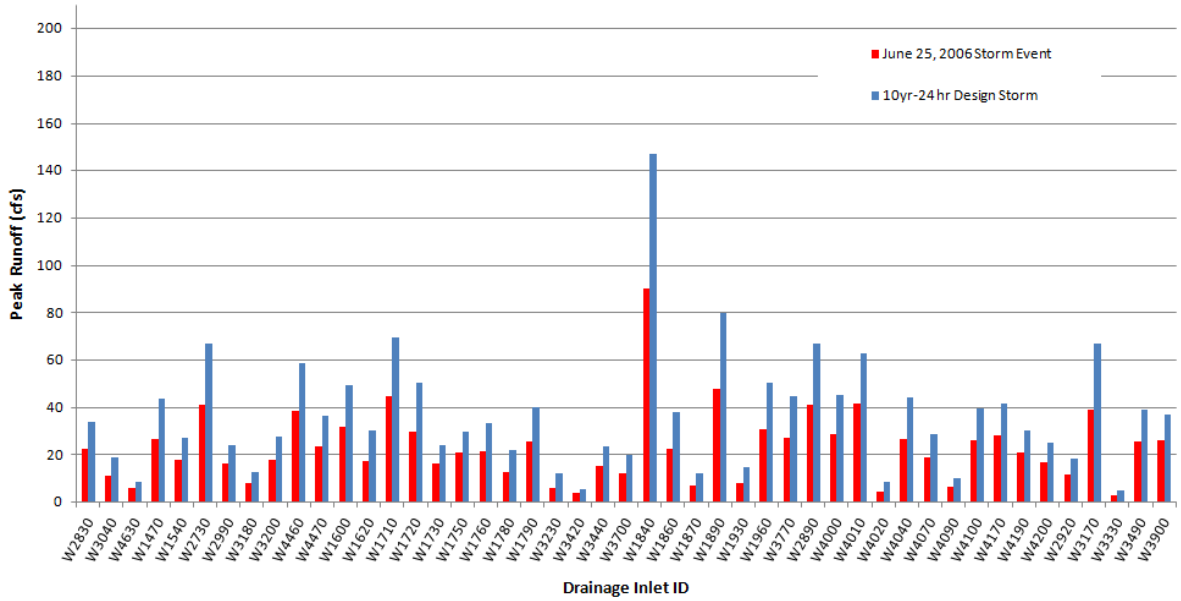
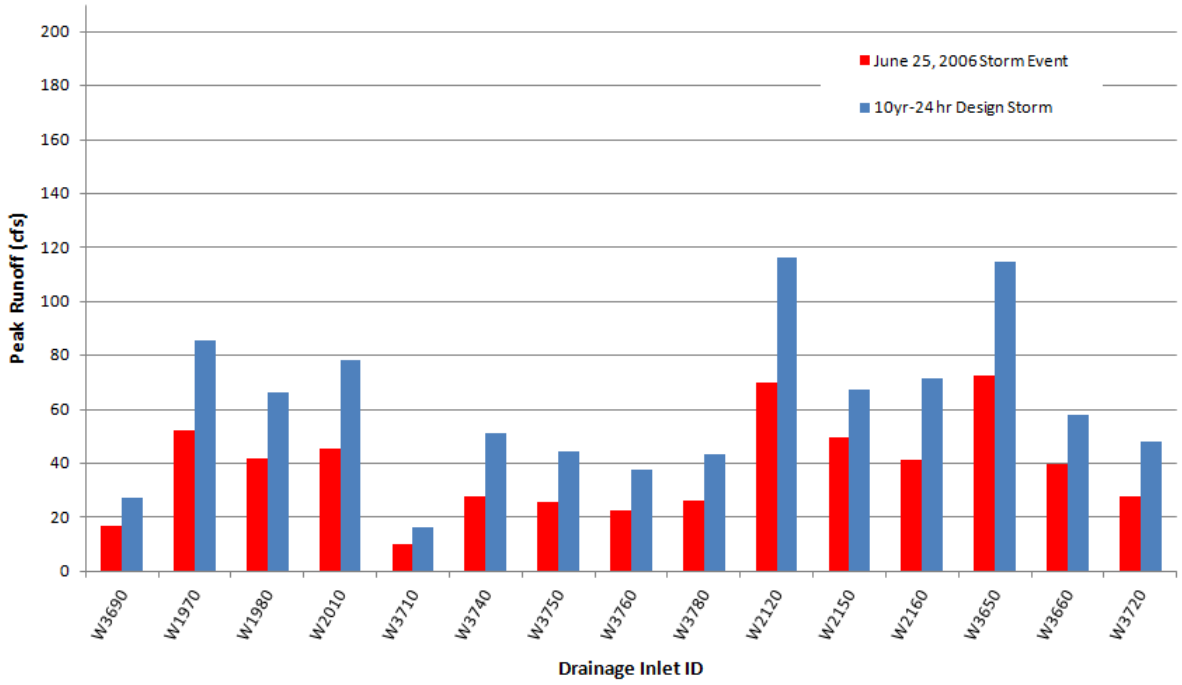


FIGURE 11
Peak Runoff: Lower Area Subwatersheds (South of N. Carlin Springs Rd.)



4 Hydraulic Modeling

The watershed was analyzed using the widely used and industry-accepted private domain stormwater management computer model PCSWMM 2011. The core simulation engine of this model is based on EPA's SWMM 5. PCSWMM 2011 was used to simulate the hydraulic performance of the stormwater collection system.

4.1 Simulation for Two Storm Events

Hydraulic simulations were performed for the two rainfall distributions:

- June 2006 storm event based on the rain gauge at the Donaldson Run lift station
- 10yr-24 hr storm based on SCS Type II distribution

4.2 Drainage Network

The physical data for the stormwater collection system were imported into the model primarily from the geodatabase provided by the County. This geodatabase was updated for the missing physical data listed in **Appendix A**. Model input data included the following:

- Physical data for nodes (catchbasin, manhole, junction, etc.), such as invert and crown elevations
- Physical data for conduits, such as invert elevations, size, shape, material, and length
- Transect data for stream segments

- Physical data for Beaver Pond and VDOT Pond

4.3 Stream Segments

County staff provided transects of stream segments indicating the following elevations: (1) centerline of stream, (2) top of bank, and (3) break lines of changes in slope. This information was incorporated in the model.

4.4 Modeling Ponds in PCSWMM 2011

Beaver Pond and VDOT Pond are located midway in the watershed. These ponds are represented by multiple links and nodes in the ArcGIS PGDB. However, in PCSWMM 2011 these ponds are modeled as storage nodes. Some assumptions were made to generate the storage curve for each pond.

4.4.1 Beaver Pond Storage Curve

The 2010 Rice Associates survey data is limited to the following:

- Minimum survey elevation is 256 feet
- Maximum survey elevation is 261 feet
- No elevations were obtained for the vegetation (cattails)
- Pond invert was based on the top-of-sediment (TS) elevations (approximately 253 feet)
- Pond invert elevation is equal to the average top of sediment elevation of 253 feet
- Pond area for an elevation of 253 feet is equal to the area for a elevation of 256 feet
- Area covered by cattail was digitized using the orthophotos as a reference
- Based on mapping, the vegetation impacts storage up to an elevation of 256 feet

Table 6 shows the storage curves for the Beaver Pond. **Figure 12** shows the survey data.

TABLE 6
Beaver Pond Storage Curve

				Input to PCSWMM 2011	
Contour Elevation (ft)	Pond Area (ft^2)	Vegetation Area (ft^2)	Storage Area (ft^2)	Depth (ft)	Storage Area (ft^2)
253	180,839	99,289	81,550	0	81,550
256	180,839	99,289	81,550	3	81,550
257	191,216	0	191,216	4	191,216
258	199,993	0	199,993	5	199,993
259	208,217	0	208,217	6	208,217
260	216,663	0	216,663	7	216,663
261	225,456	0	225,456	8	225,456

4.4.2 VDOT Pond Storage Curve

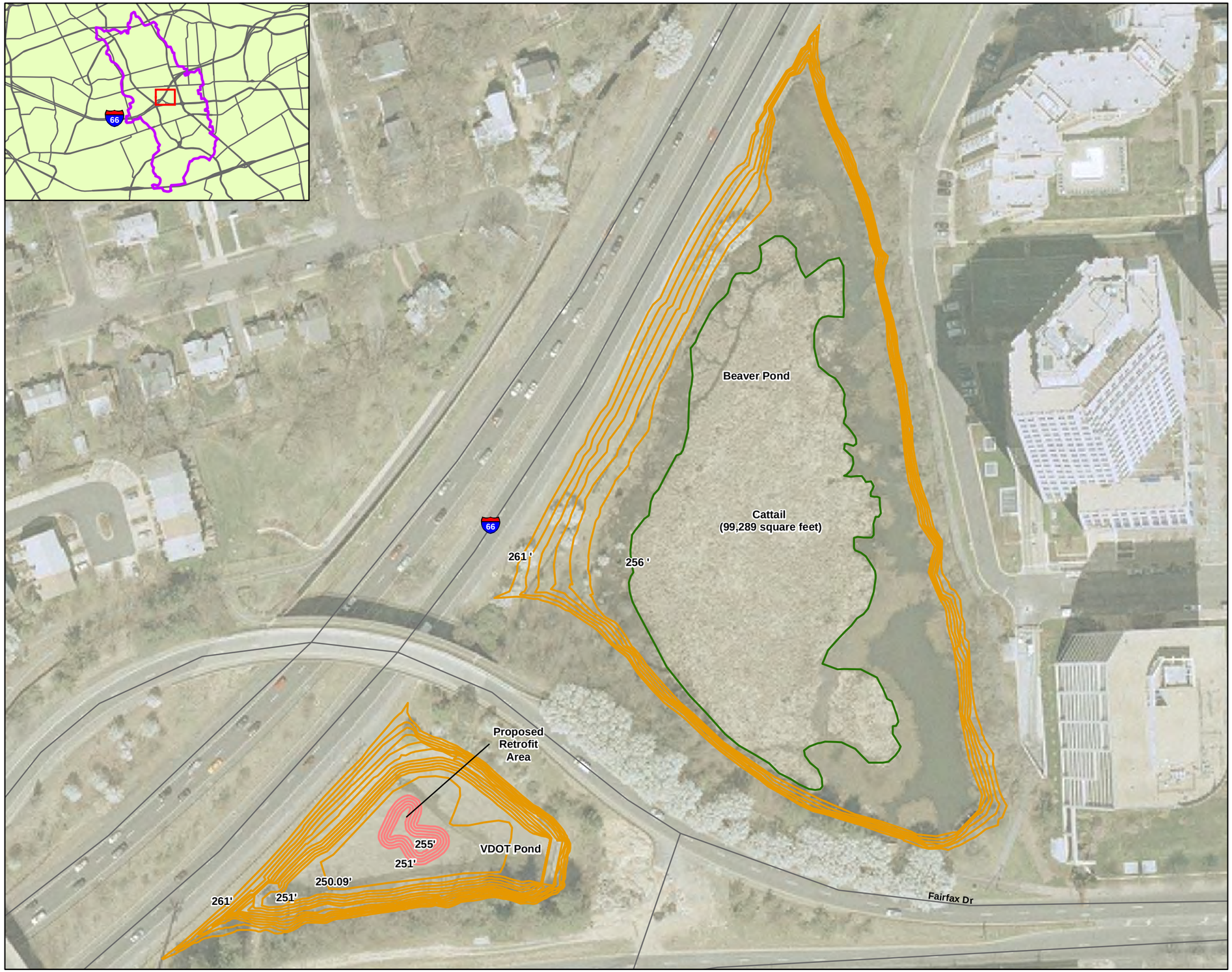
The pond storage curve was developed using the information obtained from VDOT's *SWM Pond Plan*:

- The minimum survey elevation is 250.09 feet. A contour was created using the surveyed points.
- The maximum survey elevation is 261 feet.
- The proposed retrofit area has a minimum elevation of 251 feet and a maximum elevation of 255 feet.
- It is assumed the retrofit area for an elevation of 250.09 is the same as the area for an elevation of 251 feet.
- Based on mapping, the retrofit area impacts storage up to an elevation of 255 feet.

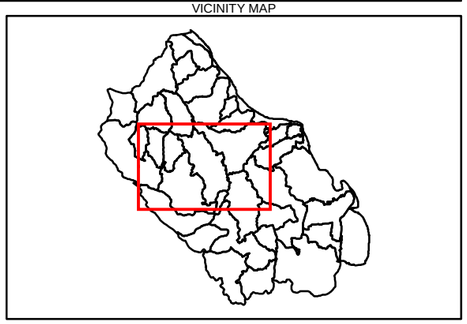
Table 7 shows the storage curves for the VDOT Pond and **Figure 12** shows the survey data.

TABLE 7
VDOT Pond Storage Curve

				Input to PCSWMM 2011	
Contour Elevation (ft)	**Pond Area (ft^2)**	**Retrofit Area (ft^2)**	**Storage Area (ft^2)**	**Depth (ft)**	**Storage Area (ft^2)**
250.09	14,310	3,132	11,178	0	11,178
251	22,004	3,132	18,872	0.91	18,872
252	24,153	2,442	21,711	1.91	21,711
253	26,412	1,812	24,601	2.91	24,601
254	28,483	1,224	27,259	3.91	27,259
255	30,489	705	29,785	4.91	29,785
256	34,060	0	34,060	5.91	34,060
257	36,711	0	36,711	6.91	36,711
258	39,145	0	39,145	7.91	39,145
259	41,761	0	41,761	8.91	41,761
260	44,501	0	44,501	9.91	44,501
261	47,810	0	47,810	10.91	47,810



VICINITY MAP



Legend

- Outer Edge
- Retrofit Area
- Vegetation Area
- Roads
- Modeled (Revised) Watershed Boundary

N

0 50 100
Feet

FIGURE 12
Pond Survey Data
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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4.4.3 Sedimentation in the Beaver Pond

The 2010 survey data from Rice Associates revealed some sedimentation in Beaver Pond. As part of the model development, it was decided that two scenarios would be modeled and the results discussed with the County:

- Scenario 1: model the pond without sedimentation
- Scenario 2: model the pond with sedimentation

A TM was submitted to the County on March 22, 2011, explaining each scenario modeled. A meeting was held on March 23 to discuss the results. (The TM and meeting minutes are included in **Appendix D**.)

Without sedimentation, the pond invert elevation was assumed to be 251 feet (downstream invert of a 66-inch pipe). With sedimentation, the pond invert of approximately 253 feet (based on the Rice Associates survey) was used. With sedimentation, the pond was modeled as 8 feet deep, as compared to 10 feet deep without sedimentation.

The following are other major adjustments made to scenario 1:

- The invert of the 66-inch pipe from Ballston Plaza (between 11th St. North and Fairfax Dr.) was adjusted up to the TS elevation of 253 feet, and diameters were reduced to maintain the adjusted invert elevation and existing crown elevation. This was also done for the triple-box inlet culvert.
- Two "dummy" nodes were added to the links for the 66-inch pipe and triple-box culvert. The locations of the dummy nodes were determined by extrapolating the pond invert elevation of 253 feet, with sedimentation, within the pipelines. Downstream of the dummy nodes included the reduced diameters. The existing database diameters were maintained in the model upstream of the dummy nodes.
- The triple-box culvert dummy node was located approximately 75 feet upstream of its outlet; hence the adjustment of invert and diameter were for only the lowest 75 feet of that culvert.
- The 66-inch-pipe dummy node was nearly 400 feet upstream from the outlet.

Concern was expressed about the adjustment of the 66-inch pipe for such a long distance (±400 feet). It was decided that the County would arrange to open the lids of the manholes along this sewer line to visually inspect for the presence of sedimentation. The visual inspection revealed standing water and silt; therefore, the County decided that the assumptions/model input described in the TM and presented at the March 23 meeting are reasonable. Thus placing the dummy node approximately 400 feet upstream of the outfall seems to be a reasonable approximation of the field conditions.

4.4.4 Ponds' Outlet Control Structures

The Beaver Pond outlet control structure consists of a V-notch weir with stop logs. A site visit performed by RK&K revealed that the V-shaped notches are blocked. The riser holds the water back until the top elevation; therefore, the weir was modeled with a crest elevation of 255.63 feet (top lower wall) and length of 54 feet.

The VDOT Pond outlet control structure information was obtained from VDOT's existing SWM riser structure modification drawing. The structure consists of the following:

- Riser weir wall with four openings, each 10.9 feet wide and 2 feet high, and with an invert elevation of 256.19 feet (One of the openings has a galvanized steel plate blocking 7.4 feet of the width of the opening.)
- 24-inch PVC low-flow orifice with an invert elevation of 252.50 feet

4.4.5 Ponds' Initial Conditions

- Beaver Pond has an initial water surface elevation of 255.63 feet, defined by the weir crest elevation.
- VDOT Pond has an initial water surface elevation of 252.5 feet, defined by the invert elevation of the 24-inch PVC low-flow orifice.

4.5 Head Losses

4.5.1 Inlet and Outlet Losses

Energy losses were assigned to represent losses encountered going from one pipe to another through an access hole. Manhole losses were applied at junctions labeled "manholes" in the GIS, and inlet losses were applied at all other junctions (i.e., catch basins, detention outlets, end walls, grate inlets, junctions) between pipes, between culverts, and between pipes and culverts. Inlet losses were also applied at junctions between streams and both culverts and pipes. The head loss coefficients are listed in **Table 8**.

TABLE 8
Standard Head Loss Coefficients

Structure Configuration	Loss Coefficient
Inlet—straight run	0.50
Inlet—angled through	
90°	1.50
60°	1.25
45°	1.10
22.5°	0.70
Manhole—straight run	0.15
Manhole—angled through	
90°	1.00
60°	0.85
45°	0.75
22.5°	0.45

Source: U.S. DOT, *Urban Drainage Design Manual,* 2nd ed., Hydraulic Engineering Circular No. 22, 2001.

4.5.2 Friction Head Losses

Values for roughness were set using established or previously reported values. **Tables 9 and 10** list standard roughness values used in the model for the different conduit types and natural streams, respectively.

TABLE 9
Standard Roughness Values for Pipes and Culverts

Element	Manning's *n*
Concrete pipe	0.014
Concrete rectangular conduit	0.015

Source: James, W., *User's Guide to SWMM5*, 12th ed., CHI, 2008. p. 766.

TABLE 10
Standard Roughness Values for Natural Streams

Element	Manning's *n*	Comment
Main channel	0.014 or 0.028	0.014 for concrete bottom
Overbanks	0.014 or 0.035	0.014 for concrete wall

Sources: James, W., *User's Guide to SWMM5*, 12th ed., CHI, 2008. p. 766; surveyor-provided photos.

4.6 Boundary Conditions

The boundary condition of the Lubber Run SWMM was extended beyond the Lubber Run watershed boundary by including approximately 230 additional lengths of stream to include potential backwater impacts from the confluence of Lubber Run and Four Mile Run. The outfall boundary condition data of Four Mile Run was provided by the Northern Virginia Regional Commission, which provided a time series of depth results from the Four Mile Run watershed model for the two selected storm events listed above and extracted the water depth at the confluence of Lubber Run with Four Mile Run. These depths were converted to water level by adding the invert elevation of the outfall for each point in the time series. These data will be delivered to the County with the final model delivery.

4.7 Storage Node

When a rainfall event is input into a model node and the flow exceeds the capacity of that node, the excess volume floods to the ground surface and is lost to the conveyance system. However, this flooding is almost never representative of field conditions, and the model should be adjusted. This is often the case in models that represent a portion of the stormwater collection system. In the Lubber Run watershed model, 28 percent of the length of the piping network, albeit the largest pipes, is included in the model. Runoff can be restricted at inlet nodes and never enter the modeled system when, in fact, they are attenuated through the piping network upstream that is not included in the model and conveyed through the existing stormwater collection system. Therefore, if needed, the maximum storage capacity of the piping network upstream of the model can be calculated, and storage nodes can be added to the model.

4.8 Simulation Options

4.8.1 Routing Method

Dynamic wave was selected as the routing method for the following reasons:

- It solves the complete one-dimensional Saint Venant flow equations and therefore produces the most theoretically accurate results.
- It can account for channel storage, backwater, entrance/exit losses, and flow reversal.

4.8.2 Time Step

Generally, it is recommended that the time steps be the same for runoff computation, routing computation, and reporting. The time steps selected for the Lubber Run watershed model are as follows:

- Runoff computation
  - Dry weather: 2 seconds
  - Wet weather: 2 seconds
- Routing computation: 2 seconds
- Reporting: 2 seconds

5 Hydraulic Model Results

5.1 Comparison of Data to Reports of Flooding

The Lubber Run watershed model results were compared to the anecdotal flooding reports for the June 2006 storm event provided by the County. Most of the anecdotal flooding complaints from the June 2006 storm event are in the same locations as the flooding nodes reported by the Lubber Run watershed model, as shown in **Figure 13**.

5.2 Inlet Capacity

As mentioned in Section 4, storage will be added to the most upstream nodes if there are restrictions routing the total runoff.

Storage was initially added at six inlet nodes for the June 2006 storm event to reflect the amount of storage capacity that exists in the upstream piping network (pipes smaller than 36 inches). However, for the inlet nodes that still reported flooding after this initial amount of storage was added, storage volume continued to be increased incrementally until the inlet node no longer flooded. Therefore, the modeled storage volume is either equal to the system storage capacity upstream of the inlet node or the maximum storage volume required to convey the storm hyetograph. Storage was expanded to a total of 16 nodes for the 10yr-24hr SCS Type II storm event.

Table 11 shows (1) the nodes with restricted inlet capacity, (2) the calculated storage capacity of the piping network upstream of the inlet node (pipes smaller than 36 inches), and (3) the average and maximum storage volume used for each storm event. The average storage volume used reflects the average (zero to maximum) storage volume used over the entire storm event (24 hours). **Figure 14** shows the location of the restricted nodes identified in **Table 11**.

VICINITY MAP

Legend

- Flooded Node in Model
- June 2006 Flood Reports Stormwater
- Modeled Stormwater Mains ≥ 36"
- Stormwater Mains < 36"
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400

Feet

FIGURE 13
June 2006 Event – Model Comparison
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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VICINITY MAP

Legend

- Storage Node
- Modeled Stormwater Mains ≥ 36"
- Streams
- Subwatershed
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 14
Storage Nodes
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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TABLE 11
Storage Node Summary

Node ID	System Storage Capacity Upstream of Inlet Node	June 2006 Storm Event			10yr-24hr SCS Type II Storm		
		Modeled Storage Capacity	Average Storage Used	Maximum Storage Used	Modeled Storage Capacity	Average Storage Used	Maximum Storage Used
5955	9,612	NA	NA	NA	19,214	1,557	17,304
6022	17,248	NA	NA	NA	17,248	1,300	17,123
6104	9,142	25,000	5,187	22,886	75,000	13,756	70,263
6907	8,905	8,905	838	3,789	32,400	3,303	31,801
7147	22,628	NA	NA	NA	38,780	4,305	36,127
8669	2,071	2,071	177	1,150	2,071	171	1,831
8915	6,009	NA	NA	NA	6,009	493	5,234
9731	469	NA	NA	NA	3,540	190	3,491
10077	4,731	NA	NA	NA	4,731	751	4,685
10566	4,337	6,420	610	5,857	57,780	6,124	55,376
10686	4,291	NA	NA	NA	4,291	296	3,598
10771	1,565	NA	NA	NA	1,565	117	1,392
10974	2,209	NA	NA	NA	15,600	1,385	14,563
11188	3,225	3,225	177	1,339	12,750	788	10,315
11622	7,569	NA	NA	NA	70,640	26,250	65,823
11887	7,092	7,092	1,050	6,676	81,000	10,884	66,536

All values in cubic feet. NA, not applicable.

5.3 Conveyance Capacity

The conveyance capacity of the existing stormwater collection system during the storm events listed in Section 4 was evaluated based these evaluation criteria:

- If the hydraulic grade line (HGL) rose above the ground surface, the structure was considered flooded.
- If the HGL rose to within 1 foot of the ground surface, the structure was considered to have insufficient "freeboard."
- If the HGL rose above the crown of the pipe but below the insufficient freeboard mark, the structure was considered surcharged.
- At stream-to-pipe or pipe-to-stream nodes (or connections), if the HGL rose above the pipe crown (pipe submerged), this node was also considered surcharged.

Pipes were evaluated for these conditions on the upstream and downstream ends and categorized on the basis of the least desirable condition. Results are summarized in **Table 12** for the June 2006 storm event and the 10yr-24 hr SCS Type II storm.

The hydraulic model predicts that approximately 59 percent of the Lubber Run stormwater collection system is experiencing capacity limitations during the June 2006 event and 91 percent is experiencing capacity limitations during the 10yr-24hr SCS Type II storm.

The details of the pipes with flooding, insufficient freeboard, and surcharged conditions are summarized in **Tables 13** and **14. Tables 15** and **16** provide details on the stream segments. As discussed previously, cross section information was provided as input to the model. All flows from both storms stayed within the cross section and were not lost from the model. In some cases, the HGL did reach above the top of bank but still stayed within the stream cross section; that is, the streams fully conveyed the flow within the model.

A plan view of the watershed depicting the inlets, manholes, and other point structures experiencing these conditions is provided in **Figures 15** and **16.**

TABLE 12
Summary of Conveyance Capacity Limitations

Scenario (with Storage)	Modeled System (Linear Feet)[a]	HGL Flooding Ground Surface		HGL Within 1 Foot of Ground Surface		HGL Surcharging Pipe Crown		Capacity Limitations	
		Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System	Linear Feet	Percent of Modeled System
June 2006 storm event	35,091	4,197	12	6,630	19	9,920	28	20,746	59
10yr-24hr SCS Type II storm	35,091	9,720	28	11,905	34	10,203	29	31,827	91

HGL, hydraulic grade line.
[a]The modeled system in this table includes the pipe network described in Table 2. It does not include natural stream channels.

VICINITY MAP

Legend

- Flooded
- Insufficient Freeboard
- Surcharged
- Sufficient Conveyance Capacity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 15
Conveyance Capacity - June 2006 Storm
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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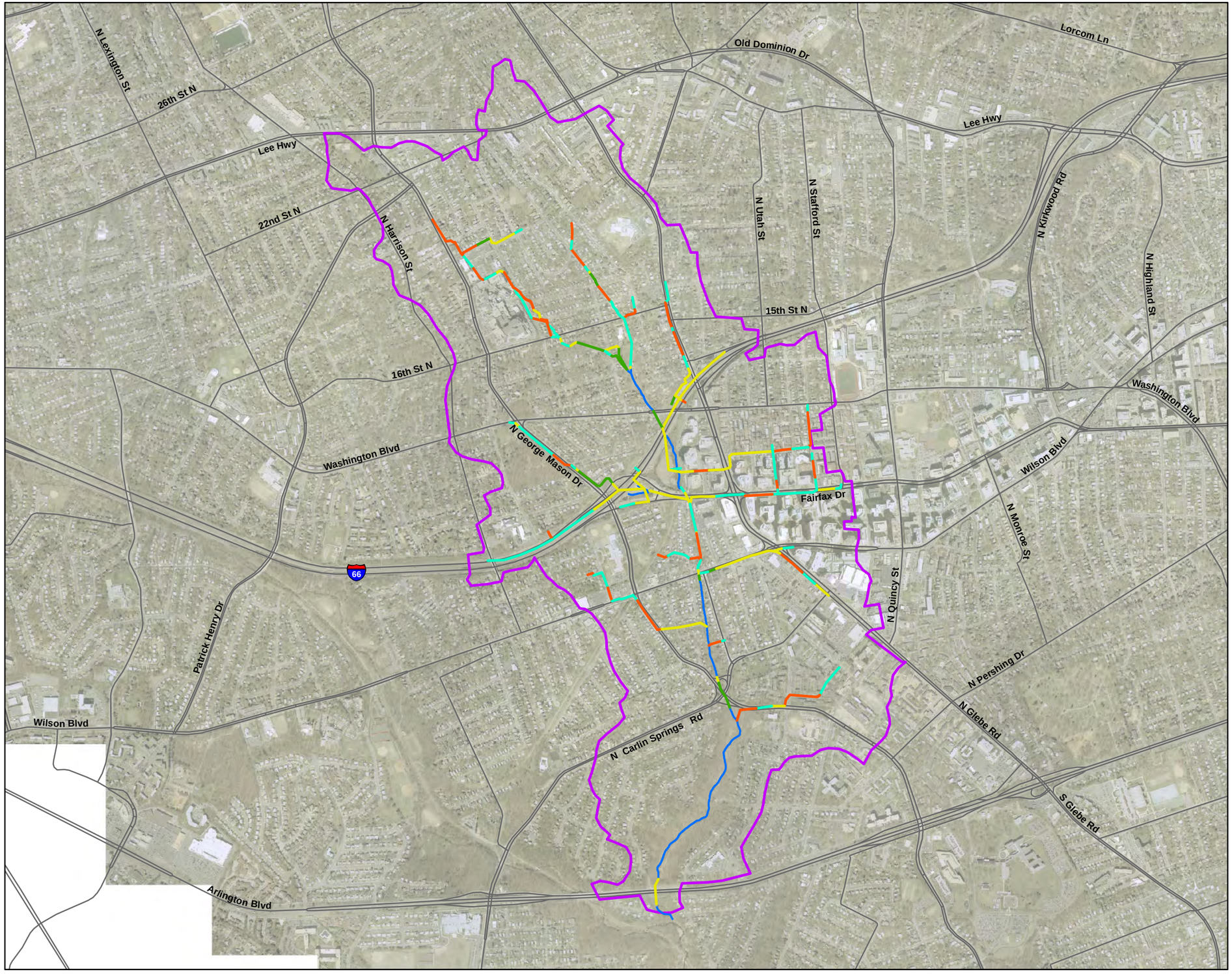

VICINITY MAP

Legend

- Flooded
- Insufficient Freeboard
- Surcharged
- Sufficient Conveyance Capcity
- Streams
- Roads
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE 16
Conveyance Capacity - 10-yr 24-hr Storm
Lubber Run Watershed
Arlington County Storm Capacity Analysis

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TABLE 13
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
10234	12194	12193	432.6	3	65.0	9.7	6	10.8	0.6	2.4	0	840	RIM	Y	Y	Y	Flooding
10236	12193	12242	91.8	3.5	91.1	9.5	10.8	8.4	2.4	1.2	840	153	Y	Y	Y	Y	Flooding
10237	12242	12293	84.0	3.5	103.7	12.5	8.4	7.8	1.2	0	153	0	Y	0.89	Y	Y	Flooding
10245	12293	12295	179.8	3.5	150.7	16.0	7.8	8.4	0	0.6	0	0	0.89	RIM	Y	Y	Ins. freeboard
10246	12295	12334	223.0	3.5	150.7	16.8	8.4	14.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
10247	12334	12354	231.0	3.5	150.7	15.7	14.4	79.8	0.6	77.4	0	92,570	RIM	Y	Y	Y	Flooding
10274	12354	12485	131.0	3.5	117.2	13.8	79.8	0	77.4	0	92,570	0	Y	N	Y	N	Flooding
16825	7674	7696	32.0	4.5	138.0	8.7	89.4	88.2	0	0	0	0	N	N	2.26	1.86	Surcharge
16827	7696	7695	75.0	4.5	167.4	10.5	88.2	37.2	0	0	0	0	N	N	1.86	0.56	Surcharge
16883	8792	9021	237.1	2-5x6	149.6	4.1	0	0	0	0	0	0	N	N	N	0.28	Surcharge
16917	9298	9311	148.9	4.5	65.8	5.2	78.6	0	0.6	0	61	0	Y	N	Y	3.07	Flooding
16918	9287	9298	136.0	4.5	67.6	6.6	76.2	78.6	0.6	0.6	0	61	RIM	Y	Y	Y	Flooding
16919	9260	9287	225.1	4	33.0	3.7	63.6	76.2	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
16920	9311	9326	317.6	5	88.4	6.5	0	84	0	0	0	0	N	0.69	2.57	Y	Ins. freeboard
16937	9696	VDOT Pond	96.5	3	15.5	2.2	145.2	0	0	0	0	0	N	N	2.98	4.18	Surcharge
16948	9851	9897	240.0	2-6x8	230.2	3.3	0	24.6	0	0	0	0	N	N	N	0.52	Surcharge
16982	11188	11143	68.8	3	38.3	7.0	2.4	3	0	0	0	0	N	N	0.53	0.61	Surcharge
16983	11143	11075	155.0	3	38.5	6.7	3	6.6	0	0.6	0	0	N	RIM	0.63	Y	Ins. freeboard
17317	11476	11449	169.9	4	114.4	10.9	0	81	0	0	0	0	N	N	N	1.17	Surcharge
17318	11449	11483	81.2	4.5	133.3	9.2	81	0	0	0	0	0	N	N	1.17	0.06	Surcharge
17327	11357	11521	298.7	4	74.8	6.6	0	30	0	0	0	0	N	N	N	1.15	Surcharge
17329	11622	11628	41.0	3	90.1	12.8	1.8	11.4	0	0	0	0	N	N	0.84	2.44	Surcharge
17347	11887	11890	6.0	3	63.0	9.5	29.4	4.8	0	0	0	0	0.32	N	Y	0.72	Ins. freeboard
17366	11987	11996	17.0	2-8x10	1461.4	9.2	0	0	0	0	0	0	N	N	0.73	N	Surcharge
18030	14510	14737	252.5	7x12	1579.6	23.9	122.4	0	0	0	0	0	N	N	10.59	2.36	Surcharge
20414	7480	7588	112.9	3	75.2	10.8	1.2	0	0	0	0	0	N	N	1.25	N	Surcharge
20620	7469	7536	73.0	3.5	85.0	9.2	84	87	0.6	0	0	0	RIM	0.81	Y	Y	Ins. freeboard
20621	7536	7664	187.0	3.5	85.2	9.6	87	86.4	0	0	0	0	0.81	N	Y	1.73	Ins. freeboard
20622	7957	7994	62.0	4x6.33	203.7	10.3	0	0	0	0	0	0	N	N	0.85	N	Surcharge
20817	11628	11643	55.0	3	90.1	12.8	11.4	4.2	0	1.2	0	141	N	Y	2.44	Y	Flooding
20818	11643	11671	122.5	3x4.83	86.3	7.6	4.2	36.6	1.2	3.6	141	1,520	Y	Y	Y	Y	Flooding
20819	11671	11684	17.0	3	76.0	12.6	36.6	0	3.6	0	1,520	0	Y	N	Y	N	Flooding
21160	14405	14510	110.0	7x12	1571.1	23.7	0	122.4	0	0	0	0	N	N	17.29	10.59	Surcharge

TABLE 13 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
21780	9799	9864	86.6	3-6x10	838.1	4.7	42	66	0	0	0	0	N	N	1.52	1.48	Surcharge
21781	9864	9978	101.5	2-6x10	838.2	7.0	66	61.2	0	0	0	0	N	N	1.48	1.35	Surcharge
24246	6973	24153	170.0	4	113.6	11.0	0	0	0	0	0	0	N	0.75	N	Y	Ins. freeboard
24247	24153	7198	170.0	4	113.0	10.0	0	0	0	0	0	0	0.75	N	Y	N	Ins. freeboard
24256	7333	7394	155.0	3	76.9	10.9	2.4	46.8	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
24258	7423	24162	182.0	4.5	172.4	10.8	86.4	89.4	0.6	10.8	0	1,968	RIM	Y	Y	Y	Flooding
24259	24162	7494	182.0	4.5	163.9	10.3	89.4	90	10.8	85.2	1,968	167,400	Y	Y	Y	Y	Flooding
24260	7147	7333	168.0	3.5	79.4	11.0	0	2.4	0	0.6	0	0	N	RIM	N	Y	Ins. freeboard
24267	10480	10289	457.6	4.5	64.4	6.0	0	1.2	0	0	0	0	N	N	N	0.08	Surcharge
24273	24161	6710	108.0	5	206.6	10.5	84.6	83.4	0	0	0	0	N	N	5.42	7.49	Surcharge
24274	6862	24171	31.2	5	206.7	10.5	91.8	87.6	0	0	0	0	0.23	0.81	Y	Y	Ins. freeboard
24275	24171	24161	127.0	5	206.7	10.5	87.6	84.6	0	0	0	0	0.81	N	Y	5.42	Ins. freeboard
24276	8964	24172	60.0	3	26.1	6.1	44.4	76.2	0.6	0.6	127	0	Y	RIM	Y	Y	Flooding
24277	24172	9223	60.0	3	25.2	4.8	76.2	59.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
24283	11521	11517	29.8	4	114.4	9.6	30	0	0	0	0	0	N	N	1.30	N	Surcharge
24285	24176	24177	5.0	4	128.2	15.5	79.2	84.6	0	0	0	0	N	N	1.19	3.44	Surcharge
24298	9978	24187	16.6	2-6x10	1056.0	9.1	61.2	17.4	0	0	0	0	N	N	1.35	0.29	Surcharge
24299	24187	10046	51.2	2-6x10	1057.7	10.6	17.4	16.8	0	0	0	0	N	N	0.29	0.29	Surcharge
24302	9524	Dummy Node	208.0	5.5	115.8	4.9	94.2	97.8	0	0	0	0	N	N	6.34	5.73	Surcharge
24302_2	Dummy Node	9543	75.0	5.23	115.8	5.4	97.8	99.6	0	0.6	0	0	N	0.00	6.00	Y	Ins. freeboard
24305	7394	24160	52.0	3	76.9	10.9	46.8	79.8	0.6	0	0	0	RIM	N	Y	1.13	Ins. freeboard
24306	24160	7445	15.0	3	76.9	11.1	79.8	0	0	0	0	0	N	N	1.23	N	Surcharge
24307	10927	24177	40.0	2-6x10	1153.5	9.6	84	84.6	0	0	0	0	N	N	1.67	1.44	Surcharge
24308	24177	10969	8.0	2-6x10	1255.2	11.1	84.6	0	0	0	0	0	N	N	1.44	N	Surcharge
24314	24190	24176	122.0	4	128.9	17.3	0	79.2	0	0	0	0	N	N	N	1.19	Surcharge
24315	11890	12057	283.7	3	62.3	9.5	4.8	7.2	0	0.6	0	0	N	RIM	0.72	Y	Ins. freeboard
24317	12057	24191	122.5	3	61.4	8.7	7.2	7.2	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
24318	24191	12194	69.7	3	61.4	10.0	7.2	6	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
3009	6907	7023	97.8	3	49.3	8.2	0	10.2	0	0	0	0	N	0.60	N	Y	Ins. freeboard
3084	7023	7181	147.7	3	49.0	6.9	10.2	17.4	0	0	0	0	0.60	N	Y	0.94	Ins. freeboard
3108	7181	7233	69.0	3	49.0	7.9	17.4	0	0	0	0	0	N	N	0.94	N	Surcharge
3225	7233	7480	243.0	3	49.0	8.5	0	1.2	0	0	0	0	N	N	N	1.25	Surcharge

TABLE 13 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
5623	6104	6122	30.9	3	49.4	7.3	85.2	21.6	0	0	0	0	0.42	0.74	Y	Y	Ins. freeboard
5627	5955	6132	185.0	3.5	90.6	13.2	0	28.8	0	5.4	0	1,279	N	Y	N	Y	Flooding
5640	6122	6180	96.2	3	49.4	7.4	21.6	46.8	0	0	0	0	0.74	N	Y	1.08	Ins. freeboard
5646	6180	6194	24.7	3	49.4	7.0	46.8	40.2	0	0	0	0	N	N	1.14	0.76	Surcharge
5659	6194	6257	130.5	3	49.4	7.2	40.2	42	0	0	0	0	N	N	0.90	0.63	Surcharge
5664	6121	6278	149.9	3	68.9	12.1	0	1.2	0	0	0	0	N	N	N	3.28	Surcharge
5665	6286	6273	72.8	3.5	93.2	9.7	63.6	64.8	16.2	0	4,856	0	Y	N	Y	4.08	Flooding
5666	6132	6286	178.1	3.5	81.3	9.3	28.8	63.6	5.4	16.2	1,279	4,856	Y	Y	Y	Y	Flooding
5672	6273	6302	41.4	3.5	93.2	11.9	64.8	63	0	0.6	0	0	N	0.00	4.08	Y	Ins. freeboard
5675	6309	6250	69.7	3	49.4	7.8	33	0	0	0	0	0	N	N	0.17	N	Surcharge
5678	6257	6313	131.8	3	49.4	7.0	42	54.6	0	0	0	0	N	N	0.63	0.66	Surcharge
5679	6313	6309	57.3	3	49.4	7.0	54.6	33	0	0	0	0	N	N	0.66	0.17	Surcharge
5698	6278	6372	114.5	3	68.9	12.8	1.2	5.4	0	0.6	0	0	N	RIM	3.28	Y	Ins. freeboard
5716	6341	6423	207.0	3.5	80.4	11.4	0	82.2	0	4.8	0	498	N	Y	N	Y	Flooding
5726	6423	6460	32.3	3.5	77.6	10.4	82.2	81.6	4.8	0	498	0	Y	0.82	Y	Y	Flooding
5727	6434	6460	28.8	3.5	117.6	12.2	79.2	81.6	46.8	0	42,820	0	Y	0.82	Y	Y	Flooding
5744	6372	6539	202.6	3.5	68.9	7.3	5.4	20.4	0.6	1.8	0	247	RIM	Y	Y	Y	Flooding
5745	6460	6544	105.7	5	178.0	13.4	81.6	85.2	0	0.6	0	0	0.82	RIM	Y	Y	Ins. freeboard
5761	6539	6637	115.0	3.5	92.0	9.6	20.4	26.4	1.8	0	247	0	Y	0.15	Y	Y	Flooding
5768	6544	6676	135.0	5	178.0	9.1	85.2	87.6	0.6	0	0	0	RIM	0.52	Y	Y	Ins. freeboard
5776	6637	6692	40.0	3.5	92.0	9.6	26.4	36	0	0	0	0	0.15	0.34	Y	Y	Ins. freeboard
5785	6692	6721	60.0	3.5	92.0	9.6	36	10.8	0	0	0	0	0.34	N	Y	0.46	Ins. freeboard
5786	6710	6727	55.6	5.5	206.4	8.8	83.4	81.6	0	0	0	0	N	N	6.99	7.03	Surcharge
5797	6721	6741	21.0	3.5	92.0	9.9	10.8	0	0	0	0	0	N	N	0.51	N	Surcharge
5819	6676	6834	185.0	5	185.2	9.4	87.6	91.8	0	78.6	0	107,200	0.52	Y	Y	Y	Flooding
5830	6834	6862	42.0	5	206.8	10.5	91.8	91.8	78.6	0	107,200	0	Y	0.23	Y	Y	Flooding
5887	6727	7005	263.0	5.5	200.1	9.1	81.6	82.8	0	0.6	0	0	N	RIM	7.03	Y	Ins. freeboard
5891	7005	7014	16.2	5.5	223.7	10.1	82.8	81.6	0.6	0	0	0	RIM	N	Y	1.22	Ins. freeboard
5892	7014	7015	8.0	3.5	74.7	7.8	81.6	93.6	0	6	0	1,663	N	Y	3.22	Y	Flooding
5906	7015	7061	88.7	3.5	62.9	6.5	93.6	91.2	6	78	1,663	13,880	Y	Y	Y	Y	Flooding
5912	7014	7076	82.2	4.5	167.0	10.5	81.6	83.4	0	0.6	0	0	N	RIM	2.22	Y	Ins. freeboard
5939	7061	7131	61.5	3.5	56.9	6.3	91.2	90	78	79.2	13,880	29,840	Y	Y	Y	Y	Flooding
5946	7076	7153	79.3	4.5	167.0	10.5	83.4	82.2	0.6	0.6	0	0	RIM	0.00	Y	Y	Ins. freeboard

TABLE 13 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
5983	7232	7255	22.5	3.5	70.8	7.4	95.4	88.2	81.6	0	38,390	0	Y	0.08	Y	Y	Flooding
5991	7153	7269	116.5	4.5	164.9	10.8	82.2	78	0.6	0.6	0	0	0.00	RIM	Y	Y	Ins. freeboard
6027	7255	7345	91.0	3.5	75.3	7.8	88.2	90.6	0	0	0	0	0.08	N	Y	2.58	Ins. freeboard
6032	7345	7369	86.2	3.5	75.3	7.8	90.6	89.4	0	0	0	0	N	N	2.58	2.66	Surcharge
6043	7269	7423	211.9	4.5	150.5	11.9	78	86.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
6055	7369	7458	93.0	3.5	75.3	7.8	89.4	96.6	0	0	0	0	N	N	2.66	3.17	Surcharge
6059	7458	7469	88.0	3.5	75.3	7.9	96.6	84	0	0.6	0	0	N	RIM	3.17	Y	Ins. freeboard
6542	6308	6434	178.6	3.5	118.5	12.3	80.4	79.2	0	46.8	0	42,820	0.70	Y	Y	Y	Flooding
6543	6302	6308	23.4	3.5	118.5	12.3	63	80.4	0.6	0	0	0	0.00	0.70	Y	Y	Ins. freeboard
6568	7131	7232	161.7	3.5	75.1	7.8	90	95.4	79.2	81.6	29,840	38,390	Y	Y	Y	Y	Flooding
7788	7664	7695	37.9	4	86.9	3.4	86.4	37.2	0	0	0	0	N	N	1.31	1.98	Surcharge
7789	7494	7674	216.0	4.5	138.0	8.7	90	89.4	85.2	0	167,400	0	Y	N	Y	2.26	Flooding
7798	7695	7724	43.3	4.83x7.58	249.0	8.4	37.2	64.2	0	0	0	0	N	N	1.15	0.57	Surcharge
7799	7724	7785	66.5	4.83x7.58	262.3	8.9	64.2	45	0	0	0	0	N	N	0.57	0.45	Surcharge
7800	7785	7840	92.8	4.83x7.58	262.8	8.9	45	7.8	0	0	0	0	N	N	0.45	0.16	Surcharge
7801	7840	7834	48.0	4.83x7.58	281.9	9.5	7.8	0	0	0	0	0	N	N	0.18	N	Surcharge
7803	7834	7795	53.0	4.83x7.58	281.8	9.8	0	0	0	0	0	0	N	N	0.34	N	Surcharge
7832	8025	8172	189.2	3	85.8	14.1	0	2.4	0	0	0	0	N	N	N	0.79	Surcharge
7833	8172	8232	67.8	3	95.5	13.5	2.4	0	0	0	0	0	N	N	0.79	0.40	Surcharge
7839	8308	8360	49.6	3.5	95.2	10.9	0	0	0	0	0	0	N	N	0.32	N	Surcharge
7840	8360	8386	63.7	3.5	95.1	11.5	0	0	0	0	0	0	N	N	0.03	N	Surcharge
8012	8635	8628	9.2	3.5	23.6	4.1	0	0	0	0	0	0	N	0.79	N	Y	Ins. freeboard
8013	8628	8588	65.5	3.5	23.4	2.4	0	88.2	0	0	0	0	0.79	N	Y	0.98	Ins. freeboard
8014	8588	8569	26.6	3.5	23.3	2.4	88.2	0	0	0	0	0	N	N	1.12	1.32	Surcharge
8038	9339	9363	48.0	5.5	78.7	3.3	88.8	91.2	0	0	0	0	N	N	5.74	5.71	Surcharge
8062	9021	Dummy Node2	40.0	3-6x10	904.6	6.2	0	7.2	0	0	0	0	N	0.42	N	Y	Ins. freeboard
8062_2	Dummy Node2	Beaver Pond	75.2	3-4.87x10	782.6	5.9	7.2	0	0	0	0	0	0.42	N	Y	0.79	Ins. freeboard
8102	9223	9260	56.6	4	25.2	3.4	59.4	63.6	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8118	8669	8767	99.6	3	26.6	5.9	13.2	16.2	0	0.6	0	0	N	RIM	0.77	Y	Ins. freeboard
8120	8767	8964	185.6	3	26.6	6.0	16.2	44.4	0.6	0.6	0	127	RIM	Y	Y	Y	Flooding
8137	9336	9339	129.4	5	78.6	4.6	87	88.8	0	0	0	0	N	N	7.80	6.24	Surcharge
8142	9326	9336	131.1	5	78.6	6.9	84	87	0	0	0	0	0.69	N	Y	7.80	Ins. freeboard

TABLE 13 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8182	9725	9825	118.8	4.42x6.92	126.9	5.5	0	0	0	0	0	0	N	N	1.23	1.18	Surcharge
8197	10077	10036	182.6	3	16.5	3.5	103.8	145.8	0	0	0	0	N	N	2.19	2.62	Surcharge
8201	10289	10101	264.5	4.42x6.92	89.4	5.4	1.2	67.8	0	0	0	0	N	N	0.26	0.57	Surcharge
8202	10101	10024	167.2	4.42x6.92	83.6	4.5	67.8	82.8	0	0	0	0	N	N	0.67	0.90	Surcharge
8205	10024	9862	209.1	4.42x6.92	83.6	3.5	82.8	94.8	0	0	0	0	N	N	1.10	1.16	Surcharge
8206	9862	9825	39.1	4.42x6.92	92.5	3.7	94.8	0	0	0	0	0	N	N	1.25	1.18	Surcharge
8224	10013	VDOT Pond	109.4	3	16.5	2.3	274.2	0	0	0	0	0	N	N	3.37	3.92	Surcharge
8226	9897	9930	136.3	2-6x8	234.4	3.1	24.6	36	0	0	0	0	N	N	0.52	0.88	Surcharge
8227	9930	9938	18.8	2-6x8	234.3	3.0	36	36.6	0	0	0	0	N	N	0.88	0.90	Surcharge
8228	9938	9961	80.6	2-6x8	234.3	2.9	36.6	42	0	0	0	0	N	N	0.90	1.11	Surcharge
8229	9961	9978	92.8	2-6x8	236.2	2.5	42	61.2	0	0	0	0	N	N	1.11	1.35	Surcharge
8231	10046	10173	175.0	2-6x10	1171.0	11.9	16.8	27	0	0	0	0	N	N	0.29	0.44	Surcharge
8242	9543	9552	157.6	4.93	115.8	6.1	99.6	102.6	0.6	0	0	0	0.00	N	Y	4.55	Ins. freeboard
8243	9552	9555	110.2	4.5	115.8	7.3	102.6	112.8	0	0	0	0	N	N	4.98	4.26	Surcharge
8245	9555	9561	49.9	3.99	115.8	9.3	112.8	133.8	0	0	0	0	N	N	4.77	4.13	Surcharge
8246	9561	Beaver Pond	75.0	3.79	115.8	10.3	133.8	0	0	0	0	0	N	N	4.33	1.87	Surcharge
8250	9497	9524	89.1	5.5	99.8	4.2	93	94.2	0	0	0	0	N	N	6.44	6.34	Surcharge
8262	9977	10046	67.1	6	166.9	13.1	0	16.8	0	0	0	0	N	N	N	0.29	Surcharge
8289	9478	9497	26.1	5.5	95.1	4.0	93	93	0	0	0	0	N	N	6.48	6.44	Surcharge
8291	9507	9545	50.2	3	16.9	4.8	72.6	98.4	0	0	0	0	N	N	0.62	1.40	Surcharge
8295	9545	9556	23.9	3	16.2	4.4	98.4	121.2	0	0	0	0	N	N	1.40	1.75	Surcharge
8302	9556	9696	160.7	3	15.5	2.8	121.2	145.2	0	0	0	0	N	N	1.87	2.33	Surcharge
8305	10036	10013	206.8	3	16.5	2.3	145.8	274.2	0	0	0	0	N	N	2.62	3.27	Surcharge
8309	9363	9478	139.1	5.5	95.1	4.0	91.2	93	0	0	0	0	N	N	5.72	6.48	Surcharge
8507	10974	10951	84.0	3	29.9	4.2	2.4	0.6	0	0	0	0	N	N	0.39	0.06	Surcharge
8508	10951	10990	40.0	3	30.0	4.3	0.6	0	0	0	0	0	N	N	0.25	N	Surcharge
8512	10943	11014	86.0	3.5	29.3	5.3	0	0	0	0	0	0	RIM	N	Y	N	Ins. freeboard
8542	10448	10480	61.4	3.5	46.1	5.1	0	0	0	0	0	0	N	N	0.05	0.08	Surcharge
8546	10574	10480	247.4	3	24.7	4.0	0	0	0	0	0	0	N	N	N	0.58	Surcharge
8555	10686	10726	104.2	3	38.6	6.6	0	0.6	0	0	0	0	N	N	N	0.04	Surcharge
8556	10726	10701	52.0	3	38.6	5.7	0.6	0	0	0	0	0	N	N	0.14	N	Surcharge
8565	10733	10746	36.0	3	38.1	8.8	0	78	0	0	0	0	N	N	N	1.00	Surcharge

TABLE 13 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 2006 Storm Event (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8566	10746	10722	102.0	3	38.1	7.1	78	85.8	0	75	0	254,900	N	Y	1.00	Y	Flooding
8567	10722	10761	49.5	3	62.2	13.2	85.8	82.8	75	0	254,900	0	Y	N	Y	5.48	Flooding
8569	10683	10761	78.5	2-6×10	1193.2	9.9	81	82.8	0	0	0	0	0.72	N	Y	2.48	Ins. freeboard
8570	10761	10907	152.9	2-6×10	1152.9	9.6	82.8	85.2	0	0	0	0	N	N	2.48	2.00	Surcharge
8571	10907	10927	15.0	2-6×10	1153.3	9.6	85.2	84	0	0	0	0	N	N	2.00	1.67	Surcharge
8578	10824	10879	173.0	4	128.6	12.2	8.4	0	0	0	0	0	N	N	2.41	N	Surcharge
8591	10173	10428	261.2	2-6×10	1171.3	11.5	27	48.6	0	0	0	0	N	N	0.44	1.58	Surcharge
8593	10428	10437	9.0	2-6×10	1172.9	11.4	48.6	40.2	0	0	0	0	N	N	1.58	1.16	Surcharge
8594	10437	10683	303.3	2-6×10	1190.0	10.0	40.2	81	0	0	0	0	N	0.72	1.16	Y	Ins. freeboard
8640	10583	10618	118.2	3	40.5	5.7	12.6	12.6	0	0	0	0	N	N	3.48	4.16	Surcharge
8652	11075	11062	31.0	3	36.1	5.5	6.6	7.2	0.6	0	0	0	RIM	0.43	Y	Y	Ins. freeboard
8653	11062	10940	231.0	3	34.8	5.3	7.2	6	0	0.6	0	0	0.43	RIM	Y	Y	Ins. freeboard
8654	10940	10806	182.0	3.5	50.8	7.5	6	8.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8655	10806	10665	230.0	3.5	49.2	5.3	8.4	13.8	0.6	0	0	0	RIM	N	Y	3.74	Ins. freeboard
8656	10665	10618	91.4	3.5	49.2	5.1	13.8	12.6	0	0	0	0	N	N	3.99	4.61	Surcharge
8657	10618	10614	100.0	3.5	95.7	9.9	12.6	7.8	0	0	0	0	N	N	4.76	5.08	Surcharge
8658	10614	10679	158.0	4	95.7	8.0	7.8	11.4	0	0	0	0	N	N	5.83	5.49	Surcharge
8659	10679	10696	67.2	4	113.7	9.5	11.4	11.4	0	0	0	0	N	N	5.49	5.06	Surcharge
8660	10696	10744	132.0	4	113.7	9.1	11.4	55.2	0	0	0	0	N	N	5.06	4.96	Surcharge
8672	10744	10824	233.0	4	113.7	9.1	55.2	8.4	0	0	0	0	N	N	5.01	2.25	Surcharge

US, upstream; DS, downstream; Y, yes; N, no; Ins., insufficient.

TABLE 14
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
10234	12194	12193	432.6	3	66.2	9.9	9.6	16.8	0.6	11.4	0	12,120	RIM	Y	Y	Y	Flooding
10236	12193	12242	91.8	3.5	89.6	9.4	16.8	15.6	11.4	11.4	12,120	18,050	Y	Y	Y	Y	Flooding
10237	12242	12293	84.0	3.5	101.0	12.5	15.6	15.6	11.4	0	18,050	0	Y	N	Y	5.75	Flooding
10245	12293	12295	179.8	3.5	155.2	16.1	15.6	15.6	0	0	0	0	N	N	8.42	7.24	Surcharge
10246	12295	12334	223.0	3.5	155.3	16.8	15.6	18	0	0	0	0	N	0.39	7.24	Y	Ins. freeboard
10247	12334	12354	231.0	3.5	155.2	16.1	18	28.2	0	25.2	0	73,320	0.39	Y	Y	Y	Flooding
10274	12354	12485	131.0	3.5	117.2	13.8	28.2	0	25.2	0	73,320	0	Y	N	Y	N	Flooding
16586	9896	9925	218.0	6	226.5	8.0	9.6	10.2	0	0	0	0	0.44	N	Y	2.53	Ins. freeboard
16825	7674	7696	32.0	4.5	137.6	8.7	35.4	34.2	0	0	0	0	0.80	0.21	Y	Y	Ins. freeboard
16827	7696	7695	75.0	4.5	166.8	10.5	34.2	18.6	0	0	0	0	0.21	0.37	Y	Y	Ins. freeboard
16830	7910	7883	38.0	4.5	103.7	6.7	3.6	1.2	0	0	0	0	N	N	0.18	0.05	Surcharge
16831	7918	7910	43.2	4.5	103.7	6.5	8.4	3.6	0	0	0	0	N	N	0.45	0.18	Surcharge
16832	7931	7918	45.0	4.5	103.7	6.5	0	8.4	0	0	0	0	N	N	0.69	0.40	Surcharge
16883	8792	9021	237.1	2-5×6	241.5	4.1	24	0	0	0	0	0	N	N	0.77	0.88	Surcharge
16917	9298	9311	148.9	4.5	81.2	5.1	22.8	9	0.6	0	107	0	Y	N	Y	5.59	Flooding
16918	9287	9298	136.0	4.5	81.2	6.6	21	22.8	0.6	0.6	0	107	RIM	Y	Y	Y	Flooding
16919	9260	9287	225.1	4	35.9	3.7	20.4	21	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
16920	9311	9326	317.6	5	80.7	6.2	9	29.4	0	0	0	0	N	N	5.09	7.91	Surcharge
16937	9696	VDOT Pond	96.5	3	28.9	4.1	123.6	16.2	0	0	0	0	N	N	4.25	5.36	Surcharge
16948	9851	9897	240.0	2-6×8	296.7	3.5	0	25.2	0	0	0	0	N	N	1.50	2.12	Surcharge
16982	11188	11143	68.8	3	44.0	7.0	13.8	13.8	0	0	0	0	N	N	3.88	3.65	Surcharge
16983	11143	11075	155.0	3	44.0	6.6	13.8	16.2	0	0	0	0	N	N	3.67	4.43	Surcharge
17315	11502	11495	40.9	4	155.3	13.8	12	0	0	0	0	0	N	N	1.34	N	Surcharge
17316	11495	11476	154.1	4	155.3	16.2	0	1.2	0	0	0	0	N	N	N	0.19	Surcharge
17317	11476	11449	169.9	4	155.3	12.4	1.2	28.8	0	0	0	0	N	N	0.88	3.52	Surcharge
17318	11449	11483	81.2	4.5	191.8	12.1	28.8	0	0	0	0	0	N	N	3.52	0.38	Surcharge
17327	11357	11521	298.7	4	91.2	7.3	12	20.4	7.2	1.2	3,198	109	Y	Y	Y	Y	Flooding
17329	11622	11628	41.0	3	99.4	14.1	16.2	24.6	0	0	0	0	0.60	N	Y	3.04	Ins. freeboard
17347	11887	11890	6.0	3	61.1	9.2	24	3	0	0	0	0	0.96	N	Y	0.16	Ins. freeboard
17366	11987	11996	17.0	2-8×10	1647.2	10.3	0	15.6	0	0	0	0	N	N	1.67	0.69	Surcharge
17367	11996	12009	18.9	2-8×10	1647.3	10.3	15.6	7.8	0	0	0	0	N	N	0.69	0.24	Surcharge
17368	12009	12042	35.0	2-8×10	1656.5	10.5	7.8	0	0	0	0	0	N	N	0.24	N	Surcharge
18030	14510	14737	252.5	7×12	1451.0	21.9	70.8	0	0	0	0	0	N	N	7.17	0.96	Surcharge

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
20414	7480	7588	112.9	3	86.3	12.2	18	15	7.8	0.6	1,110	0	Y	RIM	Y	Y	Flooding
20422	7338	7445	178.4	4	150.5	14.2	0.6	0	0	0	0	0	0.39	N	Y	N	Ins. freeboard
20424	7445	7778	340.0	5	250.3	13.9	0	8.4	0	0.6	0	0	N	RIM	1.09	Y	Ins. freeboard
20620	7469	7536	73.0	3.5	84.6	9.1	27.6	31.2	9.6	0	2,258	0	Y	0.39	Y	Y	Flooding
20621	7536	7664	187.0	3.5	84.6	9.5	31.2	31.2	0	0	0	0	0.39	0.35	Y	Y	Ins. freeboard
20622	7957	7994	62.0	4×6.33	226.8	11.2	10.2	0	0	0	0	0	0.60	N	Y	0.34	Ins. freeboard
20817	11628	11643	55.0	3	99.4	14.1	24.6	21.6	0	14.4	0	6,843	N	Y	3.04	Y	Flooding
20818	11643	11671	122.5	3×4.83	86.3	7.6	21.6	27.6	14.4	20.4	6,843	10,980	Y	Y	Y	Y	Flooding
20819	11671	11684	17.0	3	76.0	12.6	27.6	0	20.4	0	10,980	0	Y	N	Y	N	Flooding
21160	14405	14510	110.0	7×12	1445.4	21.8	0	70.8	0	0	0	0	N	N	12.52	7.17	Surcharge
21780	9799	9864	86.6	3-6×10	905.4	5.0	30	31.8	0	0	0	0	0.79	N	Y	2.98	Ins. freeboard
21781	9864	9978	101.5	2-6×10	905.4	7.6	31.8	31.2	0	0	0	0	N	N	2.98	2.86	Surcharge
24246	6973	24153	170.0	4	127.1	11.0	0	6	0	5.4	0	1,475	N	Y	N	Y	Flooding
24247	24153	7198	170.0	4	121.5	10.0	6	9	5.4	0	1,475	0	Y	0.93	Y	Y	Flooding
24256	7333	7394	155.0	3	90.0	12.7	22.2	27.6	0.6	13.8	0	4,174	RIM	Y	Y	Y	Flooding
24258	7423	24162	182.0	4.5	180.2	11.3	31.2	36	0.6	13.8	0	9,171	RIM	Y	Y	Y	Flooding
24259	24162	7494	182.0	4.5	163.9	10.3	36	36.6	13.8	29.4	9,171	76,790	Y	Y	Y	Y	Flooding
24260	7147	7333	168.0	3.5	90.0	11.0	15	22.2	0	0.6	0	0	0.38	RIM	Y	Y	Ins. freeboard
24262	9508	24163	52.0	4	143.5	12.2	1.2	0	0	0	0	0	N	N	0.02	N	Surcharge
24267	10480	10289	457.6	4.5	78.8	5.5	13.8	22.8	0	0.6	0	0	N	RIM	3.56	Y	Ins. freeboard
24271	11014	24169	142.0	3.5	44.8	5.9	7.2	7.8	0.6	0.6	0	0	RIM	0.00	Y	Y	Ins. freeboard
24272	24169	11179	108.0	3.5	46.6	5.9	7.8	7.2	0.6	3	0	748	RIM	Y	Y	Y	Flooding
24273	24161	6710	108.0	5	200.7	10.2	28.2	26.4	0	0	0	0	N	N	5.60	6.18	Surcharge
24274	6862	24171	31.2	5	200.7	10.2	42	33.6	0	0	0	0	0.29	0.77	Y	Y	Ins. freeboard
24275	24171	24161	127.0	5	200.7	10.2	33.6	28.2	0	0	0	0	0.77	N	Y	5.60	Ins. freeboard
24276	8964	24172	60.0	3	28.0	6.1	18.6	21	12	0.6	29,540	0	Y	RIM	Y	Y	Flooding
24277	24172	9223	60.0	3	28.0	4.7	21	19.2	0.6	4.2	0	815	RIM	Y	Y	Y	Flooding
24280	24174	9404	50.0	3	28.6	4.5	8.4	10.2	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
24281	9797	24175	75.0	3.5	40.4	4.2	10.8	11.4	0	0	0	0	N	N	3.58	3.47	Surcharge
24282	24175	9809	110.0	3.5	40.4	4.2	11.4	12	0	0	0	0	N	N	3.47	3.38	Surcharge
24283	11521	11517	29.8	4	155.3	12.4	20.4	9.6	1.2	0	109	0	Y	N	Y	2.20	Flooding
24285	24176	24177	5.0	4	139.4	11.2	34.8	38.4	0	0	0	0	0.92	N	Y	3.93	Ins. freeboard
24292	24183	24174	185.0	3	28.5	8.9	0	8.4	0	0.6	0	0	N	RIM	N	Y	Ins. freeboard

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
24298	9978	24187	16.6	2-6×10	1138.0	9.5	31.2	24	0	0	0	0	N	N	2.86	1.84	Surcharge
24299	24187	10046	51.2	2-6×10	1137.8	10.7	24	23.4	0	0	0	0	N	N	1.84	2.33	Surcharge
24302	9524	Dummy Node	208.0	5.5	151.3	6.4	43.8	48	0	0	0	0	N	N	6.01	5.53	Surcharge
24302_2	Dummy Node	9543	75.0	5.23	151.4	7.0	48	51	0	11.4	0	12,890	N	Y	5.80	Y	Flooding
24305	7394	24160	52.0	3	81.8	11.6	27.6	30	13.8	0	4,174	0	Y	N	Y	1.43	Flooding
24306	24160	7445	15.0	3	81.9	11.7	30	0	0	0	0	0	N	N	1.53	0.10	Surcharge
24307	10927	24177	40.0	2-6×10	1204.2	10.0	38.4	38.4	0	0	0	0	N	N	2.19	1.93	Surcharge
24308	24177	10969	8.0	2-6×10	1350.9	11.7	38.4	0	0	0	0	0	N	N	1.93	N	Surcharge
24309	11182	24188	97.4	4	95.9	9.3	8.4	8.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
24310	24188	11357	205.8	4	95.9	10.3	8.4	12	0.6	7.2	0	3,198	RIM	Y	Y	Y	Flooding
24311	11517	24189	54.8	4	155.3	12.4	9.6	9	0	0	0	0	N	N	3.20	1.53	Surcharge
24312	24189	11502	170.3	4	155.3	12.4	9	12	0	0	0	0	N	N	1.53	1.23	Surcharge
24314	24190	24176	122.0	4	139.2	15.4	0	34.8	0	0	0	0	N	0.92	N	Y	Ins. freeboard
24315	11890	12057	283.7	3	61.8	9.3	3	12.6	0	0.6	0	0	N	RIM	0.16	Y	Ins. freeboard
24317	12057	24191	122.5	3	61.8	8.8	12.6	11.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
24318	24191	12194	69.7	3	62.1	10.0	11.4	9.6	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
3009	6907	7023	97.8	3	59.9	8.5	19.2	27	0	0	0	0	0.10	0.46	Y	Y	Ins. freeboard
3084	7023	7181	147.7	3	59.8	8.5	27	28.2	0	0.6	0	0	0.46	RIM	Y	Y	Ins. freeboard
3108	7181	7233	69.0	3	59.9	8.8	28.2	11.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
3225	7233	7480	243.0	3	60.9	9.2	11.4	18	0.6	7.8	0	1,110	RIM	Y	Y	Y	Flooding
5622	6022	6121	103.0	3	92.3	13.1	16.8	17.4	0	5.4	0	1,494	0.06	Y	Y	Y	Flooding
5623	6104	6122	30.9	3	49.7	7.4	36.6	16.2	0	0	0	0	0.32	0.65	Y	Y	Ins. freeboard
5627	5955	6132	185.0	3.5	129.2	13.4	14.4	20.4	0	18	0	32,930	0.73	Y	Y	Y	Flooding
5640	6122	6180	96.2	3	49.7	7.4	16.2	27	0	0	0	0	0.65	N	Y	1.18	Ins. freeboard
5646	6180	6194	24.7	3	49.7	7.0	27	25.2	0	0	0	0	N	N	1.24	0.88	Surcharge
5659	6194	6257	130.5	3	49.7	7.1	25.2	25.8	0	0	0	0	N	N	1.02	0.75	Surcharge
5664	6121	6278	149.9	3	85.0	12.1	17.4	19.8	5.4	0	1,494	0	Y	N	Y	3.39	Flooding
5665	6286	6273	72.8	3.5	95.3	9.9	23.4	23.4	19.2	0	20,580	0	Y	N	Y	4.06	Flooding
5666	6132	6286	178.1	3.5	81.3	9.3	20.4	23.4	18	19.2	32,930	20,580	Y	Y	Y	Y	Flooding
5672	6273	6302	41.4	3.5	95.3	11.8	23.4	22.8	0	12	0	6,263	N	Y	4.06	Y	Flooding
5675	6309	6250	69.7	3	49.7	7.9	23.4	0	0	0	0	0	N	N	0.51	N	Surcharge
5678	6257	6313	131.8	3	49.7	7.0	25.8	30.6	0	0	0	0	N	N	0.75	0.87	Surcharge

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
5679	6313	6309	57.3	3	49.7	7.0	30.6	23.4	0	0	0	0	N	N	0.87	0.51	Surcharge
5698	6278	6372	114.5	3	85.0	12.9	19.8	21	0	0.6	0	0	N	RIM	3.39	Y	Ins. freeboard
5716	6341	6423	207.0	3.5	96.4	11.6	0	25.2	0	13.2	0	10,430	N	Y	N	Y	Flooding
5726	6423	6460	32.3	3.5	77.7	10.5	25.2	25.2	13.2	0	10,430	0	Y	N	Y	3.62	Flooding
5727	6434	6460	28.8	3.5	118.9	12.4	24	25.2	22.2	0	32,520	0	Y	N	Y	4.22	Flooding
5744	6372	6539	202.6	3.5	85.0	8.8	21	22.2	0.6	18	0	24,790	RIM	Y	Y	Y	Flooding
5745	6460	6544	105.7	5	178.2	13.3	25.2	29.4	0	0.6	0	0	N	RIM	3.12	Y	Ins. freeboard
5761	6539	6637	115.0	3.5	92.0	9.6	22.2	22.8	18	0.6	24,790	0	Y	RIM	Y	Y	Flooding
5768	6544	6676	135.0	5	178.2	9.1	29.4	34.2	0.6	0	0	0	RIM	0.63	Y	Y	Ins. freeboard
5776	6637	6692	40.0	3.5	92.0	9.6	22.8	23.4	0.6	0	0	0	0.00	0.24	Y	Y	Ins. freeboard
5785	6692	6721	60.0	3.5	92.0	9.6	23.4	22.2	0	0	0	0	0.24	N	Y	0.47	Ins. freeboard
5786	6710	6727	55.6	5.5	200.7	8.7	26.4	24.6	0	0	0	0	N	N	5.68	5.95	Surcharge
5797	6721	6741	21.0	3.5	92.0	9.9	22.2	0	0	0	0	0	N	N	0.52	N	Surcharge
5819	6676	6834	185.0	5	193.1	9.8	34.2	41.4	0	23.4	0	72,070	0.63	Y	Y	Y	Flooding
5830	6834	6862	42.0	5	200.8	10.2	41.4	42	23.4	0	72,070	0	Y	0.29	Y	Y	Flooding
5887	6727	7005	263.0	5.5	200.7	9.2	24.6	25.8	0	7.2	0	2,873	N	Y	5.95	Y	Flooding
5891	7005	7014	16.2	5.5	222.4	10.1	25.8	24.6	7.2	0	2,873	0	Y	N	Y	1.19	Flooding
5892	7014	7015	8.0	3.5	75.5	7.9	24.6	43.8	0	13.8	0	8,586	N	Y	3.19	Y	Flooding
5906	7015	7061	88.7	3.5	62.9	6.5	43.8	39	13.8	17.4	8,586	5,384	Y	Y	Y	Y	Flooding
5912	7014	7076	82.2	4.5	159.7	10.0	24.6	27	0	0.6	0	0	N	RIM	2.19	Y	Ins. freeboard
5939	7061	7131	61.5	3.5	56.9	6.3	39	37.2	17.4	21	5,384	27,700	Y	Y	Y	Y	Flooding
5946	7076	7153	79.3	4.5	160.7	10.2	27	25.2	0.6	0.6	0	0	RIM	0.00	Y	Y	Ins. freeboard
5983	7232	7255	22.5	3.5	71.1	7.4	46.2	34.2	25.2	9.6	19,450	1,087	Y	Y	Y	Y	Flooding
5991	7153	7269	116.5	4.5	158.5	10.8	25.2	17.4	0.6	0.6	0	0	0.00	RIM	Y	Y	Ins. freeboard
6027	7255	7345	91.0	3.5	74.4	7.7	34.2	37.8	9.6	0	1,087	0	Y	N	Y	2.58	Flooding
6032	7345	7369	86.2	3.5	74.4	7.8	37.8	36.6	0	0	0	0	N	N	2.58	2.68	Surcharge
6043	7269	7423	211.9	4.5	150.9	12.0	17.4	31.2	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
6055	7369	7458	93.0	3.5	74.4	7.7	36.6	48	0	0	0	0	N	N	2.68	3.21	Surcharge
6059	7458	7469	88.0	3.5	74.4	7.8	48	27.6	0	9.6	0	2,258	N	Y	3.21	Y	Flooding
6542	6308	6434	178.6	3.5	119.8	12.5	24.6	24	0	22.2	0	32,520	0.70	Y	Y	Y	Flooding
6543	6302	6308	23.4	3.5	119.8	12.5	22.8	24.6	12	0	6,263	0	Y	0.70	Y	Y	Flooding
6568	7131	7232	161.7	3.5	75.1	7.8	37.2	46.2	21	25.2	27,700	19,450	Y	Y	Y	Y	Flooding
6579	7245	7338	109.3	4	121.7	10.6	2.4	0.6	0	0	0	0	N	0.39	0.47	Y	Ins. freeboard

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
6582	7198	7245	56.0	4	121.5	9.7	9	2.4	0	0	0	0	0.93	N	Y	0.47	Ins. freeboard
7758	7931	7957	77.0	5.25×8.17	226.8	7.7	0	10.2	0	0	0	0	N	0.60	0.19	Y	Ins. freeboard
7763	7883	7844	96.4	4.5	115.6	7.3	1.2	3.6	0	0	0	0	N	N	0.05	0.10	Surcharge
7764	7844	7878	35.0	4.5	118.8	7.7	3.6	0	0	0	0	0	N	N	0.10	N	Surcharge
7768	7778	8143	339.2	5	270.5	13.8	8.4	12	0.6	0	0	0	RIM	N	Y	1.32	Ins. freeboard
7769	8143	8156	15.0	5	291.5	16.3	12	0	0	0	0	0	N	N	1.32	N	Surcharge
7788	7664	7695	37.9	4	86.1	3.3	31.2	18.6	0	0	0	0	0.35	0.37	Y	Y	Ins. freeboard
7789	7494	7674	216.0	4.5	137.6	8.7	36.6	35.4	29.4	0	76,790	0	Y	0.80	Y	Y	Flooding
7798	7695	7724	43.3	4.83×7.58	249.1	8.4	18.6	20.4	0	0	0	0	0.37	N	Y	1.60	Ins. freeboard
7799	7724	7785	66.5	4.83×7.58	267.8	9.0	20.4	19.8	0	0	0	0	N	N	1.60	1.41	Surcharge
7800	7785	7840	92.8	4.83×7.58	267.8	9.0	19.8	17.4	0	0	0	0	N	0.23	1.41	Y	Ins. freeboard
7801	7840	7834	48.0	4.83×7.58	307.6	10.4	17.4	13.8	0	0	0	0	0.23	N	Y	0.66	Ins. freeboard
7803	7834	7795	53.0	4.83×7.58	307.6	10.4	13.8	0	0	0	0	0	N	N	1.04	N	Surcharge
7804	7795	7769	57.0	4.83×7.58	307.5	11.1	0	0	0	0	0	0	N	N	0.17	N	Surcharge
7826	7588	7635	52.0	3	86.3	13.2	15	7.8	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
7827	7635	7861	228.3	3	88.6	16.0	7.8	11.4	0.6	3.6	0	439	RIM	Y	Y	Y	Flooding
7829	7861	8025	135.3	3	102.9	14.6	11.4	10.2	3.6	0.6	439	0	Y	RIM	Y	Y	Flooding
7832	8025	8172	189.2	3	102.9	14.6	10.2	16.2	0.6	0	0	0	RIM	N	Y	4.25	Ins. freeboard
7833	8172	8232	67.8	3	120.9	17.1	16.2	13.8	0	0	0	0	N	N	4.25	2.52	Surcharge
7837	8232	8260	42.1	3.5	120.9	13.4	13.8	0	0	0	0	0	N	N	2.02	N	Surcharge
7838	8260	8308	71.8	3.5	120.8	13.3	0	0	0	0	0	0	N	N	1.41	N	Surcharge
7839	8308	8360	49.6	3.5	120.8	12.6	0	12	0	0	0	0	N	N	4.70	2.67	Surcharge
7840	8360	8386	63.7	3.5	120.8	12.6	12	8.4	0	0	0	0	N	N	3.35	0.78	Surcharge
7849	7955	8024	92.7	5	51.7	2.6	7.2	8.4	0	0	0	0	N	N	2.57	2.46	Surcharge
7851	8024	8102	139.6	5	51.8	2.6	8.4	12.6	0	0	0	0	N	N	2.46	2.36	Surcharge
7862	8250	8414	227.5	5	68.8	3.5	18.6	21.6	0	0	0	0	N	N	3.64	0.89	Surcharge
7864	8102	8250	257.4	5	52.1	2.7	12.6	18.6	0	0	0	0	N	N	2.36	3.64	Surcharge
7941	8915	8922	68.0	3.5	115.1	12.0	9	8.4	0	0	0	0	0.83	N	Y	2.16	Ins. freeboard
7954	8922	8995	94.0	3.5	115.1	12.4	8.4	2.4	0	0	0	0	N	N	2.37	1.48	Surcharge
7988	9184	9348	300.0	3.5	111.5	12.0	7.8	11.4	1.2	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
7994	8995	9184	314.0	3.5	112.1	14.6	2.4	7.8	0	1.2	0	0	N	RIM	1.54	Y	Ins. freeboard
7997	8569	8792	251.7	2-5×6	248.5	4.2	23.4	24	0	0	0	0	N	N	0.77	0.77	Surcharge
7998	8526	8569	74.8	5	139.0	8.6	0	23.4	0	0	0	0	N	N	N	0.77	Surcharge

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8012	8635	8628	9.2	3.5	36.7	3.8	24	23.4	0	12	0	7,421	N	Y	0.97	Y	Flooding
8013	8628	8588	65.5	3.5	35.3	3.7	23.4	38.4	12	0	7,421	0	Y	N	Y	1.86	Flooding
8014	8588	8569	26.6	3.5	35.3	3.7	38.4	23.4	0	0	0	0	N	N	2.00	2.27	Surcharge
8038	9339	9363	48.0	5.5	80.7	3.4	36.6	39	0	0	0	0	N	N	6.44	6.68	Surcharge
8062	9021	Dummy Node2	40.0	3-6×10	1038.4	6.4	0	24	0	0	0	0	N	N	N	0.70	Surcharge
8062_2	Dummy Node2	Beaver Pond	75.2	3-4.87×10	1027.9	7.0	24	0	0	0	0	0	N	N	1.83	1.49	Surcharge
8063	8386	8526	179.8	3.5	120.8	13.6	8.4	0	0	0	0	0	N	N	1.56	N	Surcharge
8064	8414	8569	202.9	5	69.2	3.5	21.6	23.4	0	0	0	0	N	N	0.89	0.77	Surcharge
8076	9234	9311	75.0	3	67.1	9.8	6.6	9	0.6	0	0	0	RIM	N	Y	1.04	Ins. freeboard
8102	9223	9260	56.6	4	29.1	3.4	19.2	20.4	4.2	0.6	815	0	Y	RIM	Y	Y	Flooding
8118	8669	8767	99.6	3	43.3	6.1	15.6	15.6	0	0.6	0	0	0.79	RIM	Y	Y	Ins. freeboard
8120	8767	8964	185.6	3	43.3	6.1	15.6	18.6	0.6	12	0	29,540	RIM	Y	Y	Y	Flooding
8137	9336	9339	129.4	5	80.7	4.1	33.6	36.6	0	0	0	0	N	N	6.55	6.94	Surcharge
8142	9326	9336	131.1	5	80.7	6.8	29.4	33.6	0	0	0	0	N	N	7.91	6.55	Surcharge
8162	9455	9464	84.0	4	116.4	9.3	14.4	13.2	11.4	0	19,080	0	Y	0.78	Y	Y	Flooding
8163	9464	9508	68.0	4	126.4	10.2	13.2	1.2	0	0	0	0	0.78	N	Y	0.02	Ins. freeboard
8182	9725	9825	118.8	4.42×6.92	179.6	7.3	0	18	0	0	0	0	N	N	2.67	2.40	Surcharge
8183	9825	VDOT Pond	138.8	2-6×8	326.8	3.6	18	16.2	0	0	0	0	N	N	0.82	1.07	Surcharge
8197	10077	10036	182.6	3	26.5	3.7	54	124.2	0	0	0	0	0.06	N	Y	4.15	Ins. freeboard
8201	10289	10101	264.5	4.42×6.92	131.3	5.3	22.8	28.8	0.6	0	0	0	RIM	N	Y	4.54	Ins. freeboard
8202	10101	10024	167.2	4.42×6.92	131.3	5.3	28.8	35.4	0	0	0	0	N	N	4.64	3.75	Surcharge
8205	10024	9862	209.1	4.42×6.92	131.3	5.3	35.4	47.4	0	0	0	0	N	N	3.95	2.39	Surcharge
8206	9862	9825	39.1	4.42×6.92	150.6	6.1	47.4	18	0	0	0	0	N	N	2.48	2.40	Surcharge
8220	9348	9455	223.0	3.5	137.2	14.3	11.4	14.4	0.6	11.4	0	19,080	RIM	Y	Y	Y	Flooding
8224	10013	VDOT Pond	109.4	3	26.5	3.8	165	16.2	0	0	0	0	N	N	4.66	5.10	Surcharge
8226	9897	9930	136.3	2-6×8	287.5	3.1	25.2	27.6	0	0	0	0	N	N	2.12	2.46	Surcharge
8227	9930	9938	18.8	2-6×8	289.3	3.0	27.6	28.2	0	0	0	0	N	N	2.46	2.47	Surcharge
8228	9938	9961	80.6	2-6×8	290.5	3.0	28.2	29.4	0	0	0	0	N	N	2.47	2.65	Surcharge
8229	9961	9978	92.8	2-6×8	295.5	3.1	29.4	31.2	0	0	0	0	N	N	2.65	2.86	Surcharge
8231	10046	10173	175.0	2-6×10	1237.8	12.1	23.4	25.2	0	0.6	0	0	N	RIM	2.33	Y	Ins. freeboard

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8235	9509	Beaver Pond	32.0	3	58.6	10.7	0.6	0	0	0	0	0	0.97	N	Y	N	Ins. freeboard
8242	9543	9552	157.6	4.93	126.7	6.6	51	54.6	11.4	0	12,890	0	Y	N	Y	5.14	Flooding
8243	9552	9555	110.2	4.5	126.7	8.0	54.6	63	0	0	0	0	N	N	5.57	4.98	Surcharge
8245	9555	9561	49.9	3.99	126.7	10.1	63	79.8	0	0	0	0	N	N	5.49	4.79	Surcharge
8246	9561	Beaver Pond	75.0	3.79	126.7	11.2	79.8	0	0	0	0	0	N	N	4.99	2.57	Surcharge
8250	9497	9524	89.1	5.5	122.5	5.2	41.4	43.8	0	0	0	0	N	N	6.32	6.01	Surcharge
8262	9977	10046	67.1	6	266.1	12.0	7.8	23.4	0	0	0	0	N	N	1.56	2.33	Surcharge
8263	9925	9926	197.8	6	225.7	8.3	10.2	5.4	0	0	0	0	N	N	2.53	1.85	Surcharge
8264	9926	9940	129.7	6	222.5	8.2	5.4	10.2	0	0	0	0	N	N	1.85	1.93	Surcharge
8265	9940	9977	32.0	6	222.0	8.6	10.2	7.8	0	0	0	0	N	N	1.93	1.56	Surcharge
8289	9478	9497	26.1	5.5	112.4	4.7	41.4	41.4	0	0	0	0	N	N	6.58	6.32	Surcharge
8291	9507	9545	50.2	3	28.9	4.1	30.6	51.6	0	0	0	0	0.87	N	Y	3.22	Ins. freeboard
8295	9545	9556	23.9	3	28.9	4.1	51.6	81.6	0	0	0	0	N	N	3.22	3.36	Surcharge
8302	9556	9696	160.7	3	28.9	4.1	81.6	123.6	0	0	0	0	N	N	3.48	3.60	Surcharge
8305	10036	10013	206.8	3	26.5	3.8	124.2	165	0	0	0	0	N	N	4.15	4.56	Surcharge
8309	9363	9478	139.1	5.5	112.4	4.7	39	41.4	0	0	0	0	N	N	6.69	6.58	Surcharge
8318	9644	9734	101.3	3	22.4	3.5	11.4	10.8	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8330	9809	9820	87.4	3.5	40.4	4.2	12	10.8	0	0	0	0	N	N	3.44	4.30	Surcharge
8335	9820	9856	59.5	4.5	41.8	3.6	10.8	10.2	0	0	0	0	N	0.43	3.44	Y	Ins. freeboard
8373	9871	9878	143.5	5	108.1	5.5	12.6	10.8	0.6	0	0	0	RIM	0.49	Y	Y	Ins. freeboard
8374	9878	9884	80.7	6	153.2	5.4	10.8	11.4	0	0	0	0	0.49	0.31	Y	Y	Ins. freeboard
8375	9884	9901	244.1	6	153.2	5.4	11.4	12	0	6	0	767	0.31	Y	Y	Y	Flooding
8376	9901	9910	148.4	6	182.2	6.4	12	12	6	0.6	767	0	Y	RIM	Y	Y	Flooding
8387	9910	9877	35.8	6	182.1	6.4	12	10.8	0.6	0	0	0	RIM	0.48	Y	Y	Ins. freeboard
8388	9877	9889	45.3	6	182.1	6.5	10.8	9	0	0	0	0	0.48	N	Y	1.84	Ins. freeboard
8397	9463	9568	106.1	3	51.8	7.6	9	11.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8398	9568	9574	7.1	3	51.7	7.3	11.4	10.8	0.6	0	0	0	RIM	RIM	Y	Y	Ins. freeboard
8399	9574	9693	111.8	3	51.8	7.4	10.8	10.8	0	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8400	9693	9757	78.9	3	48.8	7.1	10.8	10.8	0.6	9	0	7,045	RIM	Y	Y	Y	Flooding
8401	9757	9813	48.7	3	49.2	7.0	10.8	11.4	9	0	7,045	0	Y	0.34	Y	Y	Flooding
8402	9813	9878	61.9	3	71.7	10.2	11.4	10.8	0	0	0	0	0.34	0.49	Y	Y	Ins. freeboard
8412	9734	9820	78.2	3.5	22.4	3.5	10.8	10.8	0.6	0	0	0	RIM	N	Y	3.67	Ins. freeboard

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8419	9311	9463	196.1	3	55.3	8.2	9	9	0	0.6	0	0	N	RIM	1.10	Y	Ins. freeboard
8420	9596	9644	50.0	3	22.4	3.8	10.8	11.4	8.4	0.6	14,620	0	Y	RIM	Y	Y	Flooding
8423	9404	9596	185.1	3	28.6	4.0	10.2	10.8	0.6	8.4	0	14,620	RIM	Y	Y	Y	Flooding
8425	9731	9788	53.1	3	25.0	3.5	11.4	10.2	0	0.6	0	0	0.10	RIM	Y	Y	Ins. freeboard
8426	9788	9797	59.1	3.5	25.0	2.6	10.2	10.8	0.6	0	0	0	RIM	N	Y	3.39	Ins. freeboard
8434	9856	9860	221.1	4.5	70.3	5.6	10.2	11.4	0	0.6	0	0	0.43	RIM	Y	Y	Ins. freeboard
8435	9860	9871	135.5	5	108.1	6.4	11.4	12.6	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8440	9889	9896	150.6	6	219.5	7.8	9	9.6	0	0	0	0	N	0.44	2.04	Y	Ins. freeboard
8487	10771	10762	227.3	3	40.0	5.7	13.8	12	0	0.6	0	0	0.95	RIM	Y	Y	Ins. freeboard
8488	10762	10687	246.6	3	40.0	5.7	12	12.6	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8507	10974	10951	84.0	3	40.6	5.8	19.2	17.4	0	3.6	0	1,013	0.10	Y	Y	Y	Flooding
8508	10951	10990	40.0	3	40.6	5.8	17.4	13.8	3.6	0.6	1,013	0	Y	RIM	Y	Y	Flooding
8509	10990	10943	125.0	3	40.6	5.8	13.8	6.6	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8512	10943	11014	86.0	3.5	41.6	5.5	6.6	7.2	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8514	11179	11241	88.6	4	64.7	5.9	7.2	8.4	3	0.6	748	0	Y	RIM	Y	Y	Flooding
8517	11241	11221	107.0	4	64.9	5.3	8.4	8.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8518	11221	11225	39.0	4	65.5	5.7	8.4	7.8	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8519	11225	11182	157.0	4	66.9	6.3	7.8	8.4	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8542	10448	10480	61.4	3.5	64.1	6.7	15.6	13.8	10.8	0	15,400	0	Y	N	Y	4.56	Flooding
8546	10574	10480	247.4	3	40.0	5.7	15	13.8	0.6	0	0	0	RIM	N	Y	5.06	Ins. freeboard
8548	10687	10574	247.2	3	40.0	5.7	12.6	15	0.6	0.6	0	0	RIM	RIM	Y	Y	Ins. freeboard
8550	10421	10448	55.3	3	75.9	10.7	12.6	15.6	0	10.8	0	15,400	N	Y	2.70	Y	Flooding
8555	10686	10726	104.2	3	64.9	9.2	10.8	16.8	0	9	0	6,594	0.89	Y	Y	Y	Flooding
8556	10726	10701	52.0	3	46.5	6.6	16.8	13.2	9	0	6,594	0	Y	0.52	Y	Y	Flooding
8557	10701	10672	51.6	3	46.6	7.0	13.2	12	0	0	0	0	0.52	0.73	Y	Y	Ins. freeboard
8558	10672	10648	47.8	3	45.5	6.4	12	13.8	0	0	0	0	0.73	0.14	Y	Y	Ins. freeboard
8559	10648	10678	138.0	3	45.5	6.4	13.8	14.4	0	0	0	0	0.14	0.21	Y	Y	Ins. freeboard
8560	10678	10695	50.0	3	45.5	7.1	14.4	13.2	0	0	0	0	0.21	0.34	Y	Y	Ins. freeboard
8563	10695	10733	50.0	3	45.5	9.0	13.2	13.8	0	0.6	0	0	0.34	RIM	Y	Y	Ins. freeboard
8565	10733	10746	36.0	3	45.5	8.8	13.8	36	0.6	0	0	0	RIM	0.42	Y	Y	Ins. freeboard
8566	10746	10722	102.0	3	45.5	6.7	36	40.8	0	34.2	0	173,200	0.42	Y	Y	Y	Flooding
8567	10722	10761	49.5	3	77.3	10.9	40.8	37.2	34.2	0	173,200	0	Y	0.42	Y	Y	Flooding
8569	10683	10761	78.5	2-6×10	1260.1	10.5	36	37.2	7.8	0	5,774	0	Y	0.42	Y	Y	Flooding

TABLE 14 (CONTINUED)
Pipes Experiencing Surcharging or Higher Conditions in the 10-Year, 24-Hour SCS Type II Storm (with Storage)

Conduit ID	Node ID		Length (ft)	Diameter/ Pipe Dimension (ft)	Maximum Flow (ft^3/s)	Maximum Velocity (ft/s)	Duration of Surcharge (min)		Duration of Flooding (min)		Flooding Volume (ft^3)		Insufficient Freeboard/ Depth Below Rim (ft)		Surcharge/Depth Above Crown (ft)		Summary Condition
	US	DS					US	DS	US	DS	US	DS	US	DS	US	DS	
8570	10761	10907	152.9	2-6×10	1203.8	10.0	37.2	39	0	0	0	0	0.42	N	Y	2.56	Ins. freeboard
8571	10907	10927	15.0	2-6×10	1204.2	10.0	39	38.4	0	0	0	0	N	N	2.56	2.19	Surcharge
8578	10824	10879	173.0	4	140.5	12.9	15.6	0	0	0	0	0	N	N	1.66	N	Surcharge
8591	10173	10428	261.2	2-6×10	1237.8	11.4	25.2	30.6	0.6	0	0	0	RIM	N	Y	3.36	Ins. freeboard
8593	10428	10437	9.0	2-6×10	1237.9	11.4	30.6	29.4	0	0	0	0	N	N	3.36	3.10	Surcharge
8594	10437	10683	303.3	2-6×10	1267.0	10.6	29.4	36	0	7.8	0	5,774	N	Y	3.10	Y	Flooding
8639	10566	10583	161.7	3	51.4	7.3	25.2	27.6	0	0	0	0	0.27	N	Y	3.60	Ins. freeboard
8640	10583	10618	118.2	3	51.4	7.3	27.6	22.2	0	0	0	0	N	N	4.06	3.82	Surcharge
8652	11075	11062	31.0	3	44.1	6.2	16.2	16.2	0	0	0	0	N	N	4.43	4.51	Surcharge
8653	11062	10940	231.0	3	44.0	6.2	16.2	15	0	0.6	0	0	N	RIM	4.51	Y	Ins. freeboard
8654	10940	10806	182.0	3.5	66.4	7.7	15	16.8	0.6	2.4	0	258	RIM	Y	Y	Y	Flooding
8655	10806	10665	230.0	3.5	66.4	6.9	16.8	22.8	2.4	0	258	0	Y	N	Y	4.38	Flooding
8656	10665	10618	91.4	3.5	66.4	6.9	22.8	22.2	0	0	0	0	N	N	4.63	4.27	Surcharge
8657	10618	10614	100.0	3.5	101.2	10.5	22.2	15	0	0	0	0	N	N	4.42	2.46	Surcharge
8658	10614	10679	158.0	4	101.2	8.5	15	21	0	0	0	0	N	N	3.21	3.88	Surcharge
8659	10679	10696	67.2	4	119.5	9.5	21	20.4	0	0	0	0	N	N	3.88	3.43	Surcharge
8660	10696	10744	132.0	4	119.5	9.5	20.4	28.8	0	0	0	0	N	N	3.43	4.06	Surcharge
8672	10744	10824	233.0	4	119.5	9.5	28.8	15.6	0	0	0	0	N	N	4.11	1.50	Surcharge

US, upstream; DS, downstream; Y, yes; N, no; Ins., insufficient.

TABLE 15
2006 Storm Event Stream Results

Conduit ID	Node ID		Length (ft)	Depth (ft)	Maximum Flow (ft^3/s)
	US	DS			
10111	11043	11254	316.3	9.63	1254.3
10229	11684	11987	466	18.32	1464.2
10230	12333	12362	34.7	12.18	1527.4
10231	12362	12485	166.8	12.18	1527.4
10344	12485	12622	213.7	21.67	1644.6
10348	12622	12885	509.2	21.67	1666.7
10402	13762	14008	336.3	42.23	7653.4
10403	14008	14405	528.9	46.47	11334.7
17391	12885	13251	508.6	31.06	1704.7
17392	13251	13298	54.5	34.96	1704.8
18035	14737	14764	37.6	32.84	1566.3
18036	14764	14919	351.6	32.84	1693.0
20628	8195	8229	66.1	6.43	323.1
20649	8229	8423	233.3	8.56	559.4
20820	11483	11684	275.4	9.63	1390.4
20822	11254	11427	255.5	9.63	1260.7
20823	11427	11483	85	9.63	1269.8
20855	13298	13397	110.5	34.96	1726.0
20856	13397	13762	496.4	34.96	1744.2
21835	8156	8229	73.2	8.28	237.3
8058	8423	8529	136.5	9.36	581.7
8060	8529	8646	121.5	9.36	675.1
8061	8646	8746	127.6	9.64	604.4

TABLE 16
10-Year, 24-Hour SCS Type II Stream Results

Conduit ID	Node ID		Length (ft)	Depth (ft)	Maximum Flow (ft^3/s)
	US	DS			
10111	11043	11254	316.3	9.63	1350.5
10229	11684	11987	466	18.32	1653.7
10230	12333	12362	34.7	12.18	1748.5
10231	12362	12485	166.8	12.18	1749.2
10344	12485	12622	213.7	21.67	1865.5
10348	12622	12885	509.2	21.67	1902.1
10402	13762	14008	336.3	42.23	2978.6
10403	14008	14405	528.9	46.47	4950.5
17391	12885	13251	508.6	31.06	1959.8
17392	13251	13298	54.5	34.96	1961.2
18035	14737	14764	37.6	32.84	1448.2
18036	14764	14919	351.6	32.84	1573.3
20628	8195	8229	66.1	6.43	387.5
20649	8229	8423	233.3	8.56	677.7
20820	11483	11684	275.4	9.63	1571.3
20822	11254	11427	255.5	9.63	1364.9
20823	11427	11483	85	9.63	1382.9
20855	13298	13397	110.5	34.96	1998.6
20856	13397	13762	496.4	34.96	2030.8
21835	8156	8229	73.2	8.28	291.3
8058	8423	8529	136.5	9.36	719.1
8060	8529	8646	121.5	9.36	845.4
8061	8646	8746	127.6	9.64	740.4

Data Gaps

Appendix A
Technical Memorandum: GIS Data Gaps in the Storm Sewer System

Task 2: GIS Data Gaps in the Storm Sewer System: Lubber Run

PREPARED FOR: Allan Rowley/Arlington County

PREPARED BY: CH2M HILL

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Rita Fordiani/CH2M HILL

DATE: November 30, 2010

PROJECT NUMBER: 392309.LR

1 Introduction

This memorandum describes the Lubber Run storm sewer data obtained from Arlington County staff and the work performed to determine if all the necessary information was obtained for use in the PC-SWMM (storm sewer system hydrologic and hydraulic computer model). Some information is still missing or is incorrect for 196 links and 196 nodes. The data gaps represent 52 percent of the storm data with a diameter equal to or greater than 36 inches. In all cases, an assumption can be applied that is reasonable for modeling purposes.

2 Storm Data Files

2.1 GIS Database

Initial base layers (GIS shapefiles) were obtained from Arlington County in June 2010. CH2M HILL worked closely with Marianna Subert at the County throughout September, October, and November as she completed the storm sewer data gathering for the Lubber Run sewershed. Ms. Subert exhausted the as-built information available to her directly from the County and completed data updates in the County's Cassworks database program. James Gilliland (Arlington County) exported this to ArcGIS PGDB (personal geodatabase), which we were able to link with GIS shapefiles obtained in June 2010. Our meetings and e-mail communications were very useful and resulted in a delivery of a final ArcGIS PGDB containing the necessary sewer information in a format compatible with our modeling needs. Mr. Gilliland delivered the final ArcGIS PGDB to CH2M HILL on November 15, 2010.

It is important to note that 25 conduits with diameters greater than or equal to 36 inches were identified as being disconnected from the main network. Ms. Subert explained to CH2M HILL that these 25 conduits are connected to detention outlets and are considered storage structures and should not be modeled. It was then discovered that 50 percent of these pipes do not have a detention outlet connected to them. On November 10, Ms. Subert

informed CH2M HILL that the County is in the process of looking at the source documents again for details but that these conduits most likely are not of concern for the capacity study.

Additionally, some conflicts were found between the data in the nodes shapefile and in the links shapefile. A couple of nodes have storage capacity (i.e, the node elevation is below the link elevations and creates a sump); others have an invert elevation higher than the pipe's invert elevation. The assumption made in the tables of Section 2.3 is to correct the invert elevations in the nodes shapefile. The reasons to support this assumption are:

- More than 90 percent of the pipes have an upstream invert elevation (in the link shapefile) equal to the invert elevation of the node, so it is assumed that sumps do not exist in the system.
- It was determined that the invert elevation in some nodes was erroneous when compared with the information in as-built drawings and that the links shapefile typically contained data matching the as-built drawings

If the County purposely designed these nodes with storage capacity, the assumptions made will have to be corrected.

Currently, there are many links and nodes identified in the ArcGIS PGDB that make up the two ponds (VDOT and Beaver Dam) associated with Lubber Run. Additional information on these ponds has been requested from the County. Depending on the type of data available, these ponds may be reflected in the model differently. Although these links and nodes are referenced in the tables in Section 2.3, a final decision will be made when the additional information is received.

2.2 Survey Information

The Lubber Run storm system contains a natural stream system directly connected to the storm pipe network. These stream channels will also be modeled.

During a preliminary review of the ArcGIS PGDB, it was determined that there was a need to survey key stream cross sections. CH2M HILL staff met with County staff to examine this issue in more detail. On September 1, 2010, CH2M HILL submitted a technical memorandum and associated maps showing the location of the cross sections to be surveyed and locations where the rim and invert elevations of existing culverts into those streams were required. The September 1 memorandum is included in Attachment A. The survey data were delivered to CH2M HILL on November 12, 2010.

2.3 Data Gaps and Observations

Together, the GIS database and survey have been extremely helpful in filling existing data gaps. The following figures and tables show the data from the links (pipes, streams, ditches, channels) and nodes (manholes, catch basins, yard inlets, etc.) that had been noted as missing. Please note the tables show missing information as well as information that seem erroneous or difficult to reconcile with the modeling needs; the latter gaps are described as "observations." Assumptions are proposed to fill missing data gaps and correct observations for modeling purposes. Figures identifying the "observations" are not included in this memorandum but are available if required.

For presentation purposes, the sewershed was divided into three areas (see Figure 1):

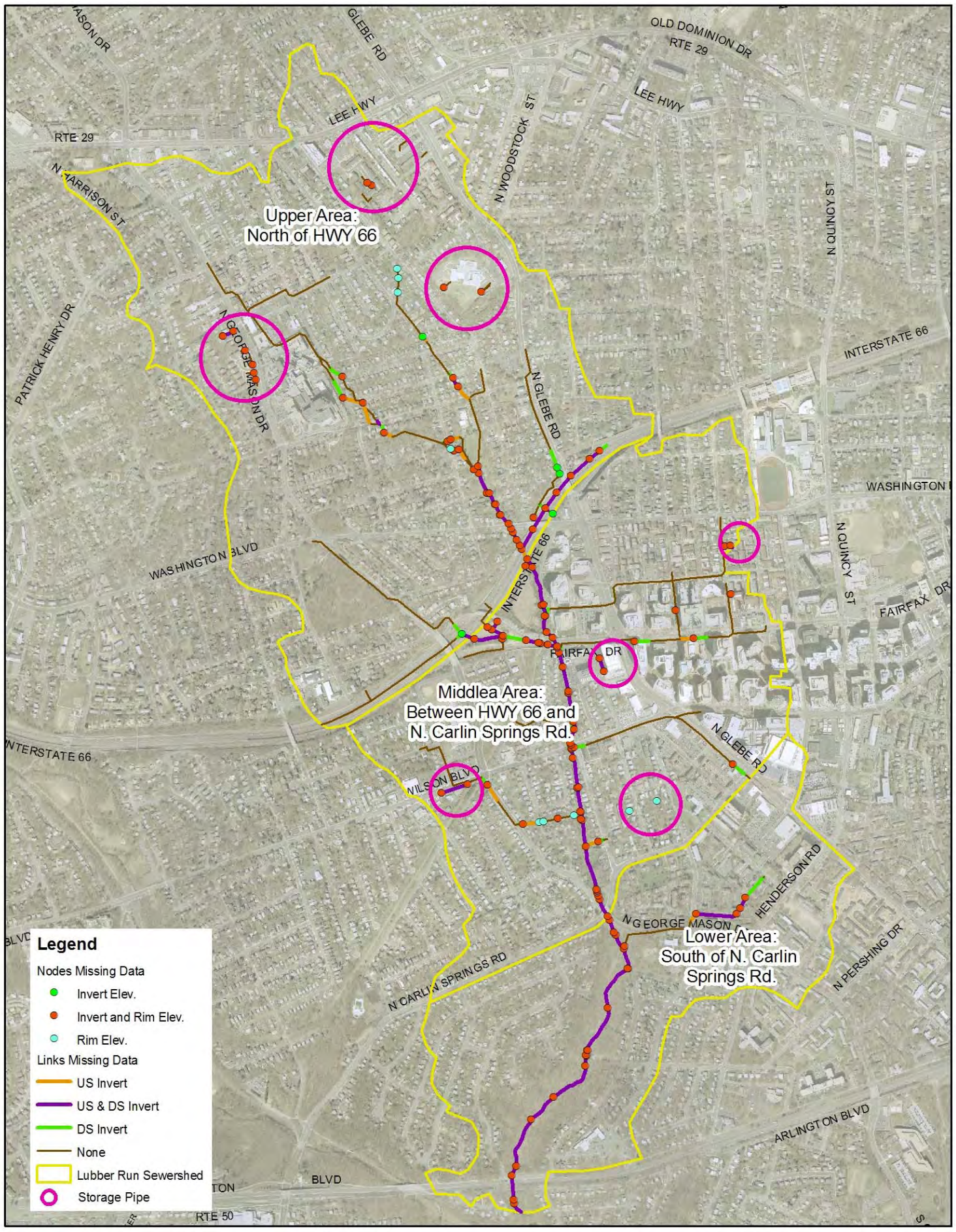
- Upper area: north of I-66
- Middle area: between I-66 and N. Carlin Springs Rd.
- Lower area: south of N. Carlin Springs Rd

Figure 1 shows the data gaps for the entire sewershed and highlights the location of the 25 storage pipes described in Section 2.1. Figures 2–4 show the same information but in greater detail by geographic area: upper, middle, and lower areas, respectively.

Table 1 provides information on links that have missing information. It provides the geographic area, link location (upper, middle or lower area), GIS ID, the upstream (US) and downstream (DS) node GIS ID associated with the link, the type of link, diameter/dimension, the information that is missing, proposed assumptions to fill in this data in the modeling, observations about the data in the final ArcGIS PGDB, and proposed assumptions to correct this data in the modeling.

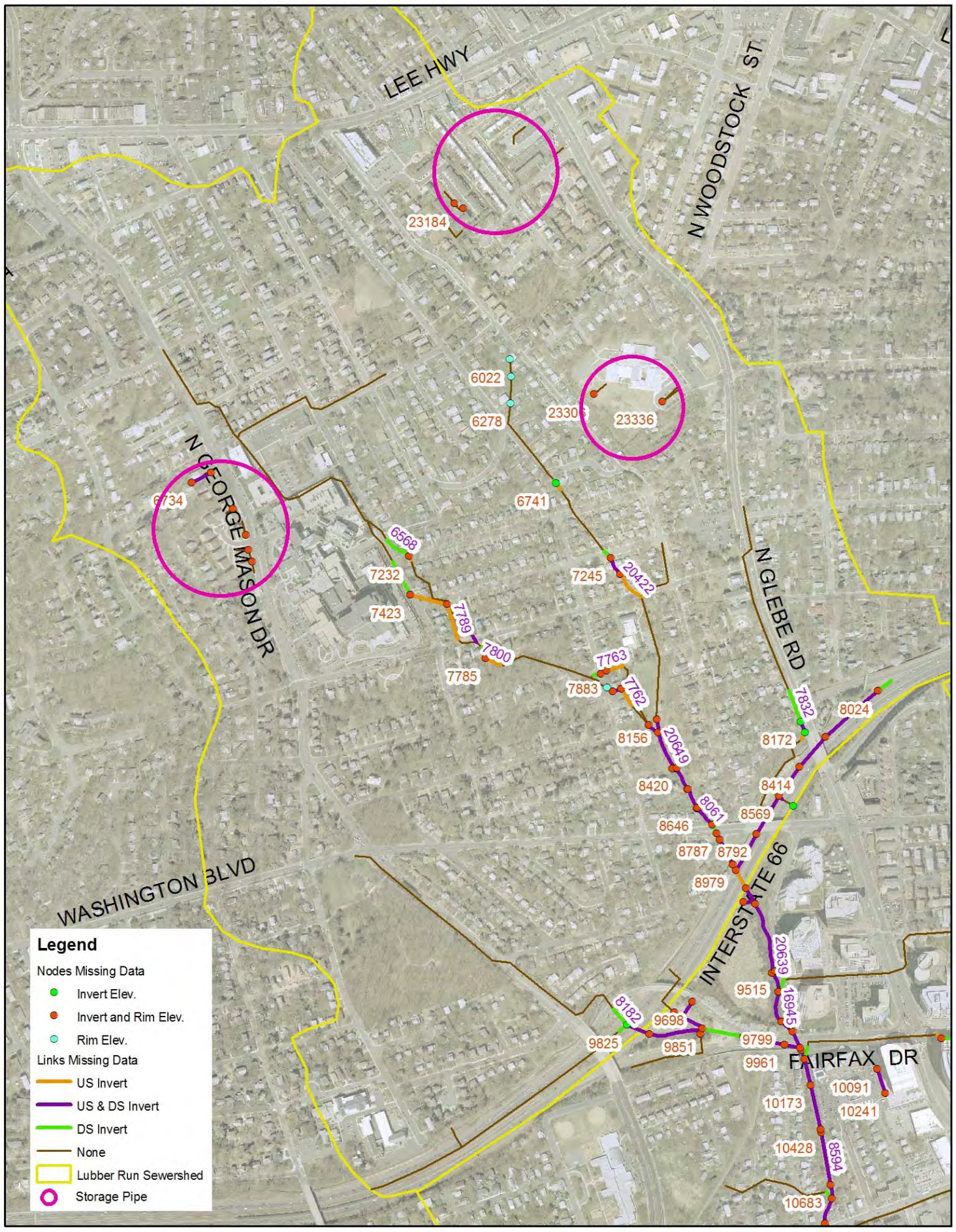
Table 2 provides information on nodes that have missing information. It provides the node location (upper, middle, or lower area), GIS ID, the node type, the information that is missing, proposed assumptions to fill in this data in the modeling, observation about the data in the final ArcGIS PGDB, and proposed assumptions to correct this data in the modeling. Please note that to avoid duplicating information, solutions to fill the missing invert elevations of the nodes are included in Table 1.

FIGURE 1
Overall Data Gaps



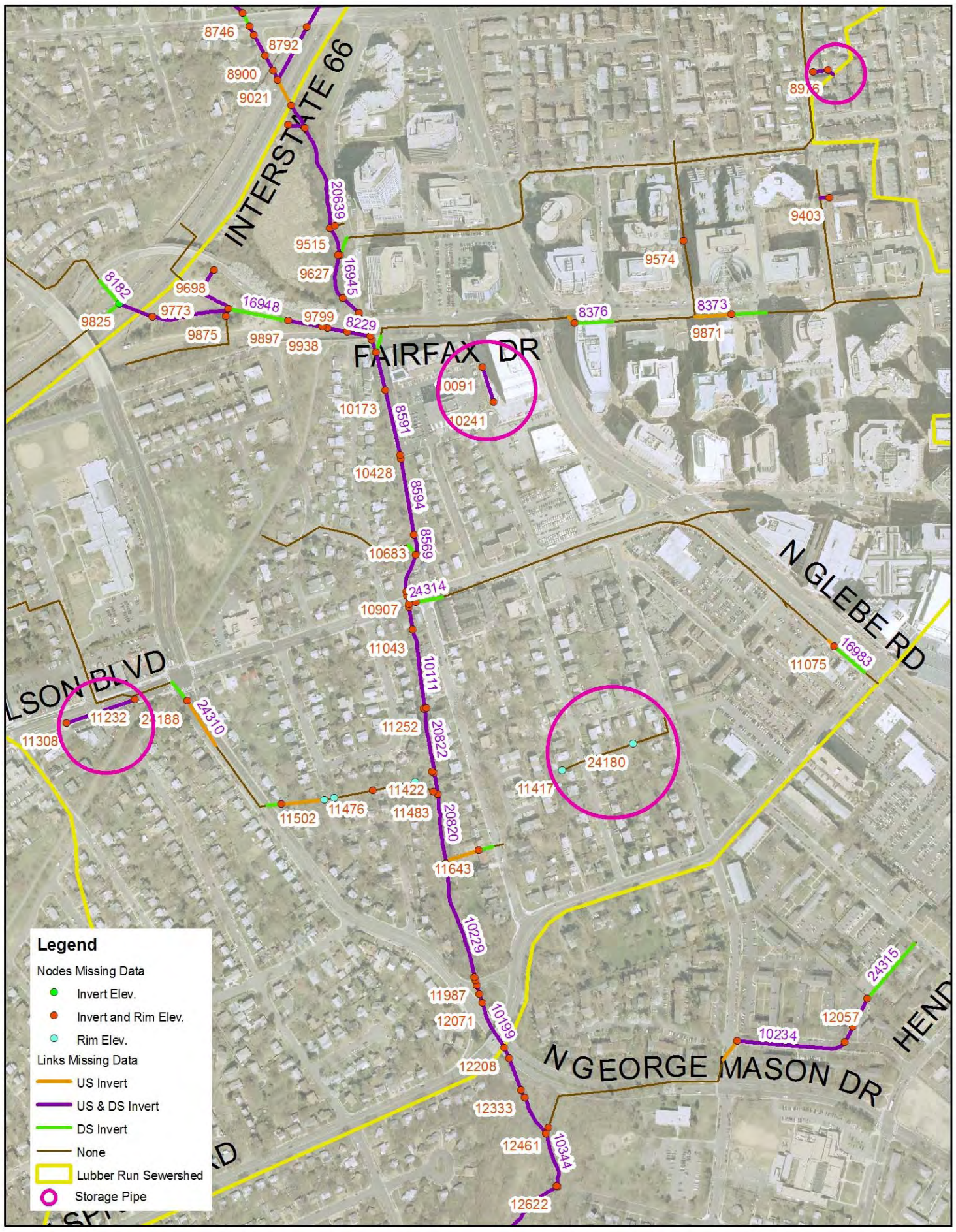
Prepared By CH2MHILL Prepared For Arlington County	**Arlington County Stormwater Capacity Analysis** Lubber Run Sewershed Nov, 2010	N	**Data Gaps and Storage Pipes**

FIGURE 2
Data Gaps—Upper Area (North of I-66)



Prepared By CH2MHILL Prepared For Arlington County	**Arlington County Stormwater Capacity Analysis** Lubber Run Sewershed Nov, 2010	N	**Data Gaps and Storage Pipes in Upper Area**

FIGURE 3
Data Gaps—Middle Area (Between I-66 and N. Carlin Springs Rd.)



Prepared By CH2MHILL Prepared For Arlington County	**Arlington County Stormwater Capacity Analysis** Lubber Run Sewershed Nov, 2010	N	**Data Gaps and Storage Pipes in Middle Area**

FIGURE 4
Data Gaps—Lower Area (South of N. Carlin Springs Rd)

Prepared By CH2MHILL Prepared For Arlington County	**Arlington County Stormwater Capacity Analysis** Lubber Run Sewershed Nov, 2010	N
		Data Gaps in Lower Area

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	6568	7131	7232	Circular Pipe	42"	DS Invert	These two links (GID 6568 and 5983) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	5983	7232	7255	Circular Pipe	42"	US Invert	These two links (GID 6568 and 5983) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	24258	7423	24162	Circular Pipe	54"	US Invert	These two links (GID 24258 and 6043) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	6043	7269	7423	Circular Pipe	54"	DS Invert	These two links (GID 24258 and 6043) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	24259	24162	7494	Circular Pipe	54"	DS Invert	These two links (GID 24259 and 7789) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	7789	7494	7674	Circular Pipe	54"	US Invert	These two links (GID 24259 and 7789) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	7799	7724	7785	Elliptical	91"x58"	DS Invert	These two links (GID 7799 and 7800) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	7800	7785	7840	Elliptical	91"x58"	US Invert	These two links (GID 7799 and 7800) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts	—	—
Upper Area: North of I-66	5797	6721	6741	Circular Pipe	42"	DS Invert	These two links (GID 5797 and 5806) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Upper Area: North of I-66	5806	6741	6777	Circular Pipe	42"	US Invert	These two links are (GID 5797 and 5806) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Upper Area: North of I-66	7998	8526	8569	Circular Pipe	60"	DS Invert	Take the upstream invert from Node GID 8526. Take the downstream invert from Node 8569, whose invert was obtained interpolating existing and surveyed data	—	—
Upper Area: North of I-66	8014	8588	8569	Circular Pipe	42"	US & DS Invert	Take the upstream invert from Node GID 8588. Take the downstream invert from Node 8569, whose invert was obtained interpolating existing and surveyed data	—	—
Upper Area: North of I-66	16830	7910	7883	Circular Pipe	54"	US & DS Invert	These three links (GID 16830, 16831, and 7763) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—
Upper Area: North of I-66	16831	7918	7910	Circular Pipe	54"	DS Invert	These three links (GID 16830, 16831, and 7763) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	7763	7883	7844	Circular Pipe	54"	US Invert	These three links (GID 16830, 16831, and 7763) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	The downstream invert appears to be an anomaly	Take the invert from immediately downstream pipe (Link 7764)
Upper Area: North of I-66	7760	7994	8028	Circular Pipe	72"	DS Invert	These three links (GID 7760, 7761, and 7762) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—
Upper Area: North of I-66	7761	8028	8005	Circular Pipe	72"	US & DS Invert	These three links (GID 7760, 7761, and 7762) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—
Upper Area: North of I-66	7762	8005	8095	Circular Pipe	72"	US Invert	These three links (GID 7760, 7761, and 7762) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—
Upper Area: North of I-66	20422	7338	7445	Circular Pipe	48"	US Invert	These three links (GID 20422, 6579, and 6582) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—
Upper Area: North of I-66	6579	7245	7338	Circular Pipe	48"	US & DS Invert	These three links (GID 20422, 6579, and 6582) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—
Upper Area: North of I-66	6582	7198	7245	Circular Pipe	48"	DS Invert	These three links (GID 20422, 6579, and 6582) are us and ds from each other and the missing data could be obtained interpolating the slope for the three links from the 2 known inverts	—	—
Upper Area: North of I-66	7832	8025	8172	Circular Pipe	36"	DS Invert	These three links (GID 7832, 7833 and 7837) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Upper Area: North of I-66	7833	8172	8232	Circular Pipe	36"	US & DS Invert	These three links (GID 7832, 7833 and 7837) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Upper Area: North of I-66	7837	8232	8260	Circular Pipe	42"	US Invert	These three links (GID 7832, 7833 and 7837) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Upper Area: North of I-66	20628	8195	8229	Stream Channel	N/A	US & DS Invert	Take the upstream invert from the survey. The downstream invert could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	21835	8156	8229	Stream Channel	N/A	US & DS Invert	These five links (GID 21835, 20649, 8058, 8060, and 8061) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	20649	8229	8423	Stream Channel	N/A	US & DS Invert	These five links (GID 21835, 20649, 8058, 8060, and 8061) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	8058	8423	8529	Stream Channel	N/A	US & DS Invert	These five links (GID 21835, 20649, 8058, 8060, and 8061) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	8060	8529	8646	Stream Channel	N/A	US & DS Invert	These five links (GID 21835, 20649, 8058, 8060, and 8061) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	8061	8646	8746	Stream Channel	N/A	US & DS Invert	These five links (GID 21835, 20649, 8058, 8060, and 8061) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	16865	8746	8787	Box	3 -10'x6'	DS Invert	These six links (GID 16865, 16876, 16877, 16858, 16856 and 8062) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	The pipe upstream invert elev. in the GIS file is different than the surveyed data	Use surveyed value
Upper Area: North of I-66	16876	8787	8823	Box	3 -10'x6'	US & DS Invert	These six links (GID 16865, 16876, 16877, 16858, 16856 and 8062) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	16877	8823	8900	Box	3 -10'x6'	US & DS Invert	These six links (GID 16865, 16876, 16877, 16858, 16856 and 8062) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	16858	8900	8979	Box	3 -10'x6'	US & DS Invert	These six links (GID 16865, 16876, 16877, 16858, 16856 and 8062) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	16856	8979	9021	Box	3 -10'x6'	US & DS Invert	These six links (GID 16865, 16876, 16877, 16858, 16856 and 8062) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	8062	9021	9101	Box	3 -10'x6'	US Invert	These six links (GID 16865, 16876, 16877, 16858, 16856 and 8062) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Upper Area: North of I-66	7849	7955	8024	Circular Pipe	60"	DS Invert	These seven links (GID 7849, 7851, 7864, 7862, 8064, 7997, and 16883) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the known invert and the one obtained interpolating the survey data	—	—
Upper Area: North of I-66	7851	8024	8102	Circular Pipe	60"	US & DS Invert	These seven links (GID 7849, 7851, 7864, 7862, 8064, 7997, and 16883) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the known invert and the one obtained interpolating the survey data	—	—
Upper Area: North of I-66	7864	8102	8250	Circular Pipe	60"	US & DS Invert	These seven links (GID 7849, 7851, 7864, 7862, 8064, 7997, and 16883) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the known invert and the one obtained interpolating the survey data	—	—

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	7862	8250	8414	Circular Pipe	60"	US & DS Invert	These seven links (GID 7849, 7851, 7864, 7862, 8064, 7997, and 16883) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the known invert and the one obtained interpolating the survey data	—	—
Upper Area: North of I-66	8064	8414	8569	Circular Pipe	60"	US & DS Invert	These seven links (GID 7849, 7851, 7864, 7862, 8064, 7997, and 16883) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the known invert and the one obtained interpolating the survey data	—	—
Upper Area: North of I-66	7997	8569	8792	Box	2 - 6'x5'	US & DS Invert	These seven links (GID 7849, 7851, 7864, 7862, 8064, 7997, and 16883) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the known invert and the one obtained interpolating the survey data	—	—
Upper Area: North of I-66	16883	8792	9021	Box	2 - 6'x5'	US & DS Invert	These seven links (GID 7849, 7851, 7864, 7862, 8064, 7997, and 16883) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the known invert and the one obtained interpolating the survey data	—	—
Upper Area: North of I-66	8182	9725	9825	Elliptical	83"x53"	DS Invert	These two links (GID 8182 and 8183) are us and ds from each other and the missing data could be obtained interpolating the slope from the known invert and the invert obtained from the survey	—	—
Upper Area: North of I-66	8183	9825	9876	Box	2 - 8'x6'	US & DS Invert	These two links (GID 8182 and 8183) are us and ds from each other and the missing data could be obtained interpolating the slope from the known invert and the invert obtained from the survey	Pipe not included in updated GIS shapefile (pipes 36 inches or higher)	Add pipe from original file
Upper Area: North of I-66	8206	9862	9825	Elliptical	83"x53"	DS Invert	The missing data could be obtained interpolating the slope from the known invert (Link GID 8182) and the invert obtained from the survey (Link GID 8183)	—	—
Upper Area: North of I-66	20648	8422	8423	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 8058)
Upper Area: North of I-66	7861	8420	8423	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 8058)
Upper Area: North of I-66	8057	8531	8529	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 8060)
Upper Area: North of I-66	8059	8652	8646	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 8061)
Upper Area: North of I-66	5792	6734	6685	Arch	64"x43"	US & DS Invert	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	7788	7664	7695	Box	7'x4'	US & DS Invert	Take inverts from immediately upstream and downstream links (GID 20621 and 778)	—	—

TABLE 1
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Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	8012	8635	8628	Circular Pipe	42"	US Invert	Use the slope of immediately downstream pipe (Link ID 8013 - 42 in pipe) to extrapolate the missing invert	—	—
Upper Area: North of I-66	7769	8143	8156	Circular Pipe	60"	N/A	—	The pipe downstream invert elev. is different than the surveyed data	Use surveyed value
Upper Area: North of I-66	23110	23246	23247	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23111	23247	02-841C	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23112	23249	02-841C	Circular Pipe	42"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23118	23255	02-841B	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23106	23242	02-841A	Circular Pipe	48"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23096	23209	23208	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23101	23216	23217	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23102	23217	23218	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23056	23185	23184	Circular Pipe	2 - 54"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23311	23184	94-499A	Circular Pipe	2 - 54"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23044	23175	94-499B	Circular Pipe	54"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23043	23178	23175	Circular Pipe	54"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	20626	8007	8195	Circular Pipe	54"	N/A	—	The pipe downstream invert elev. is higher the surveyed value.	Use surveyed values
Upper Area: North of I-66	20625	8095	8195	Circular Pipe	72"	N/A	—	The pipe downstream invert elev. is different than the surveyed value	Use surveyed value
Upper Area: North of I-66	5665	6286	6273	Circular Pipe	42"	N/A	—	The pipe downstream invert elev. is lower than the node invert elev.	Take invert from immediately downstream pipe (Link GID 5672 -42")
Upper Area: North of I-66	5689	6250	6341	Circular Pipe	42"	N/A	—	The pipe upstream invert elev. is lower than the node invert elev.	Change the node invert
Upper Area: North of I-66	5716	6341	6423	Circular Pipe	42"	N/A	—	The pipe upstream invert elev. is higher than the node invert elev.	Take invert from immediately upstream pipe (Link GID 5689 - 42")
Upper Area: North of I-66	5891	7005	7014	Circular Pipe	66"	N/A	—	The pipe upstream invert elev. is higher than the node invert elev.	Change the node invert
Upper Area: North of I-66	7826	7588	7635	Circular Pipe	36"	N/A	—	The pipe upstream invert elev. is higher than the node invert elev.	Take invert from immediately upstream pipe (Link GID 20414 - 36")
Upper Area: North of I-66	23138	23268	02-865B	Circular Pipe	2 - 48"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	23147	23279	02-865B	Circular Pipe	2 - 48"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Upper Area: North of I-66	24247	24153	7198	Circular Pipe	21"	N/A	—	The pipe size is inconsistent with the size of immediately upstream and downstream pipes (48").	Use 48 " (as-built 4620-132)
Upper Area: North of I-66	16937	9696	9747	Circular Pipe	36"	N/A	—	The pipe downstream invert elev. is different than the surveyed value	Use surveyed value
Middle Area: Between I-66 and N. Carlin Springs Rd.	8387	9910	9877	Circular Pipe	72"	US Invert	These two links (GID 8387 and 8376) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8376	9901	9910	Circular Pipe	72"	DS Invert	These two links (GID 8387 and 8376) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	16983	11143	11075	Circular Pipe	36"	DS Invert	These two links (GID 16983 and 8652) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—

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Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	8652	11075	11062	Circular Pipe	36"	US Invert	These two links (GID 16983 and 8652) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8435	9860	9871	Circular Pipe	60"	DS Invert	These three links (GID 8435, 8373, and 8374) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	These three links (GID 8435, 8373, and 8374) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts
Middle Area: Between I-66 and N. Carlin Springs Rd.	8373	9871	9878	Circular Pipe	60"	US Invert	These three links (GID 8435, 8373, and 8374) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	The downstream invert appear to be an anomaly	These three links (GID 8435, 8373, and 8374) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts
Middle Area: Between I-66 and N. Carlin Springs Rd.	8374	9878	9884	Circular Pipe	72"	N/A	These three links (GID 8435, 8373, and 8374) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	The upstream invert appear to be an anomaly	These three links (GID 8435, 8373, and 8374) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts
Middle Area: Between I-66 and N. Carlin Springs Rd.	24309	11182	24188	Circular Pipe	48"	DS Invert	These two links (GID 24309 and 24310) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24310	24188	11357	Circular Pipe	48"	US Invert	These two links (GID 24309 and 24310) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24312	24189	11502	Circular Pipe	48"	US Invert	These two links (GID 24312 and 24311) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24311	11517	24189	Circular Pipe	48"	DS Invert	These two links (GID 24312 and 24311) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	The pipe upstream invert elev. is lower than the node invert elev.	Change the node invert
Middle Area: Between I-66 and N. Carlin Springs Rd.	20817	11628	11643	Circular Pipe	36"	DS Invert	These two links (GID 20817 and 20818) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	The pipe upstream invert elev. is lower than the node invert elev.	Change the node invert
Middle Area: Between I-66 and N. Carlin Springs Rd.	20818	11643	11671	Arch	7.5'x3'	US Invert	These two links (GID 20817 and 20818) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	20651	9101	9185	Stream Channel	N/A	US & DS Invert	These four links (GID 20651, 20639, 16944, and 16945) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	Beaver Dam Pond	This link may be reflected in the model differently
Middle Area: Between I-66 and N. Carlin Springs Rd.	20639	9185	9526	Stream Channel	N/A	US & DS Invert	These four links (GID 20651, 20639, 16944, and 16945) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	Beaver Dam Pond	This link may be reflected in the model differently

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	16944	9526	9627	Stream Channel	N/A	US & DS Invert	These four links (GID 20651, 20639, 16944, and 16945) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	Beaver pond	This link may be reflected in the model differently
Middle Area: Between I-66 and N. Carlin Springs Rd.	16945	9627	9799	Stream Channel	N/A	US & DS Invert	These four links (GID 20651, 20639, 16944, and 16945) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	Beaver pond	This link may be reflected in the model differently
Middle Area: Between I-66 and N. Carlin Springs Rd.	8246	9561	9628	Circular Pipe	66"	DS Invert	Use slope of upstream pipe (Link ID 8245- 66 in pipe) to extrapolate the missing invert	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	16942	9628	9627	Ditch	N/A	US & DS Invert	—	The ditch was not surveyed	This ditch will not be modeled. The immediately upstream link (GID 8246) will be connected to the immediately downstream link (GID 16945)
Middle Area: Between I-66 and N. Carlin Springs Rd.	21780	9799	9864	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	21781	9864	9978	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24298	9978	24187	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24299	24187	10046	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8231	10046	10173	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8591	10173	10428	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8593	10428	10437	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8594	10437	10683	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	8569	10683	10761	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8570	10761	10907	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8571	10907	10927	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24307	10927	24177	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24308	24177	10969	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	16979	10969	11043	Box	2 - 10'x6'	US & DS Invert	These fourteen links (GID 21780, 21781, 24298, 24299, 8231, 8591, 8593, 8594, 8569, 8570, 8571, 24307, 24308, and 16979) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8567	10722	10761	Circular Pipe	36"	DS Invert	The downstream invert can be obtained interpolating the know inverts from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10111	11043	11254	Open Channel	N/A	US & DS Invert	These five links (GID 10111, 20822, 20823, 20820, and 10229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	20822	11254	11427	Open Channel	N/A	US & DS Invert	These five links (GID 10111, 20822, 20823, 20820, and 10229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	20823	11427	11483	Open Channel	N/A	US & DS Invert	These five links (GID 10111, 20822, 20823, 20820, and 10229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	20820	11483	11684	Open Channel	N/A	US & DS Invert	These five links (GID 10111, 20822, 20823, 20820, and 10229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10229	11684	11987	Open Channel	N/A	US & DS Invert	These five links (GID 10111, 20822, 20823, 20820, and 10229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	16948	9851	9897	Box	2 - 8'x6'	DS Invert	These five links (GID 16948, 8226, 8227, 8228, and 8229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	The pipe upstream invert elev. is higher than the surveyed value	Use the surveyed value
Middle Area: Between I-66 and N. Carlin Springs Rd.	8226	9897	9930	Box	2 - 8'x6'	US & DS Invert	These five links (GID 16948, 8226, 8227, 8228, and 8229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8227	9930	9938	Box	2 - 8'x6'	US & DS Invert	These five links (GID 16948, 8226, 8227, 8228, and 8229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8228	9938	9961	Box	2 - 8'x6'	US & DS Invert	These five links (GID 16948, 8226, 8227, 8228, and 8229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8229	9961	9978	Box	2 - 8'x6'	US & DS Invert	These five links (GID 16948, 8226, 8227, 8228, and 8229) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8304	9698	9773	Ditch	N/A	US & DS Invert	—	The pipe upstream of this ditch is less than 36" and connected to the Beaver pond. The ditch was not surveyed	This ditch will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	16882	9174	9185	Stream Channel	N/A	US & DS Invert	—	The pipes upstream of this stream are less than 36"	This stream will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 20639)
Middle Area: Between I-66 and N. Carlin Springs Rd.	16949	9875	9851	Ditch	N/A	US & DS Invert	—	The ditch was not surveyed	This ditch will not be modeled. The immediately upstream link (GID 8224) will be connected to the immediately downstream link (GID 16948)
Middle Area: Between I-66 and N. Carlin Springs Rd.	20821	11481	11483	Ditch	N/A	US & DS Invert	—	The ditch was not surveyed	This ditch will not be modeled. The immediately upstream link (GID 17318) will be connected to the immediately downstream link (GID 20820)
Middle Area: Between I-66 and N. Carlin Springs Rd.	16943	9515	9526	Ditch	N/A	US & DS Invert	—	The ditch was not surveyed	This ditch will not be modeled. The immediately upstream link (GID 8235) will be connected to the immediately downstream link (GID 16944)
Middle Area: Between I-66 and N. Carlin Springs Rd.	8398	9568	9574	Circular Pipe	36"	DS Invert	Take the invert data from as-built 4620-143	The pipe upstream invert elev. is inconsistent with as-built 4620-143	Take the invert data from as-built 4620-143
Middle Area: Between I-66 and N. Carlin Springs Rd.	8262	9977	10046	Circular Pipe	72"	DS Invert	The downstream invert can be obtained interpolating the know inverts from the survey	The pipe upstream invert elev. is higher than the node invert elev.	Use slope of upstream pipe (Link ID 8264 - 72 in pipe) to extrapolate the upstream invert
Middle Area: Between I-66 and N. Carlin Springs Rd.	24314	24190	24176	Circular Pipe	48"	DS Invert	Use slope of immediately upstream pipe (Link ID 24313 - 48 in pipe) to extrapolate the missing invert	—	—

TABLE 1
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Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	24285	24176	24177	Circular Pipe	48"	US & DS Invert	Use slope of upstream pipe (Link ID 24313 - 48 in pipe) to extrapolate the upstream invert. Take the downstream invert interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8108	9403	9404	Circular Pipe	24	US & DS Invert	Use the slope of pipe (Link 24280 - 36 in pipe) to extrapolate the missing inverts	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	8265	9940	9977	Circular Pipe	72"	N/A	—	The pipe has a slope of zero and the downstream invert elev. is lower than the node invert elev.	Use the slope of upstream pipe (Link ID 8264 - 72 in pipe) to extrapolate the downstream invert
Middle Area: Between I-66 and N. Carlin Springs Rd.	8419	9311	9463	Circular Pipe	36"	N/A	—	The pipe downstream invert elev. is inconsistent with as-built 4620-143	Take the invert data from as-built 4620-143
Middle Area: Between I-66 and N. Carlin Springs Rd.	8397	9463	9568	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4620-143	Take the invert data from as-built 4620-143
Middle Area: Between I-66 and N. Carlin Springs Rd.	8399	9574	9693	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4620-143	Take the invert data from as-built 4620-143
Middle Area: Between I-66 and N. Carlin Springs Rd.	8400	9693	9757	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4620-143	Take the invert data from as-built 4620-143
Middle Area: Between I-66 and N. Carlin Springs Rd.	8401	9757	9813	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4620-143	Take the invert data from as-built 4620-143
Middle Area: Between I-66 and N. Carlin Springs Rd.	8402	9813	9878	Circular Pipe	36"	N/A	—	The pipe upstream invert elev. is inconsistent with as-built 4620-143	Take the invert data from as-built 4620-143
Middle Area: Between I-66 and N. Carlin Springs Rd.	8224	10013	9875	Circular Pipe	36"	N/A	—	The pipe downstream invert elev. is different than the surveyed value	Use the surveyed value
Middle Area: Between I-66 and N. Carlin Springs Rd.	24292	24183	24174	Circular Pipe	36"	N/A	—	The pipe upstream invert elev. is higher than the downstream invert elev. (adverse slope)	Take invert from US node (GID 24182)
Middle Area: Between I-66 and N. Carlin Springs Rd.	8653	11062	10940	Circular Pipe	36"	N/A	—	The pipe downstream invert elev. is lower than the node invert elev.	Take invert from immediately downstream pipe (Link GID 8654 - 36")

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	8250	9497	9524	Circular Pipe	66"	N/A	—	The pipe downstream invert elev. is higher than the upstream invert elev. (adverse slope)	These two links (GID 8250 and 24302) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts
Middle Area: Between I-66 and N. Carlin Springs Rd.	24302	9524	9543	Circular Pipe	66"	N/A	—	The upstream invert elev. appear to be an anomaly	These two links (GID 8250 and 24302) are us and ds from each other and the missing data could be obtained interpolating the slope for both links from the 2 known inverts
Middle Area: Between I-66 and N. Carlin Springs Rd.	24276	8964	24172	Circular Pipe	36"	N/A	—	The pipe upstream invert elev. is higher than the node invert elev.	Take invert from Node GID 8964
Middle Area: Between I-66 and N. Carlin Springs Rd.	20824	11422	11427	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 20823)
Middle Area: Between I-66 and N. Carlin Springs Rd.	10112	11252	11254	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 20822)
Middle Area: Between I-66 and N. Carlin Springs Rd.	20637	10091	10241	Arch	103"x71"	US & DS Invert	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	16887	9012	8976	Circular Pipe	36"	US & DS Invert	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	16888	8976	8985	Circular Pipe	36"	US & DS Invert	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	20813	11308	11231	Open Channel	N/A	US & DS Invert	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	24288	11324	24180	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	24289	24180	11392	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	10116	11286	11324	Circular Pipe	36"	N/A	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	10121	11392	11404	Circular Pipe		Size	—	Detention pipe disconnected from sewer system	This pipe will not be modeled

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Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	10133	11404	11417	Arch		Size	—	Detention pipe disconnected from sewer system	This pipe will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	8578	10824	10879	Circular Pipe	48"	N/A	—	The pipe downstream invert elev. is lower than the node invert elev.	Use the invert from immediately downstream pipe (Link 24313- 48")
Middle Area: Between I-66 and N. Carlin Springs Rd.	24280	24174	9404	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4630-145	These five links (GID 24280, 8423, 8420, 8318, and 84212) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from as-built 4630-145
Middle Area: Between I-66 and N. Carlin Springs Rd.	8423	9404	9596	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4630-145	These five links (GID 24280, 8423, 8420, 8318, and 84212) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from as-built 4630-145
Middle Area: Between I-66 and N. Carlin Springs Rd.	8420	9596	9644	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4630-145	These five links (GID 24280, 8423, 8420, 8318, and 84212) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from as-built 4630-145
Middle Area: Between I-66 and N. Carlin Springs Rd.	8318	9644	9734	Circular Pipe	36"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4630-145	These five links (GID 24280, 8423, 8420, 8318, and 84212) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from as-built 4630-145
Middle Area: Between I-66 and N. Carlin Springs Rd.	8412	9734	9820	Circular Pipe	42"	N/A	—	The pipe upstream and downstream invert elev. are inconsistent with as-built 4630-145	These five links (GID 24280, 8423, 8420, 8318, and 84212) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from as-built 4630-145
Middle Area: Between I-66 and N. Carlin Springs Rd.	16936	9747	9773	Stream Channel	N/A	US & DS Invert	These two links (GID 16936 and 20635) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	VDOT detention pond	This link may be reflected in the model differently
Middle Area: Between I-66 and N. Carlin Springs Rd.	20635	9773	9851	Stream Channel	N/A	US & DS Invert	These two links (GID 16936 and 20635) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	VDOT detention pond	This link may be reflected in the model differently
Middle Area: Between I-66 and N. Carlin Springs Rd.	16947	9876	9851	Stream Channel	N/A	US & DS Invert	Take invert data from the survey	VDOT detention pond	This link may be reflected in the model differently
Middle Area: Between I-66 and N. Carlin Springs Rd.	17366	11987	11996	Box	2 - 10'x8'	US & DS Invert	These seven links (GID 17366, 17367, 17368, 10198, 10199, 10200, 10201) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	17367	11996	12009	Box	2 - 10'x8'	US & DS Invert	These seven links (GID 17366, 17367, 17368, 10198, 10199, 10200, 10201) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	17368	12009	12042	Box	2 - 10'x8'	US & DS Invert	These seven links (GID 17366, 17367, 17368, 10198, 10199, 10200, 10201) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10198	12042	12071	Box	2 - 10'x8'	US & DS Invert	These seven links (GID 17366, 17367, 17368, 10198, 10199, 10200, 10201) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10199	12071	12208	Box	2 - 10'x8'	US & DS Invert	These seven links (GID 17366, 17367, 17368, 10198, 10199, 10200, 10201) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	10200	12208	12238	Box	2 - 10'x8'	US & DS Invert	These seven links (GID 17366, 17367, 17368, 10198, 10199, 10200, 10201) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	10201	12238	12333	Box	2 - 10'x8'	US & DS Invert	These seven links (GID 17366, 17367, 17368, 10198, 10199, 10200, 10201) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	24315	11890	12057	Circular Pipe	36"	DS Invert	These five links (GID 24315, 24317, 24318, 10234, and 10236) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Lower Area: South of N. Carlin Springs Rd	24317	12057	24191	Circular Pipe	36"	US & DS Invert	These five links (GID 24315, 24317, 24318, 10234, and 10236) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Lower Area: South of N. Carlin Springs Rd	24318	24191	12194	Circular Pipe	36"	US & DS Invert	These five links (GID 24315, 24317, 24318, 10234, and 10236) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Lower Area: South of N. Carlin Springs Rd	10234	12194	12193	Circular Pipe	36"	US & DS Invert	These five links (GID 24315, 24317, 24318, 10234, and 10236) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Lower Area: South of N. Carlin Springs Rd	10236	12193	12242	Circular Pipe	42"	US Invert	These five links (GID 24315, 24317, 24318, 10234, and 10236) are us and ds from each other and the missing data could be obtained interpolating the slope for the links from the 2 known inverts	—	—
Lower Area: South of N. Carlin Springs Rd	10230	12333	12362	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Lower Area: South of N. Carlin Springs Rd	10231	12362	12485	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	10344	12485	12622	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	10348	12622	12885	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	17391	12885	13251	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	17392	13251	13298	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	20855	13298	13397	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	20856	13397	13762	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	10402	13762	14008	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	10403	14008	14405	Stream Channel	N/A	US & DS Invert	These ten links (GID 10230, 10231, 10344, 10348, 17391, 17392, 20855, 20856, 10402, and 10403) are us and ds from each other and the missing data could be obtained interpolating the slope from the inverts obtained from the survey	—	—
Lower Area: South of N. Carlin Springs Rd	21160	14405	14510	Arch	12'x7'	US & DS Invert	These four links (GID 21160, 18030, 18035, and 18036) are us and ds from each other and the missing data could be obtained using the slope from Link GID 10403 to extrapolate the missing inverts	—	—
Lower Area: South of N. Carlin Springs Rd	18030	14510	14737	Arch	12'x7'	US & DS Invert	These four links (GID 21160, 18030, 18035, and 18036) are us and ds from each other and the missing data could be obtained using the slope from Link GID 10403 to extrapolate the missing inverts	—	—
Lower Area: South of N. Carlin Springs Rd	18035	14737	14764	Ditch	N/A	US & DS Invert	These four links (GID 21160, 18030, 18035, and 18036) are us and ds from each other and the missing data could be obtained using the slope from Link GID 10403 to extrapolate the missing inverts	This is not a ditch but a stream channel	Correct type of link

TABLE 1
Missing Link Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable;

Area	Link GIS ID	US Node ID	DS Node ID	Type	Diam./Pipe Dimension	Missing data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Lower Area: South of N. Carlin Springs Rd	18036	14764	14919	Stream Channel	N/A	US & DS Invert	These four links (GID 21160, 18030, 18035, and 18036) are us and ds from each other and the missing data could be obtained using the slope from Link GID 10403 to extrapolate the missing inverts	Watershed Outfall	—
Lower Area: South of N. Carlin Springs Rd	17393	13250	13251	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 17392)
Lower Area: South of N. Carlin Springs Rd	10228	12461	12485	Ditch	N/A	US & DS Invert	—	The ditch was not surveyed	This ditch will not be modeled. The immediately upstream link (GID 10274) will be connected to the immediately downstream link (GID 10344)
Lower Area: South of N. Carlin Springs Rd	10345	12624	12622	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 10348)
Lower Area: South of N. Carlin Springs Rd	10347	13300	13298	Ditch	N/A	US & DS Invert	—	The pipes upstream of this ditch are less than 36". The ditch was not surveyed	This ditch will not be modeled. The sub-sewershed runoff will be routed to the immediately downstream link (GID 20855)

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	8652	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Upper Area: North of I-66	8531	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Upper Area: North of I-66	8422	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Upper Area: North of I-66	8420	End Wall	Invert and Rim Elev.	—	The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Upper Area: North of I-66	23247	Grate Inlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23248	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23256	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23245	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	6734	Manhole	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	6685	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23336	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23306	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23275	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23184	Junction	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	9021	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8979	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8900	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8823	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8792	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	8787	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8746	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8667	Grate Inlet	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8646	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8569	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8529	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8423	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8414	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8250	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8229	Catchbasin	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8195	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8156	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8102	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8028	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8024	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	8005	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	7910	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	7883	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	7785	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	7494	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	7423	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	7338	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	7245	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	7232	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Upper Area: North of I-66	9825	Manhole	Invert Elev.	Included in Table 1	—	—
Upper Area: North of I-66	8635	Grate Inlet	Invert Elev.	Included in Table 1	—	—
Upper Area: North of I-66	8232	Manhole	Invert Elev.	Included in Table 1	—	—
Upper Area: North of I-66	8172	Manhole	Invert Elev.	Included in Table 1	—	—
Upper Area: North of I-66	6741	Manhole	Invert Elev.	Included in Table 1	—	—
Upper Area: North of I-66	6313	Catchbasin	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	8628	Grate Inlet	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	7147	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	7005	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	6973	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	6862	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	6834	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	6777	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	6423	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	6250	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Upper Area: North of I-66	6104	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Upper Area: North of I-66	23246	Grate Inlet	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23249	Grate Inlet	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23255	Grate Inlet	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23242	Grate Inlet	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23279	Grate Inlet	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23268	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23300	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23175	Grate Inlet	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23178	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23185	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23209	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23208	Catchbasin	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23218	Catchbasin	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23217	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	23216	Catchbasin	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Upper Area: North of I-66	7994	Manhole	Rim Elev.	Take Rim Elev. from contour lines	—	—
Upper Area: North of I-66	6278	Grate Inlet	Rim Elev.	Take Rim Elev. from contour lines	—	—
Upper Area: North of I-66	6121	Yard Inlet	Rim Elev.	Take Rim Elev. from contour lines	—	—
Upper Area: North of I-66	6022	Yard Inlet	Rim Elev.	Take Rim Elev. from contour lines	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	11481	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed	The node will not be modeled. The immediately upstream pipe will be connected to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	9875	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed	The node will not be modeled. The immediately upstream pipe will be connected to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	9628	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed	The node will not be modeled. The immediately upstream pipe will be connected to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	9515	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	The node is in a ditch that was not surveyed	The node will not be modeled. The immediately upstream pipe will be connected to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	11422	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	11252	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	9174	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	11308	End Wall	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	11232	Manhole	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	10241	Junction	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	10091	Grate Inlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	8985	Detention Outlet	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	8976	Catchbasin	Invert and Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	24176	Junction	Invert and Rim Elev.	—	This node is in a ditch and the ditch was not surveyed.	This node will not be modeled. The flow from upstream pipes will be routed to the immediately downstream pipe.
Middle Area: Between I-66 and N. Carlin Springs Rd.	12071	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	12042	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	12009	Catchbasin	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11996	Catchbasin	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11987	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11684	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11643	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24189	Catchbasin	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	11483	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11476	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11427	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9403	Detention Outlet	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11254	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24188	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11075	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11043	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10969	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24177	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10927	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	10907	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10761	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10683	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10437	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10428	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10173	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	10046	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	24187	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9978	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9961	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9938	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	9930	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9910	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9897	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9876	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9871	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9864	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9851	Detention Outlet	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9799	Detention Outlet	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9773	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9747	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9627	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	9574	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9526	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9185	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9101	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11502	Catchbasin	Rim Elev.	Take Rim Elev. from contour lines	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11495	Catchbasin	Rim Elev.	Take Rim Elev. from contour lines	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	11449	Manhole	Rim Elev.	Take Rim Elev. from contour lines	—	—
Middle Area: Between I-66 and N. Carlin Springs Rd.	9698	End Wall	Invert and Rim Elev.	—	The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Middle Area: Between I-66 and N. Carlin Springs Rd.	11628	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	11517	Catchbasin	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9404	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	10824	Catchbasin	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	10583	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9977	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9940	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9878	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9856	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9820	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9813	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9757	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9734	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9693	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	9568	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9555	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9543	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9524	Catchbasin	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9463	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	24174	Catchbasin	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	24183	Other	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9326	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9287	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	9260	Manhole	N/A	—	Revise Invert Elevation	Proposed assumption to correct invert elev. included in Table 1
Middle Area: Between I-66 and N. Carlin Springs Rd.	11404	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Middle Area: Between I-66 and N. Carlin Springs Rd.	11392	Catchbasin	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	11324	Manhole	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	11286	Catchbasin	N/A	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	11417	Grate Inlet	Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Middle Area: Between I-66 and N. Carlin Springs Rd.	24180	Yard Inlet	Rim Elev.	—	This node is connected to a storage pipe	This node will not be modeled
Lower Area: South of N. Carlin Springs Rd	12461	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed	The node will not be modeled. The immediately upstream pipe will be connected to the immediately downstream pipe
Lower Area: South of N. Carlin Springs Rd	13300	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Lower Area: South of N. Carlin Springs Rd	13250	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Lower Area: South of N. Carlin Springs Rd	12624	End Wall	Invert and Rim Elev.	—	The node is in a ditch that was not surveyed. The pipes upstream of this node are less than 36 in	This node will not be modeled. The subshed runoff will be routed to the immediately downstream pipe
Lower Area: South of N. Carlin Springs Rd	14764	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	14737	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	14510	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	14405	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Lower Area: South of N. Carlin Springs Rd	14008	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	13762	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	13397	Other	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	13298	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	13251	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12885	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12622	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12485	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12362	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12333	End Wall	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12238	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12208	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12194	Catchbasin	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12193	Manhole	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

TABLE 2
Missing Node Information (ID = Identification number in GIS; US = Upstream; DS = Downstream; N/A = not applicable)

Area	Node GIS ID	Type	Missing Data	Proposed Assumptions for Missing Data	Observation	Proposed Assumptions for Observations
Lower Area: South of N. Carlin Springs Rd	24191	Junction	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—
Lower Area: South of N. Carlin Springs Rd	12057	Yard Inlet	Invert and Rim Elev.	Take Rim Elev. from contour lines. Proposed assumption for invert elev. included in Table 1	—	—

N/A: Not Applicable

VICINITY MAP

Legend

- Roads
- Original Watershed Boundary
- Modeled (Revised) Watershed Boundary

N

0 700 1,400
Feet

FIGURE A1
Boundary Anomalies
Lubber Run Watershed
Arlington County Storm Capacity Analysis

CH2MHILL

Attachment A

Lubber Run Stream Cross Sections

TO: Allan Rowley/ Arlington County
Elizabeth Thurber/ Arlington County

COPIES: Jackie Luque/ CH2M HILL
Cheri Salas/ CH2M HILL

FROM: Tara Ajello/ CH2M HILL

DATE: September 1, 2010

Attached to this document are 5 maps showing the locations of the cross sections that need to be surveyed.

Surveying Information:

Generally, for an approximately 150-foot-wide corridor, we would need approximately 17 points. We would need a minimum of 9 points (center of creek, both edges of water, 2 sets of points defining the channel, and 1 set of points defining the floodplain). The additional points needed are those that represent significant breaks in ground slopes.

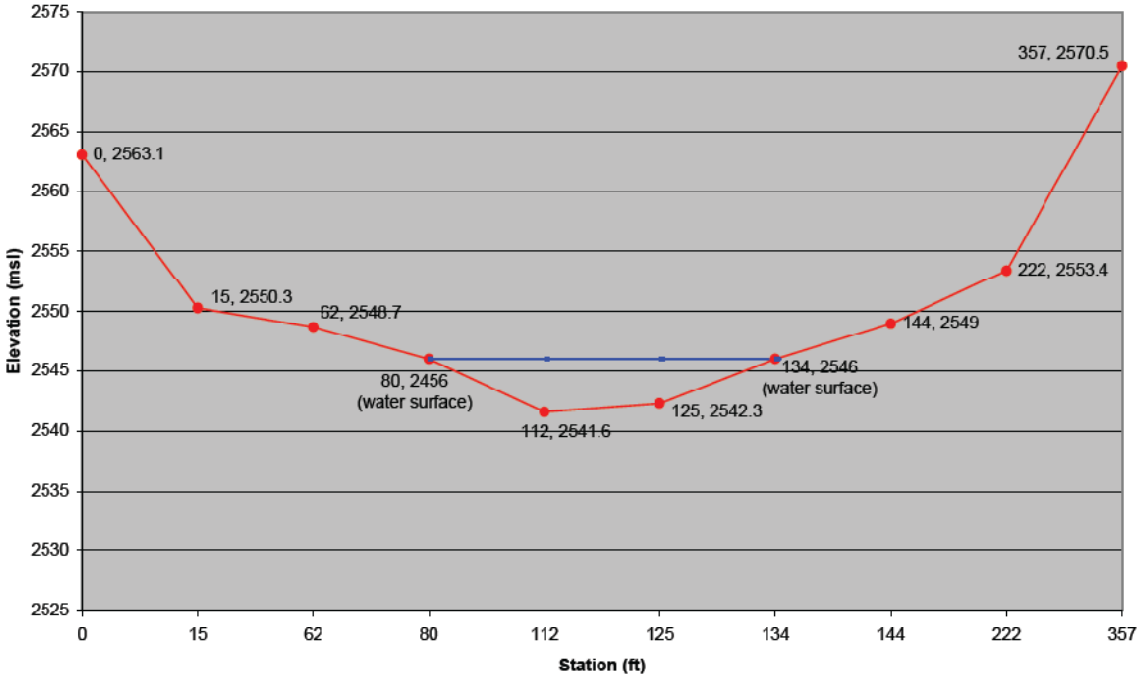
Cross section data should include distance/ elevation data for each station including water surface elevation. The stations for each cross section should start at the far left side of the flood plain, oriented to the user looking downstream. The cross- section alignment should be perpendicular to the general flow of the watercourse.

Follow the topography to determine the points to take, not a set even increment of distance.

It is desired to have photographs taken of every cross section and culvert.

The products of the surveying will be the photos, an x,y plot of each cross section, and the x,y coordinates in Excel. Please label the water's edge points (water surface elevation) and the tops of channel banks on the cross section, see example below.

The cross section labels are provided on the maps. If the team needs to add a cross section in the field because of a change in hydraulic characteristics, please follow the same labeling scheme and provide the new cross section name labeled on a map.


Elevation (msl)
2575
2570
2565
2560
2555
2550
2545
2540
2535
2530
2525
0
15
62
80
112
125
134
144
222
357
Station (ft)
0, 2563.1
15, 2550.3
62, 2548.7
80, 2456
(water surface)
112, 2541.6
125, 2542.3
134, 2546
(water surface)
144, 2549
222, 2553.4
357, 2570.5

Appendix B
Arlington County Soil Profile Assumptions Used in PCSWMM File

APPENDIX B
Arlington County Soil Profile Assumptions Used in PCSWMM Files

Soil Map Units	Composition and Profile	Assumption[a]	Selected Model Profile
4A	Sassafras 40% (0–6 inches sandy loam); urban 35%; Neabsco 15% (0–8 inches loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
4B	Urban 70%; Sassafras 15% (0–6 inches sandy loam); Neabsco 10% (0–8 inches loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
4C	Urban 70%; Sassafras 15% (0–6 inches sandy loam); Neabsco 10% (0–8 inches loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
6B	Glenelg 90% (0–1 inch loam; 1–6 inches silt loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
6C	Glenelg 90% (0–1 inch loam; 1–6 inches silt loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
6D	Glenelg 50% (0–1 inch loam; 1–6 inches silt loam); Manor 45% (0–6 inches sandy loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
7A	Glenelg 45% (0–1 inch loam; 1–6 inches silt loam); urban 40%	Pervious, mostly Glenelg; 1–6 inches	Silty loam
7B	Glenelg 45% (0–1 inch loam; 1–6 inches silt loam); urban 40%	Pervious, mostly Glenelg; 1–6 inches	Silty loam
7C	Glenelg 45% (0–1 inch loam; 1–6 inches silt loam); urban 40%	Pervious, mostly Glenelg; 1–6 inches	Silty loam
7D	Glenelg 45% (0–1 inch loam; 1–6 inches silt loam); urban 40%	Pervious, mostly Glenelg; 1–6 inches	Silty loam
9C	Sassafras 85% (0–6 inches sandy loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
10B	Urban 70%; Glenelg 20% (0–1 inch loam; 1–6 inches silt loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
10C	Urban 70%; Glenelg 20% (0–1 inch loam; 1–6 inches silt loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam

APPENDIX B (CONTINUED)
Arlington County Soil Profile Assumptions Used in PCSWMM Files

Soil Map Units	Composition and Profile	Assumption[a]	Selected Model Profile
10D	Urban 70%; Glenelg 20% (0–1 inch loam; 1–6 inches silt loam)	Pervious, mostly Glenelg; 1–6 inches	Silty loam
11B	Urban 70%; Sassafras 25% (0–6 inches sandy loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
11C	Urban 70%; Sassafras 15% (0–6 inches sandy loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
11D	Urban 70%; Sassafras 20% (0–6 inches sandy loam)	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
12	Urban 85%; Udorthents 15%	Pervious Udorthents	Loam
13	Udorthents 90%	Pervious Udorthents	Loam
15D	Sassafras 45% (0–6 inches sandy loam); urban 40%	Pervious, mostly Sassafras; 0–6 inches	Sandy loam
16B	Urban 70%; Woodstown 20% (0–7 inches sandy loam)	Pervious Woodstown; assume 0–7 inches	Sandy loam

Note: Soil composition and profile information from USDA and NRCS, 2007, "Soil Survey of Arlington County, Virginia" (available at http://soildatamart.nrcs.usda.gov/Manuscripts/VA013/0/Arlington.pdf.
[a] Selected characteristics of top 6 inches of soil profile for modeling runoff.

Appendix C
Hyetograph Data

APPENDIX C
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
0	0.000	0.0000
5	0.000	0.0484
10	0.000	0.0486
15	0.000	0.0476
20	0.000	0.0509
25	0.000	0.0525
30	0.000	0.0482
35	0.000	0.0535
40	0.000	0.0491
45	0.000	0.0507
50	0.000	0.0540
55	0.000	0.0530
60	0.000	0.0533
65	0.000	0.0532
70	0.120	0.0534
75	0.000	0.0524
80	0.000	0.0558
85	0.000	0.0574
90	0.000	0.0530
95	0.000	0.0583
100	0.000	0.0539
105	0.000	0.0556
110	0.000	0.0589
115	0.000	0.0578
120	0.000	0.0581
125	0.000	0.0582
130	0.000	0.0573
135	0.000	0.0615
140	0.000	0.0618
145	0.000	0.0570
150	0.000	0.0584
155	0.000	0.0632
160	0.000	0.0587
165	0.000	0.0604
170	0.000	0.0637

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
175	0.000	0.0627
180	0.000	0.0629
185	0.000	0.0629
190	0.000	0.0631
195	0.000	0.0621
200	0.000	0.0654
205	0.000	0.0672
210	0.000	0.0626
215	0.000	0.0674
220	0.000	0.0688
225	0.000	0.0641
230	0.000	0.0643
235	0.000	0.0685
240	0.000	0.0677
245	0.000	0.0678
250	0.000	0.0672
255	0.000	0.0707
260	0.000	0.0732
265	0.000	0.0724
270	0.000	0.0726
275	0.000	0.0726
280	0.000	0.0728
285	0.000	0.0720
290	0.000	0.0745
295	0.000	0.0780
300	0.000	0.0774
305	0.000	0.0775
310	0.000	0.0769
315	0.000	0.0801
320	0.000	0.0836
325	0.000	0.0806
330	0.000	0.0775
335	0.000	0.0871
340	0.000	0.0839
345	0.000	0.0810

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
350	0.000	0.0844
355	0.120	0.0876
360	0.000	0.0870
365	0.240	0.0872
370	0.120	0.0866
375	0.240	0.0898
380	0.240	0.0933
385	0.360	0.0903
390	0.120	0.0871
395	0.240	0.0968
400	0.120	0.0936
405	0.120	0.0906
410	0.000	0.0941
415	0.000	0.0973
420	0.000	0.0967
425	0.000	0.0969
430	0.000	0.0962
435	0.000	0.0997
440	0.000	0.1022
445	0.000	0.1015
450	0.000	0.1017
455	0.000	0.1016
460	0.120	0.1018
465	0.120	0.1011
470	0.000	0.1035
475	0.240	0.1072
480	1.440	0.1063
485	1.560	0.1057
490	1.080	0.1146
495	1.080	0.1158
500	0.960	0.1199
505	0.000	0.1267
510	0.240	0.1259
515	0.360	0.1348
520	0.120	0.1400

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
525	1.440	0.1403
530	0.600	0.1413
535	0.120	0.1477
540	0.600	0.1555
545	0.120	0.1550
550	0.120	0.1548
555	0.000	0.1549
560	0.240	0.1550
565	0.360	0.1547
570	0.480	0.1550
575	0.720	0.1594
580	0.120	0.1630
585	0.240	0.1697
590	0.000	0.1788
595	0.000	0.1854
600	0.000	0.1892
605	0.000	0.1972
610	0.000	0.2096
615	0.000	0.2192
620	0.000	0.2261
625	0.120	0.2356
630	0.000	0.2481
635	0.000	0.2599
640	0.000	0.2757
645	0.000	0.2920
650	0.000	0.3083
655	0.000	0.3238
660	0.000	0.3407
665	0.000	0.3692
670	0.000	0.4054
675	0.000	0.4416
680	0.000	0.4925
685	0.000	0.5096
690	0.000	0.5696
695	0.000	1.0590

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
700	0.000	2.0449
705	0.000	2.8482
710	0.000	5.0925
715	0.000	6.7422
720	0.000	4.2836
725	0.000	1.0223
730	0.000	0.6866
735	0.000	0.8119
740	0.000	0.6292
745	0.000	0.5675
750	0.000	0.4643
755	0.000	0.4088
760	0.000	0.3917
765	0.000	0.3718
770	0.000	0.3449
775	0.000	0.3235
780	0.000	0.3083
785	0.000	0.2922
790	0.000	0.2750
795	0.000	0.2644
800	0.000	0.2585
805	0.000	0.2473
810	0.000	0.2308
815	0.000	0.2234
820	0.000	0.2155
825	0.000	0.2072
830	0.000	0.1994
835	0.000	0.1910
840	0.000	0.1832
845	0.000	0.1795
850	0.000	0.1755
855	0.000	0.1716
860	0.000	0.1669
865	0.000	0.1644
870	0.000	0.1645

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
875	0.000	0.1598
880	0.000	0.1599
885	0.000	0.1573
890	0.000	0.1528
895	0.000	0.1486
900	0.000	0.1449
905	0.000	0.1455
910	0.000	0.1418
915	0.000	0.1376
920	0.000	0.1331
925	0.000	0.1305
930	0.000	0.1306
935	0.000	0.1259
940	0.000	0.1261
945	0.000	0.1235
950	0.000	0.1190
955	0.000	0.1147
960	0.000	0.1111
965	0.000	0.1118
970	0.000	0.1067
975	0.000	0.1095
980	0.000	0.1102
985	0.000	0.1056
990	0.000	0.1066
995	0.000	0.1069
1000	0.000	0.1025
1005	0.000	0.1012
1010	0.000	0.1017
1015	0.000	0.1018
1020	0.000	0.1015
1025	0.000	0.0970
1030	0.000	0.0963
1035	0.000	0.0977
1040	0.000	0.0943
1045	0.000	0.0926

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
1050	0.000	0.0971
1055	0.000	0.0920
1060	0.000	0.0924
1065	0.000	0.0884
1070	0.000	0.0889
1075	0.000	0.0917
1080	0.000	0.0867
1085	0.000	0.0875
1090	0.000	0.0826
1095	0.000	0.0854
1100	0.000	0.0858
1105	0.000	0.0818
1110	0.000	0.0822
1115	0.000	0.0772
1120	0.000	0.0817
1125	0.000	0.0797
1130	0.000	0.0773
1135	0.840	0.0764
1140	0.360	0.0724
1145	0.600	0.0776
1150	0.000	0.0739
1155	0.480	0.0718
1160	0.600	0.0733
1165	0.000	0.0716
1170	0.120	0.0674
1175	0.240	0.0676
1180	0.240	0.0686
1185	0.000	0.0640
1190	0.240	0.0647
1195	0.000	0.0676
1200	0.000	0.0624
1205	0.000	0.0629
1210	0.000	0.0631
1215	0.000	0.0627
1220	0.000	0.0635

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
1225	0.000	0.0618
1230	0.000	0.0579
1235	1.680	0.0626
1240	0.960	0.0640
1245	2.880	0.0590
1250	4.800	0.0601
1255	2.640	0.0624
1260	1.800	0.0578
1265	2.040	0.0632
1270	1.920	0.0586
1275	2.160	0.0609
1280	1.920	0.0620
1285	2.040	0.0570
1290	2.640	0.0584
1295	2.400	0.0631
1300	2.040	0.0592
1305	2.880	0.0575
1310	1.560	0.0583
1315	2.280	0.0580
1320	1.920	0.0581
1325	1.440	0.0581
1330	1.200	0.0581
1335	0.600	0.0579
1340	0.480	0.0586
1345	0.240	0.0569
1350	0.360	0.0530
1355	0.720	0.0578
1360	0.240	0.0592
1365	0.000	0.0542
1370	0.000	0.0552
1375	0.000	0.0575
1380	0.000	0.0530
1385	0.000	0.0583
1390	0.000	0.0538
1395	0.000	0.0561

APPENDIX C (CONTINUED)
Five-Minute Hyetograph Data

Time (Minutes)	2006 Storm Event (in./hr)	10-Year, 24-Hour Storm (in./hr)
1400	0.120	0.0571
1405	0.000	0.0521
1410	0.120	0.0536
1415	0.120	0.0583
1420	0.120	0.0544
1425	0.120	0.0527
1430	0.240	0.0534
1435	0.720	0.0532

Appendix D
Beaver Pond Meeting

Modeling Beaver Pond in PCSWMM

PREPARED FOR: Elizabeth Thurber/ Arlington County

PREPARED BY: CH2MHILL

COPIES: RK&K

DATE: March 22, 2011

PROJECT NUMBER: 392309.LR

GIS Data

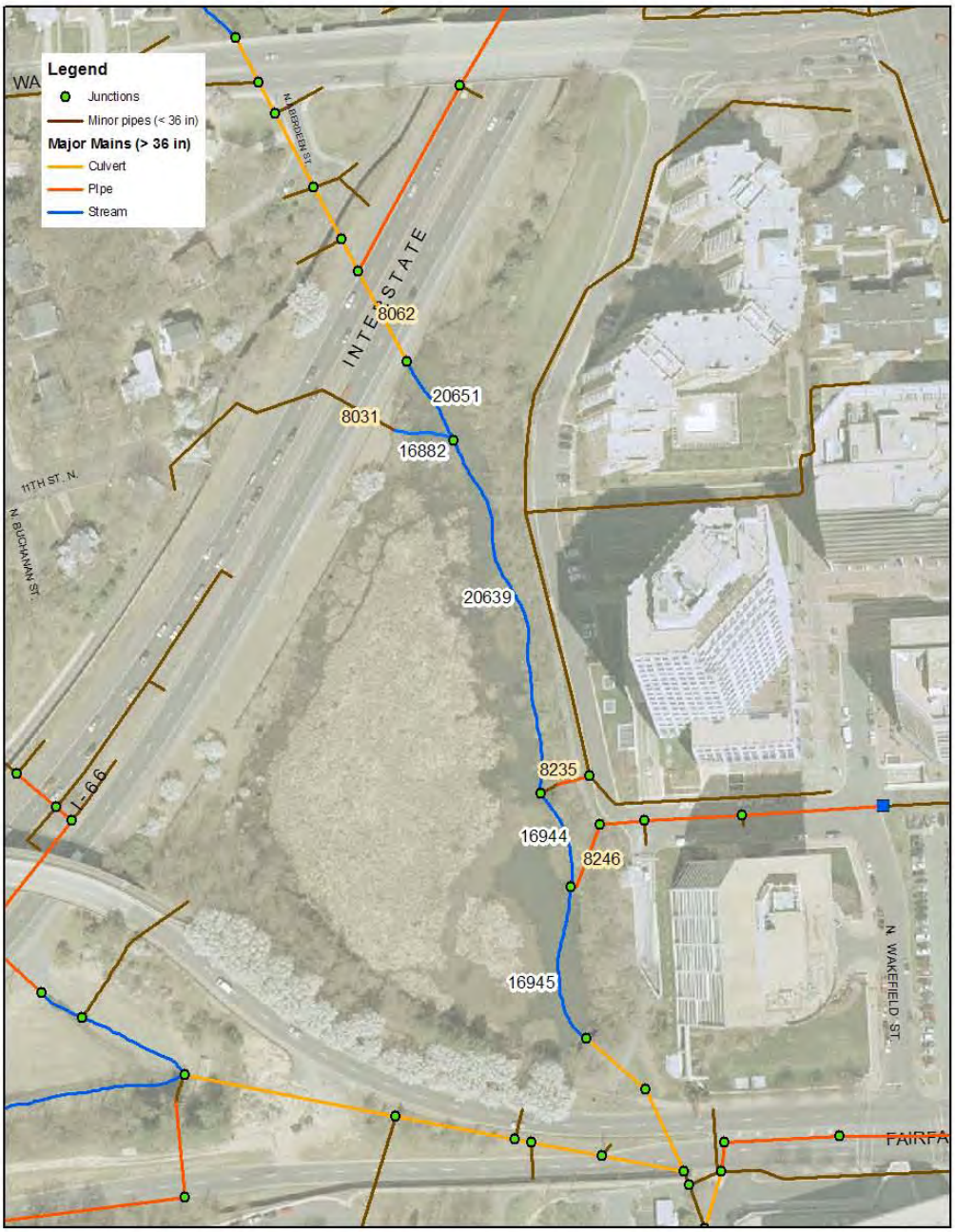
- See Figure 1 for GIS diagram
- In GIS, the Beaver Pond is represented by natural streams (Link GIS ID: 20651, 20639, 16944, 16945, and 16882)
- Table 1 shows the pipes that discharge into the Beaver Pond

TABLE 1
Pipes Discharging to the Beaver Pond

Link GIS ID	Dimension	US Invert (ft)	DS Invert (ft)	Notes
8062	3-10'x6'	253.94	251.87	The DS invert was obtained from survey
8235	36"	258.5	257	
8246	66"	251.3	251	The DS invert was extrapolated
8031	24 "			Minor pipe not modeled as pipe. The runoff is routed to the storage node

US: Upstream
DS: Downstream

FIGURE 1
ArcGIS Data



Beaver Pond 2010 Survey Data

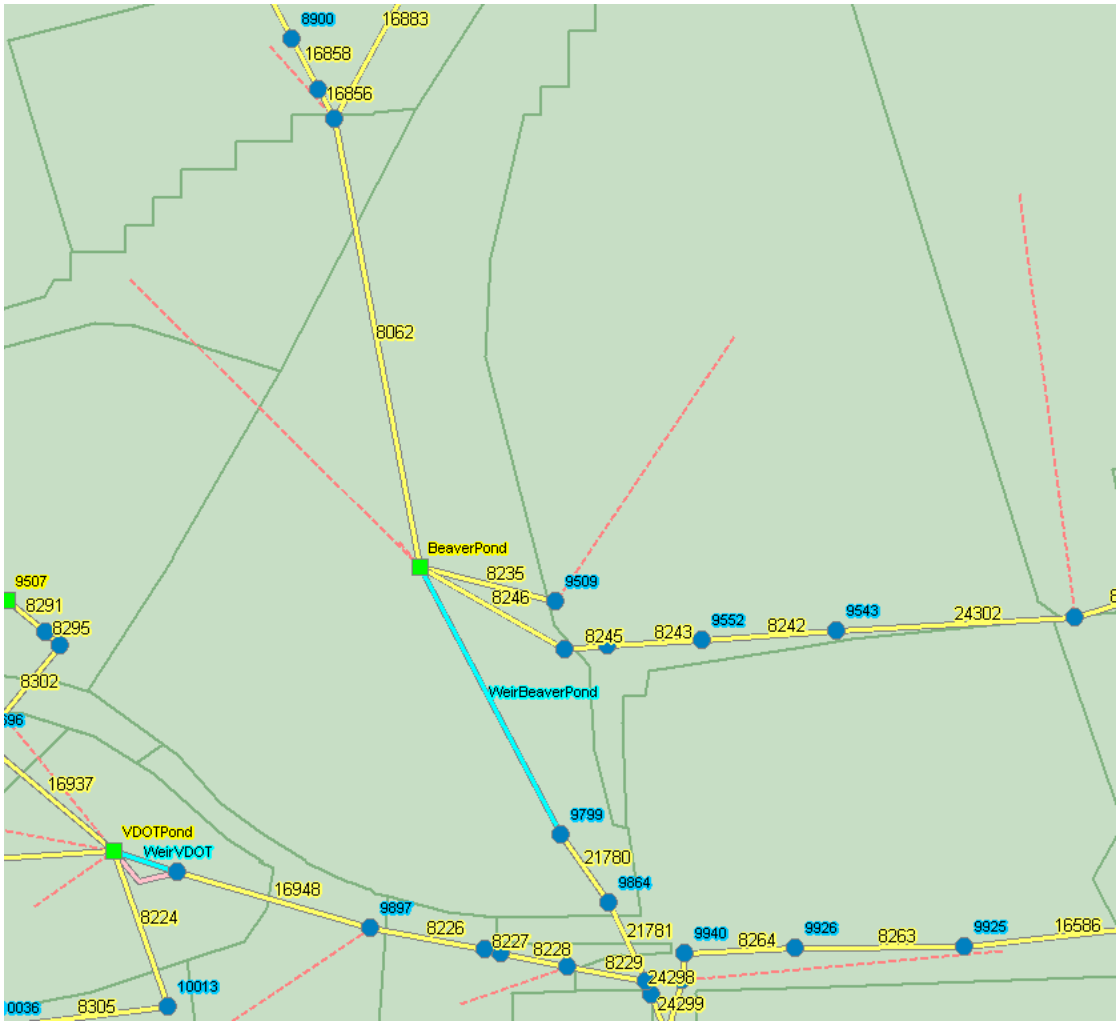
- Taken from 2010 "Beaver Pond Survey" by Rice Associates; sheets 4, 5, and 6
- The average elevation of the top silt is 253'
- No elevations were obtained within the cattails
- The minimum survey elevation is 256'
- The maximum survey elevation is 261'

PCSWMM Models

Model without Sedimentation

Figure 2 shows the pond network without sedimentation. Please note that this diagram is not to scale and the lengths of links in the diagram are not reflective of reality.

FIGURE 2
Model Network- No Sedimentation



Storage Unit

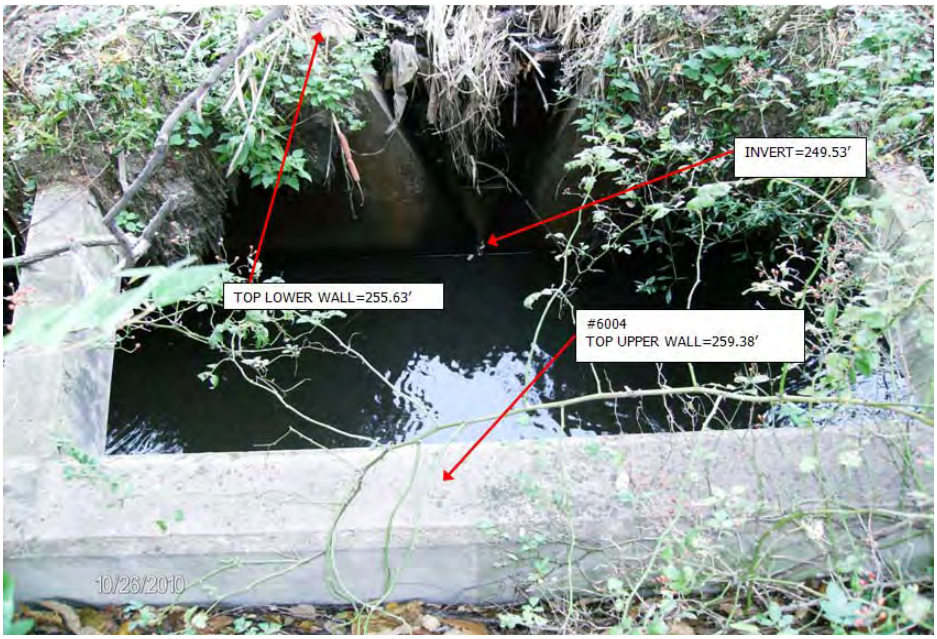
- The ArcGIS links (Link GIS ID: 20651, 20639, 16944, 16945, and 16882; all stream lengths) are modeled as a storage unit
- The invert of the storage unit is assumed to be 251 ft (downstream elevation of link 8246)
- Table 2 shows the depth-area relationship of the storage unit. Note the area for an elevation of 251' is assumed be equal to the area for an elevation of 256' (minimum survey elevation)

TABLE 2
Beaver Pond Depth-Area Relationship

Stage Contour Elevation (ft)	Pond Area (sq ft)	Vegetation Area (sq ft)	Storage Area (sq ft)	PCSWMM input Data	
				Depth (ft)	Area (sq ft)
251			81549.6	0	81549.6
256	180838.7	99289.2	81549.6	5	81549.6
257	191215.9		191215.9	6	191215.9
258	199992.5		199992.5	7	199992.5
259	208217.4		208217.4	8	208217.4
260	216663.4		216663.4	9	216663.4
261	225456.2		225456.2	10	225456.2

Outlet Control Structure (weir)

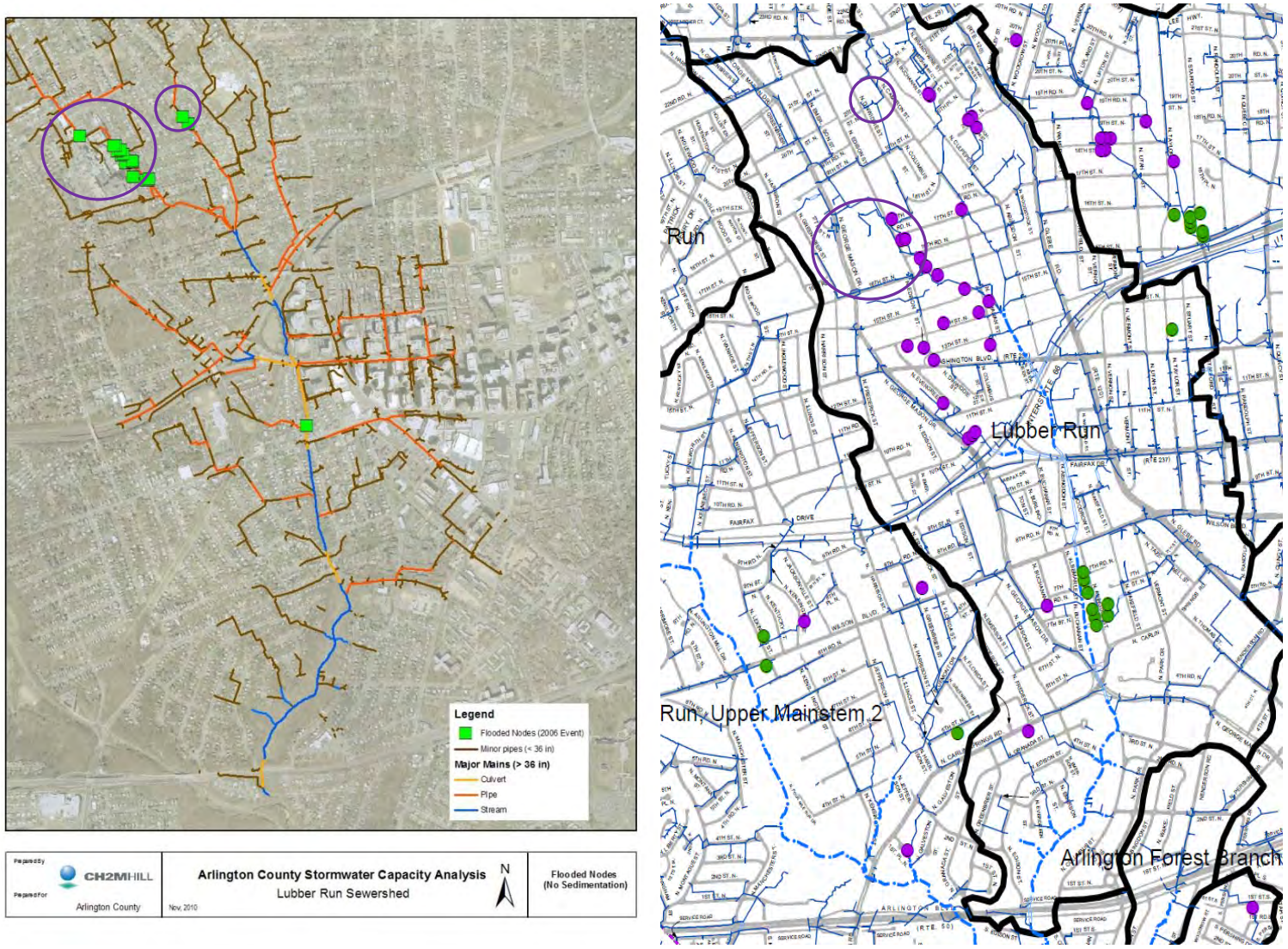
- The outlet structure is a V-Notch weir with stop logs
- Site visit performed by RK&K revealed the v-shaped notches are blocked and no flow is going through the riser (or through the low flow orifice). Water will not flow over the riser until it reaches the top elevation.
- The weir was modeled with a crest elevation of 255.63′ (top lower wall) and length of 34′



Model Results (2006 Event)

Figure 3 shows the majority of the modeled flooded nodes (WSEL > Rim Elevation) coincide with the June 2006 Storm anecdotal data. Note some of the flooded nodes in the anecdotal data are within minor pipes that are not modeled.

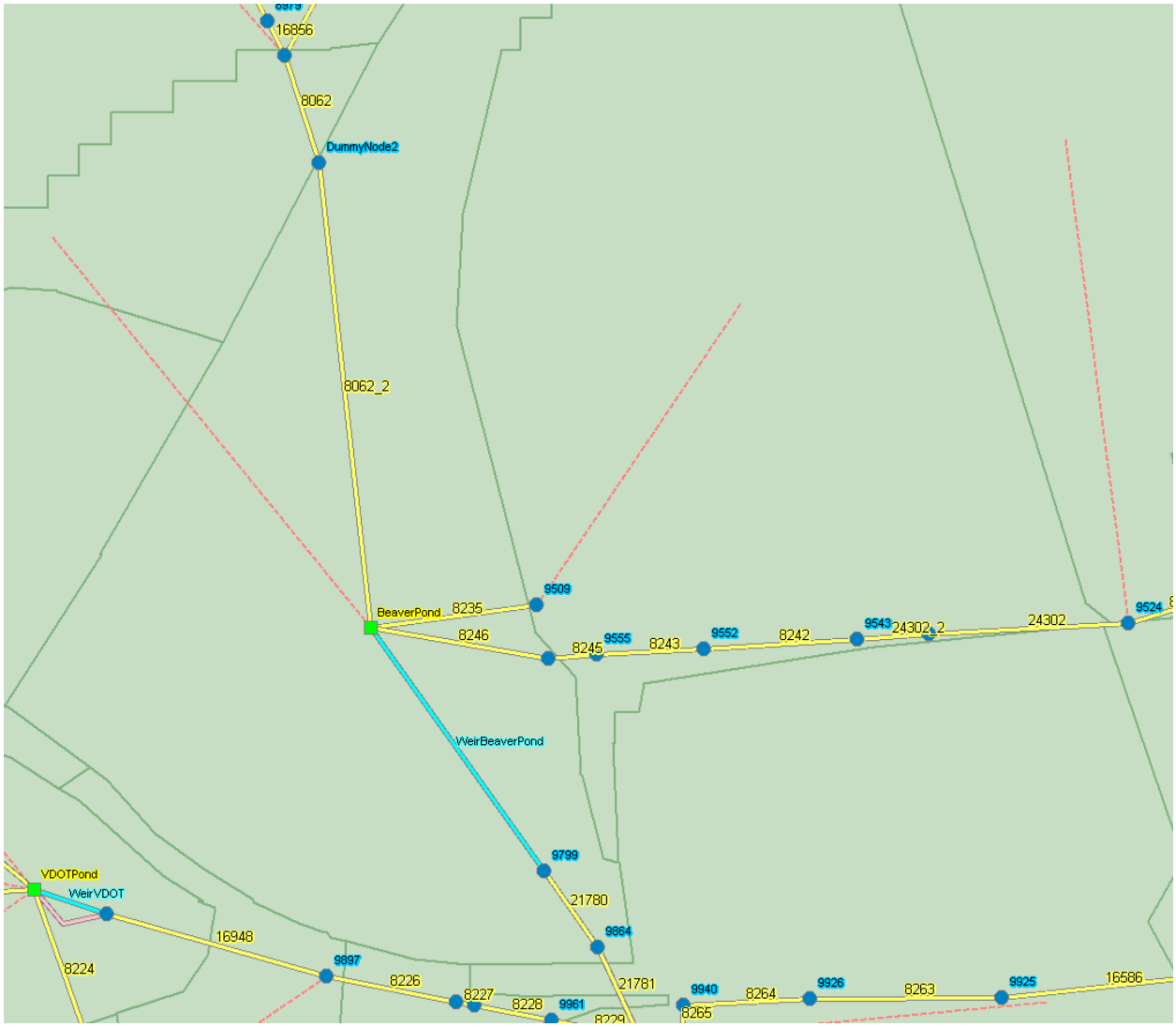
FIGURE 3
Model Results- No Sedimentation (2006 Event)



Model with Sedimentation

Figure 4 shows the pond network with sedimentation. Please note that this diagram is not to scale and the lengths of links in the diagram are not reflective of reality.

FIGURE 2
Model Network- No Sedimentation



Storage Unit

- The ArcGIS links (Link GIS ID: 20651, 20639, 16944, 16945, and 16882; all stream lengths) are modeled as a storage unit
- The invert of the storage unit is assumed to be 253 ft (average elevation of top of silt obtained from survey)

- Table 3 shows the depth-area relationship of the storage unit. Note the area for an elevation of 253′ is assumed be equal to the area for an elevation of 256′ (minimum survey elevation).

TABLE 3
Beaver Pond Depth-Area Relationship

Stage Contour Elevation (ft)	Pond Area (sq ft)	Vegetation Area (sq ft)	Storage Area (sq ft)	PCSWMM input Data	
				Depth (ft)	Area (sq ft)
253			81549.6	0	81549.6
256	180838.7	99289.2	81549.6	3	81549.6
257	191215.9		191215.9	4	191215.9
258	199992.5		199992.5	5	199992.5
259	208217.4		208217.4	6	208217.4
260	216663.4		216663.4	7	216663.4
261	225456.2		225456.2	8	225456.2

Changes to Pipes that discharge into the Beaver Pond

- The invert elevations and dimensions of some pipes were adjusted to take into account the sedimentation. (see Table 3 and Table 4)
- Dummy nodes were added to identify the limit between the original and modified data.

TABLE 3
Original Data

Link	Original US Invert	Original DS Invert	Pipe Length (ft)	Original Dimension (ft)
8062	253.94	251.87	115.19	3 – 10′x6′
24302	253.6	252.45	283	5.5
8242	252.45	252.01	157.6	5.5
8243	252.01	251.5	110.19	5.5
8245	251.5	251.3	49.9	5.5
8246	251.3	251	75	5.5

US: Upstream
DS: Downstream

TABLE 4
Modified Data

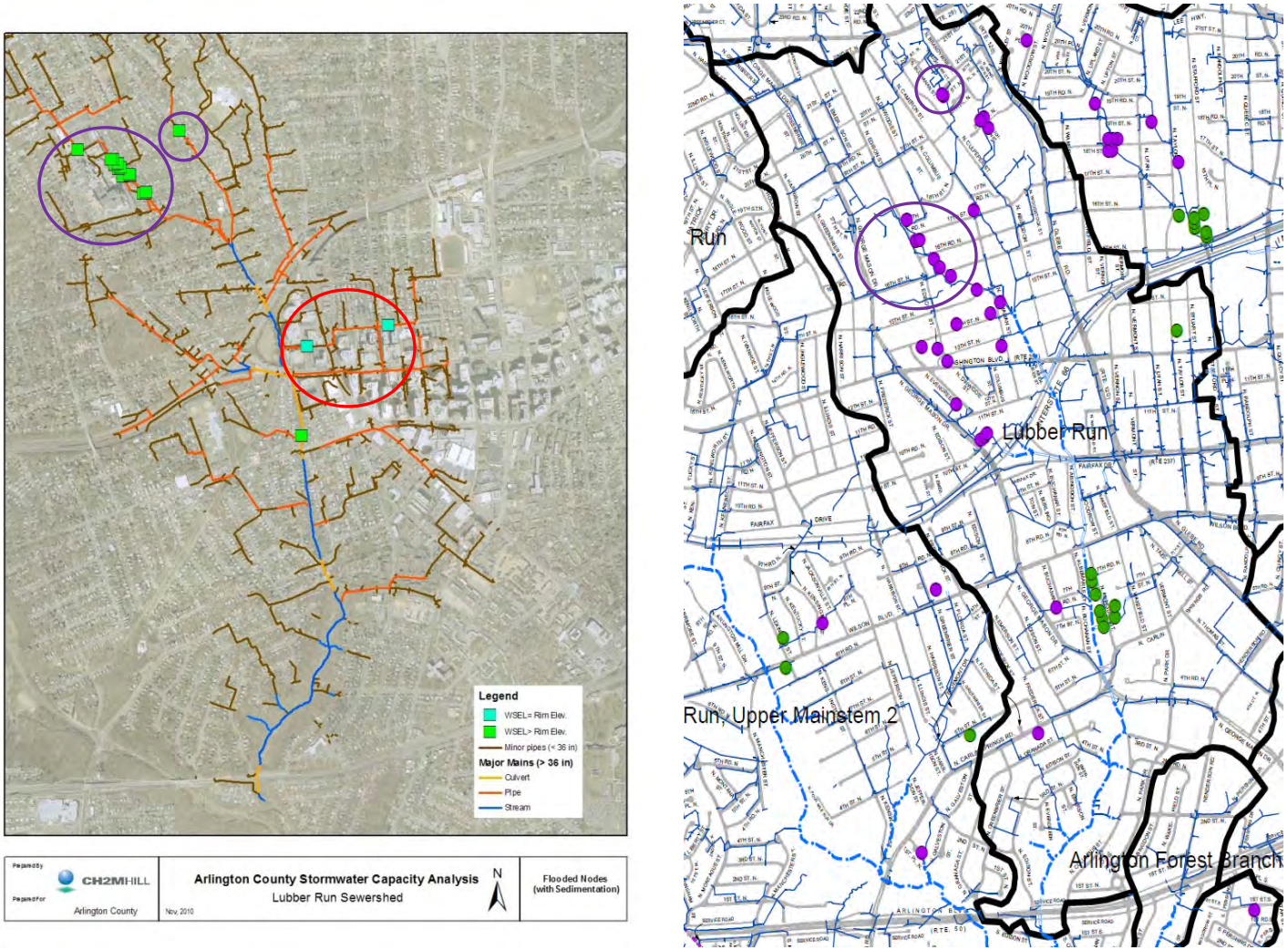
Link	US Invert (ft)	DS Invert (ft)	Pipe Length (ft)	Updated Dimension (ft)
8062	253.94	253.003	40	3- 10x6
8062_2	253.003	253.00	75.19	3-10x4.87
24302	253.6	253.02	208	5.5
24302_2	253.02	253.0196	75	5.23
8242	253.019	253.011	157.6	4.93
8243	253.011	253.006	110.19	4.54
8245	253.006	253.003	49.9	3.99
8246	253.003	253.000	75	3.79

US: Upstream
DS: Downstream

Model Results (2006 Event)

Similarly to the model without sedimentation, Figure 4 shows the majority of the flooded nodes (WSEL > Rim Elevation) coincide with the anecdotal data; however, there are two nodes (east of the Beaver Pond) with a maximum WSEL equal to the rim elevation. No complaints in this area were noted during the June 2006 storm.

FIGURE 4
Model Results-With Sedimentation (2006 Event)



MEETING MINUTES from MARCH 23, 2010 - Revised March 29, 2010

Present:

Arlington County: Liz T., Allan R., Joanne G.
CH2MHill: Tara A., Kate M. Via phone: Jackie L, Rita F.
RKK Via phone: Bill S.

BEAVER POND

Tara handed out a Technical Memorandum with figures and tables summarizing model inputs and results of the method for handling the Beaver Pond. Bill should have received his copy via email. Key points:

1. Invert for the 66 inch pipe near Ballston Plaza development was part of the data gaps, so the invert was input based on extrapolating the slope of the pipes. The 66 inch and 36 inch pipe inverts were not accessible for the field survey.
2. Two scenarios were run: **With Sedimentation** and **Without Sedimentation**
3. The Beaver Pond is modeled as a storage node. Three links discharge into the node: the triple box, the 66 inch and the 36 inch. The 24 inch pipe located near the triple box is too small for the model, but the sub-catchment drains directly to the storage node, not thru the triple box.
4. **Without Sedimentation** modeled the cattail region as an "island" without storage between the pond invert and top of cattails. Specifically, the area at 251 (pond bottom) and 256 (top of cattails) is the same. Reference Table 2 in the tech memo.
5. The pond invert was set to 251' based on the extrapolated downstream invert elevation of the 66" pipe. That is, it was determined that the 66" pipe had a downstream invert of 251 which was the lowest invert and so the pond invert was set to that elevation. This also compared well to the average BS information.
6. Since the stop logs at the outlet control structure appear to be blocked, the crest is taken to be the top of the structure 255.63. No water passes thru the v-notch weir.
7. For the June 2006 storm, the results of this analysis compared favorably to the drainage complaint map. The major difference was flooding predicted in areas where storm sewers are less than 36 inch in diameter and are not part of this study. In addition, flooded nodes upstream of the VDOT pond are not reported by the PCSWMM model; this could be attributed to the differences in the pond (VDOT drawings are dated 2009 and anecdotal data is from 2006).
8. **With Sedimentation** the pond invert was based on the TS elevations from the Rice survey and was approximately 253. The pond was then only 8 ft. deep, not 10 ft. as in the **Without Sedimentation** scenario.

9. The 66 inch pipe from Ballston Plaza was adjusted for inverts and diameter of pipe. This was also done for the triple box inlet culvert. Two "dummy" nodes were added to the links for the 66 inch and the triple box. The locations of the dummy nodes were determined by extrapolating the pond invert, with sedimentation, within the pipelines.
10. The triple box dummy node was located approximately 75 ft. upstream of its outlet. Hence the adjustment of invert and diameter were only for the lowest 75 ft. of that culvert.
11. The 36 inch pipe needed no adjustment.
12. The 66 inch pipe dummy node was nearly 400 ft. upstream from the outlet.
13. **With Sedimentation** scenario results indicated flooding that compared well with the 2006 drainage complaint map for the area upstream of the pond. However, WSE's in two nodes upstream of Ballston Plaza were predicted to be at the rim elevation. Since the WSE was predicted to be at the rim elevation and not actually flooded, there would be no anecdotal evidence of flooding in that region. This needs to be validated.
14. There was concern expressed about the adjustment of the 66 inch pipe for such a long distance (400 ft. +/-). It was decided that Arlington would arrange to open the lids of the manholes along this sewer line to visually inspect for the presence of sedimentation. If there is no evidence of sedimentation, an adjustment to the model input will be made. In particular, an option using weirs in the outlets discharging to the pond may need to be modeled.
15. Bill asked if Tara could provide the maximum WSE in the storage node for both scenarios that have already been modeled.
16. Everyone present concurred that the assumptions being made in the model are conservative and should result in higher WSE's rather than lower WSE's.
17. Liz and Tara will summarize this meeting. Everyone will review the tech memo and provide comments, questions and concerns to Liz next week. Liz will forward same to Tara, by March 31, 2011 for resolution.

At this point Bill S. left the conference. On a different matter related to Lubber Run, Allan asked Tara to provide flows for Lubber Run for use with amphitheater analysis.

SPOUT RUN DATA GAPS/NEEDS

Tara outlined several areas where data gaps need to be filled, or Arlington needs to make decisions and provide guidance. Several decisions were also made regarding same:

1. For open channels in lower portion of Spout Run, where surveyed cross sections are required: Does Arlington want the cross section to extend to the limits of the FEMA flood plain?
2. It was decided to end the Spout Run model at the last 36 inch or greater, pipe discharging to the channel. This is near X-SEC 12, near Spout Run Parkway,

upstream of the Bridge, as depicted on Tara's maps. Hence, there is no need to provide survey data for the Bridge.

3. CH2MHill will provide photos of the X-SEC's for purposes of determining and documenting "n" values. However, the surveyors need to clearly flag and label the cross sections for reference. Surveyors will not be asked to take the photos.
4. X-SEC's 02 and 03 will not be needed. X-SEC 01 must be done.
5. Arlington must review the remaining proposed X-SEC's and let Tara know which ones we are doing, and who will survey. Arlington's Survey Dept. may have a three to four week back-log. Use the same procedure as was used for Lubber Run.

The meeting then turned to a discussion of Crossman Run design iterations, as opposed to the capacity iterations.

DESIGN ITERATION FOR CROSSMAN RUN

Tara passed out four profiles of the Crossman Run storm sewer system in the areas where flooding was predicted. The analysis used the 2006 storm. It was discussed that the normal procedure used for design would be in the order of Iteration 4, 9 and 13. Iterations 4 and 9 are not desirable due to pipe size decreasing in the downstream direction. Iteration 13 is the analysis most useful to Arlington. The analysis only upsized pipes. Inverts were not dropped. It was agreed that CH2MHill should not try to drop inverts, since too many other factors, such as other utility crossings, need to be considered. Design Engineers would determine those details. Other key points:

1. Tara is to provide flow data for Iteration 13, for use by our Design Engineers.
2. The type II 10 yr. storm should also be analyzed.
3. Although the western branch of the "Y" is predicted to flood, there will be no capital projects proposed for that region due to the existence of overland relief. We do need to be sure that the flow is captured and conveyed to the downstream main trunk in Sycamore St. so that we can be sure those pipes have sufficient capacity. We cannot let the flow be "lost".
4. Liz is to send Tara information about the Autodesk program that possibly integrates SWMM models into CADD.

Prior to adjourning, a short discussion of the VDOT sediment pond located adjacent to the Beaver Pond considered whether or not we should be concerned with anecdotal evidence of flooding in that area. The model does not predict flooding. It was determined that any anecdotal evidence is most likely not relevant anymore since VDOT completely cleaned the pond out and may have even re-graded the entire pond. The plans

used for that operation were the basis for the model. That work was done by VDOT last year.

The following **Action Items** shall be addressed:

1. Inspect manholes for sediment along 400 ft. of the 66 inch storm sewer located in Ballston Plaza. – Arlington County
2. Spout Run X-SEC selection – Arlington County
3. Spout Run X-SEC survey limit to the Flood Plain Limits – Y or N – Arlington County
4. Spout Run survey schedule – Arlington County
5. Maximum WSE for Beaver Pond storage for Bill S. – Tara
6. Crossman Run Design Iteration Flows – Tara
7. CADD program details to Tara – Liz
8. Crossman Run Design Iteration using Type II 10 Yr. – Tara
9. Comments/questions/concerns over tech memo forwarded to Liz – Bill S. and Arlington County
10. Lubber Run flows for use with amphitheater - Tara

Appendix B
GIS Updates from March 2012 and Rim Updates from September 2012

GIS Updates from March 2012

ID	Asset Type	Update Description
11622	Junction	Updated entry loss coefficients of downstream pipe as a result of node changing from a catchbasin junction to a manhole.
11643	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from an end wall junction to a manhole.
8526	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from a grate inlet junction to a manhole.
7480	Junction	Updated entry/exit loss coefficients of upstream/downstream pipe as a result of node changing from a catchbasin junction to a manhole.
8628	Junction	Changed rim from 260.13 feet to 264 feet.
8229	Junction	Node changed from a catchbasin junction to a junction; however, entry/exit loss coefficients were not impacted.
7785	Junction	Node changed from a manhole junction to a catchbasin; however, entry/exit loss coefficients were not impacted.
20623	Conduit	Added 72" × 54" elliptical pipe.

Rim Elevation Updates from September 2012

Junction ID	Original Model Rim Elevation (ft)	Revised Rim Elevation (ft)
9287	277.30	268.00
7014	310.50	306.83
6273	336.76	333.29
6727	317.95	315.86
9543	263.55	266.00
10448	261.54	264.23