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Water Distribution System Analysis

Woodlief

Rolesville, North Carolina

Prepared For:

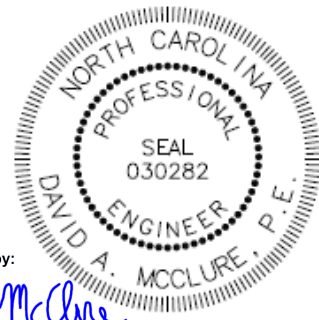
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October 31, 2024

WR Project Number: 23-0045



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10/31/2024

David A McClure, P.E.

Table of Contents

A.	Project Description.....	1
B.	Design Requirements.....	1
C.	Fire Hydrant Test.....	2
D.	Model Calibration	3
E.	Assumptions.....	3
F.	Fire Flow Analysis Summary.....	3
G.	Fire Flow Results.....	4

Appendices

Appendix A	Project Map
Appendix B	Hydrant Test and Simulated Pump Curve
Appendix C	Static Pressure Calibration
Appendix D	Residual Pressure Calibration
Appendix E	Phase 1 Fire Flow Analysis
Appendix F	Phase 2 Fire Flow Analysis
Appendix G	Phase 3 Fire Flow Analysis

A. PROJECT DESCRIPTION

WithersRavenel (WR) has completed an analysis of the water distribution system for the proposed Woodlief project (Project). The Project is located near the intersection of Rolesville Road and Fowler Road in Rolesville, NC. The water distribution system will be owned and operated by the City of Raleigh.

The Project is expected to be comprised of 253 units. The phasing plan is shown in **Table 1**.

Table 1 Phasing Plan	
Phase 1	127
Phase 2	59
Phase 3	67

To ensure adequate pressure and fire protection for the Project a hydraulic analysis has been conducted utilizing a hydrant flow test. **Appendix A** contains a map of the water distribution system for Project and surrounding areas.

B. DESIGN REQUIREMENTS

A fire flow analysis is required to properly size the water distribution system serving the site. With proper line sizes, engineers can verify that the water distribution system can adequately deliver the necessary flow and meet the required system pressure. The required fire flow is based on the North Carolina Fire Prevention Code. The requirements for one and two-family dwellings are outlined in **Table 2**.

Table 2 Required Fire Flow One and Two Family Dwellings *Type V-B Construction	
*Fire Flow Calculation Area (ft²)	Fire Flow @ 20 psi (gpm)
0-3,600	1,000
3,601-4,800	1,750
4,801-6,200	2,000
6,201-7,700	2,250
7,701-9,400	2,500
9,401-11,300	2,750
*See North Carolina Fire Code Appendix B	

All dwellings within the project will have a fire flow area less than 3,600 ft² and will require an available fire flow of 1,000 gpm. This flow must be available while maintaining a minimum pressure of 20 psi throughout the system.

C. FIRE HYDRANT TEST

Using Bentley’s WaterGEMS software, a hydraulic analysis was constructed for a portion of the existing and proposed water distribution system. **Appendix A** shows the water distribution system schematic including pipes, Junctions, reservoirs, pumps, hydrants, and existing and proposed water lines.

WR staff conducted a hydrant flow test on April 24, 2024. This flow data was used as a boundary condition for predicting the available fire flow within the site. The “hydrant test” approach is an accepted method that provides sufficiently accurate predictions of flow and pressure and involves observing the pressure at each test hydrant under two conditions. The first condition is that no hydrants are discharging water. The second condition is that nearby hydrant(s) are opened, and the flow rate measured.

Appendix B contains the hydrant test results. **Table 3** summarizes the existing conditions based on the provided hydrant test and serves as a check to verify that the model is properly calibrated.

Table 3 Hydrant Test Data	
Hydrant Flowed	approximately 880 feet south of the intersection of Rolesville Road and Catlett Farm Road
Flow Rate	1,234 gpm
Hydrant Measuring Pressure	intersection of Rolesville Road and Catlett Farm Road
Static Pressure	74 psi
Residual Pressure	62 psi
Projected Flow at 20 psi	2,780 gpm

Utilizing the flow data, residual pressures corresponding to other flow rates at the test hydrant were computed via the fire flow equation described in National Fire Protection Association (NFPA) 291; “Recommended Practice for Fire Flow Testing and Marking of Hydrants”, shown here for convenience.

$$Q_r = Q_f * \left(\frac{H_r}{H_f} \right)^{0.54}$$

Q _r =	Flow available at the desired residual pressure
Q _f =	Flow obtained from hydrant test
H _r =	Pressure drop to desired residual
H _f =	Pressure drop during hydrant flow test

The pressure/flow relationship at the boundary of the model was simulated in the hydraulic model using a “virtual” pump with a multi-point rating curve. The two initial points of the pump curve were obtained from the hydrant flow test data; the additional points were calculated using the fire flow equation above for various pressures. **Appendix B** contains the simulated pump curve report used in the model.

D. MODEL CALIBRATION

A hydraulic model of the water distribution system was constructed. Calibration of the model was used to verify the accuracy of the model predictions against actual data. A simulation was performed to calibrate the system under static conditions (no hydrant flowing). Hydrant “H-Pressure” corresponds to the hydrant at the intersection of Rolesville Road and Catlett Farm Road where system pressure was obtained. A static pressure of 74 psi was reported and the model also reported a pressure of 74 psi at Hydrant “H-Pressure”. A second calibration of the model simulated the test pressure while the hydrant was flowing. Hydrant “H-Flow” depicts the hydrant at the approximately 880 feet south of the intersection of Rolesville Road and Catlett Farm Road where the flow rate was measured. The results of this calibration test match that of the field test in that 1,234 gpm was withdrawn from Hydrant “H-Flow” while measuring a residual pressure of 62 psi at Hydrant “H-Pressure”.

Based on the results of the calibration, the model matched actual field test data and is therefore capable of accurately predicting available fire flow. **Appendix C** is a summary of the modeling results showing the existing static conditions and includes the Reservoir, Pump, Junction, Hydrant, and Pipe Reports. **Appendix D** is similar to **Appendix C** except it is the summary of the residual conditions with the test hydrant flowing.

E. ASSUMPTIONS

The analysis requires that assumptions be made about the existing and proposed water distribution systems. The analysis is dependent on the hydrant test which only reveals conditions at one moment in time. The available hydraulic grade will of course vary and is dependent on the conditions at the time the hydrant test was conducted. To determine friction losses in pipes using the Hazen-Williams equation a roughness factor (C) of 120 was used for ductile iron pipes to simulate the behavior of an older system.

F. FIRE FLOW ANALYSIS SUMMARY

WaterGEMS contains a fire flow analysis tool within the program. This procedure permits the automatic application of fire flow demands at each Junction in the system. In addition to the fire flow demand, the peak day demand has been included in the calculations. The peak day demand (based on 15A NCAC 18C .0409) is:

$$253 \text{ residential units} \times 400 \frac{\text{gpd}}{\text{unit}} = 101,200 \text{gpd} \approx 70 \text{ gpm}$$

G. FIRE FLOW RESULTS

Appendix E through **Appendix G** contains a summary of the results of the fire flow analysis. The Woodlief project with 1,000 gpm fire flow and 70 gpm peak day demand provides a minimum pressure of 50 psi at the critical node (H-1) in Phase 3. With a residual pressure of 20 psi H-1 will provide a fire flow of 1,464 gpm. This meets the fire flow requirements.

Appendix A

Project Map

J:\23\0045-Public_Woodlief Assemblage\Utilities\04-Design Phase\04-02-Modeling\Woodlief\WSS.dwg - Wednesday, October 30, 2024 4:43:15 PM - DMCCCLURE



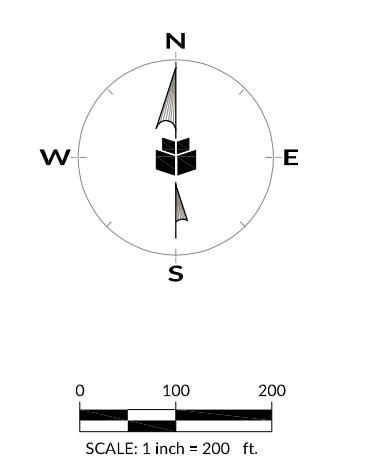
Color Coding Legend
Pipe: Diameter (in)

- <= 6
- <= 8
- <= 16
- Other

WOODLIEF

ROLESVILLE | WAKE COUNTY

WATER SYSTEM MAP



WR Job No. 23-0045 DATE 10.31.2021
 DRN: WR DGN: WR CKD: WR

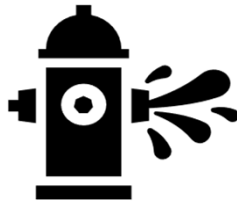
Appendix B
Hydrant Test and Simulated Pump Curve

Hydrant Test Data

Project Name	Woodlief
WR Project #	23-0045
Test Date	April 24, 2024
Flow Hydrant Location	approximately 880 feet south of the intersection of Rolesville Road and Catlett Farm Road
Pressure Hydrant Location	intersection of Rolesville Road and Catlett Farm Road

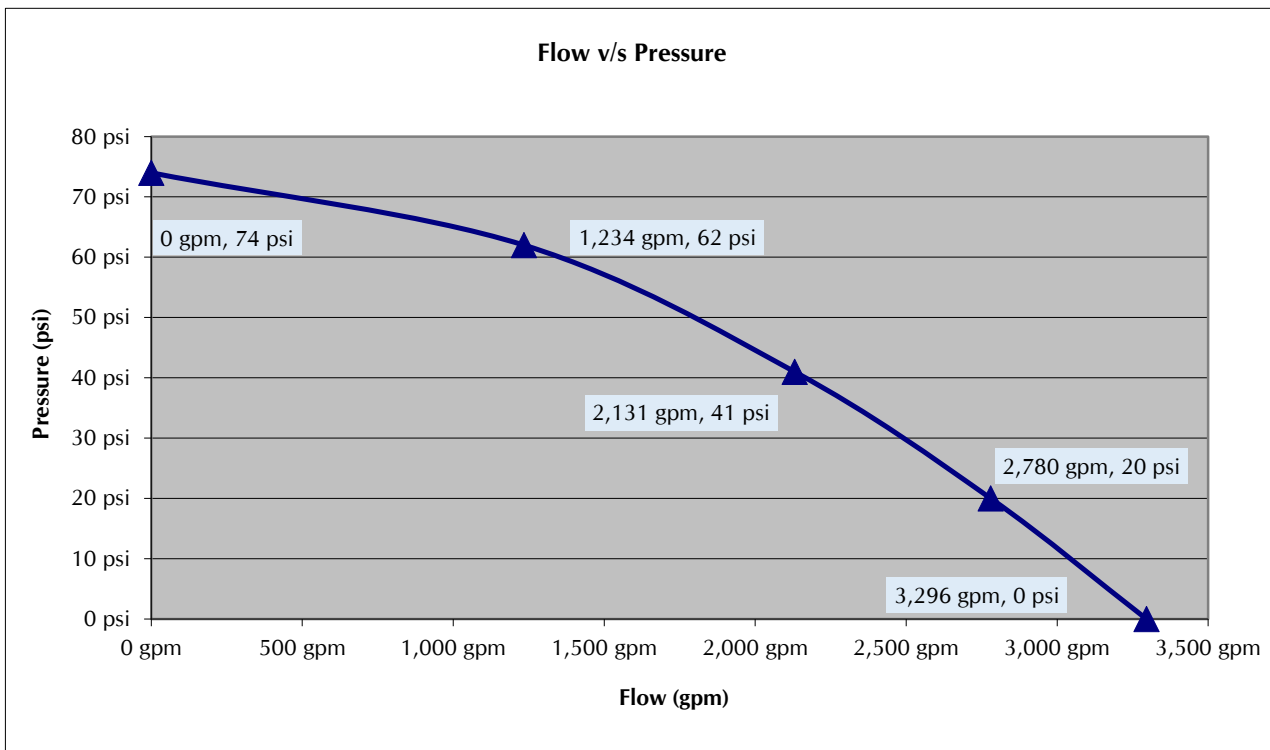
Hydrant Test

Test Hydrant Static Pressure	74 psi
Test Hydrant Residual Pressure	62 psi
Nozzle 1 Pressure	14 psi
Nozzle 1 - 2" Pitotless Flow (from chart)	617 gpm
Nozzle 2 Pressure	14 psi
Nozzle 2 - 2" Pitotless Flow (from chart)	617 gpm
Total Calculated Flow	1,234 gpm
Pressure Drop	12 psi



Flow/Pressure Relationship

Flow	Pressure	Head
0 gpm	74 psi	171 ft
1,234 gpm	62 psi	143 ft
2,131 gpm	41 psi	95 ft
2,780 gpm	20 psi	46 ft
3,296 gpm	0 psi	0 ft



Woodlief
Pump Definition Detailed Report: Boundary Condition
Active Scenario: Flow Test - Residual

Element Details

ID	577	Notes
Label	Boundary Condition	

Pump Curve

Flow (gpm)	Head (ft)
0	171
1,234	143
2,131	95
2,780	46
3,296	0

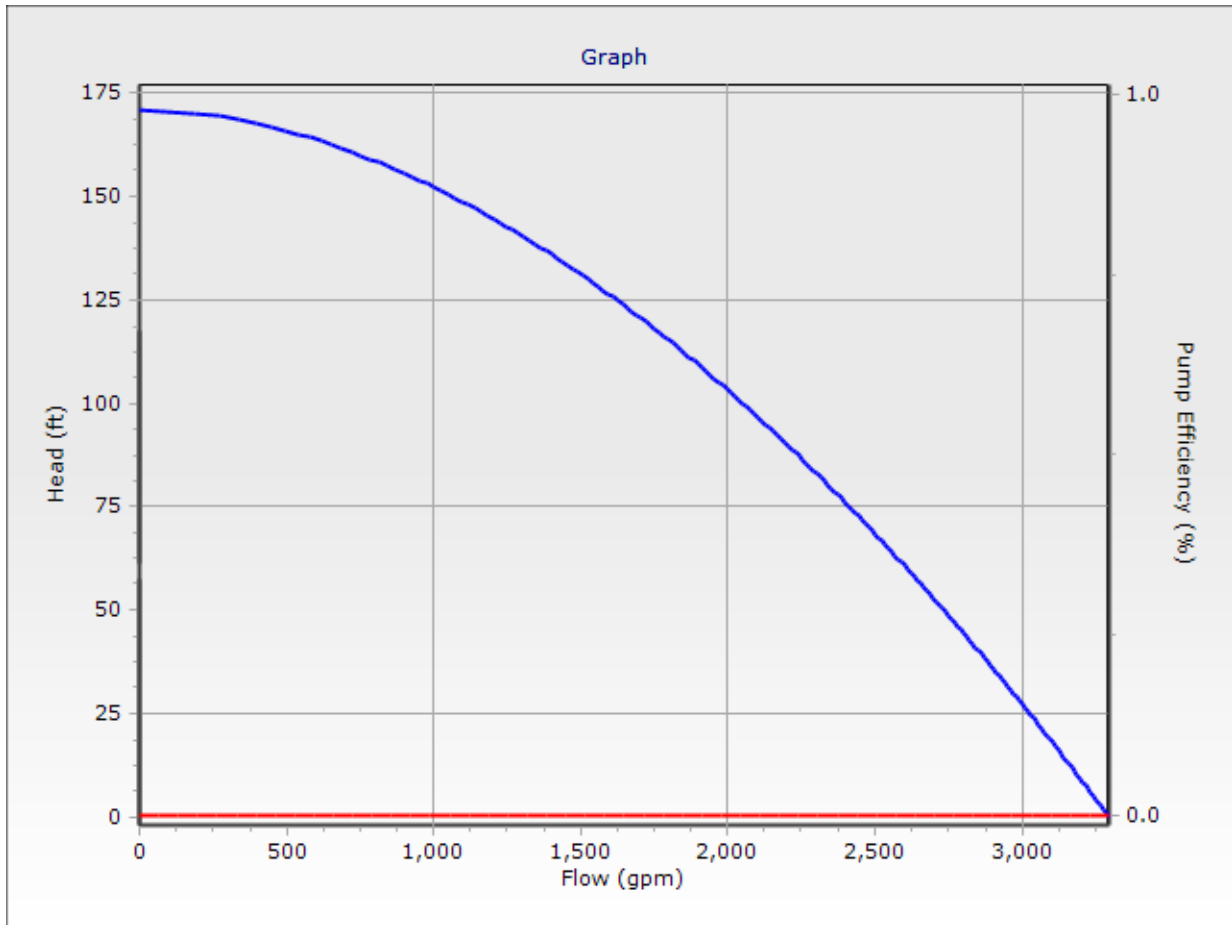
Pump Efficiency Type

Pump Efficiency Type	Best Efficiency Point	Motor Efficiency	100.0 %
BEP Efficiency	0.0 %	Is Variable Speed Drive?	False
BEP Flow	0 gpm		

Transient (Physical)

Inertia (Pump and Motor)	0.000 lb·ft ²	Specific Speed	SI=25, US=1280
Speed (Full)	0 rpm	Reverse Spin Allowed?	True

Woodlief
Pump Definition Detailed Report: Boundary Condition
Active Scenario: Flow Test - Residual



Appendix C

Static Pressure Calibration

Woodlief
FlexTable: Hydrants
Active Scenario: Flow Test - Static

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
H-25	386	0	547	70
H-Flow	377	0	547	73
H-Pressure	376	0	547	74

Woodlief
FlexTable: Junctions
Active Scenario: Flow Test - Static

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
J-2	365	0	547	79
J-29	376	0	547	74
J-31	376	0	547	74
J-37	378	0	547	73
J-50	383	0	547	71
J-51	385	0	547	70
J-52	386	0	547	70
J-53	391	0	547	67

Woodlief
FlexTable: Pipes

Active Scenario: Flow Test - Static

Label	Diameter (in)	Material	Hazen-Williams C	Flow (Absolute) (gpm)	Velocity (ft/s)
P-1	6	DIP	120	0	0.00
P-2	6	DIP	120	0	0.00
P-3	6	DIP	120	0	0.00
P-82	100	DIP	120	0	0.00
P-83	100	DIP	120	0	0.00
P-75	16	DIP	120	0	0.00
P-76	16	DIP	120	0	0.00
P-77	16	DIP	120	0	0.00
P-78	16	DIP	120	0	0.00
P-79	16	DIP	120	0	0.00
P-80	16	DIP	120	0	0.00
P-81	16	DIP	120	0	0.00

Woodlief
FlexTable: Pumps
Active Scenario: Flow Test - Static

Label	Pump Definition	Hydraulic Grade (Suction) (ft)	Hydraulic Grade (Discharge) (ft)	Flow (Total) (gpm)	Pump Head (ft)
PMP-1	Boundary Condition	376	547	0	171

Woodlief
FlexTable: Reservoirs
Active Scenario: Flow Test - Static

Label	Elevation (ft)	Flow (Out net) (gpm)	Hydraulic Grade (ft)
R-1	376	0	376

Appendix D
Residual Pressure Calibration

Woodlief
FlexTable: Hydrants

Active Scenario: Flow Test - Residual

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
H-25	386	0	518	57
H-Flow	377	1,234	517	61
H-Pressure	376	0	519	62

Woodlief
FlexTable: Junctions
Active Scenario: Flow Test - Residual

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
J-2	365	0	519	67
J-29	376	0	519	62
J-31	376	0	519	62
J-37	378	0	518	61
J-50	383	0	518	58
J-51	385	0	518	58
J-52	386	0	518	57
J-53	391	0	518	55

Woodlief
FlexTable: Pipes

Active Scenario: Flow Test - Residual

Label	Diameter (in)	Material	Hazen-Williams C	Flow (Absolute) (gpm)	Velocity (ft/s)
P-1	6	DIP	120	1,234	14.00
P-2	6	DIP	120	0	0.00
P-3	6	DIP	120	0	0.00
P-82	100	DIP	120	1,234	0.05
P-83	100	DIP	120	1,234	0.05
P-75	16	DIP	120	0	0.00
P-76	16	DIP	120	0	0.00
P-77	16	DIP	120	0	0.00
P-78	16	DIP	120	0	0.00
P-79	16	DIP	120	0	0.00
P-80	16	DIP	120	0	0.00
P-81	16	DIP	120	1,234	1.97

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FlexTable: Pumps

Active Scenario: Flow Test - Residual

Label	Pump Definition	Hydraulic Grade (Suction) (ft)	Hydraulic Grade (Discharge) (ft)	Flow (Total) (gpm)	Pump Head (ft)
PMP-1	Boundary Condition	376	519	1,234	143

Woodlief
FlexTable: Reservoirs
Active Scenario: Flow Test - Residual

Label	Elevation (ft)	Flow (Out net) (gpm)	Hydraulic Grade (ft)
R-1	376	1,234	376

Appendix E
Phase 1
Fire Flow Analysis

Woodlief
Fire Flow Node FlexTable: Fire Flow
Active Scenario: Phase 1

Label	Elevation (ft)	Pressure (psi)	Pass?	Fire Flow (Needed) (gpm)	Pressure @ Total Flow Needed (psi)	Fire Flow (Available) (gpm)	Pressure (Calculated Residual @ Available Fire Flow) (psi)	Junction w/ Minimum Pressure (Zone @ Total Flow Needed)	Pressure (Calculated Zone Lower Limit) (psi)
H-2	368	77	True	1,000	51	1,528	20	J-4	21
H-4	370	76	True	1,000	52	1,582	20	J-9	21
H-6	372	76	True	1,000	53	1,636	20	J-13	21
H-7	374	75	True	1,000	54	1,691	20	J-21	22
H-9	377	74	True	1,000	55	1,805	20	J-40	21
H-12	378	73	True	1,000	58	2,017	20	J-40	21
H-15	368	77	True	1,000	54	1,637	20	J-7	22
H-18	372	76	True	1,000	56	1,759	20	J-18	22
H-21	374	75	True	1,000	60	2,060	20	J-53	23
H-22	372	76	True	1,000	58	1,901	20	J-18	21
H-24	376	74	True	1,000	63	2,355	20	J-53	21

Woodlief
FlexTable: Hydrants
Active Scenario: Phase 1

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
H-2	368	0	547	77
H-4	370	0	547	76
H-6	372	0	547	76
H-7	374	0	547	75
H-9	377	0	547	74
H-12	378	0	547	73
H-15	368	0	547	77
H-18	372	0	547	76
H-21	374	0	547	75
H-22	372	0	547	76
H-24	376	0	547	74
H-25	386	0	547	70
H-Flow	377	0	547	73
H-Pressure	376	0	547	74

Woodlief
FlexTable: Junctions
Active Scenario: Phase 1

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
J-2	365	0	547	79
J-3	366	1	547	78
J-4	368	2	547	78
J-5	368	0	547	78
J-7	368	1	547	77
J-9	370	4	547	77
J-11	371	1	547	76
J-12	372	2	547	76
J-13	372	1	547	76
J-15	372	1	547	76
J-16	372	0	547	76
J-17	373	2	547	75
J-18	373	0	547	75
J-21	374	3	547	75
J-22	374	1	547	75
J-24	375	1	547	75
J-25	375	0	547	74
J-26	375	2	547	74
J-28	376	0	547	74
J-29	376	0	547	74
J-31	376	0	547	74
J-32	376	1	547	74
J-36	377	3	547	73
J-37	378	0	547	73
J-38	378	6	547	73
J-40	378	0	547	73
J-50	383	0	547	71
J-51	385	0	547	70
J-52	386	0	547	69
J-53	391	0	547	67

Woodlief
FlexTable: Pipes
Active Scenario: Phase 1

Label	Diameter (in)	Material	Hazen-Williams C	Flow (Absolute) (gpm)	Velocity (ft/s)
P-1	6	DIP	120	0	0.00
P-2	6	DIP	120	0	0.00
P-3	6	DIP	120	0	0.00
P-6	6	DIP	120	0	0.00
P-7	6	DIP	120	0	0.00
P-8	6	DIP	120	0	0.00
P-10	6	DIP	120	0	0.00
P-11	6	DIP	120	0	0.00
P-16	6	DIP	120	0	0.00
P-17	6	DIP	120	0	0.00
P-22	6	DIP	120	0	0.00
P-24	6	DIP	120	0	0.00
P-25	6	DIP	120	0	0.00
P-27	6	DIP	120	0	0.00
P-28	8	DIP	120	2	0.01
P-29	8	DIP	120	16	0.10
P-31	8	DIP	120	0	0.00
P-33	8	DIP	120	8	0.05
P-34	8	DIP	120	35	0.22
P-38	8	DIP	120	6	0.04
P-41	8	DIP	120	0	0.00
P-42	6	DIP	120	1	0.01
P-45	8	DIP	120	0	0.00
P-46	8	DIP	120	0	0.00
P-50	8	DIP	120	11	0.07
P-51	6	DIP	120	1	0.01
P-54	8	DIP	120	7	0.04
P-56	8	DIP	120	35	0.23
P-57	8	DIP	120	3	0.02
P-58	8	DIP	120	3	0.02
P-59	8	DIP	120	5	0.03
P-60	8	DIP	120	15	0.10
P-61	8	DIP	120	7	0.05
P-65	8	DIP	120	26	0.16
P-67	8	DIP	120	1	0.01
P-71	8	DIP	120	20	0.13
P-82	100	DIP	120	35	0.00
P-83	100	DIP	120	35	0.00
P-75	16	DIP	120	0	0.00
P-76	16	DIP	120	0	0.00
P-77	16	DIP	120	35	0.06
P-78	16	DIP	120	0	0.00
P-79	16	DIP	120	0	0.00
P-80	16	DIP	120	0	0.00
P-81	16	DIP	120	0	0.00

Woodlief
FlexTable: Pumps
Active Scenario: Phase 1

Label	Pump Definition	Hydraulic Grade (Suction) (ft)	Hydraulic Grade (Discharge) (ft)	Flow (Total) (gpm)	Pump Head (ft)
PMP-1	Boundary Condition	376	547	35	171

Woodlief
FlexTable: Reservoirs
Active Scenario: Phase 1

Label	Elevation (ft)	Flow (Out net) (gpm)	Hydraulic Grade (ft)
R-1	376	35	376

Appendix F
Phase 2
Fire Flow Analysis

Woodlief
Fire Flow Node FlexTable: Fire Flow
Active Scenario: Phase 2

Label	Elevation (ft)	Pressure (psi)	Pass?	Fire Flow (Needed) (gpm)	Pressure @ Total Flow Needed (psi)	Fire Flow (Available) (gpm)	Pressure (Calculated Residual @ Available Fire Flow) (psi)	Junction w/ Minimum Pressure (Zone @ Total Flow Needed)	Pressure (Calculated Zone Lower Limit) (psi)
H-2	368	77	True	1,000	52	1,563	20	J-4	21
H-4	370	76	True	1,000	53	1,622	20	J-9	21
H-6	372	76	True	1,000	54	1,682	20	J-13	21
H-7	374	75	True	1,000	55	1,742	20	J-21	22
H-9	377	74	True	1,000	56	1,869	20	J-40	21
H-12	378	73	True	1,000	59	2,108	20	J-53	22
H-13	377	73	True	1,000	60	2,131	20	J-53	21
H-14	368	77	True	1,000	63	2,171	20	J-53	24
H-15	368	77	True	1,000	63	2,181	20	J-53	24
H-16	374	75	True	1,000	62	2,202	20	J-53	22
H-17	372	76	True	1,000	62	2,214	20	J-53	23
H-18	372	76	True	1,000	63	2,241	20	J-53	23
H-19	375	74	True	1,000	62	2,248	20	J-53	24
H-20	379	72	True	1,000	61	2,293	20	J-53	22
H-21	374	75	True	1,000	63	2,300	20	J-53	24
H-22	372	76	True	1,000	63	2,306	20	J-53	22
H-23	383	71	True	1,000	60	2,365	20	J-53	22
H-24	376	74	True	1,000	63	2,453	20	J-53	21

Woodlief
FlexTable: Hydrants
Active Scenario: Phase 2

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
H-2	368	0	547	77
H-4	370	0	547	76
H-6	372	0	547	76
H-7	374	0	547	75
H-9	377	0	547	74
H-12	378	0	547	73
H-13	377	0	547	73
H-14	368	0	547	77
H-15	368	0	547	77
H-16	374	0	547	75
H-17	372	0	547	76
H-18	372	0	547	76
H-19	375	0	547	74
H-20	379	0	547	72
H-21	374	0	547	75
H-22	372	0	547	76
H-23	383	0	547	71
H-24	376	0	547	74
H-25	386	0	547	70
H-Flow	377	0	547	73
H-Pressure	376	0	547	74

Woodlief
FlexTable: Junctions
Active Scenario: Phase 2

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
J-2	365	0	547	79
J-3	366	1	547	78
J-4	368	2	547	78
J-5	368	1	547	78
J-6	368	1	547	77
J-7	368	1	547	77
J-9	370	4	547	77
J-11	371	1	547	76
J-12	372	2	547	76
J-13	372	1	547	76
J-14	372	0	547	76
J-15	372	1	547	76
J-16	372	0	547	76
J-17	373	2	547	75
J-18	373	2	547	75
J-20	373	2	547	75
J-21	374	3	547	75
J-22	374	1	547	75
J-23	374	2	547	75
J-24	375	1	547	75
J-25	375	0	547	74
J-26	375	2	547	74
J-27	375	2	547	74
J-28	376	0	547	74
J-29	376	0	547	74
J-31	376	0	547	74
J-32	376	1	547	74
J-33	377	2	547	74
J-35	377	0	547	73
J-36	377	3	547	73
J-37	378	0	547	73
J-38	378	6	547	73
J-39	378	0	547	73
J-40	378	0	547	73
J-42	379	2	547	72
J-43	379	0	547	72
J-46	381	0	547	72
J-49	383	0	547	71
J-50	383	0	547	71
J-51	385	0	547	70
J-52	386	0	547	69
J-53	391	0	547	67

Woodlief
FlexTable: Pipes
Active Scenario: Phase 2

Label	Diameter (in)	Material	Hazen-Williams C	Flow (Absolute) (gpm)	Velocity (ft/s)
P-1	6	DIP	120	0	0.00
P-2	6	DIP	120	0	0.00
P-3	6	DIP	120	0	0.00
P-6	6	DIP	120	0	0.00
P-7	6	DIP	120	0	0.00
P-8	6	DIP	120	0	0.00
P-9	6	DIP	120	0	0.00
P-10	6	DIP	120	0	0.00
P-11	6	DIP	120	0	0.00
P-12	6	DIP	120	0	0.00
P-13	6	DIP	120	0	0.00
P-16	6	DIP	120	0	0.00
P-17	6	DIP	120	0	0.00
P-19	6	DIP	120	0	0.00
P-21	6	DIP	120	0	0.00
P-22	6	DIP	120	0	0.00
P-23	6	DIP	120	0	0.00
P-24	6	DIP	120	0	0.00
P-25	6	DIP	120	0	0.00
P-26	6	DIP	120	0	0.00
P-27	6	DIP	120	0	0.00
P-28	8	DIP	120	0	0.00
P-29	8	DIP	120	16	0.10
P-30	8	DIP	120	0	0.00
P-31	8	DIP	120	3	0.02
P-32	8	DIP	120	1	0.00
P-33	8	DIP	120	8	0.05
P-34	8	DIP	120	33	0.21
P-35	8	DIP	120	5	0.03
P-38	8	DIP	120	4	0.03
P-39	8	DIP	120	0	0.00
P-41	8	DIP	120	0	0.00
P-42	6	DIP	120	1	0.01
P-43	8	DIP	120	0	0.00
P-44	8	DIP	120	1	0.01
P-45	8	DIP	120	0	0.00
P-46	8	DIP	120	0	0.00
P-48	8	DIP	120	18	0.12
P-49	8	DIP	120	19	0.12
P-50	8	DIP	120	11	0.07
P-51	6	DIP	120	1	0.01
P-54	8	DIP	120	7	0.04
P-56	8	DIP	120	33	0.21
P-57	8	DIP	120	3	0.02
P-58	8	DIP	120	0	0.00
P-59	8	DIP	120	2	0.01

Woodlief
FlexTable: Pipes
Active Scenario: Phase 2

Label	Diameter (in)	Material	Hazen-Williams C	Flow (Absolute) (gpm)	Velocity (ft/s)
P-60	8	DIP	120	15	0.10
P-61	8	DIP	120	5	0.03
P-62	8	DIP	120	7	0.04
P-63	8	DIP	120	4	0.02
P-65	8	DIP	120	26	0.16
P-67	8	DIP	120	1	0.01
P-68	8	DIP	120	14	0.09
P-69	8	DIP	120	16	0.10
P-71	8	DIP	120	20	0.13
P-72	8	DIP	120	4	0.02
P-73	8	DIP	120	5	0.03
P-82	100	DIP	120	52	0.00
P-83	100	DIP	120	52	0.00
P-75	16	DIP	120	19	0.03
P-76	16	DIP	120	0	0.00
P-77	16	DIP	120	33	0.05
P-78	16	DIP	120	0	0.00
P-79	16	DIP	120	0	0.00
P-80	16	DIP	120	19	0.03
P-81	16	DIP	120	19	0.03

Woodlief
FlexTable: Pumps
Active Scenario: Phase 2

Label	Pump Definition	Hydraulic Grade (Suction) (ft)	Hydraulic Grade (Discharge) (ft)	Flow (Total) (gpm)	Pump Head (ft)
PMP-1	Boundary Condition	376	547	52	171

Woodlief
FlexTable: Reservoirs
Active Scenario: Phase 2

Label	Elevation (ft)	Flow (Out net) (gpm)	Hydraulic Grade (ft)
R-1	376	52	376

Appendix G
Phase 3
Fire Flow Analysis

Woodlief
Fire Flow Node FlexTable: Fire Flow
Active Scenario: Phase 3

Label	Elevation (ft)	Pressure (psi)	Pass?	Fire Flow (Needed) (gpm)	Pressure @ Total Flow Needed (psi)	Fire Flow (Available) (gpm)	Pressure (Calculated Residual @ Available Fire Flow) (psi)	Junction w/ Minimum Pressure (Zone @ Total Flow Needed)	Pressure (Calculated Zone Lower Limit) (psi)
H-1	364	79	True	1,000	50	1,464	21	J-10	20
H-2	368	77	True	1,000	52	1,557	20	J-4	21
H-3	368	77	True	1,000	52	1,560	20	J-10	20
H-4	370	76	True	1,000	53	1,615	20	J-9	21
H-5	373	75	True	1,000	53	1,658	20	J-19	21
H-6	372	76	True	1,000	54	1,674	20	J-13	21
H-7	374	75	True	1,000	54	1,734	20	J-21	22
H-8	377	73	True	1,000	55	1,788	20	J-41	20
H-9	377	74	True	1,000	56	1,859	20	J-40	21
H-10	380	72	True	1,000	55	1,886	20	J-48	21
H-11	382	71	True	1,000	57	2,061	20	J-48	21
H-12	378	73	True	1,000	59	2,096	20	J-53	22
H-13	377	73	True	1,000	59	2,117	20	J-53	21
H-14	368	77	True	1,000	63	2,158	20	J-53	24
H-15	368	77	True	1,000	63	2,168	20	J-53	24
H-16	374	75	True	1,000	61	2,189	20	J-53	22
H-17	372	76	True	1,000	62	2,200	20	J-53	23
H-18	372	76	True	1,000	62	2,227	20	J-53	23
H-19	375	74	True	1,000	61	2,233	20	J-53	24
H-20	379	72	True	1,000	60	2,276	20	J-53	21
H-21	374	75	True	1,000	62	2,287	20	J-53	24
H-22	372	76	True	1,000	63	2,292	20	J-53	22
H-23	383	71	True	1,000	60	2,348	20	J-53	22
H-24	376	74	True	1,000	63	2,437	20	J-53	21

Woodlief
FlexTable: Hydrants
Active Scenario: Phase 3

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
H-1	364	0	547	79
H-2	368	0	547	77
H-3	368	0	547	77
H-4	370	0	547	76
H-5	373	0	547	75
H-6	372	0	547	76
H-7	374	0	547	75
H-8	377	0	547	73
H-9	377	0	547	74
H-10	380	0	547	72
H-11	382	0	547	71
H-12	378	0	547	73
H-13	377	0	547	73
H-14	368	0	547	77
H-15	368	0	547	77
H-16	374	0	547	75
H-17	372	0	547	76
H-18	372	0	547	76
H-19	375	0	547	74
H-20	379	0	547	72
H-21	374	0	547	75
H-22	372	0	547	76
H-23	383	0	547	71
H-24	376	0	547	74
H-25	386	0	547	69
H-Flow	377	0	547	73
H-Pressure	376	0	547	74

Woodlief
FlexTable: Junctions
Active Scenario: Phase 3

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
J-1	364	3	547	79
J-2	365	0	547	79
J-3	366	1	547	78
J-4	368	2	547	77
J-5	368	1	547	78
J-6	368	1	547	77
J-7	368	1	547	77
J-8	368	3	547	77
J-9	370	4	547	77
J-10	370	0	547	77
J-11	371	1	547	76
J-12	372	2	547	76
J-13	372	1	547	76
J-14	372	0	547	76
J-15	372	1	547	76
J-16	372	0	547	76
J-17	373	2	547	75
J-18	373	2	547	75
J-19	373	2	547	75
J-20	373	2	547	75
J-21	374	3	547	75
J-22	374	1	547	75
J-23	374	2	547	75
J-24	375	1	547	75
J-25	375	0	547	74
J-26	375	2	547	74
J-27	375	2	547	74
J-28	376	0	547	74
J-29	376	0	547	74
J-30	376	2	547	74
J-31	376	0	547	74
J-32	376	1	547	74
J-33	377	2	547	74
J-34	377	1	547	74
J-35	377	0	547	73
J-36	377	3	547	73
J-37	378	0	547	73
J-38	378	6	547	73
J-39	378	0	547	73
J-40	378	0	547	73
J-41	379	2	547	73
J-42	379	2	547	72
J-43	379	0	547	72
J-44	380	2	547	72
J-45	380	1	547	72
J-46	381	1	547	72
J-47	382	1	547	71

Woodlief
FlexTable: Junctions
Active Scenario: Phase 3

Label	Elevation (ft)	Demand (gpm)	Hydraulic Grade (ft)	Pressure (psi)
J-48	382	0	547	71
J-49	383	0	547	71
J-50	383	0	547	71
J-51	385	0	547	70
J-52	386	0	547	69
J-53	391	0	547	67

Woodlief
FlexTable: Pipes
Active Scenario: Phase 3

Label	Diameter (in)	Material	Hazen-Williams C	Flow (Absolute) (gpm)	Velocity (ft/s)
P-1	6	DIP	120	0	0.00
P-2	6	DIP	120	0	0.00
P-3	6	DIP	120	0	0.00
P-4	6	DIP	120	0	0.00
P-5	6	DIP	120	0	0.00
P-6	6	DIP	120	0	0.00
P-7	6	DIP	120	0	0.00
P-8	6	DIP	120	0	0.00
P-9	6	DIP	120	0	0.00
P-10	6	DIP	120	0	0.00
P-11	6	DIP	120	0	0.00
P-12	6	DIP	120	0	0.00
P-13	6	DIP	120	0	0.00
P-14	6	DIP	120	0	0.00
P-15	6	DIP	120	0	0.00
P-16	6	DIP	120	0	0.00
P-17	6	DIP	120	0	0.00
P-18	6	DIP	120	0	0.00
P-19	6	DIP	120	0	0.00
P-20	6	DIP	120	0	0.00
P-21	6	DIP	120	0	0.00
P-22	6	DIP	120	0	0.00
P-23	6	DIP	120	0	0.00
P-24	6	DIP	120	0	0.00
P-25	6	DIP	120	0	0.00
P-26	6	DIP	120	0	0.00
P-27	6	DIP	120	0	0.00
P-28	8	DIP	120	5	0.03
P-29	8	DIP	120	16	0.10
P-30	8	DIP	120	19	0.12
P-31	8	DIP	120	0	0.00
P-32	8	DIP	120	1	0.00
P-33	8	DIP	120	8	0.05
P-34	8	DIP	120	38	0.24
P-35	8	DIP	120	3	0.02
P-36	8	DIP	120	12	0.08
P-37	8	DIP	120	1	0.01
P-38	8	DIP	120	9	0.06
P-39	8	DIP	120	0	0.00
P-40	8	DIP	120	17	0.11
P-41	8	DIP	120	0	0.00
P-42	6	DIP	120	1	0.01
P-43	8	DIP	120	18	0.12
P-44	8	DIP	120	1	0.01
P-45	8	DIP	120	3	0.02
P-46	8	DIP	120	0	0.00

Woodlief
FlexTable: Pipes
Active Scenario: Phase 3

Label	Diameter (in)	Material	Hazen-Williams C	Flow (Absolute) (gpm)	Velocity (ft/s)
P-47	8	DIP	120	0	0.00
P-48	8	DIP	120	32	0.20
P-49	8	DIP	120	32	0.20
P-50	8	DIP	120	11	0.07
P-51	6	DIP	120	1	0.01
P-52	8	DIP	120	17	0.11
P-53	6	DIP	120	2	0.02
P-54	8	DIP	120	7	0.04
P-55	8	DIP	120	0	0.00
P-56	8	DIP	120	38	0.24
P-57	8	DIP	120	3	0.02
P-58	8	DIP	120	5	0.04
P-59	8	DIP	120	8	0.05
P-60	8	DIP	120	15	0.10
P-61	8	DIP	120	10	0.07
P-62	8	DIP	120	4	0.03
P-63	8	DIP	120	1	0.01
P-64	8	DIP	120	9	0.06
P-65	8	DIP	120	26	0.16
P-66	8	DIP	120	14	0.09
P-67	8	DIP	120	1	0.01
P-68	8	DIP	120	9	0.06
P-69	8	DIP	120	11	0.07
P-70	8	DIP	120	3	0.02
P-71	8	DIP	120	20	0.13
P-72	8	DIP	120	1	0.01
P-73	8	DIP	120	2	0.02
P-74	8	DIP	120	7	0.04
P-82	100	DIP	120	70	0.00
P-83	100	DIP	120	70	0.00
P-75	16	DIP	120	32	0.05
P-76	16	DIP	120	0	0.00
P-77	16	DIP	120	38	0.06
P-78	16	DIP	120	0	0.00
P-79	16	DIP	120	0	0.00
P-80	16	DIP	120	32	0.05
P-81	16	DIP	120	32	0.05

Woodlief
FlexTable: Pumps
Active Scenario: Phase 3

Label	Pump Definition	Hydraulic Grade (Suction) (ft)	Hydraulic Grade (Discharge) (ft)	Flow (Total) (gpm)	Pump Head (ft)
PMP-1	Boundary Condition	376	547	70	171

Woodlief
FlexTable: Reservoirs
Active Scenario: Phase 3

Label	Elevation (ft)	Flow (Out net) (gpm)	Hydraulic Grade (ft)
R-1	376	70	376