COMMONWEALTH OF VIRGINIA
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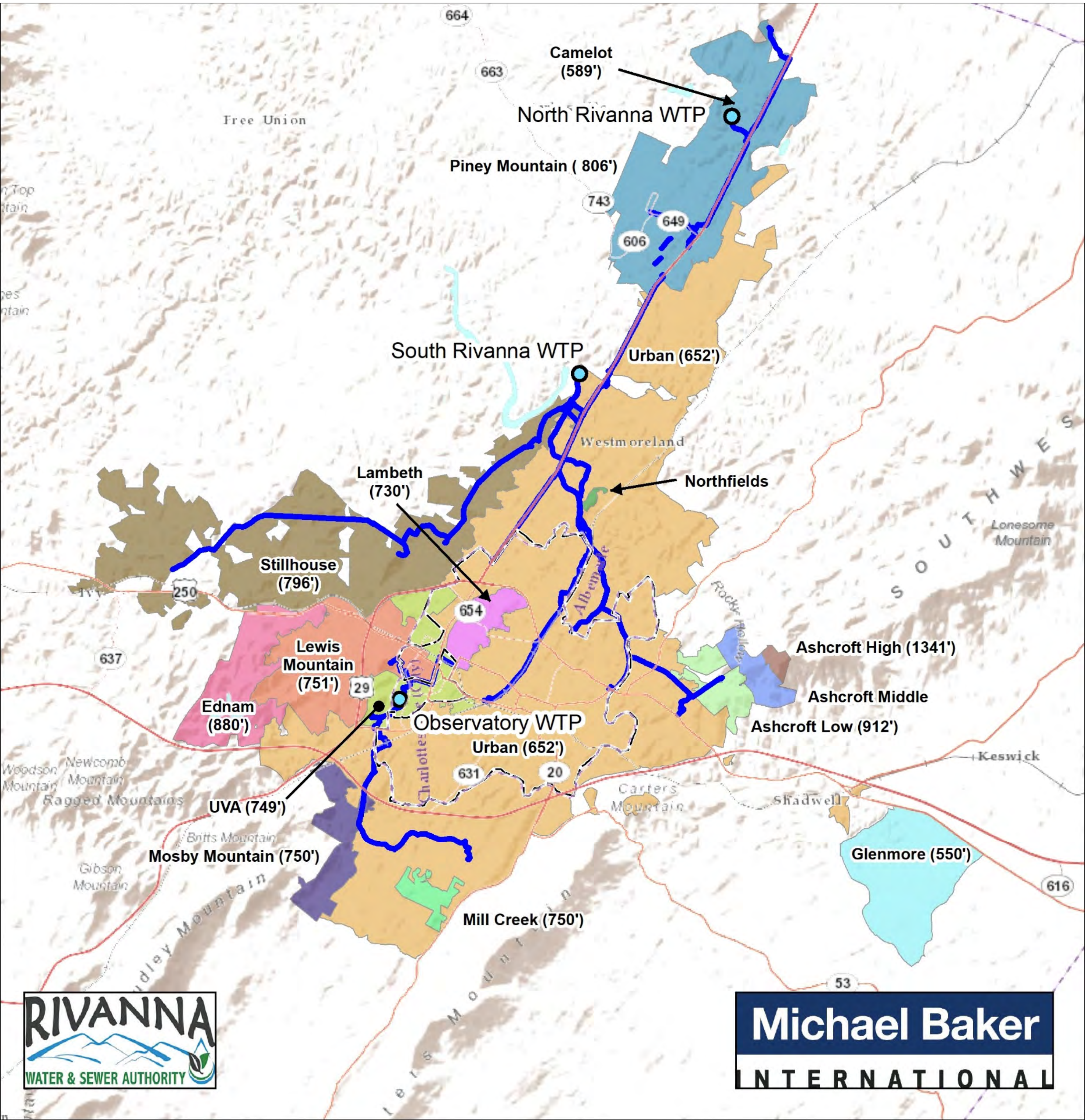
URBAN FINISHED WATER MASTER PLAN

Michael Baker International, Inc.

April 29, 2022



RIVANNA WATER & SEWER AUTHORITY

Michael Baker INTERNATIONAL

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Urban Finished Water Master Plan
Final Report

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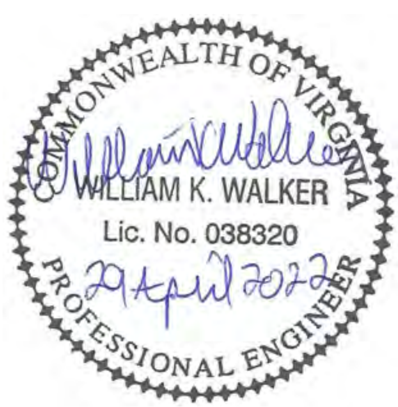

List of Acronyms

ACSA	Albemarle County Service Authority
ADD	Average Day Demand
AFF	Available Fire Flow
ARPS	Airport Road Pump Station
ARV	Air Release Valve
CAP	Condition Assessment Program
CI	Cast Iron
CIP	Capital Improvement Project
City	City of Charlottesville
CWL	Central Waterline
DI	Ductile Iron
EPA	Environmental Protection Agency
EPS	Extended Period Simulation
ERC	Equivalent Residential Connection
ESRI	Environmental Systems Research Institute
EST	Elevated Storage Tank
fps	Feet per Second
FSS	Fire suppression storage
FY	Fiscal Year
GIS	Geographical Information System
gpd	Gallons per Day
gpm	Gallons per Minute
GST	Ground Storage Tank
HGL	Hydraulic Grade Line
HP	Hydropneumatic
IDM	Inch-Diameter Mile
MDD	Maximum Day Demand
MG	Million Gallons
MGD	Million Gallons per Day
NFF	Needed Fire Flow
NGIC	National Ground Intelligence Center
NRW	Non-Revenue Water
NRWL	North Rivanna Waterline
NRWTP	North Rivanna Water Treatment Plant
O&M	Operation and Maintenance
OBWTP	Observatory Water Treatment Plant
PER	Preliminary Engineering Report
PRV	Pressure Reducing Valve
PS	Pump Station

psi	Pounds per Square Inch
PZ	Pressure Zone
RMR	Ragged Mountain Reservoir
RWSA	Rivanna Water and Sewer Authority
SCADA	Supervisory Control and Data Acquisition
SFRR	South Fork Rivanna Reservoir
SRWL	South Rivanna Waterline
SRWTP	South Rivanna Water Treatment Plant
SSOAP	Sanitary Sewer Overflow Analysis and Planning
TDH	Total Dynamic Head
UFWMP	Urban Finished Water Master Plan
USWDF	Urban System Water Demand Forecast
UVA	University of Virginia
UPZ	Urban Pressure Zone
WTP	Water Treatment Plant
VDH	Virginia Department of Health

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Executive Summary

ES-1 Introduction

The Urban Finished Water Master Plan (UFWMP) provides a comprehensive evaluation of the urban finished water system, which is comprised of three utilities: the Rivanna Water and Sewer Authority (RWSA), the City of Charlottesville (City), and the Albemarle County Service Authority (ACSA). The UFWMP focuses specifically on distribution, pumping, and storage of finished (potable) water including evaluation of alternatives to resolve current operational challenges and to meet future water demands.

The UFWMP is subdivided into 10 sections, which cover the following areas:

- Information about the existing system, development of criteria, *Sections 1-3*.
- Modeling analysis, findings, and recommendations for system improvements, *Sections 4 – 8*
- Discussion on further data collection and analysis, *Section 9*
- Summary of recommendations, *Section 10*. Information includes planning-level cost estimates and an implementation plan for recommended alternatives.

ES-2 Model Development

As water systems and regulatory requirements have become more complex, planning and analysis efforts have moved from applying standard rules of thumb to dynamic evaluation of system operation within identified constraints. A calibrated, dynamic water model is therefore a key tool in modern planning analyses. The RWSA's water model was last calibrated in 2012, and it had been updated periodically to reflect changes in the RWSA's and the ACSA's systems. Michael Baker updated the model's pipe network, representation of pumping and storage facilities, and distribution of demand to provide a sound basis for UFWMP recommendations.

Michael Baker used geographic information system (GIS) data provided by each utility and water meter data provided by the City and the ACSA to update the RWSA's WaterGEMS model of the urban finished water transmission and distribution system. The RWSA provided demand projections as tabular and GIS data. The RWSA's average day demand (ADD) has been approximately 9.6 million gallons per day (MGD) for the past few years, dropping from 11 MGD at the turn of the century. ADD projections have also been revised downward, from 17.0 MGD in 2060 per the 2010 projection to 14.3 MGD in 2070 per the 2020 projection (Section 3.1).

SCADA data was obtained to complement existing information. Previously-planned CIPs were also obtained from each utility. These planned CIPs were assumed to be in place by 2030, the first of three UFWMP planning horizons.

ES-3 Planning Scenarios

Michael Baker evaluated system performance for four planning timeframes (years):

- Existing conditions (2020),
- 10-year projection (2030),
- 25-year projection (2045), and
- 50-year projection (2070).

Operating scenarios focused on conditions that stress the system hydraulically, such as maximum day demand for hot/dry days, imbalanced production from the water treatment plants (WTPs), a transmission main or storage tank temporarily out of service, etc. Additionally, all future operating scenarios assumed that the North Rivanna WTP (NRWTP) was off-line, with the RWSA's proposed Airport Road Pump Station (ARPS) supplying water to the North Rivanna pressure zone to simulate maximum hydraulic stress on the Urban Pressure Zone (UPZ). Preliminary results from assuming the NRWTP is off-line also provided information on system performance, supporting the decision to decommission the WTP in FY25.

ES-4 System Analysis and Findings

Overview

The UFWMP identified three key challenges facing the RWSA:

1. Hydraulic isolation of the Observatory WTP, the Southern Loop Waterline, and the Observatory and Avon Street Tanks from the rest of the RWSA transmission system in the UPZ.
2. Wide pressure band and narrow tank operating range in individual pressure zones (PZs), with development at high elevation within a PZ encroaching into the elevation range of the storage tank(s) serving that PZ.
3. Short-cycling of tanks and pump stations, which results from limited storage above the minimum tank operating level.

The following sections identify recommendations for each asset class within the transmission system.

Distribution System

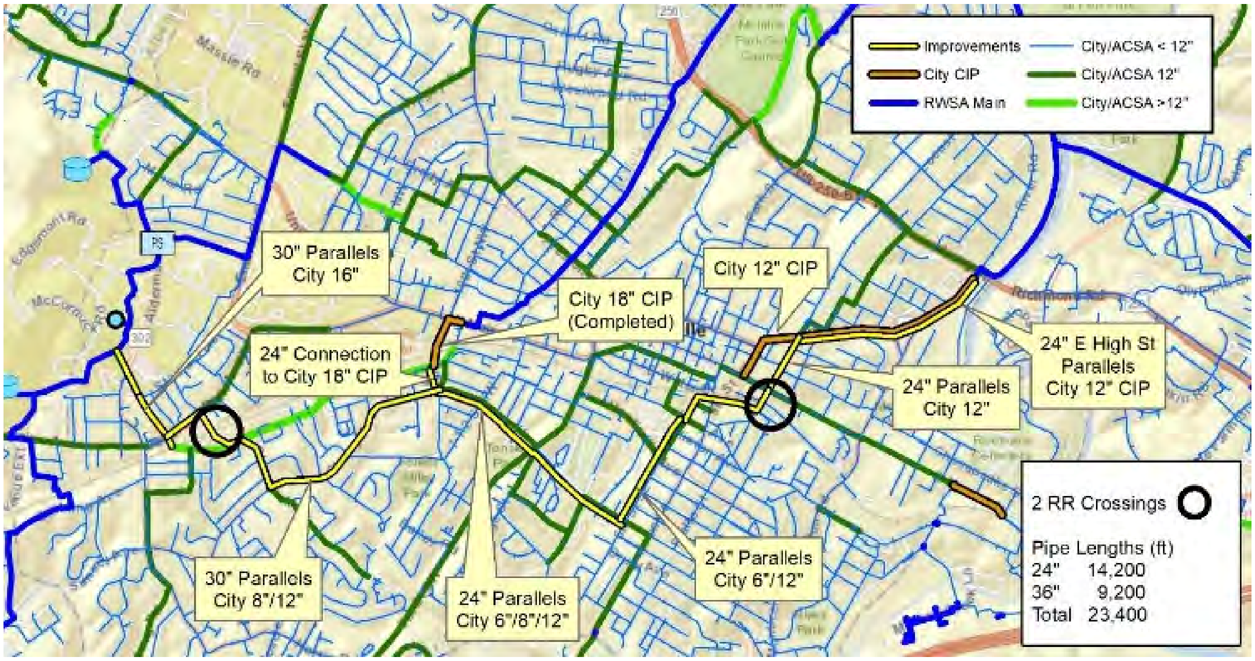
The RWSA's waterlines, which form the backbone of the urban finished water system, transport water from the WTPs to the tanks and utility distribution networks for delivery to retail customers.

The key take-away from the near-term and long-term scenario evaluations is that the existing system is inefficient in moving water away from the vicinity of the OBWTP. This adversely affects the RWSA's flexibility to adjust WTP operations when imbalanced water production is required, and it will limit the maximum effective output from the upgraded OBWTP, even during periods of balanced water production. As demands continue to increase into the future, the hydraulic inefficiencies will pose greater operational challenges unless resolved.

While not a "finished water" project, completing the SFRR-to-RMR Raw Water Pipeline, including its connection to the OBWTP, will have a significant impact on improving redundancy and resilience for providing finished water to the urban system. This project will give the RWSA flexibility in moving raw water from either major reservoir to either major WTP, providing a "behind the scenes" redundancy to the finished water connections between the major WTPs.

Results from model simulations carried out for the UFWMP confirmed that the existing system cannot efficiently move water between the Observatory WTP and the Pantops area. The recommended improvement to address this existing challenge is the Central Waterline (CWL). Michael Baker evaluated multiple potential parallel alignments through the City.

The various parallel options ("North", "Middle", "South", and "Railroad") have an estimated total project cost ranging from $25 million (M) to $31 M. These alignments generally follow, from west to east, a western connection to either the Observatory Waterline or the Southern Loop Waterline, a connection to the Urban Waterline in the center of the City, and an eastern connection to the Pantops Waterline at U.S. Route 250/E. High Street. The RWSA completed a routing study of CWL alignment alternatives. At the time the UFWMP was prepared, the "South" alignment, generally shown below, was determined through stakeholder meetings to be the preferred option.



(All figures are oriented with north at the top unless otherwise noted.)

The UFWMP also identifies areas where proposed transmission mains can close capacity gaps and provide resilience and redundancy to the urban water system. This includes supporting waterlines serving single-feed areas and at critical crossings.

In 2018, the RWSA completed its wholesale metering project to track inter-jurisdictional transfer of finished water between the City and the ACSA. If accounting for transfer of water between the City (via RWSA main) and the University of Virginia (UVA), the City's largest water customer, is important during emergency situations or atypical operating conditions, then installing a flow meter and valve vault at the normally-closed existing RWSA-UVA cross-connection just downstream of the Alderman Road pump station is recommended.

Storage Facilities

Considering the RWSA's and the ACSA's storage tanks, and excluding UVA's storage tanks and the RWSA's Woodburn Road tank, total urban system finished water storage is approximately 13.8 million gallons (MG). A maximum of only 7.0 MG is accessible, however, due to regulatory operational constraints which require either providing a minimum system pressure of 20 psi (12VAC5-590-510.C and 12VAC5-590-640.B.3.c), or limiting tanks floating on pressure zones to a maximum operating range of 30 feet (12VAC5-590-1080.D), whichever is more strict. An additional 0.6 MG is accessible as "surcharge" storage at the RWSA's Observatory and Avon Street Tanks but is not considered to be part of normal operating storage for the UFWMP. Based on current operations, 5.4 MG of storage is active. Without alternative measures (capital projects as well as operations adjustments), required accessible storage for 2070 is approximately 5.1 MG based on the following assumptions:

- In-zone fire suppression storage of maximum needed fire flow, and
- Operating storage associated with assumed daytime pump station schedules.

Maximum needed fire flow (NFF) values should be evaluated in a detailed fire flow investigation in each PZ and should include the confirmed presence (or proposed addition) of approved automatic sprinkler systems. The evaluation should also include potential impacts to the operation of storage tanks and pump stations. Although the existing active storage (5.4 MG) exceeds the 2070 required accessible storage (5.1 MG), much of the active storage (70%, or 3.7 MG) is within the UPZ, and existing pump stations may not have the firm capacity to satisfy maximum NFF. Adequate fire suppression storage (FSS) would therefore need to be supplied within each PZ. FSS within a given PZ can be reduced by pumping water into the PZ, an option that requires resilience of pumping facilities and a larger operating range for low-service pumps. The UFWMP identifies the following actions for each RWSA PZ (hydraulic grade line (HGL) provided for reference):

- North (HGL 805 feet) – This is the RWSA's highest-elevation PZ. It is currently served solely by the NRWTP. It will be served in the future by the RWSA's planned ARPS.
    - No action for Piney Mtn. Tank.
    - For the future ARPS tank(s), if installed, reduce water age by using a flow-through configuration and refilling via an altitude valve rather than allowing the tank(s) to float on the UPZ. Provide a parallel valve that will allow the tank(s) to instead float on the UPZ on an as-needed basis.
- Stillhouse (HGL 795 feet) – This is the RWSA's second-highest-elevation PZ after the North PZ.
    - Adjust variable frequency drive (VFD) pump controls to cycle tank once per day.
    - If need is confirmed by results from detailed fire flow investigation, install a duplicate ground storage tank (GST) with 0.73 MG capacity.
- Lewis Mountain (HGL 750 feet) – This PZ is adjacent to and has the same maximum hydraulic grade line as the UVA PZ.
    - Adjust variable frequency drive (VFD) pump controls to cycle tank once per day.
    - If needed pending results from detailed fire flow investigation, install a duplicate ground storage tank (GST) with 0.52 MG capacity.
- Urban (HGL 652 feet) – This is the RWSA's largest PZ and the source of water for all other PZs except the North. When the NRWTP is decommissioned, the UPZ will be the source of finished water for all other PZs.
    - Adjust WTP operating protocols and tank operating levels to promote tank turnover. (See Sections 7.6.4, 7.6.5, and 8.3.)
    - Conduct a study to evaluate the feasibility of the following:

- Retail utilities' ability to address high-elevation customers encroaching on the UPZ tanks' operating range (recover up to 2.8 MG of dead storage).
- Retail utilities' ability to install main-line pressure reducing valves (PRVs) at selected locations and where cost-effective to create new pressure sub-zones and reduce the number of individual PRVs required.

With capital improvement recommendations, the urban water system will have sufficient treatment and conveyance capacity to satisfy 2070 requirements with a minimal increase in storage, provided the following actions are taken:

- Eliminate as much dead storage as possible from within the maximum 30-foot operating range allowed by VDH for tanks that float on a PZ. Where encroaching on the tank's operating range, coordinate with the retail utilities to conduct a detailed study of potential improvements for implementation, which may include one or more of the following actions, where appropriate:
  - Move the customer to a higher existing or new PZ
  - Install a private pump
  - Upgrade an existing private pump
  - Upgrade a service lateral (i.e., supply line to sprinkler system) to reduce friction loss (pressure drop), thereby offsetting lower pressure associated with a reduced allowable minimum tank operating level
- Recalibrate hydraulic model to better assess tank recommendations and standard operating protocols, as well as to inform water quality.
- Expand operating range of smaller GSTs by lowering minimum acceptable water level where feasible.
- Relocate the larger GSTs (standpipes) to higher ground or, at end of useful life, convert to ESTs on existing site to recover inaccessible storage and/or eliminate dead storage.

<u>Pumping Facilities</u>

The UFWMP determined that existing pumping facilities have sufficient capacity to satisfy demands for various operating conditions through 2070. Changes in operating protocols will, however, promote tank turnover and reduce withdrawal from the UPZ during critical times. Additionally, the NFF analysis recommended in the previous section may identify adjustments to pumping and storage facilities to improve system resilience. As mentioned in the Storage Facilities section, the level for turning on low-service pumps can be decreased to promote tank turnover and reduce water age, with the caveat that the system continues to provide the required level of fire protection. The UFWMP also determined that a finished water pump station is not required at the Observatory WTP once the CWL has been completed, and that a separate Airport PZ supported by the ARPS will not be required by 2070.

Operation and Maintenance (O&M) Programs

RWSA conducts multiple O&M programs that are already programmed into the Capital Improvement Plan and O&M budgets. These include:

- Utility right-of-way clearing and mowing (annually or biennially)
- Valve maintenance and repair (on-going)
- Tank inspection (every 5 years) and painting (approximately every 20 years)
- Safe yield and water demand studies (every 10 years)

These regular on-going maintenance programs were not evaluated further for this UFWMP and the associated budgets are not included in this report.

ES-5 Summary of Recommendations

To address current and future demands and operational challenges of the urban finished water system, the following recommendations are presented in Tables ES-1 and ES-2 with approximate timing and estimated planning level costs. Total program cost, including engineering, construction administration and inspection, legal, administrative, and easement acquisition costs, is estimated to be $155.3M through 2070, with approximate budget schedule shown in Table ES-3.

Table ES-1. Prioritized Recommendations for Urban Finished Water System CIPs

Recommendation	Report Section	Category	Complete By	Estimated Project Cost
South Rivanna River Second Crossing	6.3.7	Redundancy	2025	$5.8M
Airport Road Pump Station	8.4.3	Conveyance	2025	$4.0M
Airport Road Pump Station Waterline – Phase 1	8.4.3	Conveyance	2025	$6.0M
Airport Road Pump Station Waterline – Phase 2	8.4.3	Conveyance	2030	$1.4M
Central Waterline	6.2.4	Conveyance	2030	$31.0M
Stillhouse 0.73 MG GST	7.6.1	Storage	2030	$1.7M
Lewis Mtn. Operations	7.6.2	Storage	2030	$0.2M
Lewis Mtn. 0.5 MG GST	7.6.2	Storage	2030	$0.9M
North Rivanna Waterline Reinforcement	6.3.6	Resilience	2030	$4.3M
North Rivanna River Second Crossing	6.3.7	Redundancy	2030	$1.2M
Emmet/Seminole Waterline Phase 1 (24" Gap)	6.2.3	Redundancy	2030	$8.5M
Pressure Surge Mitigation	8.4.4	Resilience	2035	$0.7M
Emmet/Seminole Waterline Phase 2 (30" Connection to CWL)	6.2.3	Redundancy	2035	$9.5M
Alderman Road PS Discharge Inter-connection	6.3.1	Resilience	2045	$0.4M
Single-Feed Bypasses	6.3.4	Resilience	2045	$1.3M
Rivanna River Second Crossing at Pantops	6.3.7	Redundancy	2045	$4.8M
Observatory Waterline Replacement	6.3.5	Resilience	2045-50	$1.9M
South Rivanna Waterline Replacement	6.3.5	Resilience	2055-60	$27.6M
Avon Street Waterline	6.3.8	Redundancy	2060-65	$10.3M
North Rivanna Waterline Replacement	6.3.5	Resilience	2065-70	$10.6M
South Rivanna Waterline Replacement Rio to Hydraulic	6.3.8	Conveyance	2070	$9.6M
Replace Pantops and Avon Street Tanks at end of useful life	7.6.4	Storage	2070	$8.9M
Airport Road Tanks	7.6.3	Storage	2070	$2.8M
Total of Capital Improvement Projects				**$153.4M**

Table ES-2. Recommendations for Urban Finished Water System Investigations/Studies

Recommendation	Report Section	Category	Phase	Schedule	Estimated Cost
Comprehensive Waterline Condition Assessment	6.3.5	Asset / Operations Management	Study	2030	$800,000
Investigate Pressure Surges and Prepare Mitigation PER	8.4.4	Asset / Operations Management	Study	2030	$100,000
Comprehensive Electro-Mechanical Condition Assessment	8.4.5	Asset / Operations Management	Study	2030	$200,000
Water Model Hydraulic and Water Quality Calibration	9.2 7.6.6	Operations Management	Study	2030	$400,000
Storage and Operations Evaluation	7.6.6 9.3	Storage	Study	2030	$400,000
Total of Investigations / Studies					**$1.9M**

Table ES-3. Urban Finished Water Program Budget by Planning Horizon

Planning Horizon	Estimated Cost
2030	$68.8M
2045	$16.7M
2070	$69.8M
Total	**$155.3M**

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Urban Finished Water Master Plan

April 29, 2022

1. Introduction

1.1. Scope of Report

The Rivanna Water and Sewer Authority (RWSA) engaged Michael Baker International, Inc. (Michael Baker) to prepare a master plan for the urban finished water system, which includes three utilities: the RWSA, the City of Charlottesville (City), and the Albemarle County Service Authority (ACSA). The University of Virginia (UVA) operates its own distribution system and is primarily a customer of the City. This Urban Finished Water Master Plan (UFWMP) evaluates alternatives for resolving current operational challenges and anticipated deficiencies associated with future water demands through planning year 2070. The UFWMP presents planning-level cost estimates and an implementation plan for recommended alternatives to enable the RWSA to achieve its goals: plan, deliver, and maintain dependable infrastructure in a financially responsible manner.

1.2. Project Background

The RWSA initiated preparation of the UFWMP, an item on its Capital Improvement Plan (CIP), as an outgrowth of two parallel efforts which forecast significant upgrades to the urban finished water system:

- evaluation of options for completing the eastern leg of the Southern Loop transmission main (Avon to Pantops Waterline)
- preliminary engineering and planning for the future Airport Pressure Zone (PZ) and associated Airport Road Pump Station (ARPS)

During those separate efforts, the RWSA determined that a holistic approach to evaluating the performance of the entire finished water system as the best path forward for the RWSA, thus advancing the schedule of the UFWMP CIP by several years.

The UFWMP is an element of the RWSA's 2017 Strategic Plan. Under Work Authorization No. 8, the RWSA asked Michael Baker to provide engineering services to develop the UFWMP. Tasks include the following:

- data collection and review
- validation of the hydraulic model, and hydraulic modeling analysis
- meetings with RWSA staff and stakeholders
- coordination with other ongoing projects that impact the UFWMP

- identification of improvements required to enhance system efficiency and the ability to meet future demands
- identification of opportunities to improve system resilience and redundancy
- development of timing and cost estimates of required improvements
- development of the UFWMP document

Key inputs to the UFWMP include the following:

- the RWSA's Urban System Water Demand Forecast (USWDF) (April 2020 by others)
- 2017 retail water meter data from the City and the ACSA
- GIS, operations, and SCADA data for water system assets
- planned and completed CIPs for all three utilities

1.3. General Description of the Urban Area Water System

The RWSA provides finished water on a wholesale basis to the City and ACSA retail utilities, both of which deliver water to their customers via their distribution systems. The City provides retail water in bulk to UVA, and both the City and the ACSA provide water to outlying UVA facilities via individual retail meters. The RWSA does not have any retail customers of its own.

On average, the RWSA treats raw water at a rate of 9.6 million gallons per day (MGD) to produce finished (potable) water at three water treatment plants (WTPs):

- South Rivanna WTP (SRWTP) – 12 MGD current capacity, 16 MGD by year 2045
- Observatory WTP (OBWTP) – 7.7 MGD current capacity, 10 MGD by year 2023
- North Rivanna WTP (NRWTP) – 2 MGD current capacity

The RWSA owns and operates four sources of water to supply the urban system:

- South Rivanna Reservoir (SFRR) – supplies the SRWTP
- Ragged Mountain Reservoir (RMR) – supplies the OBWTP
- North Rivanna Intake – supplies the NRWTP
- Sugar Hollow Reservoir – supplies the RMR

In addition to the above facilities, the RWSA owns and maintains two PSs, seven storage tanks (including Woodburn), and 45 miles of transmission mains ("waterlines") to supply finished water to the ACSA and City retail distribution systems. The ACSA owns and operates PSs, storage tanks, and pressure reducing valves (PRVs) to maintain 10 PZs outside the UPZ. The City owns and maintains the Lambeth PS to manage the Lambeth PZ. An overview of the urban finished water system is shown in Figure 1, and a schematic diagram is shown in Figure 2.

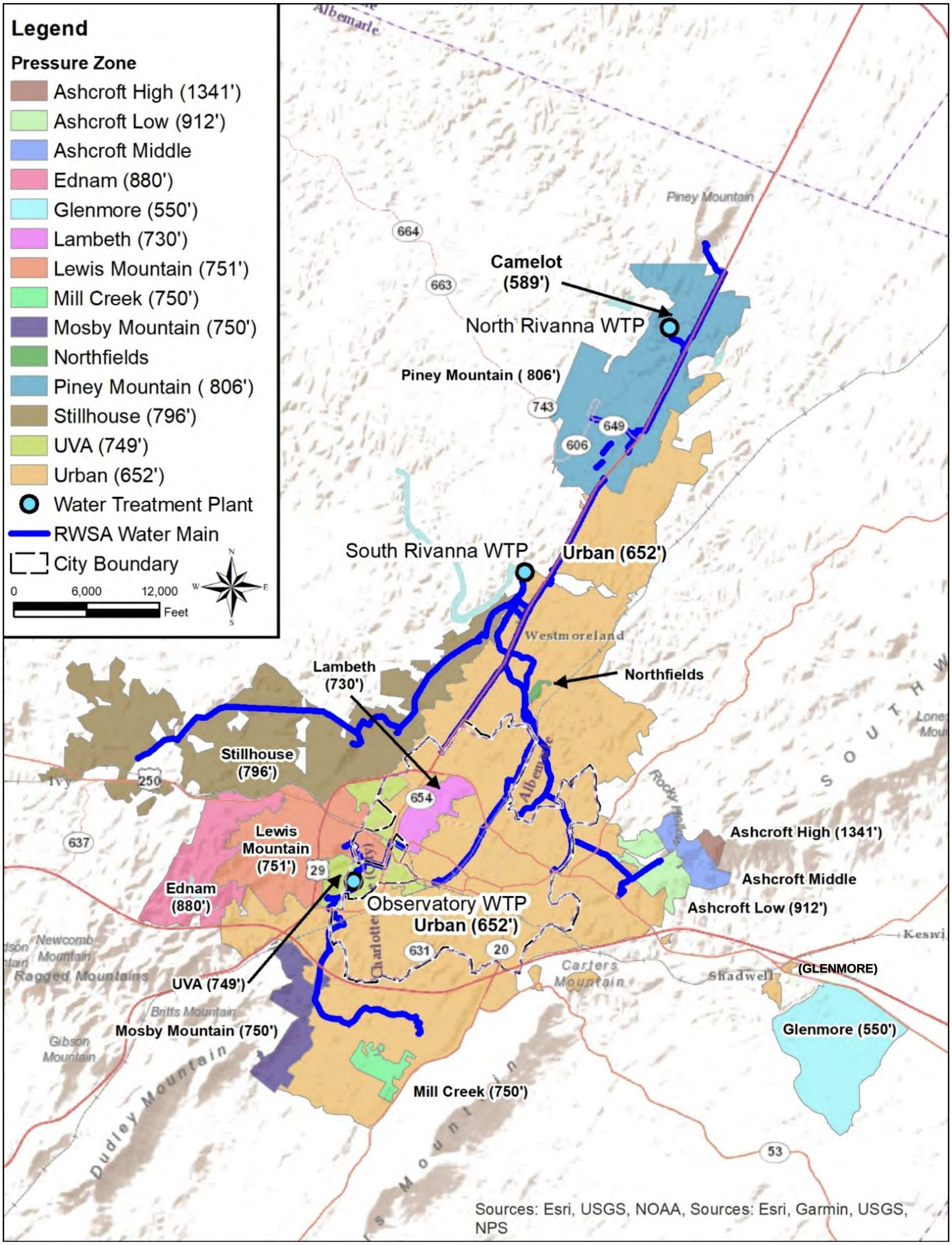

Figure 1: Urban Finished Water System Pressure Zone Map

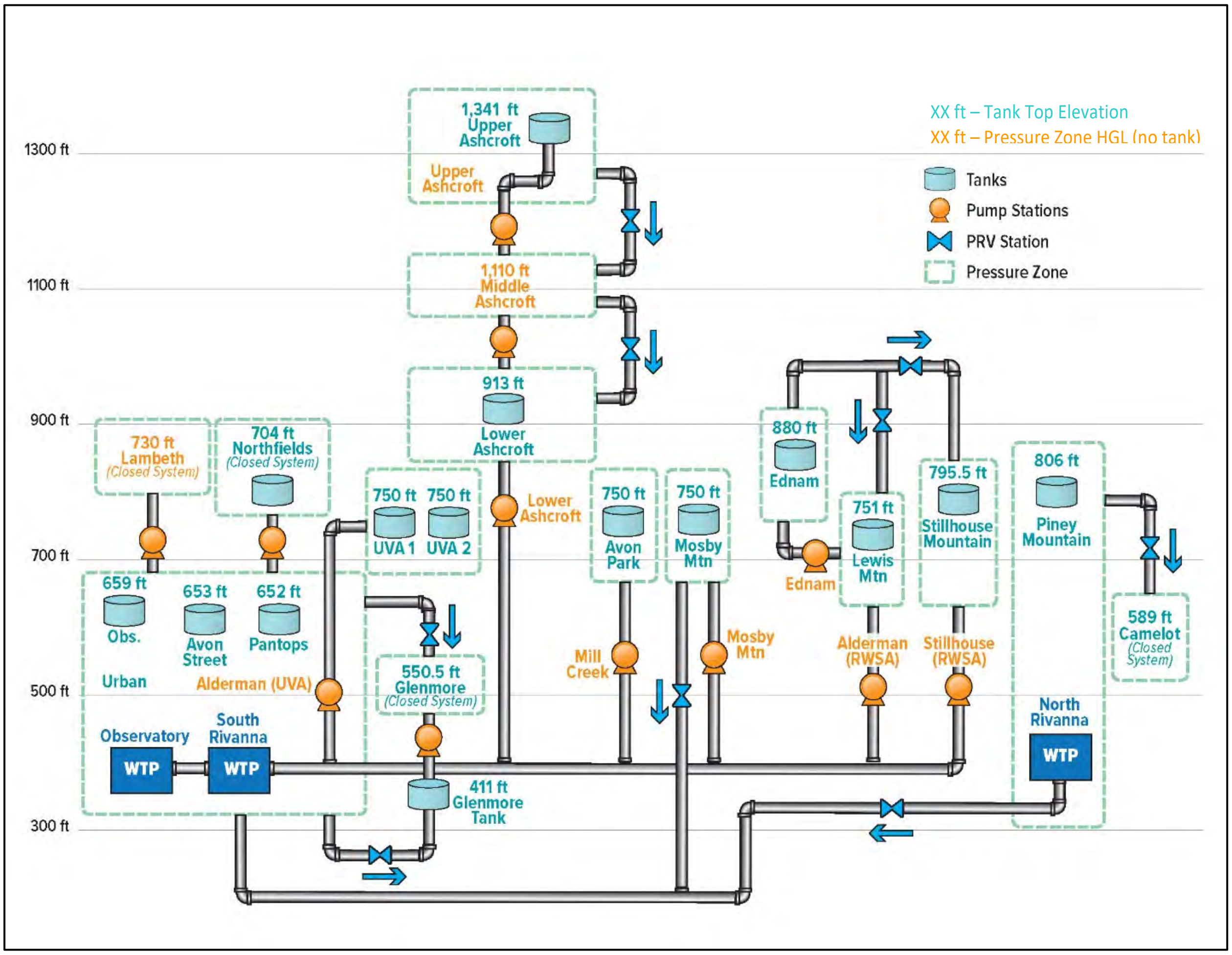

Figure 2: Urban Finished Water System Schematic

1.3.1. Project Approach

To complete the UFWMP, Michael Baker performed several data collection, research, and evaluation tasks. The primary utility-specific data utilized in this study included the following:

- Geographical information system (GIS) data on water mains and appurtenances
- System-wide RWSA finished water model that includes RWSA, City, and ACSA infrastructure
- Utility retail metering data, CIP data, and hydrant flow testing data
- Utility operation and maintenance (O&M) data for water distribution facilities

Michael Baker held a series of three (3) workshops with representatives of the RWSA, the City, and the ACSA for the following purposes:

- Obtain and verify O&M data represented in the RWSA's model of the urban water system
- Obtain responses regarding data gaps, data analysis, and preliminary findings
- Present project progress
- Verify that the direction of the UFWMP was meeting the intent of the Strategic Plan

1.3.2. UFWMP Organization

The UFWMP is organized into the following sections:

- Section 1: Introduction – An overview of the project.
- Section 2: Summary of Existing Information – A summary of data, including important assumptions, that served as a basis for the development of the UFWMP.
- Section 3: System Base Conditions – An overview of system performance, and development of criteria used to evaluate the improvement alternatives that are presented in this report.
- Section 4: Planning Scenarios – Detailed information regarding the various demand and operational scenarios used for identifying required improvements.
- Section 5: Existing Conditions Baseline – An overview of water system performance for evaluating recommended improvements.
- Section 6: Waterlines – An overview of operations, capacity, and challenges associated with transmission mains.
- Section 7: Storage Tanks – An overview of operations, storage categories, and challenges associated with storage tanks.
- Section 8: Pumping Facilities – An overview of operations and challenges associated with pump stations, including finished water pumps at WTPs.
- Section 9: Data Collection Activities – A discussion on data collection and analysis to inform design and operations decisions.
- Section 10: Summary of Recommendations and Implementation Plan – An overview of recommended improvements, timing, and associated cost estimates.

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2. Summary of Existing Information

2.1. Geographic Information System

GIS data served as the foundational data input for this project. Throughout the course of the UFWMP, each utility provided Michael Baker with a copy of its GIS data pertinent to the urban water system, most recently in February 2020 (City), May 2020 (RWSA), and August 2020 (ACSA). Demand projections were also provided as GIS data. Michael Baker assumed all GIS data to be accurate to the best of the data owner's knowledge.

2.2. Existing Water Meters

To supplement the water meter geospatial location provided in a GIS geodatabase or as a shapefile, Michael Baker was provided with spreadsheets tabulating either total monthly water consumption values for every ACSA retail water meter account or total annual water consumption values for every City retail water meter account. The metered water consumption was provided for Fiscal Year 2017 (FY17), i.e., July 2016 through June 2017. This data was originally provided to Hazen and Sawyer (Hazen) for the purpose of preparing the USWDF. To align the UFWMP with the USWDF, Michael Baker utilized this same meter data, either by linking the data associated with each table record to the corresponding GIS entry via ACSA customer meter ID, or by matching City customer account addresses to meter addresses.

2.3. Supervisory Control and Data Acquisition

For the USWDF, each of the three utilities provided supervisory control and data acquisition (SCADA) data, where available up to mid-November 2018, for its facilities. For the UFWMP and at Michael Baker's request, this data was supplemented with other timeframes and locations. A summary of SCADA data availability is provided in Appendix A.

2.4. Hydraulic Model

The following terms are defined for application to the RWSA's hydraulic model of the finished water transmission and distribution system.

Update: To replace outdated model information with current information, such as pipe size, location, C factor, or alignment; pump curves and operating rules; storage tank operating levels; and water demands, both metered and unmetered.

Validate: To verify that model simulation results adequately mimic historical SCADA data. Given the nature of the available historical data, validation efforts for the UFWMP focused on the performance of the storage tanks.

Calibrate: To undertake a rigorous, system-wide field testing and data collection effort followed by detailed evaluation of model results, focusing on values for local parameters such as flow rate, pressure loss, or concentration of disinfection chemicals.

Prior to the UFWMP, the RWSA's urban system water model was most recently updated for the "Avon to Pantops" project to mimic system operations, focusing on the SRWTP. As part of the UFWMP, the model was again updated to reflect existing physical and operational conditions throughout the entire transmission and distribution network. For example, much of the City's distribution system has been renewed since 2012, and the RWSA hydraulic model now contains those improvements. The location and magnitude of customer water demands is also current, reflecting not only changes in localized water use but also new demands associated with system expansion into previously unserved areas. The model was then validated for the UFWMP.

The model was last calibrated circa 2012; recommendations for recalibration are included in Section 9.2. Due to the limitations in scope, schedule, and funding for the UFWMP, the hydraulic model was not recalibrated. A detailed description of model background, inputs, updates, and validation for the UFWMP is presented in Appendix B. Hydrant test data provided by the retail utilities and utilized to update localized pipe C factors is presented in Appendix C.

2.5. Capital Improvement Projects

Each utility provided information on recently completed, currently in progress, and planned CIPs. All planned CIPs are assumed to be in place by the year 2030, the first of three UFWMP forecast horizons. The CIPs are summarized in Table 1.

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Table 1. Planned and Completed Capital Improvement Projects

Project	Owner	Description	Status
Ivy Road / Emmet Street	City	Construct parallel 6" main	Completed
Main Street Water Main	City	Replace dilapidated 18" main at 9th Street SW with new 18" main along Roosevelt Brown Boulevard and Main Street to 9th Street SW	Completed
West Main Street	City	Replace older 10" main with 12" main from Jefferson Park Avenue to Roosevelt Brown Boulevard, and from 9th Street SW to Ridge McIntire Road	Planned but on-hold
East High Street	City	Replace older 6" and 8" mains with 12" main on 9th Street NE from Market Street to E High Street, and on E High Street to Long Street	In Design
East Market Street	City	Replace older 4" and 6" mains with 12" main on E Market Street from Franklin Street to Marchant Street	Planned
Brandywine Drive	City	Replace older 6" main with 8" main	Completed
South Rivanna River 24" Crossing	RWSA	Construct 24" second crossing of the South Rivanna River from the SRWTP to Rio Mills Road at Seminole Trail	In Design
Central Waterline	RWSA	Construct new transmission main to better hydraulically connect OBWTP, Observatory Tank, Avon Street Tank, and the Pantops area	In Design
Airport Road Pump Station and Pipeline	RWSA	Construct new pump station and appurtenances at northern terminus of Berkmar Drive to supplement NRWTP	Construction
Wholesale Meters	RWSA	Construct jurisdictional meters to monitor compliance with water allocation agreement	Completed
Stillhouse Pump Station	RWSA	Construct replacement for Canterbury Hills PS	Completed
Glenmore Pump Station and Tank	ACSA	Construct pump station, tank, and PRV to maintain a reduced pressure zone at Glenmore	Completed
Mosby Mountain Pump Upgrades	ACSA	Replace pumps	Completed
Ednam Pump Upgrades	ACSA	Replace pumps	Completed

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3. System Base Conditions

3.1. Projected Demands for Planning Horizon

The planning horizon for the UFWMP includes existing conditions as well as forecast demand for 10, 25, and 50 years into the future. The planning horizon is therefore referenced to years 2020, 2030, 2045, and 2070. The RWSA developed future demands for the UFWMP planning horizon via the USWDF prepared by Hazen. Since realized demand has been fairly steady for over 10 years at approximately 9.6 MGD, the FY18 demand is assumed to be valid for the year 2020 in this report.

Future demand was calculated based on unit water use by land use type applied to projected growth, added to existing demand. Compared to the prior demand forecast AECOM completed for the RWSA in 2011, future demand is now expected to be significantly lower in the year 2060 (17.0 vs. 13.8 MGD, respectively, Figure 3). This can be attributed in part to changes in unit water use realized by changes in personal habits and by installation of appliances and fixtures that are more water-efficient. A more detailed discussion on the differences between the previous and current demand projections is presented in the USWDF.

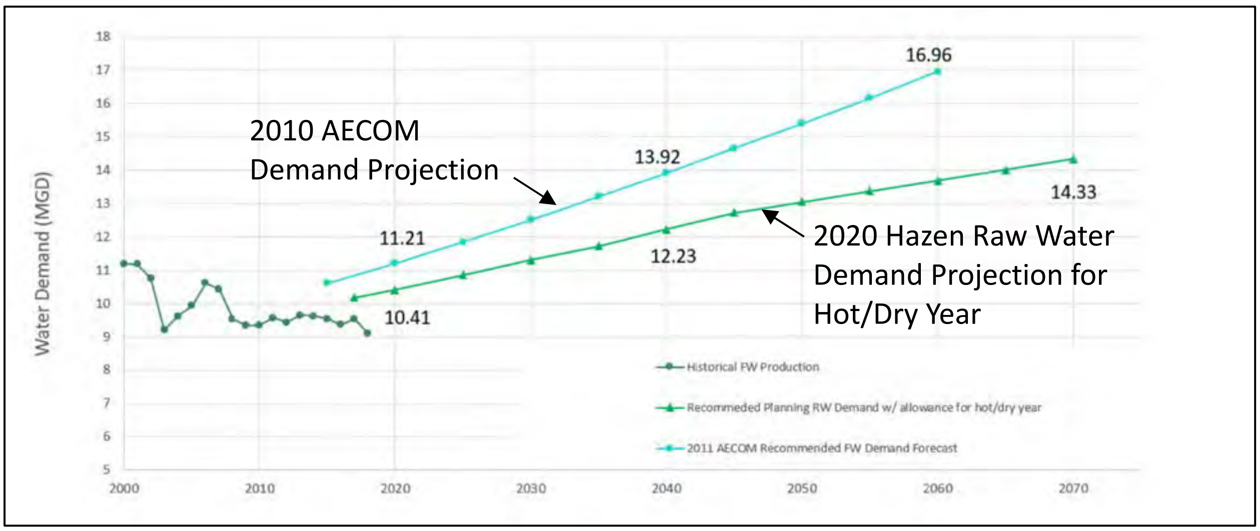

Figure 3. Historical Water Demand vs. Demand Projections Prepared in 2011 and 2020 .

Regardless of the demand scenario being evaluated, whether short- or long-term, the system goals remain the same: to identify the improvements required to enhance water system efficiency and provide the ability to meet future demands. System demands for the planning horizon are presented in Table 2. For the UFWMP, hot/dry conditions are assumed unless otherwise noted, as the high demand places greater stress on the water transmission and distribution system. For comparison purposes, the USWDF recommended planning finished water demands are shown in Table 3.

Table 2. UFWMP Demand Projections (MGD) for Planning Horizon

Demand \ Year	2020	2030	2045	2070
	Retail / Unmetered / Total			
Average Day	8.33 / 1.05 / 9.38	9.31 / 1.17 / 10.48	10.47 / 1.32 / 11.79	11.77 / 1.48 / 13.25
Avg. Hot/Dry Day	8.83 / 1.11 / 9.94	9.87 / 1.24 / 11.11	11.10 / 1.40 / 12.50	12.47 / 1.57 / 14.04
Max. Hot/Dry Day	12.98 / 1.64 / 14.62	14.50 / 1.82 / 16.32	16.32 / 2.06 / 18.38	18.34 / 2.31 / 20.65

Notes: Retail demand includes UVA "middle growth" demand.
System-wide Hot/Dry demand premium is 6% of average demand.
System-wide maximum demand premium is 47% of average demand.

Table 3. USWDF Demand Projections (MGD) for Planning Horizon

Demand \ Year	2020	2030	2045	2070
Average Day Finished Water (Tables 3-9 and 3-10)	9.38	10.48	11.78	13.25
Hot/Dry Avg. Day Finished Water (Table 5-1)	10.1	11.0	12.4	13.9
Hot/Dry Peak Day Finished Water (Table 5-2)	14.9	16.1	18.2	20.5

Notes: Retail demand includes UVA "middle growth" demand.
Unmetered water for average day (Table 2) does not change for hot/dry and peak days.
Average Day FW from Table 3-10, adjusted for higher Retail Total as presented in Table 3-9.

UFWMP demand projections beyond 2030 are slightly higher than those presented in the USWDF, as unmetered water is assumed to increase as demand increases from average to hot/dry and/or maximum day conditions. Based on data presented in the USWDF, unmetered water is approximately 12.6% of retail demand. As discussed in Section 3.2.3, unmetered water was distributed throughout the model based on IDM of the piping system.

To meet increasing demand, the RWSA is increasing treatment capacity at both the OBWTP and the SRWTP. Current and future WTP rated capacities are presented in Table 4. The NRWTP is scheduled to be decommissioned in 2025.

Table 4. Current and Future WTP Rated Capacity (MGD)

Year / WTP	Observatory	South Rivanna	North Rivanna
2020	7.7 (5.0†)	12	2
2030	10	12	0
2045	10	16	0
2070	10	16	0

†Production limited by raw water pumping capacity

3.2. Operational Issues and Problematic Areas

A primary objective of the UFWMP is to recommend solutions to operational issues and problematic areas. In addition to addressing current issues, the UFWMP must identify issues that may be realized in the future. Based on information provided by RWSA operations staff at the first UFWMP workshop in April 2019 and afterwards via e-mail, challenges to operating the present-day system include the following:

- General
  - Seasonal influence on sources of raw water and the resulting ability to supply the urban system from impacted WTPs
  - Ability to maintain water service when transmission mains are temporarily closed
  - Corridors that cannot be accessed easily for performing maintenance or completing repairs due to their remote location, difficult terrain, high traffic volume, or a congested corridor
  - Encroachment on storage tank operating range by development at higher elevations
  - Storage tank off-line for maintenance
- Urban PZ
  - Maintaining water in Pantops Tank during periods of high demand
  - Ability to fill Avon Street Tank during periods of high demand
  - Low operational volume relative to Pantops Tank total volume
  - Lower pressure and water availability when Stillhouse PS is active
- Other PZs
  - Increasing frequency of main breaks in the North PZ
  - High water age in the western end of the Stillhouse PZ
  - Frequency of cycling the Stillhouse Tank and PS

The most important challenges facing the urban system are centered around efficiently moving water through the system to where it is needed while providing adequate pressure, especially during times of unbalanced production from the WTPs, or under other adverse operating conditions.

3.3. Seasonality and High Demand

The bulk of current challenges in operating the system are associated with periods of high demand with little to no support from the SRWTP. Hydraulically, the OBWTP is not well-connected to the northern and eastern portion of the urban system. Its influence on system performance is therefore generally limited to the Lewis Mtn., Ednam, UVA, and Mosby Mtn. PZs, and to the UPZ south and west of downtown Charlottesville (i.e., along the 20-inch Southern Loop Waterline).

During periods of high demand, because the OBWTP cannot support the eastern UPZ, the Pantops Tank relies on the SRWTP for refilling. The Stillhouse PS, however, is located close to the SRWTP and therefore draws off water for the Stillhouse PZ before that water can reach the bulk of the UPZ. This can result in depressed pressure and tank levels in the UPZ, particularly at Pantops.

To refill Pantops Tank during periods of high demand, the RWSA can increase production at the OBWTP and increase the transfer of water into the Lewis Mtn. PZ via the Alderman Road PS, which "makes space" in the system for OBWTP water. The ACSA installed and has adjusted the pressure settings at the Flordon PRV between the Ednam and Stillhouse PZs to relieve the demand placed on the Stillhouse PS. RWSA pumps from the UPZ to the Lewis Mtn. PZ, and ACSA pumps from the Lewis Mtn. PZ to the Ednam PZ (Figure 2).

3.4. Seasonal Modes of Operation

The SRWTP (current maximum capacity 12 MGD) is the primary source of finished water, with the OBWTP (current maximum treatment capacity of 7.7 MGD is limited to 5.0 MGD due to raw water pumping constraints) operating during daytime hours to augment SRWTP production. During drought conditions, however, production is reduced at the SRWTP and increased at the OBWTP to maximize the use of RMR. Minimum in-stream flow requirements (i.e., the amount of water that must remain in-stream below a dam in order to sustain the local ecological community) further reduce the amount of water available to the RWSA for withdrawal and treatment during drought conditions.

Even if raw water supply and treatment capacity were not limited, it is difficult, as noted in Section 3.3, for the OBWTP to support a majority, if not all, of the urban system during periods of high demand given the hydraulic restrictions to moving finished water north and east of downtown Charlottesville. Completion of the SFRR-to-RMR Raw Water Pipeline will alleviate hydraulic stress in the urban finished water transmission system during drought conditions, assuming there are no other constraints in operating the WTPs: RMR water will be routed for treatment not only to the OBWTP, as is currently the case, but also to the SRWTP, which is better-equipped to supply more finished water to the urban system.

3.5. Preferred Operational Requirements

A primary objective of the UFWMP is to recommend solutions to operational issues and problematic areas. The RWSA provided Michael Baker with operations standards and preferences, including the following:

- Water Treatment Plants
  - Limit production to 90% of capacity
- NRWTP
  - Turn on at approximately 8 a.m. and run until the Piney Mtn. Tank is full
- SRWTP
  - Target discharge pressure 80 pounds per square inch (psi)
  - Turn pumps on and off manually
  - Pump 4 is operated by variable frequency drive (VFD) controls, is the primary pump, and is followed in order by Pumps 1, 2, and 3 as demand increases
  - During the course of the UFWMP, VFD controls were added to Pump 3 as part of the SRWTP Improvements Project
- Storage Tanks
  - One refill cycle per day under ADD conditions (This does not imply a complete turnover of the entire tank each day. Rather, it is refilling the amount that has been depleted during the day to bring the tank back to "full volume.")
  - Must operate above low alarm ("minimum allowable") level
  - Prefer to operate above "preferred minimum" level
- UPZ Tanks
  - Operate within 5 feet of each other
  - 5 to 10 feet of active operating range
  - Prefer complete refill, but must recover to recurring high level
- Pantops Tank (seasonal adjustments to altitude valve)
  - Summer maximum level: 39 feet
  - Winter maximum level: 34 feet (to improve turnover during lower demand)
- Stillhouse PS
  - Reduce pumping rate if having difficulty filling Pantops Tank
- Alderman Road PS (RWSA side)
  - Increase pumping rate if having difficulty filling Pantops Tank: offset reduced Stillhouse PS output by pumping to Lewis Mtn. PZ, Ednam PZ, and then Flordon and Farmington PRVs

In consultation with the RWSA, Michael Baker developed additional operations criteria for evaluating system performance:

- Main velocity less than 10 fps
- Minimum pipeline pressure no more than 5 psi below that for existing conditions
- Maximum pipeline pressure 150 psi, alarm at 175 psi, must be no more than 200 psi
- Water age less than 14 days
    - Detailed water quality analysis requires testing data and calibration of not only the hydraulic model but also the decay coefficients for disinfection compounds.
    - In the absence of modeling the decay of disinfection compounds, which increases as temperature increases, water age is used as a surrogate for water quality.
    - The urban water system typically has good water quality (water age < 14 days), with retail utilities flushing lines to "freshen" water when needed based on test results or customer complaints.
    - The RWSA can reduce UPZ tank operating levels during periods of low demand (e.g., winter) to reduce water age and improve water quality.
- Maintain or improve existing conditions Available Fire Flow (AFF)
- System redundancy and resilience to special operating conditions
    - Transmission main or storage tank temporarily out of service
    - Temporarily reduced WTP capacity

Still other criteria were used for system pressure:

- Minimum pressure 20 psi at any point in time during a fire flow event (Virginia Department of Health (VDH) regulation 12VAC5-590-510)
- Minimum operating pressure 40 psi (This was a requirement of the 2003 Residential Building Code but has since been removed.)

Adequate pressure is the primary benchmark for evaluating system performance: as velocity increases, pressure decreases due to friction losses. Therefore, to maintain adequate system pressure, pipe size and/or flow must be adjusted accordingly. Many water utilities prefer to keep main velocities below 10 fps, if not lower, but allow stubs serving fire hydrants to have higher velocities during fire flow conditions.

It should be noted that minimum pressure goals do not apply at PSs, where local pressure can drop significantly on the suction side of pumps due to the smaller pipe size and resulting high flow velocity. A detailed evaluation of pump suction pressure is beyond the scope of this report.

The baseline for comparing system performance is existing conditions ADD on a hot/dry day. Results from this scenario are used to establish the AFF, pressure, and velocity criteria under future configurations and demands.

As indicated by RWSA's operations standards and preferences, normal operations of facilities can have competing goals. Most notable is the withdrawal of UPZ water by the Stillhouse PS, which occasionally, results in challenges to refill the Pantops Tank. To compensate, the RWSA typically reduces Stillhouse PS output and/or increase Observatory WTP and Alderman Road PS output.

3.6. Growth Areas

Based on GIS data provided by the RWSA, future demand associated with growth in projected population and employment was assigned to the existing water distribution network. Some areas are expected to see significant growth through 2070 (Table 5, Figure 4):

Table 5. Current and Future Demand in Projected High-Growth Areas

Location	Description	2017 gpd	2070 gpd
1	Birdwood Golf Course / Ivy Road Corridor Redevelopment	2,000	98,000
2	UVA (Main Campus)	1.25M	1.40M
3	Pepsi-Cola Bottling Company	44,000	66,000
4	UVA Research Park	26,000	150,000
5	NGIC	45,000	88,000
6	West of Berkmar Drive, South of Airport	14,000	60,000

Except for the Birdwood Golf Course / Ivy Road Corridor, all of the areas anticipated to provide significant growth in demand are served by existing large-diameter mains. Most areas where moderate growth is anticipated are also served by large-diameter mains. Where projected demand is not near the existing distribution system, the demand is assigned to an assumed connection point on the existing system.

In the future, demand may not change or may even decrease, depending on projections. These cases are also addressed via assignment of demands to the model for the scenarios to be evaluated. Model scenarios are presented in the next section.

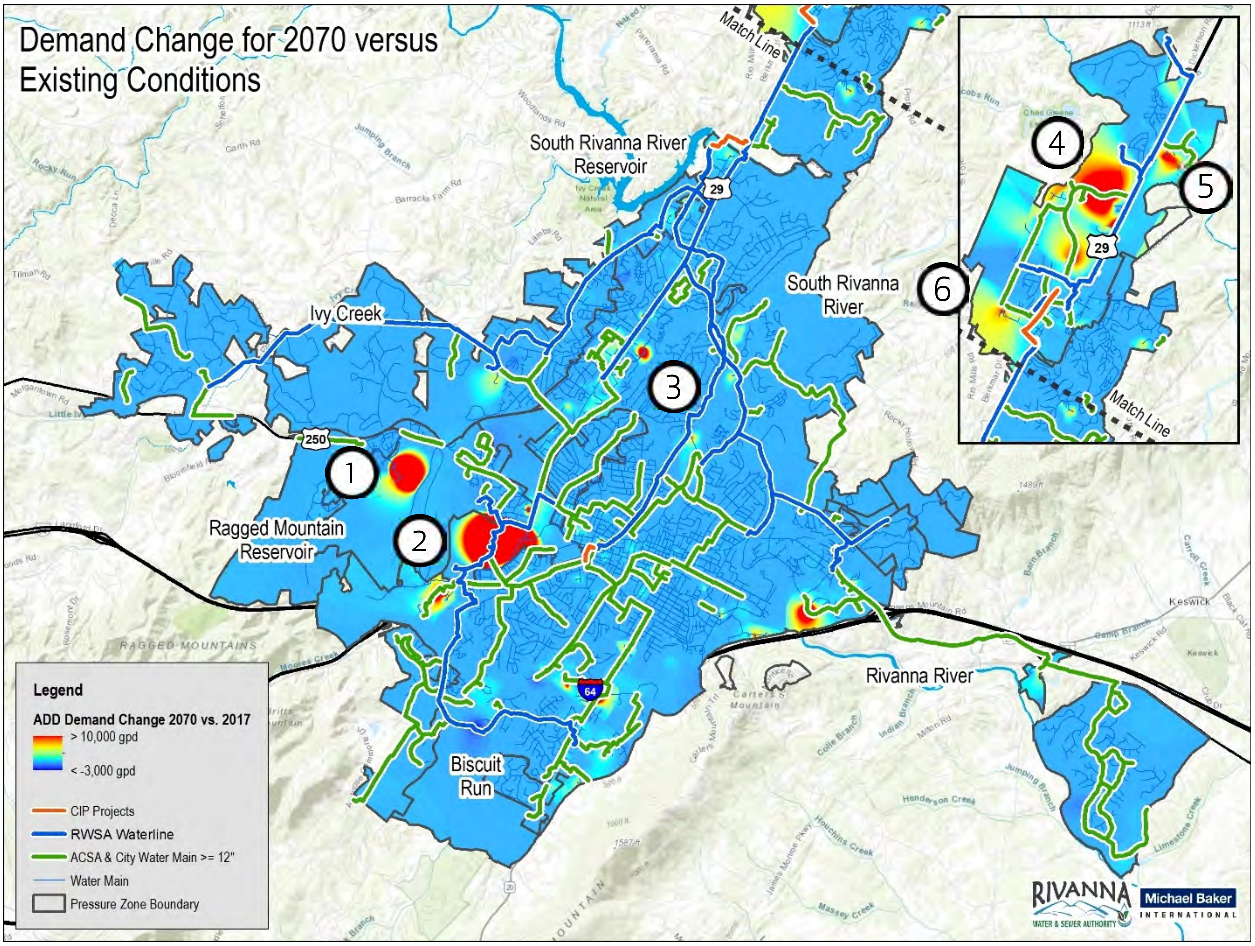

Figure 4. Projected Change in Average Day Demand from 2020 to 2070.

(End of section.)

4. Planning Scenarios

Two inputs affect planning scenarios for the UFWMP: projected demand and system operations. Each is discussed in more detail in the following sections, followed by a brief discussion on the approach to scenario management.

4.1. Water Treatment Plant Production

For the purposes of the UFWMP, the demands developed from 2017 retail water meter readings are assumed to be valid for the year 2020. Development and distribution of demand projections are discussed in Sections 3.1 and 3.6, respectively, and cover the following timeframes (years):

- 2020 (Existing Conditions)
- 2030 (10-Year Projection)
- 2045 (25-Year Projection)
- 2070 (50-Year Projection)

Facility configurations are divided into production and conveyance options, which focus on the ability to move water from a WTP to the area(s) of need. The RWSA provided timelines for current and planned future capacity upgrades at both the OBWTP and the SRWTP, as shown in Table 6. For the purposes of the UFWMP, the NRWTP is assumed to be off-line (and now it will be decommissioned in FY25), as this scenario imparts the most hydraulic stress on the transmission and distribution system, particularly when the OBWTP is the only source of finished water, as water must be taken from the northern UPZ to support the North PZ.

Table 6. WTP Capacities (MGD) for Planning Horizon

Facility Capacity by Year	2020	2030	2045	2070
SRWTP	12	12	16	16
NRWTP	2	0	0	0
OBWTP	7.7 (5.0†)	10	10	10

†Production limited by raw water pumping capacity

Periods of low to moderate demand typically do not stress the distribution system hydraulically, especially when the SRWTP is providing a majority of the production; planning scenarios therefore focus on high-demand situations for each planning horizon. During periods of higher demand, the RWSA typically operates best when water production by the two primary WTPs, OBWTP and SRWTP, is balanced. A balanced condition is, however, not always feasible, and understanding operational challenges and how to mitigate them was further investigated with modeling. To better understand the hydraulic stress on the system, the ratio of water production between the OBWTP and SRWTP was skewed more heavily towards one WTP or the other, with the goal of achieving a 25% - 75% split for modeling purposes. Such a ratio may be necessary, for example, during drought conditions, when the amount of water available from the SFRR is curtailed.

Due to the demand associated with a given planning timeframe (year) and the capacity of a given WTP, a 75% production target may not be achievable. In this case, the WTP production was maximized to 90% of its rated capacity, with the remaining demand satisfied by the other WTP. WTP production ratios are presented in Table 7 (hot/dry ADD) and Table 8 (hot/dry MDD). Only ratios that result in the most hydraulic stress on the transmission and distribution system were evaluated. Note that the OBWTP cannot provide 75% of hot/dry MDD for any planning timeframe. With OBWTP production maximized, as demand continues to increase in the future, the SRWTP must supply the additional demand.

Table 7. OBWTP/SRWTP Hot/Dry ADD Target Production Ratios

Year	Demand (MGD)	Capacity (MGD)	Metric	OBWTP / SRWTP Target Production Ratio		
		OBWTP / SRWTP		25 / 75	50 / 50	75 / 25
2020	10.1	7.7 (5.0†) / 12	Outflow (MGD)	2.5 / 7.6	5.0 / 5.1	-
			Ratio	25 / 75	50 / 50	-
2030	11.3	10 / 12	Outflow (MGD)	2.8 / 8.5	5.65 / 5.65	8.5 / 2.8
			Ratio	25 / 75	50 / 50	75 / 25
2045	12.7	10 / 16	Outflow (MGD)	3.15 / 9.55	6.35 / 6.35	9* / 3.7
			Ratio	25 / 75	50 / 50	71 / 29
2070	14.3	10 / 16	Outflow (MGD)	3.55 / 10.75	7.15 / 7.15	9* / 5.3
			Ratio	25 / 75	50 / 50	63 / 37

†Production limited by raw water pumping capacity
*Production limited to 90% of rated WTP capacity

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Table 8. OBWTP/SRWTP Hot/Dry MDD Target Production Ratios

Year	Demand (MGD)	Capacity (MGD)	Metric	OBWTP / SRWTP Target Production Ratio		
		OBS / SR		25 / 75	50 / 50	75 / 25
2020	14.9	7 (5‡) / 11	Outflow (MGD)	5.0‡ / 9.9*	5.0‡ / 9.9*	-
			Ratio	34 / 66	34 / 66	-
2030	16.6	10 / 12	Outflow (MGD)	4.15 / 12.45	8.3 / 8.3	9.0* / 7.6
			Ratio	25 / 75	50 / 50	54 / 46
2045	18.7	10 / 16	Outflow (MGD)	4.7 / 14.0	9.0* / 9.7	-
			Ratio	25 / 75	48 / 52	-
2070	21.0	10 / 16	Outflow (MGD)	6.6 / 14.4*	9.0* / 12.0	-
			Ratio	31 / 69	43 / 57	-

‡Production limited by raw water pumping capacity
*Production limited to 90% of rated WTP capacity

4.2. System Operations

Scenarios for system operations focus on providing adequate pressure, with no more than a 5 psi drop in minimum pressure compared to the baseline scenario. System operations are affected by three classes of facilities: waterlines, pumps, and storage tanks. Redundancies in these facilities contribute to overall system resilience, which is the ability to accommodate adverse operating conditions while maintaining adequate service. Appendix D summarizes urban water system facilities. System operations for each facility class are discussed in detail in Sections 6 (Waterlines), 7 (Storage Tanks), and 8 (Pumping Facilities).

4.3. Redundancy / Resilience

Redundancy and resilience are related but not synonymous. Redundancy is the presence of an alternative for performing a function, without needing to take additional action to use that alternative. For example, the Observatory and Avon Street Tanks provide redundant storage to the southwestern part of the urban finished water system: if one of the tanks is off-line temporarily, the other tank can automatically provide water to the system without taking special measures, as the tanks are hydraulically well-connected to each other.

Resilience is the system's ability to withstand an adverse event while providing an acceptable level of service. In contrast to redundancy, resilience can require that special action be taken. For example, in single-feed areas, if the transmission main breaks, the RWSA has options for mobilizing equipment and crews to effect a bypass while the break is being repaired.

Recommendations for adding system redundancy and improving system resilience are presented for each type of facility in Sections 6, 7, and 8.

4.4. Scenario Management Approach

The general approach to scenario management is to identify improvements necessary for adequate system performance under two conditions: near-term imbalanced WTP production, and long-term peak demand (2070 hot/dry MDD). Improvements necessary for the near term may not be required for the long term but must be made, given demand projections and planned schedule of WTP production capacities.

Operational scenarios are used to develop recommendations to improve system performance if model results indicate that performance criteria are not met. Recommendations are then verified and refined as necessary to address special operating conditions, such as a tank or water main being out of service. Special operating conditions are discussed in more detail in each facility's respective section.

(End of section.)

5. Existing Conditions Baseline

5.1. Baseline Condition

The baseline for evaluating the impact of a given scenario on system performance is existing ADD for hot/dry conditions. Under this scenario:

- The RWSA's proposed ARPS, instead of the NRWTP, supplies water to the North PZ.
- The OBWTP operates for 12 hours a day and produces a total of 1.8 MG per day.
- The SRWTP operates continuously and provides 7.6 MG per day.
- Total combined WTP production is 9.4 MGD.

Figure 5 presents modeled minimum system pressures for comparison purposes, and Figure 6 shows modeled tank levels in the UPZ. The ARPS is assumed to be on-line to simulate the most hydraulic stress on the northern UPZ, once it is in service. The graph in Figure 7 demonstrates estimated impact of the ARPS on the hydraulic grade line (HGL) in the northern UPZ.

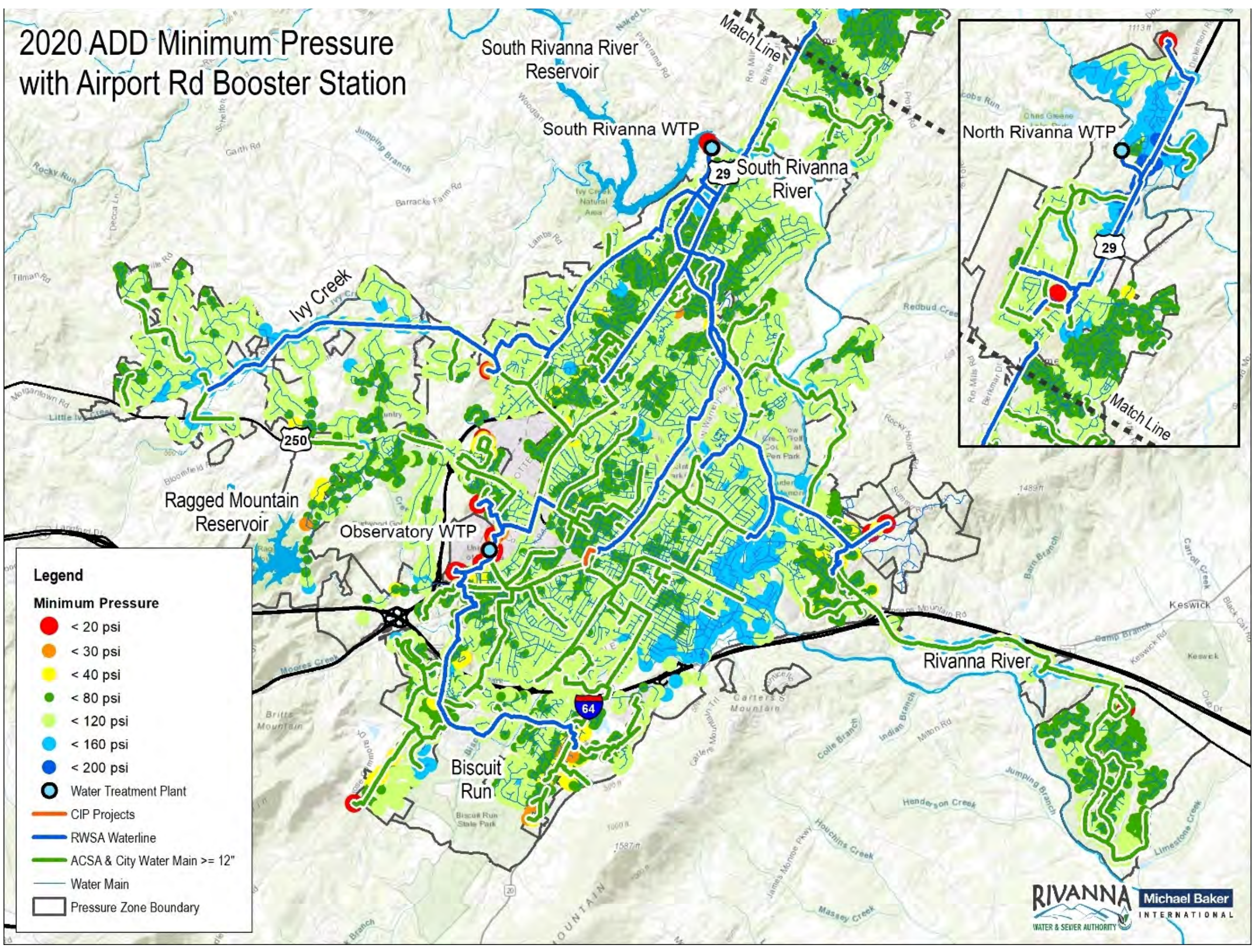

Figure 5. Minimum System Pressures for Baseline Condition.

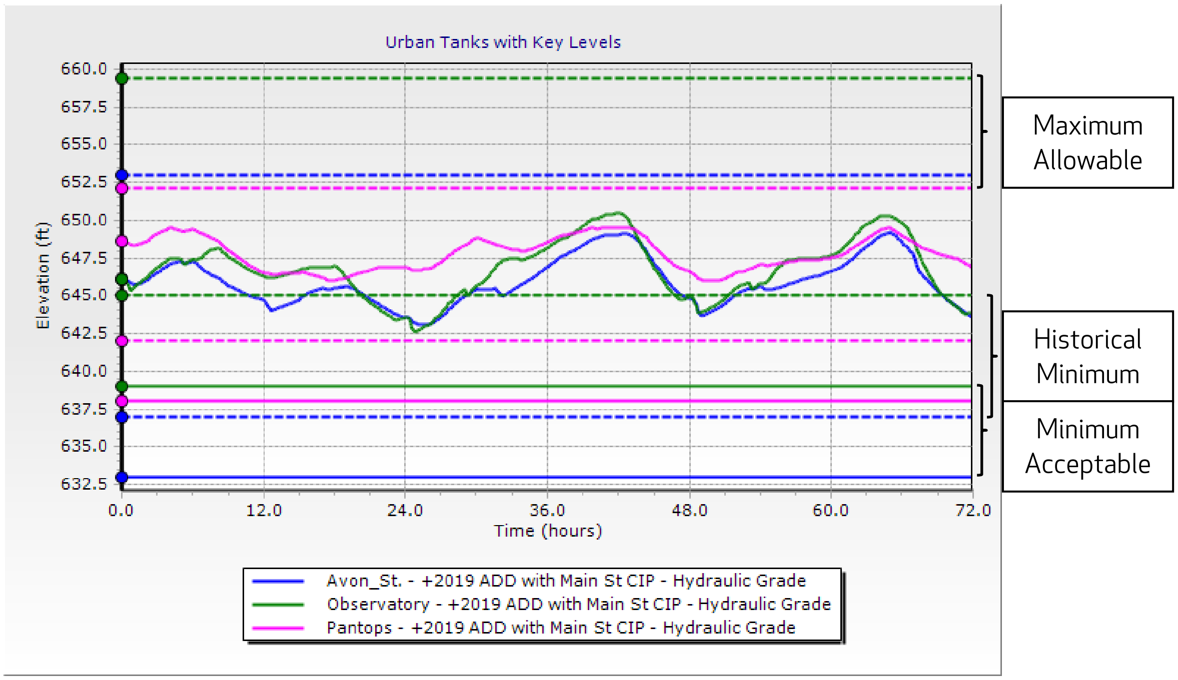

Figure 6. Urban Zone Tank Level Performance for Baseline Condition.

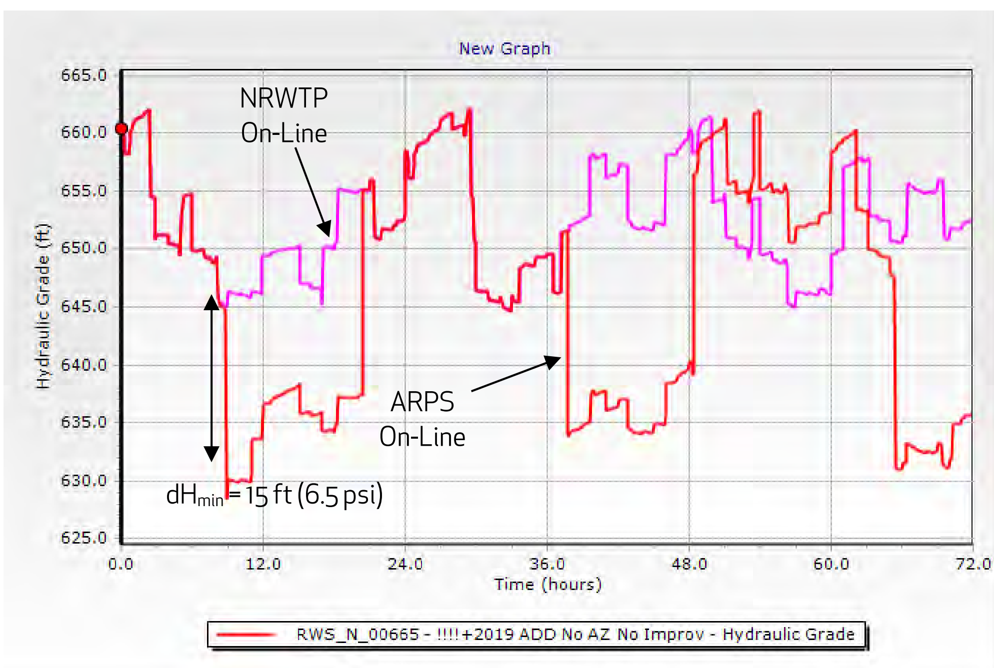

Figure 7. HGL at Seminole Trail and Ashwood for NRWTP vs. ARPS as Supply.

As Figure 5 shows, pressures are highest along the North Rivanna River and Seminole Trail in the North PZ, along the Rivanna River in the UPZ, and along Ivy Creek in the Stillhouse PZ. These areas are all low in elevation relative to the PZ's HGL, and the ACSA has installed individual

PRVs to reduce pressure for these customers. The lowest pressures are at high elevations, such as the OBWTP and its vicinity, and storage tanks. The suction side of pumps also exhibit localized low pressures; this is most readily seen at the ARPS and the SRWTP.

In Figure 6 and all other graphs of UPZ tank levels, the dashed lines represent the upper allowable and historical lower operating range of a given tank, and the solid lines represent the minimum acceptable level ("alarm level") of each tank. The reference lines are color coded by tank, and the color scheme is consistent throughout.

For existing conditions, the UPZ tanks float fairly closely to each other, and they refill completely almost every day if not daily over the course of a three-day ADD simulation. Of all storage facilities in the urban finished water system, the UPZ tanks are the most sensitive to changes in operations. Unlike the UPZ tanks, tanks in other PZs are supplied by PSs and are therefore influenced by changes in operations only if the total dynamic head (TDH) exceeds a pump's ability to refill its tank. This typically only happens when pressure on the suction side of the pump is depressed. Recommendations that result in maintaining pressure within the UPZ therefore also directly contribute to maintaining pressure in the higher PZs.

5.1.1. Finished Water Geographical Distribution

Figure 8 presents the modeled geographical distribution of finished water for existing ADD conditions, as simulated in the hydraulic model given the following assumptions:

- The NRWTP starts refilling the Piney Mtn. Tank at 8 a.m. at a rate of 900 gpm.
- UVA refills its tanks quickly (4,100 gpm) just after midnight and tops them off at 5 a.m.
- UVA pumps at a lower rate (1,200 gpm) during day/evening hours (8:15 a.m. to 11 p.m.).
- The OBWTP operates from 7 a.m. to 7 p.m. at a rate of 2,500 gpm.
- The SRWTP operates continuously, producing 5,900 gpm when refilling Pantops Tank, and 4,300 gpm at all other times.
- The Woodburn tank is refilled at midnight and provides 0.18 MGD process water for the SRWTP.

Of interest is the contribution of SRWTP water to that consumed in the southwestern part of the urban system. Due to current WTP operating schedules and limitations in the hydraulic connectivity of the existing transmission system, water from the OBWTP most directly supports the Lewis Mtn. and Ednam PZs via the Alderman Road PS, areas of the UPZ connected directly to the Southern Loop Waterline, and the Mosby Mtn. and Mill Creek PZs. The SRWTP supports Stillhouse and the remainder of the UPZ, including downtown Charlottesville, Lambeth, Avon Street as far south as I-64, Pantops, Ashcroft, and Glenmore.

While the concept is counter-intuitive, a majority of water moving past the Lambeth PS intake is moving from the SRWTP towards the OBWTP and the Alderman Road PS intake (Figure 9), given the operating assumptions described above. The Alderman Road PS draws water from both directions, with the OBWTP and Observatory Tank providing a majority of the water pumped into the UVA and Lewis Mtn. PZs. WTP production schedule for the results presented in Figure 8 and Figure 9 is shown in Table 9 and Figure 10. The amount of SRWTP water reaching the southwestern part of the system will vary depending on WTP operating rates and schedules, UVA pumping rates and schedules, overall demand in the southwestern area compared to OBWTP production, and other operations decisions and actions made from day to day.

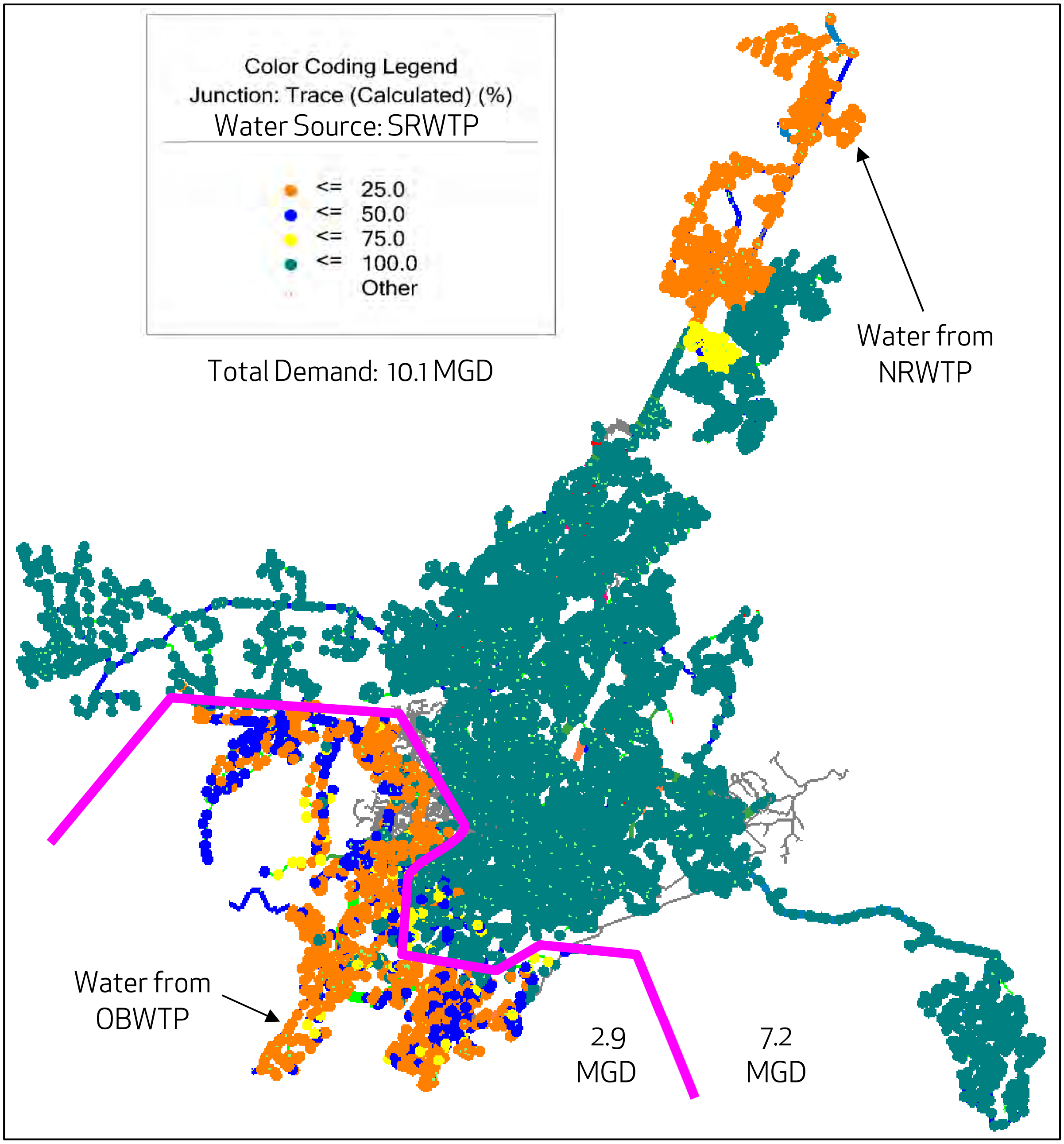

Figure 8. Water Source Tracing for 2020 ADD Conditions.

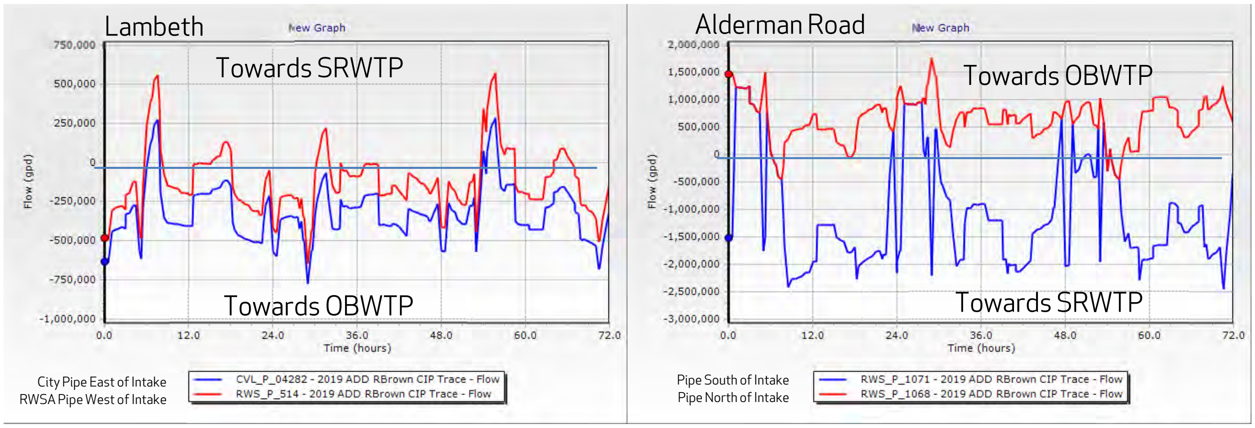

Figure 9. Flow Direction at Alderman Road and Lambeth PS Intakes for 2020 ADD.

Table 9. WTP Production Schedule for 2020 Average Day Demand

WTP	Average Flow Rate When Producing Water (MGD)	Operating Schedule
SRWTP	6.76	24 hours
NRWTP	1.29	8 a.m. – 3 p.m.
OBWTP	3.59	7 a.m. – 7 p.m.

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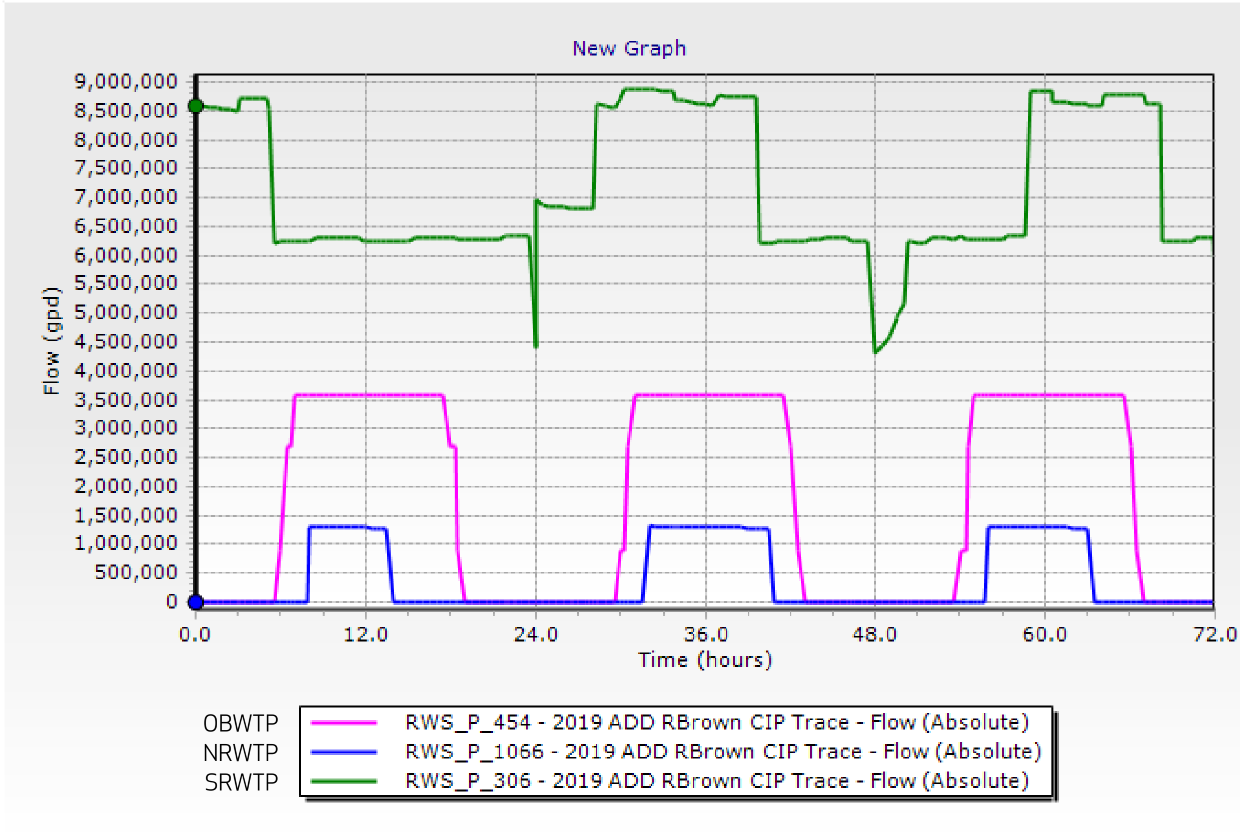

Figure 10. WTP Production Schedule for 2020 ADD.

From a review of Figure 9, the Lambeth PS is supplied almost exclusively by the SRWTP. Flow going past the intake is added to flow coming from the SRWTP via the City's 10-inch water main in Emmet Street (Figure 11), to provide on average 0.5 MGD to the Alderman Road PS (both the UVA side and the RWSA side). During the day, the OBWTP supplies the Alderman Road PS with approximately 1.75 MGD.

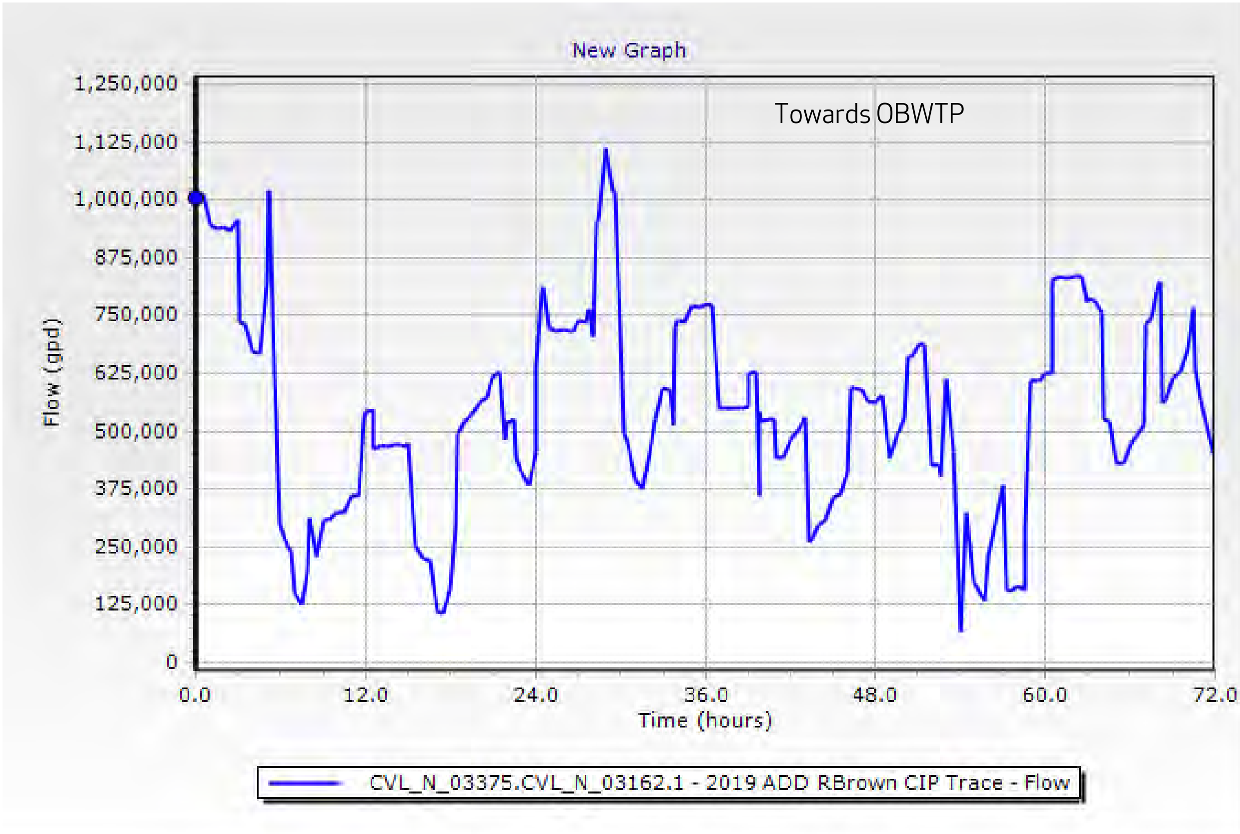

Figure 11. Flow in City 10-inch Emmet Street Main at Lambeth Commons for 2020 ADD.

5.1.2. Fire Flow Considerations

Both the ACSA and the City provided information on needed fire flow (NFF) for some of the non-residential properties within their jurisdictions (Appendix E) but did not provide information on whether buildings with high NFF values have approved automatic sprinkler systems. Michael Baker geolocated the provided NFF values for further processing. For customer meters without NFF provided, Michael Baker assigned NFF based on meter classification, assuming 1,000 gpm for single-family residences and 1,500 gpm for all other customer categories (NFPA 1, 18.4.5). Michael Baker assigned water meters to the nearest hydrant and used the highest NFF, whether provided or assumed, to evaluate the system's ability to provide fire flow.

Fire flow evaluations were modeled at 7 a.m. with tanks set at the lowest level at 7 a.m. from a three-day simulation. Based on how WaterGEMS conducts AFF calculations, pump operations had to be anticipated to appropriately set pump status prior to initiating the calculation. For most PSs, this meant turning on both the lead pump and the (first) lag pump. For the Lambeth PZ, this meant turning on the high-flow pump and turning off the low-flow pumps. Figure 12 shows locations where AFF, based on the hydraulic modeling evaluations completed for the UFWMP, does not meet or exceed the provided or assumed NFF.

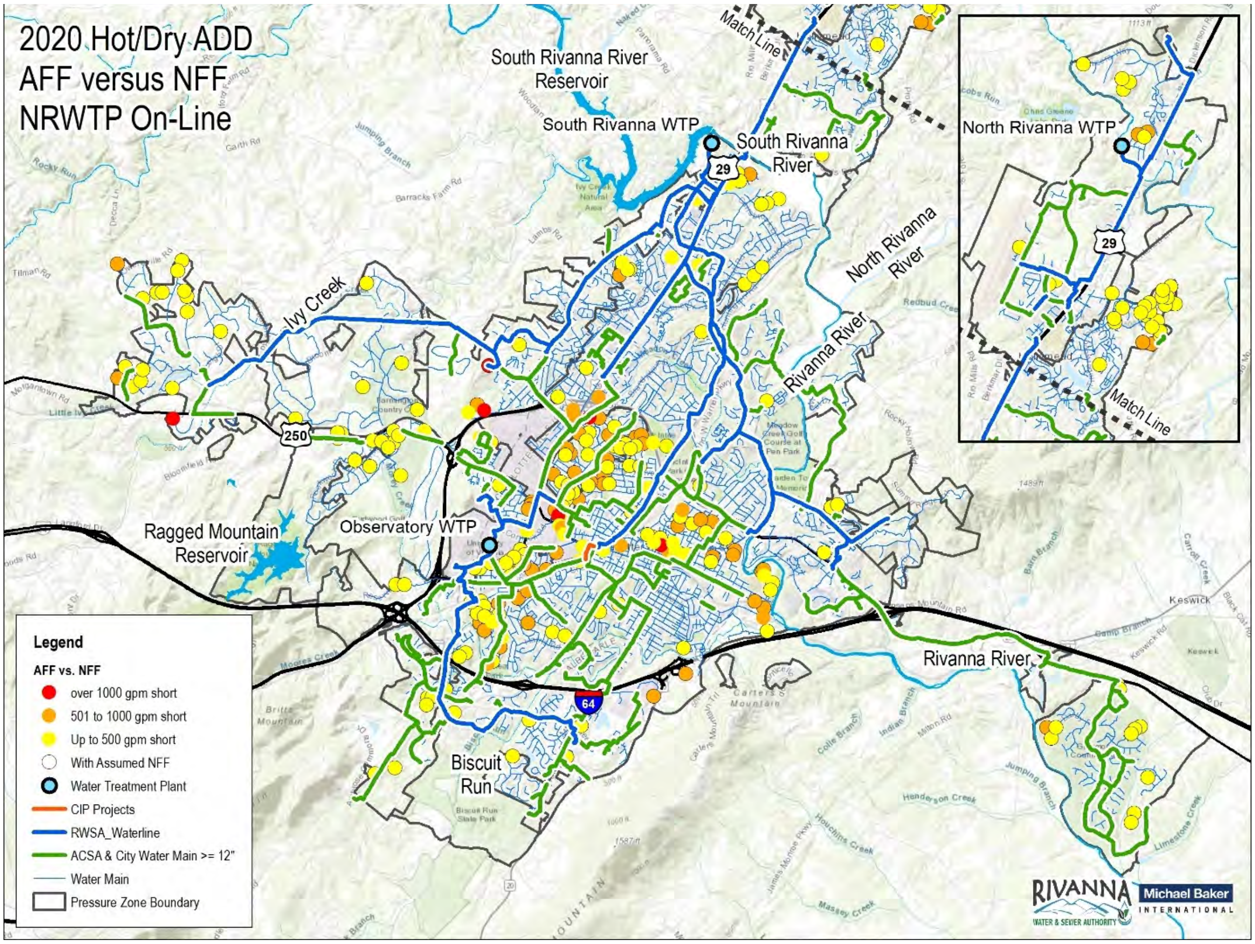

Figure 12. AFF vs. NFF for Baseline Condition (2020 hot/dry ADD).

For the UFWMP, AFF evaluations are for qualitative purposes only: they indicate where system pressure may be insufficient to deliver NFF, even if pressure without a fire flow event is above the minimum acceptable level per the criteria presented in Section 3.5. Of interest, clusters of low AFF are located along the Emmet Street corridor in the gap between the South Rivanna Waterline (at Seminole Trail/Hydraulic Rd) and the Observatory Waterline (near Lambeth PS), and along the gaps in between the Observatory WTP, Urban Waterline, and Pantops Waterline, supporting where the Central Waterline and Emmet St. Waterline are needed.

The locations outlined in Figure 12 are generally on smaller ACSA and City mains, which may indicate more localized issues, whether in the model or in the field. The results of AFF evaluations can be utilized to identify areas for further investigation, such as calibration of localized hydraulic model parameters to recent hydrant test data (Section 9.2), and field verification of valve settings, both of which are beyond the scope of the UFWMP.

Each retail water utility is responsible for verifying the ability of its distribution system to provide the required fire flow. Where the retail utility model indicates adequate AFF compared to the RWSA model, Michael Baker recommends coordination between the RWSA and the City/ACSA to verify model conditions, e.g., tank levels, pipe C factors, demands, and time of day. The scope of the UFWMP is to recommend ways that the RWSA's transmission and storage network can deliver the required amount of bulk finished water while maintaining the required minimum pressure. The retail utilities are responsible for providing minimum pressure within the distribution system to support retail customer demands, including provision of fire flow.

5.2. Near-Term Sole-Source WTP Production

One of the RWSA's key challenges for the near term is transmitting finished water when production out of the WTPs is imbalanced. The hydraulic analyses presented in this section assume that all average daily demand is supplied by only one WTP, and that planned near-term treatment plant upgrades have been completed. This analysis evaluates scenarios that provide the most imbalanced stress on the distribution system and aids in identifying the hydraulic challenges of the overall system.

If the SRWTP is the only source to the UPZ, the Pantops Tank, which is hydraulically well-connected to the SRWTP, operates near its desired range. Refilling the Avon Street and Observatory Tanks, in contrast, can be a challenge, and generally these tanks float approximately five feet lower than the Pantops Tank. In addition, the Observatory Tank operates below its preferred minimum level and occasionally near its minimum acceptable level for this scenario. This indicates that the system struggles to get water from the SRWTP to the area around the OBWTP. Figure 13 presents estimated tank levels for when the SRWTP is the only source of finished water. Minimum system pressures are within 5 psi of those exhibited for normal operating conditions (Figure 14). Although the system is generally functional in this scenario, operations can be challenging and since the UPZ tanks are not completely filling, the amount of operating, fire suppression, and reserve storage is reduced - thereby reducing the resiliency and reliability of the system.

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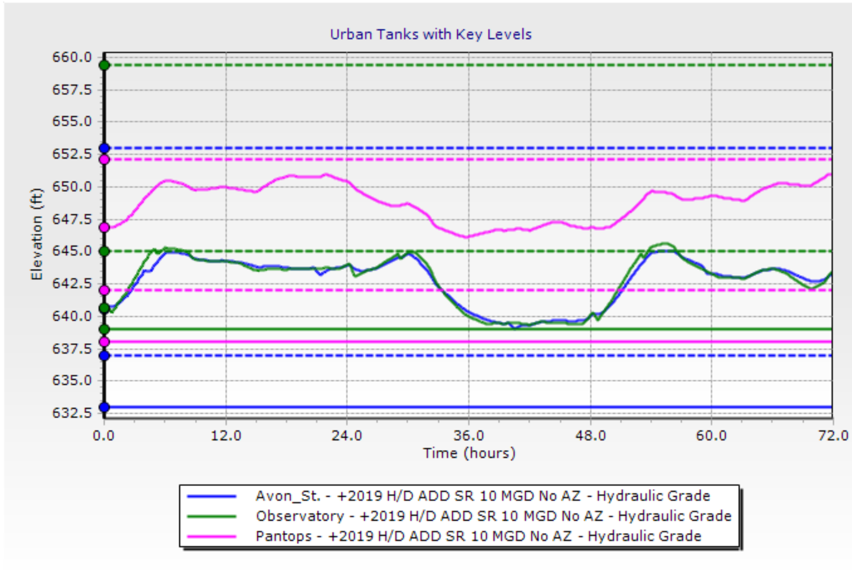

Figure 13. Urban Zone Tank Level Performance for SRWTP as Only Supply.

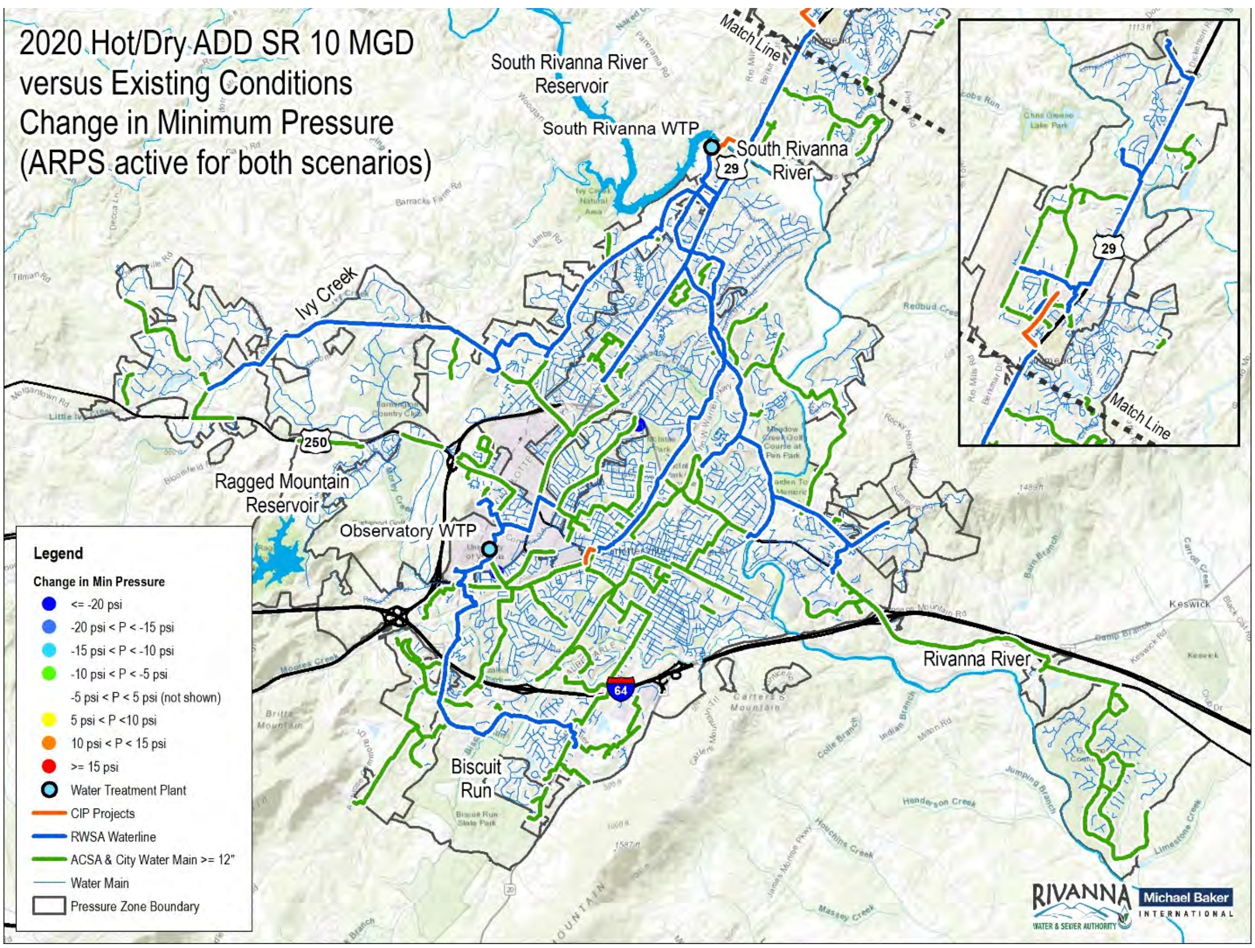

Figure 14. Change in Baseline Minimum Pressure for the SRWTP as Only Supply.

If, however, the OBWTP is the only source, the modeling shows that the Pantops Tank operates below its current minimum acceptable range. The Avon Street and Observatory Tanks, in contrast, remain full with very little turnover. Figure 15 presents estimated tank levels for when the OBWTP is the only source of finished water. This indicates that the system struggles to get water away from the OBWTP to the rest of the system. The water backs up in the southwestern portion of the UPZ in the Observatory and Avon Tanks and cannot effectively move to the northeastern portions of the UPZ.

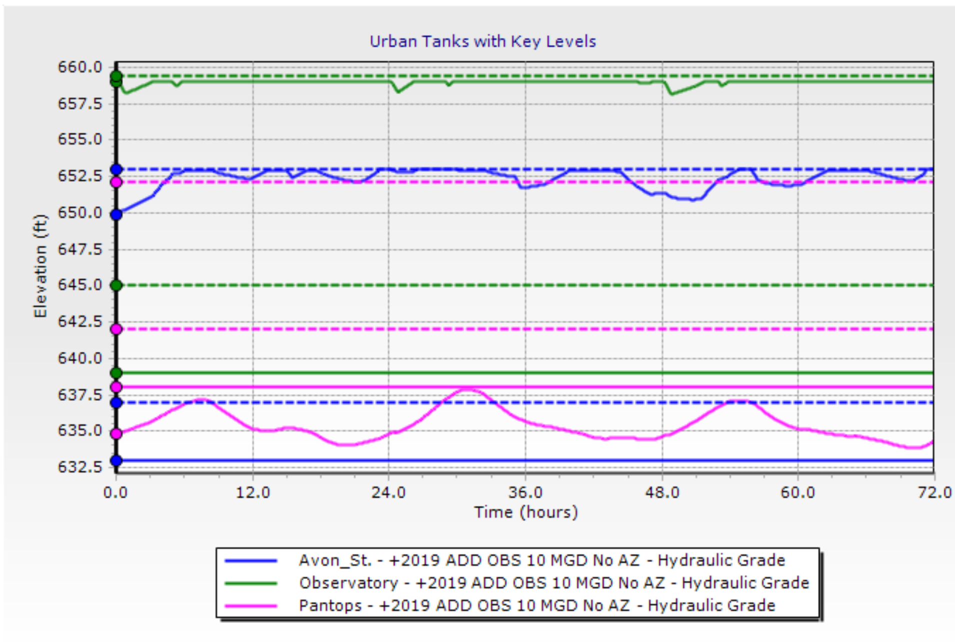

Figure 15. UPZ Tank Levels for Existing Pipe Network with the OBWTP as Only Supply.

Minimum pressures are noticeably higher near the OBWTP and noticeably lower in the north and east ends of the UPZ (Figure 16). These changes reflect the difficulty in moving water away from the OBWTP, and the impact is exacerbated when withdrawing UPZ water by the planned ARPS when the SRWTP is not on-line.

Both of the challenging operating scenarios described above (NRWTP and SRWTP off-line, or NRWTP and OBWTP off-line) will be feasible from a WTP capacity standpoint in the near future, once the OBWTP upgrades (and RMR to OBWTP raw water line) and the ARPS construction are completed. Even though the OBWTP operates by gravity (with no high service pumps), it was designed with a maximum HGL of 673 feet at the overflow weir, which is adequate to deliver water to the system. However, the existing lack of transmission capacity to move water away from the OBWTP will restrict the RWSA's ability to convey the full 10 MGD out of and away from the OBWTP. Operating the OBWTP as the primary or sole source of finished water will therefore require significant finished water transmission main improvements in order to be an operationally viable alternative. Although anticipated to be an uncommon occurrence, operating the OBWTP as the sole source of production may be warranted during a drought, catastrophic event at the SRWTP or SFRR, or SRWTP transmission waterline outage. Transmission capacity improvements to move finished water north and east of the OBWTP are therefore important for redundancy and resilience.

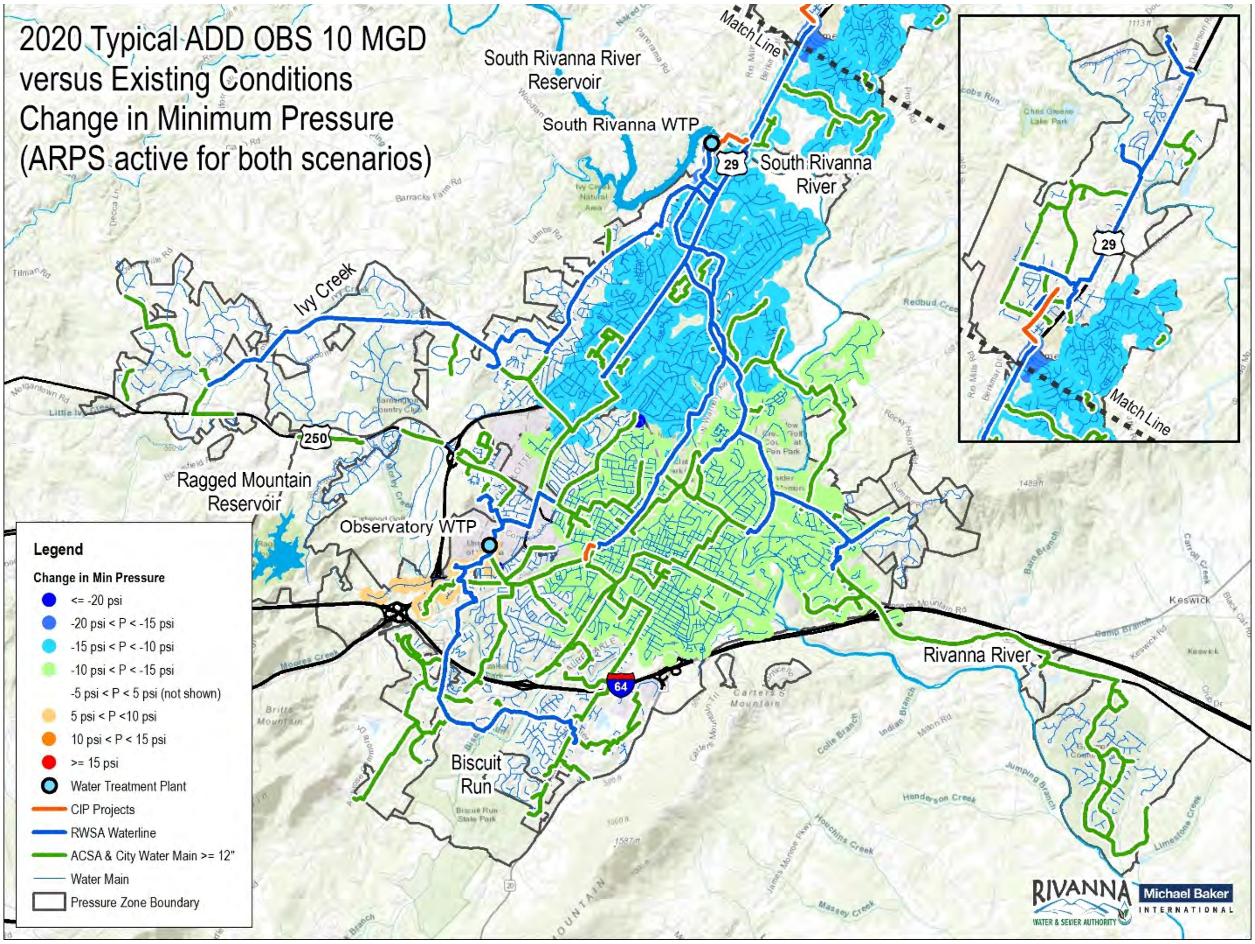

Figure 16. Change in Baseline Minimum Pressure for the OBWTP as Only Supply.

5.3. Long-Term Balanced WTP Production

The objective of this scenario is to evaluate whether the existing urban water system, together with planned long-term WTP upgrades, has sufficient conveyance capacity to provide water service during periods of very high demand, specifically 2070 maximum day demand. This scenario assumes the following conditions: 2070 MDD during typical (i.e., not hot/dry) conditions, balanced water production from the OBWTP and the SRWTP, and OBWTP capacity upgraded to 10 MGD.

In this modeled scenario, total system MDD is approximately 19 MGD, with the OBWTP and SRWTP averaging 8.2 and 10.6 MGD, respectively, over a 24-hour period. The maximum hourly production rates are within the preferred 90% WTP capacity ranges of 9.0 and 10.8 MGD, respectively. As with the near-term scenario in which the SRTWP is the sole source of water for the urban system, under this scenario minimum system pressure does not change significantly from the baseline condition (Figure 17).

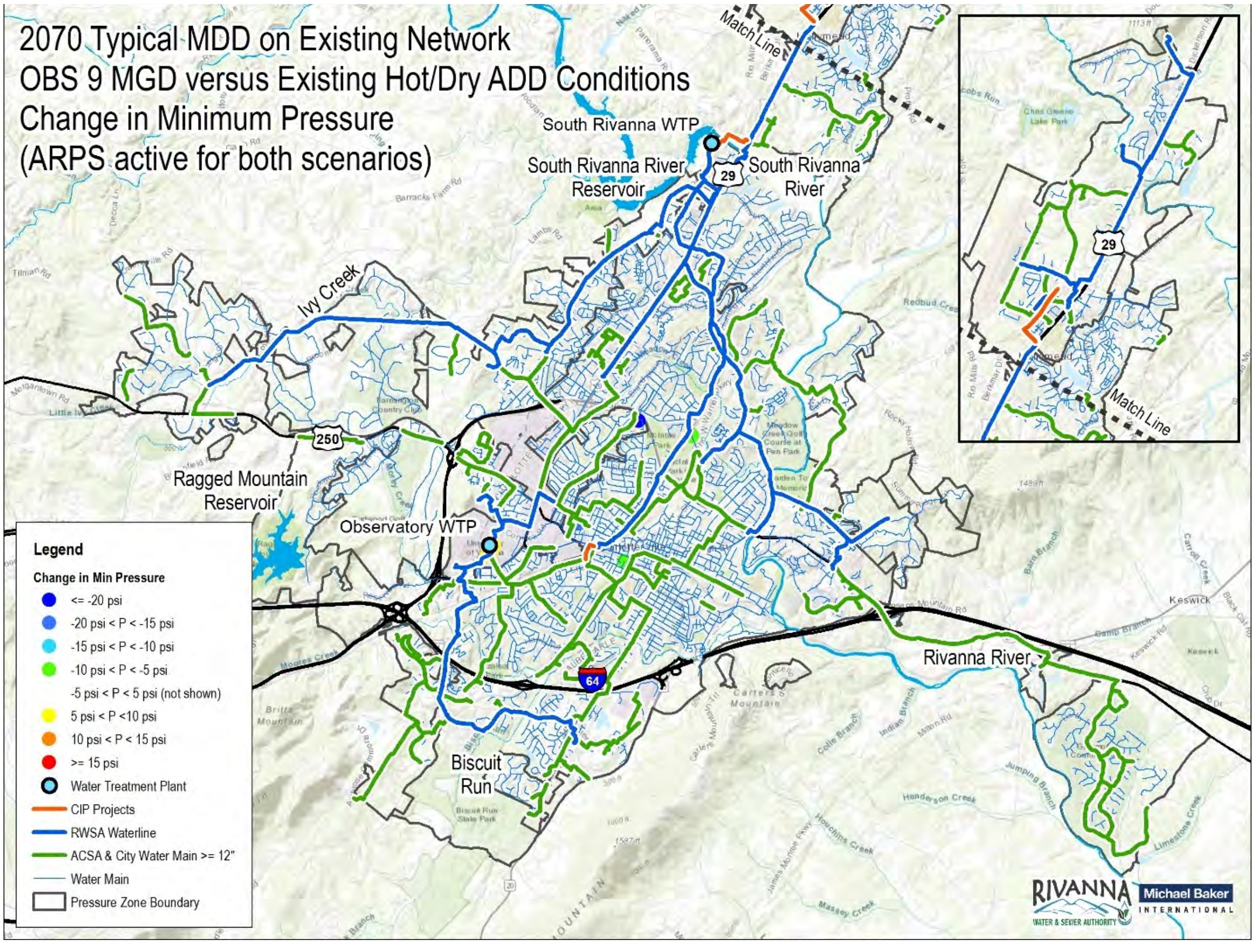

Figure 17. Change in Baseline Minimum Pressure with Balanced WTP Production.

A three-day MDD simulation provides insight on a worst case scenario of back to back maximum day demands. A three-day simulation is also used in part to make sure that there is repeatability in the results, and that control strategies implemented in the model result in the desired performance metrics. The demands, tank operating volumes, and pump station operations control whether a given part of the system exhibits a 24-hour repeating pattern in HGL/pressure, so the extended simulation provides information on how the system can or cannot recover and whether the assumed control strategies are adequate. Results from multi-day MDD simulations indicate that the finished water system, with recommended conveyance improvements and storage management changes, and with planned WTP capacity upgrades, will be able to withstand a period of several days during which total demand exceeds production capacity.

For this scenario, while system performance is not ideal and does not meet all RWSA goals, it is marginally functional. The UPZ tanks are close to achieving a minimum of five feet of turnover per day, and they are all above the minimum tank level (Figure 18). However, the tanks float approximately 10 feet apart, which is not preferred: the Observatory Tank has the highest HGL, and the Pantops Tank has the lowest HGL and falls below the preferred operating range part of the time.

Since the Pantops and Avon Tanks would operate at lower elevations, the volumes of operating storage, fire suppression storage, and reserve storage are significantly diminished - thereby reducing the reliability and resiliency of the distribution system. This is consistent with the near-term results of other model runs: the existing pipe network cannot move water efficiently away from the OBWTP to support Pantops and the northern UPZ. Another indicator of the difficulty in moving water is that the SRWTP discharge pressure is below the preferred operating target (80 psi) for most of the three-day simulation (Figure 19): the SRWTP must support more of the UPZ because the OBWTP water cannot move away from its plant efficiently.

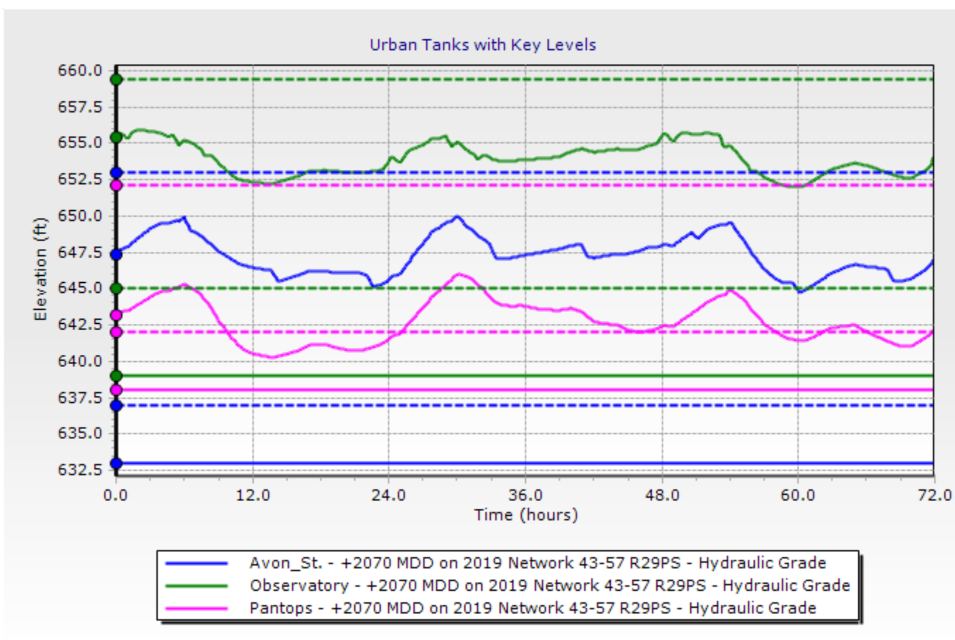

Figure 18. Urban Zone Tank Levels for 2070 Typical MDD on Existing System.

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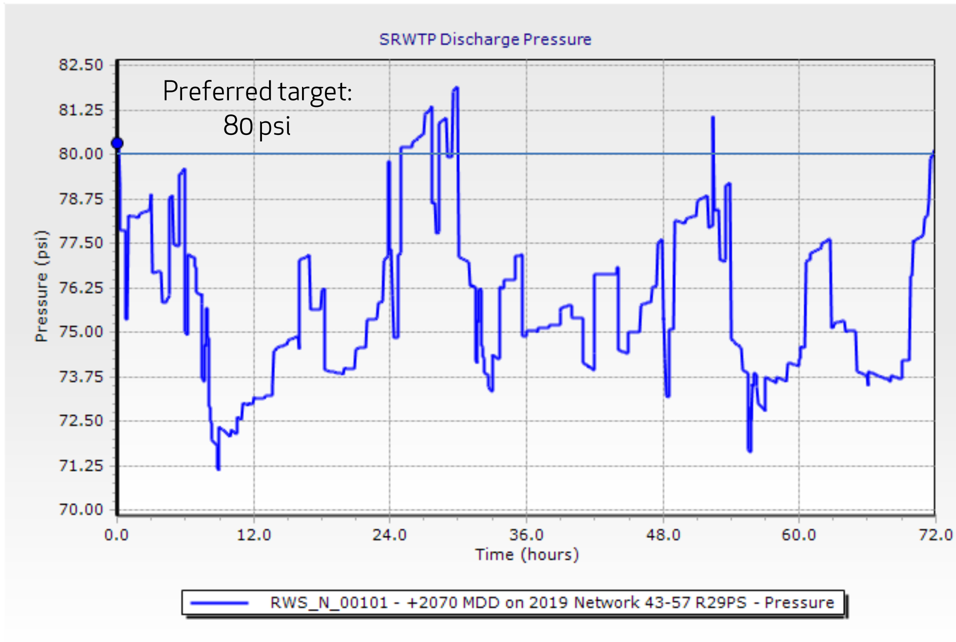

Figure 19. SRWTP Discharge Pressure for 2070 Typical MDD on Existing System.

The key take-away from the near-term and long-term scenario evaluations is that the existing system is inefficient in moving water to and from the vicinity of the OBWTP. This adversely affects the RWSA's current flexibility to adjust WTP and tank operations when imbalanced water production is required, and it limits the maximum effective output from the OBWTP, even during periods of balanced water production. As demands continue to increase into the future, the hydraulic inefficiencies will pose greater operational challenges unless resolved.

While not a "finished water" project, completing the SFRR to RMR Raw Water Pipeline, including its connection to the OBWTP, will have a significant impact on improving redundancy and resilience for providing finished water to the urban system. This project will give the RWSA flexibility in moving raw water from either major reservoir to either major WTP, providing an indirect but valuable redundancy to the finished water connections between the major WTPs.

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6. Waterlines

The RWSA's waterlines, which form the backbone of the urban finished water system, transport water from the WTPs to the utility distribution networks for delivery to retail customers.

6.1. System Operations

Generally, if the system has adequate pressure, then friction losses are minor. This means that the size of the transmission main is well-suited to the flow being carried. If pressures are too low in a given part of the system, increasing conveyance capacity to the under-served area may be required. Piping alternatives to increase conveyance capacity include upsizing existing mains, installing parallel mains, and installing pipe on new alignments (e.g., gap closures). Piping alternatives are the primary tool for addressing adverse operating conditions, and water transmission main gap closure is a primary recommendation of the UFWMP (Figure 20).

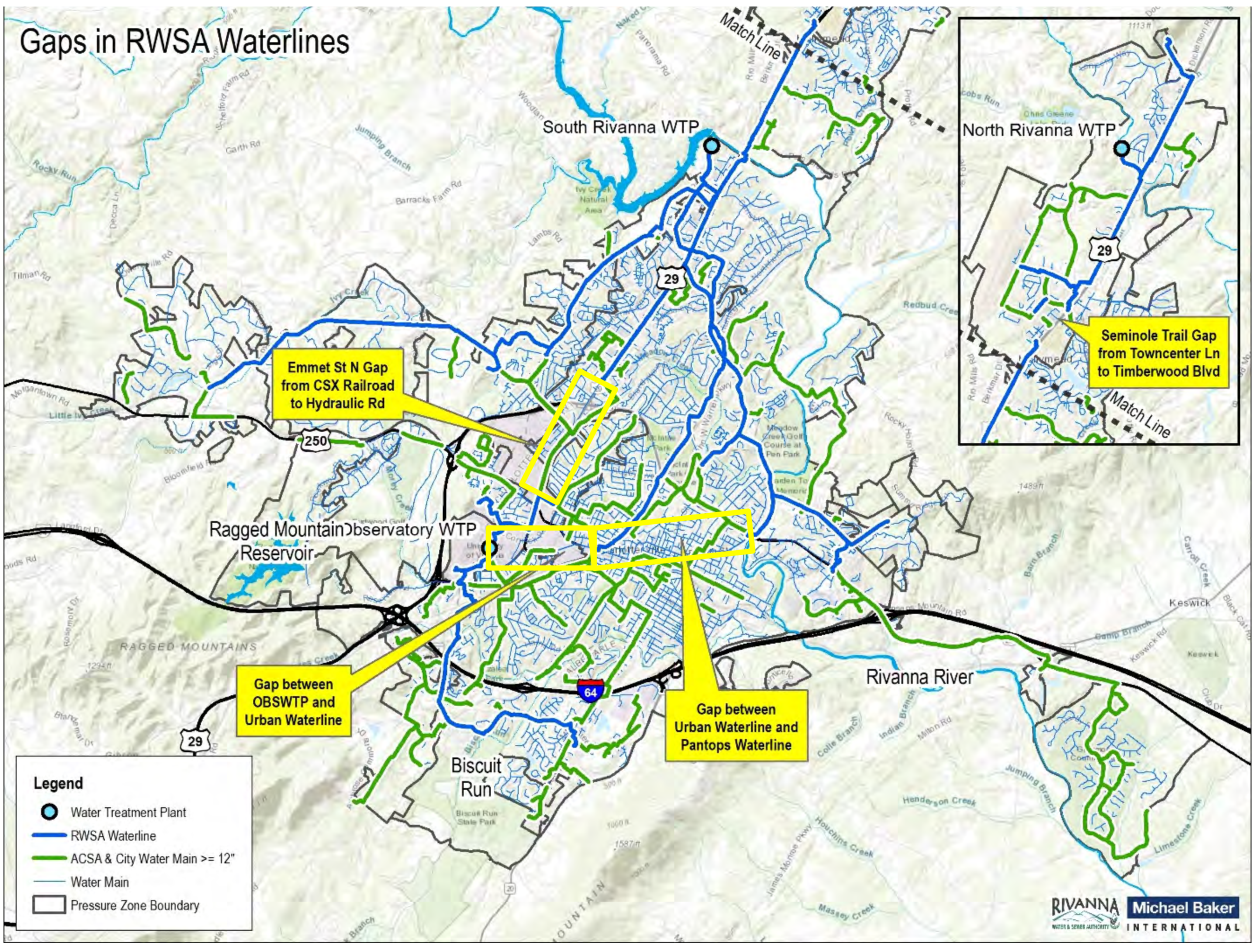

Figure 20. Existing Gaps in the RWSA's Finished Water Transmission Network.

Of the timeframes evaluated for the UFWMP, hydraulic conditions for the year 2030 are the most susceptible to imbalanced production between the OBWTP and the SRWTP, assuming the OBWTP is the primary source of water. 2030 is therefore more likely than later years to highlight challenges in moving water from the upgraded OBWTP to the rest of the UPZ. This is because, with OBWTP production maximized, the increase in production to meet higher demand must come from the SRWTP. The SRWTP will therefore satisfy more of the total system demand, reducing the percentage of system demand (and, by extension, geographical reach) that the OBWTP must satisfy.

The greatest hydraulic stress on the system given a 75/25 production ratio will be when demand reaches 12 MGD, with the OBWTP producing its maximum 9 MGD (i.e., at 90% of capacity). Before completing the SFR-to-RMR Raw Water Pipeline, this scenario applies to drought conditions, when withdrawal at the SRWTP is restricted due to minimum flow requirements at the South Fork Rivanna River Dam to sustain the downstream ecological community.

For situations when imbalanced water production is skewed towards the OBWTP, unless treatment capacity at the OBWTP is increased further, the SRWTP must increase production as demand increases beyond 12 MGD. (75% of 12 MGD is 9 MGD, which is the 90% capacity limit when the OBWTP is upgraded to 10 MGD.) This will act as "back pressure" on the OBWTP, moving the divide between water produced at either plant toward the OBWTP, and thus alleviating hydraulic stress on the urban system to move water further away from the OBWTP.

Similarly, for any given year, as the production ratio is adjusted to be less skewed towards the OBWTP, the increased SRWTP production will "push" against the OBWTP production. This will also move the divide between water produced at either plant toward the OBWTP. This "divide" scenario is unfavorable, as water "backs up" in the southwestern part of the UPZ system – as discussed in Section 5.2. For this reason, increasing conveyance between the OBWTP and the UPZ north and east of downtown Charlottesville is the key recommendation for addressing the RWSA's challenges in operating the urban finished water system.

Previous analyses have focused on moving water eastward from the OBWTP. Water must, however, also be moved north of the OBWTP when production at the SRWTP is diminished. For this operating condition, moving water north is critical: the Stillhouse PS and, in the future, the ARPS will draw heavily from any water produced by the SRWTP. Completing the Central Waterline (CWL) therefore not only directly supports the Pantops area to the east of the OBWTP but also the northern UPZ via "reverse" flow in the Pantops and Urban Waterlines. Water can also be delivered north of the OBWTP by completing a redundant transmission main on Emmet Street and Seminole Trail. This would enable the OBWTP to more directly support the Stillhouse PS when production at the SRWTP is diminished.

6.2. Conveyance Capacity

Recognizing the challenges in moving water between the southwestern part of the urban water system, which is hydraulically well-connected to the OBWTP, and the rest of the system, which is hydraulically well-connected to the SRWTP, the RWSA evaluated several potential corridors for improving conveyance, as shown in Figure 21. Early on in development of the UFWMP, alternatives for bi-directional pumping of finished water (Figure 22) were evaluated in parallel with passive options, which require installation of larger pipe. The RWSA expressed a preference for passive (pipes only) rather than active (pumped) capacity improvements due to the following concerns:

- Water age in the new transmission mains when the pump stations are not in use
- Expense of constructing, operating, and maintaining additional pumping facilities
- Increased system vulnerability due to mechanical failure of “active options”
    - o “Passive” improvements are automatically and always in service and do not need to be turned on and off.

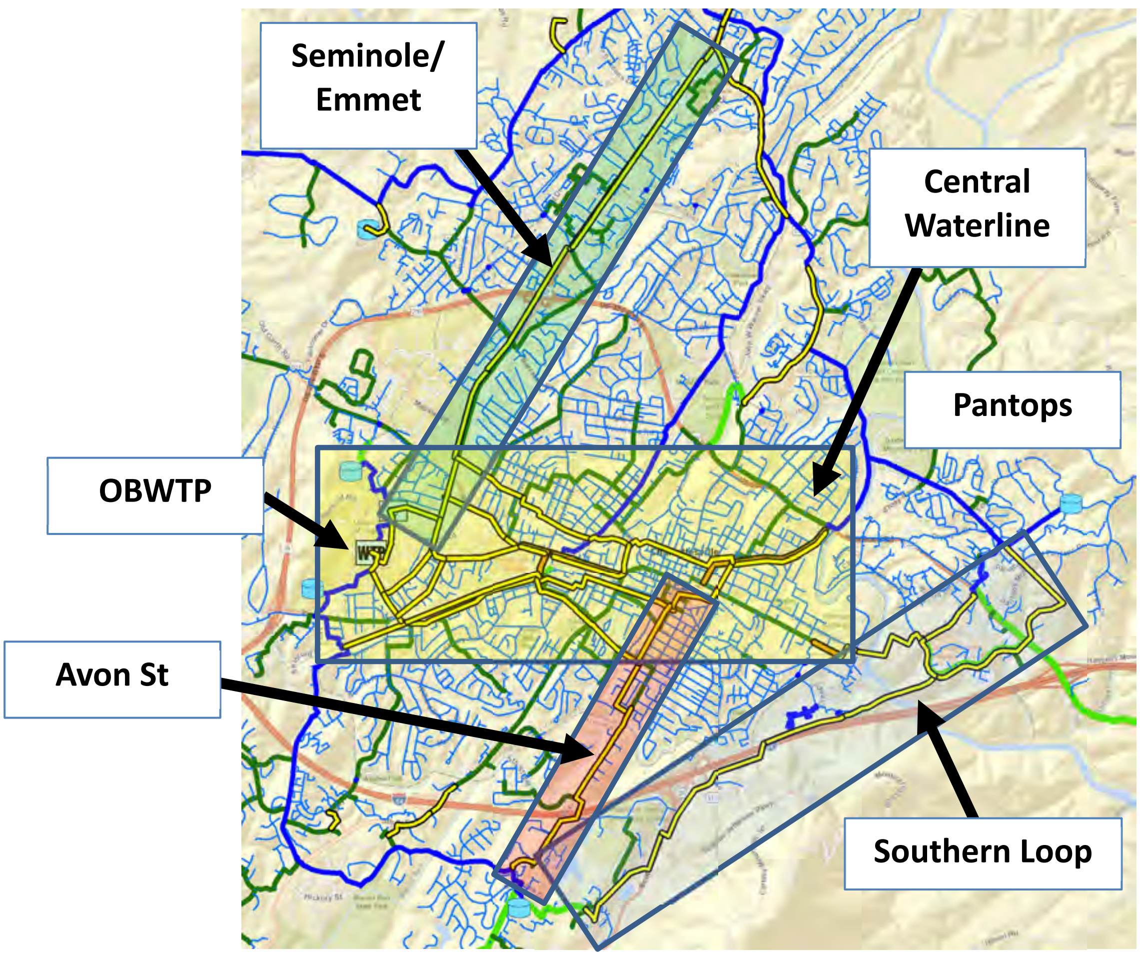

Figure 21. Potential Corridors for Improving Conveyance from the OBWTP to Pantops.

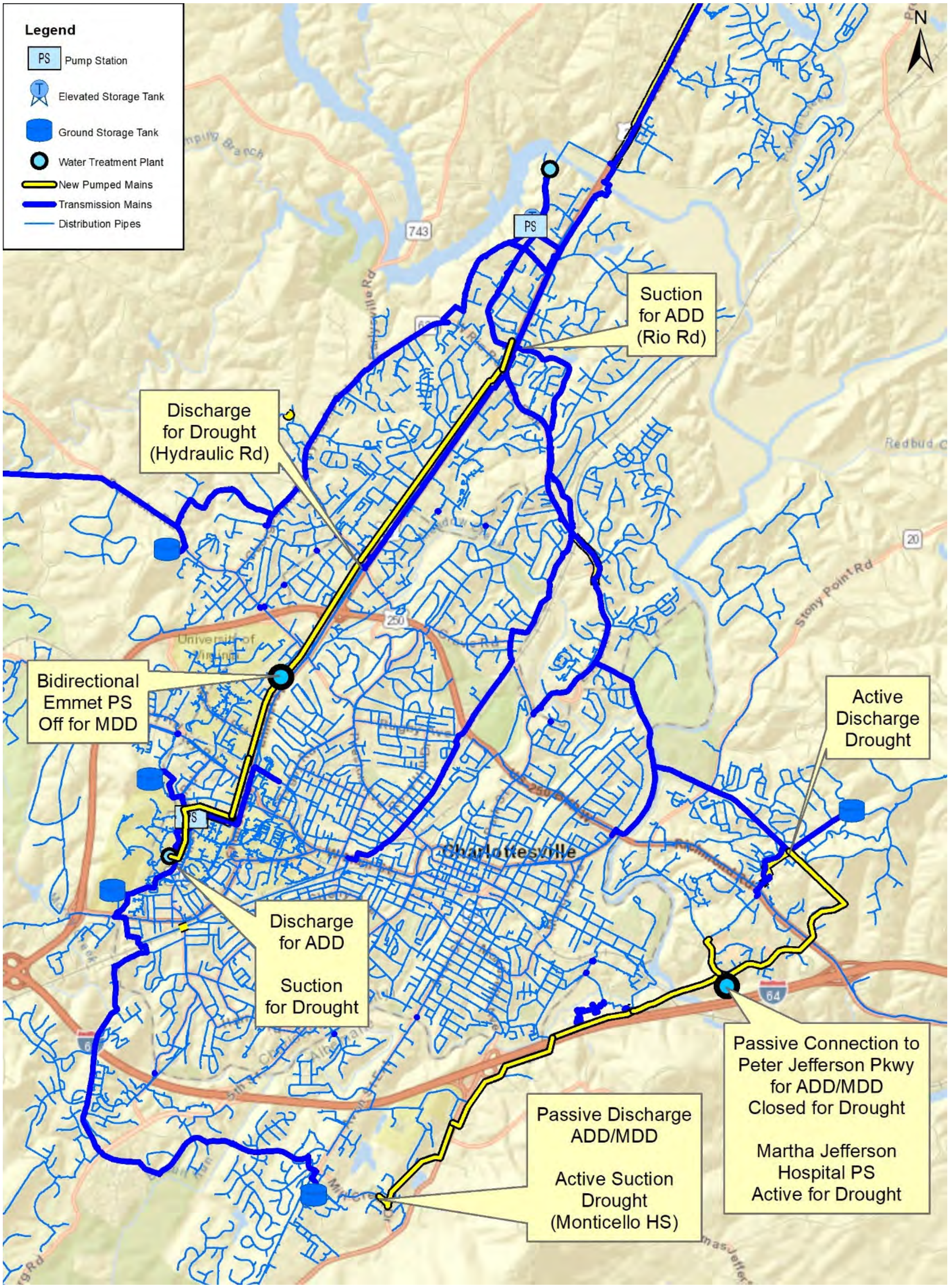

Figure 22. Concepts for Bi-Directional Pumping of Finished Water for 2070 Demands.

6.2.1.Southern Loop

Most recently, the RWSA evaluated the long-planned extension of the Southern Loop Waterline eastward from its current terminus at the Avon Tank (near Monticello High School) to Pantops. Pursuit of this potential project was discontinued after a more detailed review revealed challenges with excessive water age and a minimal effect in improving overall system hydraulics (i.e., moving water away from the OBWTP). Other waterline alignments across the center of the City were demonstrated to have a greater impact on improving hydraulics. Evaluations conducted as part of the UFWMP confirmed potential issues with excessive water age for extending the Southern Loop Waterline to Pantops.

6.2.2. Avon Street

Avon Street is another alignment considered previously and evaluated under the UFWMP. Portions of the Avon Street corridor are already served by 12-inch ACSA and City mains, from Southern Parkway to Elliott Avenue. The current Avon Street corridor provides some redundancy in moving water between the Avon Street and Pantops Tanks, and installing a parallel RWSA waterline through the corridor would provide redundancy to the existing 12-inch distribution main.

While this route would improve the existing system's performance, it does not solve the operational inefficiency issues of conveying water between the OBWTP and the Pantops area. Using the Avon Street corridor results in only a modest increase in conveyance between the OBWTP and Pantops due to the long waterline route and lack of connectivity to areas of higher water demand. The existing Southern Loop Waterline is only a 20" diameter main; as such, it does not provide sufficient hydraulic capacity to serve as a water source and connection point for extending transmission from OBWTP area to the northern and eastern parts of the system. This alignment would also require laying additional pipe to close the gap between the Southern Loop and the Urban and Pantops Waterlines. Although the Avon Street alignment does not provide a primary solution to the challenge of conveying water efficiently between the OBWTP and Pantops, conveyance improvements in this corridor should be considered for redundancy and resilience as opportunities arise (Section 6.3.8).

6.2.3. Emmet Street / Seminole Trail

The Emmet / Seminole corridor fills a gap in the RWSA transmission system and provides a direct link between the OBWTP and the SRWTP, which are the RWSA's two primary WTPs serving the urban system. The southern portion of the Emmet / Seminole corridor divides the academic area of UVA's campus from a majority of the residential and athletic areas, is relatively narrow, and contains a number of utilities.

A 16-inch RWSA waterline is understood to convey water from the OBWTP, passing dormitories and the Dell on its way to the City's Lambeth PS. From there, a City water main continues on to serve western parts of downtown Charlottesville. North of the Lambeth branch connection, the Emmet / Seminole corridor is served by an aging City main that is 10 to 12 inches in diameter. This main eventually connects to the southern terminus of the RWSA's 18-inch South Rivanna Waterline (SRWL).

A number of roadway and development projects are planned in the near future along the Emmet / Seminole corridor and enumerated as follows on Figure 23:

1. UVA Data Science Building / Contemplative Commons
2. UVA Ivy Corridor
3. Emmet Streetscape
4. Barracks-Emmet Intersection Improvements
5. Hydraulic / Route 250 Smart Scale
6. Hydraulic / Seminole Grade Separation

The recommended size for the Emmet / Seminole Waterline is 30 inches from the CWL to the 16-inch branch serving the City's Lambeth PS, continuing on as 24-inch pipe to fill the gap between the Lambeth branch and the southern terminus of the RWSA's 18-inch SRWL at Hydraulic Road (Figure 23). Alternatively, a connection to the CWL can also be accomplished by replacing the existing 16" waterline with a 30" waterline from the Dell back to the OBWTP 24" along the existing route (Alderman Rd, McCormick Rd, and through the UVA dormitories) in lieu of a direct connection to the CWL on Stadium Road. Final routing will need to be coordinated with UVA and the City.

The planned roadway and development projects provide an opportunity to relocate and upsize existing RWSA waterlines and to install a new large-diameter RWSA waterline that parallels a smaller City water main. This will increase conveyance capacity in the corridor and directly connect the RWSA transmission network between the OBWTP and the SRWTP.

When evaluated as an alternative to the CWL, the Emmet / Seminole alignment has a negligible impact on supplying water from the OBWTP to Pantops: the route is long and hydraulically inefficient, conveying water 4.5 miles north to Seminole Trail and Rio Road before turning around and traveling over 5 miles around the outskirts of the City to the Pantops area (Figure 21). While not as hydraulically imperative as the CWL, the Emmet / Seminole Waterline should nevertheless be constructed as budget or other construction opportunities allow, because it provides redundancy to the Urban and Pantops Waterlines in moving water between the OBWTP and the SRWTP, it provides additional connectivity between OBWTP and the Stillhouse PS, SRWTP, and the proposed Airport Road PS. Better connectivity to the SRWTP and the northern part of the UPZ provides some redundancy to the CWL for the projected high-growth areas of UVA campus and the Ivy Road corridor during a CWL shut-down or main break.

Of the total Emmet St/Seminole Trail alignment, the highest priority ("Phase 1") should be installation of the section of 24-inch pipe to fill the gap between the RWSA's 16-inch (near Lambeth PS) and 18-inch transmission main (intersection of Hydraulic Rd and Seminole Trail). This section parallels a City 10-inch to 12-inch main, some of which is older cast iron (CI) pipe. Other segments ("Phase 2") may be constructed as opportunities arise, e.g., as betterment to utility relocation, or as a component of a road project undertaken by another entity (VDOT, UVA, City, etc.).

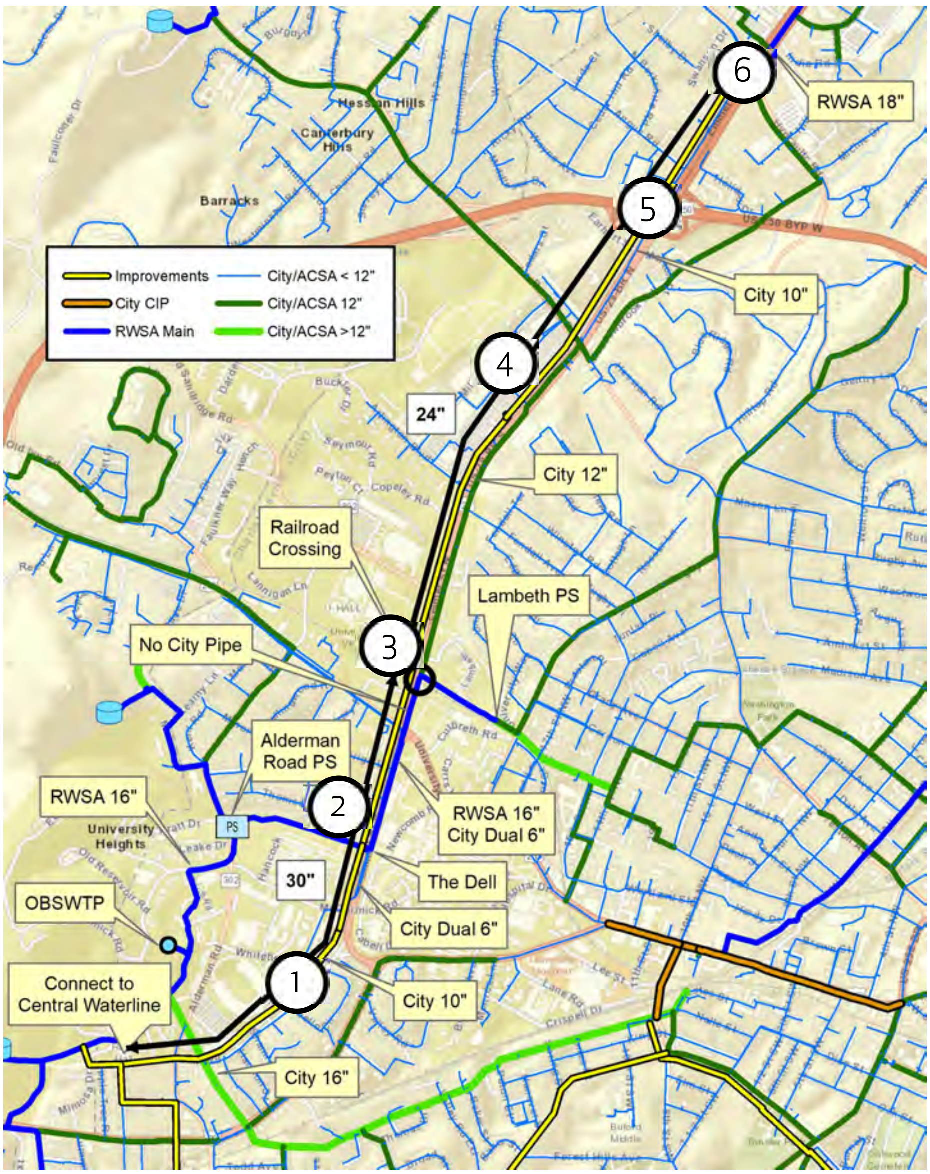

Figure 23. Emmet / Seminole Waterline Alignment.

Project	Emmet/Seminole Waterline
Complete By	Phase 1 – 2030 (24-inch Gap Segment); Phase 2 – 2035 (30-inch Connection to CWL)
Total Cost	$18.0M (Phase 1: $8.5M; Phase 2: $9.5M)
Benefits	• Improves movement of water between the WTPs during periods of imbalanced water production • Provides capacity in corridors (UVA campus and Ivy Road) that will become underserved when they undergo significant development planned to occur in the near future

Implementation Comments	• Prioritize construction of gap segment, from Lambeth PS to Hydraulic Road
	• Construct other sections in conjunction with projects by other entities
	  o Betterment of relocation of existing waterline (e.g., VDOT)
	  o Concurrent parallel work (e.g., UVA, City, etc.)

6.2.4. Central Waterline

Following prior work for the Avon to Pantops route evaluation phase, Michael Baker modeled and recommended an alignment from the OBWTP to Pantops. This central corridor alignment through the City roughly paralleled the Norfolk Southern and Buckingham Branch railroad corridors. For the UFWMP, an east-west alignment, referred to as the "Central Waterline," (CWL) was confirmed as the most hydraulically beneficial to future system operations.

Although multiple, potential CWL alignments (north, middle, south, and along the railroad) were evaluated hydraulically, they all had several characteristics in common

- New large-diameter main leaving the vicinity of OBWTP
- Gradual decrease in diameter from west to east due to interconnections at key locations in the City
- Linking the 24" waterline near OBWTP to the 24" Urban Waterline (in Main St) and the 18" Pantops Waterline (at E. High St/Long St.)

Other characteristics considered for possible alignments of the CWL include the following:

- Location and timing of other capital improvement projects or development projects – roads, utilities, streetscape projects, major buildings, etc.
- Impact of construction on individual property owners and the community in general

- Requirements for crossing / paralleling railroads
- Constructability
- Traffic, Parking, and Sidewalk Impacts
- Neighborhoods and Public Impacts
- Existing Underground and Overhead Utility Congestion
- Access
- Construction Cost
- Easements and Permitting

A summary of each corridor and its key features follows:

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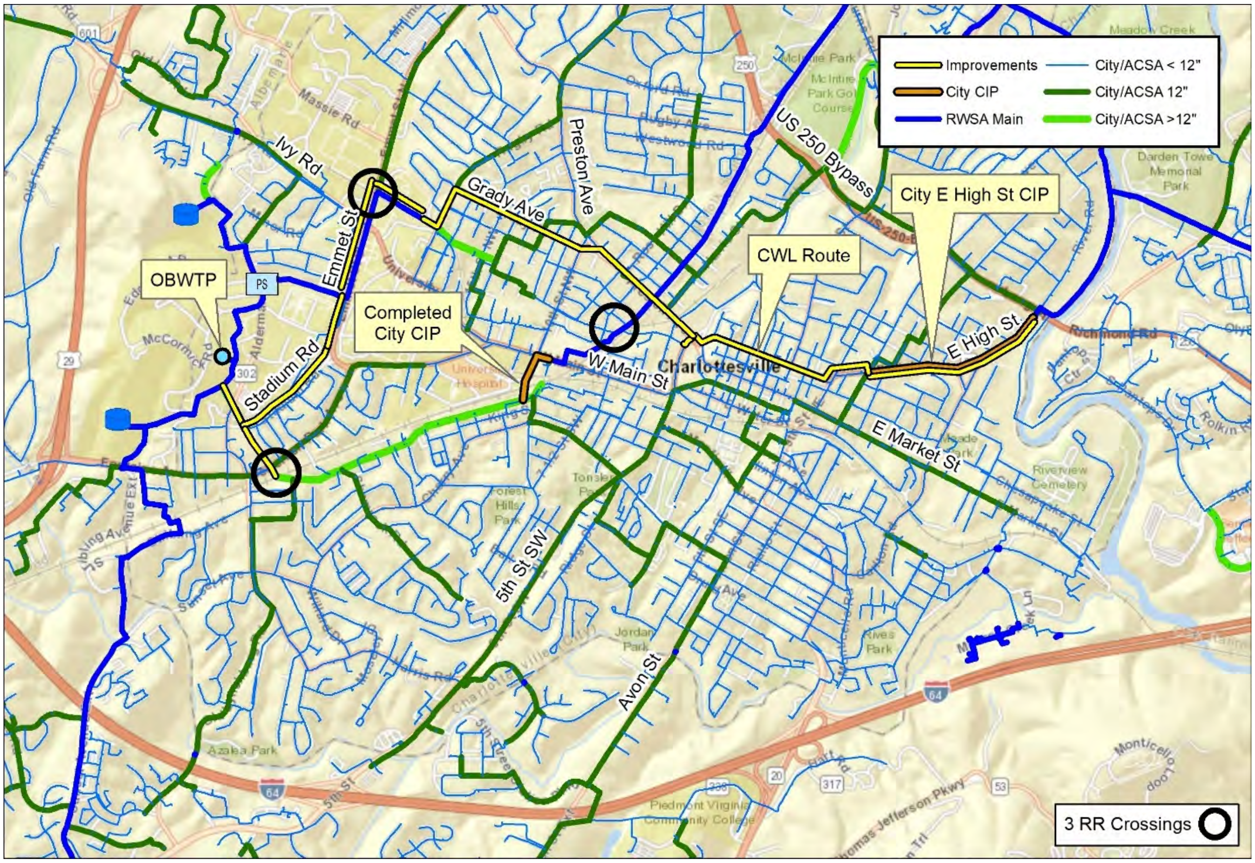

Figure 24. Central Waterline Northern Corridor.

- Generally, follows Emmet Street north, then cuts through neighborhood streets in the northern part of the City and through downtown to E. High Street
- Overlaps with the E. High Street CIP project
- Narrow and congested neighborhood streets in the north, and congested and heavily trafficked downtown streets, present challenges to construction including traffic detours and impacts to parking, sidewalk, and biking lanes
- Downtown City water mains provide decent connectivity already in the center of the City, reducing the overall hydraulic impact of the Central Waterline with this route
- An additional railroad crossing is required for this option versus the other three options
- Length is approximately 23,000 feet

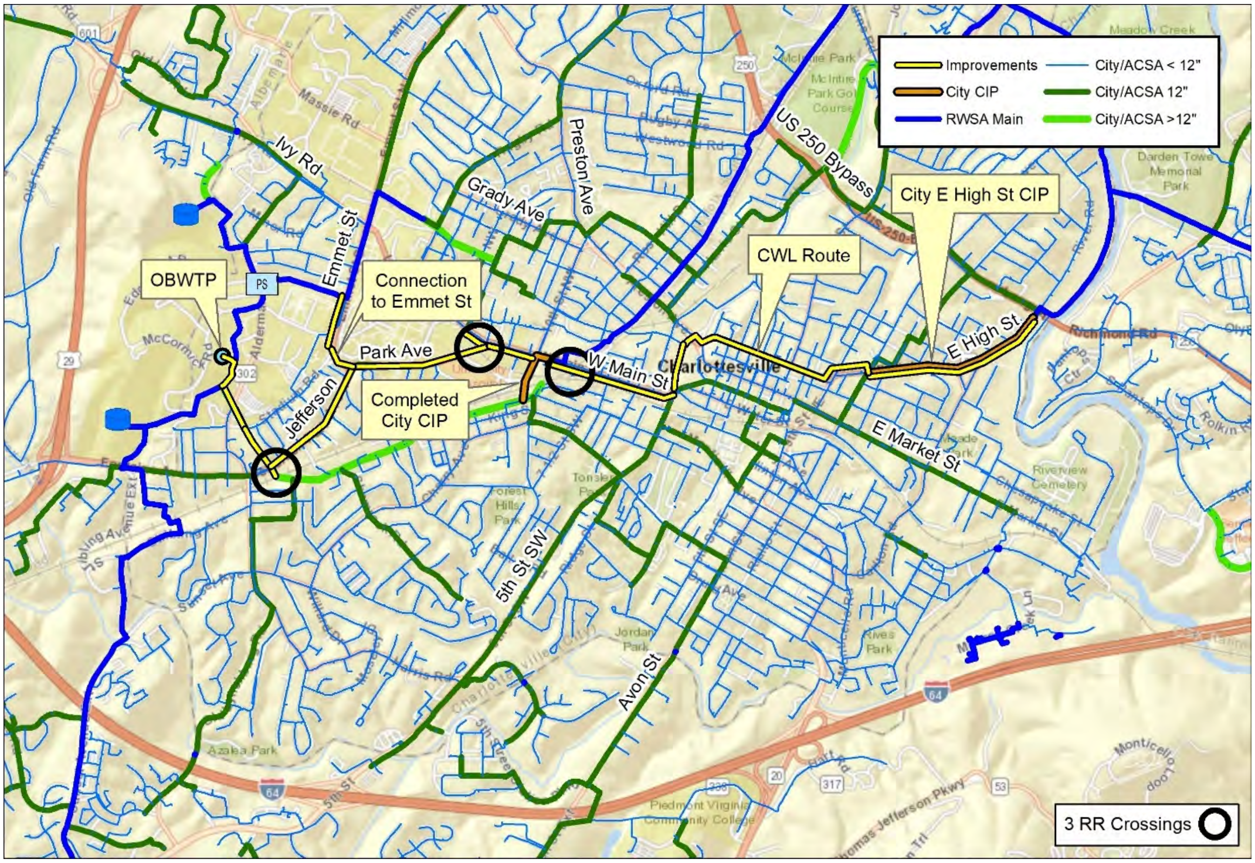

Figure 25. Central Waterline Middle Corridor.

- Generally, traverses through or around UVA campus/ streets, then east through neighborhood streets in the west side of the City, and through downtown to E. High Street
- Overlaps with West Main Street CIP, which has been indefinitely postponed
- Overlaps with E. High Street CIP
- Narrow and congested neighborhood streets in the north, and congested and heavily trafficked downtown streets, present challenges to construction including traffic detours and impacts to parking, sidewalks, and biking lanes
- Downtown City water mains provide decent connectivity already in the center of the City, reducing the overall hydraulic impact of the Central Waterline with this route
- Length is approximately 20,000 feet and is one of the shortest routes

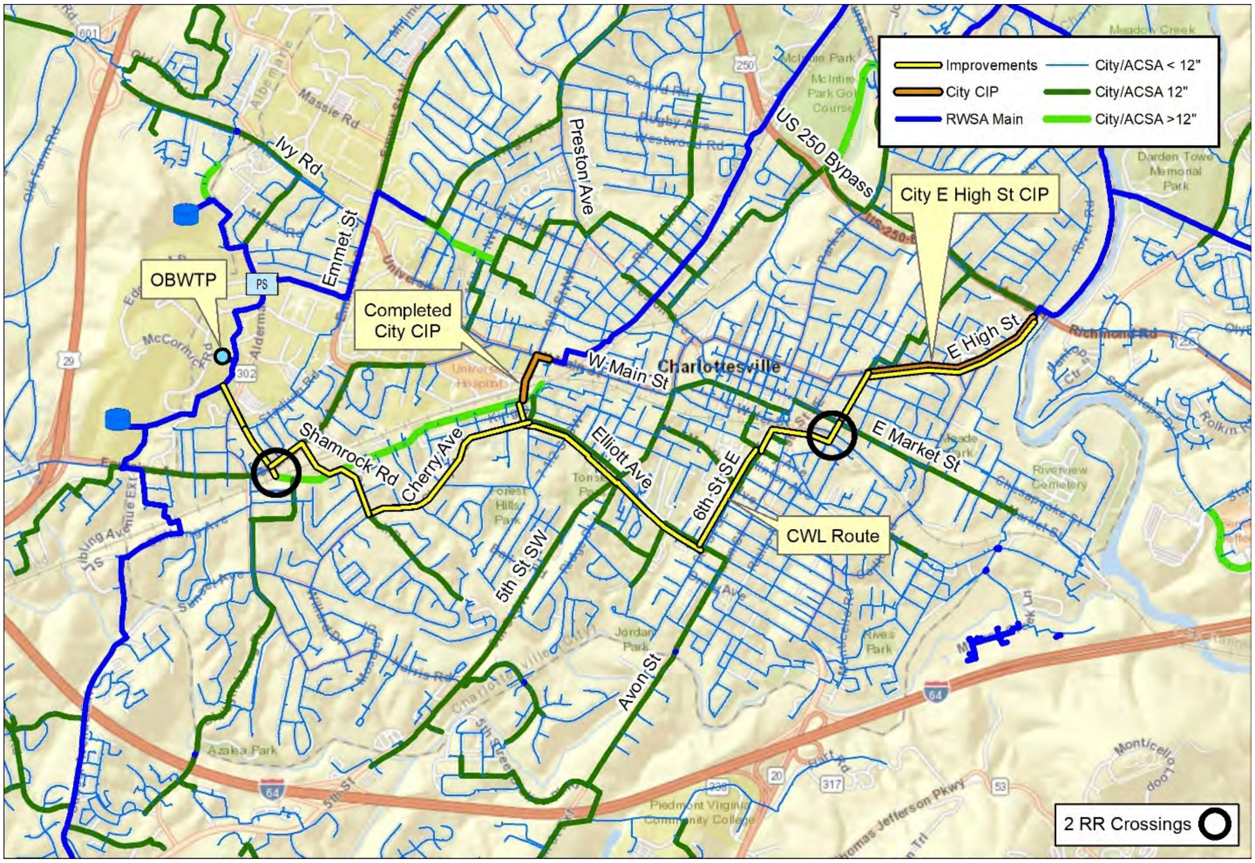

Figure 26. Central Waterline Southern Corridor.

- Generally, heads south from OBWTP through UVA and western City streets, heads across the railroad, and follows Cherry Avenue corridor east to the Avon Street corridor; then follows neighborhood and commercial area streets in the eastern part of the City to E. High Street
- Overlaps with E. High Street CIP project
- Utilizes streets with wider rights-of-way (less congestion, less traffic impact) where possible
- Reduces construction impact on narrow neighborhood streets
- Provides greater hydraulic benefits by allowing for connections across the currently less well-connected southern part of the City system and better connectivity to the Avon Street Tank
- Length is approximately 25,000 feet, making this the longest route

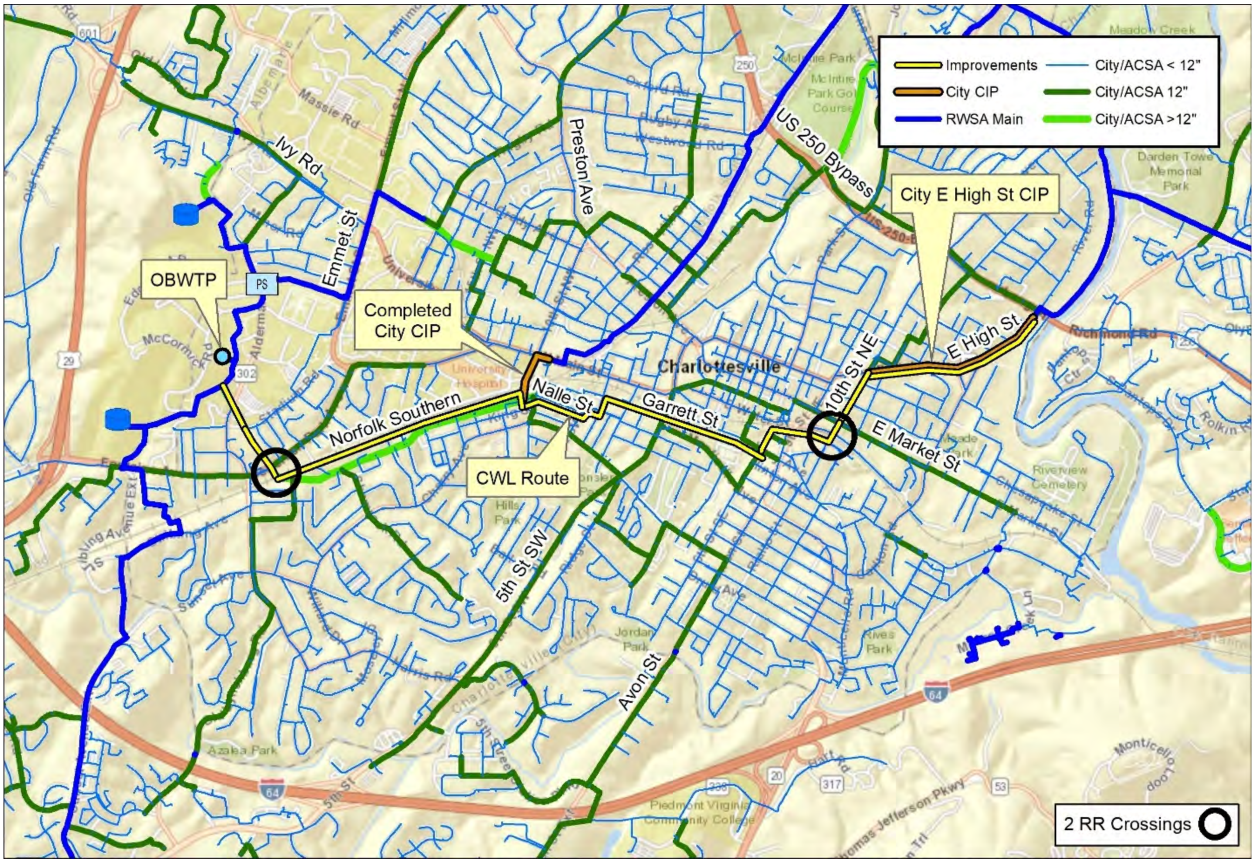

Figure 27. Central Waterline Railroad Corridor.

- Generally, heads south from OBWTP through UVA and City streets, then south across the Norfolk-Southern railroad before running east and parallel to the railroad; then through the southern part of downtown to E. High Street
- Overlaps with E. High Street CIP project
- The segment parallel to the railroad likely requires significant impact to residential properties along the southern side of the railroad, due to limited available space amongst challenging existing grades and existing utilities. Extensive private agreements and clearing of the treed buffer between residential homes and the railroad is likely.
- Length is approximately 22,000 feet and is one of the shortest routes

Upon completion of the hydraulic analysis and planning-level evaluations, RWSA coordinated with the City and ACSA, as stakeholders, to further evaluate the possible routes which included a hybrid north/south route and a Route 250 Bypass Route. The Railroad Corridor was removed from consideration due to the significant constructability challenges and likely residential property impacts compared to other available routes. The Middle Corridor was also removed from detailed consideration: compared to the other available routes, it provided less hydraulic benefit, while also having more constructability challenges through the narrow and heavily trafficked downtown City streets. The indefinite postponement of the City's West Main Street CIP removed a possible ability to coordinate the waterline installation with already-planned disturbance in the downtown area. The north/south hybrid route and the Route 250 Bypass Route would be extremely long, expensive, and have significant impacts to traffic and neighborhoods and were not considered any further.

The "southern" CWL alignment, presented in Figure 28, is recommended for the following reasons:

- Utilizes streets with wider rights-of-way where possible to reduce traffic, parking, and neighborhood impacts
- Utilizes streets with lower traffic volumes to reduce traffic impacts
- Reduces construction impact on downtown Charlottesville
- Provides two railroad crossings within the City limits which provides redundancy
- Provides better hydraulic connectivity from the SRWTP to southern portions of the City and to the Avon Street Tank via existing larger diameter City distribution mains
- Provides opportunities for project coordination with the City's new 12-inch water main in E High St

A short spur ties in with the Urban Waterline near W. Main St./9th St. SW. In the near term, that spur must at minimum connect to the City's new 18-inch main in Roosevelt Brown Boulevard. This will provide required hydraulic connectivity until the RWSA can construct the railroad crossing and connection to the Urban Waterline.

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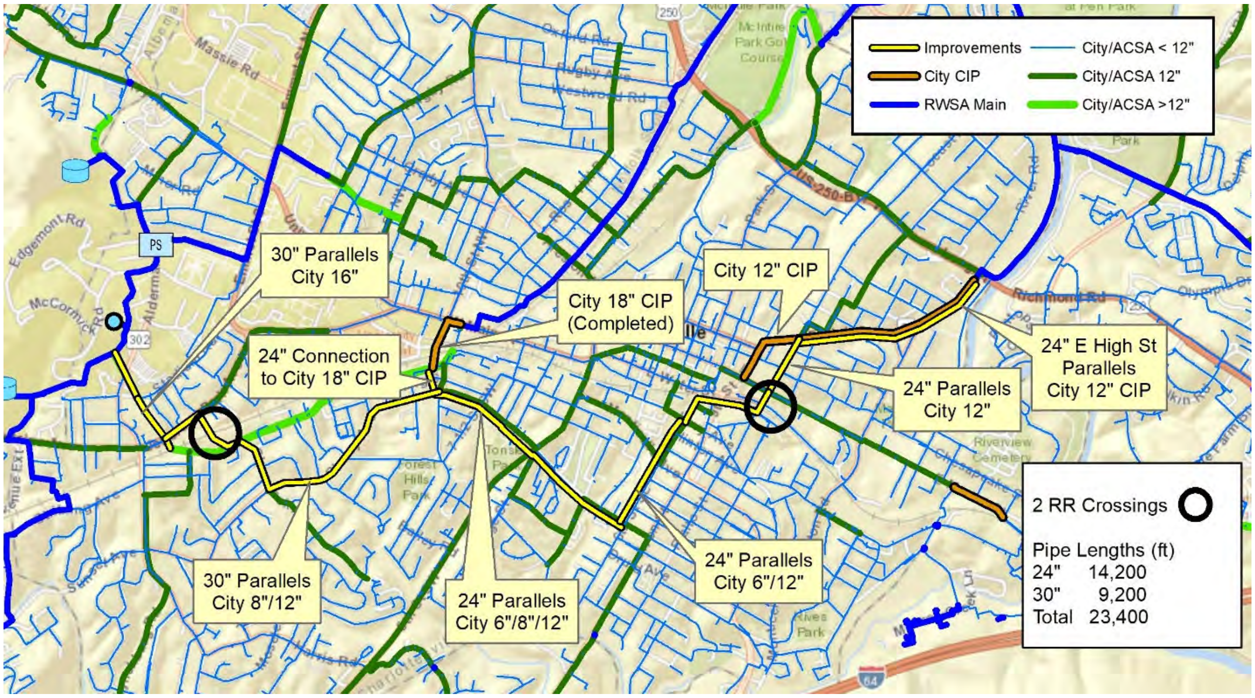

Figure 28. Recommended Central Waterline Alignment.

Constructing the CWL in entirety, including the spur connection, results in tank level performance (Figure 29) that is comparable to the baseline condition (Figure 6), even with imbalanced production and most of the demand supplied by the OBWTP (8 MGD for 2030 hot/dry ADD conditions, vs. 11.3 MGD total system demand). For this water production scenario, construction of the CWL would allow the tanks to float within five feet of each other, and the operating range varies from three feet at the Pantops Tank to five feet at the Observatory Tank.

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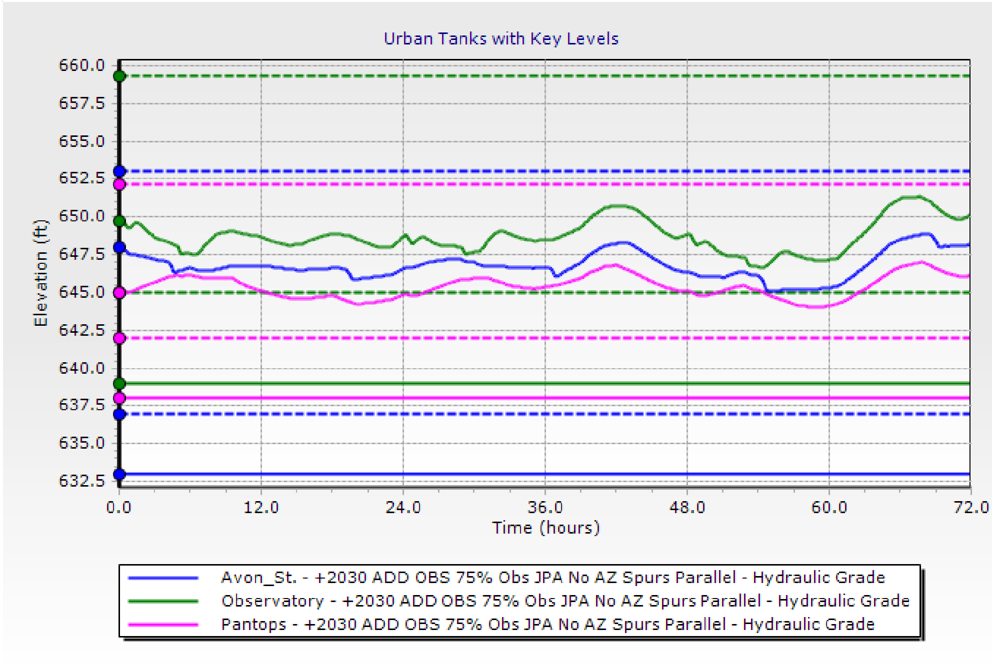

Figure 29. Urban Zone Tank Levels for 2030 ADD with CWL Including Spur.
(Imbalanced Production: 71% from OBWTP, 29% from SRWTP)

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Project	Central Waterline
Complete By	2030
Total Cost	$31.0M
Benefits	• Addresses hydraulic inefficiencies • Improves movement of water to/from OBWTP and tanks, and within the distribution system • Increases system flexibility and resilience • Provides redundancy to waterlines with difficult access by adding crossings of two railroads (Norfolk Southern, Buckingham Branch) and two major roads (Ridge Street/5th Street SW, and Long Street)
Implementation Comments	• Emmet Street Waterline "Phase 2" will provide redundancy when both it and the CWL are in service • An alignment following a longer route may require larger pipe • Conduct detailed hydraulic analysis for pipe sizing and to determine inter-connection locations and/or strategic stub-out locations after concluding alignment study

6.2.5. Airport Road Pump Station Waterline

As discussed later in Section 8.4.3, RWSA has planned for installation of the Airport Road Pump Station (ARPS), which will support the northern UPZ and provide reliable supply to the North PZ once NRWTP is decommissioned. The PS, which is currently proceeding to construction, will require suction and discharge pipelines (Figure 30) to receive supply from SRWTP on the suction side and provide capacity to the North PZ on the discharge side.

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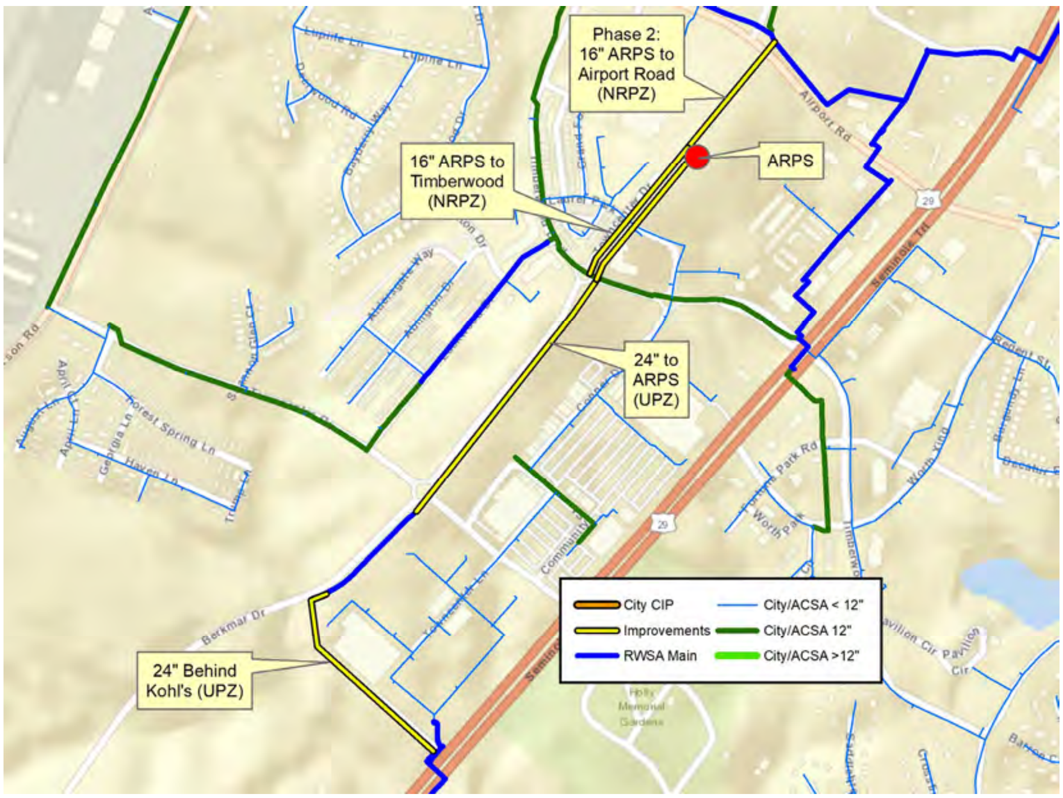

Figure 30. ARPS Waterline.

Approximately 3,800 linear feet of 24-inch suction main and 900 linear feet of 16-inch discharge main will be installed with the ARPS, as Phase 1 of the ARPS Waterline. Phase 2 of the ARPS Waterline will include approximately 800 linear feet of 16-inch main, slated for installation when VDOT completes extension of Berkmar Drive.

Project	Airport Road Pump Station Waterline
Complete By	Phase 1 – 2025 (with ARPS); Phase 2 – 2030 (with Berkmar Drive extension)
Total Cost	$7.4M
Benefits	• Provides direct supply/discharge to ARPS from the transmission system • Provides dependable supply to the North PZ once NRWTP is decommissioned
Implementation Comments	• Phase 1 under construction with ARPS • Phase 2 to be constructed along with Berkmar Drive extension

6.3. Vulnerability, Resilience, and Redundancy

For the purposes of the UFWMP, system vulnerability means susceptibility to an interruption in the ability to distribute finished water to customers. Interruptions can be caused by any one of a number of factors:

- Temporary shut-downs of WTP's, tanks, or watermains for maintenance, whether planned or emergency
- Longer-term shut-downs (e.g., natural disaster, scour at waterway)
- Failures related to age, operations, or damage by others

Other types of vulnerabilities, such as contamination of the raw water supply, or loss or over-application of disinfection means, are beyond the scope of this report but should be part of an overall risk assessment.

As stated in Section 4.3, redundancy and resilience are related but not synonymous. Redundancy is having an alternative for performing a function, without needing to take additional action to use that alternative. Resilience is a system's ability to withstand an adverse event while providing an acceptable level of service. Concerns regarding resilience and redundancy include resilience in providing water to single-feed areas if the transmission main or upstream supply facility (PS, WTP) is off-line, and redundancy in providing water at critical crossings. These topics are discussed in more detail below.

6.3.1. Inter-connection Resilience

One opportunity to add redundancy to the system lies within the Lewis Mtn. PZ. A cross-connection exists between the discharge mains for the RWSA vs. the UVA side of the Alderman Road PS. This cross-connection is normally valved off but can be opened for emergency situations, with UVA providing water to the Lewis Mtn. PZ (City), and vice versa. If accounting for inter-jurisdictional transfer of water during emergencies is desired, then a flow meter and vault are required at the cross-connection. This is assigned as an RWSA project, as the RWSA owns the transmission main and operates its side of the Alderman Road PS.

Project	Install Meter on Cross-Connection to UVA
Complete By	2045
Total Cost	$0.4M
Benefits	• Provides bi-directional redundancy for each side of Alderman Road PS
Implementation Comments	• Valve vault with meter provides accounting of water exchanged between utilities

6.3.2. Sourcing of Raw Water

Seasonality can influence not only water demand but also the supply of raw water. Currently, each raw water source is dedicated to a single WTP, as shown in Figure 31. At this time, the SRWTP can only process water from the SFRR, the OBWTP can only process water from the RMR, and the NRWTP can only process water from the NRR. Once the SFRR-to-RMR Raw Water Pipeline and RMR Raw Water Return PS are completed (Figure 32), the RWSA will gain the ability to not only transfer water from the SFRR to the RMR but also to move water from the RMR to the SRWTP, and from the SFRR to the OBWTP. This project will provide the urban system with greater resilience to adverse climatology while also providing redundancy in total treatment capacity relative to demand. While this project is not a component of the finished water system, it has a direct effect on the future resilience of the RWSA's ability to manufacture and deliver finished water. It should therefore be a high priority in CIP planning.

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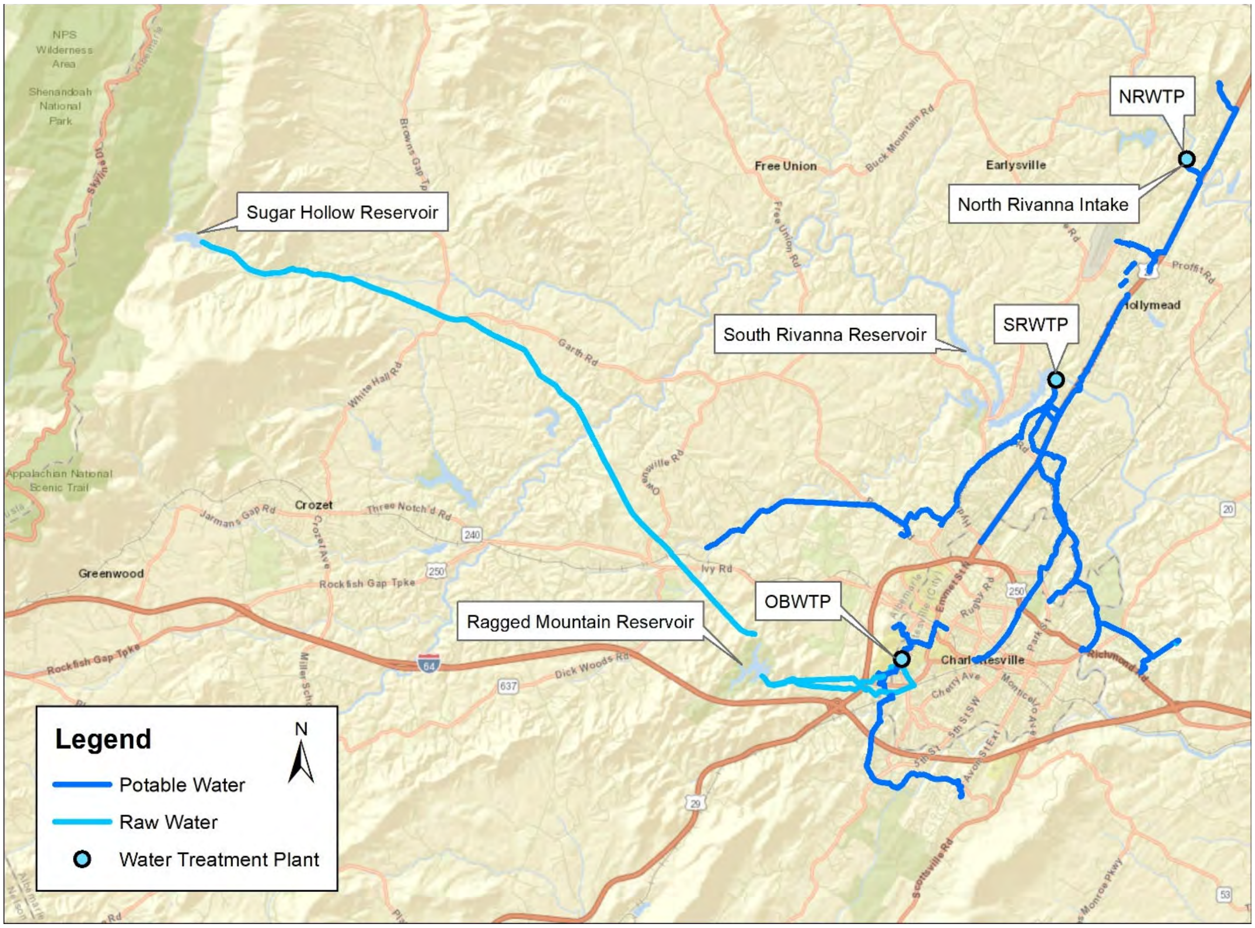

Figure 31. RWSA Urban System Raw and Finished Water Mains and WTPs.

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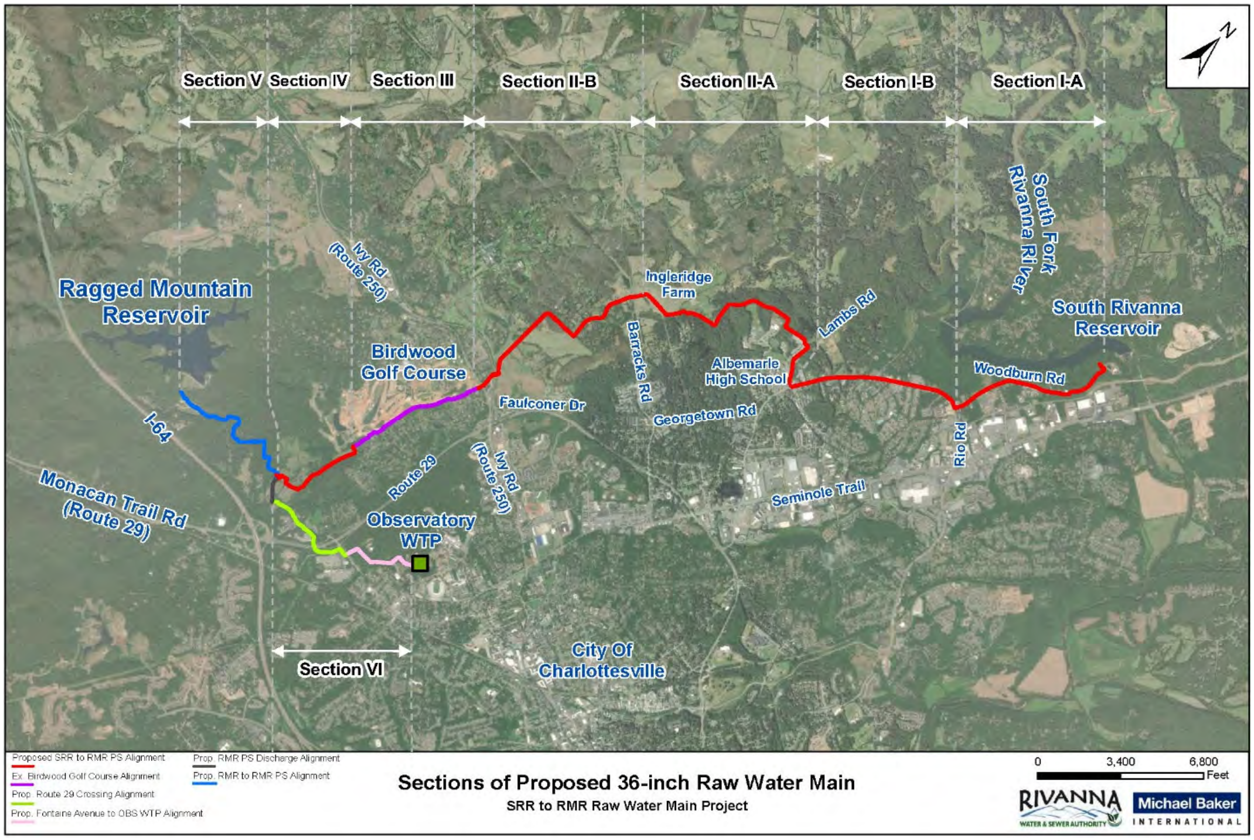

Figure 32. SFRR to RMR and RMR to OBWTP Raw Water Lines and Pump Station.

6.3.3. Main Closures

One area of concern for the RWSA regarding redundancy is the ability to provide water when a transmission main or storage tank is out of service, due to either planned or unplanned outages. Michael Baker reviewed 15 years of data on transmission main breaks and selected locations in the model to simulate a pipe closure (Figure 33). Criteria for selecting the locations included the following:

- Cut off transmission main at key location
- Long path (resulting in high head (pressure) loss) to re-route flow
- Limited options / small sizes of pipe parallel to closed main

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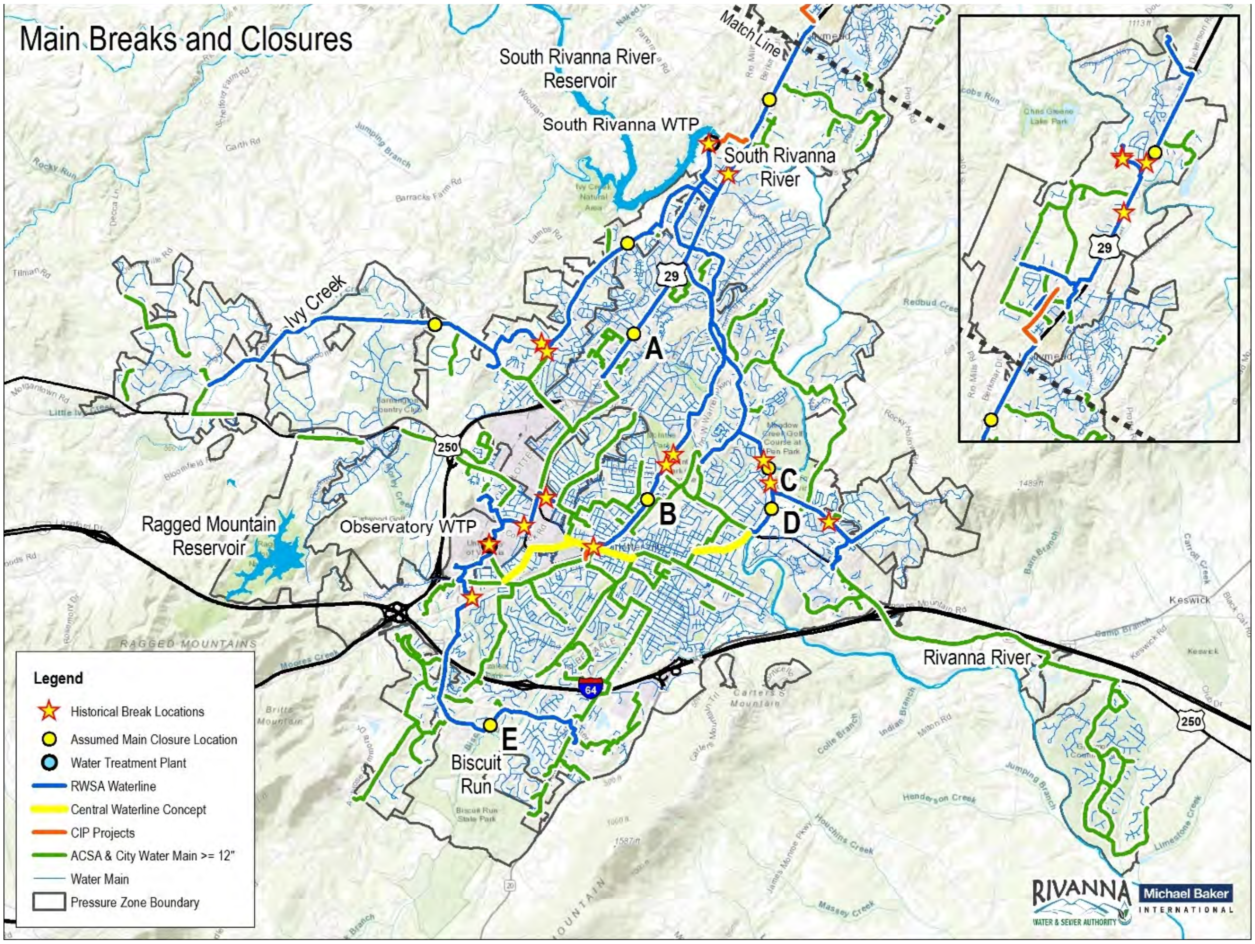

Figure 33. Historical and Modeled Waterline Closures vs. Interim CWL.

Once the future CWL is in service, there may be periods of time when a segment of the CWL is temporarily closed for repairs, to make a new interconnection, or to perform a relocation. Confirming that the Urban Finished Water system functions as required with a segment of the CWL temporarily out of service can show that the CWL, as a whole, does provide sufficient hydraulic improvement to the system on its own.

Evaluations assumed a portion of the proposed future CWL was out of service (as reflected in the downtown gap in the yellow line in Figure 31), thus simulating a partial CWL closure. With the SRWTP providing 75% of MDD demand, of the five locations (A through E in Figure 31) in the UPZ with a simultaneous simulated main closure, the one with the most adverse impact was on the Southern Loop Waterline, near the Covenant School (pipe RWS_P_631, letter "E"). For this location, and with projected 2030 MDD on a hot/dry day, the UPZ tanks did not track as closely together as desired (Figure 34).

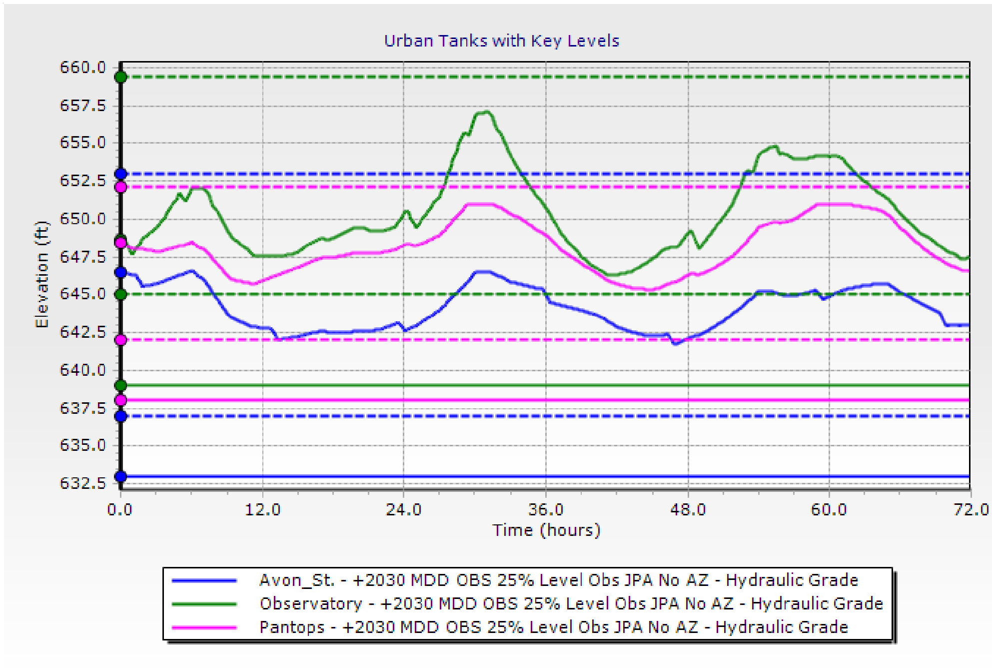

Figure 34. Urban Zone Tank Levels with Southern Loop Waterline Closure.
(2030 MDD, SRWTP provides 75% of production)

Because it was isolated from the Observatory Tank (due to a main closure at E), the Avon Street Tank floated in parallel with the Pantops Tank, but lower. This condition resulted from the network of smaller City pipes through which water traveled in order to reach the larger City/ACSA Avon Street main and eventually the tank. All three UPZ tanks remained within their preferred operating ranges, confirming the adequacy of the CWL recommendation. For the other four waterline closure locations, the UPZ tanks generally floated within two feet of each other. The production ratio was skewed towards the SRWTP to apply greater stress to the system for providing water to the southern end of the UPZ.

In addition to the direct CWL connectivity from the Observatory Waterline to the Urban and Pantops Waterlines, constructing key interconnections with City mains provides an alternate route for getting water to Pantops and for moving water between the northern and southern areas of the UPZ. The number and location of interconnections will be identified during hydraulic analysis associated with the detailed design of the CWL.

Figure 35 shows locations of historical main breaks, which may be related to pressure surges similar to those discussed below. The figure also shows lengths of CI pipe serving single-feed areas (see next section). Of note are historical main breaks immediately downstream of each WTP, possibly due to pressure spikes related to pump operations. While there are numerous reasons for main breaks, pressure surges can be a leading cause. Section 9.1 includes recommendations for a detailed review of pumping facility operations (see recommendation for Operations Evaluation in Section 10).

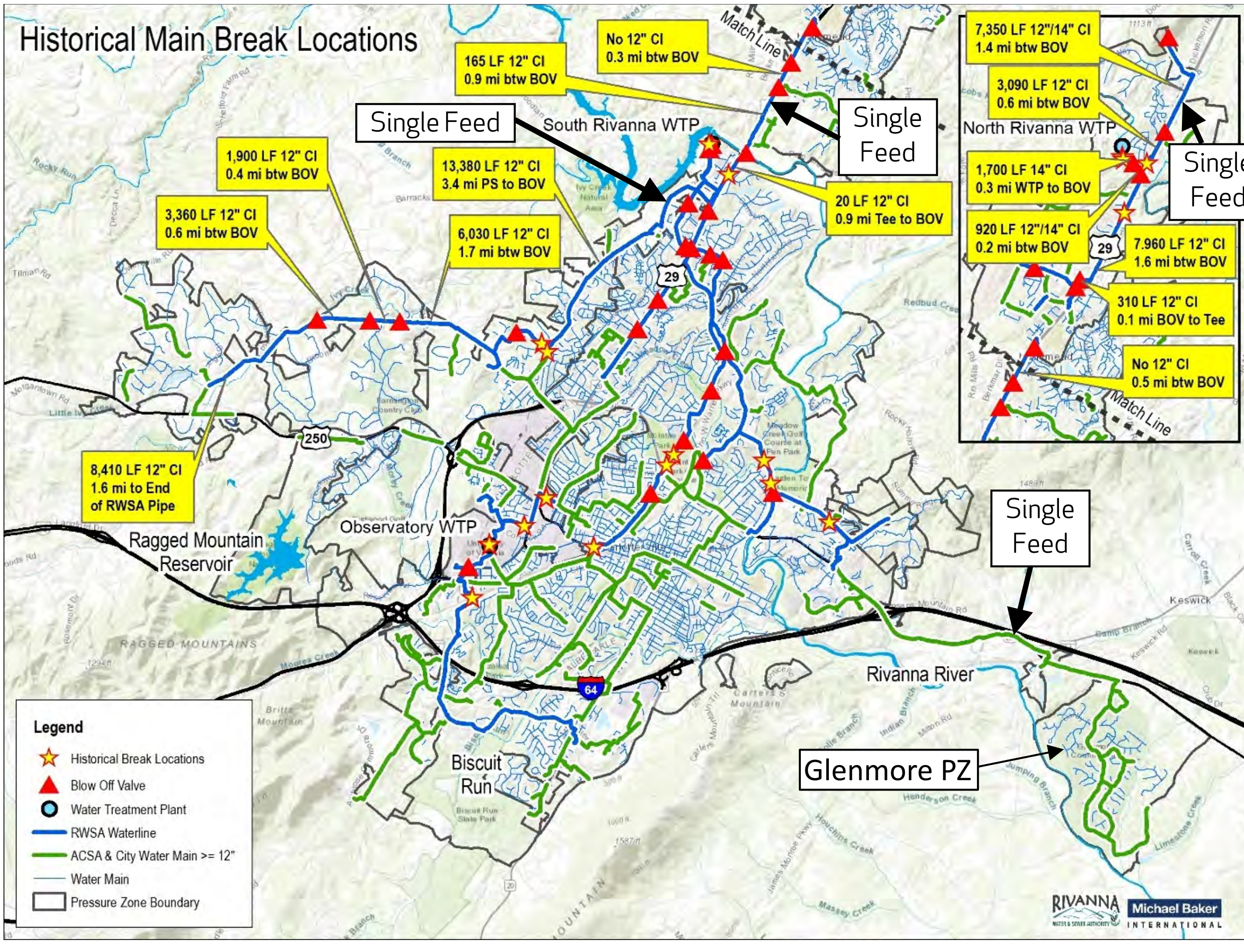

Figure 35. Historical Main Breaks 2008 – 2020.
Single-feed mains, blow-off valves, and CI pipe.

6.3.4. Single-Feed Areas

One area of vulnerability that is being addressed over time is that of single-feed areas, where an area is served by only one large-diameter transmission main. At present, three areas are classified as single-feed areas: the North PZ north of Lewis and Clark Drive, the Stillhouse PZ, and the Glenmore PZ. All three of these PZs serve ACSA customers exclusively, and the mains serving each single-feed area are shown in Figure 35. The RWSA operates the North and Stillhouse PZs, and the ACSA operates the Glenmore PZ.

North PZ

The ACSA has already installed large-diameter parallel mains in and south of Lewis and Clark Drive to add redundancy to the RWSA mains that deliver finished water from the NRWTP to the vicinity of the Charlottesville-Albemarle Airport. When the ARPS is on-line and the NRWTP is off-line, however, the entire North PZ will be a single-feed area from the UPZ via the 24-inch North Rivanna Waterline (NRWL) in Seminole Trail, from Polo Grounds Road to Towncenter Drive.

A previous challenge within the system was redundancy to the NRWTP. This was addressed by installing connections on the low pressure and high pressure water mains on Seminole Trail (Route 29) near the Kohl's store at Hollymead, whereby RWSA can mobilize a portable pump and quickly make the waterline connections to push water from the UPZ into the North PZ. This temporary PS setup was used during upgrades to the NRWTP, and its potential future need will be addressed once the planned ARPS is constructed and brought online to serve the same function. The portable pump will be retained as a backup to the ARPS when the NRWTP is decommissioned (planned for 2025). The pump could also be mobilized, if needed, for temporary bypass around a main closure.

Stillhouse PZ

Stillhouse PZ is fed exclusively by the Stillhouse PS and a 12-inch RWSA trunk line. An emergency pump connection at the former Canterbury Hills PS site enables a portable pump to push water from the UPZ into the Stillhouse PZ. The ACSA has also constructed two PRV vaults, Farmington and Flordon, to augment pressure in the southwestern Stillhouse PZ with water from the Ednam PZ. Finally, the ACSA has already constructed several segments of a large-diameter main in Ivy Road to parallel the RWSA's finished water main in the northwestern Stillhouse PZ.

Glenmore PZ

Glenmore is served exclusively by a 16-inch ACSA transmission main. Recent completion of the Glenmore Tank and PS adds resilience to that system, providing water storage and the ability to support the Glenmore PZ for a short time if the transmission main is temporarily out of service.

Michael Baker holistically reviewed GIS data provided by the RWSA to determine the location of single-feed alignments and how to economically address a main outage. With the advent of large-diameter lay-flat hoses suitable for potable water applications, the means now exists to temporarily bypass a closed main with a surface-laid pipe. Suggested steps to implement a temporary bypass using lay-flat hose follow:

- Select the size of the bypass pipe
- Identify the valves to close and the connection points for the bypass
- Arrange for temporary access to properties blocked by the bypass
- Implement the bypass

In the current system, both single-feed areas (Stillhouse and the North PZ) supplied by the RWSA are served by 12-inch mains. Michael Baker assumed that 12-inch lay-flat hose up to 1,000 feet long is available, and that the hose would connect to a fire hydrant at either end of the bypass. Depending on required flow rates and local piping configuration at either end of the temporary bypass, a bypass pump may be required. In addition to laying the bypass pipe, the main closure would need to be isolated by closing a valve on either side. A review of GIS data revealed that while only a handful of additional "hydrants" would need to be installed given the assumed maximum bypass length, several isolation valves would be required (Figure 36), as only newer transmission mains (e.g., 24-inch main north of the South Rivanna River, 12-inch Stillhouse Waterline north of Stillhouse Tank) were installed with periodic isolation valves.

On the Stillhouse Waterline, several hydrants are recommended just west of the Stillhouse Tank. These hydrants may be installed at any time. On the NRWL, three additional hydrants are recommended, between Lewis and Clark Drive and Briarwood Drive. These hydrants could be installed in conjunction with the planned second North Rivanna River crossing.

In the future, when the RWSA's proposed ARPS is on-line, the North PZ will become a single-feed area. This main already includes periodic hydrants and isolation valves; only one additional bypass connection point (hydrant) is recommended, just south of the ACSA connection at Hollymead Drive. This hydrant may be planned for installation when the waterline is extended to serve the proposed ARPS. Any pipe used for an emergency RWSA waterline bypass connection should be at least 8 inches in diameter, as flow could be as high as 2 MGD, which corresponds to a velocity of 8.9 fps in 8-inch pipe. Larger pipe is more expensive but will reduce the pressure loss from one end of the bypass to the other.

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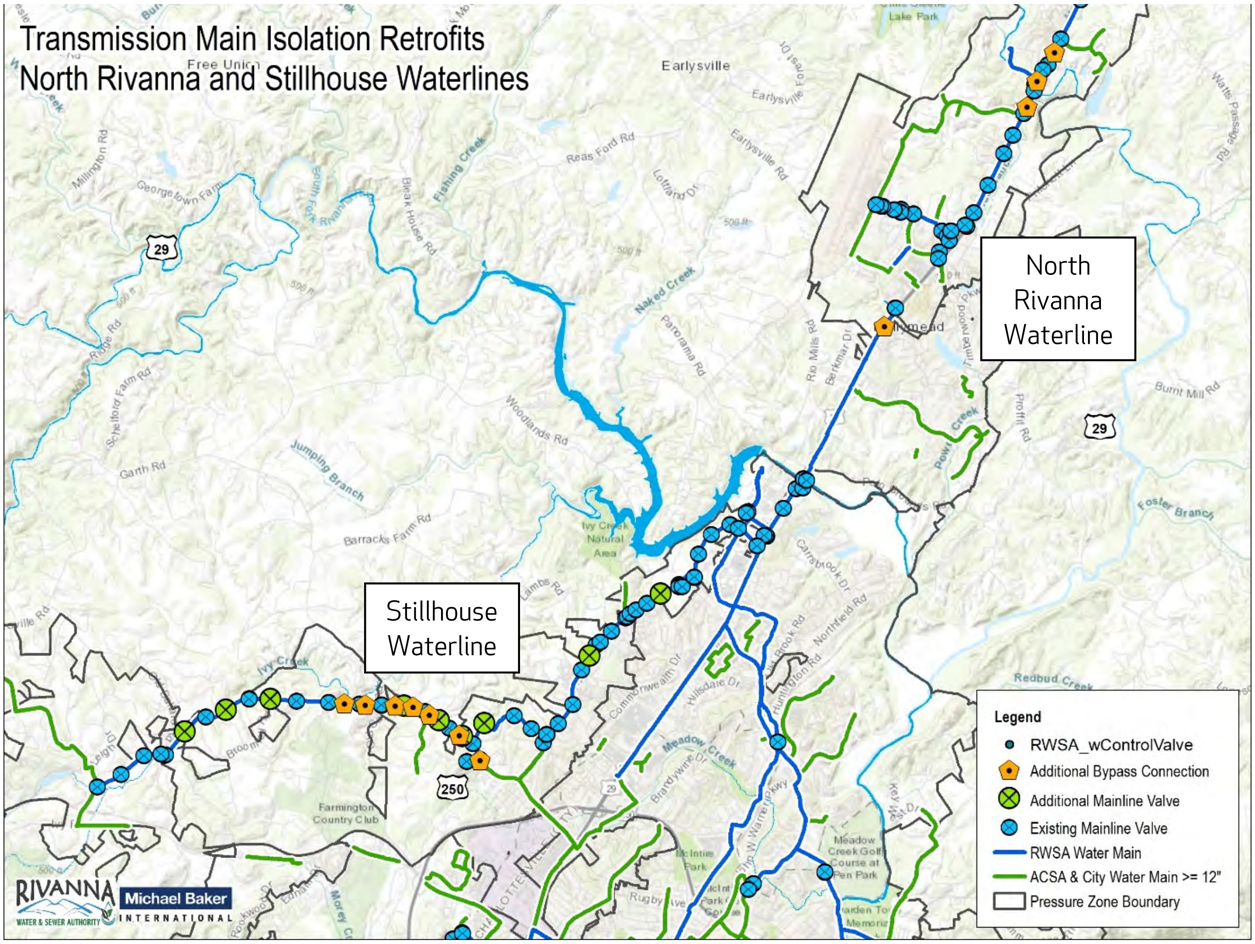

Figure 36. Reinforcement of Single-Feed Waterlines.

Project	Single-Feed Bypass Connections
Complete By	2045
Total Cost	$1.3M
Benefits	• Support downstream customers during waterline closure • Lower cost compared to installing parallel pipeline
Implementation Comments	• Install waterline isolation valves and hydrants as necessary • Connect 12" lay-flat hose between hydrants to bypass waterline closure • Defer western Stillhouse if the ACSA completes its Ivy Road pipeline • Mobilize portable RWSA pump to former Canterbury Hills PS site as needed

6.3.5. Aging Infrastructure and Main Breaks

A review of the RWSA's GIS data revealed that the older waterlines – South Rivanna, North Rivanna, and Stillhouse -are comprised primarily of cast iron (CI) pipe installed in the 1960's, with some CI pipe near the OBWTP installed as far back as the 1940's. Approximately half of the main breaks in recent years have been associated with these CI pipes (Figure 37).

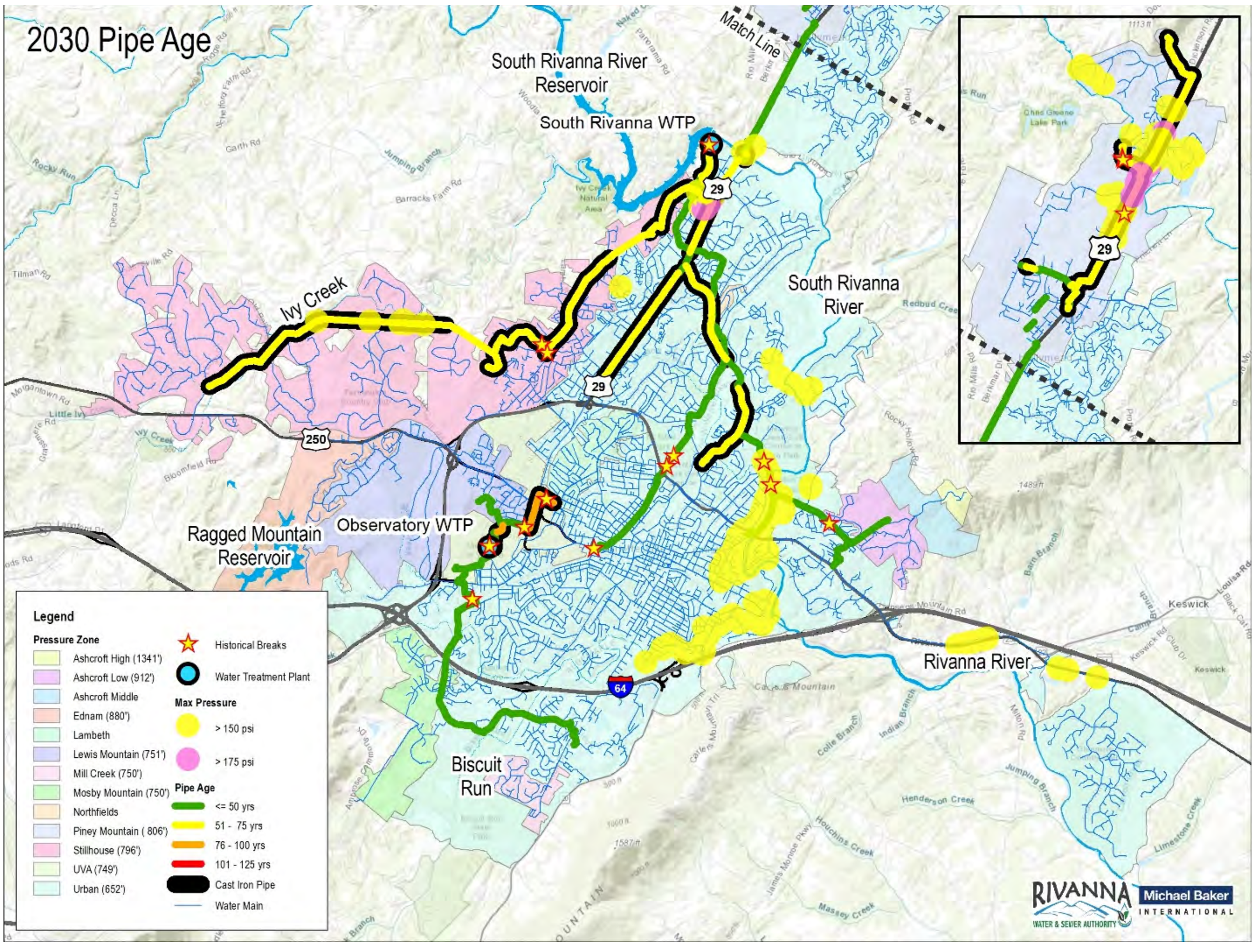

Figure 37. Location and 2030 Age of Existing CI Pipe vs. Recent Main Breaks.

Over half of the RWSA's transmission pipe is CI pipe, primarily 12 to 24-inches in diameter (Table 10). In the late 1960's, the RWSA began installing ductile iron (DI) pipe, phasing out installation of CI pipe by the early 1970's. Transmission main material (represented by color) and size and age (represented by center of circles) are shown in Figure 38.

Table 10. Length of Water Pipe by Size and Material

Diam. (in.)	Cast Iron	Ductile Iron	Total
<=10"	803	797	1600
12"	61,050	22,292	83,342
14"	6827	19	6846
16"	4467	3534	8001
18"	22,094	12,615	34,710
20"	-	20	20
24"	8678	29,555	38,233
30"	29	14,786	14,814
36"	-	2386	2386
Total	103,948	86,004	189,952

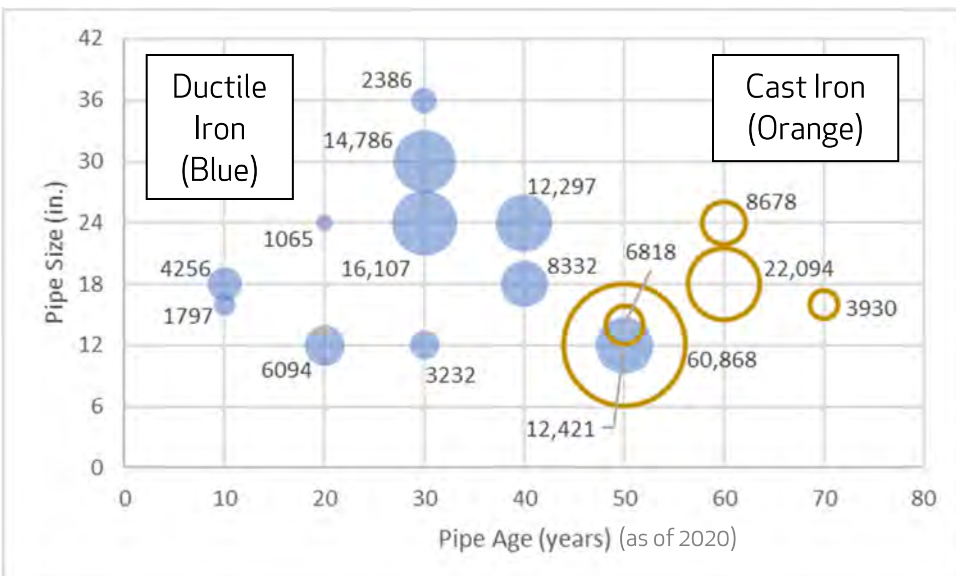

Figure 38. Length, Age and Size of Installed Cast Iron and Ductile Iron Pipe.

Without any other information, pipe age is often used as a surrogate to infer pipe condition. A review of the RWSA's data on recent main breaks, however, reveals that breaks are associated with older CI as well as newer DI pipe. Whenever a main break occurs, its cause should be investigated and determined to the greatest extent possible. A main break can occur for a variety of possibly overlapping reasons, including:

- Corrosion of interior or exterior pipe wall
- Failure of pipe connection hardware (bolts, etc. on fittings and valves)
- Displacement of pipe bedding
- Repeated pressure surges that reduce pipe wall elasticity over time
- Extreme, momentary spikes or drops in pressure

Breaks that have occurred in recent years on the NRWL may be related to pressure surges associated with system operations, whether by customers or the NRWTP pump control valves. Better management of pressure surges within the North PZ will serve to extend the useful life of the pipe. Review of Figure 37 reveals that breaks have also occurred just downstream of both the SRWTP and the OBWTP. A comprehensive condition assessment program is therefore recommended to accomplish the following:

- Identify the source and severity of pressure surges
- Identify leaks (unmetered water consumption)
- Identify air pockets, which result in increased system pressure
  - Locate malfunctioning air release valves (ARVs)
  - Locate where ARVs may be needed
- Via non-destructive as well as destructive testing, determine whether pipe in its existing condition complies with original or current design requirements, whichever are more stringent

Project	Comprehensive Waterline Condition Assessment
Complete By	2030
Total Cost	$0.8M
Benefits	• Determine remaining useful life, especially of CI pipe • Locate air pockets and leaks • Collect pipe and soil samples • Identify areas with high corrosion potential and identify any ongoing corrosion
Implementation Comments	• Perform in phases to spread cost over multiple fiscal years • Focus initial efforts on older CI pipe not impacted by upcoming projects • Locating and reducing leaks reduces unmetered water, reducing operating costs and recovering condition assessment cost • Complete in parallel to Pressure Surge Investigation (6.3.6) to inform assessment

Based on an assumption of 100 years of useful life for cast iron pipe, replacement of the following sections of pipeline are recommended for inclusion in the RWSA's long-term CIP (2045 through 2070) as "placeholders", though Comprehensive Waterline Condition Assessment will inform whether portions of these pipelines should be replaced sooner or later than the assumed 100 years of useful life. Note that the Stillhouse Waterline was installed circa 1973, and therefore is not recommended for inclusion until after 2070.

Project	Observatory Waterline Cast Iron Pipe Replacement
Complete By	2050
Total Cost	$1.9M
Benefits	• Replace aging cast iron pipe (installed circa 1949) at end of useful life
Implementation Comments	• Limits from OBWTP to Alderman Road PS, and from Emmet Street to Lambeth PS (approximately 2,100 LF) • Assume 6-inch diameter increase for additional capacity

Project	South Rivanna Waterline Cast Iron Pipe Replacement
Complete By	2060
Total Cost	$27.6M
Benefits	• Replace aging cast iron pipe (installed circa 1963) at end of useful life
Implementation Comments	• Limits from SRWTP to Park Street via Rio Road East (approximately 22,000 LF) • Assumes South Rivanna Waterline along Seminole Trail, from Rio Road to Hydraulic Road, is replaced earlier; programmed separately (see Section 6.3.8) • Assume 6-inch diameter increase for additional capacity

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Project	North Rivanna Waterline Cast Iron Pipe Replacement
Complete By	2070
Total Cost	$10.6M
Benefits	• Replace aging cast iron pipe (installed circa 1969) at end of useful life
Implementation Comments	• Limits include all of cast iron portions (approximately 15,200 LF) not already programmed as part of North Rivanna Waterline Reinforcement (see Section 6.3.6) • Assume 6-inch diameter increase for additional capacity

6.3.6. Pressure Surges and High Water Main Pressure

Pressure surges occur on a time scale much shorter than standard monitoring equipment is capable of capturing. Specialized data loggers are required to observe the fast-acting pressure behavior of a system (Section 8.4.4). Depending on make and model, such equipment can be deployed on a temporary or permanent basis. Pressure monitoring should be implemented throughout the transmission system as part of a robust asset management program, particularly as the existing infrastructure continues to age: by 2070, the NRWL and SRWL will be over 100 years old, and the Stillhouse Waterline will be almost 100 years old (Figure 39).

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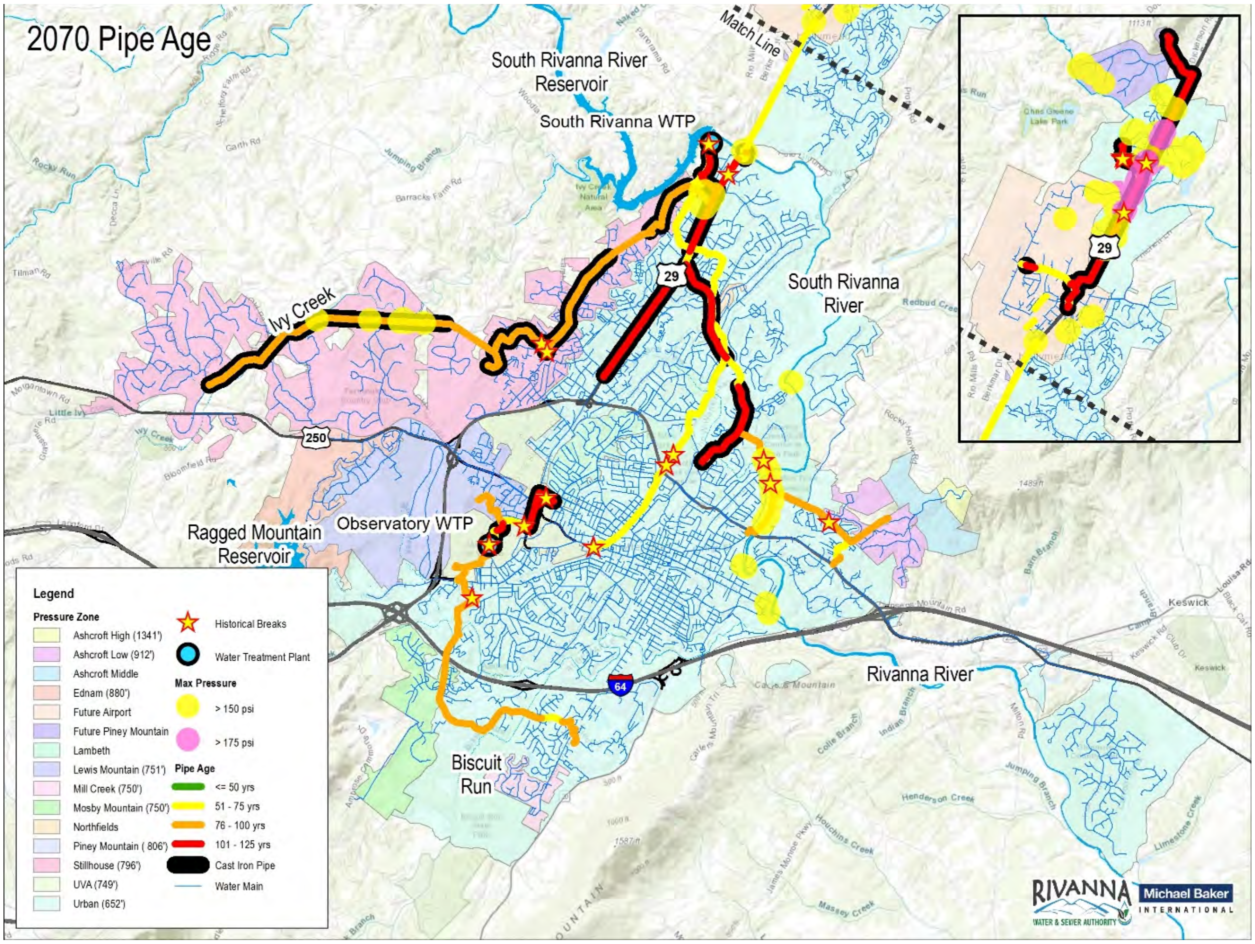

Figure 39. Location and 2070 Age of Existing CI Pipe vs. Recent Main Breaks.

Review of RWSA GIS records indicates that pressure rating of installed pipelines is not recorded, therefore all installed pipe is assumed to be rated for 200 psi. Assuming sources of excessive pressure transients are identified and mitigated, existing pipe rated at 200 psi should be replaced with pipe having a higher pressure class where water main pressure exceeds the alarm level of 175 psi (404 feet of head). Of the four PZs operated by the RWSA, only the North PZ has pipe over 400 feet below the tank-full level (Figure 40), with static pressure up to 188 psi at the following locations:

- North Rivanna River crossing
- Seminole Trail north of Briarwood Drive (Herring Branch relocated)

Based on Albemarle County topographic data with a contour interval of four feet, approximately 6,000 feet of 12-inch cast-iron water main should be replaced, as shown in Figure 38 in the vicinity of NGIC, to address low-elevation pipe subject to high system pressure.

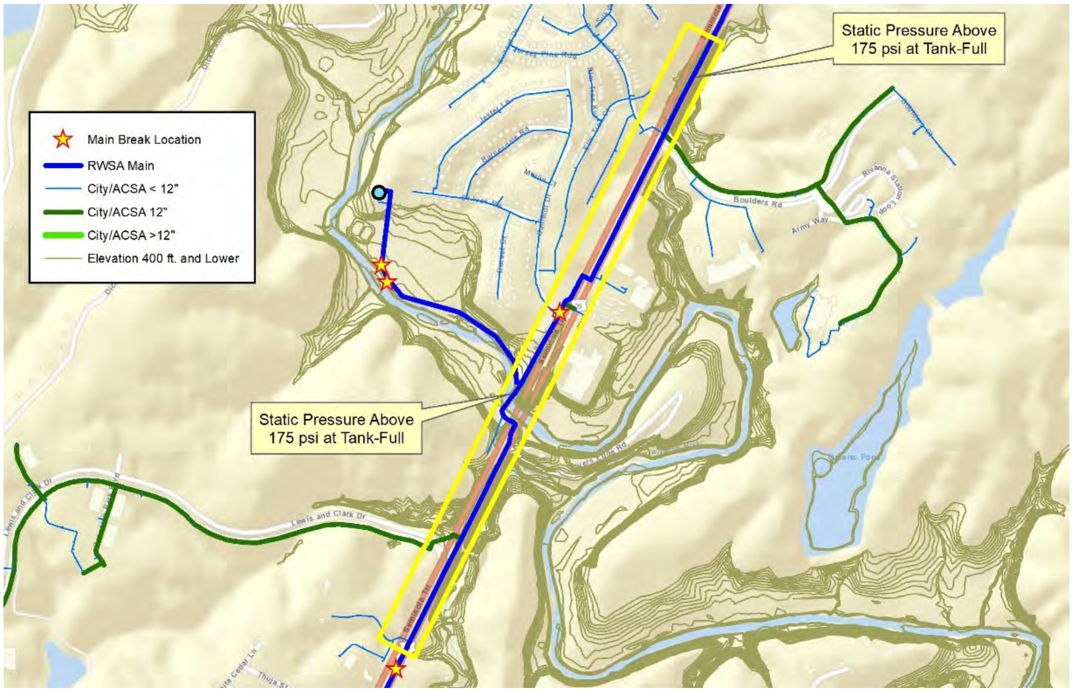

Figure 40. Locations of Excessive Pressure on North Rivanna Waterline.

Project	North Rivanna Waterline Reinforcement
Complete By	2030
Total Cost	$4.3M
Benefits	• Improve system resilience to high pressure when Piney Mtn. Tank is full • Increase diameter from 12-inches to 18-inches for additional capacity
Implementation Comments	• Coordinate with second North Rivanna River Crossing • Install pipe with 250 psi or higher pressure class • Can push back installation timing if pressure transients are mitigated following Pressure Surge Investigation

6.3.7. Difficult Access and Critical Crossings

In addition to single-feed areas and aging infrastructure, other aspects of vulnerable areas include crossings that would be difficult to access for completing emergency repairs, such as at railroads, river crossings, and major highways. These types of crossings typically require long lead times as well as permitting for construction and maintenance activities. Where not already present, functional redundancy for such crossings is recommended, whether at each location or elsewhere in the system to provide water via an alternative route without incurring a significant adverse impact to service.

Transmission mains that parallel or cross waterways may be difficult to access, especially during or immediately after flood events, which can scour the stream bank or stream bed in which the pipe is installed. These locations include crossings of the North Rivanna, South Rivanna, and Rivanna Rivers; and crossings of Ivy Creek and adjacent swampy areas. Mains near major water courses or that cross major roadways or railroads are shown in Figure 41.

The RWSA operates waterlines at several major crossings (Figure 41), defined for the purposes of the UFWMP as rivers, highways and high-volume roadways, and railroads. While the existing transmission system has redundancies for a number of major crossings, additional redundancies are recommended to improve system resilience. At present, each river has only one crossing:

- North Rivanna River: 12-inch DI pipe (NRWL)
- South Rivanna River: 12-inch DI pipe (NRWL)
- Rivanna River: 24-inch DI pipe (Pantops Waterline)

Several other crossings are located at Ivy Creek (12-inch Stillhouse Waterline) and along Routes 29 and 250. Redundancies for these crossings are also discussed.

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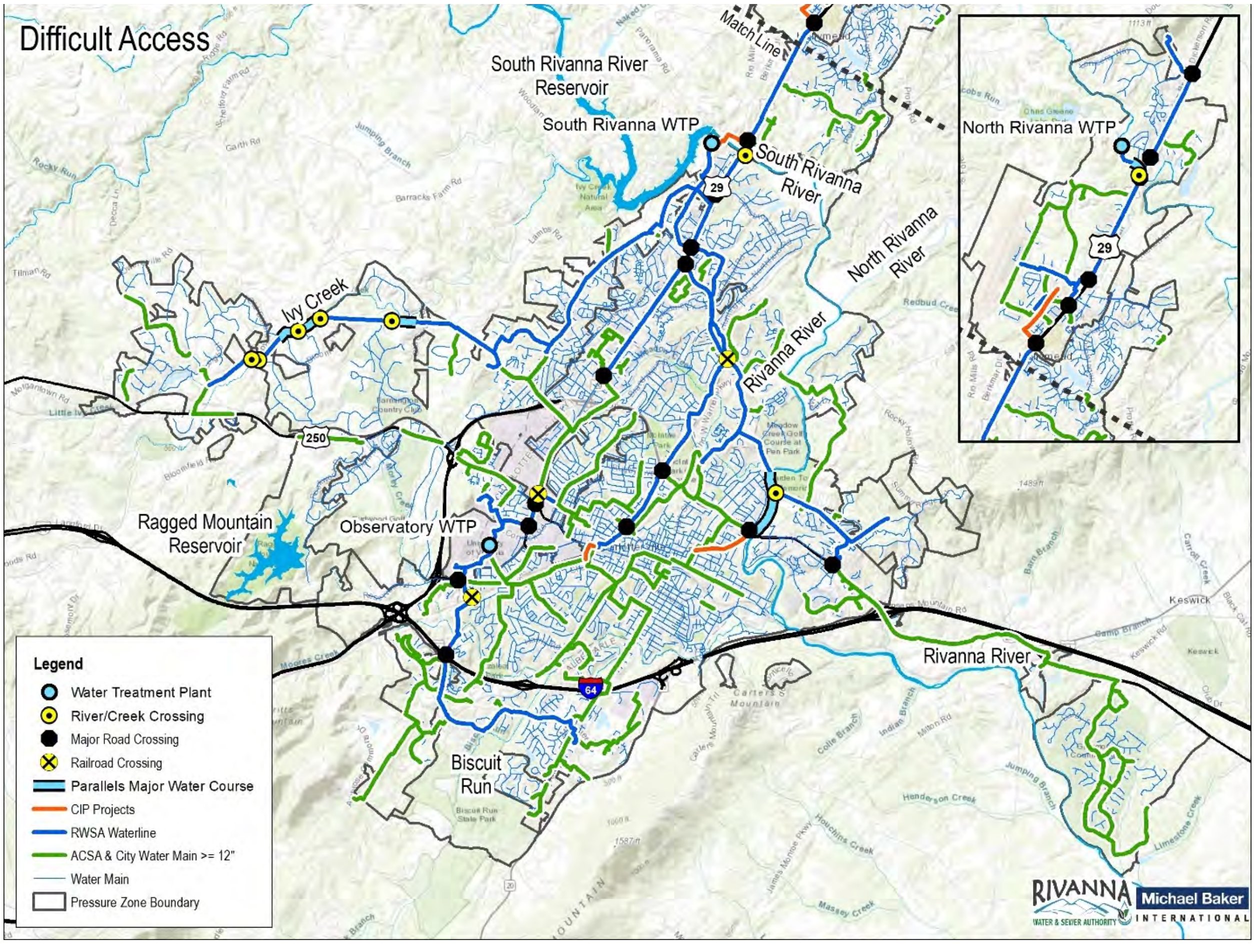

Figure 41. Waterlines Difficult to Access due to Railroad, Major Road, or Water Course.

<u>North Rivanna River</u>

A second 12-inch crossing is planned at the North Rivanna River. Operationally, both crossings would be active, with the ability to isolate each one and still maintain service if a crossing needs to be taken off-line. If the Airport PZ is created in the future, or if the North PZ along Seminole Trail is otherwise converted to the UPZ, then each crossing can be dedicated to a separate PZ, with the ability to revert the area along Seminole Trail to the Piney Mtn. PZ during emergency situations. As of this writing, the RWSA is in the early planning stages for this redundant crossing. An alignment concept is shown in Figure 42.

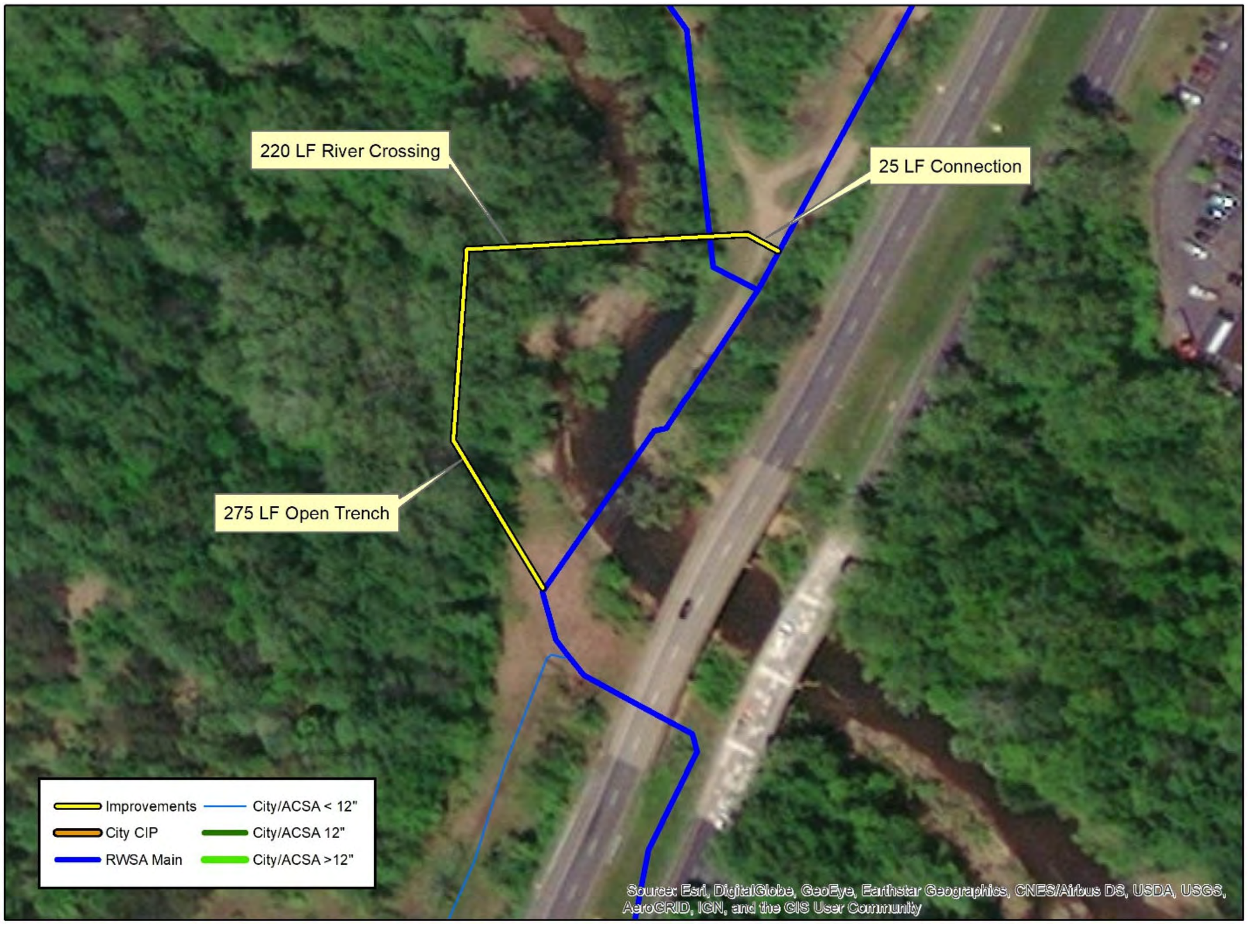

Figure 42. Conceptual Alignment for Second North Rivanna River Crossing.

Project	North Rivanna River Second Crossing
Complete By	2030
Total Cost	$1.2M
Benefits	• Redundant 12" crossing
Implementation Comments	• Operate both pipes in parallel • Provides flexibility to support 2 pressure zones along Seminole Trail in the future • Install pipe with higher pressure class (min. 250 psi)

South Rivanna River

At the South Rivanna River, the RWSA is in the preliminary design stage for installing a 24-inch crossing near the SRWTP, which will provide redundancy to the existing 12-inch NRWL crossing of the South Rivanna River as well as increased capacity to serve the future ARPS and growth both in the North PZ and in the UPZ north of the South Rivanna River.

Project	South Rivanna River Second Crossing
Complete By	2025
Total Cost	$5.8M
Benefits	• Redundant 24" crossing to existing 12" crossing • Required to support northern UPZ and North PZ via future ARPS when NRWTP is decommissioned in 2025
Implementation Comments	• Design in progress • Construction Administration already funded

Rivanna River

Along the Rivanna River, the ACSA has its own crossings parallel to the RWSA's Pantops Waterline: a 12-inch polyvinyl chloride pipe at Town Branch, from Dunlora Farm Road to Key West Drive; and an 8-inch DI pipe near the western end of Riverbend Drive. In order to provide equivalent capacity to the RWSA's 24-inch waterline, an additional 20-inch crossing would be required. Given that a 12-inch pipe is planned for the City's East Market Street CIP and that the ACSA's existing distribution main in Peter Jefferson Parkway is 16-inch pipe, a 16-inch crossing is suggested from East Market Street at Steephill Street to Peter Jefferson Parkway (Figure 43) to provide some redundancy. An additional Rivanna River crossing also provides redundancy to two U.S. Route 250 crossings. Because this crossing would connect pipes from two different jurisdictions, a wholesale meter would be required.

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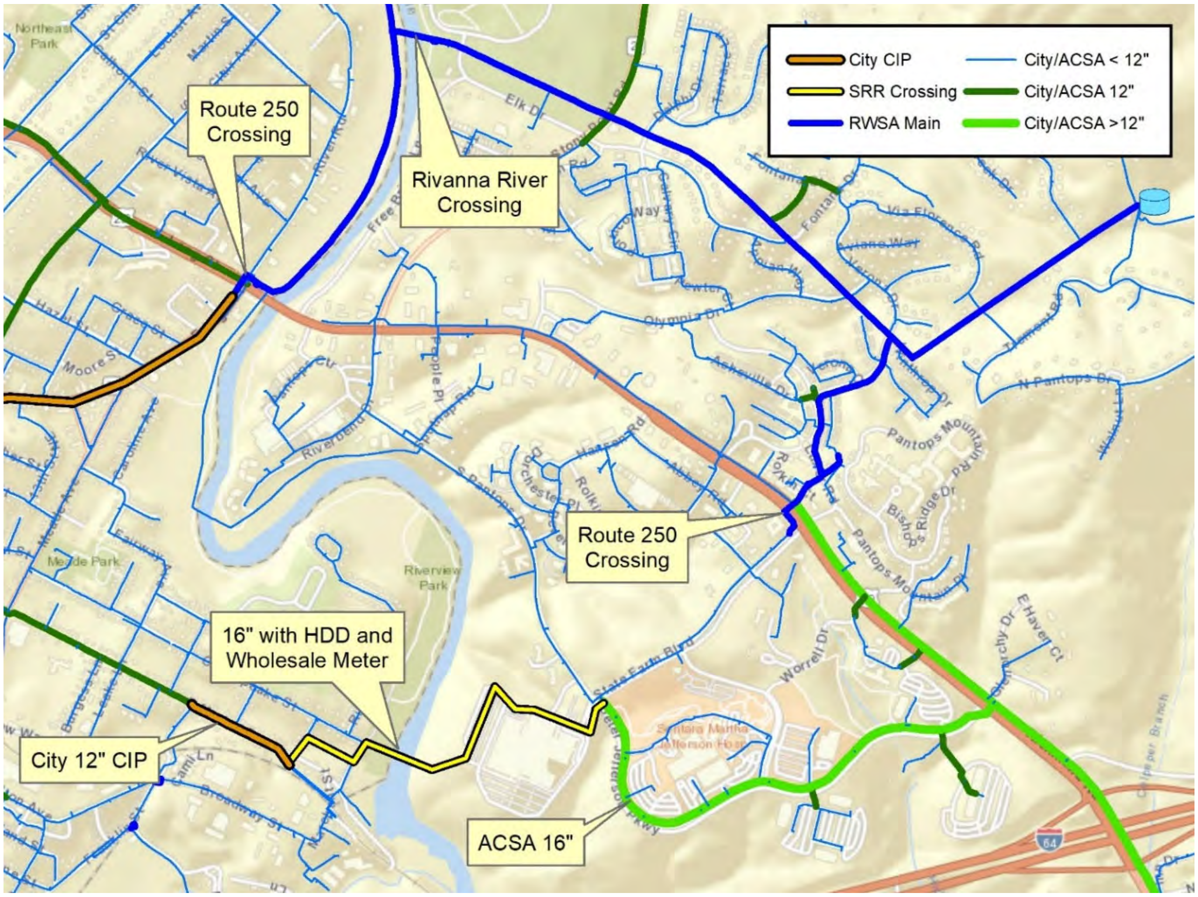

Figure 43. Location of Redundant Rivanna River Crossing.

Project	Rivanna River Second Crossing at Pantops
Complete By	2045
Total Cost	$4.8M
Benefits	• Redundant 16" crossing to 24" Pantops Waterline crossing • Fills City/ACSA gap to provide redundant U.S. Route 250 crossing
Implementation Comments	• Requires wholesale meter vault (inter-jurisdictional transfer of water) • Coordinate with City's East Market Street 12" CIP

Ivy Creek

Redundancy to the five Ivy Creek crossings in the western Stillhouse PZ can be provided by the RWSA installing isolation valves and bypass connections (hydrants). These improvements are included in the costs/schedule presented in Section 6.3.4.

Major Roads

The existing transmission system crosses Route 29, a major thoroughfare, almost a dozen times, whether by design or due to the expansion of Route 29 into a divided roadway. Many of these crossings already have redundancy, whether via a parallel RWSA waterline or a network of retail utility pipelines. As future opportunities arise, such as with the recent Rio Road grade separation project and the upcoming Hydraulic Road grade separation project, the RWSA should relocate existing waterlines from the interior to the outside of the public right-of-way, and extend the SRWL towards UVA.

The Urban and Pantops Waterlines cross Route 250 in three locations to deliver water to downtown Charlottesville and Pantops. Adding a Rivanna River crossing improves hydraulic connectivity between downtown and the Pantops Tank in the event that the Pantops Waterline is out of service.

Railroads

The CWL addresses redundancy to the Norfolk Southern and CSX (Buckingham Branch) railroad crossings near the OBWTP. The Norfolk Southern railroad crossing at Rio Road is already addressed by the parallel Southern Waterline and Urban Waterline.

6.3.8. Infrastructure Capacity Gaps

To improve redundancy, other gaps in the conveyance capacity of the transmission and distribution network should also be filled. In the near term and with interconnection spurs to City mains, the CWL achieves that goal for the RWSA within the transmission network, while also providing redundancy to several crossings of railroads and major roadways. Long-term, however, and with timing dependent on how growth occurs as well as what streetscape/ roadway projects or other CIPs are undertaken in the corridor over the next 25 years, the RWSA should pursue a transmission main upgrade to the SRWL on Seminole Trail, upsizing and replacing existing CI pipe (Section 6.3.5) and extending the waterline south via Emmet Street to the RWSA's 16-inch Observatory Waterline serving the City's Lambeth PS (Section 6.2.3) and, ultimately, to the CWL.

Replacement of aging cast iron South Rivanna Waterline along Seminole Trail, from Rio Road to Hydraulic Road, will result in improved conveyance and therefore reduced pressure loss as demand along this corridor continues to increase. This segment of the South Rivanna Waterline is recommended to be programmed as a separate CIP item from the other South Rivanna cast iron replacement identified in Section 6.3.5, as the Seminole Trail corridor will likely see roadway improvements present opportunities for replacement as betterment prior to the 2055-60 timeframe.

Project	South Rivanna Waterline Replacement Rio to Hydraulic
Complete By	2070
Total Cost	$9.6M
Benefits	• Replace aging 18" CI pipe with 24" DI pipe • Reduce friction (pressure) loss moving water to/from northern UPZ
Implementation Comments	• Complete piecemeal as VDOT improves Seminole Trail • If roadway project conflicts necessitate relocation of the existing 18-inch at roadway project cost, upsizing to 24-inch at that time would present an opportunity for RWSA to fund the "upsize" pro-rate only – estimated in the $1.2M range • Optionally 700 feet of 18" CI pipe installed in 2015 for VDOT's Rio / Hydraulic grade separation project can remain in place

Participating stakeholders may also complete similar projects to improve overall system function and provide redundancy to RWSA waterlines, in the event that a waterline is temporarily closed. As these would be stakeholder projects, estimated project costs are presented for informational purposes but not included as part of a CIP program for the RWSA. Additionally, a timeline for project completion is not provided.

The City has been aggressively upgrading its network of primary distribution mains in recent years. Some potential gaps that may yet be filled include the following (Figure 44):

- 6th Street Southeast, between Monticello Avenue and Elliott Avenue
- Jefferson Park Avenue, from Monroe Lane to Main Street West
- Heather Heyer Way, from Water Street to East Main Street

The 6th Street Southeast pipe might be deferred, depending on the final alignment of the CWL.

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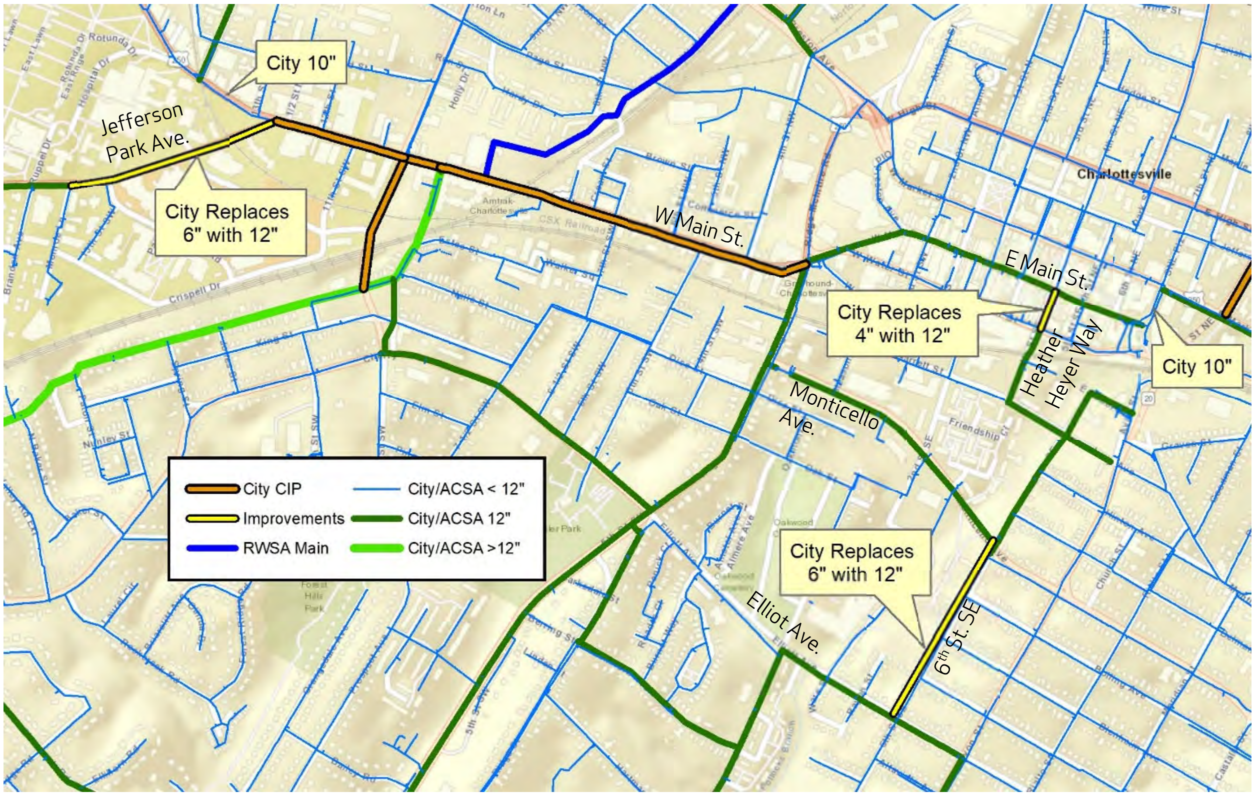

Figure 44. Potential Capacity Improvements for City Distribution System.

Project	Potential City Conveyance Improvements
Complete By	2070
Total Cost	$2.M
Benefits	• Fill gaps in larger-diameter City distribution network • Provide limited redundancy if the CWL is temporarily closed
Implementation Comments	• Incorporate into overall City water CIP program

Likewise, several gaps in the ACSA distribution system can also be filled. For example, hydraulic connectivity between the Southern Loop Waterline and areas north of Interstate 64 could be improved, as shown in Figure 45. Completing one or both of these connections would add to the redundancy provided by the ACSA's Avon Street water main, thus improving system resilience for serving the southern Urban System.

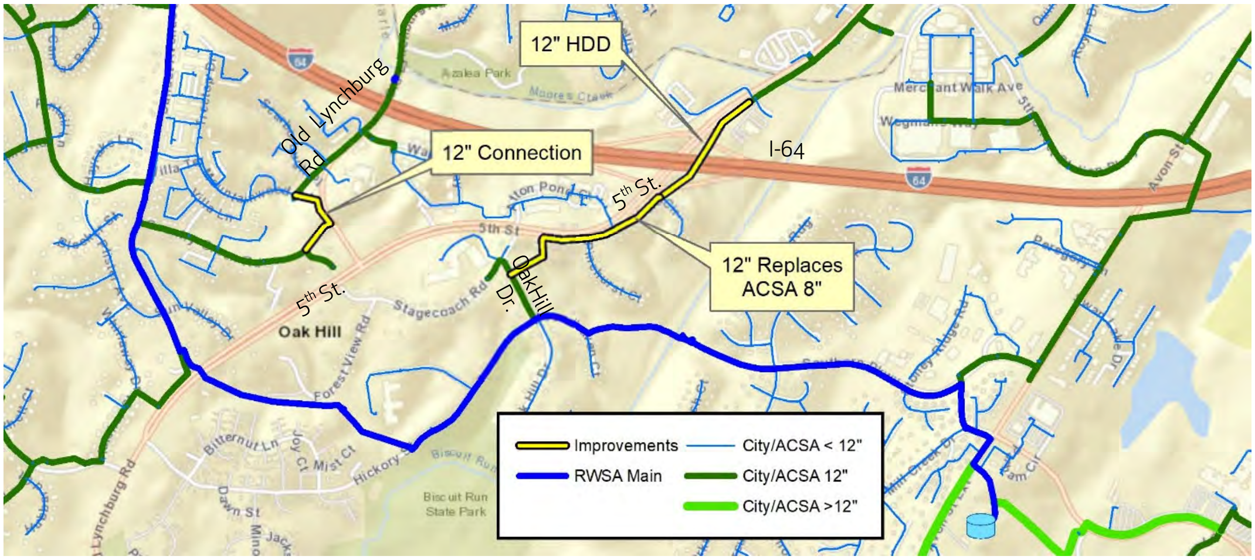

Figure 45. Potential Gap Closures in ACSA Distribution System.

Project	Potential ACSA Conveyance Improvements
Complete By	2070
Total Cost	$3.9M
Benefits	• Fill gaps in larger-diameter ACSA distribution network • Provide limited redundancy if the Southern Loop Waterline is temporarily closed
Implementation Comments	• Incorporate into overall ACSA water CIP program

Depending on the timing and location of future urban zone growth and whether the ACSA has closed the gaps identified in Figure 45, the RWSA may opt to upgrade conveyance along Avon Street, from the CWL to the Southern Loop. This corridor is currently served by 12-inch ACSA and City mains, and the CWL should connect to the City main (Figure 46). Anticipated design and construction cost is $10.3M, and anticipated timeline is in the early 2060s. An Avon Street Waterline provides redundancy to the Southern Loop railroad and interstate crossings and improves system resilience in serving areas south of I-64.

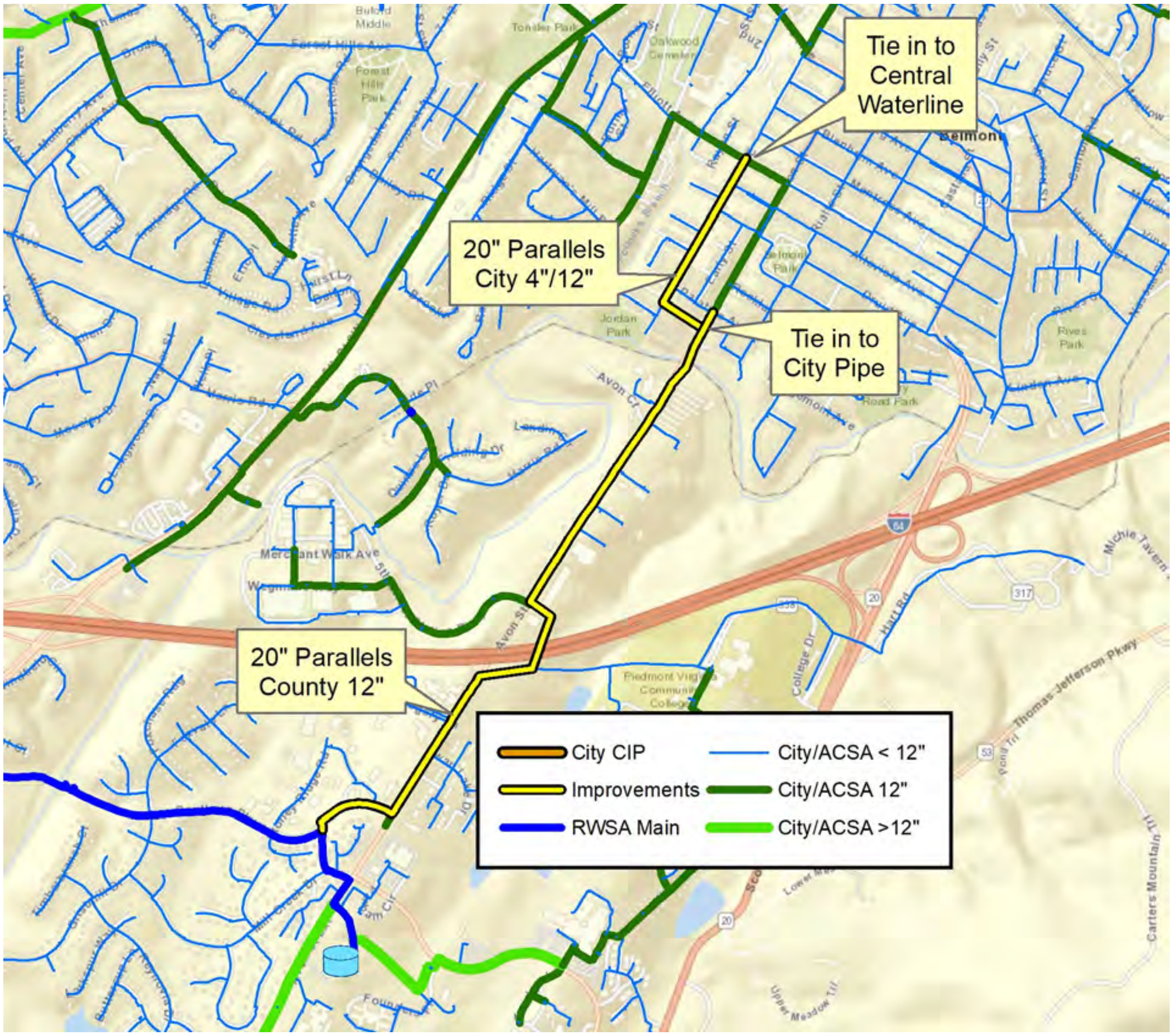

Figure 46. Potential Long-Term Gap Closure in RWSA Transmission System.

Project	Avon Street Waterline
Complete By	2065, or as needed based on hydraulics associated with future growth
Total Cost	$10.3M
Benefits	• High-capacity redundancy to Southern Loop railroad and interstate crossings
Implementation Comments	• Improve hydraulic connectivity between Avon Street Tank and Central Waterline if warranted by growth/demand • Provide loop from OBWTP to Avon Street Tank

6.4. Summary of Recommendations for RWSA Waterlines

Waterline recommendations are presented in Table 11. These recommendations are in addition to CIPs that are either already identified or in the early stages of design. Figure 41 is reproduced below as Figure 47, annotated to indicate which recommended projects address waterline challenges.

Table 11. Summary of Recommendations for RWSA Waterlines

Recommendation	Report Section	Category	Complete By	Total Project Cost
South Rivanna River Second Crossing	6.3.7	Redundancy	2025	$5.8M
Airport Road Pump Station Waterline – Phase 1	6.2.5	Conveyance	2025	$6.0M
Airport Road Pump Station Waterline – Phase 2	6.2.5	Conveyance	2030	$1.4M
Central Waterline	6.2.4	Conveyance	2030	$31.0M
Waterline Condition Assessment	6.3.5	Resilience	2030	$0.8M
North Rivanna Waterline Reinforcement	6.3.6	Resilience	2030	$4.3M
North Rivanna River Second Crossing	6.3.7	Redundancy	2030	$1.2M
Emmet/Seminole Waterline	6.2.3	Redundancy	2035	$18.0M
Alderman Road PS Discharge Inter-connection	6.3.1	Resilience	2045	$0.4M
Single-Feed Bypasses	6.3.4	Resilience	2045	$1.3M
Rivanna River Second Crossing at Pantops	6.3.7	Redundancy	2045	$4.8M
Observatory Waterline Replacement	6.3.5	Resilience	2045-50	$1.9M
South Rivanna Waterline Replacement	6.3.5	Resilience	2055-60	$27.6M
Avon Street Waterline	6.3.8	Redundancy	2060-65	$10.3M
North Rivanna Waterline Replacement	6.3.5	Resilience	2065-70	$10.6M
South Rivanna Waterline Replacement Rio to Hydraulic	6.3.8	Conveyance	2070	$9.6M

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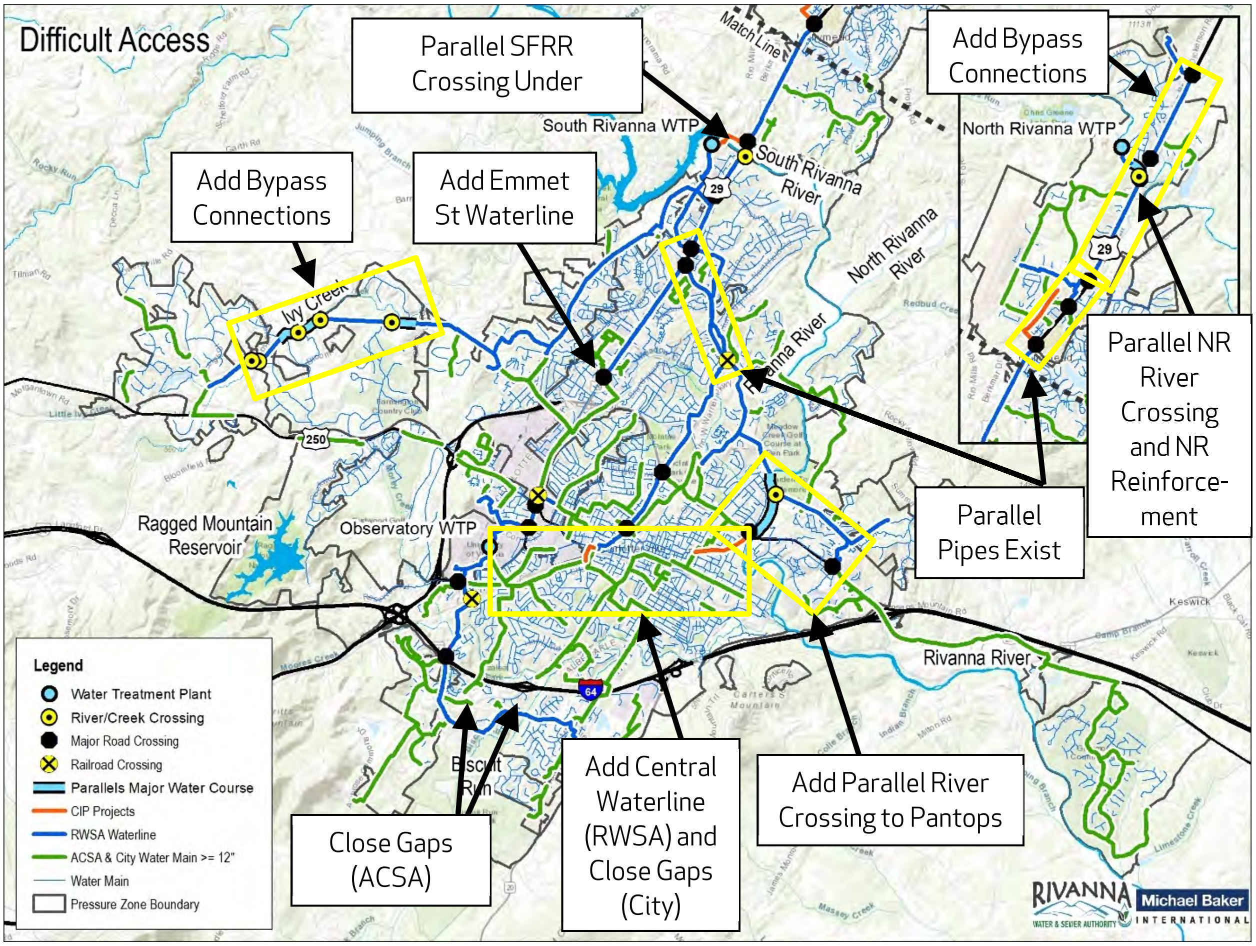

Figure 47. Projects to Address Waterline Challenges

(End of section.)

7. Storage Tanks

7.1. System Operations

For typical operations, storage tanks buffer the difference between water production and demand. This enables facilities to operate at a more uniform rate, with tanks absorbing the shock of sudden changes in demand, thus buffering changes in system pressure associated with the change in demand. Tanks also provide initial fire suppression water, with pump station output and/or WTP production adjusting in response to changes in tank level as water is withdrawn from the tank. Finally, tanks provide water to all or part of a PZ if a WTP or PS is off-line or cannot refill the tank for a short period of time due to a planned or emergency short-term (24 hours or less) closure of a facility or pipeline.

The RWSA's tanks within the UPZ provide water supply in conjunction with the SRWTP, which is operated continuously. Given the low hydraulic connectivity between the southern and western areas and the rest of the urban water system for existing conditions, the Observatory and Avon Street Tanks operate as a semi-isolated subzone of the UPZ. The performance of these tanks is therefore closely tied to production at the OBWTP, which is operated approximately 12 hours a day under normal conditions. With the OBWTP shut down for the night and SRWTP production close to or exceeding demand, the Observatory and Avon Street Tank levels respond to SRWTP production, especially once the Pantops Tank is full.

Outside the UPZ, each separate PZ has one tank, which serves as the source of water for its respective PZ when not being refilled by pumping operations. A tank will also provide water to customers in its vicinity when intra-day PZ demand exceeds the pumping rate. Except for the RWSA's 1 MG Woodburn Tank, which is an elevated storage tank (EST), all other large storage tanks on the urban water system are ground storage tanks (GSTs). Except for the ACSA's Glenmore Tank, all of the GSTs float on their PZ. Appendix F contains a more in-depth presentation of background information as well as supporting narratives and data for scenarios, including those used to develop the recommendations presented in Section 7.6.

7.2. Woodburn Tank Special Case

The RWSA's Woodburn Tank is treated as a special case. Normally this tank is isolated from the UPZ, providing domestic and backwash process water to the SRWTP: at 652.2 feet, its overflow elevation is below the highest HGL (over 660 feet) generated by the SRWTP when delivering water to the UPZ. When the SRWTP is off-line, however, the RWSA can isolate the Woodburn Tank from the SRWTP and open a valve to allow the Woodburn Tank to float on the UPZ. In all scenarios for which the SRWTP is off-line, the Woodburn Tank floats on the UPZ. Even though the Woodburn Tank is isolated from the UPZ when the SRWTP is on-line, domestic and process water usage is accounted for, such that the total SRWTP finished water capacity available to the UPZ is reduced by the domestic/process demand of the SRWTP itself.

7.3. Storage Categories

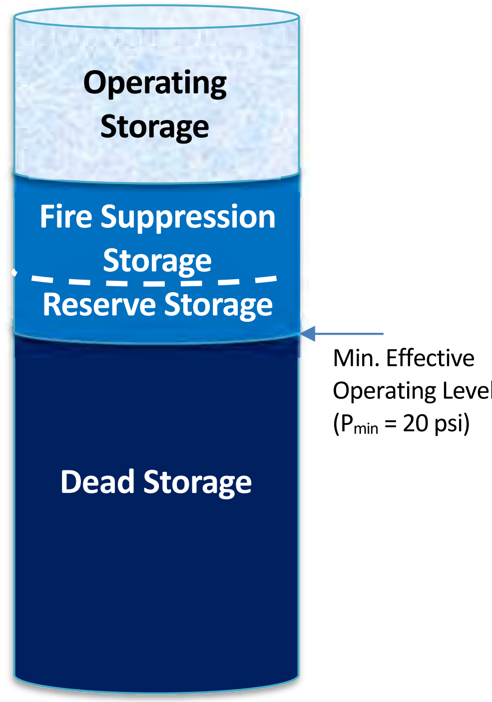

Figure 48. Water Tank Storage Volume Components.

Storage tanks must accommodate up to three categories of water: operating storage, reserve storage, and fire suppression storage. A fourth category, dead storage, may also be present (Figure 48). Dead storage is the volume in a tank that is inaccessible due to either tank construction or operations requirements (e.g., tank bottom elevation is below that required to maintain minimum pressure). For the UFWMP, evaluation of urban finished water system storage includes ACSA tanks.

Managing water storage tanks factors into the water system's ability to maintain adequate pressure for a range of operating conditions (scenarios). Ideally, each tank will cycle through its operating volume once per day and refill completely for each cycle, with the operating range representing the maximum cumulative difference between PZ demand and water supplied.

The volume of fire suppression storage required within a PZ is dependent on several factors:

- Maximum NFF and the associated fire flow duration
- Location of storage relative to fire flow demand
- Make-up capacity of water system under normal operating conditions
- Locally-sourced water to make up the difference between NFF and AFF (e.g., a dry hydrant at a pond)

Outside the UPZ, maximum NFF within the PZ exceeds firm capacity of the supporting pump station, assuming sprinkler systems are not installed. Fire suppression water must therefore be supplied by the PZ storage tank in combination with its pump station unless augmented by another source such as a dry hydrant at a pond or lake. While current VDH regulations do not require fire suppression storage within a PZ, it is good practice to provide the required fire suppression volume (two to four hours of maximum NFF) within the PZ as redundancy to pumps supplying some of the fire suppression water to the PZ. Fire flow duration is dependent on flow rate and is presented in Table 12.

Table 12. Fire Flow Duration

Duration (Hours)	Fire Flow (gpm)		Reference
	Low	High	
1	0	1,000	NFPA 1, Section 18.4.5.1
2	>1,000	<3,000	NFPA 1, Table 18.4.5.2.1
3	3,000	<4,000	
4	4,000	-	

All storage tanks are assumed to be able to drain dry via a bottom outlet, such that there is no dead storage due to type of tank construction. For the UFWMP, dead storage is calculated based on 20 psi static residual pressure at the assumed highest customer meter elevation. Given that a detailed evaluation of operational requirements, including identification of minimum tank levels required to provide NFF, is beyond the scope of the UFWMP, an in-depth review of tank operational requirements is recommended. This review should include an assessment of buildings with high-value NFF and whether the NFF can be reduced due to presence of approved automatic sprinkler systems. For the purposes of the UFWMP, fire suppression volumes are presented assuming sprinkler systems are not installed, and the volume of dead storage is estimated by making the following assumptions:

- Customers at high elevation within a PZ do not have private booster pumps installed
- The minimum allowable tank level corresponds to maintaining a minimum static pressure of 20 psi at the highest customer meter elevation
- Provision of NFF does not influence pressure at the assumed highest-elevation customer meter and does not cause pressure to go below 20 psi elsewhere in the water system (excludes tanks and adjacent hydrants and transmission mains)

Given existing system characteristics, estimated storage volumes by category are presented in Table 13. Nearly all of the urban system dead storage (5.2 of 5.5 MG) is in the UPZ tanks, with the Pantops Tank accounting for just over half of the total urban system estimated dead storage. Reserve storage and fire suppression storage are calculated by subtracting operating and dead storage from total storage. RWSA tank characteristics are presented for the UPZ in Figure 49 and for other PZs in Figure 50. Reserve storage and fire suppression storage are located below the tank's alarm level, which is set to alert system operators when a storage tank drops below its normal minimum operating level (i.e., operating storage has been depleted).

Table 13. Existing Storage Volumes by Category

Tank[1]	Base Elevation (ft)	Operating Min. Level (ft)	Estimated Storage Volume (MG)				
			Total	Operating[2]		Dead[3]	Reserve/Fire[4]
				Active	Surcharge		
Piney Mtn.	767	10	0.80	0.59	-	-	0.21
Pantops	612	26	5.01	1.75	-	2.79	0.47
Avon Street	607	26	2.05	0.85	0.04	1.21	-0.05[5]
Observatory	620	19	3.30	1.10	0.59	1.21	0.40
Lewis Mtn.	726	18	0.52	0.14	-	-	0.38
Stillhouse	746	20	0.73	0.20	-	-	0.53
Ednam*	810	40	0.30	0.13	-	0.09	0.08
Mosby Mtn.*	720	5	0.19	0.17	-	-	0.02
Avon Park*	696	40	0.25	0.04	-	0.20	0.01
Glenmore	376	12	0.78	0.51	-	-	0.27
TOTAL	-	-	13.93	5.48	0.63	5.50	2.32

1. All tanks are GSTs and owned by the RWSA, except * owned by the ACSA
2. Active is operating range excluding Surcharge height (tank level exceeding UPZ HGL of 652 feet)
3. Based on HGL associated with static 20 psi at assumed highest-elevation customer meter
4. Reserve/Fire Suppression = Total – Operating – Dead
5. Avon Street Tank operating levels 1 foot above UPZ HGL and 1 foot below assumed dead storage level

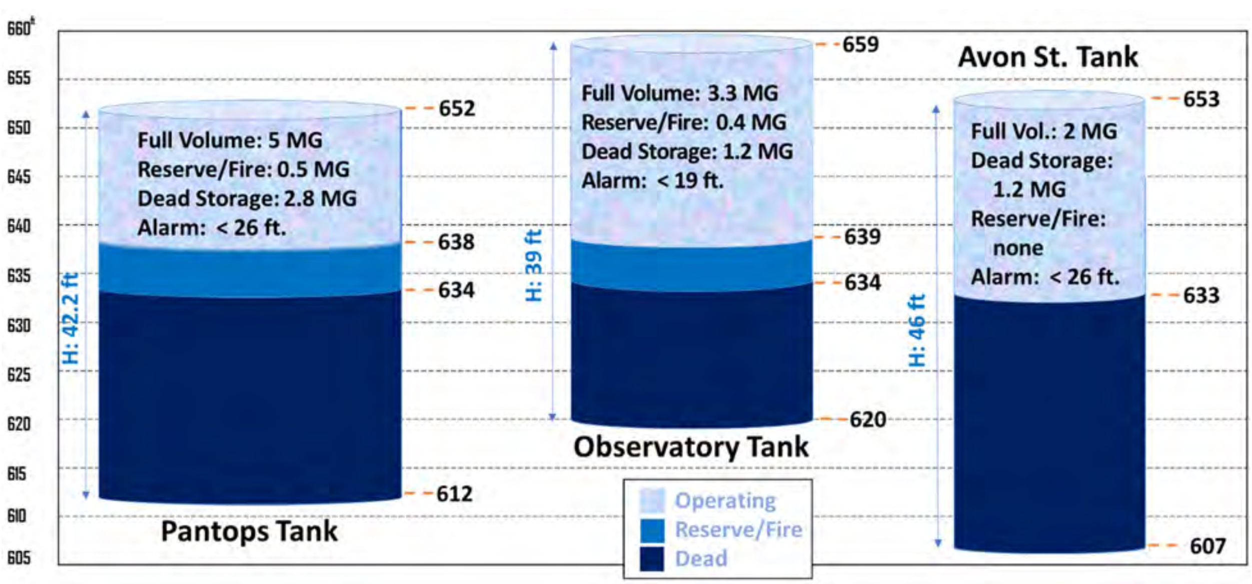

Figure 49. RWSA Urban Pressure Zone Current Storage Tank Ranges.

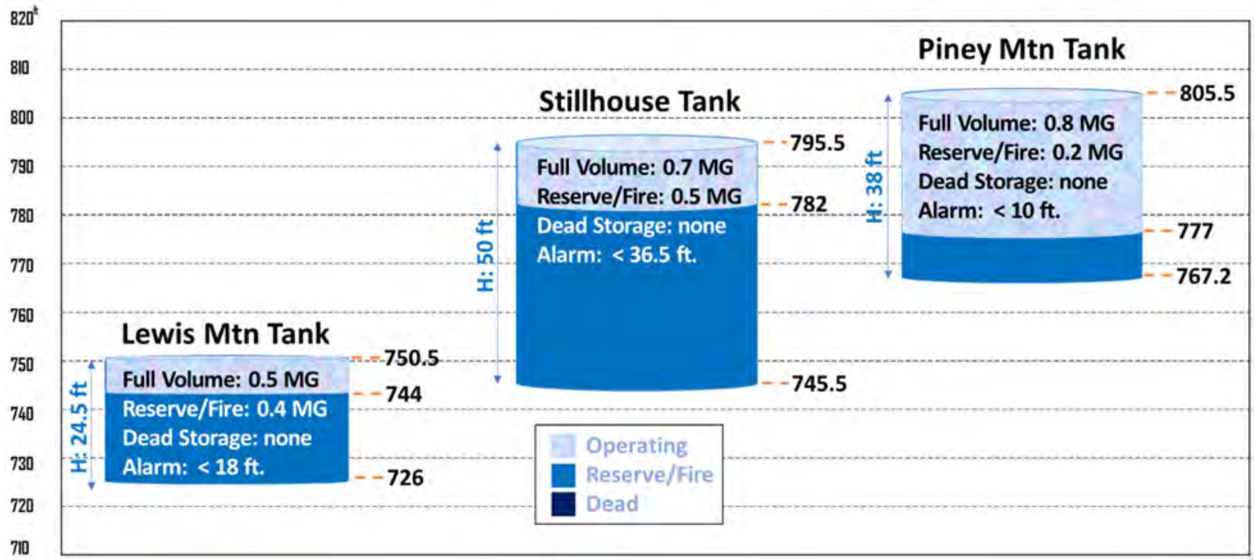

Figure 50. RWSA Current Storage Tank Ranges Outside the Urban Pressure Zone.

7.4. Regulatory Requirements

According to current VDH regulations, water utilities are required to provide sufficient effective storage to meet maximum daily water demand at the design year (2070 for the UFWMP). Compliance is normally demonstrated by use of a hydraulic model. In the absence of a hydraulic model, effective storage shall be one-half of the maximum daily demand at the design year (12VAC5-590-640.B.3.a). For tanks that float on their PZ, the minimum storage elevation is that required to provide a minimum pressure of 20 psig throughout the tank's service area at maximum daily demand (12VAC5-590-640.B.3.c).

The current regulations give waterworks operators more flexibility in managing their systems. For the RWSA, this means that, with the planned WTP capacity upgrades, UPZ conveyance improvements recommended in Section 6 can mitigate some of the current operations challenges described below.

7.5. Operations Challenges

7.5.1. Dead Storage

Review of Figure 48 shows that as dead storage increases relative to total tank volume, average residence time of water in the tank also increases, thereby increasing water age. This is because, assuming reserve storage and fire suppression storage are held constant, operating storage must be reduced, thereby reducing tank turnover.

Dead storage presented in Table 13 is based on a pressure of 20 psi at the assumed highest customer meter elevation. Key HGLs and pressures are presented in Table 14.

Table 14. Key Levels in Storage Tanks

Tank	Base Elevation (ft)	Overflow Elevation (ft)	Highest Meter Elev. (ft)	Location	HGL (ft) for Meter at 20 psi	Pressure (psi) at Highest Meter for Tank Full
Piney Mtn.	767	805.5	692	250' downhill from tank	738	49
Pantops	612	652	588	1641 Stonecrop Court 1650 Stonecrop Court	634	28
Avon Street	607	653				
Observatory	620	659				
Lewis Mtn.	726	750.5	673	Crestwood Drive (University Village)	719	34
Stillhouse	746	795.5	694	685 Flordon Drive	740	44
Ednam	810	880	785	436 Rookwood Drive	831	41
Mosby Mtn.	720	753	653	2059 Ridgetop Drive	699	43
Avon Park	696	750.5	694	1960 Tudor Court	740	24
Glenmore	375.75	410.75	420	2215 Waterside Way	N/A	N/A

The UFWMP identifies opportunities to significantly reduce, if not completely eliminate, dead storage within the RWSA's tanks, as dead storage does not enhance system function and, from a water quality perspective, detracts from it. The primary challenges to storage and operating the tanks are as follows:

- Tank volume relative to PZ demand
- Development encroaching into tank operating range (i.e., building at high elevation relative to the tank bottom elevation)
- Hydraulic connectivity of tank to water source(s) and customers
- System pressure management inhibiting tank turnover

7.5.2. Wide Pressure Bands

For a maximum allowable customer pressure of 80 psi and a minimum acceptable customer pressure of 40 psi, the maximum operating range of a PZ is 40 psi, or 92 feet of head. For ease of planning, pressure bands are typically organized into 100-foot (43-psi) increments. By utilizing PRVs and allowing water main pressure to go as high as 150 psi (Section 3.5), a PZ's pressure band can be extended to 110 psi, or approximately 250 feet. All of the PZs with storage tanks have a head range of 250 to 300 feet from the tank-full HGL to the HGL corresponding to 80 psi at the lowest customer meter, with the Piney Mtn. (North) PZ head range approaching 400 feet (Appendix F).

Given the wide pressure bands, actions may be required by the retail utilities for customers falling outside the acceptable water main operating range of 40 to 150 psi:

- For low-elevation (high-pressure) customers:
  - Install PRV vaults to create new, intermediate PZs
  - Install individual PRVs
- For high-elevation (low-pressure) customers:
  - Identify minimum acceptable pressure, if less than 40 psi
  - Reconfigure distribution system to move customers to a higher PZ (individual PRVs may be required)
  - Install pumps and hydropneumatic tanks to create new, intermediate PZs
  - Install private pumps

ACSA has indicated that, based on past experience, retrofitting existing customers with private pumps is not a desirable course of action. Where hydropneumatic tanks or private pumps are not installed, the customer pressure requirement can encroach into the storage range of the tank, thus reducing the effective operating range of the tank (Table 14). This results in dead storage (inaccessible water), which increases the carrying cost of the tank, reduces tank turnover, increases water age, and leads to degraded water quality. This phenomenon impacts both RWSA and ACSA tanks.

7.5.3. Tank Turnover

To promote turnover and reduce water age, operators can increase a tank's operating range by lowering pump start levels. Such action requires coordination with the retail utility to evaluate customer pressure requirements and identify how to meet those requirements with a lower tank level. In the long term, if replacement storage is elevated, customers whose maximum static pressure will exceed 80 psi will require an individual PRV. This option typically can be done without entering a customer's property, by installing the PRV at the water meter.

7.5.4. Future Storage Needs

Storage needs are calculated based on the assumed highest-elevation customer meter within a PZ. Adding 20 psi static pressure to the meter elevation provides the minimum HGL to support fire flow. This HGL will be either within the tank or below the tank bottom (Figure 51). Utilizing the tank diameter, the height to provide the required fire suppression storage is then added to calculate the normal minimum operating level. The normal maximum operating level is assumed to coincide with the tank overflow elevation. Maximum operating storage is the difference between the normal minimum and maximum tank levels.

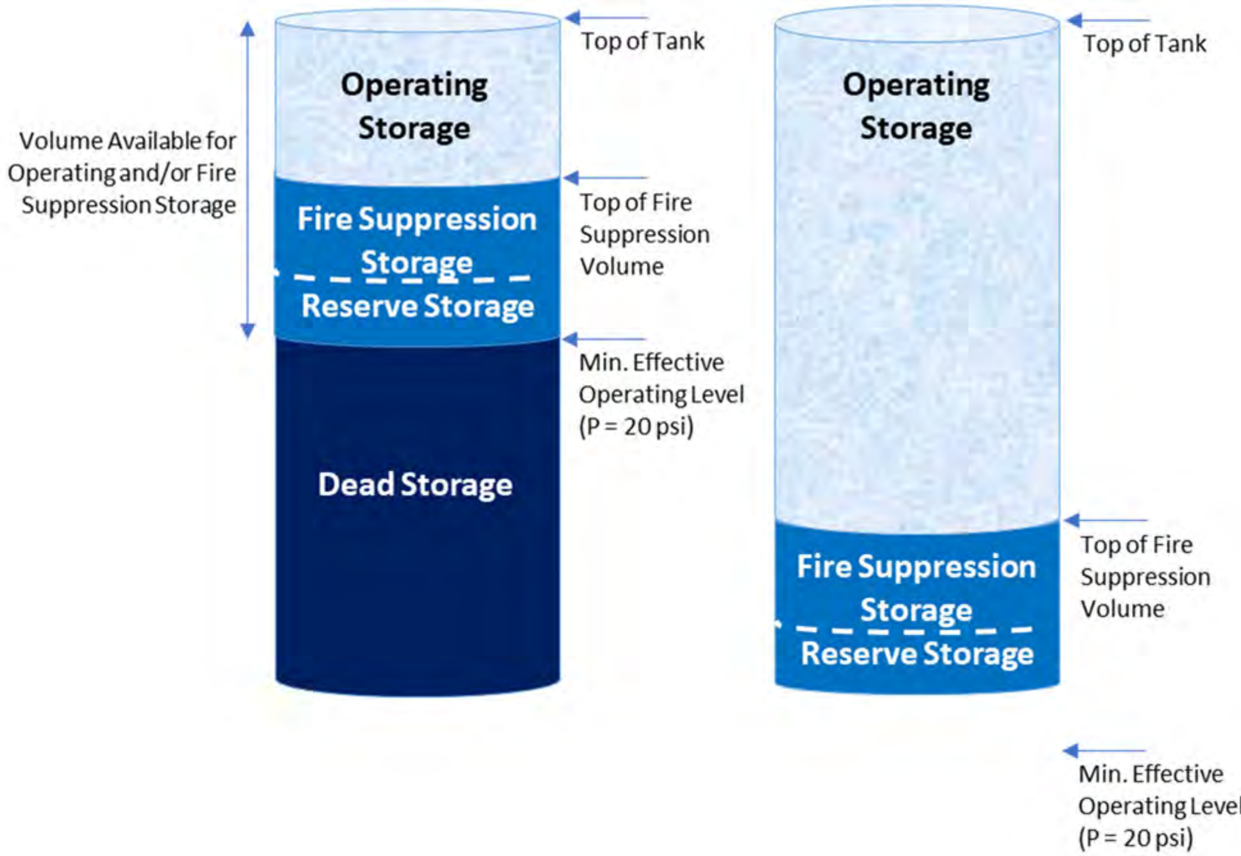

Figure 51. Storage Calculation Schematic.

Future storage requirements are presented in Appendix F. Operating storage is calculated based on an assumed pump schedule (not to exceed existing PS capacity), projected 2070 ADD, and the diurnal pattern specific to the PZ. Fire suppression storage is calculated based on maximum NFF and its associated duration, less any excess firm capacity at the supporting PS. Assuming buildings with the highest NFF within each PZ are not sprinklered, an additional 0.64 MG of accessible storage is required, distributed across three PZs: the RWSA's Lewis Mtn. (0.33 MG, see Section 7.6.2), and the ACSA's Mill Creek (0.20 MG) and Mosby Mtn. (0.11 MG).

7.6. Operations Recommendations

This section presents an overview of recommendations for RWSA storage facilities. Additional information is presented in Appendix F. To confirm recommendations, a comprehensive storage evaluation should be conducted, to include coordination with retail utilities to verify the existence of approved sprinkler systems for high-NFF customers, and identification of adjustments needed for PS operating protocols and setpoints.

7.6.1. Stillhouse Storage

The 0.7 MG Stillhouse Tank is 50 feet tall and 50 feet in diameter, with a current operating range of only eight feet (0.12 MG), between tank levels of 40.5 and 48.5 feet. The bottom end of the current operating range provides a water pressure of 40 psi to the assumed highest-elevation customer meter. Based on SCADA data as well as model simulations for MDD conditions (Figure 52, red graph), the tank cycles several times per day, dropping from full to "pumps on" level in three hours or less during the day. The current system therefore does not meet the RWSA operations criterion of one cycle per day.

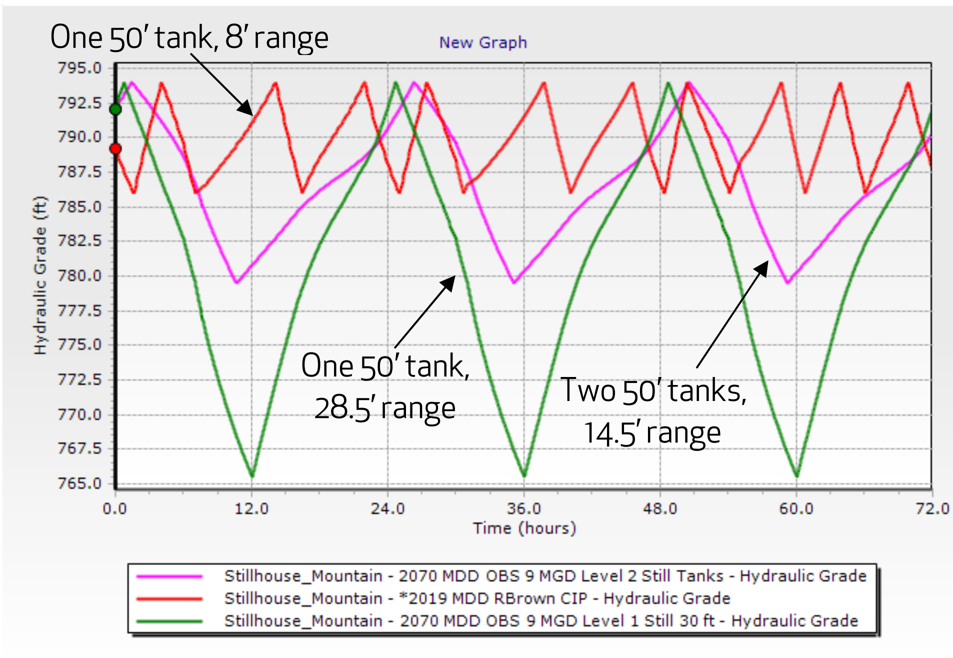

Figure 52. Stillhouse Tank Level for One vs. Two Tanks.

To improve system resilience and address frequent tank cycling, installing a duplicate 50-foot diameter GST 50 feet tall (0.73 MG capacity) adjacent to the existing site, and increasing the operating range from 8 feet to at least 14 feet (pump on at tank level 34 feet, Figure 52) but no more than 30 feet are recommended and have the following benefits:

- Meets VDH criterion for tank level management by utilizing no more than the top 30 feet for normal operations
- Provides the required fire suppression volume within the bottom 20 feet
- Provides the following pressures to the assumed highest-elevation customer meter:
  - 22 psi when the water level reaches the bottom of the tanks
  - 31 psi for a tank level of 20 feet (approximately 13 customers below 40 psi)
  - 37 psi for a tank level of 34 feet (approximately 4 customers below 40 psi)

- Provides an operations buffer of 0.20 MG between tank levels of 20 and 34 feet
- Utilizes existing site access and pipe system, reducing cost vs. using a new site

Project	Second Stillhouse Tank - Install 50-foot Diameter 0.73 MG GST 50 Feet High (Base El. 745.5 feet)
Complete By	2030, if necessary after investigating status of building sprinkler systems
Total Cost	$1.7M
Benefits	• Provides additional storage for PZ • Reduces cycling frequency of Stillhouse PS • Provides redundancy of storage for maintenance activities
Implementation Comments	• Increase normal operating range to at least 14 feet, optionally up to VDH maximum of 30 feet • Fire suppression storage provided in bottom 20 feet of 2-tank system

7.6.2. Lewis Mtn. Storage

As with the Stillhouse Tank, the Lewis Mtn. Tank has a limited operating range, therefore the tank and Alderman Road PS cycle approximately twice per day, which does not meet the RWSA's preferred one-cycle operations criterion. By adjusting the pump on/off levels to increase the operating range from 4.5 to 9.5 feet in the near term, the number of cycles can be reduced from two to one per day for 2070 ADD, as shown in Figure 53. Based on type of construction, the highest-elevation customer is assumed to have a private pump installed. With an extended operating range, minimum pressure at the next-highest elevation customer is 35 psi, and a minimum tank level is 14.5 feet (0.31 MG in storage).

Given current tank operating levels, a two-tank system with a second 60-foot diameter tank will provide the required fire suppression storage (0.84 – 0.13 = 0.71 MG, Appendix F, Table 6) below the existing alarm level of 18 feet. As with Stillhouse, an identical, duplicate tank for the Lewis Mtn. PZ provides the necessary storage volumes while also providing operational flexibility when one tank must be taken off-line for maintenance, and it satisfies the Lewis Mtn. storage need identified in Section 7.5.4. One tank by itself will not satisfy the fire suppression storage requirement, therefore redundancies such as opening the UVA interconnection should be planned in case of a significant fire event while one of the tanks is off-line.

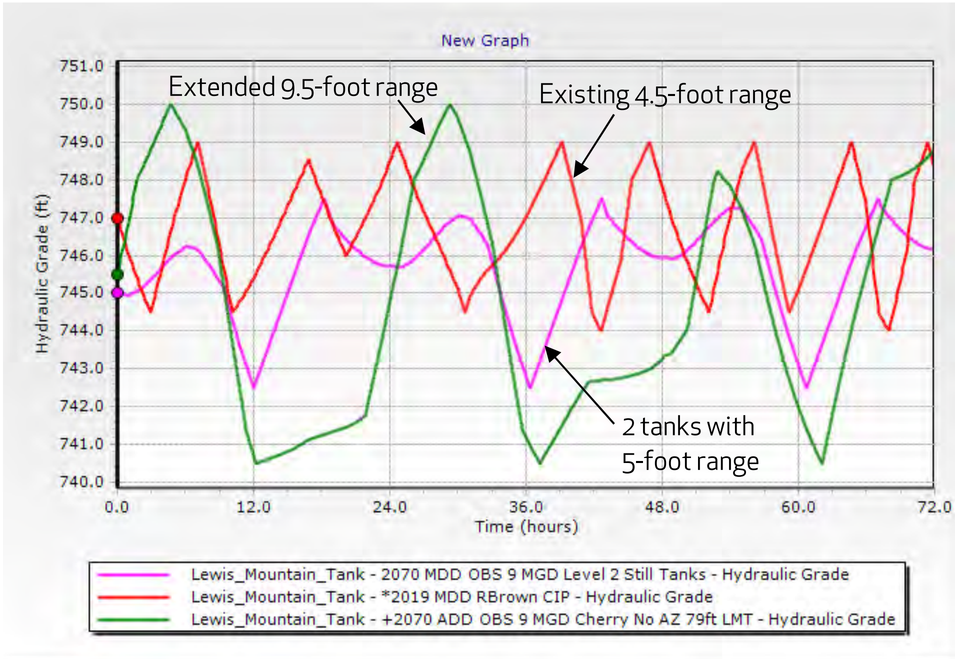

Figure 53. Lewis Mtn. Tank Level for Existing vs. Extended Operating Range.

Project	0.5 MG Supplemental Ground Storage Tank
Complete By	2030, if necessary after investigating status of building sprinkler systems
Total Cost	$0.9M
Benefits	• Provides 86% of fire suppression volume in-zone (14% from PS) • Provides resilience when one tank is off-line for maintenance
Implementation Comments	• Utilize full operating range of 24.5 feet • Existing site already graded for second tank of same size • Plan for fire flow redundancy in case of significant fire event

7.6.3. ARPS Storage

Prior North PZ analyses included phased provision of two 1-MG storage tanks at the ARPS (Figure 54). At the time, these tanks were envisioned to float on the UPZ, i.e., the suction side of the ARPS. While the UFWMP determined that the tanks are not required hydraulically, if the RWSA installs storage at the ARPS, it should be configured for one-way flow from the UPZ to the ARPS, with an altitude valve for refilling the future tank(s). A reverse-flow isolation valve parallel to the altitude valve should, however, be installed to allow the future tank(s) to float on the UPZ during emergency conditions. Compared to a through-flow arrangement, a tank floating on the UPZ results in increased water age within the tank's supply main. Water age could then become quite high by the time water reaches the Piney Mtn. Tank and the customers served by it. A placeholder long-term CIP line item is included here, should the RWSA elect to proceed with the tanks in the future.

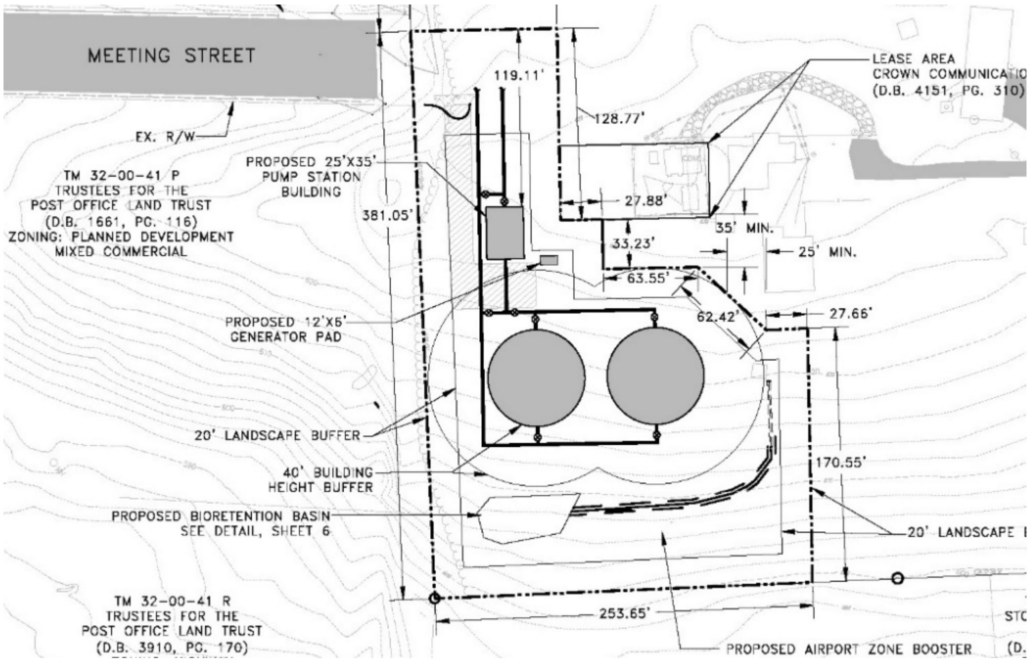

Figure 54. Airport Road Pump Station 2014 Conceptual Site Plan.

Project	Airport Road Tanks
Complete By	2070
Total Cost	$2.8M
Benefits	• Provide support to ARPS when running at high flow or for extended duration • Provides emergency storage for UPZ
Implementation Comments	• Configure as one-way flow from UPZ to ARPS to mitigate water age

7.6.4. Operating Range for the Urban Pressure Zone

Given a maximum UPZ HGL of 652 feet and the 30-foot maximum operating range allowed by VDH regulations for storage tanks floating on a PZ, the UPZ normal operating HGL could be allowed to go as low as 622 feet. Based on information presented in Table 15, the RWSA can recover over half of UPZ dead storage in the near term by working with the ACSA and possibly also the City to address customers adversely impacted by lowering the minimum normal operating and/or fire flow UPZ HGL:

- Identify high-elevation customers to move to a higher existing or new PZ
  - Retail utility installs isolation valves and individual or zonal PRVs
- Install private pumps for isolated high-elevation customers remaining in the UPZ
- Identify upgrades to existing private pumps required to address higher TDH

Table 15. UPZ Threshold Elevations for Minimum Allowable HGL of 622 Feet

Meter Elev. (feet)	Static Pressure (psi)	Description	No. of UPZ Customers Above Elev.	Customers to Move to Higher PZ	Private Pumps to Install
576	20	Minimum residual for fire flow	23	19	4
553	30	ACSA minimum allowable pressure	210	147	63
530	40	ACSA minimum preferred pressure	909	712	197

Lowering the UPZ fire flow operating range from the current HGL of 634 feet to an HGL of 623 feet impacts approximately 23 customers above elevation 577 feet: minimum static pressure would drop below 20 psi. Lowering the UPZ normal operating range to a minimum HGL of 622 feet impacts approximately 900 customers above elevation 530 feet: minimum pressure would drop below 40 psi (Figure 55). For the latter, up to 200 private pumps would be required if the remaining high-elevation customers are moved to lower-pressure subzones created from the ACSA's Mill Creek PZ and the RWSA's Lewis Mtn. PZ.

Evaluation of extended operating ranges should take ACSA development requirements into account (20 psi residual assuming 3 gpm demand at the service connection). Assuming the existing four feet of reserve/fire suppression storage is retained, the normal minimum HGL could be as low as 626 feet. If a minimum operating range below 638 feet is determined to be viable, and if ACSA or customers are concerned about operating at lower pressures than they have historically been accustomed to, then the ACSA may want to first temporarily implement the lower range as a test prior to committing to the lower operating range for the long term.

The potential Avon Street Extension PZ discussed in Appendix F will enable the RWSA to recover 2.8 MG of dead storage and does not require any private pumps. The 11-foot operating range to recover, between HGL 634 feet (current normal minimum) and HGL 622 feet (minimum 20 psi), would be dedicated to fire/reserve storage.

When they are eventually retired and based on their respective sizes, the Pantops Tank (constructed in 1981) should be moved uphill, and the Avon Street Tank (constructed ca. 1988) should be replaced with an EST. Both new tanks should have a minimum storage elevation of

622 feet or the then-allowable minimum HGL, whichever is higher. (A minimum elevation of 622 feet corresponds to a 30-foot maximum normal operating range for the UPZ HGL of 652 feet.) Aligning the top of the tanks to facilitate a maximum HGL of 659, matching the OBS tank, will improve operating range as well. With proper preventive maintenance and barring a foundation failure (perhaps due to an earthquake), both existing GSTs should be expected to last at least 100 years.

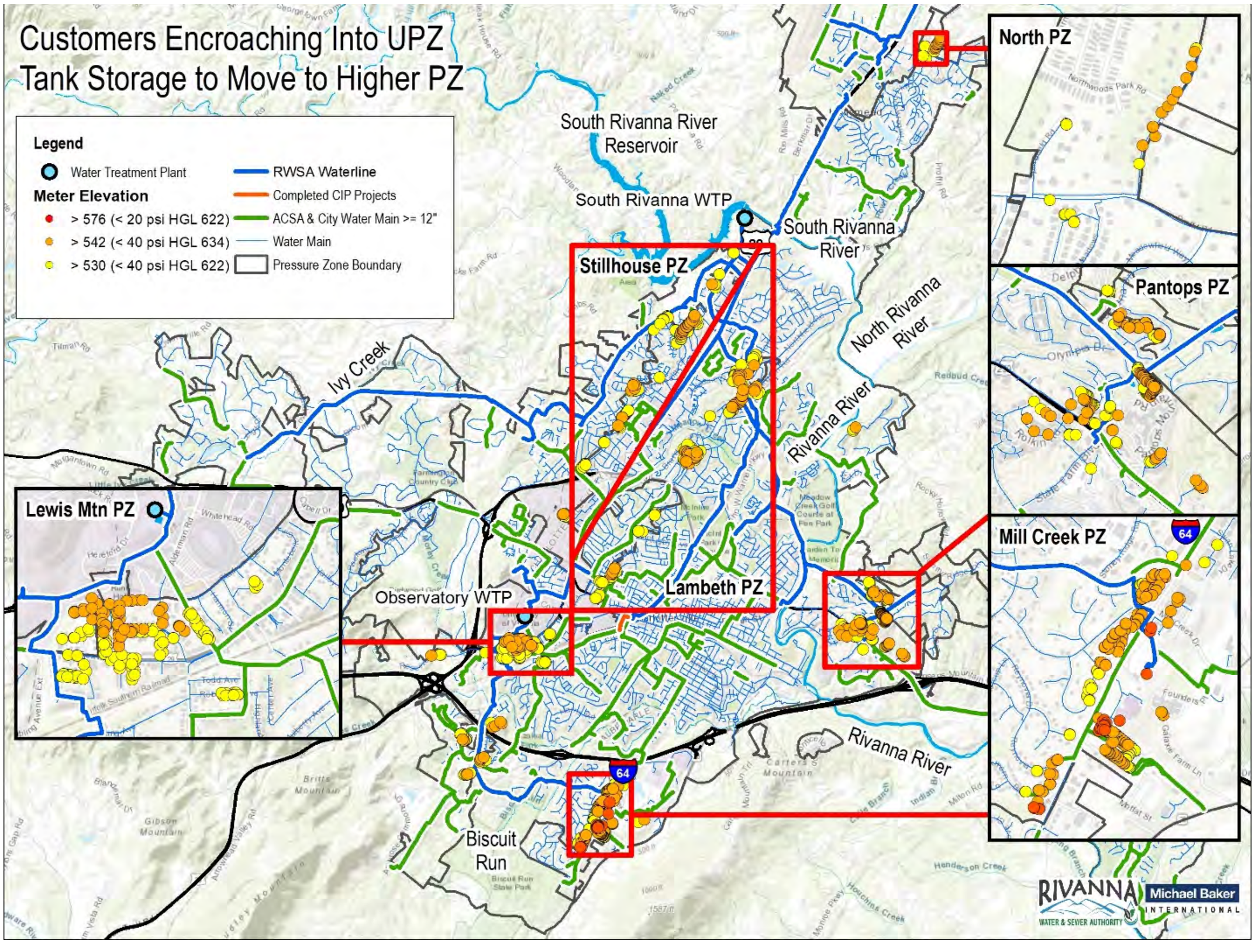

Figure 55. UPZ Customers to Move to Higher PZ or Install Private Pump.

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Project	ACSA Recovers 2.8 MG Dead Storage in the Urban PZ
Complete By	2045
Total Cost	$2.3M ($0.82/gallon)
Benefits	• Addresses encroachment into tank operating range
Implementation Comments	• Creating a new ACSA PZ along Avon Street Extension for UPZ connections above elev. 575 feet is the most economical solution • Install private or zonal PRVs and additional pipe as needed

Project	Replace Pantops and Avon Street Tanks at end of useful life
Complete By	2070
Total Cost	$8.9M
Benefits	• Eliminate dead storage • Improve turnover and reduce water age
Implementation Comments	• Move Pantops Tank uphill • Replace Avon Street GST with EST • Confirm tank sizes and locations based on then-projected needs • Evaluate raising max HGL to 659 at each tank to align with OBS tank

7.6.5. Operating Range for Other RWSA Pressure Zones

As with the UPZ, installing private pumps to boost pressure for high-elevation customers can extend the operating range of the RWSA's Stillhouse and Lewis Mtn. Tanks. For a water level at the tank bottom, each tank can provide 23 psi static pressure to the highest-elevation customer, meeting fire flow requirements provided dynamic pressure loss is less than 3 psi.

<u>Stillhouse</u>

Based on a review of model data, and assuming a minimum allowable static pressure of 40 psi with the tank at the bottom of a 30-foot operating range (i.e., tank level 20 feet or HGL 765.5 feet), only 13 customers above an elevation of 673 feet within the Stillhouse PZ may require private pumps: six residences on Oak Circle near Ivy Lane, and seven residences on Flordon Drive. Estimated total cost is less than $100,000 and is accounted for in the total cost of a second Stillhouse storage tank (Section 7.5.1). If private pumps are not installed and the normal operating range is expanded to 30 feet, the minimum customer pressure will be 31 psi when the tank is at the normal minimum level.

Piney Mtn.

The current operating range of the Piney Mtn. Tank is a function of PZ demand and NRWTP operations, including pump flow rate and start time of pumping. When the PZ is supported in the future by the RWSA's planned ARPS, alternative operations of the Piney Mtn. Tank become feasible. For the UFWMP, Michael Baker assumed that the ARPS VFD would be set to maintain a discharge HGL of 780 feet, which corresponds to a static operating range of 25 feet for the tank (HGL between 780 and 805 feet). Normal tank operating range can be as much as 28 feet, taking into account transmission losses and a minimum level of 10 feet preferred by RWSA operations staff. Minimum static pressure is 22 psi within the North PZ when the HGL is at the bottom of the tank.

7.6.6. Water Age

For the UFWMP, water age is used as a surrogate for water quality, i.e., whether the disinfection method has lost its efficacy. The RWSA goal is to maintain a chlorine concentration of 2 mg/l for water leaving the WTPs. Water quality simulations for disinfection constituents require a model calibrated for both hydraulics and water quality processes; the existing RWSA water model, while updated and validated to support the UFWMP, has not been fully hydraulically calibrated, and it does not include water quality constituents. The model is out of hydraulic calibration due to the following:

- Time elapsed (10 years) since last calibration
- System-wide assignment of apparent low C factors based on pipe size, material, and age given limited extent of flow tests during the 2012 calibration effort (some system valves may not have been set as assumed)
- Identification of inaccurate pipe C factors given results from recent hydrant flow tests

Water age is affected by demand, path taken through the distribution system, and residence time and mixing in storage facilities. The higher the storage volume and lower the demand, the longer the residence time in a tank. Residence time can be further increased if the tank operating range is restricted by customers either at higher elevations or requiring higher pressure. Both retail utilities indicated that water age can be a problem, with action taken to flush lines and freshen finished water upon receiving customer complaints.

For the purposes of the UFWMP, all tanks are assumed to be completely mixed. Depending on tank geometry and inlet/outlet configuration, stratification may occur, which can lead to water quality issues. Taken together with fire suppression storage and reserve storage, which are seldom utilized, dead storage contributes to increased water age and can lead to water quality issues, particularly west of the Stillhouse Tank and in Mill Creek.

In order to address dead storage and mitigate potential water quality issues, the RWSA, together with retail utility stakeholders, should undertake a thorough review of current and future retail customer pressure requirements, including sprinkler and pump suction pressures, to determine the minimum allowable level for each tank that will satisfy the VDH 20 psi residual pressure criterion for fire flow conditions. Where a significant percentage of tank volume is confirmed to be dead storage, tanks should be relocated to higher ground or replaced with short ESTs (e.g., the ACSA's Avon Park Tank). Multi-column (0.05 to 1.0 MG) and pedestal (0.05 to 0.75 MG) ESTs tend to have smaller volumes, whereas fluted column ESTs typically have larger volumes (0.2 to 2.0 MG) (Phoenix Fabricators and Erectors).

Project	Comprehensive Storage Evaluation
Complete By	2030
Total Cost	$250,000
Benefits	• Identify specific customers driving management of tank levels o Connection elevation, pressure requirement • Identify least-cost option for accessing entire tank volume • Detailed review of NFF requirements including presence of automatic sprinkler systems in Lewis Mtn and Stillhouse PZs
Implementation Comments	• Confirms/updates recommendations identified in the UFWMP • Reducing inactive storage improves tank turnover and water quality

Project	Comprehensive Water Quality Calibration of Hydraulic Model
Complete By	2030
Total Cost	$210,000
Benefits	• Virtually test proposed changes to facility / system operations
Implementation Comments	• Requires recalibration of hydraulic model first (Section 9.2) • Requires 95% or better SCADA data reliability • Requires mobilization of field monitoring equipment

7.6.7. Storage Tank Out of Service

For evaluating a tank outage, water production for 2030 ADD was skewed in favor of the WTP currently not well-connected to the tank taken out of service. In other words, if the Pantops Tank was assumed to be out of service, the OBWTP was set to provide 75% of demand, and if either the Observatory Tank or Avon Street Tank was assumed to be out of service, the OBWTP was set to provide only 25% of demand. Simulating closures of the CWL (as a stress test) near the OBWTP and near downtown, and with City inter-connections to the CWL at strategic locations, hydraulic evaluations demonstrated that the UPZ tanks floated closely together and remained within their preferred operating ranges whether the Pantops Tank (Figure 56), Observatory Tank (Figure 57), or Avon Street Tank (Figure 58) was assumed to be off-line.

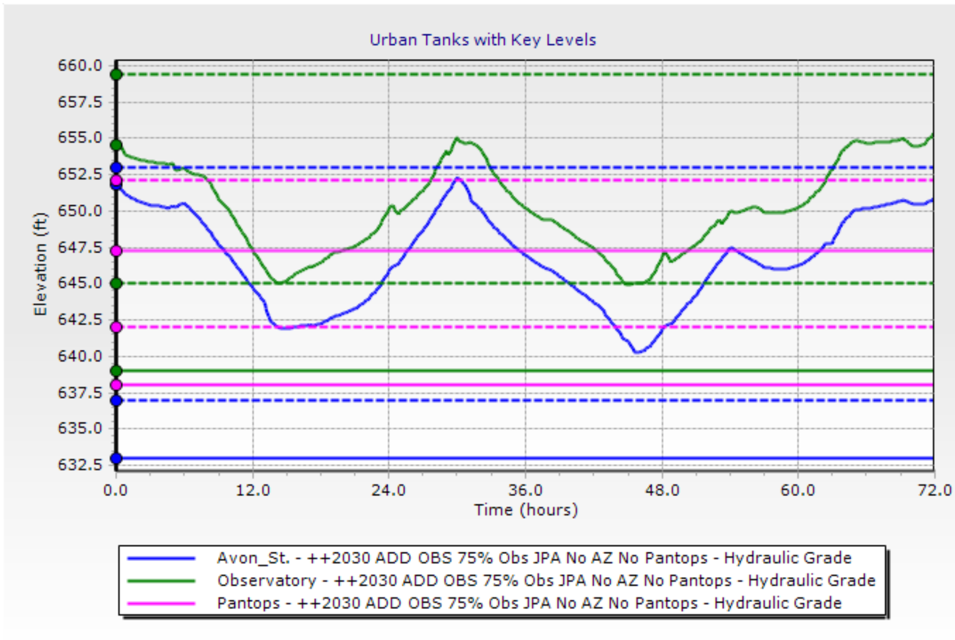

Figure 56. Urban Zone Tank Levels with Pantops Tank Off-line.
(2030 ADD, OBWTP provides 75% of production)

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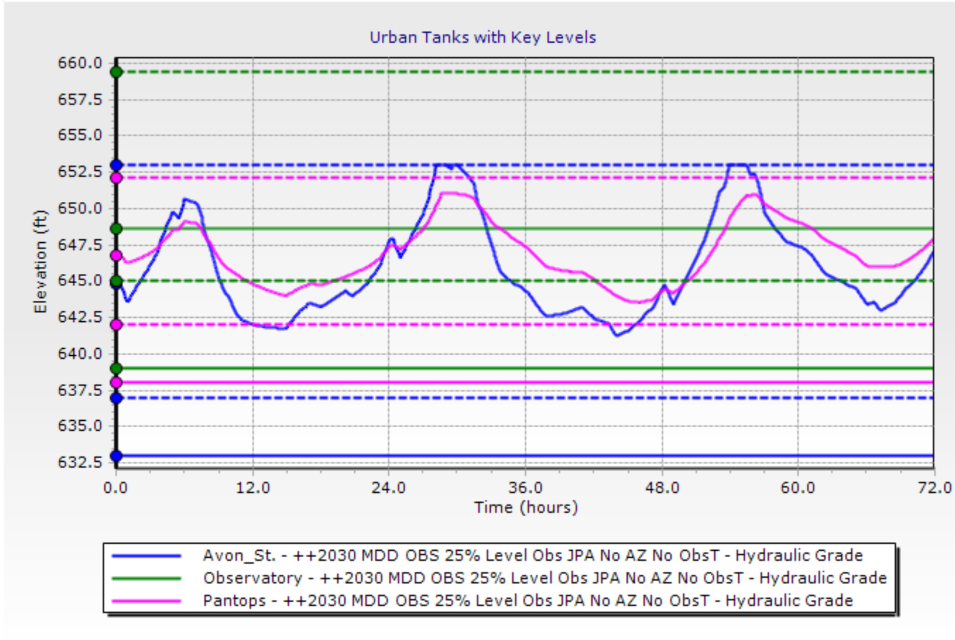

Figure 57. Urban Zone Tank Levels for 2030 ADD with the Observatory Tank Off-line.
(2030 ADD, OBWTP provides 25% of production)

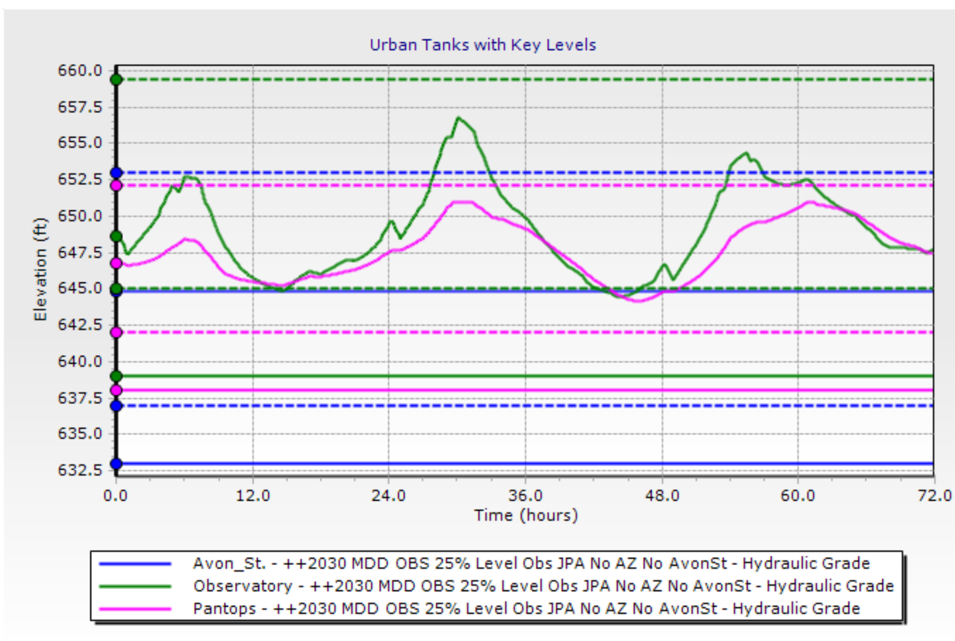

Figure 58. Urban Zone Tank Levels with Avon Street Tank Off-line.
(2030 ADD, OBWTP provides 25% of production)

Outside the UPZ, taking a tank out of service requires adjusting the operating mode of the supporting PS and evaluating temporary, alternative provision of NFF. When evaluating upgrades to existing PSs or installing future PSs, the RWSA should consider VFD controls and/or a recirculation valve to more easily support a PZ with only one tank, when that tank is off-line. A portable tank (e.g., up to 15,000 gallons) could be mobilized to assist in managing pressure during periods of low demand; this is one means to avoid short-cycling of pumps if a recirculation valve is not already installed at the supporting PS.

7.7. Summary of Recommendations for Storage Tanks

Due to current operational requirements, a significant percentage of existing storage cannot be accessed. The system has sufficient storage to satisfy 2070 requirements, provided the following recommended actions are taken:

- Together with the ACSA, investigate eliminating 2.8 MG of UPZ dead storage above an HGL of 623 feet by moving customers to a new, higher PZ along Avon Street Extension
- At end of useful life for existing GSTs, relocate smaller GSTs to higher ground or convert to ESTs on existing site to recover/eliminate dead storage and improve water quality

Recommended actions for RWSA tanks, primarily to mitigate dead storage and address operations challenges, are presented in Table 16. All estimated costs for storage tanks assume that new tanks are built with the tank bottom at the PZ minimum operating level, which is several feet above the bottom of existing tanks. Depending on how far above the existing tank bottom the minimum operating level is, locating new tanks at existing tank sites can significantly increase the required tank size and cost. Unused storage will be added to the system, increasing water age and the potential for water quality issues due to reduced turnover as operating volume becomes a smaller percentage of total tank volume.

Table 16. Recommendations for RWSA Tanks

Tank	Cost	Timeframe	Recommendations
All UPZ	$0.25M	2025	Coordinate storage evaluation with retail utilities to move high-elevation customers to a higher PZ and recover dead storage
Stillhouse	$1.7M	2025	Add second 50-foot high, 50-foot diameter 0.73 MG GST Extend operating range per storage evaluation (up to 30 feet)
Lewis Mtn.	$0.2M	2025	Add emergency connection meter at Alderman Road PS
Lewis Mtn.	$0.9M	2030	Add second 24.5-foot high, 60-foot diameter 0.5 MG GST
Piney Mtn.	$0	2025	Extend operating range per storage evaluation (up to 30 feet) once the ARPS is on-line and supplying the PZ with water

(End of section.)

8. Pumping Facilities

The RWSA and both retail utilities operate remote PSs to move water throughout the urban system. The RWSA also operates finished water pumps at the SRWTP and the NRWTP. Both constant-speed and VFD-controlled pumps are operated, with most constant-speed pumps being phased out over time.

8.1. System Operations

For PZs with lower demand, the PS is typically equipped with a low-flow pump and an identical back-up pump. A high-flow pump may also be installed to provide fire flow, perhaps in lieu of providing fire suppression storage within the PZ. The RWSA's Alderman Road PS is equipped with two low-flow pumps and a high-flow pump, and it pumps into a PZ with a storage tank. The City's Lambeth PS, on the other hand, is equipped with two small VFD-controlled pumps and two large fire flow pumps, and it pumps into a PZ with no storage.

The RWSA evaluated the future of the NRWTP and plans to decommission it in 2025. Except for establishing baseline AFF, which is based on existing conditions, the UFWMP model scenarios assume that the NRWTP is off-line and the North PZ is served by the ARPS, as this operating condition properly reflects the future withdrawal of water from the UPZ to support the North PZ.

8.1.1. Pump Station Capacity

Several pump replacement upgrades were completed in recent years at the RWSA's Alderman Road PS, the ACSA's Ednam PS and Mosby Mountain PS, and the City's Lambeth PS. In addition, the RWSA's Stillhouse PS was constructed to replace the Canterbury Hills PS. The primary challenge in operating existing PSs is related to high capacity at a given PS having the unintended consequence of diverting too much water away from the preferred UPZ delivery area on the suction side of the station.

For the UFWMP, Michael Baker did not identify significant value in further upgrading existing PS capacities (Table 17, see also Section 6 of Appendix F) either at this time or in the future to accommodate projected hot/dry 2070 MDD conditions. Capacity upgrades may be identified in the future for one or more of the following reasons:

- Replace constant-speed pump controllers with VFDs
- Outcome from a detailed review of system operations
- demand increases significantly beyond the current projection
- NFF increases beyond the existing tank/PS system ability to provide fire flow
- PS capacity increases rather than tank storage to provide fire flow

Table 17. Pump Station Design and Firm Capacities vs. Projected 2070 Demand

Pressure Zone	Pump Station	Design Flow (gpm)	Design TDH (feet)	No. of Pumps	Firm Capacity (gpm)	Firm TDH (feet)	2070 ADD (gpm)
North	ARPS	1055	150	2	1055	150	561
Lewis Mtn.	Alderman Road	600 1000	110 118	2 1	1155	121	371
Stillhouse	Stillhouse	1244	212	2	1244	212	612
Ednam	Ednam	600	190	2	600	190	36
Mosby Mtn.	Mosby Mtn.	500	111	2	500	111	70
Avon Park	Mill Creek	700	129	2	700	129	37
Glenmore	Glenmore	188	172	2	188	172	100
Lambeth	Lambeth	450 1530	95 95	2 2	2430	95	138

In addition to evaluating the need for upgrades to existing PSs, Michael Baker evaluated installation of additional PSs within the UPZ to facilitate transmission of bulk finished water, in lieu of or in addition to transmission main upgrades. This option was, however, eliminated early on (see Section 6.2). An additional PS location at the OBWTP was also evaluated but ultimately determined to not be needed hydraulically. By not adding new PSs, the RWSA can reduce if not completely eliminate the following:

- Construction and O&M (e.g., power) cost of additional facilities (excluding the ARPS)
- Additional labor costs to operate and maintain additional pumping facilities
- Risk of water service interruption due to a pumping facility being off-line

8.1.2. WTP Discharge Capacity

At the SRWTP, finished water is pumped into the transmission system. Pump 4 has the largest pump capacity and has a VFD. It is the primary pump because it is the largest at 8 MGD. A new surge valve installed on the distribution header pipe opens at 100 psi. SRWTP pump capacity and pressure range decreases, in order, from Pump 4 down to Pump 1. The primary challenge in managing the SRWTP is maintaining discharge pressure at operating extremes, when the system is either starving for water or the tanks are full. The RWSA recently replaced the VFD on Pump 4, added VFD controls to Pump 3, and replaced Pump 1 as part of the SRWTP Improvements Project. SRWTP high service pump capacities are as follows:

- Pump 4 – 8 MGD w/ VFD
- Pump 3 – 6 MGD w/ VFD
- Pump 2 – 4 MGD

- Pump 1 – 3 MGD

Unlike the SRWTP, the OBWTP discharges by gravity into the transmission system. Prior to the UFWMP, hydraulic evaluations (including model simulations) assumed an OBWTP discharge HGL slightly higher than the UPZ target HGL. Those evaluations therefore considered installing a PS at the OBWTP to increase the HGL downstream of the plant.

During the UFWMP study, the RWSA provided record drawings showing that the OBWTP's controlling hydraulic feature is a chlorine contact tank discharge weir with a crest elevation of 673 feet, which is over 20 feet (9 psi) above the target HGL (pressure) for the UPZ. Downstream of the weir, water plunges into a vault and enters the transmission system via a 24-inch main. The water level on the downstream side of the weir depends on the OBWTP production rate vs. system demands and the Observatory Tank level.

The SRWTP normally operates at a discharge pressure of approximately 80 psi, which corresponds to an HGL of approximately 657 feet (assuming the discharge pressure gauge elevation is approximately 472 feet). The OBWTP cannot operate with a discharge HGL higher than 673 feet, or the plant would otherwise flood. This HGL corresponds to a pressure of 87 psi at the SRWTP. Even with a higher discharge HGL capability (up to 10 MGD), the OBWTP will struggle to move water (7.2 MGD, see Figure 8) north of the Observatory Waterline due to the high pressure losses associated with moving water from the RWSA's Observatory and Southern Loop Waterlines through the City's network of smaller water mains to reach the RWSA's Urban, Pantops, and South Rivanna Waterlines, unless transmission improvements are made to connect these waterlines to the OBWTP via the Central Waterline.

Based on the record drawings, Michael Baker reconfigured the water model to reflect the hydraulics of the OBWTP discharge and determined that a discharge PS is not needed at the OBWTP, unless the RWSA desires the discharge HGL to be higher than the existing weir crest elevation. The primary challenge in operating the OBWTP is getting water away from the WTP and out to the northern and eastern portions of the service area, as they are not hydraulically well-connected currently: the finished water backs up in the vicinity of the OBWTP and Observatory Tank. Therefore, to increase OBWTP finished water discharge capacity, a transmission main is required in parallel to the interconnected network of smaller City mains, rather than a discharge pump station, which would also require the retail utilities to install individual PRVs for their customers near the OBWTP.

8.2. Existing Pump Stations and the ARPS

Pump stations are assumed to have sufficient redundancy and resilience to address localized issues such as a loss of power or the highest-capacity pump being out of service. Given the hydraulic (capacity-related) transmission main improvements identified under the UFWMP, PS upgrades were not identified at this time. Michael Baker did determine, however, that given the preliminary pump selection for the ARPS and reduced demand projections, the proposed system will be able to support the entire North PZ , including for fire flow requirements during hot/dry MDD conditions, without creating an Airport PZ in the future.

During the course of the UFWMP, design commenced on the RWSA's ARPS CIP. In the 2018 model, the ARPS was represented as a conceptual facility in an approximate location, with pump curves for various demand conditions and network scenarios (with and without a separate Airport PZ) based on a single flow/head design point. For the 2020 model, the ARPS location was updated by Michael Baker to align with the conceptual site plan drawings dated July 2014. Based on the inability of the 2018 model's high-capacity single-point pump curves to successfully run the ARPS given a network configuration representing existing conditions and given updated demand projections, Michael Baker researched and implemented a full-range pump curve to satisfy model conditions. The final pump curve utilized for the UFWMP was confirmed by SEH, the RWSA's design consultant for the ARPS CIP, and is very similar to the full-range pump curve identified by Michael Baker.

Providing AFF within the North PZ is a key concern if an Airport Road PZ is created, as existing building sprinkler systems were potentially designed for the current HGL of 805 feet rather than a lower future (Airport PZ) HGL of 780 feet – a decrease of 10 psi from existing to proposed pressure. Michael Baker recommends that the RWSA confer with the ACSA on model assumptions regarding fire flow analysis for this property and other customers with a high documented NFF, as the ACSA distribution system may need to be upgraded in several locations.

For all applicable scenarios evaluated by the UFWMP, the ARPS is assumed to operate in a pressure-sustaining mode based on discharge HGL (target: 785 feet), occasionally ramping up to full speed to refill the Piney Mtn. Tank when it drops to the "refill" level. If the lead pump is at full speed and either the Piney Mtn. Tank continues to drop or the discharge HGL drops to 780 feet, then the lag pump is turned on – typically, this occurred only during dynamic fire flow simulations. ARPS pump operations are shown in Figure 59, with the lead pump running at approximately 80% speed when on but not refilling the Piney Mtn. Tank. For higher-demand scenarios, the minimum pump speed will be higher. If demand drops below the output of the pump at minimum speed, the pump will shut down, in which case the entire North PZ will be supported by the Piney Mtn. Tank until the ARPS is called on to refill the tank.

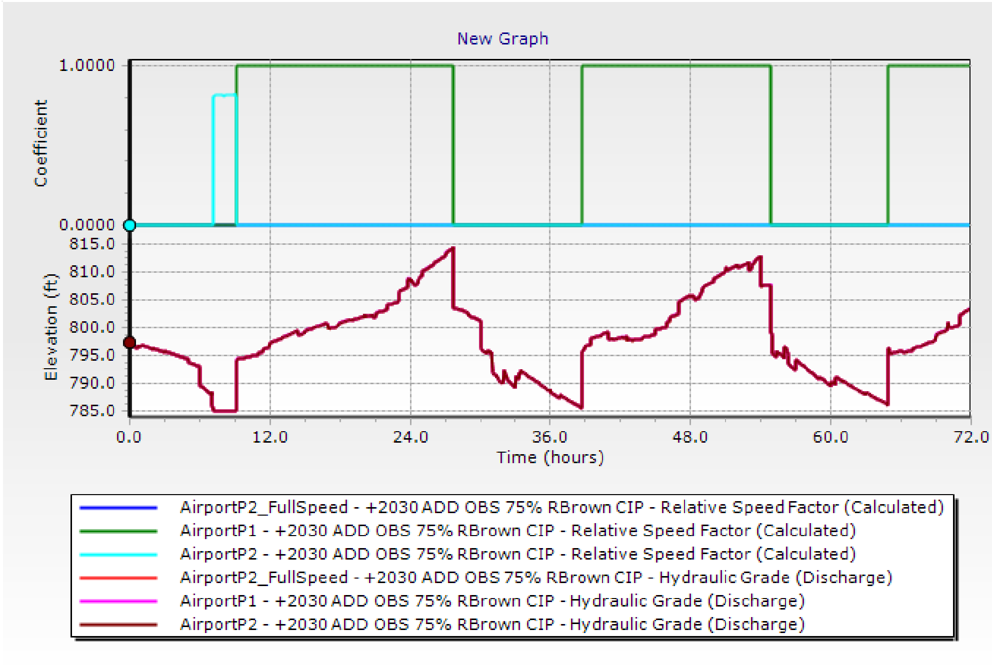

Figure 59. ARPS Pump Speed and Discharge HGL for 2030 Hot/Dry ADD Conditions.

8.3. Water Treatment Plant Production

The SRWTP is currently operated in a manner that chases or matches demand. In contrast, the OBWTP and NRWTP are typically operated at a near-constant rate and only during the day, when demand is highest. Industrial processes tend to be more efficient when operated in a constant manner, with storage tank operating volumes accounting for the differences in demand vs. water supplied.

The UFWMP assumed future WTP production would be either constant or stepped, partly to force turnover in the UPZ tanks, but also because the WaterGEMS software would not correctly simulate a VFD set to maintain a discharge pressure at the SRWTP: even with the maximum speed factor set to 1.0, the VFD-controlled pump would over-speed by several factors rather than utilize the control rules that called for turning on additional pumps. For model scenarios, changes in WTP production are driven primarily by tank levels.

For future scenarios, the NRWTP is assumed to be off-line in order to stress the hydraulic capacity of the water system, and staff supporting the NRWTP are assumed to be reassigned to the OBWTP to enable 24-hour operations. Because pressure and flow are in a much more limited range at the ARPS, a pressure-controlled VFD pump was simulated successfully at this location, albeit with modification to the model setup: the VFD-controlled pump had to be "turned off" and a duplicate full-speed pump "turned on" when refilling the Piney Mtn. Tank.

While not a "finished water" project, completing the SFRR to RMR Raw Water Pipeline, including its connection to the OBWTP, will have a significant impact on improving redundancy and resilience for providing finished water to the urban system. This project will give the RWSA flexibility in moving raw water from either major reservoir to either major WTP, providing a "behind the scenes" redundancy to the finished water connections between the major WTPs.

8.4. Operations Challenges

8.4.1. Stillhouse Pump Station

Due to its proximity to the SRWTP, the Stillhouse PS can quickly and significantly impact delivery of SRWTP finished water to the UPZ. Reducing Stillhouse PS output results in a drop in pressure within the Stillhouse PZ, thus triggering the ACSA's Flordon and Farmington PRVs to open. This mode of operation relieves pressure on delivering water to the UPZ but requires additional pumping, as water must move through the RWSA's Alderman Road PS and the ACSA's Ednam PS in order to supplement via the PRVs what the Stillhouse PS and Tank are not providing.

The Stillhouse PS must run more frequently than other PSs because the Stillhouse Tank storage volume is modest compared to ADD. The RWSA has indicated that the Stillhouse PS can run up to 16 hours per day during high-demand conditions. Based on both SCADA data and model simulations, the existing tank cycles several times per day, indicating that an increase in storage is required for existing conditions. In addition, once full the tank level decreases rapidly, another indication that system storage is mis-matched to demand. Increasing operating storage volume will also help the RWSA to better manage flow of water to the Urban and Stillhouse PZs. Management of the Stillhouse PZ is covered in more detail in Section 6, and recommendations for additional storage within the Stillhouse PZ are covered in Section 7.6.

8.4.2. Alderman Road Pump Station

As discussed in Section 7.6.2, adjusting the operating range of the Lewis Mtn. Tank satisfies the operational goal of one tank cycle per day. A preliminary review of retail customer elevations reveals that approximately 90 private pumps are required to extend the tank operating range and still provide at least 40 psi of service pressure. Pressure requirements of building sprinkler systems must also be investigated.

8.4.3. Airport Road Pump Station

A future operational challenge involving competing goals is providing water from the UPZ to the RWSA's future ARPS once the NRWTP is decommissioned. The impact of the ARPS in reducing pressure in the northern UPZ, compared to existing conditions, and on delivery of water from the SRWTP to the UPZ is not anticipated to be as significant as that of the Stillhouse PS. The impact of the ARPS on the UPZ is nevertheless similar, resulting in lower but still adequate pressure in the northern UPZ. The NRWTP cannot be decommissioned until the 24-inch second South Rivanna River crossing is installed to augment the existing 12-inch crossing. This crossing is currently in design, and a more detailed discussion is presented in Section 6.

For the UFWMP, Michael Baker explored several options for controlling the ARPS discharge. The primary setpoint utilized the VFD pump to maintain a discharge HGL of 780 feet. For normal operations, the ARPS lead pump was assumed to increase to full speed to refill the Piney Mtn. Tank to 805 feet (overflow level), reverting to VFD mode once the tank was full. For this type of operation, the Piney Mtn. Tank operating range could be as high as 28 feet, from a minimum level of 10 feet to a maximum level of 38 feet. Actual ARPS operations will be determined by the designer in coordination with the RWSA.

Output from the ARPS also increased if discharge pressure dropped, for example in response to a fire flow event. For this scenario, additional pumps turned on in series once the lead pump was at full speed and if the discharge HGL was still below the target level. Additional pumps were turned off in a similar manner, once the Piney Mtn. Tank was full and if discharge pressure exceeded a given setpoint, with the lead pump ultimately reverting to VFD mode to maintain the desired discharge HGL.

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Project	Airport Road Pump Station
Complete By	2025
Total Cost	$4.0M
Benefits	• Capacity and pressure to serve the North Zone and northern Urban Zone, especially once NRWTP is retired
Implementation Comments	• Separate Airport PZ not needed through 2070 • VFD Pumps to maintain discharge HGL • Full speed pumping to refill Piney Mountain Tank and for fire flow events

8.4.4. North PZ Pressure Surges

Pressure surges in water systems are typically associated with fast-acting valves and pumps that start and/or stop quickly. The magnitude of a pressure surge is affected by pipe size and change in flow rate. The presence of surge management equipment, its proximity to the source of the surge, and its operation can mitigate the intensity of a surge event. Fast-acting surges, called transients, occur in a matter of milliseconds. The total magnitude of a surge event is therefore often not captured by pressure monitoring gauges typically installed on water systems, which sample and record system pressure at a time step longer than the duration of the transient. Specialized (high-frequency) pressure gauges, such as those owned by the ACSA, are therefore required to monitor for transients.

Depending on system operating pressure, pipeline design, pipe material, and the nature of transients, pressure surges that exceed the pipe's design pressure can reduce pipe elasticity over time. The pipe then becomes more susceptible failure. Pipe material also has an effect on the magnitude of transients. Due to its higher elasticity, plastic pipe attenuates the intensity of a transient pressure wave, more than stiffer iron pipe does, as the pressure wave travels down the pipeline. For pressure zones with in-zone storage, pressure surges are attenuated at water tanks before the tank reflects the pressure wave back into the pipe system.

After the second UFWMP workshop and in consultation with the RWSA, the ACSA collected high-frequency pressure monitoring data in the North PZ near the National Ground Intelligence Center (NGIC) due to complaints received from that facility. Similar complaints had been raised and investigated in 2015, before the NRWTP granular activated carbon (GAC) and pump upgrades were completed; one outcome of that investigation was a recommendation for the facility to modify its on-site valve operations.

After a review of the new monitoring data as well as correspondence related to the previous complaints, some spikes in pressure appear to be directly related to the NRWTP starting up at the beginning of the day (Figure 60). Abrupt drops in pressure appear to be related to the opening of a fast-acting valve elsewhere in the system and unrelated to operation of the NRWTP, as well as to shut-down of the NRWTP pumps at the end of the day. Although control valves intended to mitigate pressure surge associated with pump operations are installed at the NRWTP, the valves appear to require adjustment to slow down their speed of operation and thus mitigate positive and negative pressure surges associated with operation of the NRWTP.

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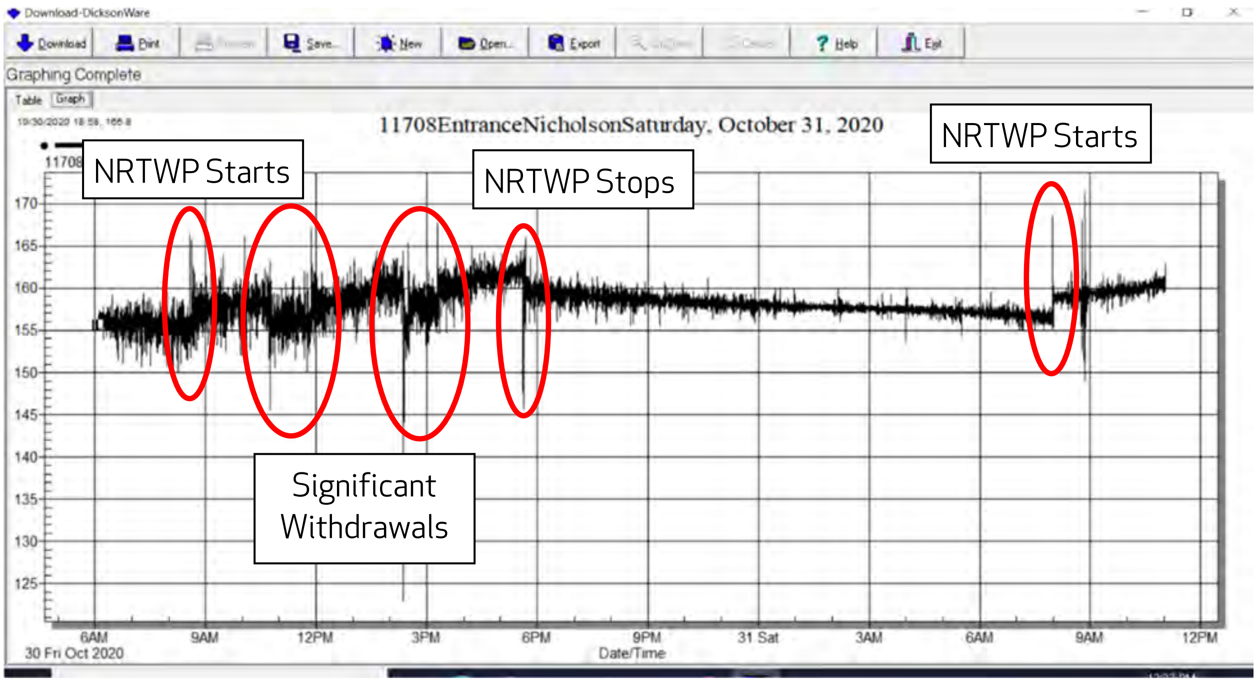

Figure 60. Low-frequency Pressure Trace in the North PZ near the NGIC.

Pressure data from October 30, 2020 indicates two significant drops in system pressure, at approximately 10:45 a.m. for one hour and 2:15 p.m. for 1.5 hours. The drops in pressure may be due to large, sustained withdrawals. A review of RWSA SCADA data and ACSA meter data is recommended and may indicate whether any customers (e.g., Albemarle County Fire Rescue, Charlottesville-Albemarle Airport Fire Department) need to be contacted to investigate operations, determine whether those operations create pressure surges, and recommend options to mitigate significant pressure surges.

The duration of pressure oscillation associated with abrupt changes in pressure appears to be approximately five seconds, with the Piney Mtn. Tank serving to dampen the magnitude of the oscillations (Figure 61). Pressure surges may also be mitigated when the high-pressure wave reaches the PRV at the NRWTP before being reflected back out into the system. (The PRV discharges water into the clearwell.) Investigation of sources and magnitudes of pressure surges is recommended, to be followed by recommendations for operations and equipment modifications to mitigate the severity of those surges. Additional discussion of North PZ pressure surges is presented in Appendix G.

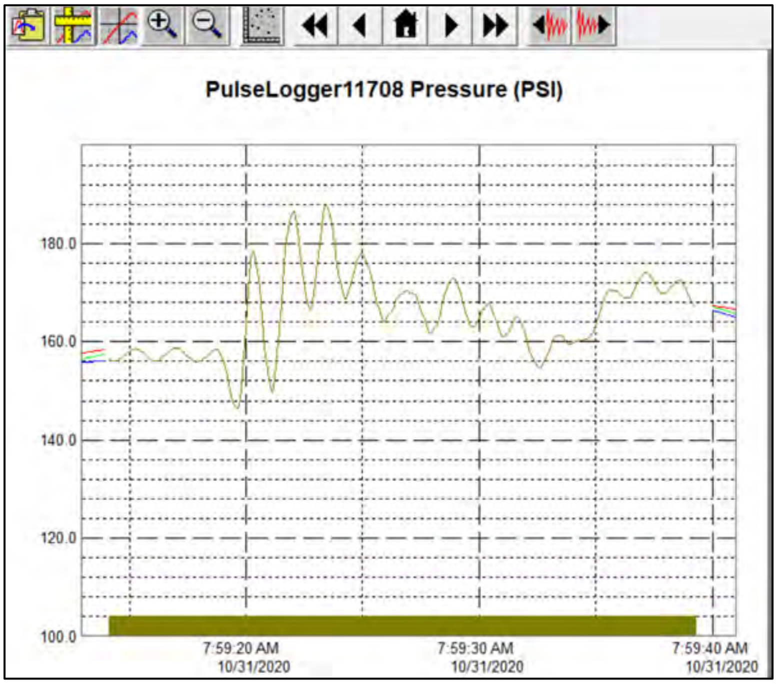

Figure 61. High-frequency Pressure Transient in the North PZ near the NGIC.

Figure 61 also demonstrates the difference in data collected by typical pressure monitoring equipment vs. high-frequency monitoring equipment. On October 31, the peak pressure recorded by typical equipment is only 168 psi (Figure 60), whereas the peak pressure recorded by the high-frequency equipment is approximately 188 psi (Figure 61).

To best protect the pipeline, surge mitigation equipment should be located as close to the transient source as possible. To be effective, installed equipment must be verified to be working as intended, to include commissioning activities as well as periodic (e.g., annual) follow-up testing. Common equipment options include the following:

- Pressure/surge relief valve
- Hydropneumatic tank
- Slow-acting control valve

To assess the frequency and magnitude of transient pressure surges within the transmission system, further study of pressure surges is recommended as part of a pipeline condition assessment program (Section 6.3.5). In addition to assessing pipe condition and its remaining useful life to plan for orderly replacement in advance of failure, a transient study should identify the locations and causes of surge events within the transmission system and recommend ways to mitigate the surges. Once transient sources are identified, the RWSA's WaterGEMS model can be used to perform a HAMMER simulation of surge events for existing conditions and with proposed surge mitigation equipment.

In follow-up to the recommended pipeline condition assessment, more detailed investigation of any transient observations is recommended. Activities should include coordination with customers on improving their water use operations to not induce transients, and preparation of a PER to identify options for mitigating pressure transients, whether generated by the RWSA or another party. Transient mitigation equipment is most effective if installed as closely as possible to the source of the transient.

Project	Investigate Pressure Surges and Implement Mitigation Recommendations
Complete By	2030
Total Cost	$0.8M ($0.1M for Investigation, $0.7M for Mitigation)
Benefits	• Reduce frequency and severity of transient-induced stress on pipelines, appurtenances, and equipment • Extend useful life of existing assets • Reduce frequency of waterline breaks and associated unplanned costs
Implementation Comments	• Coordinate with waterline condition assessment • Initiate in conjunction with or independent of waterline condition assessment program • Install permanent monitoring equipment at all PS facilities

8.4.5. Condition of Electro-mechanical Equipment

As with waterlines, a condition assessment of pumping facilities is recommended. Electro-mechanical investigations should include review of electrical contactors, transformers, and motors for excess heat generation, and review of rotating equipment for failing seals and bearings and mis-alignment of drive shafts. Addressing identified issues prolongs equipment life and reduces O&M costs. By assessing remaining useful life of equipment, orderly replacement can be planned and budgeted. Assuming electro-mechanical condition assessment of finished water pumps has not been performed, it should be budgeted for completion within five (fiscal) years.

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Project	Comprehensive Electro-Mechanical Condition Assessment
Complete By	2030
Total Cost	$0.2M
Benefits	• Determine remaining useful life of pumps, controllers, switches, etc. • Identify preventive maintenance needs, e.g.: o Cable connector replacements o Bearing repacking/replacement o Mechanical realignment
Implementation Comments	• Identify issues before they become visible and/or result in failure

8.5. Summary of Recommendations for Pumping Facilities

Most if not all of the RWSA's pumping facilities are equipped with some sort of pump control, whether via motor control (VFD or soft starter) or discharge valve control. Study of pressure surges is recommended as part of a comprehensive condition assessment program. The study should identify the sources and causes of unacceptable surge events, determine whether any of the identified surge events are associated with RWSA pumping facilities, and prepare recommendations to mitigate those surges, regardless of source, in order to protect RWSA assets.

If any unacceptable pressure surges are associated with RWSA pumping facilities, the RWSA's WaterGEMS model can be utilized to perform a HAMMER simulation of surge events for existing conditions as well as with proposed mitigation equipment. For unacceptable surge pressures determined to be caused by others, the RWSA should work with the customer's retail utility to review customer operations and advise the customer of operations changes, including installation of mitigation equipment, that will alleviate unacceptable pressure surges.

Options for addressing pressure surges originating at PSs or elsewhere in the distribution system include the following:

- fine-tuning the settings of installed surge management equipment
- installing surge management equipment
- installing pump soft starters or VFD controllers for constant-speed pumps
- installing HP tanks or surge relief valves

Recommendations for RWSA pumping facilities are presented in Table 18. Conducting a pressure surge investigation for normal and atypical operating conditions is a key component informing other recommendations.

Table 18. Recommendations for RWSA Pumping Facilities.

Item	Pump Facility	Cost	Schedule	Recommendations
1	All	$100,000	2025	Pressure surge investigation / mitigation PER (parallels multi-year waterline condition assessment program)
2	All	$133,000	2025	Operations investigation
3	NRWTP	N/A	2023	Adjust pump control valves based on findings in #1
4	Stillhouse PS	N/A	2023 2025	Adjust VFD speed changes based on findings in #1 Adjust operations based on findings in #2
5	Alderman Road PS	$300,000	2023	Adjust soft start/stop times based on findings in #1
6	SRWTP	N/A	2023	Adjust VFD speed changes and soft start/stop times based on findings in #1
7	All	$700,000	2030	Install surge mitigation equipment where needed

(End of section.)

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9. Data Collection Activities

Data collection provides the foundation for detailed management and design decisions, filling gaps in information. Many of the activities described in this section focus on field work, from condition assessment to testing to interviews of operations staff.

9.1. Condition Assessment

Condition assessment provides a snapshot view of the condition of existing assets, from pipes to pumps to buildings. In and of itself, pipe age is not sufficient cause to incur the cost of replacing an entire pipeline. Although the RWSA may be more concerned about replacing CI pipe, DI pipe can also be susceptible to premature failure, especially if protective coatings were damaged during transport or installation and not noticed or repaired, or at a later date by others. A particularly corrosive pocket of soil can also foster deterioration of a segment of buried pipe more quickly, regardless of the material being DI or CI pipe. The useful life of CI pipe can range from 50 to 150 years or more, depending on the following factors:

- age (wall thickness)
- corrosivity of local soils
- presence of stray electrical currents
- operating conditions (e.g., frequency and severity of pressure surges)
- damage incurred during or after construction

A condition assessment program (CAP) should be linked to an asset management program. A CAP involves periodic evaluation as well as constant monitoring of waterlines, and periodic inspection of waterline corridors/easements and pumping facilities. A comprehensive CAP should evaluate the following:

For pipes:

- pressure behavior, including transients, within the pipe system
- presence of air pockets and acoustic indicators of leaks within the pipe system
- external condition of pipe walls and connections, particularly in areas with corrosive soils and/or with stray electrical currents (e.g., vicinity of high-voltage power lines or petroleum/gas pipelines with impressed current cathodic protection)
- condition of pipe casings
- condition of cathodic protection systems
- remaining useful life of pipe given condition and pressure findings
- surface condition of easement/corridor, looking for indications of
    - leaks and/or soil migration, including at vaults and aerial crossings
    - erosion of overburden adjacent to waterways
    - exposure of pipe or loss of cover at shallow water crossings

  - deteriorated pipe coatings, connections, and/or supports at aerial crossings

For pump stations:

- review monitoring data (flow, suction and discharge pressure, power consumption) to verify pump performance relative to manufacturer's curve
- indications of settling or soil ingress
- indications of electro-mechanical wear
  - acoustic investigation of motors and pumps
  - visual assessment of pumps and motors for leaks and cracking
  - thermal imaging of electrical motors, panels, and controllers

Based on findings for waterlines, the RWSA can then program acquisition of right of way and waterline replacement into its CIP program well in advance of waterlines reaching the end of their useful life, regardless of pipe material or age. Due to their smaller footprint, findings of pump station deficiencies can be addressed more quickly, perhaps in the year following the condition assessment. A sample CAP might be scheduled as shown in Figure 62.

Year	1	2	3	4	5	6	11	16	21	26	31	36	41	46
Review of SCADA Data	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Visual inspection of aerial and shallow pipe crossings	●						●		●		●		●	
Visual reconnaissance of pipeline corridors			●			●		●		●		●		●
Pipeline Condition Assessment – Section 1	●													
Pipeline Condition Assessment – Section 2		●												
Booster Station Condition Assessment			●											
Pipeline Condition Assessment – Section 3				●										
Pipeline Condition Assessment – Section 4					●									
WTP Finished Water Condition Assessment						●								
Pipeline Condition Assessment Follow-up							●		●		●		●	
Pump Facility Condition Assessment Follow-up								●		●		●		●

Figure 62. Conceptual Schedule for Condition Assessment Program.

9.2. Hydraulic Model Calibration

As a foundation to further investigation of each of the topics discussed previously in this section, the water model should be put through a rigorous program of hydraulic and water quality calibration. Such a program would collect data over a minimum three-month timeframe and require over 95% SCADA data reliability, i.e., no sensors off-line or out of calibration for an extended period of time. Model calibration should include the following:

- Existing, recent hydrant flow test data accompanied by tank level, pump station status, and WTP production data
- Additional hydrant tests to fill in spatial information gaps or where the distribution system has changed since the last local hydrant tests were performed

- Temporary intra-day metering of high-volume customers
- Temporary monitoring throughout the distribution system of:
  - HGL/pressure (average every five minutes)
  - Disinfectant concentration (average hourly)

Once fully calibrated for hydraulics and water quality, the model provides the RWSA with a desktop tool to quantify expected hydraulic as well as water quality impacts due to proposed changes in operations. Model results inform planning decisions for taking a waterline, storage tank, or WTP out of service, whether temporarily or for an extended period of time. A calibrated water model also provides the RWSA with the ability to develop and test alternative strategies for daily and seasonal operation of pumping and storage facilities.

Project	Comprehensive Model Calibration of Hydraulics
Complete By	2030
Total Cost	$180,000
Benefits	• Virtually test proposed changes to facility/system operations
Implementation Comments	• Requires 95% or better SCADA data reliability • Requires mobilization of field monitoring equipment • Update network and demands annually • Timeline assumes Central Waterline, South Rivanna River Second Crossing, ARPS, and Emmet/Seminole "Phase 1" are all completed first

9.3. Storage and Operations Evaluations

Completing a detailed evaluation of factors affecting storage in each PZ is recommended. Information gained will provide guidance on adjusting operating levels to improve turnover while providing adequate fire suppression storage. Data to review includes the following:

- Customer elevations and pressure requirements (e.g., sprinkler supply)
- NFF for existing and anticipated development
- Reduction in NFF for buildings with approved automatic sprinkler systems
- PZ boundary adjustments

An operations review includes the following activities:

- Interviews of staff at the RWSA and retail utilities, including UVA (gap analysis)
  - Documented facility and operations protocols vs. institutional knowledge
  - Production and delivery of finished water
  - Normal as well as atypical and emergency conditions

  - Update model controls with any operations changes made after UFWMP workshops
- Verification that manufacturer recommended maintenance schedules and activities are being followed, and that industry best management practices have been implemented.
- Verification of adequate sprinkler system and private pump performance for reduced normal minimum operating levels at storage tanks.

Project	Storage Evaluation
Complete By	2030
Total Cost	$250,000
Benefits	• Reduce fire suppression volume • Increase operating range to improve turnover and reduce PS cycling
Implementation Comments	• Identify buildings with sprinkler systems and assess whether design NFF (for calculating fire suppression storage) can be reduced • Assess palatability of mitigation strategies for customers adversely impacted by reducing the normal minimum tank level

Project	Operations Evaluation
Complete By	2030
Total Cost	$150,000
Benefits	• Improve efficiency in manufacture and delivery of finished water • Formalize in-house knowledge and protocols
Implementation Comments	• Identify opportunities to improve automation • Improve staff confidence in performance of tanks

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10. Summary of Recommendations and Implementation Plan

In order to address operational challenges for current and future demands, the UFWMP presents recommendations for future work. Recommendations can be generalized into two categories: capital improvements and data analysis. Several capital improvements can proceed into design immediately, whereas others will benefit from being refined following data collection and analysis.

Evaluations are recommended to provide more detailed information for improving system operations and designing infrastructure improvements. These activities may be undertaken at the RWSA's discretion. For many of the evaluations, monitoring or other data must be acquired to provide a knowledge base of system behavior or customer requirements.

To address current and future demands and operational challenges in the urban finished water system, capital project recommendations are presented in Table 19 with approximate timing and estimated costs, and investigation/study recommendations are presented in Table 20. The estimated cost for each project includes planning-level estimates for engineering, permitting, land/easement acquisition, construction, and other associated costs. Total program cost is estimated to be $153.9M through 2070 (Table 21,Figure 63). Additional information for capital project costs, including a detailed breakdown of cost items, is presented in Appendix I.

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Table 19. Prioritized Recommendations for Urban Finished Water System CIPs

Recommendation	Report Section	Category	Complete By	Estimated Project Cost
South Rivanna River Second Crossing	6.3.7	Redundancy	2025	$5.8M
Airport Road Pump Station	8.4.3	Conveyance	2025	$4.0M
Airport Road Pump Station Waterline – Phase 1	8.4.3	Conveyance	2025	$6.0M
Airport Road Pump Station Waterline – Phase 2	8.4.3	Conveyance	2030	$1.4M
Central Waterline	6.2.4	Conveyance	2030	$31.0M
Stillhouse 0.73 MG GST	7.6.1	Storage	2030	$1.7M
Lewis Mtn. Operations	7.6.2	Storage	2030	$0.2M
Lewis Mtn. 0.5 MG GST	7.6.2	Storage	2030	$0.9M
North Rivanna Waterline Reinforcement	6.3.6	Resilience	2030	$4.3M
North Rivanna River Second Crossing	6.3.7	Redundancy	2030	$1.2M
Emmet/Seminole Waterline Phase 1 (24" Gap)	6.2.3	Redundancy	2030	$8.5M
Pressure Surge Mitigation	8.4.4	Resilience	2035	$0.7M
Emmet/Seminole Waterline Phase 2 (30" Connection to CWL)	6.2.3	Redundancy	2035	$9.5M
Alderman Road PS Discharge Inter-connection	6.3.1	Resilience	2045	$0.4M
Single-Feed Bypasses	6.3.4	Resilience	2045	$1.3M
Rivanna River Second Crossing at Pantops	6.3.7	Redundancy	2045	$4.8M
Observatory Waterline Replacement	6.3.5	Resilience	2045-50	$1.9M
South Rivanna Waterline Replacement	6.3.5	Resilience	2055-60	$27.6M
Avon Street Waterline	6.3.8	Redundancy	2060-65	$10.3M
North Rivanna Waterline Replacement	6.3.5	Resilience	2065-70	$10.6M
South Rivanna Waterline Replacement Rio to Hydraulic	6.3.8	Conveyance	2070	$9.6M
Replace Pantops and Avon Street Tank	7.6.4	Storage	2070	$8.9M
Airport Road Tanks	7.6.3	Storage	2070	$2.8M
Total of Capital Improvement Projects				**$153.4M**

Table 20. Recommendations for Urban Finished Water System Investigations/Studies

Recommendation	Report Section	Category	Phase	Complete By	Estimated Cost
Comprehensive Waterline Condition Assessment	6.3.5	Asset / Operations Management	Study	2030	$800,000
Investigate Pressure Surges and Prepare Mitigation PER	6.3.6	Asset / Operations Management	Study	2030	$100,000
Comprehensive Electro-Mechanical Condition Assessment	8.4.5	Asset / Operations Management	Study	2030	$200,000
Water Model Hydraulic and Water Quality Calibration	9.2 7.6.6	Operations Management	Study	2030	$400,000
Storage and Operations Evaluation	7.6.6 9.3	Storage	Study	2030	$400,000
Total of Investigations / Studies					**$1.9M**

Table 21. Urban Finished Water Program Budget by Planning Horizon

Planning Horizon	Estimated Cost
2030	$68.8M
2045	$16.7M
2070	$69.8M
Total	**$155.3M**

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Project	By (year)	Total ($M)	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
South Rivanna River Second Crossing	2025	5.8	5.8									
Airport Road Pump Station	2025	4.0	4.0									
Airport Road Waterline Phase 1	2025	6.0	6.0									
Airport Road Waterline Phase 2	2030	1.4		1.4								
Central Waterline	2030	31.0	10.0	21.0								
Stillhouse Tank	2030	1.7		1.7								
Lewis Mtn. Operations	2030	0.2		0.2								
Lewis Mtn. Tank	2030	0.9		0.9								
North Rivanna Waterline Reinforcement	2030	4.3	0.5	3.8								
North Rivanna River Second Crossing	2030	1.2	0.2	1.0								
Pressure Surge Mitigation	2035	0.7			0.7							
Emmet/Seminole Waterline	2035	18.0	2.9	6.5	8.6							
Alderman Interconnection Meter	2045	0.4					0.4					
Single-Feed Bypasses	2045	1.3				0.6	0.7					
Rivanna River Second Crossing to Pantops	2045	4.8				0.5	4.3					
Observatory Waterline OBSWTP to Lambeth PS	2050	1.9						1.9				
Replace South Rivanna Waterline in Seminole	2060	27.6							16.0	11.6		
Avon Street Waterline	2055	10.3								3.0	7.3	
Replace North Rivanna Waterline	2070	10.6									3.0	7.6
South Rivanna Waterline Rio to Hydraulic	2070	9.6	As opportunities arise (betterment, repair, etc.)							0.6	4.5	4.5
Replace Pantops and Avon Street Tanks	2070	8.9										8.9
Airport Road Storage Tanks	2070	2.8										2.8
Waterline Condition Assessment	2030	0.8		0.8								
Surge Investigation	2030	0.1		0.1								
Electro-Mechanical Condition Assessment	2030	0.2		0.2								
Hydraulic and Water Quality Model Calibration	2030	0.4		0.4								
Storage/Operations Evaluation	2030	0.4		0.4								
Total		155.3	29.4	38.4	9.3	1.1	5.4	1.9	16.0	15.2	14.8	23.8

LEGEND — Timeline for Project: Needed By (dark grey); Possible (Need, Opportunity) (light grey)

Figure 63. Timeline and Budget for Recommended CIPs and Studies.

(End of section.)

Appendix A

GIS Feature Classes / Data Layers

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GIS Data Utilized for Urban Finished Water Master Plan

Source	Data Date	Data Type	Contents
Albemarle County	Various	Shapefile	2-foot Contour 4-foot Contour
Albemarle County Service Authority	August 2020	Geodatabase	Hydrant Main Node System Valve
	June 2019	Shapefile	Blow-off Box Fire Lateral Fitting Lateral Production Well PRV Pump Pump Station Tank
	November 2018	Shapefile	Water Meter
City of Charlottesville	February 2020	Geodatabase	Hydrant Main Node Valve
	December 2018	Shapefile	Water Meter
	June 2019	Shapefile	Lateral
Rivanna Water and Sewer Authority	May 2020	Geodatabase	Control Valve Main Node Pump Station System Valve Tank Treatment Plant
	December 2019	Geodatabase	Demand Projections
	June 2019	Shapefile	Hydrant Pressure Zone Tap

SCADA Data Utilized for Urban Finished Water Master Plan

Owner	Facility	Start	End	Comments
RWSA	OBSWTP	1/1/2010	11/14/2018	Flow meter off-line starting 1/15/18 Disinfection process change 7/30/18
	OBSWTP (Bulk Daily)	7/1/2018	7/31/2018	
	SRWTP	3/21/2013	11/14/2018	
	NRWTP	5/10/2013	11/14/2018	
	Stillhouse Tank	5/30/2012	11/14/2018	
	Piney Mtn. Tank	5/30/2012	11/14/2018	
	Pantops Tank	5/30/2012	11/14/2018	Add July 2019 data for hydrant tests
	Avon Street Tank	5/30/2012	11/14/2018	Add July 2019 data for hydrant tests
	Observatory Tank	5/30/2012	11/14/2018	Add July 2019 data for hydrant tests
	Lewis Mtn Tank	5/30/2012	11/14/2018	
	Alderman Rd Pump	6/22/2010	11/14/2018	
	Stillhouse Pump	6/19/13	11/14/2018	
ACSA	Mosby Mtn Tank	6/20/2017	10/31/2019	No data for CY17
	Mosby Mtn Pump	5/25/2017	10/31/2019	No data for CY17, new pumps 1/22/19
	Ednam Tank & Pump	10/28/2014	10/31/2019	New pumps 10/18/19
	Avon Park Tank	6/1/2017	10/31/2019	
	Mill Creek Pump	6/2/2017	11/30/2018	
	Ashcroft Tanks & Pump	1/1/2015	10/31/2019	Not active in model, data not used
UVA	Alderman Rd Pump	11/28/2017	2/26/2018	

Any periodic gaps in data not specifically referenced in the table are otherwise not identified.

Appendix B

Hydraulic Model Background, Inputs, Updates, and Validation

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1. Hydraulic Model Validation

1.1. Hydraulic Model Background

For the wholesale metering project, RWSA provided Michael Baker with the then-current version of the calibrated comprehensive urban area hydraulic model. The model was built and calibrated by others in 2012 for RWSA and includes pertinent finished water infrastructure elements for RWSA, ACSA, and the City. Although the physical assets are included in the model inventory, UVA's campus is represented as a single customer with demands fluctuating according to historical records. Several ACSA PZs are also represented as single point-of-connection demands on the suction side of the pumps that draw water from the UPZ: Ashcroft, which is comprised of three small pressure zones, some with tanks; and the portion of Northfields that is served by a hydropneumatic (HP) tank.

The original model was built on the Wallingford software platform and was converted by Michael Baker to the Bentley WaterGEMS software suite for use in the wholesale metering design project. For that effort, Michael Baker confirmed that the hydraulic model retained the correct controls and boundary conditions. Michael Baker subsequently modified the model in 2018 when preparing an update to the Preliminary Engineering Report (PER) for the Airport PZ, and when evaluating possible alignments and associated system performance for completion of the Southern Loop (Avon to Pantops Water Main) to move finished water in bulk from the Avon Street Tank in the vicinity of Monticello High School to the Pantops area.

1.2. Geographic Information System

RWSA, ACSA, and the City each provided Michael Baker with a copy of Geographic Information System (GIS) data pertinent to the water utilities in the urban service area, most recently in May 2020, August 2020, and February 2020, respectively. GIS is a software-based analysis and mapping tool that is especially useful for keeping detailed geospatial records of infrastructure. In addition to utility GIS data, Michael Baker downloaded topographic data (two- and four-foot contours) from Albemarle County to assign elevation to new assets in RWSA's system-wide water model. Other GIS datasets included retail water meter locations and RWSA's area-based projections of future water demand.

ACSA and RWSA water system GIS data was transmitted to Michael Baker in the form of a geodatabase, which bundles several feature classes (data layers) together into a single folder structure. City water system GIS data was transmitted to Michael Baker in the form of shapefiles, with each data layer comprised of its own set of component files. RWSA demand projection data was transmitted to Michael Baker as shapefiles supplemented with data tables.

Each feature class or data layer represents a specific type of infrastructure in the water system. This includes categories such as water mains, tanks, pump stations, pumps, valves, fire hydrants, water services (taps and laterals), water meters, and fittings. The GIS data transmitted to Michael Baker included separate features for RWSA's water system, ACSA's water system, and the City's water system; therefore, all of the elements within the urban water system could be assigned to the correct utility owner.

Ideally, each feature (element or item) in a geodatabase or shapefile has complete attribute (characteristic) data associated with it. Some of the GIS attributes are required for building and maintaining a computer model of the water system, while others provide useful information to improve the model. For example, each pipe in a water main layer must have an individual diameter and length. While not required, pipe material, installation date, and a unique identifier (ID) are also beneficial. Water storage tanks have a different set of attribute data, such as overflow elevation and tank volume. As with pipes, some of the tank GIS attributes are required to develop and maintain a computer model, while others are not.

GIS served as the foundational data input for this project. It is important to note that all GIS data was assumed to be accurate. Of specific note, valve status data (i.e., open vs. closed) was heavily relied on. Where model validation results were inconsistent with supplied monitoring data or GIS network information appeared to be incomplete (see next section), Michael Baker conferred with the appropriate utility owner to verify valve status and/or network connectivity. Appendix A provides a summary of the feature classes / data layers received or obtained by Michael Baker during this study, as well as other GIS data utilized for this project.

1.3. Existing Water Meters

As a supplement to the water meter geospatial location provided in a GIS geodatabase or as a shapefile, Michael Baker was provided with spreadsheets tabulating either total monthly water consumption values for every ACSA retail water meter account or total annual water consumption values for every City retail water meter account. The flow values were provided for Fiscal Year (FY) 2017, i.e., July 2016 through June 2017 ("FY17"). Michael Baker was able to link the flow information associated with each account to the corresponding GIS entry, either by directly linking ACSA data via meter ID or by matching the City account and meter addresses.

1.3.1. City

According to City records, there are approximately 14,350 retail water meters owned by the City. The City assigns one of several classes to each account. A summary of the City's meters by class is provided in Table 1.

The City utilizes several master meters. Water that is pumped into the UVA system is metered through a 14-inch UVA-owned master meter at the Alderman Road PS. In addition, the City has one master meter to measure the flow pumped into the Lambeth PZ, which is located entirely within the City limits.

1.3.2. ACSA

According to ACSA records, there are approximately 17,250 retail water meters owned by ACSA. A summary of ACSA's meters by class and quantity is provided in Table 1.

Table 1. City and ACSA Meter Classifications

Meter Class	Description	City Quantity	ACSA Quantity
C	Commercial	1,366	882
E	Medical	5	-
G	Gov't / Institutional	133	185
I	Industrial	7	34
M	Multi-Family	1,761	511
O	Office	-	208
R, S	SF Residential	11,049	15,152
W	Irrigation	27	-
Total		*14,348*	*17,248*

1.3.3. RWSA

Because RWSA delivers water exclusively to two wholesale customers (ACSA and the City), RWSA does not own any retail meters. Source water meters are installed at the three WTPs. The SRWTP has a 24-inch diameter orifice plate meter, and the NRWTP has a 16-inch orifice plate meter. A 24-inch venturi meter is installed on the raw water line supplying the OBSWTP, and a potable water deduct meter tallies RWSA use of finished water at the facility. Both the Stillhouse PS and the Alderman Road PS have water meters.

In 2018, RWSA completed a program to install 25 wholesale meters, which are used to monitor compliance with the ACSA-City water allocation agreement. Wholesale meter flow data is recorded hourly, and water consumption is computed monthly. Since the wholesale meters were newly installed and some calibration was still on-going, the data was not utilized for the UFWMP project. In the future, the RWSA should evaluate the potential use of wholesale metering data during subsequent UFWMP updates and any model calibration efforts.

1.4. Model Updates

The RWSA's water model was updated for the "Avon to Pantops" project to mimic system operations, focusing on the SRWTP, and will be referred to herein as the "2018" version. As part of the UFWMP, the model was again updated to reflect existing physical and operational conditions throughout the entire transmission and distribution network and will be referred to herein as the "2020" version.

1.4.1. Pipe Network

The pipe network was updated to reflect changes in pipe size, connectivity, material, and alignment that have occurred since 2012. In many cases, this involved better information on the location of pipes, but it also included several pipe replacement projects, notably within the City. The model network was updated by linking directly to RWSA and ACSA GIS data via asset ID for links (pipes) and nodes (tanks, hydrants, "system" valves, and key fittings).

Due to a change in the management of City pipe network data, all pipe segments in the City GIS had been split at isolation valves. Taken together with either improved location of water assets or construction of new/replacement pipelines, the model network did not match well to the City GIS (Figure 1). City pipes were therefore updated by loading the GIS as a background layer to update alignments, manually adding and deleting connections where necessary to correctly represent the network, and comparing selection sets based on pipe diameter between the GIS and the model.

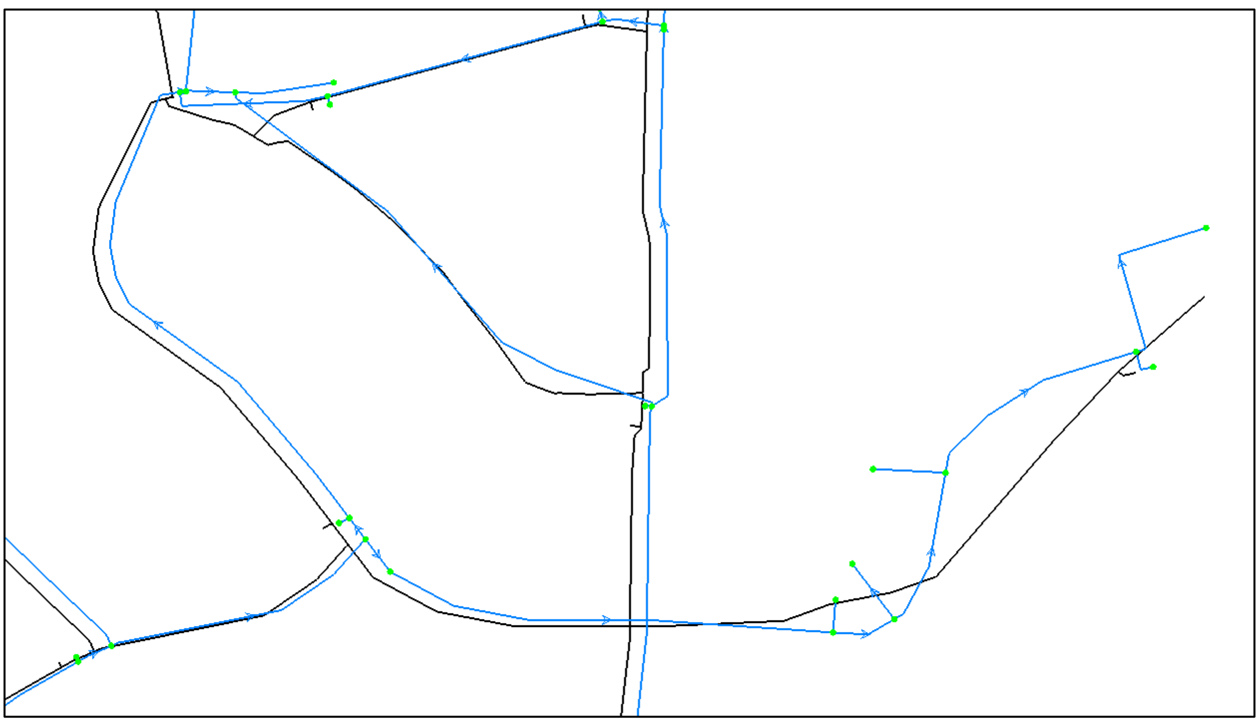

Figure 1: Comparison of Prior Model Network to Current GIS.
(2018 model network in blue, 2020 GIS data in black)

1.4.2. Operations

Operations input obtained by Michael Baker at project workshops resulted in updates to the following:

- Pump curves at WTPs and PSs
- Pump controls based on one or more of the following:
  - Tank level
  - Discharge pressure
  - Time of day
- PRV setpoints
- Activating the Lambeth PS and PZ
- PZ boundaries
- Creation of ACSA's Glenmore PZ

1.4.3. Demand Distribution

Water meter data provided by the RWSA, the City, and the ACSA to Hazen and Sawyer (Hazen) for the USWDF totaled 8.3 MGD (including 1.25 MGD for UVA) for 2017 average day demand (ADD). Demand was assigned to pipes (Figure 2) using laterals where provided, otherwise to the nearest pipe. ACSA billed water use was loaded to the model by directly linking to the meter GIS data.

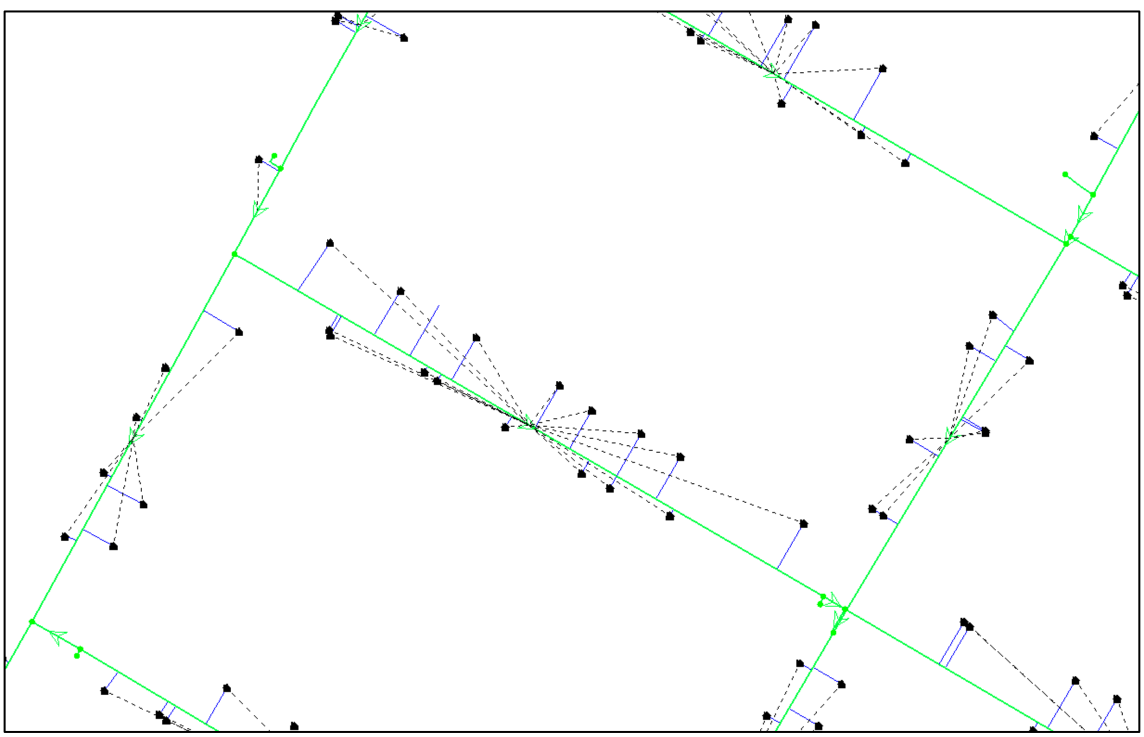

Figure 2. Assignment of Retail Water Meters to Model Pipes.

City billed water use did not link to GIS meter data via the Device No. or Cust. Serv. Address columns in the table provided: only 59.3% and 58.0% of demand volume was successfully matched to the "Serial_Num" field or concatenated address from the meter data, respectively. A review of the data revealed that a Device No. could have multiple addresses and vice versa, therefore the data was processed by reviewing unmatched table addresses and assigning the nearest address from the GIS meter location. After processing, 99.9% of the City billed water use was matched to its GIS location and loaded to the model.

UVA demand was assigned to the pipe serving the UVA side of the Alderman Road PS, and domestic/process water consumption at the SRWTP was assigned to the 24-inch main near the plant (Figure 3). The ACSA's Ashcroft and Northfields PZs are also represented by point demands. For expediency, unmetered water was distributed based on inch-diameter mile (IDM), a characteristic based on pipe size and length, and assigned to the "end" node of each pipe.

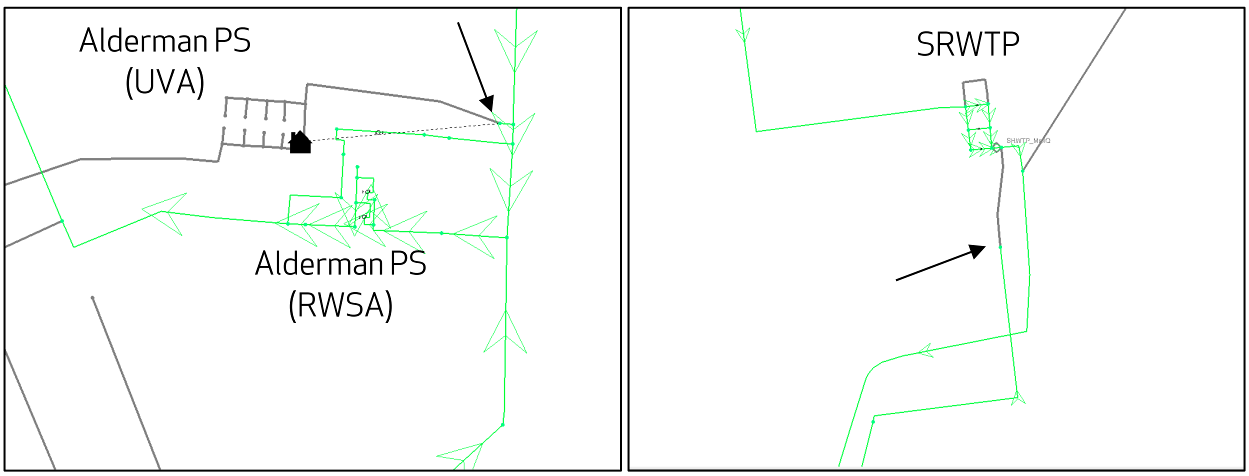

Figure 3. Load Points for UVA Demand and SRWTP Domestic/Process Demand.
(UVA demand load point shown at left, SRWTP process demand load point shown at right)

Demand projections developed in 2020 by Hazen were provided as a table downstream of the UVA 14-inch meter at the Alderman Road PS, and as multi-part GIS polygons for the rest of the Urban system. The previous demand projection was prepared by AECOM and finalized in 2011. For ADD in the Urban system, Hazen's recommended planning projection is 14 MGD (includes UVA moderate-growth demand of 1.4 MGD) for year 2070 compared to AECOM's projection of 17 MGD (includes on-grounds 1.73 MGD for UVA) for year 2060. The reduction in projected demand may be due, in part, to observed and anticipated reduction in per capita water consumption as water use becomes more efficient. A summary of Hazen's demand projections is provided in Table 2, and UFWMP modeled demands are provided in Table 3. The 2017 metered demand is assumed to be representative of 2020 retail demand. For the purposes of the UFWMP, unmetered water is assumed to be proportional to demand, therefore as demand increases above ADD, unmetered water also increases.

Table 2. Hazen Demand Projections (MGD)

Demand Component	2017	2030	2045	2070
Average Day Retail Consumption[1]	8.33	9.31	10.47	11.77
Unmetered Water[2]	1.05	1.17	1.32	1.48
Recommended Planning Finished Water Demand Hot/Dry Extreme[3]	-	11.0	12.4[4]	13.9

[1]USWDF Table 3-9, higher than "Retail Total" in USWDF Table 3-10
[2]USWDF Table 3-10
[3]USWDF Table 5-1
[4]Breakpoint at 2045, demand extrapolated from reported earlier and later projected trends

Table 3. UFWMP Model Demands (MGD)

Demand Component	2020	2030	2045	2070
Average Day Finished Water Consumption[1]	9.38	10.48	11.79	13.25
Hot/Dry Day Finished Water Consumption[2]	9.94	11.11	12.50	14.04
Maximum Hot/Dry Day Finished Water Consumption[3]	14.62	16.33	18.38	20.64
SRWTP Process/Domestic Water[4]	0.175	0.20	0.225	0.25
Total Average Day Finished Water Production	9.56	10.68	12.02	13.50
Total Hot/Dry Day Finished Water Production	10.12	11.31	12.72	14.29
Total Maximum Finished Water Production	14.90	16.53	18.60	20.89

[1]Average Day Consumption is sum of Retail Consumption and Unmetered Water in Table 5

[2]System hot/dry day demand premium is 6%: 7.46% for ACSA, 2.62% for City, 9.50% for UVA per USWDF Table C-2 (99th percentile)

[3]Maximum day peaking factor is 1.47 (USWDF Section 4), applied to hot/dry day demand

[4]SRWTP Process/Domestic Water demand not applicable to scenarios where SRWTP is off-line

The demand (water use) loaded to the model represents an annual average water consumption. Evaluation of seasonal variations in demand on a per-meter basis was beyond the scope of work for this project. If a more accurate evaluation of system performance due to seasonal variation in individual retail demand is desired, water billing data would be needed from the City on a monthly rather than annual basis. Unless otherwise noted, evaluated scenarios utilize hot/dry day demands.

1.4.4. Hydrant Test Results

Hydrant test results were provided by ACSA and the City and applied to the model to verify and update hydraulic model friction factors. Due to significant changes in the model representation of the City's water distribution network, friction factor validation efforts focused on using available SCADA data and hydrant tests conducted in 2018.

A total of 19 hydrant tests were simulated in the model under steady-state conditions. For each hydrant test simulation to mimic the real network conditions at the time of the test as closely as possible, the tank levels, pump status, and daily demands were adjusted in the model based on the SCADA data corresponding to the time of day of each test. The reported flow was added to each flowing hydrant, and the pressure drop at the observation hydrant was checked.

The pressure drop in each model hydrant test was compared to the field data. Hazen-Williams C factors and/or local valve settings were adjusted when the difference in pressure drop between the model and the field data exceeded five psi. For pressure drops that were within ± 5 psi between the model simulation and the field test, the pipe C factors and local valve settings were not adjusted.

Some of the low Hazen-Williams C factors (36, 50, 66) in the model as calibrated in 2012 could not be supported by the hydrant test results because the simulation resulted in too much of a pressure drop. Changing all Hazen-Williams C factors to 120 in the model was also evaluated, but this resulted in not enough pressure drop for many of the field hydrant tests evaluated in the model. Thus, model C factors were updated only in those areas covered by the hydrant tests. Hydrant test and model result information is presented in Appendix C.

1.5. Diurnal Patterns

Diurnal patterns represent the temporal variations in water demand for a municipal water distribution system or a PZ over a 24-hour cycle. Based on results from model validation, described below, Michael Baker determined that updated diurnal patterns unique to each PZ were required. The dry weather flow analysis module of the EPA's SSOAP Toolbox was utilized to develop average weekday and weekend MDD and ADD diurnal patterns for each PZ comprising the urban water system. Only the weekday pattern was selected for use in the model: the daily as well as peak hour demands are higher for weekdays than for weekends, therefore weekdays place greater stress on the water distribution system.

1.5.1. MDD Diurnal Patterns

Based on a review of monthly water production as well as wholesale customer billed consumption for calendar years 1981 to 2019, July is the month with the highest demand most years. The years of 2016 (no water restrictions in place) and 2018 (water restrictions in place) were selected for further analysis.

The date with the highest production in each year was July 25, 2016, and July 2, 2018. MDD patterns were developed system-wide for each water use condition from the selected days. Another set of MDD patterns was developed by averaging the days with a daily demand above 11.5 MGD for July 2016 and above 9.8 MGD for July 2018. Finally, day-specific MDD patterns were also developed. The day-specific and high-use multi-day diurnal patterns produced the best results in comparison to the SCADA data, and results generated by the two patterns were not significantly different from each other. The day-specific MDD patterns were therefore utilized for the project. In the model, the hourly MDD pattern factors are normalized to the 2017 ADD demands. This enables the model to track only one demand file for each year, with the applied diurnal pattern scaling that demand up or down to represent high- and low-use conditions.

To mimic the real network conditions for specific days, global demand adjustment factors were applied in the model to provide a system-wide demand within ± 0.5% of the calculated daily production. Monthly unmetered water use was scaled proportionally based on the daily water production rate and was applied in the model as a constant flow rate. The control of operations for various pump on/off levels were fine-tuned based on the tank level SCADA data. After confirmation from project team members as to timeframe of pump curve applicability, older pump curves were utilized for the Lambeth PS, North Rivanna WTP, and Mosby Mountain PS to calibrate the model to conditions without and with water use restrictions (2016 and 2018, respectively). An older pump curve was applied to the Ednam Forest PS only for the condition with no water use restrictions (2016).

1.5.2. ADD Diurnal Patterns

ADD diurnal patterns were developed by utilizing calendar year 2017 15-minute SCADA data from RWSA and ACSA, which would align with the meter data that were loaded into the model as the base demand. System-wide ADD was estimated by using the mass balance equation:

$$Q_{Demand} = Q_{Production} \pm \Delta V_{Tank\ Storage} / \Delta t$$

where Q_{Demand} = daily demand

$Q_{Production}$ = rate of production from water treatment plants

$\Delta V_{Tank\ Storage}$ = change in tank storage within the system

Δt = time between tank level measurements

Demand for each PZ was estimated by using a modified version of the mass balance equation:

$$Q_{Demand\ PZ} = \Delta V_{Tank\ Storage} / \Delta t + Q_{pump}$$

where $Q_{Demand\ PZ}$ = demand in particular PZ

$\Delta V_{Tank\ Storage}$ = volume taken out of tank storage

Δt = time between tank level measurements

Q_{pump} = measured pump flow rates

Review of the SCADA data revealed that the PS data was consistently one time step ahead of the tank data for the Lewis Mountain and Mosby Mountain PZs. The time of applying the PS data to the demand calculation was therefore adjusted to better align with the tank level data. A discrepancy was also observed with the Ednam Forest PS data, but due to its inconsistency, that data was not adjusted. Due to discrepancies between SCADA pump flow rates and calculated changes in tank volume, negative demands calculated by utilizing the Ednam Forest, Mill Creek, and Mosby Mountain PS data were disregarded. Therefore, only tank outflow was utilized to calculate demand for the Ednam, Avon Park, and Mosby Mountain PZs, respectively:

$$Q_{\text{Demand PZ}} = \Delta V_{\text{Tank Storage}} / \Delta t$$

where $Q_{\text{Demand PZ}}$ = demand in particular PZ

$\Delta V_{\text{Tank Storage}}$ = volume taken out of tank storage

Δt = time between tank level measurements

Net demand in the Urban PZ was calculated by the following mass balance equation:

$$Q_{\text{Demand Net Urban}} = Q_{\text{Production}} - Q_{\text{Demand PZ}} - Q_{\text{UVA}}$$

where $Q_{\text{Demand Net Urban}}$ = demand in Urban PZ

Q_{UVA} = estimated UVA demand (see "UVA Demands" below)

Calculated full-year demand time-series were loaded into the EPA SSOAP Toolbox to develop the average water use ADD diurnal patterns. Days with anomalous water use were excluded from the diurnal pattern calculation. SCADA data was missing for ACSA's Ednam Tank and PS for the year 2017. Since Ednam draws from the Lewis Mountain PZ, Ednam PS flows can be identified by a period of sustained high demand in the Lewis Mountain PZ. The 2017 Lewis Mountain data was processed into two demand time series: an estimated Ednam demand, and the residual (net) Lewis Mountain demand.

When comparing the estimated 2017 Ednam demand to water meter consumption as well as demand calculated from 2018 and 2019 Ednam SCADA data, it was determined that further investigation was required, as the apparent 2017, 2018, and 2019 Ednam demands were approximately two (2), five (5), and four times the 2017 average daily metered consumption of 0.0336 MGD, respectively (see Figure 7). It was later determined that the apparent increase in demand was likely associated with flow from the Ednam PZ to the Stillhouse PZ via ACSA's PRVs (primarily Flordon).

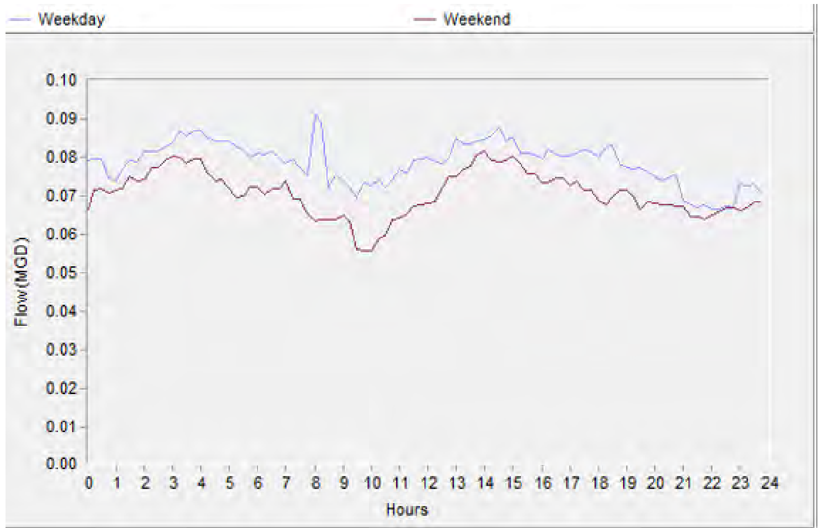

Figure 4. Ednam Estimated ADD Diurnal Pattern for 2017.

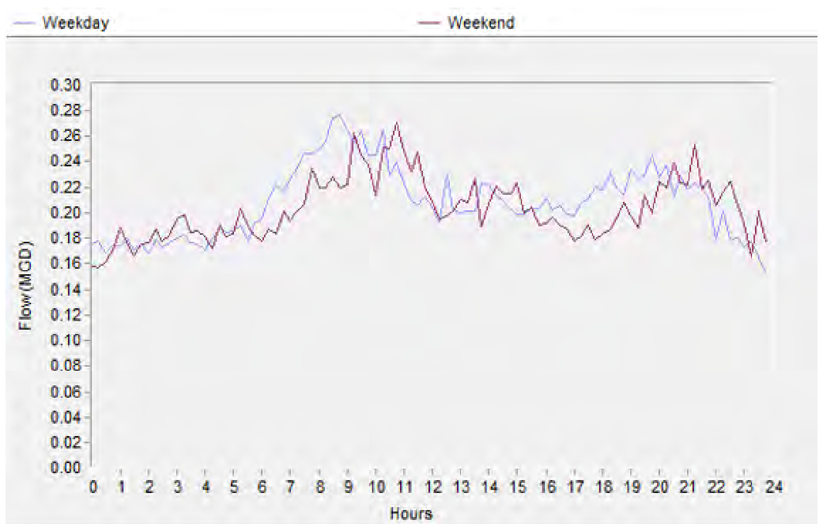

Figure 5. Ednam ADD Diurnal Pattern for 2018 from SCADA Data.

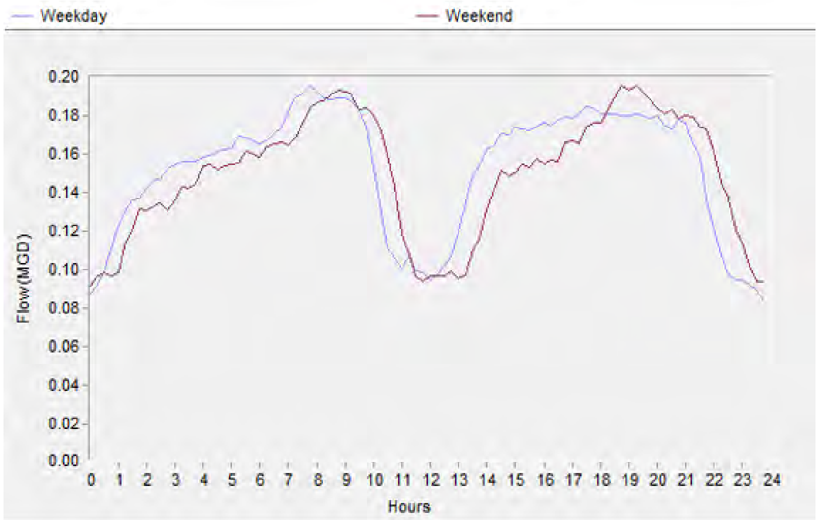

Figure 6. Ednam ADD Diurnal Pattern for 2019 from SCADA Data.

Beyond ADD base patterns, it was observed that there were differences in winter vs. summer daytime water use in both 2017 and 2018, which indicated signs of irrigation. Therefore, summer (high-use) ADD patterns were developed as well for conditions with and without water use restrictions. It is noted that ACSA's Glenmore PZ, created in 2019, was on the Urban PZ for the time period covered by the SCADA data. As a newer development, Glenmore is assumed to exhibit irrigation water use, relative to annual average demand, similar to that of Stillhouse. The Stillhouse diurnal pattern was therefore assigned to ACSA's Glenmore and Ashcroft PZs. The ADD diurnal patterns developed for each individual pressure zone were used as a base to assist future water use considerations.

1.5.3. UVA Diurnal Patterns

Three months of 15-minute UVA Alderman Road PS SCADA data from late November 2017 to late February 2018 were utilized to update the UVA diurnal pattern for withdrawing water from the UPZ. From the SCADA data, regular flow spikes were apparent right after midnight. These spikes, which correspond to a demand spike exhibited by the UPZ ADD diurnal pattern at approximately 12:30 a.m., are assumed to be associated with quickly refilling UVA's two main water storage tanks. The average flow rate during tank refill operations (4,550 gpm, or 6.56 MGD) corresponds to a velocity of 9.5 feet per second (fps) in the 14-inch PS discharge pipe, and a velocity of 7.3 fps in UVA's 16-inch water main. The average pattern developed by the EPA SSOAP Toolbox was modified during the early morning hours to preserve the peak flow rate when refilling the UVA tanks (Figure 9).

From the SCADA data, the UVA Alderman pumps were observed to run at a reduced capacity of approximately 1,150 gpm (1.65 MGD) for the majority of daylight hours and well into the evening. The daytime run duration varied and was sometimes broken into two or three segments, depending on water use for a given day (see Figure 8). As with other locations in the urban area water system, the UVA pumping data was processed using the EPA SSOAP Toolbox to develop average weekday and weekend usage patterns. Only the weekday pattern was selected for further processing, as the daily and peak hour demands are not as high for weekends as for weekdays. The average pattern developed by the EPA SSOAP Toolbox was modified to preserve the peak flow rate when refilling the UVA tanks, and to simulate one daytime pump cycle at a lower flow rate, with the pumps turning on/off within one 15-minute time period (see Figure 9).

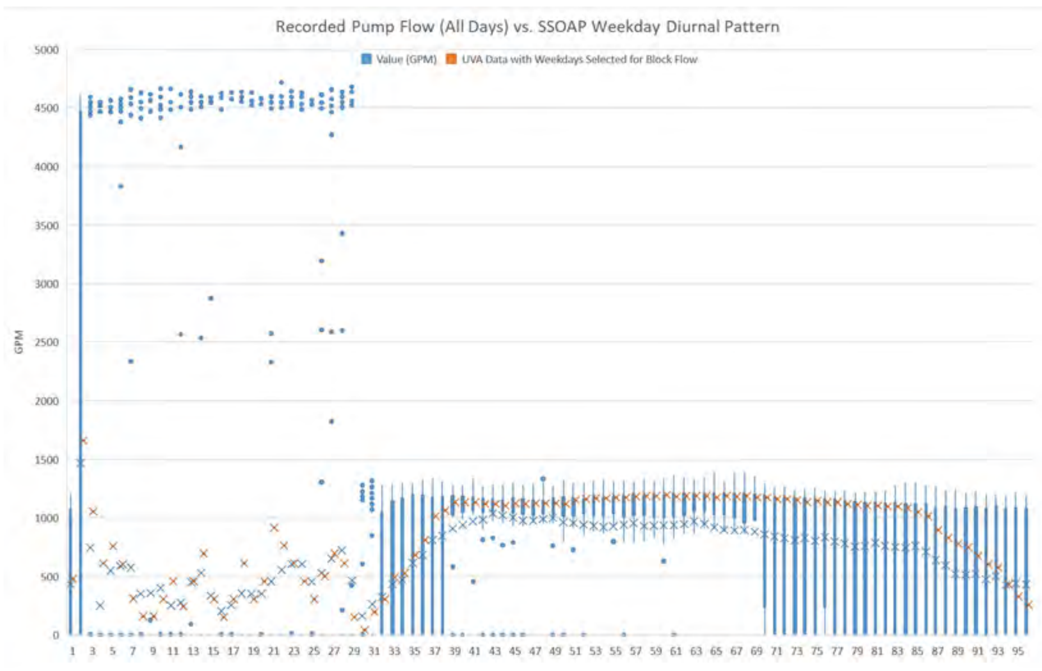

Figure 7. Box and whisker plot of UVA Alderman Pump Station data (blue) vs. SSOAP diurnal pattern (orange).

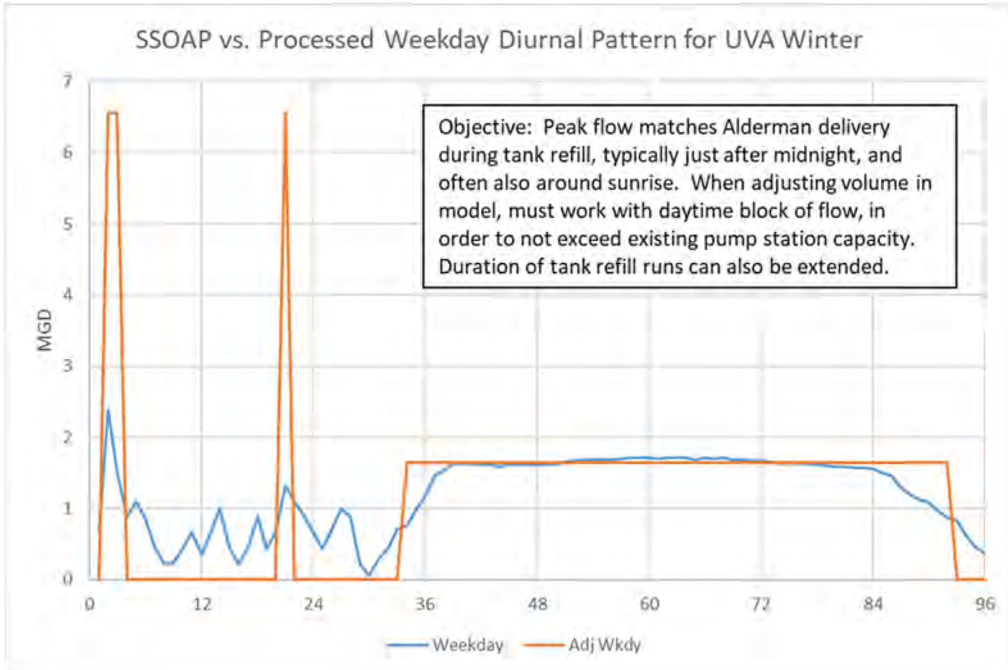

Figure 8. SSOAP vs. Final Diurnal Pattern for UVA Alderman PS.
(SSOAP data in blue, processed diurnal pattern in orange)

Copies of the modified 2017/2018 winter diurnal pattern were adjusted to account for increased year-round average demand and increased summer demand, as determined by evaluating RWSA monthly UVA consumption data for 2017. For the purposes of the Urban Finished Water Master Plan, UVA tank refill cycles were assumed to last up to 45 minutes, with two or three cycles per day, and the daytime pumping rate was assumed to range from 1.65 to 2.36 MGD, depending on season of the year, through 2070.

A comparison of the updated water usage pattern associated with the UVA Alderman Road PS to the diurnal patterns utilized by the 2018 hydraulic model is also shown in Figure 9. The 2018 Alt pattern is identical to the 2018 pattern, except that the two blocks of demand between midnight and 7 a.m. are in reverse order. It can be seen that the legacy UVA demand patterns would not place as much hydraulic stress on the distribution system as the 2020 pattern due to the 2018 pattern maximum peaking factor being less than half that of the 2020 pattern.

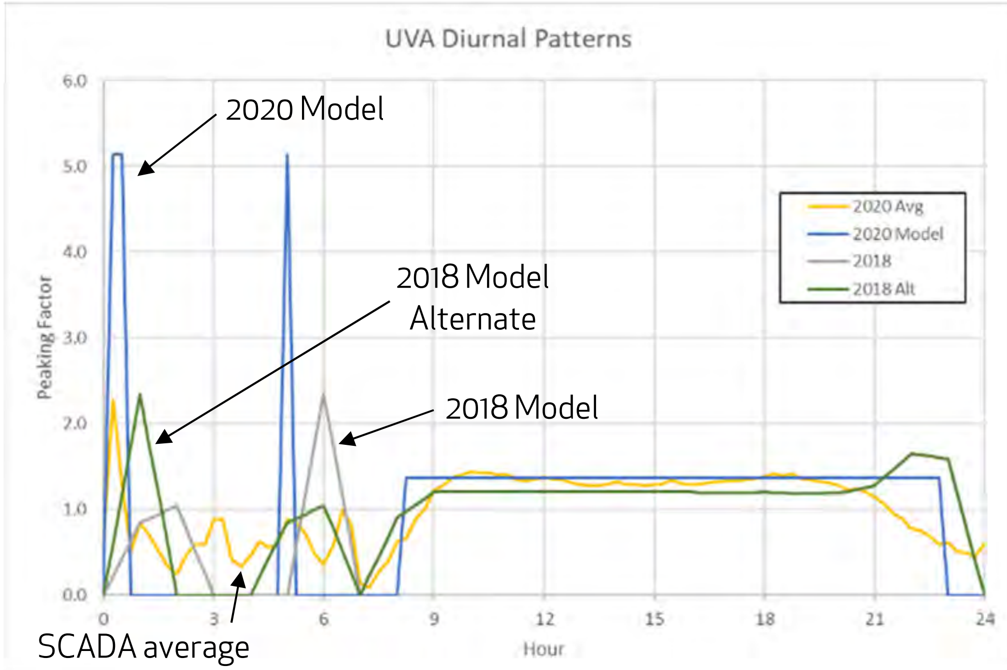

Figure 9. UVA Alderman Pump Data vs. 2018 and 2020 Model Diurnal Patterns.

A diurnal pattern that preserves the flow rate of tank refill periods and also mimics assumed regular daytime operations was developed for each demand scenario, i.e., years 2017, 2030, 2045, and 2070. As demand increases in time, the peak hour factor associated with tank refill operations decreases so that the flow rate remains the same.

1.5.4. Final 2020 Model Patterns

The final patterns utilized for UFWMP analyses are presented in Figure 10. For comparison purposes, the 2018 model diurnal patterns are presented in Figure 11. It can be seen that all of the urban system diurnal patterns except Ednam and UVA have the same general shape. (The UVA diurnal pattern development was described above.) The Ednam PZ has a very small, primarily residential demand. As such, it has higher and lower peaking factors throughout the day compared to the other urban system PZs. The 2020 model diurnal pattern also have a smoother shape, whereas the 2018 model diurnal patterns are erratic in the morning and through mid-day. The 2018 UVA diurnal pattern has a peak at the end, perhaps due to a different schedule for refilling the main tanks compared to the schedule evident in the SCADA data analyzed for the UFWMP.

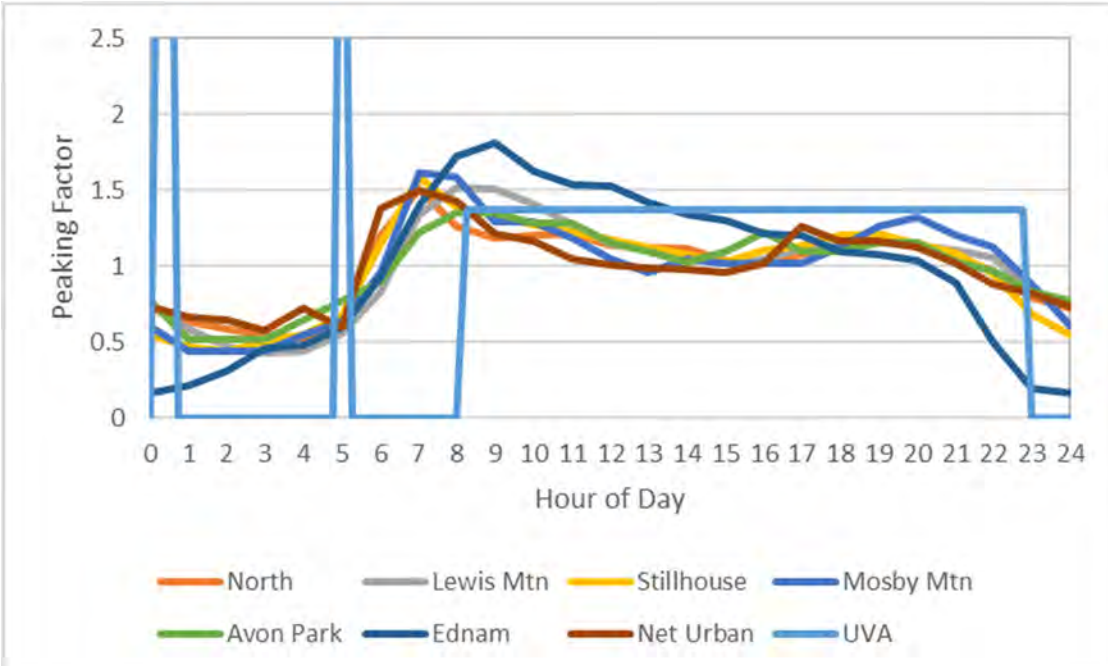

Figure 10. 2020 model diurnal patterns.

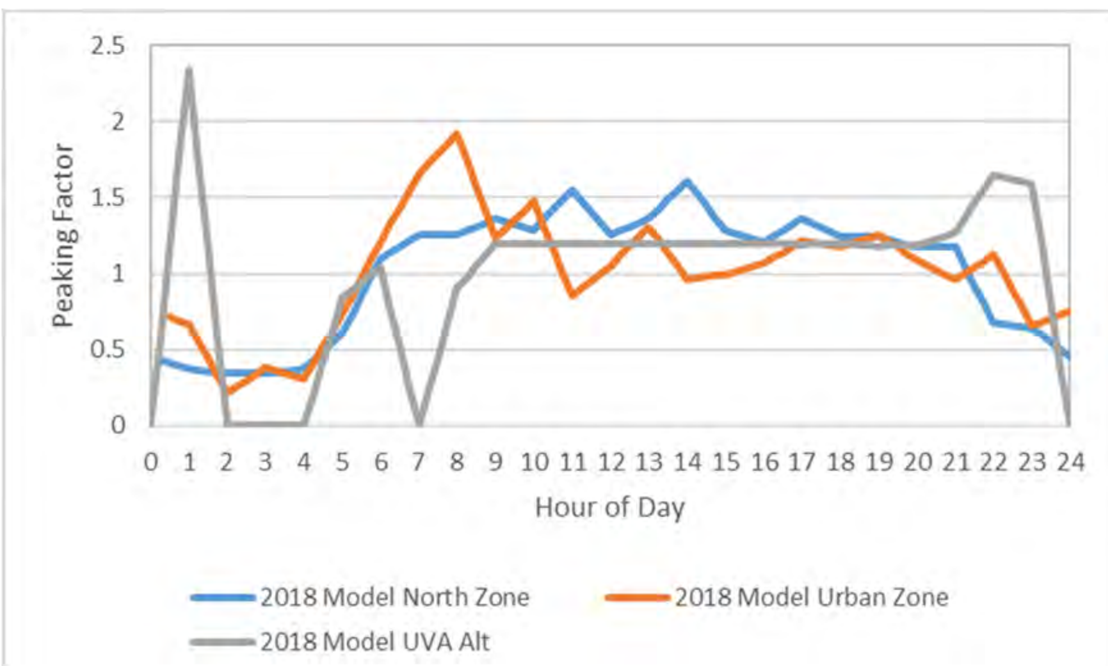

Figure 11. 2018 model diurnal patterns.

1.6. Model Validation

The purpose of validation was to verify the hydraulic performance of the distribution system (pump controls, flow of water, system pressures / tank levels) as represented in the model. The updated model (pump curves, pipe C factors, and pipe network) was validated by comparing model results to SCADA data and making adjustments to improve model accuracy. For all of the validation simulations, the model was set up as follows:

- Water production was "forced" by applying the outflow meter data at each WTP
- Initial tank levels and pump status were set based on SCADA data
- Model demand within each PZ was scaled based on SCADA data

Initial model validation efforts utilized the 2018 model's "UrbanHourly" diurnal pattern for all demands except UVA, which utilized the 2018 Alt diurnal pattern. Simulated demand, including UVA demand and unmetered water, was adjusted such that the total model demand approximated the day's water production, taking the net change in water storage (i.e., tank level) into account. (Distribution of unmetered water is discussed in Section 1.4.3.)

Typically, either July or August is the month with the highest water consumption. Compared to cooler months of the year, this is likely due to increases in not only irrigation water use but also consumptive use by building chill plants. Michael Baker reviewed water production records and selected two MDD events for model validation: July 27, 2016, and July 2, 2018. Each MDD event occurred during a period of hot weather, with other high-demand days before and/or after the selected event.

Valve status (i.e., open vs. closed) was heavily relied on. Where model validation results were inconsistent with supplied monitoring data or GIS network information appeared to be incomplete (see next section), Michael Baker conferred with the appropriate utility owner to verify valve status and/or network connectivity. Appendix A provides a summary of the feature classes / data layers received or obtained by Michael Baker during this study, as well as other GIS data utilized for the UFWMP.

1.6.1. July 2016 Single-Day Event

Given the updates described above, the model simulated smaller tanks fairly well (e.g., Stillhouse and Piney Mountain Tanks). Other tanks were not simulated as closely to the SCADA data as desired (e.g., Avon Street, Observatory, and Lewis Mountain Tanks), and the Pantops Tank was simulated poorly (Figure 12). It was therefore determined that the 2018 "UrbanHourly" diurnal pattern would not be adequate for the model to mimic operation of the entire system, hence diurnal patterns specific to each PZ were developed.

Model results more closely approximated operation of the urban water system when utilizing 2020 diurnal patterns customized to each PZ vs. using the 2018 model's generic, system-wide diurnal pattern (Figure 12).A review of Pantops Tank model data for the July 27, 2016 validation event reveals that localized model demand is approximately 400 gpm (0.6 MGD) short of actual demand. These results indicate that rather than scaling up model demand uniformly across the UPZ, demand may instead need to be shifted from the area well-connected to the OBSWTP to the area well-connected to the SRWTP.

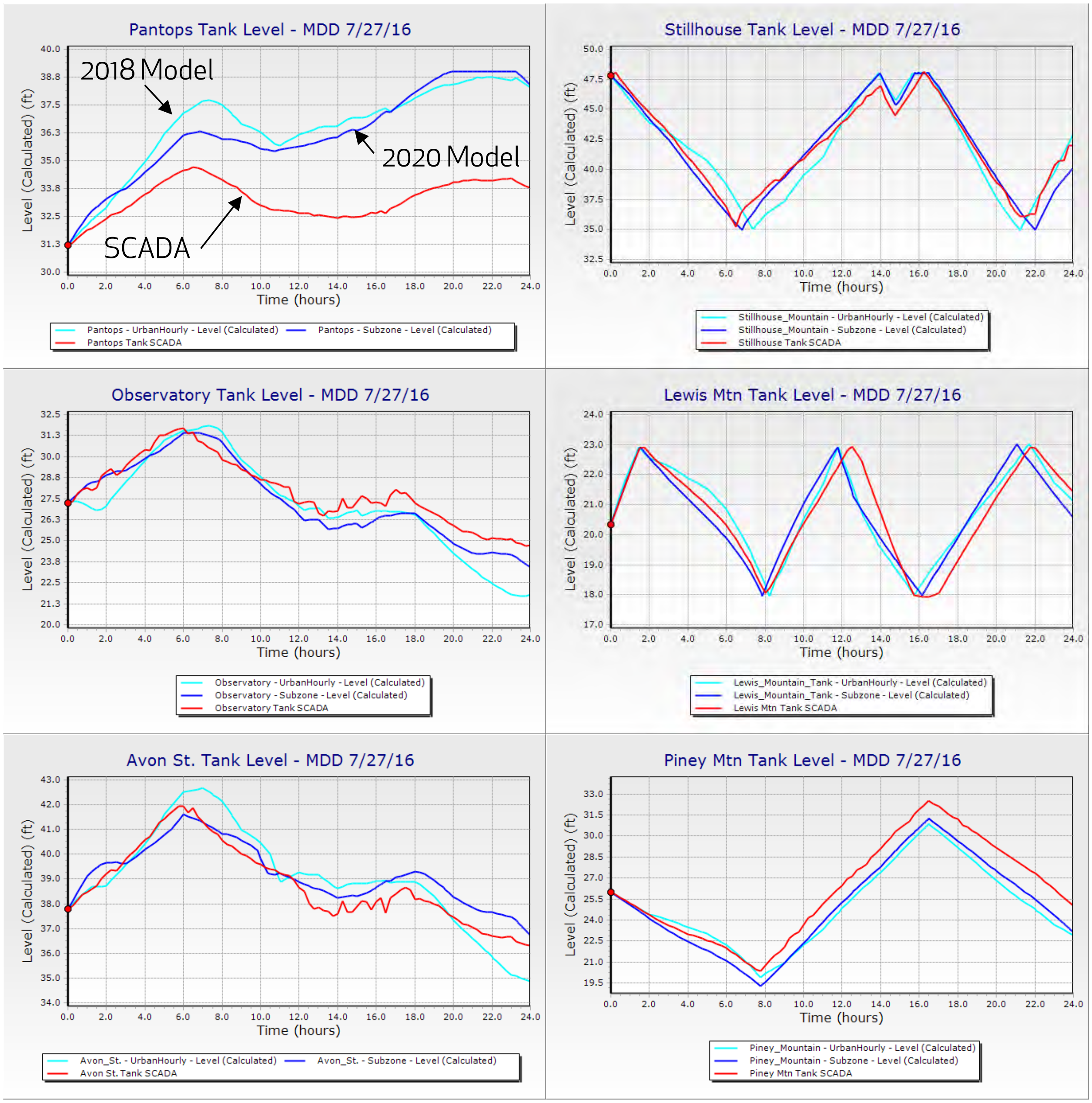

Figure 12. SCADA tank levels and model results for 7/27/16 validation event.
(2018 model UrbanHourly vs. 2020 model Subzone (PZ-specific) MDD diurnal patterns)

For the July 27, 2016 event, compared to the legacy UrbanHourly and NorthRivanna diurnal patterns, the diurnal patterns customized by PZ resulted in the 2020 model performing more closely to the SCADA data observations. Possible reasons for the adjusted model inputs not tracking the SCADA data exactly include the following:

- Single-day variations in customer water use compared to annual average consumption
- Intra-day variations in water use pattern by high-volume users and/or as a climatological or cultural phenomenon (e.g., influence of very hot weather, major entertainment event, or other factor) compared to the PZ average diurnal pattern based on annual water use
- Improved hydraulic connectivity between the OBSWTP and Pantops in the 2020 model vs. the distribution system configuration as it existed for the 2016 validation event
- Manual changes in pump station operations, in particular VFD settings and pump selections, to override default settings and protocols
- Undocumented differences in valve settings

1.6.2. July 2018 Single-Day Event

For the July 2, 2018 event, the updated model did not perform as closely to the SCADA data observations as for the July 27, 2016 event, even with the PZ-specific diurnal patterns and making adjustments to the ACSA's Flordon PRV settings. In particular, the SCADA data showed a steady level at Pantops Tank initially, followed by a decline throughout the day with a period of moderate recovery in the evening, whereas the model showed a recovery in Pantops Tank level throughout the morning, with the tank remaining full for the rest of the day (Figure 13).

Reasons for tank level discrepancies include those presented for the July 17, 2016 event. In addition, a review of chlorine concentration SCADA data revealed that the OBSWTP was online and producing water from 8 a.m. to 6 p.m., whereas the meter data showed no flow. RWSA staff confirmed that the finished water flow meter was offline during that time period and provided the volume of water and hours of operation for the day from alternate records. Results presented in Figure 13 include estimated OBSWTP delivery of finished water. A review of UPZ tank model data for the July 2, 2018 validation event reveals that model demand is approximately 950 gpm (1.4 MGD) short of actual demand.

Michael Baker investigated the apparent demand shortfall by assigning 950 gpm to the RWSA's junction node ID RWS_N_10004-1-36, where the Urban and Pantops Waterlines diverge at the intersection of East Rio Road and Greenbrier Terrace. After developing a unique diurnal pattern such that modeled Pantops Tank level mimicked the SCADA data, modeled level for the Observatory and Avon Street Tanks was slightly below the SCADA data (Figure 14), indicating that the shortfall demand may need to be assigned closer to the SRWTP.

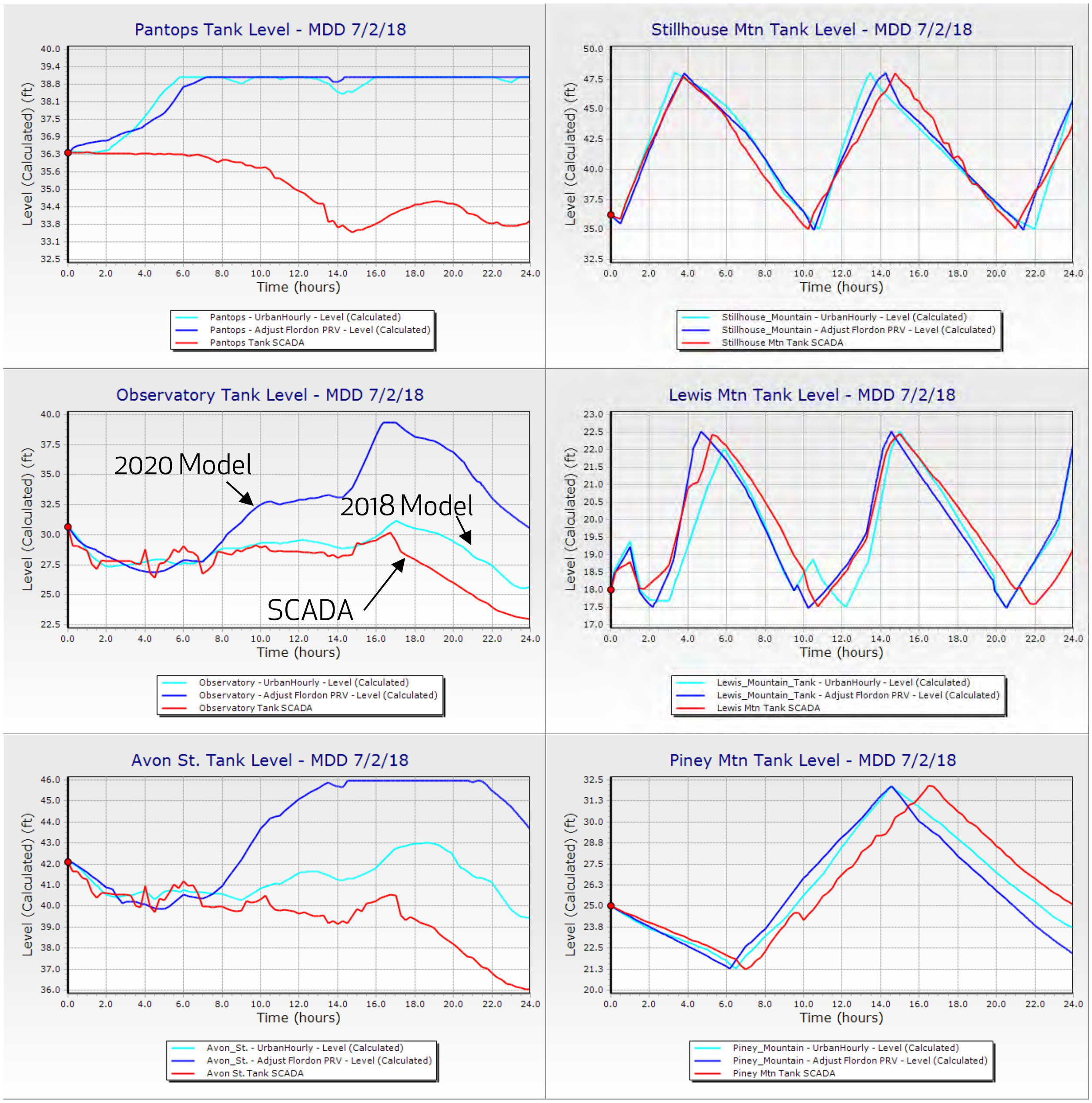

Figure 13. SCADA tank levels vs. model results for 7/2/18 validation event.
(2018 model UrbanHourly vs. 2020 model Subzone (PZ-specific) MDD diurnal patterns)

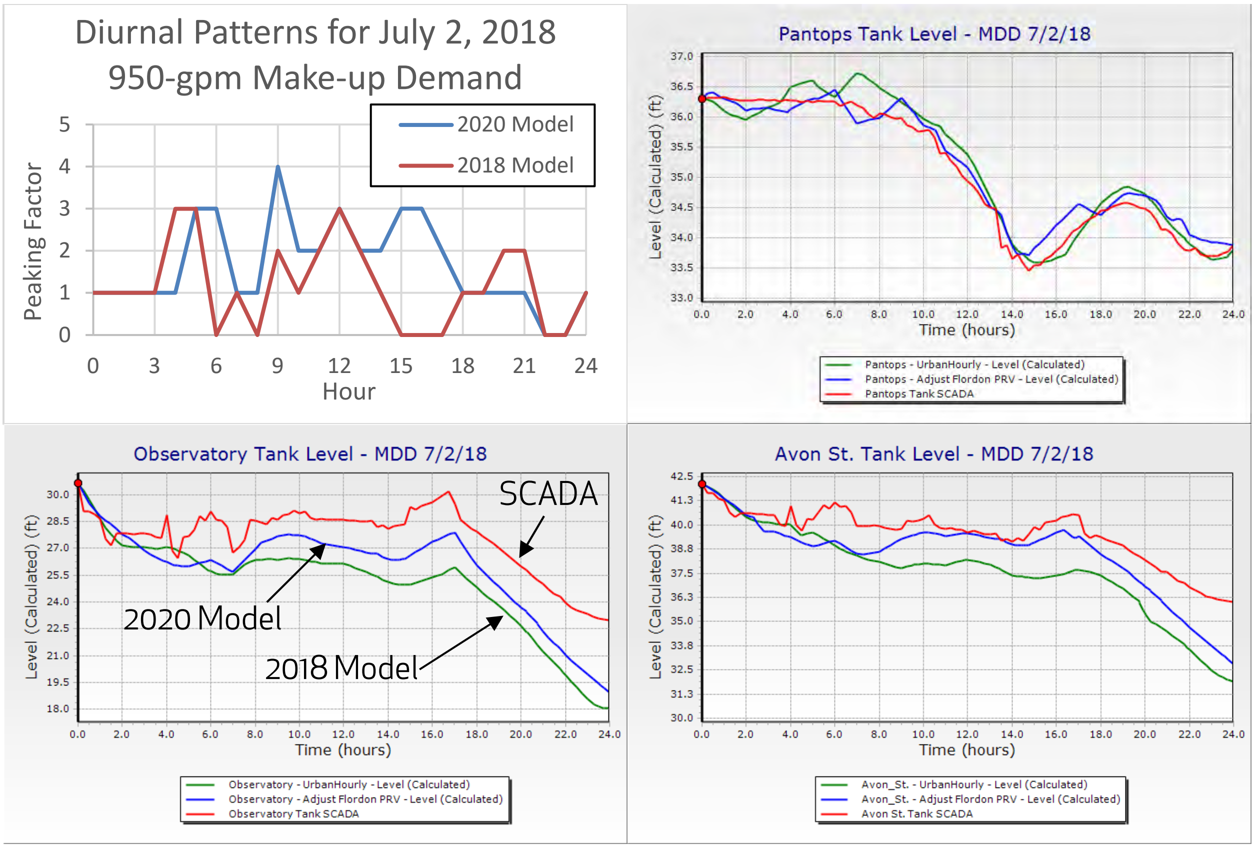

Figure 14. Model results for July 2, 2018 validation event with assumed demand make-up.

1.6.3. Week-Long Simulations

In addition to high-use single-day events, Michael Baker evaluated performance of the 2020 model for two week-long periods in July 2018. In the absence of finished water meter data for the OBSWTP, water production was developed from daily summary records provided by the RWSA (Table 4) and assumed to be constant during the hours of operation. Production volume and hours of operation at the OBSWTP were provided by the RWSA, with the start and end times estimated from a review of chlorine concentration SCADA data.

Model results compare favorably to SCADA data for UPZ tank levels (Figure 15). Systemic variations are due to variations in daily demand vs. the week-long average. For example, a review of Pantops Tank SCADA data July 18 and 19 shows the tank level remaining steady, with level in the Observatory and Avon Street tanks being higher those days compared to the rest of the week. This is due to demand those days being lower than production, with the resulting elevated tank levels (pressure) locking out the Pantops Tank. An altitude fill valve closes to avoid causing an overflow at the tank when the Pantops Water Line HGL exceeds 651 feet. A parallel check valve allows the Pantops Tank to supply water to the UPZ.

Table 4. OBSWTP Daily Production (MG) Summary for July 2018

Date	Hours Operated	Raw Flow	Finished Flow	Date	Hours Operated	Raw Flow	Finished Flow
1	6	1.284	1.474	17	10	1.819	1.575
2	10	1.778	1.606	18	10	1.878	1.418
3	11	2.295	2.067	19	9	1.577	1.576
4	10	1.801	1.602	20	10	1.795	1.601
5	9	1.636	1.721	21	7	1.245	1.023
6	10	1.762	1.595	22	5	0.852	0.667
7	14	2.778	2.951	23	10	1.774	1.434
8	7	1.245	0.979	24	9	1.227	0.962
9	10	1.883	1.616	25	10	1.806	1.427
10	10	1.688	1.529	26	8	1.493	1.246
11	10	1.795	1.600	27	9	2.046	1.826
12	10	1.864	1.961	28	7	1.347	1.057
13	10	1.812	1.362	29	5	1.036	0.765
14	10	1.820	1.409	30	6	1.097	0.903
15	9	1.812	1.598	31	8	1.503	1.264
16	9	2.024	1.866				

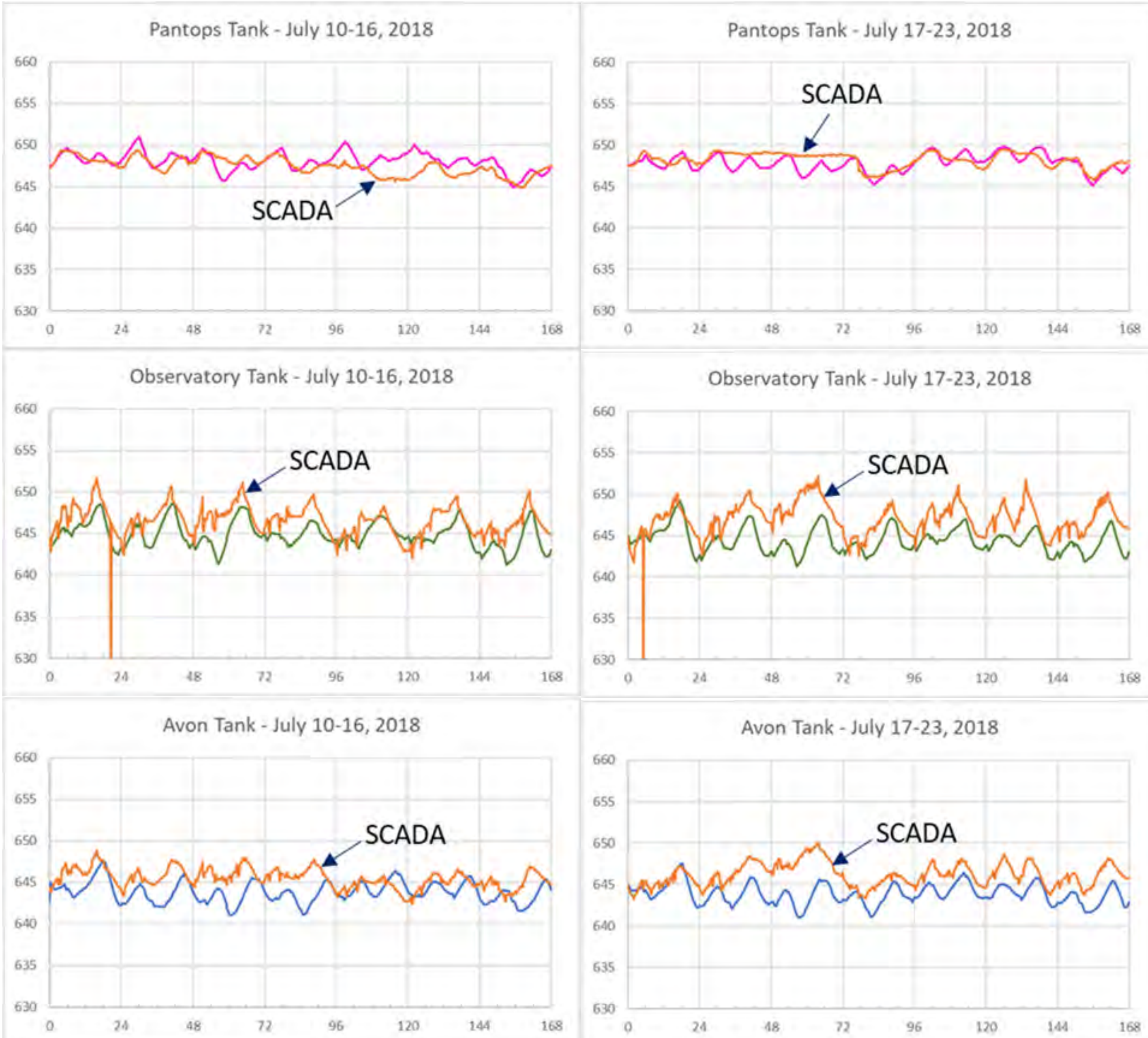

Figure 15. SCADA vs. model results for UPZ tank levels for two weeks in July 2018.

Overall, the model tracks tank level fairly well. The model tends to be slightly below the SCADA data for the Observatory and Avon Street Tanks, which may indicate that C factors are too high or a valve is open in the model but was closed in reality. Based on validation results, PZ-specific diurnal patterns are utilized for UFWMP analyses.

1.7. Model Scenarios

Approximately 180 scenarios representing various combinations of network configurations, water production schedules, pump station operating schedules, water demands, and planning timeframes were developed over the course of the UFWMP. A scenario listing is shown on the following pages, with the parent (first) scenario representing existing conditions at the start of the UFWMP.

- 2019 Network 2017 ADD
  - 2030 ADD OBS 75% Obs RR AZ
    - 2030 MDD OBS 25% Level Obs RR AZ
      - 2030 MDD OBS 25% Level Obs RR No AZ
        - +2030 MDD OBS 25% Level Obs JPA No AZ
          - +2030 Avg MDD 15.7 MGD No OBS Obs JPA No AZ
            - +2030 Avg MDD 15.7 MGD No OBS Obs JPA No A
              - FF - Urban
              - FF- ExUrban
            - +2030 Avg MDD 15.7 MGD No OBS Obs JPA No A
          - ++2030 MDD OBS 25% Level Obs JPA No AZ No ObsT
          - ++2030 MDD OBS 25% Level Obs JPA No AZ Water Ag
          - ++2030 MDD OBS 25% Level Obs JPA No AZ No Avon
        - 2030 MDD OBS 25% Level SLoop RR No AZ
        - 2030 MDD OBS 25% Level Emmet No AZ
    - 2030 ADD OBS 75% Obs RR No AZ
      - 2030 Avg ADD 10.5 MGD OBS-NR 100% Obs JPA No SR
        - 2030 Avg ADD 10.5 MGD OBS-NR 100% Obs JPA No SR W
      - +2030 ADD OBS 75% Obs JPA No AZ
        - ++2030 ADD OBS 75% Obs JPA No AZ No Pantops
          - +2030 ADD OBS 75% Obs JPA No AZ No Pantops FF@
            - FF - Urban
            - FF- ExUrban
        - ++2030 ADD OBS 75% Obs JPA No AZ Water Age
        - +2030 ADD OBS 75% Obs JPA No AZ Spurs Parallel
          - +2030 ADD OBS 75% Spurs Parallel No UPZ Tanks
      - 2030 ADD OBS 75% SLoop RR No AZ
      - 2030 ADD OBS 75% Emmet No AZ
  - 2045 ADD OBS 9 MGD Level Obs RR AZ
    - 2045 MDD OBS 25% Level Obs RR AZ
      - 2045 MDD OBS 25% Level Obs RR No AZ
        - 2045 MDD OBS 25% Level SLoop RR No AZ
    - 2045 ADD OBS 9 MGD Level SLOOP RR
      - 2045 ADD OBS 9 MGD Level SLOOP RR FF
    - 2045 ADD OBS 9 MGD Level SLOOP Lambeth
      - 2045 ADD OBS 9 MGD Level SLOOP Lambeth FF
    - 2045 ADD OBS 9 MGD Level Obs Lambeth
      - 2045 ADD OBS 9 MGD Level Obs Lambeth FF
    - 2045 ADD OBS 9 MGD Level Obs RR FF
    - 2045 ADD OBS 9 MGD Level Obs RR No AZ
      - 2045 ADD OBS 9 MGD Level Obs RR No AZ No Pantops
        - 2045 MDD OBS 9 MGD Level Obs RR No AZ No Pantops
    - +2045 ADD OBS 9 MGD Level Obs JPA No AZ
      - +2045 MDD OBS 25% SR 14.4 MGD Obs JPA No AZ
        - +2045 MDD OBS 25% SR 14.4 MGD Obs JPA No AZ No Pa

- 2070 ADD
  - 2070 MDD
    - 2070 MDD FF - 20 psi
      - 2070 MDD FF - min 1500 gpm
        - 2070 MDD FF - min 1500 gpm Demand Alt
      - 2070 MDD FF - 20 psi Demand Alt
    - 2070 ADD Drought Max OBSWTP MJH BPS
      - 2070 ADD Drought Max OBSWTP FF
      - 2070 ADD Drought Max OBSWTP No MJH BPS
        - 2070 MDD Drought Max OBSWTP No MJH BPS
    - **2070 ADD Drought Max OBSWTP UVA East Loop Obs Ave
      - 2070 ADD Drought Max OBSWTP UVA East Loop SLOOP
      - 2070 ADD Drought Max OBSWTP SLOOP Downtown
  - 2070 ADD OBS 25% Level Obs RR High
    - 2070 ADD OBS 9 MGD Obs RR High
      - 2070 ADD OBS 9 MGD Obs RR High FF
      - 2070 ADD OBS 9 MGD Obs RR High Water Age
    - 2070 ADD OBS 25% Level No Pantops
      - 2070 ADD OBS 25% Level No Pantops FF
      - 2070 ADD OBS 9 MGD No Pantops
    - 2070 MDD OBS 25% Level Obs RR High
      - !!!!2070 MDD OBS 9 MGD Level Obs RR High
        - 2070 MDD OBS 9 MGD Level Obs RR High FF
        - 2070 MDD OBS 9 MGD Level 2 Still Tanks
        - 2070 MDD OBS 9 MGD Level 1 Still 30 ft
      - 2070 MDD OBS 25% Level Obs RR High FF
    - 2070 ADD OBS 25% Level Obs RR High FF
    - 2070 ADD OBS 25% Level Obs RR High Water Age
    - 2070 ADD OBS 9 MGD Obs JPA High
      - 2070 MDD OBS 9 MGD Level Obs JPA High
        - +2070 MDD OBS 9 MGD Level Obs JPA High No AZ
          - +2070 MDD OBS 9 MGD Level Obs JPA High No A
          - +2070 MDD OBS 9 MGD Level Obs JPA High No A
            - +2070 MDD OBS 9 MGD CWLS No AZ Obs Ba
          - +2070 MDD OBS 9 MGD Level Obs JPA High No A
          - +2070 MDD OBS 9 MGD Level Obs JPA High No A
      - +2070 ADD OBS 9 MGD Obs JPA High No AZ
        - +2070 ADD OBS 9 MGD Obs JPA High No AZ No Pant
        - +2070 ADD OBS 9 MGD SLoop RR High No AZ
      - +2070 ADD OBS 9 MGD Cherry No AZ
        - +2070 ADD OBS 9 MGD Cherry No AZ 79ft LMT
    - 2070 ADD OBS 25% Level Obs JPA High
      - 2070 MDD OBS 25% Level Obs JPA High
        - +2070 MDD OBS 25% Level Obs JPA High No AZ
          - +2070 MDD OBS 25% Level SLoop High No AZ
      - 2070 ADD No OBS Obs JPA High
        - +2070 ADD No OBS Obs JPA High No AZ
      - +2070 ADD OBS 25% Level Obs JPA High No AZ

- MDD Sensitivity Analysis
  - 7/27/2016
    - Weekday > 11.5 MGD Average
    - Subzone
      - Subzone C>=100
    - UrbanHourly
  - 7/2/2018
    - Weekday > 9.8 MGD Average
    - Subzone
      - Adjust Flordon PRV
        - Adjust Flordon PRV C>=100
        - 2018 Adj Flordon July 10-16
        - 2018 Adj Flordon July 17-23
      - Subzone C>=100
    - UrbanHourly
- Base ADD Diurnal Analysis
  - Summer ADD
- +2019 ADD RBrown CIP
  - 2019 ADD RBrown CIP Water Age
    - 2019 ADD RBrown CIP Trace
  - 2019 ADD AZ OBS 10 MGD
    - !!!!2030 ADD No AZ OBS 10 MGD
    - 2019 MDD AZ Improved No OBS
      - 2019 MDD AZ Improved2 No OBS
    - 2019 ADD AZ SR 10 MGD
      - !!!!+2019 H/D ADD SR 10 MGD No AZ
      - CWL South Tie 20 2019 H/D ADD ARPS No OBS No CIP
        - CWL South Tie 24 2019 H/D ADD ARPS No OBS No C
    - 2019 MDD AZ SR 100%
    - 2019 MDD AZ OBS 100%
    - !!!!+2019 Typ ADD OBS 10 MGD No AZ
      - +2019 ADD OBS 10 MGD No AZ
        - !!!!+2019 ADD OBS 10 MGD SRX No AZ
          - !!!!+2019 ADD OBS 10 MGD SRX CWL No AZ
            - !!!!+2019 ADD OBS 10 MGD SRX CWL No AZ U
            - !!!!+2019 ADD OBS 10 MGD SRX CWL No AZ N
            - +2019 ADD OBS 10 MGD SRX CWL Kohls PS N
        - !!!!+2019 ADD OBS 10 MGD No AZ UZ EPS FF
          - !!!!+2019 ADD OBS 10 MGD SRX No AZ UZ EPS FI
          - !!!!+2019 ADD OBS 10 MGD SRX No AZ NZ EPS FI
        - !!!!+2019 ADD OBS 10 MGD No AZ NZ EPS FF
        - +2019 ADD OBS 10 MGD Kohls PS No AZ

- *2019 MDD RBrown CIP
  - 2019 MDD RBrown CIP FF
    - 2019 MDD RBrown CIP FF - Stillhouse
    - 2019 MDD RBrown CIP FF - North
    - 2019 MDD RBrown CIP FF - Lewis Mtn
    - 2019 MDD RBrown CIP FF - ACSA Urban South
    - 2019 MDD RBrown CIP FF - ACSA Forest Lakes
    - 2019 MDD RBrown CIP FF - ACSA Pantops NE
    - 2019 MDD RBrown CIP FF - Rte 29
    - 2019 MDD RBrown CIP FF - City SW
    - 2019 MDD RBrown CIP FF - City EAST
    - 2019 MDD RBrown CIP FF - City NORTH
  - +2070 MDD on 2019 Network 43-57 NRWTP
    - +2070 MDD on 2019 Network 43-57 NRWTP FF
    - +2070 MDD on 2019 Network 43-57 R29PS
      - +2070 MDD on 2019 Network 43-57 R29PS FF
      - +2070 MDD on 2019 Network 43-57 R29PS WaterAge
      - +2070 MDD on 2019 Network 43-57 R29PS Trace
      - +2070 MDD on 2019 Network OBS 25% R29PS
      - +2070 ADD on 2019 Network OBS 25% R29PS
      - +2070 ADD on 2019 Network OBS 9 MGD R29PS
    - +2070 MDD on 2019 Network 43-57 NRWTP WaterAge
    - +2070 MDD on 2019 Network 43-57 NRWTP SLOOP Cxns
- 2019 ADD AZ OBS Only No Improv
  - !!!!+2019 ADD No AZ No Improv
- +2019 ADD RBrown CIP FF
- +2030 ADD OBS 75% RBrown CIP
  - +2030 MDD OBS 2 MGD RBrown CIP
  - +2030 ADD OBS 50% RBrown CIP
  - +2030 Typ MDD OBS 50% RBrown CIP SRX
    - +2030 Typ MDD OBS 50% RBrown CIP NZ EPS FF
    - +2030 Typ MDD OBS 50% RBrown CIP UZ EPS FF
      - +2030 Typ MDD OBS 50% Obs JPA UZ EPS FF
  - +2030 Typ MDD OBS 50% RBrown CIP
  - +2030 ADD OBS 25% RBrown CIP
  - +2030 ADD OBS 75% RBrown CIP ARPS Tank
    - +2030 ADD OBS 75% RBrown CIP ARPS Tank NZ EPS FF
  - +2030 ADD OBS 75% RBrown CIP SRWTP Supports ARPS
- CWL South Tie 20 2019 H/D ADD ARPS No SR No CIP
  - CWL South Tie 24 2019 H/D ADD ARPS No SR No CIP
    - CWL South Tie 24 2019 H/D MDD ARPS No CIP FF
  - CWL South Tie 20 WWM32 2019 H/D ADD ARPS No SR No C
- CWL250 2019 H/D ADD ARPS No SR No CIP
  - CWL250 2019 H/D MDD ARPS No OBS No CIP

- UVA CC Outage
  - Max Demand Supported

Appendix C

Hydrant Test Data

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Date	time of day	Observation hydrant	Flow hydrant	Static psi	Residual psi	Caveats	flow GPM (unrounded)	closed Valve
7/3/2019	10:03 AM	11478	11480	109	58	*****	1222.987	
7/17/2019	9:25 AM	12751	12766	92.2	87.17		947.6249	
7/17/2019	10:40 AM	10365	10367	59	29.3		530.2	
7/17/2019	11:44 AM	11386	11389	76	55		1132.532	101-1-20c
7/17/2019	12:46 PM	10332	10637	104	93	*	527.841	217-1-9a
7/18/2019	9:04 AM	11040	11045	64.5	61.2		1161.332	SLW-017
7/18/2019	10:27 AM	12228	12229	81	55.1		904.0566	
7/18/2019	11:26 AM	10564	10565	47.6	40.9		912.2954	104-1-4b
7/18/2019	12:26 PM	10618	10752	107.3	82.5		629.8318	
		10723	10722			**	N/A	
12/9/2009	10:39 AM	10722	10928	104	80	***	1340.685	
		10414	10416			****	N/A	

* The map showing which hydrant to flow was incorrect. This data is for the hydrants listed, meaning the wrong one.
I can repeat with the right on next Wedneday if you want it. 10332 was incorrect.

** Can't flow test in the Piney Mountain Pressure band until early August

*** Note: older test - A series of hydrants were gauged and one flown per Walter Grayman's Opflow article (ref?) on getting a bunch done at once.
If you want the rest (5 total) from up there in North Pines let me know. Usage was less back then in 2009.

**** Key West System Upgrade, these hydrant no longer exist

***** Pre-pump station and tank. Jeremy has requested a repeat flow test post tank project compettion. Let me know if you want it.

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Residural Hydrant	Flow Hydrant ID	Pressure Zone	Pipe Size (in)	Time Stamp	Field Static P (psi)	Field Residual P (psi)	Field Test delta P (psi)	Model Static P (psi)	Model Residual P (psi)	Model Test delta P (psi)	Field ΔP - Model ΔP (psi)	Originial C Factor	Adjusted C Factor	Elevation Check
08172		Urban	8	5/10/2018 8:00	81	64	17	81.78	45.66	36.12	-19.12	120	N/A	Elev. same as GIS data
	08175	Urban	6									130	N/A	Elev. same as GIS data
	08169	Urban	8									120	N/A	Elev. same as GIS data
	08170	Urban	8									120	N/A	Elev. same as GIS data
07367		Urban	6	5/30/2018 5:30	82	72	10	85.41	63.53	21.88	-11.88	120	N/A	Elev. same as GIS data
	07370	Urban	8									120	N/A	Elev. same as GIS data
	07425	Urban	12									120	N/A	Elev. same as GIS data
06530		Urban	8	8/31/2018 13:00	54	42	12	53.09	-26	79.09	-67.09	120	N/A	Elev. same as GIS data
	06533	Urban	8									36	120	Elev. same as GIS data
	06095	Urban	12									120	N/A	Elev. same as GIS data
06514		Urban	12	10/9/2018 5:30	60	47	13	57.74	21.38	36.36	-23.36	120	N/A	Elev. same as GIS data
	06525	Urban	12									120	N/A	Elev. same as GIS data
	06510	Urban	12									120	N/A	Elev. same as GIS data
	06527	Urban	12									130	N/A	Elev. same as GIS data
04655		Urban	6	3/30/2018 8:00	114	62	52	116.46	65.25	51.21	0.79	120	N/A	Elev. same as GIS data
	04653	Urban	8									120	N/A	Elev. same as GIS data
	04654	Urban	6									130	N/A	Elev. same as GIS data
	04657	Urban	6									130	N/A	Elev. same as GIS data
04450		Urban	6	3/7/2018 8:00	74	66	8	74.87	25.8	49.07	-41.07	36	120	Elev. same as GIS data
	04445	Urban	4									120	N/A	Elev. same as GIS data
	04455	Urban	4									36	120	Elev. same as GIS data
04210		Urban	12	10/31/2018 6:00	90	78	12	92.62	83.84	8.78	3.22	120	N/A	Elev. same as GIS data
	04215	Urban	12									120	N/A	Elev. same as GIS data
	04230	Urban	12									120	N/A	Elev. same as GIS data
	04195	Urban	12									36	120	Elev. same as GIS data
04190		Urban	8	3/23/2018 9:15	79	68	11	81.82	66.43	15.39	-4.39	36	120	Elev. same as GIS data
	01110	Urban	8									50	120	Elev. same as GIS data
	04195	Urban	8									36	120	Elev. same as GIS data
03325		Urban	12	9/26/2018 5:00	82	68	14	81.15	71.73	9.42	4.58	120	N/A	Elev. same as GIS data
	03330	Urban	8									120	N/A	Elev. same as GIS data
	03320	Urban	12									36	120	Elev. same as GIS data
	01232	Urban	10									36	120	Elev. same as GIS data
03280		Urban	6	8/1/2018 5:30	86	40	46	83.3	68.57	14.73	31.27	120	N/A	Elev. same as GIS data
	03281	Urban	6									120	N/A	Elev. same as GIS data
	03192	Urban	6									120	N/A	Elev. same as GIS data
	03275	Urban	6									120	N/A	Elev. same as GIS data

Residual Hydrant	Flow Hydrant ID	Pressure Zone	Pipe Size (in)	Other adjustment	Adjusted Model Static P (psi)	Adjusted Model Residual P (psi)	Adjusted Model Test delta P (psi)	Field ΔP - Adjusted Model ΔP (psi)	C=120 Adjusted Model Static P (psi)	C=120 Adjusted Model Residual P (psi)	C=120 Adjusted Model Test delta P (psi)	C=120 Field ΔP - Adjusted Model ΔP (psi)	C=120 Pipe ID 35864 & ID 42687 Status	Field Pitot Pressure (psi)	Adjusted Flow (gpm)	Flow (gpd)	Model Demand Input (gpd)	Duration (min)
08172		Urban	8	Change Pipe CVL_P_07883 (ID 42687) status from "Closed" to "Open"	81.83	60.53	21.3	-4.3	79.33	62.29	17.04	-0.04	Open					
	08175	Urban	6											45.40	1004.40	1446336	1159795	10
	08169	Urban	8											60.00	1155.60	1664064	1334388	10
	08170	Urban	8											60.00	1155.60	1664064	1334388	10
07367		Urban	6	Change Pipe CVL_N_04252.UVA_N_02019.1 (ID 35864) status from "Closed" to "Open"	79.28	71.63	7.65	2.35	79.17	72.45	6.72	3.28	Open					
	07370	Urban	8											63.80	1191.11	1715200	1665914	5
	07425	Urban	12											60.00	1155.56	1664000	1616185	5
06530		Urban	8	Fixed pipe connection on Jefferson Park Ave Adjust pipe C factor to 120 on Oakhurst Cir, Gildersleeve Wood, and Valley Rd	53.8	41.88	11.92	0.08	53.96	44.73	9.23	2.77	Open					
									53.91	44.62	9.29	2.71	Close					
	06533	Urban	8									0.06		39.90	942.22	1356800	1073250	5
	06095	Urban	12											39.90	942.22	1356800	1073250	5
06514		Urban	12	Adjust pipe C factor to 120 along Jefferson Park Ave from Observatory Ave to Maywood Ln	57.74	43.74	14	-1	57.76	46.60	11.16	1.84	Open					
									57.72	46.46	11.26	1.74	Close					
	06525	Urban	12									0.10		50.30	1057.78	1523200	1787146	10
	06510	Urban	12											39.90	942.22	1356800	1591911	10
	06527	Urban	12											39.90	942.22	1356800	1591911	10
04655		Urban	6	None					116.38	72.92	43.46	8.54	Open					
									116.13	72.82	43.31	8.69	Close					
	04653	Urban	8									-0.15		70.10	1248.89	1798400	1575090	3
	04654	Urban	6											60.00	1155.56	1664000	1457379	3
	04657	Urban	6											70.10	1248.89	1798400	1575090	3
04450		Urban	6	Adjust pipe C factor to 120 for the pipes south of E Water St, east of 1st Street, north of I-64, and west of Nassau St	75.46	65.33	10.13	-2.13	75.31	66.02	9.29	-1.29	Open					
									75.30	65.96	9.34	-1.34	Close					
	04445	Urban	4									0.05		10.00	471.11	678400	667800	2
	04455	Urban	4											45.40	1004.44	1446400	1423799	2
04210		Urban	12	None					92.62	86.47	6.15	5.85	Open					
									92.63	86.40	6.23	5.77	Close					
	04215	Urban	12									0.08		55.50	1111.11	1600000	2451786	5
	04230	Urban	12											43.00	977.78	1408000	2157572	5
	04195	Urban	12											64.70	1200.00	1728000	2647929	5
04190		Urban	8	Adjust pipe C factor to 120 along Garrett St from Gleason St to 4th St SE	81.81	67.28	14.53	-3.53	81.64	75.95	5.69	5.31	Open					
									81.34	75.57	5.77	5.23	Close					
	01110	Urban	8									0.08		69.60	1244.44	1792000	1877923	5
	04195	Urban	8											75.20	1293.33	1862400	1951699	5
03325		Urban	12	None					80.22	75.44	4.78	9.22	Open					
									80.56	75.33	5.23	8.77	Close					
	03330	Urban	8									0.45		64.70	1200.00	1728000	2181594	5
	03320	Urban	12											50.30	1057.78	1523200	1923035	5
	01232	Urban	10											60.00	1155.56	1664000	2100794	5
03280		Urban	6	None					82.29	73.93	8.36	37.64	Open					
									82.63	73.88	8.75	37.25	Close					
	03281	Urban	6									0.39		25.10	746.67	1075200	1387346	5
	03192	Urban	6											25.10	746.67	1075200	1387346	5
	03275	Urban	6											35.50	888.89	1280000	1651603	5

Residual Hydrant	Flow Hydrant ID	Pressure Zone	Pipe Size (in)	Time Stamp	Field Static P (psi)	Field Residual P (psi)	Field Test delta P (psi)	Model Static P (psi)	Model Residual P (psi)	Model Test delta P (psi)	Field ΔP - Model ΔP (psi)	Originial C Factor	Adjusted C Factor	Elevation Check
03190		Urban	6	5/30/2018 6:00	70	56	14	71.99	58.6	13.39	0.61	120	N/A	Elev. same as GIS data
	01170	Urban	6									36	N/A	Elev. same as GIS data
	03281	Urban	6									120	N/A	Elev. same as GIS data
	03135	Urban	6									120	N/A	Elev. same as GIS data
03125		Urban	6	2/15/2018 8:45	64	50	14	66.14	55.76	10.38	3.62	120	N/A	Elev. same as GIS data
	03130	Urban	6									120	N/A	Elev. same as GIS data
	01170	Urban	6									36	N/A	Elev. same as GIS data
	03190	Urban	6									120	N/A	Elev. same as GIS data
02460		Urban	8	3/28/2018 8:45	72	66	6	74.78	65.65	9.13	-3.13	120	N/A	Elev. same as GIS data
	02005	Urban	10									120	N/A	Elev. same as GIS data
	02455	Urban	6									120	N/A	Elev. same as GIS data
	02035	Urban	8									36	N/A	Elev. same as GIS data
02280		Urban	6	2/15/2018 8:00	60	51	9	65.15	54.87	10.28	-1.28	120	N/A	Elev. same as GIS data
	02085	Urban	6									36	N/A	Elev. same as GIS data
	02285	Urban	10									36	N/A	Elev. same as GIS data
	02270	Urban	6									120	N/A	Elev. same as GIS data
02270		Urban	6	6/7/2018 6:30	62	52	10	62.42	43.65	18.77	-8.77	120	N/A	Elev. same as GIS data
	02280	Urban	6									120	N/A	Elev. same as GIS data
	02080	Urban	8									36	120	Elev. same as GIS data
	02040	Urban	6									120	N/A	Elev. same as GIS data
	02285	Urban	10									36	120	Elev. same as GIS data
02205		Urban	8	3/28/2018 8:15	78	56	22	81.46	17.95	63.51	-41.51	120	N/A	Elev. same as GIS data
	02145	Urban	12									120	N/A	Elev. same as GIS data
	02227	Urban	8									120	N/A	Elev. same as GIS data
	02210	Urban	6									120	N/A	Elev. same as GIS data
	02150	Urban	6									120	N/A	Elev. same as GIS data
02110		Urban	6	5/30/2018 5:45	80	62	18	82.15	72.33	9.82	8.18	36	N/A	Elev. same as GIS data
	02105	Urban	6									36	N/A	Elev. same as GIS data
	02115	Urban	6									36	N/A	Elev. same as GIS data
01285		Urban	10	10/31/2018 5:30	86	74	12	85.3	70.03	15.27	-3.27	36	N/A	Elev. same as GIS data
	01270	Urban	10									36	N/A	Elev. same as GIS data
	01105	Urban	6									120	N/A	Elev. same as GIS data
	01305	Urban	10									36	N/A	Elev. same as GIS data

Residual Hydrant	Flow Hydrant ID	Pressure Zone	Pipe Size (in)	Other adjustment	Adjusted Model Static P (psi)	Adjusted Model Residual P (psi)	Adjusted Model Test delta P (psi)	Field ΔP - Adjusted Model ΔP (psi)	C=120 Adjusted Model Static P (psi)	C=120 Adjusted Model Residual P (psi)	C=120 Adjusted Model Test delta P (psi)	C=120 Field ΔP - Adjusted Model ΔP (psi)	C=120 Pipe ID 35864 & ID 42687 Status	Field Pitot Pressure (psi)	Adjusted Flow (gpm)	Flow (gpd)	Model Demand Input (gpd)	Duration (min)
03190		Urban	6						71.86	66.86	5.00	9.00	Open					
									71.61	66.50	5.11	8.89	Close					
	01170	Urban	6	None								0.11		25.10	746.67	1075200	1047854	5
	03281	Urban	6											50.30	1057.78	1523200	1484459	5
	03135	Urban	6											39.90	942.22	1356800	1322291	5
03125		Urban	6						65.68	62.23	3.45	10.55	Open					
									65.70	62.20	3.50	10.50	Close					
	03130	Urban	6	None								0.05		45.40	1004.44	1446400	1688975	10
	01170	Urban	6											20.00	666.67	960000	1121001	10
	03190	Urban	6											12.40	524.44	755200	881854	10
02460		Urban	8						75.16	71.44	3.72	2.28	Open					
									74.70	70.89	3.81	2.19	Close					
	02005	Urban	10	None								0.09		50.30	1057.78	1523200	1424000	5
	02455	Urban	6											25.10	746.67	1075200	1005177	5
	02035	Urban	8											55.50	1111.11	1600000	1495798	5
02280		Urban	6						64.98	61.29	3.69	5.31	Open					
									64.81	60.60	4.21	4.79	Close					
	02085	Urban	6	None								0.52		39.90	942.22	1356800	1624730	10
	02285	Urban	10											32.70	853.33	1228800	1471453	10
	02270	Urban	6											39.90	942.22	1356800	1624730	10
02270		Urban	6		62.71	48.28	14.43	-4.43	62.55	54.79	7.76	2.24	Open					
									62.11	54.04	8.07	1.93	Close					
	02280	Urban	6	Adjust pipe C factor to 120 along 10th St NW from W Main St to Page St								0.31		39.90	942.22	1356800	1198712	5
	02080	Urban	8											45.40	1004.44	1446400	1277872	5
	02040	Urban	6											62.40	1177.78	1696000	1498389	5
	02285	Urban	10											35.50	888.89	1280000	1130860	5
02205		Urban	8		81.21	53.55	27.66	-5.66	80.03	62.63	17.40	4.60	Open					
									79.78	62.45	17.33	4.67	Close					
	02145	Urban	12	Adjust pipe C factor to 120 along Rose Hill Dr from Amherst St to Preston Ave							delta	-0.07		60.00	1155.56	1664000	1574498	5
	02227	Urban	8											64.70	1200.00	1728000	1635056	5
	02210	Urban	6											49.50	1048.89	1510400	1429160	5
	02150	Urban	6											55.50	1111.11	1600000	1513940	5
02110		Urban	6						80.88	75.62	5.26	12.74	Open					
				None					80.87	75.12	5.75	12.25	Close					
	02105	Urban	6									0.49		50.30	1057.78	1523200	1518539	5
	02115	Urban	6											48.60	1040.00	1497600	1493018	5
01285		Urban	10						85.44	80.87	4.57	7.43	Open					
									85.45	80.79	4.66	7.34	Close					
	01270	Urban	10	None								0.09		50.30	1057.78	1523200	2326599	5
	01105	Urban	6											30.10	817.78	1177600	1798715	5
	01305	Urban	10											60.00	1155.56	1664000	2541663	5

Appendix D

Facility Summary Information

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Facility Summary Information

Pump Controls

Controls are listed in priority order of execution. If not specifically identified otherwise, controls were utilized for all scenarios evaluated.

RWSA Alderman Booster Station Controls Given Lewis Mountain Tank Level	
Base	726
Pump 1 Alt. On	<741
Pump 1 Alt. Off	>747
Pump 2 On	<742
Pump 2 Off	>748
Pump 3 On	<741
Pump 3 Off	>747

RWSA North Rivanna Booster Station Controls Given Time of Day or Piney Mtn. Tank Level	
Base	767
Pump 1 Off+	>797
Pump 1 Off+	12:00 a.m.
Pump 1 On+	8:00 a.m.
Pump 2 Off	12:00 a.m.
Pump 2 On	4:00 a.m.
Pump 2 Off	>804

+Inactive for existing ADD

RWSA Observatory Booster Station Controls Given Time of Day#	
Base	620
Pump Off	12:00 a.m.
Pump On	3:00 a.m.

#Active only for Build-out MDD and Build-out ADD AZ

RWSA Airport Road Booster Station Controls Given Piney Mtn. Tank Level^	
Base	767
Pump On^^	<795
Pump Off	>803

^Intermediate MDD SL AZ, Build-out MDD
^^88% Flow for Build-out MDD

RWSA Piney Mtn. Booster Station Controls Given Piney Mtn. Tank Level##	
Base	767
Pump On	>790
Pump Off	>805

##Active only for Intermediate MDD AZ w/ and w/o SL, Build-out MDD, and Build-out ADD AZ

RWSA South Rivanna Booster Station Controls Given Pantops Tank Level	
Base	612
Pump 1 On	<645
Pump 1 Off*	>646
Pump 1 Off	>647
Pump 2 On+	<646
Pump 2 Off+	>650
Pump 3 On**	<648
Pump 3 Off**	>650

*Active only for Existing ADD
+Inactive for existing ADD
**Active only for Build-out MDD

RWSA Stillhouse Booster Station Controls Given Stillhouse Mountain Tank Level	
Base	746
Pump 1 On	< 786
Pump 1 Off	> 793
Pump 2 On	< 785
Pump 2 Off	> 791

ACSA Ednam Forest Booster Station Controls Given Ednam Tank Level		
	Elevation	Depth
Base	810	
Pump 1 On	< 859	< 49
Pump 2 On	< 858	< 48
All Pumps Off	> 878	> 68

ACSA Mosby Mtn. Booster Station Controls Given Mosby Mtn. Tank Level		
	Elevation	Depth
Base	720	
Pump 1 On	< 737	< 17
Pump 2 On	< 736	< 16
All Pumps Off	> 751	> 31

ACSA Mill Creek Booster Station Controls Given Avon Park Tank Level		
	Elevation	Depth
Base	696.1	
Pump 1 On	< 742.1	46
Pump 2 On	< 741.6	45.5
All Pumps Off	> 750.1	54

ACSA Glenmore Booster Station Controls Given Glenmore Tank Level		
	Elevation	Depth
Base	720	
Pump 1 On	< 737	< 17
Pump 2 On	< 736	< 16
All Pumps Off	> 751	> 31

Booster Stations

Booster stations are listed in three groups: those active for the 2017 timeframe, those active for later timeframes / alternatives, and those in inactive portions of the network. The Balz and Massie booster stations have been retired: the buildings still exist, but the pump equipment has been removed. Most VFDs in the model were set up with pattern-based operation, whereby a diurnal pattern developed from review of months of operating data is applied to control pump speed when pump controls (typically based on tank level, see preceding section) indicate the pump should be on. For the RWSA model, pattern-based pump controls should be replaced with the actual operational setting, typically pressure or HGL at a monitoring point in the system downstream of the pump (see e.g. Glenmore pump station).

Booster Station	Owner	Type in Model	Pump Number	Elev. (ft)	Flow (gpm)	TDH (ft)
Alderman	RWSA	VFD (Pattern-Based)	1	552.9	1,000	118
		VFD (Pattern-Based)	2	556.6	600	105
		VFD (Pattern-Based)	3	555.9	600	105
Ednam Forest	ACSA	Constant Speed	1	631.8	600	190
		Constant Speed	2	630.9	600	190
Glenmore	ACSA	VFD (Target Head)	1	375.0	188	169
		VFD (Target Head)	2	375.0	188	169
Mill Creek	ACSA	Constant Speed	1	559.2		
		Constant Speed	2	558.6		
Mosby Mountain	ACSA	Constant Speed	1	471.0	500	111
		Constant Speed	2	471.0	500	111
North Rivanna WTP	RWSA	Constant Speed	1	404.8	890	412
		VFD (Pattern-Based)	2	404.8	890	412
South Rivanna WTP	RWSA	Constant Speed	1	471.8		
		VFD (Pattern-Based)	2	471.3		
		VFD (Pattern-Based)	3	470.9		
		VFD (Pattern-Based)	4	470.9		
Stillhouse	RWSA	Constant Speed	1	539.9	884	240
		Constant Speed	2	539.6	884	240

Glenmore target HGL = 550.5 feet

Conceptual/ Future Booster Station	Owner	Type in Model	Pump Number	Elev. (ft)	Flow (gpm)	TDH (ft)
Airport Road	RWSA	Constant Speed	1	654.0	1,055	157
		Constant Speed	2	654.0	1,055	157
Avon Street Tank	RWSA	Constant Speed	1	653.0		
OBSWTP	RWSA	Constant Speed	1	642.1		
Piney Mountain Tank	RWSA	Constant Speed	1	471.9		

Booster Stations Inactive in RWSA Model	Owner	Type in Model	Pump Number	Elev. (ft)	Flow (gpm)	TDH (ft)
Alderman UVA	UVA	Not Modeled	1	714.2		
		Not Modeled	2	714.5		
Ashcroft (Lower)	ACSA	Constant Speed	1	598.9	350	265
		Constant Speed	2	598.2	350	265
Ashcroft (Middle)	ACSA	Constant Speed	1	898.6	265	250
		Constant Speed	2	898.6	265	250
Ashcroft (Upper)	ACSA	Constant Speed	1	1,028.2	289	204
		Constant Speed	2	1,027.8	289	204
Lambeth	City	Constant Speed	1	522.2	450	95
		Constant Speed	2	522.2	450	95
		Constant Speed	3	522.2	1,530	95
		VFD (Pattern-Based)	4	519.6	1,530	95
Northfields (Closed System)	ACSA	VFD (Pattern-Based)	1	473.8		
		Constant Speed				
Observatory Tank	UVA	Constant Speed	1	652		

Storage Tanks

Storage tanks are represented as an equivalent diameter for non-circular structures. Plans are requested by Michael Baker to confirm model setup. Minimum effective tank depth was requested to be added; provided information is shown below.

Modeled Water Storage Tanks	Owner	Type	Elev. (ft)		Depth (ft)			(Equiv.) Dia. (ft)
			Base	High Svc.	Min.	†Min. Effective	Max.	
*Airport Tank T-1	RWSA	GST	610	-	5	-	45	65
^Ashcroft (Lower)	ACSA	GST	901	-	1.5	-	7	10
^Ashcroft (Upper)	ACSA	GST	1,313	-	1	-	28	31
Avon Park	ACSA	GST	696	690	0	40	54	28
Avon Street	RWSA	GST	607	596	1	35	46	86
^East Water Tank	UVA	GST	719	-	2	-	30	92
Ednam	ACSA	GST	810	792	2	28	70	24.5
Glenmore	ACSA	GST	376	423	0	5[1]	26	61.5
Lewis Mountain	RWSA	GST	726	705	2	25[2]	24.5	59
Mosby Mountain	ACSA	GST	720	652	4	4	35	29
^Northfields	ACSA	HPT	473	-	180	-	231	2.1
Observatory	RWSA	GST	620	596	2	22	39	114
^Observatory Hill	UVA	EST	873	-	4.8	-	10	9.5
Pantops	RWSA	GST	612	596	2	30	40	145.5
Piney Mountain	RWSA	GST	767	697	3.77	3.77[3]	38	58
^South Rivanna	RWSA	EST	627	-	0	-	25	82
Stillhouse Mountain	RWSA	GST	746	703	2	3	50	49
^West Water Tank	UVA	GST	719	-	2	-	30	92

*conceptual/future
^inactive section of model network
†assumes 20 psi at service (model node) with highest elevation unless indicated otherwise
[1]Glenmore tank is pumped into service area
[2]Tank height insufficient to provide minimum pressure of 20 psi when full
[3]Depth obtained from RWSA model, base is high enough to provide 20 psi when tank is empty

Flow Control Valves

FCVs limit the maximum downstream flow rate. The WTP FCVs are used to limit the maximum flow into the system from the hypothetical reservoir representing the WTP. After the April 2019 workshop, the Ashcroft Lower FCV was moved to the PRV table.

Modeled Flow Control Valves	Owner	Elevation, ft	Valve Diameter, in	Flow Setting (MGD)
NRWTP	RWSA	405.5	14	2.33
SRWTP	RWSA	473.0	24	11.33
OBSWTP	RWSA	651.0	24	5.5

General Purpose Valves

GPVs currently have no control settings in the model and are assumed to retain their initial status. The RWSA GPV just north of Rio Road at Seminole Trail (U.S. Route 29) is assumed to be open.

Modeled General Purpose Valves	Owner	Elevation, ft	Valve Diameter, in	Initial Setting
Pantops	RWSA	610.5	20	Closed
Seminole Trail near Rio Road	RWSA	475.2	30	Active
^Ashcroft (Upper)	ACSA	1,030.0	6	
*South Rivanna WTP	RWSA	473.1	24	Closed

*active for 2017 existing conditions scenario
^inactive section of model network

Pressure Reducing Valves

Pressure reducing valves limit the downstream flow rate based on maintaining a maximum downstream pressure. The PRV tables are organized based on existing operations: active, bypassed, and closed. Bypassed PRVs are in service, but the valve on the main is open. Closed PRVs are flow boundaries: both the PRV and the valve on the main are closed.

Active ACSA Pressure Reducing Valves	Elev. (ft)	Pressure Setting (psi)	Size (in)
^ACSA_N_413-2-7.Ashcroft(Up)_PRV3.1	1,028.0	37	6
^ACSA_N_413-2-4.Ashcroft(Up)_PRV2.1	1,029.0	35	2
^ACSA_N_413-2-3.Ashcroft(Up)_PRV1.1	1,028.6	28	2
^ACSA_N_413-14-4.Ashcroft(Lower)_PRV3.1	829.0	38	2
^ACSA_N_413-14-3.Ashcroft(Lower)_PRV2.1	829.0	35	2
^ACSA_N_413-14-1.Ashcroft(Lower)_PRV1.1	829.0	24	6
^ACSA_N_413-13-3.Fontana_PRV3.1	572.3	57	2
^ACSA_N_413-13-2.Fontana_PRV2.1	572.6	52	2
^ACSA_N_413-13-1.Fontana_PRV1.1	573.0	47	8
Camelot_PRV3.ACSA_N_413-3-6.1	404.4	80	2
Camelot_PRV2.ACSA_N_413-3-5.1	404.4	72	2
Camelot_PRV1.ACSA_N_413-3-1.1	404.3	67	8
Ednam_PRV3.ACSA_N_145-16-6.1	627.0	50	2
Ednam_PRV2.ACSA_N_145-16-5.1	627.0	47	2
Ednam_PRV1.ACSA_N_145-16-4.1	630.2	44	6
Farmington_PRV3.ACSA_N_413-4-6.1	601.5	78	2
Farmington_PRV2.ACSA_N_413-4-3.1	601.9	72	2
Farmington_PRV1.ACSA_N_413-4-2.1	602.4	68	8
FL_North_PRV3.ACSA_N_413-5-5.1	501.8	60	2
FL_North_PRV2.ACSA_N_413-5-4.1	501.9	55	2
FL_North_PRV1.ACSA_N_413-5-1.1	502.0	50	8
Glenmore 1	422.0	40.5	8
Glenmore 2	422.0	45.5	2
Glenmore 3	422.0	45.5	2

^inactive section of model network

Bypassed ACSA Pressure Reducing Valves	Elev. (ft)	Pressure Setting (psi)	Size (in)
ACSA_N_413-7-6.Hollymead_PRV3.1	503.1	62	2
ACSA_N_413-7-3.Hollymead_PRV2.1	503.2	62	2
ACSA_N_413-7-2.Hollymead_PRV1.1	503.0	62	6
FL_South_PRV3.ACSA_N_413-6-5.1	462.3	80	2
FL_South_PRV2.ACSA_N_413-6-4.1	462.4	None	2
FL_South_PRV1.ACSA_N_413-6-1.1	462.5	None	6
Keywest_PRV3.ACSA_N_413-9-6.1	374.1	105	2
Keywest_PRV2.ACSA_N_413-9-4.1	374.1	100	2
Keywest_PRV1.ACSA_N_413-9-2.1	374.1	92	8

Closed ACSA Pressure Reducing Valves/Main	Elev. (ft)	Pressure Setting (psi)	Size (in)
ACSA_N_413-10-13.Flordon_PRV3.1	670.2	50	2
ACSA_N_413-10-12.Flordon_PRV2.1	670.2	45	2
ACSA_N_413-10-11.Flordon_PRV1.1	670.2	40	8
ACSA_N_413-8-5.Four_Seasons_PRV3.1	542.5	40	2
ACSA_N_413-8-3.Four_Seasons_PRV2.1	543.1	36	2
ACSA_N_413-8-2.Four_Seasons_PRV1.1	543.6	32	6
Woodlands_PRV3.ACSA_N_502-2-7.1	543.3	40	2
Woodlands_PRV2.ACSA_N_502-2-6.1	543.3	35	2
Woodlands_PRV1.ACSA_N_502-2-5.1	543.3	31	8

Additional Isolation Valve	Owner	Elevation, ft	Valve Diameter, in	Flow Setting (MGD)
^Ashcroft Lower	ACSA	898.9	6	0

^inactive section of model network

Pressure Sustaining Valves

Pressure sustaining valves limit the downstream flow rate based on maintaining a minimum upstream pressure.

Modeled ACSA Pressure Sustaining Valves	Elev. (ft)	Pressure Setting (psi)	Size (in)	Comment
PSV-Glenmore	374	113	6	

Appendix E

Needed Fire Flow

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Rev	Risk ID	Postal Community	Zip	Prefix 1	Low No. 1	High No. 1	Direction 1	Thoroughfare Name 1	Type 1	Suffix 1	Building Description	**NFF**	Rating
	450050161442	CHARLOTTESVILLE	22901		1400			MELBOURNE	RD		CHARLOTTESVILLE HIGH SCHOOL 2S	**5,000**	1
	45VA99156195	CHARLOTTESVILLE	22902		801			FRANKLIN	ST		CHARLOTTESVILLE FARMERS MARKET 2S	**5,000**	1
	450050160070	CHARLOTTESVILLE	22903		2000			MORTON	DR		ENGLISH INN OF CHARLOTTESVILLE 3S	**4,500**	1
	450050006410	CHARLOTTESVILLE	22901		250	270		ZAN	RD		SEMINOLE SQUARE SHOP CTR - MO 1S	**4,500**	1
	450050009490	CHARLOTTESVILLE	22901		2114			ANGUS	RD		ANGUS CENTER 2S	**4,000**	1
	45VA99149205	CHARLOTTESVILLE	22903		1221			HARRIS	ST		HABITAT FOR HUMANITY 2S	**3,500**	1
	450050005860	CHARLOTTESVILLE	22902		200	216	W	MAIN	ST		GRAND PIANO FURNITURE CO	**3,500**	2
	450050008510	CHARLOTTESVILLE	22903		201	227		4	ST	NW	CITY OF CHARLOTTESVILLE-MO	**3,500**	1
	45VA99160137	CHARLOTTESVILLE	22903		224			14	ST	NW	CAMDEN PLAZA 6S	**3,500**	1
	450050001220	CHARLOTTESVILLE	22903		400			COMMERCE	ST		CITY OF CHARLOTTESVILLE 2S	**3,500**	1
	45VA99006348	CHARLOTTESVILLE	22903		500			OLD LYNCHBURG	RD		PIEDMONT HOSPITAL LLC 3S	**3,500**	1
	450050153518	CHARLOTTESVILLE	22903		580			MASSIE	RD		UNIVERSITY OF VA-LAW SCH 4S	**3,500**	1
	450050024471	CHARLOTTESVILLE	22903		631			DICE	ST		RUSSELL BLDG 1S	**3,500**	2
	450050051830	CHARLOTTESVILLE	22903		700			HARRIS	ST		HARRIS ST SILK MILL 2S	**3,500**	1
	45VA99013681	CHARLOTTESVILLE	22903		702			CHARLTON	AVE		CHARLTON-FORREST BLD 2S	**3,500**	1
	450050013979	CHARLOTTESVILLE	22903		920			HARRIS	ST		H P BROWN CORP-CHARLOTTESVILLE DIST	**3,500**	1
	450050006310	CHARLOTTESVILLE	22903		1111			MILLMONT	ST		MOUNTAIN BOWL	**3,000**	1
	450003172880	CHARLOTTESVILLE	22906		1155			SEMINOLE	TRL		U S GOVT POST OFFICE	**3,000**	1
	450050161436	CHARLOTTESVILLE	22903		1564			DAIRY	RD		WALKER JR HIGH SCH-CLSRM/CAFE/OFF	**3,000**	1
	45VA99149468	CHARLOTTESVILLE	22903		1751			ALLIED	ST		CHARLOTTESVILLE BUSINESS PARK 1S	**3,000**	1
	45VA99160506	CHARLOTTESVILLE	22903		1819			JEFFERSON PARK	AVE		JEFFERSON SQUARE APARTMENTS 4S	**3,000**	1
	450050020240	CHARLOTTESVILLE	22902		200	300	E	WATER	ST		WATER STREET PARKING GARAGE-4S	**3,000**	1
	45VA99013363	CHARLOTTESVILLE	22901		2101			INDIA	RD		SEMINOLE SQUARE SHOPPING CTR 2S	**3,000**	1
	45VA99015240	CHARLOTTESVILLE	22901		2109			INDIA	RD		SEMINOLE TRAIL SHOPPING CENTER 2S	**3,000**	1
	450050004750	CHARLOTTESVILLE	22903		2132			IVY	RD		ST ANNE S SCH-RANDOLPH HALL	**3,000**	1
	45VA99159824	CHARLOTTESVILLE	22903		233			4	ST	NW	THE JEFFERSON SCHOOL CITY CTR 2S	**3,000**	1
	450050005247	CHARLOTTESVILLE	22902		235		W	MAIN	ST		OMNI HOTEL 8S	**3,000**	1
	45VA99152643	CHARLOTTESVILLE	22903		245	263		RIDGE MCINTIRE	RD		VINEGAR HILL SHOPPING CENTER 2S	**3,000**	1
	450050153536	CHARLOTTESVILLE	22903	3R	305			4	ST	NW	CITY OF CHARLOTTESVILLE-REPG GARAGE	**3,000**	1
	45VA99160852	CHARLOTTESVILLE	22902		310	316		4	ST	SE	NORCROSS STATION-PHASE II 4S	**3,000**	1
	45VA99160853	CHARLOTTESVILLE	22902		318	322		4	ST	SE	NORCROSS STATION-PHASE III 4S	**3,000**	1
	45VA99007016	CHARLOTTESVILLE	22902		401		E	MARKET	ST		THE ENTERPRISE CENTER 2S	**3,000**	1
	450050005060	CHARLOTTESVILLE	22902		420		E	MAIN	ST		GRAND PIANO FURNITURE	**3,000**	1
	450050006180	CHARLOTTESVILLE	22902		500	526	E	MARKET	ST		DOWNTOWN MALL 4S	**3,000**	1
	450050051823	CHARLOTTESVILLE	22903		508			HARRIS	RD		CHARLOTTESVILLE SCHOOL BD 2S	**3,000**	1
	45VA66016940	CHARLOTTESVILLE	22902		511		N	1	ST		CHARLOTTESVILLE TOWERS-1 BLDG 5S	**3,000**	1
	450050409547	CHARLOTTESVILLE	22902		600		E	WATER	ST		SPRIGG LANE INVESTMENT CORP 2S	**3,000**	2
	450050008680	CHARLOTTESVILLE	22903		617			9	ST	SW	BUFORD JR HIGH SCH-RMS/CAFE/OFF 2S	**3,000**	1
	45VA99011304	CHARLOTTESVILLE	22903		901			ROSE HILL	DR		JACKSON BURLEY MIDDLE SCHOOL 3S	**3,000**	1
	450050161445	CHARLOTTESVILLE	22902		920	930		BELMONT	AVE		GEORGE ROGERS CLARK ELEM SCH	**3,000**	1
	450050004620	CHARLOTTESVILLE	22902		100	102	E	MAIN	ST		THE COMMERCE BUILDING	**2,500**	1
	450050008770	CHARLOTTESVILLE	22903		1000			BIRDWOOD	RD		THE COVENANT SCHOOL	**2,500**	1
	450050162165	CHARLOTTESVILLE	22902		101		E	JEFFERSON	ST		FIRST UNITED METHODIST CHURCH 3S	**2,500**	1
	45VA99015239	CHARLOTTESVILLE	22901		101			SEMINOLE	CT		SEMINOLE SQUARE SHOPPING CTR 2S	**2,500**	1
	450050001722	**CHARLOTTESVILLE**	**22903**		**1049**	**1140**	**N**	**EMMET**	**ST**	**N**	**BARRACKS ROAD SHOP CTR 1S**	**2,500**	**1**
	45VA99148227	CHARLOTTESVILLE	22902		105			MONTICELLO	AVE		MONTICELLO AVE CONDO ASSOC 4S	**2,500**	1
	45VA99149856	CHARLOTTESVILLE	22902		110			5	ST	SE	WATER ST BUILDING 5S	**2,500**	1
	450050161878	CHARLOTTESVILLE	22902		111			MONTICELLO	AVE		ACAC 3S	**2,500**	1
	45VA99005066	CHARLOTTESVILLE	22902		1110			EAST MARKET	ST		MARKET SQUARE 2S	**2,500**	1
	450050001725	CHARLOTTESVILLE	22903		1121	1127	N	EMMET	ST		BARRETTS RD SHOP CTR-MO	**2,500**	1
	45VA99014585	CHARLOTTESVILLE	22903		1122			EMMET	ST	N	BARRACKS ROAD SHOPPING CENTER 1S	**2,500**	1
	450050003450	CHARLOTTESVILLE	22901		1135			RIVER	RD		KANI S INC - FURNITURE	**2,500**	2
	450050001728	CHARLOTTESVILLE	22903		1137			EMMET	ST	N	BARRACKS ROAD SHOPPING CENTER 1S	**2,500**	1
	450050006000	CHARLOTTESVILLE	22903		1200		W	MAIN	ST		KANE FURNITURE 1S	**2,500**	2
	450050004120	CHARLOTTESVILLE	22903		1214			JEFFERSON PARK	AVE		THE TOWERS NURSING HOME	**2,500**	1
	450050007745	CHARLOTTESVILLE	22901		123	135		SEMINOLE	CT		SEMINOLE SQ SHOP CTR-NORTH WING 1S	**2,500**	1

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	450050161444	CHARLOTTESVILLE	22901		1300			LONG	ST		BURNLEY MORAN ELEM SCHOOL	**2,500**	1
	450050008900	CHARLOTTESVILLE	22902		1501			6	ST	SE	SIMON CELLARS BLD 1S	**2,500**	1
	450050161443	CHARLOTTESVILLE	22903		1600			CHERRY	AVE		JAMES C JOHNSON SCHOOL	**2,500**	1
	450050000240	CHARLOTTESVILLE	22903		1739			ALLIED	ST		ALLIED REALTY 1S	**2,500**	1
	450050000525	CHARLOTTESVILLE	22903		1982			ARLINGTON	BLVD		GRADUATE CENTRE 4S	**2,500**	2
	45VA99000974	**CHARLOTTESVILLE**	**22902**		**2**			**MONTICELLO**	**RD**		**PATRICK FURNITURE 2S**	**2,500**	**1**
	450050014220	CHARLOTTESVILLE	22902		200		E	HIGH	ST		QUEEN CHARLOTTE SQUARE ASSOC 4S	**2,500**	1
	45VA99155683	CHARLOTTESVILLE	22902	ADJ	221			CARLTON	RD		KATHYS SHOPPING CENTER 6TENANTS 1S	**2,500**	1
	450050023720	CHARLOTTESVILLE	22901		2228			GREENBRIER	DR		GREENBRIER ELEMENTARY SCHOOL 1S	**2,500**	1
	450050003221	CHARLOTTESVILLE	22902		245	263		RIDGE	ST		VINEGAR HILL PLAZA 2S	**2,500**	1
	45VA99010109	CHARLOTTESVILLE	22903		247			RIDGE MCINTIRE	RD		VINAGER HILL SHOPPING CENTER 2S	**2,500**	1
	450050004940	CHARLOTTESVILLE	22902		320		E	MAIN	ST		MARSHALL BLDG 3S	**2,500**	1
	450050008000	CHARLOTTESVILLE	22902		401		E	SOUTH	ST		CHARLOTTESVILLE WHSE CORP	**2,500**	1
	450050021580	CHARLOTTESVILLE	22902		500			PARK	ST		FIRST PRESBYTERIAN CHURCH 2S	**2,500**	1
	45VA99149964	CHARLOTTESVILLE	22902		501		E	WATER	ST		WATER STREET BUILDING 5S	**2,500**	1
	45VA99002212	CHARLOTTESVILLE	22902		506		E	MAIN	ST		PESHWA INC	**2,500**	2
	45VA99008396	CHARLOTTESVILLE	22902		531			WARE	ST		STAFFORD BUILDINGS 1S	**2,500**	1
	450050002570	CHARLOTTESVILLE	22902		820		E	HIGH	ST		THE EIGHT TWENTY BLDG 3S	**2,500**	1
	450050006910	CHARLOTTESVILLE	22903		824			PRESTON	AVE		SETTLE TIRE 1S	**2,500**	1
	45VA99004914	CHARLOTTESVILLE	22903		839			ESTES	ST		MALCOLM COLE CHILD CARE CTR 2S	**2,500**	2
	450050013700	CHARLOTTESVILLE	22903		946			GRADY	AVE		MONTICELLO COMPLEX 2S	**2,500**	1
	45VA99006805	CHARLOTTESVILLE	22902		100			AVON	ST		NATIONAL OPTRONICS 2S	**2,250**	1
	450050008765	CHARLOTTESVILLE	22903		104			14	ST	NW	PIEDMONT VIRGINIA BLD 5S	**2,250**	1
	45VA99005015	CHARLOTTESVILLE	22902		108			5	ST	NE	CHARLOTTESVILLE PARKING CENTER 4S	**2,250**	1
	450050004680	CHARLOTTESVILLE	22902		108	112	E	MAIN	ST		THE JEFFERSON MO 3S	**2,250**	1
	450050005801	CHARLOTTESVILLE	22902		110	116	W	MAIN	ST		YORK PLACE 3S	**2,250**	1
	450050001652	CHARLOTTESVILLE	22903		1107		N	EMMET	ST		BARRACKS RD SHP CTR SEC A-F	**2,250**	1
	45VA99151390	CHARLOTTESVILLE	22902		1140		E	MARKET	ST		EAST MARKET OFFICE BUILDING 2S	**2,250**	2
	450050008550	CHARLOTTESVILLE	22902		1155			5	ST	SW	NITCHMAN BLDG 1S	**2,250**	1
	450050004590	CHARLOTTESVILLE	22902		120		W	HIGH	ST		CHRIST EPISCOPAL CHURCH 3S	**2,250**	1
	450050005580	CHARLOTTESVILLE	22903		1223		W	MAIN	ST		UNIVERSITY BAPTIST CHURCH 4S	**2,250**	1
	450050006008	CHARLOTTESVILLE	22903		1224		W	MAIN	ST		BLAKE BLDG 7S	**2,250**	1
	45VA99015283	CHARLOTTESVILLE	22901		123	135		SEMINOLE	CT		SEMINOLE SQUARE SHOPPING CTR 1S	**2,250**	1
	450050023680	CHARLOTTESVILLE	22903		1300			JEFFERSON PARK	AVE		JORDAN HALL - UVA MED SCH 9S	**2,250**	1
	45VA66016053	CHARLOTTESVILLE	22903		1301			EMMET	ST	N	FEDERAL EXECUTIVE INSTITUTE 3S	**2,250**	1
	450050061811	CHARLOTTESVILLE	22903		1310			EMMET	ST	N	FEDERAL EXECUTIVE INSTITUTE	**2,250**	1
	45VA99010964	CHARLOTTESVILLE	22903		1417			EMMET	ST	N	EMMET STREET SHOPS 1S	**2,250**	1
	450050001780	CHARLOTTESVILLE	22903		1417			EMMET	ST	N	MING DYNASTY BLD 1S	**2,250**	1
	450003172870	CHARLOTTESVILLE	22901		151	197		SEMINOLE	CT		SEMINOLE SQUARE SHOPPING CTR 1S	**2,250**	1
	450050007751	CHARLOTTESVILLE	22901		151	197		SEMINOLE	CT		SEMINOLE SQUARE SHOPPING CTR 1S	**2,250**	1
	450050005660	CHARLOTTESVILLE	22903		1511			UNIVERSITY	AVE		ROBINSON BLDG 2S	**2,250**	1
	450050008981	CHARLOTTESVILLE	22901		153	199		ZAN	RD		SEMINOLE SQUARE SHOPPING CTR 2S	**2,250**	1
	45VA99000050	CHARLOTTESVILLE	22903		1700	1728		ALLIED	ST		ALLIED REALTY 2S MO	**2,250**	1
	450050007320	CHARLOTTESVILLE	22903		190			RUGBY	RD		WESTMINISTER PRESBYTERIAN 3S	**2,250**	1
	45VA99013861	CHARLOTTESVILLE	22903		1900			ARLINGTON	BLVD		VIRGINIA NATIONAL BANK 2S	**2,250**	2
	450050008296	CHARLOTTESVILLE	22901		200	218		ZAN	RD		SEMINOLE SQUARE SHOP CTR	**2,250**	1
	450050160066	CHARLOTTESVILLE	22903		2002	2012		MORTON	DR		THE COMMONS OFFICE CENTER 2S	**2,250**	2
	450050160974	CHARLOTTESVILLE	22901		2036			INDIA	RD		CINEMA 4-NEIGHBORHOOD THEATRES	**2,250**	1
	450050004800	CHARLOTTESVILLE	22902		206	210	E	MAIN	ST		STANDARD DRUG CO	**2,250**	1
	450050003900	CHARLOTTESVILLE	22903		2125			IVY	RD		IVY SQUARE SHOPPING CENTER 3S	**2,250**	1
	450050004001	CHARLOTTESVILLE	22903		2132			IVY	RD		ST ANNES BELFIELD SCHOOL-MIDDLE SCH	**2,250**	1
	450050000320	CHARLOTTESVILLE	22901		2200			ANGUS	RD		MEADOWS PRESBYTERIAN CHURCH 2S	**2,250**	1
	45VA99150127	CHARLOTTESVILLE	22901		2211			HYDRAULIC	RD		EMBARQ BUILDING 3S	**2,250**	1
	45VA99146228	CHARLOTTESVILLE	22902		230		W	MAIN	ST		MAIN STREET ARENA 1S	**2,250**	1
	45VA99160851	CHARLOTTESVILLE	22902		300			4	ST	SE	NORCROSS STATION-PHASE I 4S	**2,250**	1
	450050255890	CHARLOTTESVILLE	22902	ADJ	310		E	MARKET	ST		119 4 STREET NE BLDG	**2,250**	1

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	45VA99148699	CHARLOTTESVILLE	22902		313			2	ST	SE	THE GLASS BLDG 2S	2,250	1
	450050159701	CHARLOTTESVILLE	22904		351			MCCORMICK	RD		UVA-THORNTON HALL-E WING 2S	2,250	2
	450050153388	CHARLOTTESVILLE	22902		602	604	E	MARKET	ST		CITY OF CHARLOTTESVILLE-CITY HALL	2,250	1
	450050153491	CHARLOTTESVILLE	22903		856		W	MAIN	ST		MERCHANTS INC	2,250	1
	45VA99006596	CHARLOTTESVILLE	22903		900			NATURAL RESOURCES	DR		AROMAS CAFE 3S	2,250	1
	450050018145	CHARLOTTESVILLE	22903		901			PRESTON	AVE		CHARLOTTESVILLE WELLNESS CTR 4S	2,250	2
	45VA99015916	CHARLOTTESVILLE	22902		908		E	JEFFERSON	ST		JEFFERSON STREET CONDOS OFFICE 3S	2,250	2
	45VA99015917	CHARLOTTESVILLE	22902		914		E	JEFFERSON	ST		JEFFERSON STREET CONDOS OFFICE 3S	2,250	2
	450050159490	CHARLOTTESVILLE	22902		100		W	SOUTH	ST		TOLEDANO BLDG 3S	2,000	1
	450050151702	CHARLOTTESVILLE	22903	1R	1001			GROVE	ST		ROBERT LEE CO-STGE	2,000	2
	45VA99003334	CHARLOTTESVILLE	22902		103		W	JEFFERSON	ST		CHRIST EPISCOPAL 2S	2,000	2
	450050153640	CHARLOTTESVILLE	22902		1112			EAST MARKET	ST		MARKET SQUARE 1S	2,000	1
	450050006113	CHARLOTTESVILLE	22902		1117		E	MARKET	ST		ALBEMARLE COUNTERTOPS-5 TENANTS 1S	2,000	1
	450050160215	CHARLOTTESVILLE	22903		1149			MILLMONT	ST		SLOAN S RESTAURANT	2,000	1
	45VA99011367	CHARLOTTESVILLE	22903		1200			FORREST	ST		MURRAY HIGH SCHOOL 1S	2,000	1
	450050006123	CHARLOTTESVILLE	22902		1215		E	MARKET	ST		VIRGINIA LAND HOLDINGS LLC 1S	2,000	1
	450050160614	CHARLOTTESVILLE	22903		1228	1230		CEDARS	CT		CEDARS COURT CENTER-OFFICES	2,000	1
	45VA99012644	CHARLOTTESVILLE	22902		123		E	WATER	ST		LIVE ARTS BUILDING 4S	2,000	1
	45VA99000235	CHARLOTTESVILLE	22902		1301	1307		CARLTON	AVE		CARLTON AVE CONDO ASSN 2S MO	2,000	1
	450050016300	CHARLOTTESVILLE	22903		1305	1309	W	MAIN	ST		CHARL MTR LODGE-HOWARD JOHNSON 8S	2,000	1
	450050159858	CHARLOTTESVILLE	22903		1700			UNIVERSITY	AVE		SAINT PAUL S MEMORIAL CHURCH 3S	2,000	2
	450050001590	CHARLOTTESVILLE	22901		1706			EMMET	ST	N	WOODVALE PROFESSIONAL CENTER 2S	2,000	2
	450050001210	CHARLOTTESVILLE	22903		1720			CHERRY	AVE		CHERRY AVENUE CHRISTIAN CHURCH 2S	2,000	1
	45VA99005564	CHARLOTTESVILLE	22903		1739	1741		ALLIED	ST		ALLIED REALTY BLD 1S	2,000	1
	45VA99000177	CHARLOTTESVILLE	22903		1900			ARLINGTON	BLVD		TRIPLE H PROPERTIES 1S	2,000	1
	450050004198	CHARLOTTESVILLE	22903		2023			IVY	RD		SUZANNE INC	2,000	2
	45VA99014301	CHARLOTTESVILLE	22903		2039			BARRACKS	RD		MEADOWBROOK SHOPPING CENTER 1S	2,000	1
	45VA99154326	CHARLOTTESVILLE	22902		212		E	MAIN	ST		CITIZEN BURGER BAR-3 TENANTS 3S	2,000	1
	45VA99147794	**CHARLOTTESVILLE**	**22902**		**212**		**E**	**MARKET**	**ST**		**THE SHOPS AT APRILS CORNER 2S**	**2,000**	**1**
	450050000660	CHARLOTTESVILLE	22903		2132	2146		BARRACKS	RD		BARRACKS ROAD NORTH SHP CTR-MO	2,000	1
	450050000990	CHARLOTTESVILLE	22902		220	224		CARLTON	RD		CARLTON BUSINESS PARK BLD 2S	2,000	1
	45VA99004535	CHARLOTTESVILLE	22902		220		E	MAIN	ST		WILLIAMS BUILDING 3S	2,000	2
	450050008295	CHARLOTTESVILLE	22901		241	249		ZAN	RD		SEMINOLE SQUARE-CENTRAL WING	2,000	1
	450050004147	CHARLOTTESVILLE	22903		2505			JEFFERSON PARK	AVE		JEFFERSON PARK BAPTIST CHURCH 2S	2,000	1
	45VA99156378	CHARLOTTESVILLE	22902		300	308	E	MAIN	ST		CBRE BUILDING MO 4S	2,000	1
	450050013510	CHARLOTTESVILLE	22902		301			GARRETT	ST		CAVALIER BEVERAGE CO	2,000	2
	45VA99004666	CHARLOTTESVILLE	22902		301	303	E	MAIN	ST		RAPTURE RESTAURANT- 3 TENANTS- 1S	2,000	1
	450050008180	CHARLOTTESVILLE	22902		401	411	E	WATER	ST		PEPSI-COLA BOTTLING CO OF CENTRAL V	2,000	2
	450050006200	CHARLOTTESVILLE	22902		404	410	E	MARKET	ST		MACLIN BLDG MO 3S	2,000	1
	45VA99151661	CHARLOTTESVILLE	22902		407			MONTICELLO	RD		BURLINGTON BLD 2S	2,000	1
	450050001340	CHARLOTTESVILLE	22903		5	7		ELLIEWOOD	AVE		GRANT ROSMUSSEN - MO	2,000	2
	450050150531	CHARLOTTESVILLE	22902		505			GARRETT	ST		MADDUX SUPPLY	2,000	2
	45VA99157687	CHARLOTTESVILLE	22901		615			WOODBROOK	DR		GREENWOOD FUNDING 2TENANTS 1S	2,000	2
	450050051860	CHARLOTTESVILLE	22903		750			HARRIS	ST		HARRIS BLDG 2S	2,000	1
	450050006450	CHARLOTTESVILLE	22902		823			MONTICELLO	RD		B E EASTON-MO 2S	2,000	1
	450050006940	CHARLOTTESVILLE	22903		923			PRESTON	AVE		PRESTON PLAZA 1S	2,000	1
	450050011751	**CHARLOTTESVILLE**	**22901**	**R**	**1**			**DELEVAN**	**ST**		**META T CHISHOLM BLDG 2 1S**	**1,750**	**2**
	450050158732	CHARLOTTESVILLE	22908		1			HOSPITAL	DR		UNIV OF VA-HOSPITAL PKG GAR 2S	1,750	1
	450050000170	CHARLOTTESVILLE	22903		100			ALDERMAN	RD		ST MARK LUTHERAN CHURCH 2S	1,750	1
	45VA99002025	CHARLOTTESVILLE	22902		100	300		COURT	SQ		COURT SQUARE ANNEX 4S	1,750	2
	450050007980	CHARLOTTESVILLE	22902		100		E	SOUTH	ST		WELLS FARGO ADVISORS-3 TENANTS 3S	1,750	2
	450050161579	CHARLOTTESVILLE	22903		1000			BIRDWOOD	RD		OLD MCINTIRE SCHOOL 2S	1,750	1
	450050117709	CHARLOTTESVILLE	22903		1000			EMMET	ST	N	BURGER KING 1S	1,750	1
	450050008980	CHARLOTTESVILLE	22901		101	199		ZAN	RD		SEMINOLE SQUARE SHOPPING CENTER	1,750	1
	450050005960	CHARLOTTESVILLE	22903		1018		W	MAIN	ST		BRUGH 2S	1,750	1
	45VA99152960	CHARLOTTESVILLE	22903		1035	1057		MILLMONT	ST		MILLMONT SHOPS 1S	1,750	1

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	450050001890	CHARLOTTESVILLE	22902		106			GOODMAN	ST		B J ENTERPRISES 2S	**1,750**	1
	450050006267	CHARLOTTESVILLE	22903		113	119		MAURY	AVE		IVY SQUARE 1S	**1,750**	1
	450050006205	CHARLOTTESVILLE	22902		1132			EAST MARKET	ST		MARKET SQUARE 1S	**1,750**	1
	450050008539	CHARLOTTESVILLE	22902		1135	1147		5	ST	SW	WILLOUGHBY SQ CTR MO 1S	**1,750**	1
	450050018820	CHARLOTTESVILLE	22903		1150			ROSE HILL	DR		ECK SUPPLY CO 1S	**1,750**	1
	450050005200	**CHARLOTTESVILLE**	**22902**		**117**	**121**	**W**	**MAIN**	**ST**	**NW**	**PORTICO BUILDING 3S**	**1,750**	**1**
	45VA99009438	CHARLOTTESVILLE	22911		1192			RTE 250			WENDYS-PANTOPS GAS AND FOOD 1S	**1,750**	1
	45VA99003727	CHARLOTTESVILLE	22902		120		E	MAIN	ST		120 EAST MAIN BUILDING 2S	**1,750**	1
	45VA99008387	CHARLOTTESVILLE	22902		120		E	MAIN	ST		ONE TWENTY EAST MAIN BUILDING 2S	**1,750**	1
	450050014160	CHARLOTTESVILLE	22903		1207			HARRIS	ST		SOUTHERN CHEMICAL BLDG	**1,750**	1
	450050007290	CHARLOTTESVILLE	22901		1230			RIVER	RD		STERLING WILLIAMSON	**1,750**	1
	450050018720	CHARLOTTESVILLE	22901	R	1234			RIVER	RD		W A LYNCH ROOFING CO 1S	**1,750**	1
	450050160947	CHARLOTTESVILLE	22903	2R	1240	1242		HARRIS	ST		AUTOMOTIVE PARTS INC 2S	**1,750**	1
	450050154480	CHARLOTTESVILLE	22903		1254			EMMET	ST	N	LONG JOHN SILVER S 1S	**1,750**	1
	45VA66016883	CHARLOTTESVILLE	22902		1311			CARLTON	AVE		WORKSOURCE ENTERPRISES 1S	**1,750**	1
	450050006215	CHARLOTTESVILLE	22902		1320		E	MARKET	ST		HARRY A WRIGHT S INC 2S	**1,750**	1
	450050154517	CHARLOTTESVILLE	22902		1428		E	HIGH	ST		CHARLOTTESVILLE GLASS MIRROR 2S	**1,750**	2
	45VA99003854	CHARLOTTESVILLE	22903		1505			UNIVERSITY	AVE		MULTI OCCUPANCY 2S	**1,750**	1
	45VA99000850	CHARLOTTESVILLE	22903		1509	1511		UNIVERSITY	AVE		AMORGOS/ COLLEGE INN 1S MO	**1,750**	1
	45VA99158072	CHARLOTTESVILLE	22902		1512		E	MARKET	ST		JABA TIMBERLAKE PLACE 2S	**1,750**	2
	450050161432	CHARLOTTESVILLE	22903	1R	1564			DAIRY	RD		WALKER JR HIGH SCH-AUDITORIUM/SHOP	**1,750**	1
	450050000181	CHARLOTTESVILLE	22903		1701	1717		ALLIED	ST		ALLIED REALITY CORP - MO 2S	**1,750**	1
	450050001813	CHARLOTTESVILLE	22901		1705			EMMET	ST	N	KENTUCKY FRIED CHICKEN 1S	**1,750**	1
	45VA99160224	CHARLOTTESVILLE	22901		176	198		ZAN	RD		SEMINOLE SQ -WEST RETAIL SHOPS 1S	**1,750**	1
	450050155540	CHARLOTTESVILLE	22901	R	1901			EMMET	ST	N	HOLIDAY INN-BLDG 1 1S	**1,750**	1
	450050009680	CHARLOTTESVILLE	22903		1924			ARLINGTON	BLVD		HKL PARTNERSHIP BUILDING 3S	**1,750**	1
	45VA99004834	CHARLOTTESVILLE	22901		2014			HOLIDAY	DR		ECONO LODGE LODGE 2S	**1,750**	2
	45VA66007774	CHARLOTTESVILLE	22902		203			RIDGE	ST		CITY OF CHARLOTTESVILLE FIRE 2S	**1,750**	1
	45VA99148595	CHARLOTTESVILLE	22901		2044			INDIA	RD		GENERAL DYNAMICS CORP 3S	**1,750**	1
	45VA99011099	CHARLOTTESVILLE	22903		2108			JEFFERSON PARK	AVE		APTS BLDG 3S	**1,750**	2
	450050005240	CHARLOTTESVILLE	22902		217	223	W	MAIN	ST		VANYAHRES BLDG-MO	**1,750**	2
	450050003860	CHARLOTTESVILLE	22903		2171			IVY	RD		UNIVERSITY SHOPPING CENTER 1S	**1,750**	1
	450050006260	CHARLOTTESVILLE	22902		218		W	MARKET	ST		MARKET STREET PROMENADE 2S	**1,750**	1
	450050006699	CHARLOTTESVILLE	22903		2400			OLD IVY	RD		GENERAL EASTERN MGMT/IBM 2S	**1,750**	1
	45VA99011480	CHARLOTTESVILLE	22903		271			RIDGE MCINTIRE	RD		MC DONALD S 1S	**1,750**	1
	45VA99147764	CHARLOTTESVILLE	22903		300		W	MAIN	ST		300 WEST MAIN BUILDING 3S	**1,750**	2
	45VA99006889	CHARLOTTESVILLE	22902		310	312	E	MAIN	ST		MILGRAUM CENTER 4S	**1,750**	1
	45VA99160469	CHARLOTTESVILLE	22902		319	321	E	WATER	ST		RACE JEWELERS-4 TENANTS 3S	**1,750**	1
	450050001517	CHARLOTTESVILLE	22903	1R	400			EMMET	ST	N	CAVALIER ASSOC 2S	**1,750**	1
	45VA99154332	CHARLOTTESVILLE	22902	ADJ	500			COURT	SQ		COURT SQUARE 10S	**1,750**	1
	450050159995	CHARLOTTESVILLE	22902		500	510		JEFFERSON	ST		MONTICELLO PLAZA 10S	**1,750**	1
	450050153560	CHARLOTTESVILLE	22903		510			PRESTON	AVE		BROWNS DRY CLEANERS	**1,750**	2
	450050006619	CHARLOTTESVILLE	22903	1R	608			PRESTON	AVE		JENSEN BLDG-MO 1S	**1,750**	1
	450050051821	CHARLOTTESVILLE	22903		610			HARRIS	ST		RAX RESTAURANT	**1,750**	1
	450050005340	CHARLOTTESVILLE	22903		615	619	W	MAIN	ST		ALBEMARLE HOTEL BLDG	**1,750**	2
	450050008682	CHARLOTTESVILLE	22903	1R	617			9	ST	SW	BUFORD JR HIGH SCH-AUD/SHOP 1S	**1,750**	1
	45VA99010783	CHARLOTTESVILLE	22903		705			DALE	AVE		CHARLOTTESVILLE BUSINESS PARK 2S	**1,750**	1
	450050006720	CHARLOTTESVILLE	22902		735			PARK	ST		FIRST BAPTIST CHURCH 2S	**1,750**	1
	450050051870	CHARLOTTESVILLE	22903		770			HARRIS	ST		RIVANNA PARTNERS BLDG	**1,750**	1
	450050015220	CHARLOTTESVILLE	22902		802	818	E	JEFFERSON	ST		HANTZMON WIEBEL CPA 3S	**1,750**	2
	450050153392	CHARLOTTESVILLE	22902		810		E	MARKET	ST		CITY OF CHARLOTTESVILLE-REC CTR 2S	**1,750**	2
	450050022720	CHARLOTTESVILLE	22902		828			MCINTIRE	RD		CHARLOTTESVILLE-ALBEMARLE RESCUE SQ	**1,750**	1
	45VA99015915	CHARLOTTESVILLE	22902		902		E	JEFFERSON	ST		GREAT EASTERN BUILDING 2S	**1,750**	1
	450050152261	CHARLOTTESVILLE	22903		906			WEST	ST		CHARLOTTESVILLE TRANSFER STGE	**1,750**	1
	450050153539	CHARLOTTESVILLE	22901		908			SAINT CLAIR	AVE		MT VIEW BAPTIST CHURCH 2S	**1,750**	1
	450050152266	CHARLOTTESVILLE	22903		916			WEST	ST		JONATHON VA INC - JEM WOOD DISIGN	**1,750**	1

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	450050160020	CHARLOTTESVILLE	22903		1			MORTON	DR		ONE MORTON DRIVE 6S	**1,500**	1
	450050161434	CHARLOTTESVILLE	22902		100			CARLTON	RD		J MCVAY FURNITURE REFINISHING	**1,500**	2
	450050015221	CHARLOTTESVILLE	22902		1011		E	JEFFERSON	ST		JEFFERSON MEDICAL BLDG 2S	**1,500**	1
	450050001341	CHARLOTTESVILLE	22902		1017			ELLIOTT	AVE		SOJOURNER S UNITED CHURCH 2S	**1,500**	1
	450050003470	CHARLOTTESVILLE	22901		1025			SEMINOLE	TRL		BURGER KING 1S	**1,500**	1
	45VA99154955	CHARLOTTESVILLE	22902		106			GOODMAN	ST		SKYLINE TENT COMPANY INC 3S	**1,500**	2
	45VA99009105	CHARLOTTESVILLE	22902		108			2	ST	SW	REVOLUTIONARY SOUP-2 TENANTS 2S	**1,500**	1
	45VA66016057	CHARLOTTESVILLE	22902		110		W	SOUTH	ST		SUN BOW TRADING 2S	**1,500**	1
	45VA99151500	CHARLOTTESVILLE	22903		1100			HARRIS	ST		SOUTHERN STATES PETROLEUM 1S	**1,500**	2
	450050007269	CHARLOTTESVILLE	22903		1106			ROSE HILL	DR		KING BUILDING-MO	**1,500**	1
	450050001534	CHARLOTTESVILLE	22903		1112	1114	N	EMMET	ST		BARRACKS RD SHOP CTN/JONSON CAFETER	**1,500**	1
	45VA99008449	CHARLOTTESVILLE	22903		1112			ROSE HILL	DR		BRAD INC BLD 1S	**1,500**	2
	450050008537	CHARLOTTESVILLE	22902		1133			5	ST		WILLOUGHBY SQ SHP CTR -CVS 1S	**1,500**	1
	450050018800	CHARLOTTESVILLE	22903		1138			ROSE HILL	DR		ALBEMARLE CO/CHARLOTTESVILLE HEALTH	**1,500**	1
	45VA99159981	CHARLOTTESVILLE	22901		1139			RIVER	RD		YO WEAR 2S	**1,500**	1
	450050008480	CHARLOTTESVILLE	22902		115	119		4	ST	NE	E MARKET STREET LAND TRUST 2S	**1,500**	1
	45VA66015273	CHARLOTTESVILLE	22901		1170			RIVER	RD		VFW 1S	**1,500**	1
	45VA99159660	CHARLOTTESVILLE	22902		1181			5	ST	SW	BURGER KING 1S	**1,500**	1
	45VA99157126	CHARLOTTESVILLE	22902		1221		E	MARKET	ST		THE LUNCHBOX 1S	**1,500**	1
	45VA99005487	CHARLOTTESVILLE	22901		1305			LONG	ST		RIVER VIEW CENTER 1S	**1,500**	1
	45VA99160867	CHARLOTTESVILLE	22903		1308			WERTLAND	ST		THE WAREHOUSE 5S	**1,500**	1
	45VA99147944	CHARLOTTESVILLE	22901		1400			PEN PARK	RD		MEADOWCREEK GOLF COURSE 1S	**1,500**	1
	450050000760	CHARLOTTESVILLE	22902		155			CARLTON	RD		PRECISION SMALL PARTS INC	**1,500**	1
	45VA99155845	CHARLOTTESVILLE	22902		156			CARLTON	RD		WOOLEN MILLS POINT 1S	**1,500**	1
	450050161431	CHARLOTTESVILLE	22903	2R	1564			DAIRY	RD		WALKER JR HIGH SCH-GYM	**1,500**	1
	45VA99004286	CHARLOTTESVILLE	22901		1600			EMMET	ST	N	DAYS INN OFFICE 1S	**1,500**	1
	450003002880	CHARLOTTESVILLE	22901		1600			EMMET	ST	N	DAYS INN HOTEL 2S	**1,500**	1
	45VA99000893	CHARLOTTESVILLE	22901		1613			EMMET	ST	N	MT VERNON MOTEL UNITS 170-194 2S	**1,500**	1
	450050001817	CHARLOTTESVILLE	22901		1807			EMMET	ST	N	COMFORT INN 4S	**1,500**	1
	450050161773	CHARLOTTESVILLE	22902		201		E	MAIN	ST		THE CENTRAL PLACE	**1,500**	1
	450050002803	CHARLOTTESVILLE	22902		208	212	W	WATER	ST		DAVIS BLDG-M O MERC	**1,500**	1
	450050000510	CHARLOTTESVILLE	22903		2108			BARRACKS	RD		BARRACKS ROAD NORTH SHOP CTR 1S	**1,500**	1
	45VA99004835	CHARLOTTESVILLE	22902		214		W	WATER	ST		METROPOLITAN RESTAURANT 1S	**1,500**	1
	45VA99013041	CHARLOTTESVILLE	22902		218			RIDGE	ST		MONTICELLO RIDGE CROSSING FAC 2S	**1,500**	1
	45VA99004859	CHARLOTTESVILLE	22903		2206			FONTAINE	AVE		GUADALAJARA RESTAURANT 1S	**1,500**	1
	45VA99153950	CHARLOTTESVILLE	22902		221			CARLTON	RD		KATHYS SHOPPING CRT 4 TENANTS 1S	**1,500**	1
	45VA99002824	CHARLOTTESVILLE	22902		225			DOUGLAS	AVE		BIRCKHEAD SIGNS 2S MO	**1,500**	1
	450050008299	CHARLOTTESVILLE	22901		242	244		ZAN	RD		SEMINOLE SQ SHOP CENTER	**1,500**	1
	450050021250	CHARLOTTESVILLE	22903		300			9	ST	SW	RONALD MCDONALD HOUSE	**1,500**	2
	450050153537	CHARLOTTESVILLE	22903		305			4	ST	NW	CITY OF CHARLOTTESVILLE-ADMIN BLDG	**1,500**	1
	450050000420	CHARLOTTESVILLE	22902	1R	310			AVON	ST		AVON CT BLD B - 2S	**1,500**	1
	450050022240	CHARLOTTESVILLE	22903		324		W	MAIN	ST		HORVITZ NEWSPAPER-M O	**1,500**	1
	450050160422	CHARLOTTESVILLE	22902	R	413		E	MARKET	ST		UNITED WAY BLDG-MO	**1,500**	1
	450050004170	CHARLOTTESVILLE	22902		418		E	JEFFERSON	ST		MCQUIRE WOODS BATTLE BOOTH MFG	**1,500**	2
	450050002450	CHARLOTTESVILLE	22903		500			HENRY	AVE		KINGMILL ENTERPRISES 1S	**1,500**	1
	450050001130	CHARLOTTESVILLE	22903		501			CHERRY	AVE		KIM IGA 1S	**1,500**	1
	45VA99154945	CHARLOTTESVILLE	22903		505			PRESTON	AVE		BODOS BAGEL BAKERY 1S	**1,500**	1
	450050005080	CHARLOTTESVILLE	22902		508	510	E	MAIN	ST		5-10 PARTNERS MO 4S	**1,500**	1
	450050005900	CHARLOTTESVILLE	22903		512	520	W	MAIN	ST		ET JD PERKINS BLDG 3S	**1,500**	1
	450050006860	CHARLOTTESVILLE	22903		600			PRESTON	AVE		REID S SUPERMARKET 1S	**1,500**	1
	450050008681	CHARLOTTESVILLE	22903	2R	617			9	ST	SW	BUFORD JR HIGH SCH-GYMNASIUM 1S	**1,500**	1
	450050008683	CHARLOTTESVILLE	22903	ADJ	617			9	ST	SW	CITY OF CHARLOTTESVILLE-REC CTR	**1,500**	1
	450050018740	CHARLOTTESVILLE	22903		636			ROSE HILL	DR		CITY OF CHARLOTTESVILLE 1S	**1,500**	1
	450050006990	CHARLOTTESVILLE	22903		701			PRESTON	AVE		AUTO CLINIC 1S MO	**1,500**	1
	450050005360	CHARLOTTESVILLE	22903		707	709	W	MAIN	ST		BELLA S / THE FLOWER SHOP 2S	**1,500**	1
	450050006740	CHARLOTTESVILLE	22902	R	735			PARK	ST		FIRST BAPTIST CHURCH 2S	**1,500**	1

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	45VA99004691	CHARLOTTESVILLE	22903		820	830		CHERRY	AVE		CHERRY AVE SHOPPING CENTER 1S	**1,500**	1
	450050006400	CHARLOTTESVILLE	22902		826	830		MONTICELLO	AVE		BELMONT BAPTIST CHURCH 3S	**1,500**	2
	450050160629	CHARLOTTESVILLE	22903		858		W	MAIN	ST		DANNYS QUALITY UPHOLSTERY 2S MO	**1,500**	1
	450050006111	CHARLOTTESVILLE	22902		925		E	MARKET	ST		ABC PRESCHOOL 1S	**1,500**	1
	45VA99158551	CHARLOTTESVILLE	22903		930			HARRIS	ST		GOCO INC -MAINTENANCE BLDG 1S	**1,500**	2
	450050008061	**CHARLOTTESVILLE**	**22903**					**UNIVERSITY**	**AVE**		**UVA-THE ROTUNDA 3S**	**1,500**	**1**
	450050006780	CHARLOTTESVILLE	22902		100	106		OLD PRESTON	AVE		EASTERN STANDARD-BIBBS FISH REST	**1,250**	1
	450050151701	CHARLOTTESVILLE	22903		1001			GROVE	ST		R LEE CO-STONE CRUSHING	**1,250**	1
	450050160210	CHARLOTTESVILLE	22902		1003	1005	E	HIGH	ST		PHYSICIANS/SURGEONS BLDG-MO-OFFICE	**1,250**	1
	45VA99000402	CHARLOTTESVILLE	22902		101		W	MAIN	ST		HAMILTON BLDG 2S	**1,250**	1
	45VA99006005	CHARLOTTESVILLE	22902		102		W	MAIN	ST		ORBITS BUILDING 2S	**1,250**	1
	450245001045	CHARLOTTESVILLE	22903		1022		W	MAIN	ST		GUARANTY BLD 2S	**1,250**	1
	450050004623	CHARLOTTESVILLE	22902		106		E	MAIN	ST		CHARLOTTESVILLE WEEKLY BLD 2S	**1,250**	2
	45VA99000182	CHARLOTTESVILLE	22902		1100		E	MARKET	ST		BROWER BLDG 1S	**1,250**	1
	450050154255	CHARLOTTESVILLE	22902		1101		E	JEFFERSON	ST		EAST JEFFERSON LAND TRUST 2S	**1,250**	1
	45VA99152216	CHARLOTTESVILLE	22903		1102	1108		ROSE HILL	DR		ALBEMARLE THERAPY CTR-4 TENANTS 1S	**1,250**	1
	45VA99004127	CHARLOTTESVILLE	22903		1108			FORREST	ST		PACE S TRANSFER SYSTEM 2S	**1,250**	1
	45VA99156780	CHARLOTTESVILLE	22902		111			3	ST	SE	WATER STREET BLD 2S	**1,250**	2
	45VA99005183	CHARLOTTESVILLE	22902	ADJ	1110			EAST MARKET	ST		MARKET SQUARE 2S	**1,250**	2
	45VA99005305	CHARLOTTESVILLE	22902		1119			5	ST	SW	MUNICPAL BAND CENTER 3S	**1,250**	2
	450050001724	CHARLOTTESVILLE	22903		1119		N	EMMET	ST		BARRACKS RD SHOP CTR-M O MERC	**1,250**	1
	45VA99015734	CHARLOTTESVILLE	22902		112		W	MARKET	ST		FIRST CHRISTIAN CHURCH 3S	**1,250**	3
	450050150974	CHARLOTTESVILLE	22903		1137			MILLMONT	ST		MONTGUE REALTY - MO MERC	**1,250**	1
	450050008702	CHARLOTTESVILLE	22903		114	116		10	ST	NW	C-VILLE CLASSIC CARS 1S	**1,250**	1
	45VA99005130	CHARLOTTESVILLE	22902		1144		E	MARKET	ST		GROPEN BUILDING 1S	**1,250**	1
	45VA99008439	CHARLOTTESVILLE	22902		120		E	MAIN	ST		ONE TWENTY EAST MAIN BUILDING 2S	**1,250**	1
	450050018840	CHARLOTTESVILLE	22903		1230			EMMET	ST	N	ARBY S RESTAURANT 1S	**1,250**	1
	45VA99005207	CHARLOTTESVILLE	22903		1230			EMMETT	ST	N	ARBY S RESTAURANT 1S	**1,250**	1
	45VA66016054	CHARLOTTESVILLE	22903		1300			EMMET	ST	N	SUBWAY 1S	**1,250**	1
	450050004230	CHARLOTTESVILLE	22902		1306			KNOLL	ST		GRACE OF CHARLOTTESVILLE BLD 1S	**1,250**	1
	450050160973	CHARLOTTESVILLE	22903		1319		W	MAIN	ST		UNIVERSITY THEATRES	**1,250**	1
	450050016340	CHARLOTTESVILLE	22903		1325	1327	W	MAIN	ST		HUNTER FAULCONER - MO MERC	**1,250**	1
	450050016350	CHARLOTTESVILLE	22903	R	1327	1329	W	MAIN	ST		KABOB AND CURRY-2 TENANTS 2S	**1,250**	1
	450050002540	CHARLOTTESVILLE	22902		1329		E	HIGH	ST		SARTIN BLDG - MO	**1,250**	1
	450050015680	CHARLOTTESVILLE	22901		1339			LONG	ST		RIVERSIDE WASH CLEANERS	**1,250**	1
	45VA99148817	CHARLOTTESVILLE	22903		1401			EMMET	ST		SPEEDY OIL CHANGE 1S	**1,250**	2
	450050002585	CHARLOTTESVILLE	22902		1404		E	HIGH	ST		JAK-N-JIL RESTAURNAT 1S	**1,250**	1
	45VA99005892	CHARLOTTESVILLE	22903		1501			UNIVERSITY	AVE		VASSALOS BUILDING 2S	**1,250**	1
	450050008595	CHARLOTTESVILLE	22902		1515			6	ST	SE	YELLOW CAB TRANSIT-5 TENANTS 1S	**1,250**	1
	450050005681	CHARLOTTESVILLE	22903		1517	1519		UNIVERSITY	AVE		AVENUE A ANNEX 2S	**1,250**	1
	45VA99150898	CHARLOTTESVILLE	22901		1600			EMMET	ST	N	DAYS INN 1S	**1,250**	1
	45VA99154941	CHARLOTTESVILLE	22903		1609			UNIVERSITY	AVE		BODOS BAGEL BAKERY 1S	**1,250**	1
	45VA99000894	CHARLOTTESVILLE	22901	ADJ	1613			EMMET	ST	N	MT VERNON MOTEL/AUNT SARAHS 1S	**1,250**	1
	45VA99005545	CHARLOTTESVILLE	22903		1700	1738		ALLIED	ST		ALLIED REALTY BUILDING 1734 1S	**1,250**	2
	450050000175	CHARLOTTESVILLE	22903		1703	1711		ALLIED	LN		ALLIED REALTY CORP 3S	**1,250**	1
	450050006500	CHARLOTTESVILLE	22902		1710			MONTICELLO	RD		MULTI OCCUPANCY - 2 TENANTS 1S	**1,250**	1
	450050000215	CHARLOTTESVILLE	22903		1731			ALLIED	ST		YE OLDE AND CATHY MARES SEWING 1S	**1,250**	1
	450050000230	CHARLOTTESVILLE	22903		1736			ALLIED	ST		ALLIED REALTY-MO 1S	**1,250**	1
	45VA99005249	CHARLOTTESVILLE	22902		1820			BROADWAY	ST		ANTEC BUILDING 1S	**1,250**	1
	45VA99009802	CHARLOTTESVILLE	22901		1885			SEMINOLE	TRL		RON MARTIN APPLIANCE- 2S	**1,250**	1
	45VA99161219	CHARLOTTESVILLE	22903		1932			ARLINGTON	BLVD		CPS HOME MEDICAL-3 TENANTS 3S	**1,250**	1
	450050000325	CHARLOTTESVILLE	22903		1935			ARLINGTON	BLVD		BARRACKS ROAD SHOPPING CENTER 1S	**1,250**	1
	450050006140	CHARLOTTESVILLE	22902		200		W	MARKET	ST		FELLINIS RESTAURANT 2S	**1,250**	1
	450050003740	CHARLOTTESVILLE	22901		2000			HOLIDAY	DR		LAUGHAM - HILL PETROLEUM	**1,250**	1
	450050161873	CHARLOTTESVILLE	22902		201		W	MONTICELLO	AVE		PORTICO CHURCH 1S	**1,250**	2
	450050009980	CHARLOTTESVILLE	22903		2046			BARRACKS	RD		ANDERSON CARRIAGE FOOD HOUSE 1S	**1,250**	1

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	450050006115	CHARLOTTESVILLE	22902		205			12	ST	NE	T N PRINTING 1S	**1,250**	1
	450050004000	CHARLOTTESVILLE	22903		2132			IVY	RD		ST ANNE S SCH-WALKER HSE-SL O-40	**1,250**	2
	450050000100	CHARLOTTESVILLE	22903		215			ALBEMARLE	ST		CONCRETE CONTRACTOR	**1,250**	1
	450050000685	CHARLOTTESVILLE	22903		2156	2160		BARRACKS	RD		BARRACKS ROAD NORTH SHOP CTR - MO	**1,250**	2
	450050001850	CHARLOTTESVILLE	22903		2208			FONTAINE	AVE		CARMELLO S 2S	**1,250**	1
	450050001855	CHARLOTTESVILLE	22903		2210			FONTAINE	AVE		PAUL PIZZERIA	**1,250**	1
	45VA99010121	CHARLOTTESVILLE	22902		225	227	W	MAIN	ST		THE UPSTAIRS BUILDING 2S	**1,250**	1
	450003008285	CHARLOTTESVILLE	22901		234	240		ZAN	RD		SEMINOLE TRAIL SHOPPING CENTER 1S	**1,250**	1
	45VA99001585	CHARLOTTESVILLE	22911		260			PANTOPS	CTR		PONDEROSA STEAKHOUSE 1S	**1,250**	1
	450050018340	CHARLOTTESVILLE	22902		300			PRESTON	AVE		CITIZENS COMMONWEALTH CENTER 5S	**1,250**	1
	450050008360	CHARLOTTESVILLE	22902		303			2	ST	SE	H M GLEASON 1S	**1,250**	1
	45VA99154351	CHARLOTTESVILLE	22911		304			HICKMAN	RD		PERKINS BLD 1S	**1,250**	2
	450050000419	CHARLOTTESVILLE	22902	ADJ	310			AVON	ST		AVON CT BLD D - 2S	**1,250**	1
	450050002471	CHARLOTTESVILLE	22902		315		E	HIGH	ST		CITY OF CHARLOTTESVILLE-COURTHOUSE	**1,250**	1
	450050150973	CHARLOTTESVILLE	22903		320		W	MAIN	ST		T C CORP - LE SNAIL RESTAURANT	**1,250**	1
	450050005320	CHARLOTTESVILLE	22903		321	325	W	MAIN	ST		RAY FISHER BLDG-M O MERC	**1,250**	1
	450050005322	CHARLOTTESVILLE	22903		327		W	MAIN	ST		CHARNAN LAND TRUST	**1,250**	1
	45VA99000136	CHARLOTTESVILLE	22902		329			RIVERSIDE	AVE		CHRIST COMMUNITY CHURCH 3S	**1,250**	1
	45VA99156248	CHARLOTTESVILLE	22902	R	329			RIVERSIDE	AVE		CHRIST COMMUNITY CHURCH ROOMS 1S	**1,250**	2
	450050161990	CHARLOTTESVILLE	22903		331	333	W	MAIN	ST		BULL ALLEY RESTAURANT	**1,250**	1
	450050159699	CHARLOTTESVILLE	22904		351			MCCORMICK	RD		UVA-THORNTON HALL-N WING 3S	**1,250**	1
	450050001512	CHARLOTTESVILLE	22903		380			EMMET	ST	N	PANDA GARDEN RESTAURANT 1S	**1,250**	1
	450050150421	CHARLOTTESVILLE	22902		400	402	E	MARKET	ST		UNLIMITED VITALITY	**1,250**	2
	450050005000	CHARLOTTESVILLE	22902		406	408	E	MAIN	ST		BROWNS-HOUSE GOODS	**1,250**	1
	450050159178	CHARLOTTESVILLE	22902		414		E	MAIN	ST		BUDDY S BARBEQUE	**1,250**	1
	450050006202	CHARLOTTESVILLE	22902		414		E	MARKET	ST		MARKET STREET OFFICE BUILDING 2S	**1,250**	2
	450050004580	CHARLOTTESVILLE	22902		415	417	E	MAIN	ST		NOOK RESTAURANT 2S	**1,250**	1
	45VA99010977	CHARLOTTESVILLE	22902		511	515	E	WATER	ST		C O RESTAURANT GALLERY 2S	**1,250**	1
	45VA99147922	CHARLOTTESVILLE	22903		513		W	MAIN	ST		C AND R AUTO SERVICE 2S	**1,250**	2
	450050150184	CHARLOTTESVILLE	22902		550			MEADE	AVE		JOHN KULICK-SILK SCREENING	**1,250**	2
	450050001260	CHARLOTTESVILLE	22903		600	604		CONCORD	AVE		VALLEY OFF MACHINE EQUIPMENT 1S	**1,250**	1
	45VA99155094	CHARLOTTESVILLE	22903		603			RIVANNA	AVE		INVISIBLE PATH BLD 2S	**1,250**	2
	450050159784	CHARLOTTESVILLE	22903		606			RIVANNA	AVE		CHEF TED CATERING 2S	**1,250**	1
	450050116670	CHARLOTTESVILLE	22903	2R	608	612		PRESTON	AVE		TILLMANS FURNITURE 1S	**1,250**	1
	450050001882	CHARLOTTESVILLE	22903		618			FORREST	ST		GITCHELL S STUDIO P STUDIO 1S	**1,250**	1
	450050153897	CHARLOTTESVILLE	22903		625		W	MAIN	ST		HORSE AND HOUND GASTROPUB BLD 2S	**1,250**	1
	450050008309	CHARLOTTESVILLE	22902		736		S	1	ST		JOHN M ANDERSON CONSTRUCTION 1S	**1,250**	1
	45VA99005736	CHARLOTTESVILLE	22903		810		W	MAIN	ST		AMTRACK 2S	**1,250**	1
	450050005420	CHARLOTTESVILLE	22903		811	817	W	MAIN	ST		HI-STARR LTD PARTNERSHIP-MO 2S	**1,250**	1
	45VA99002593	CHARLOTTESVILLE	22903		813	817	W	MAIN	ST		HISTARR BLDG 2S MO	**1,250**	1
	450050000800	CHARLOTTESVILLE	22902		823			MONTICELLO	RD		MO MERC 1S	**1,250**	1
	450050001160	CHARLOTTESVILLE	22903	R	835			CHERRY	AVE		RONNIE S AUTO SVC 1S	**1,250**	1
	45VA99010348	CHARLOTTESVILLE	22903		900			PRESTON	AVE		MOTO VIRGINIA 1S	**1,250**	1
	450050000160	CHARLOTTESVILLE	22903		903	905		ALBEMARLE	ST		STROTHERS BUILDING 1S	**1,250**	1
	450050005445	CHARLOTTESVILLE	22903		909		W	MAIN	ST		TOWN SQUARE BUILDING 2S	**1,250**	1
	450050002127	CHARLOTTESVILLE	22903		914			HARRIS	ST		BAILEY PRINTING INC 2S	**1,250**	1
	450050151058	CHARLOTTESVILLE	22902		923		E	MARKET	ST		FLOWERS BAKING CO	**1,250**	2
	45VA99011745	CHARLOTTESVILLE	22902		1			SNL	PLZ		SNL BUILDING 5S	**1,000**	1
	450050150160	CHARLOTTESVILLE	22902		100			MEADE	AVE		BOBBY MORRIS BODY SHOP	**1,000**	1
	450050165950	CHARLOTTESVILLE	22903		1002		W	MAIN	ST		SLIPCOVER NEEDLE CUTS ROOM	**1,000**	1
	450050114550	CHARLOTTESVILLE	22902	1R	1013			CARLTON	AVE		BRACKETT AUTO BODY SHOP	**1,000**	1
	450050008760	CHARLOTTESVILLE	22903		102			14	ST	NW	FOURTEENTH ST MALL 2S	**1,000**	1
	450050160062	CHARLOTTESVILLE	22901	1R	1025			PARK	ST		HERITAGE CHRISTIAN SCHOOL	**1,000**	1
	450050001476	CHARLOTTESVILLE	22903		104			EMMET	ST	N	UNIVERSITY OF VA 2S	**1,000**	1
	450050001700	CHARLOTTESVILLE	22903		1047	1049	N	EMMET	ST		BARRACKS ROAD SHOPPING CENTER 1S	**1,000**	2
	45VA99010212	CHARLOTTESVILLE	22902		105			RIDGE	ST		MOUNT ZION BAPTIST CHURCH 1S	**1,000**	2

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	450050008880	CHARLOTTESVILLE	22903		107			6	ST	NW	C AND R AUTO SERVICE 2S	**1,000**	3
	450050008340	CHARLOTTESVILLE	22902		109			2	ST	SE	GEAINNINI THOMAS BLDG 3S	**1,000**	1
	450050021125	CHARLOTTESVILLE	22903		109			HARMON	ST		CHEZ-VOUS CATERING 2S	**1,000**	1
	450050005165	CHARLOTTESVILLE	22902		109		W	MAIN	ST		MILLERS RESTAURANT 3S	**1,000**	1
	45VA99003402	CHARLOTTESVILLE	22903		11			ELLIEWOOD	AVE		THE PIGEON HOLE 2S	**1,000**	1
	450050008353	CHARLOTTESVILLE	22902		110	112		2	ST	NE	J R MORRIS BLDG MO MERC	**1,000**	1
	450050014140	CHARLOTTESVILLE	22903		1111			HARRIS	ST		CHARLOTTESVILLE PRESS INC 1S	**1,000**	1
	450050001025	CHARLOTTESVILLE	22903		1117			EMMET	ST	N	BARRACKS ROAD SHOPPING CENTER 1S	**1,000**	1
	450050003210	CHARLOTTESVILLE	22903		112			9	ST	SW	EAGLE AUTO BODY 1S	**1,000**	1
	450050153639	CHARLOTTESVILLE	22902		1130			EAST MARKET	ST		MARKET SQUARE 1S	**1,000**	2
	450050159320	CHARLOTTESVILLE	22903		1134			ROSE HILL	DR		KING LINDSAY PRINTING	**1,000**	2
	450050012400	CHARLOTTESVILLE	22903		1140			EMMET	ST	N	THE TAVERN 1S	**1,000**	1
	450050008710	CHARLOTTESVILLE	22903		118			11	ST	SW	U S POST OFFICE	**1,000**	1
	450050006465	CHARLOTTESVILLE	22902		1200			MONTICELLO	RD		MASTERS AUTO BODY INC 1S	**1,000**	1
	450050006010	CHARLOTTESVILLE	22903		1202		W	MAIN	ST		EL JARIPEO 1S	**1,000**	1
	450050002220	CHARLOTTESVILLE	22903		1216			HARRIS	ST		HDS FIBERS INC	**1,000**	1
	45VA66014487	CHARLOTTESVILLE	22902		123		E	MAIN	ST		WELLS FARGO BANK 8S	**1,000**	1
	45VA66016056	CHARLOTTESVILLE	22903		1232			EMMET	ST	N	ARCH S FROZEN YOGURT 2S	**1,000**	1
	450050002260	CHARLOTTESVILLE	22903		1240	1242		HARRIS	ST		GRAVES ELECTRONICS	**1,000**	1
	450050007160	CHARLOTTESVILLE	22902		1329			RIVERDALE	DR		RIVERDALE 2S	**1,000**	1
	450050013580	CHARLOTTESVILLE	22902		136	138		GARRETT	ST		STANDARD PRODUCE CO	**1,000**	1
	450050159645	CHARLOTTESVILLE	22903		1403			EMMET	ST	N	CAVALIER DINER 1S	**1,000**	1
	450050154516	CHARLOTTESVILLE	22903	R	1413			BRIARCLIFF	AVE		DON DOBBINS UPHOLSTERY SHOP 2S	**1,000**	1
	450050014520	CHARLOTTESVILLE	22902		1414		E	HIGH	ST		FISHER AUTO PARTS 2S	**1,000**	1
	45VA99154939	CHARLOTTESVILLE	22903		1418			EMMET	ST	N	BODOS BAGEL BAKERY 1S	**1,000**	1
	45VA99005016	CHARLOTTESVILLE	22903		1427			UNIVERSITY	AVE		SHEPPE BUILDING 2S	**1,000**	1
	450050014600	CHARLOTTESVILLE	22902		1522		E	HIGH	ST		CHARLIE S RESTAURANT 1S	**1,000**	1
	450050014580	CHARLOTTESVILLE	22902		1538		E	HIGH	ST		COSNER BROTHERS BODY SHOP 1S	**1,000**	1
	450050001400	CHARLOTTESVILLE	22903		16			ELLIEWOOD	AVE		BILTMORE GRILL 2S	**1,000**	1
	45VA99004290	CHARLOTTESVILLE	22901	5R	1600			EMMET	ST	N	QUALITY INN 3S	**1,000**	1
	45VA99004393	CHARLOTTESVILLE	22903		167			CHANCELLOR	ST		AMERICAN DREAM CATERING 2S	**1,000**	1
	45VA99150949	CHARLOTTESVILLE	22901		1709			EMMET	ST	N	POPEYES FRIED CHICKEN 2S	**1,000**	1
	450050000231	CHARLOTTESVILLE	22903		1738			ALLIED	ST		PEIDMONT PAINT FINISH LLC 1S	**1,000**	1
	450050000200	CHARLOTTESVILLE	22903		1745			ALLIED	ST		THE POTOMAC SERVICE CORP	**1,000**	2
	45VA99015223	CHARLOTTESVILLE	22901		1817			EMMET	ST	N	MILAN INDIAN CUISINE 1S	**1,000**	1
	450050001819	CHARLOTTESVILLE	22901		1817			EMMET	ST	N	GOODFELLOW RESTAURANT 2S	**1,000**	1
	45VA99159399	CHARLOTTESVILLE	22901		1819			EMMET	ST	N	VACANT BUILDING 1S	**1,000**	1
	450050153200	CHARLOTTESVILLE	22903		1901			THOMSON	RD		WESLEY MEMORIAL UNITED METHODIST CH	**1,000**	1
	450050153302	CHARLOTTESVILLE	22903		1909			THOMSON	RD		WESLEY MEMORIAL CHURCH 1S	**1,000**	2
	450050000400	CHARLOTTESVILLE	22903		1936			ARLINGTON	BLVD		U OF VA EMPLOYEE CREDIT UNION 2S	**1,000**	1
	450050153389	CHARLOTTESVILLE	22902		200			2	ST	NE	CITY OF CHARLOTTESVILLE-SEN CITIZEN	**1,000**	1
	450050003750	CHARLOTTESVILLE	22901		2006			HOLIDAY	DR		SZECHUAN RESTAURANT 1S	**1,000**	1
	45VA99004012	CHARLOTTESVILLE	22903		2015			IVY	RD		WISTERIA PROPERTIES 5S	**1,000**	1
	450050152499	CHARLOTTESVILLE	22901		2024			HOLIDAY	DR		DONNAS HAIR STUDIO-1 TENANT 1S	**1,000**	2
	45VA99147766	CHARLOTTESVILLE	22902		204	206	E	MARKET	ST		VACANT BUILDING 2S	**1,000**	2
	450050153391	CHARLOTTESVILLE	22902		205			RIDGE	ST		CITY OF CHARLOTTESVILLE-FIRE STA	**1,000**	1
	45VA99147765	CHARLOTTESVILLE	22902		206		E	MARKET	ST		MIDTOWN MUSIC 2S	**1,000**	2
	45VA66016620	CHARLOTTESVILLE	22902		211		E	HIGH	ST		BUCK TOSCANO TERESKERZ 2S	**1,000**	1
	45VA99155418	CHARLOTTESVILLE	22903		2115			JEFFERSON PARK	AVE		FRYS SPRING STATION 1S	**1,000**	1
	450050000640	CHARLOTTESVILLE	22903		2128			BARRACKS	RD		BARRACKS ROAD NORTH SHOP CTR	**1,000**	2
	45VA99147762	CHARLOTTESVILLE	22902		213			7	ST	NE	PRIVATE PRACTICE INC 2S	**1,000**	2
	450050000700	CHARLOTTESVILLE	22903		2162			BARRACKS	RD		PETER CHANG S CHINA GRILL 1S	**1,000**	1
	450050005861	CHARLOTTESVILLE	22902		220		W	MARKET	ST		VINEGAR HILL THEATER 1S	**1,000**	2
	45VA99157248	CHARLOTTESVILLE	22903		2200			JEFFERSON PARK	AVE		DURTY NELLYS PUB DELI-2 TENANTS 1S	**1,000**	2
	450050001840	CHARLOTTESVILLE	22903		2203	2205		FONTAINE	AVE		HOFF MOTOR 1S	**1,000**	1
	45VA99157162	CHARLOTTESVILLE	22901		230			ZAN	RD		SEMINOLE SQUARE SHOPPING CTR 1S	**1,000**	1

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	450050002312	CHARLOTTESVILLE	22901		2312			WAYNE	AVE		DRIVELINE SPECIALTY-2 TENANTS 2S	**1,000**	1
	450050005250	CHARLOTTESVILLE	22902		250		W	MAIN	ST		LEWIS CLARK SQUARE	**1,000**	1
	450050005260	CHARLOTTESVILLE	22903		301	307	W	MAIN	ST		PRIME EQUIP-RENTALS 2S	**1,000**	1
	450050005300	CHARLOTTESVILLE	22903		315		W	MAIN	ST		RUSSELL MOONEY-MO	**1,000**	1
	450050166659	CHARLOTTESVILLE	22903		337			15	ST	NW	VA AMBULATORY SURGERY SL X NET	**1,000**	1
	450050001516	CHARLOTTESVILLE	22903		400			EMMET	ST	N	AFGHAN KABOB PALACE 1S	**1,000**	1
	45VA99159417	CHARLOTTESVILLE	22902		400	402	E	JEFFERSON	ST		DELOACH ANTIQUES-1 TENANT 3S	**1,000**	2
	450050004980	CHARLOTTESVILLE	22902		404		E	MAIN	ST		DON WHITED-JEWELRY ASSEMBLY	**1,000**	2
	45VA99159049	CHARLOTTESVILLE	22903		406	408	W	MAIN	ST		MULTI-OCCUPANCY 3 TENANTS 2S	**1,000**	2
	450050006440	CHARLOTTESVILLE	22902		501	505		MONTICELLO	RD		ONE TWENTY E MAIN INVESTMENT 2	**1,000**	1
	45VA99008241	CHARLOTTESVILLE	22903		512		W	MAIN	ST		BLUE MOON CAFE 3S	**1,000**	1
	450050008045	CHARLOTTESVILLE	22902		513			STEWART	ST		513A B ALBEMARLE LOCK SAFE	**1,000**	2
	45VA99015582	CHARLOTTESVILLE	22903		631	633	W	MAIN	ST		UPSTREAM AND ASSOCIATES 2S	**1,000**	1
	45VA66016410	CHARLOTTESVILLE	22903		632		W	MAIN	ST		FIRST BAPTIST CHURCH 2S	**1,000**	1
	450050011860	CHARLOTTESVILLE	22903		701			DALE	AVE		TAYLOR BUILDING 1S	**1,000**	1
	450050072275	CHARLOTTESVILLE	22903		714	716		ROSE HILL	DR		BROWER BLDG 1S	**1,000**	2
	450050006107	CHARLOTTESVILLE	22902		805		E	MARKET	ST		GUADALAJARA MEXICAN RESTAURANT 1S	**1,000**	1
	45VA99015031	CHARLOTTESVILLE	22902		824			HINTON	AVE		THE LOCAL RESTAURANT 2S	**1,000**	1
	45VA99015030	CHARLOTTESVILLE	22902		826			HINTON	AVE		TAVOLA RESTAURANT 2S	**1,000**	1
	450050006420	CHARLOTTESVILLE	22902		826	830		MONTICELLO	AVE		BELMONT BAPTIST CHURCH 2S	**1,000**	1
	450050001360	CHARLOTTESVILLE	22903		9			ELLIEWOOD	AVE		ANNE E ALBRIGHT BLDG-RESTAURANT	**1,000**	1
	450050009460	CHARLOTTESVILLE	22903		903			ANDERSON	ST		ROBINSON FURN REPAIR/UPHOLSTERY	**1,000**	1
	450050014400	CHARLOTTESVILLE	22902		916		E	HIGH	ST		BLUE RIDGE PHARMACIES-MO	**1,000**	1
	450050001635	CHARLOTTESVILLE	22903		941			EMMET	ST	N	MCDONALD S RESTAURANT 2S	**1,000**	1
	450050002080	CHARLOTTESVILLE	22903		999			GROVE	ST		ROBERT LEE CO-MTL WKER	**1,000**	1
	450050011750	**CHARLOTTESVILLE**	**22901**		**1**			**DELEVAN**	**ST**		**META T CHISHOLM - BLDG 1 1S**	**750**	**2**
	45VA99003615	CHARLOTTESVILLE	22902		1021			LINDEN	AVE		PAULS USED CARS 1S	**750**	2
	450050017540	CHARLOTTESVILLE	22903		1021			MILLMONT	ST		RECORDING FOR THE BLIND INC	**750**	2
	450050160063	CHARLOTTESVILLE	22901	2R	1025			PARK	ST		HERITAGE CHRISTIAN SCHOOL	**750**	1
	450050160064	CHARLOTTESVILLE	22901	3R	1025			PARK	ST		HERITAGE CHRISTAIN SCHOOL	**750**	1
	450050160065	CHARLOTTESVILLE	22901	4R	1025			PARK	ST		HERITAGE CHRISTAIN SCHOOL	**750**	1
	450050151057	CHARLOTTESVILLE	22903		108			10	ST	NW	JOSEPH A TEAGUE FUNERAL HOME STGE	**750**	1
	45VA99151502	CHARLOTTESVILLE	22903	R	1100			HARRIS	ST		VIRGINIA OIL COMPANY 1S	**750**	2
	45VA99000179	CHARLOTTESVILLE	22902		1106		E	MARKET	ST		BROWER BLDG 1S	**750**	2
	450050017400	CHARLOTTESVILLE	22903		111			MAURY	AVE		LEE HUFF-SEVEN DAY JR MKT 1S	**750**	2
	450050166499	CHARLOTTESVILLE	22902		1112		E	MARKET	ST		EAST MARKET SQUARE LIMITED-BLDG 1	**750**	2
	45VA99013858	CHARLOTTESVILLE	22902		113			3	ST	SE	VIRGINIA NATIONAL BANK-1 TENANT 2S	**750**	2
	450050160768	CHARLOTTESVILLE	22902		113		W	MARKET	ST		B A HANKINS JILL T RINEHART-REST	**750**	1
	450050001540	CHARLOTTESVILLE	22903		1134			EMMET	ST	N	AAMCO TRANSMISSIONS 1S	**750**	2
	450050161859	CHARLOTTESVILLE	22902		1136		E	MARKET	ST		C R AUTO SVC LLC 1S	**750**	1
	450050014460	CHARLOTTESVILLE	22902		1142		E	HIGH	ST		STUART S BURFORD CATERER	**750**	1
	45VA99008141	CHARLOTTESVILLE	22901		1176			RIVER	RD		RAY CARR TIRES 2S	**750**	2
	45VA99011368	CHARLOTTESVILLE	22903	ADJ	1200			FORREST	ST		MURRAY HIGH SCHOOL 1S	**750**	2
	45VA66016055	CHARLOTTESVILLE	22903		1201			EMMET	ST	N	SUN TRUST BANK 1S	**750**	1
	45VA99161069	CHARLOTTESVILLE	22903		1207			GRADY	AVE		QUICK MART 1S	**750**	2
	45VA99150207	CHARLOTTESVILLE	22902		1208		E	MARKET	ST		ENVIROMENTAL STANDARD INC 1S	**750**	1
	450050009820	CHARLOTTESVILLE	22902		1210			AVON	ST		STONEY S STORE	**750**	2
	45VA99156148	CHARLOTTESVILLE	22902		1214			MONTICELLO	RD		BEYOND MEASURE WOODWORKING 1S	**750**	1
	450050002340	CHARLOTTESVILLE	22903		1229			HARRIS	ST		ALLIED REALTY CORP-BLDG A/2 3	**750**	2
	450050018721	CHARLOTTESVILLE	22901		1234			RIVER	RD		W A LYNCH ROOFING CO 1S	**750**	2
	450050160946	CHARLOTTESVILLE	22903	1R	1240	1242		HARRIS	ST		H W GRAVES	**750**	2
	45VA99152376	CHARLOTTESVILLE	22903		1248			EMMET	ST	N	LORD HARDWICKE S 2S	**750**	1
	450050001586	CHARLOTTESVILLE	22903		1250			EMMET	ST	N	SAVOUR RESTAURANT 1S	**750**	1
	450050001585	CHARLOTTESVILLE	22903		1252			EMMET	ST	N	AT T MOBILITY 1S	**750**	2
	450050008701	CHARLOTTESVILLE	22903		126			10	ST	NW	MOTOR SPECIALTY CO - MACHINE SHOP	**750**	1
	450050001630	CHARLOTTESVILLE	22903		129			EMMET	ST	N	THE VILLA 1S	**750**	1

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	450050002385	CHARLOTTESVILLE	22903		1301			HARRIS	ST		ALLIED REALTY CORP PIEDMONT CLEANER	750	2
	450050000720	CHARLOTTESVILLE	22901		1309			BELLEVIEW	AVE		B W AUTO BODY 1S	750	1
	45VA99000080	CHARLOTTESVILLE	22902		1331		E	HIGH	ST		BERT BLDG 2S	750	1
	450050002560	CHARLOTTESVILLE	22902		1331		E	HIGH	ST		1331A THE HAPPY STRIPPER INC 2S	750	1
	450050016345	CHARLOTTESVILLE	22903		1331		W	MAIN	ST		CAFE EUROPA 1S	750	1
	450050411187	CHARLOTTESVILLE	22903		1403	1409		UNIVERSITY	AVE		TIGER INVESTMENTS BLD 1S	750	1
	450050014500	CHARLOTTESVILLE	22902		1412		E	HIGH	ST		LONG BLDG/TUBBY SUB REST 1S	750	1
	450050160060	CHARLOTTESVILLE	22903	ADJ	1414			WESTWOOD	RD		HERITAGE CHRISTIAN SCHOOL	750	1
	450050160061	CHARLOTTESVILLE	22903		1414			WESTWOOD	RD		HERITAGE CHRISTIAN SCHOOL	750	1
	45VA99005124	CHARLOTTESVILLE	22902		1427			HAZEL	ST		RIVERSIDE LUNCH 2S	750	1
	45VA99155136	CHARLOTTESVILLE	22902		1500			MERIDIAN	ST		COMMONWEALTH WINES BUILDING 1S	750	2
	450050004593	CHARLOTTESVILLE	22902		1551		E	HIGH	ST		DALE S OLE VIRGINIA FRIED CHICKEN	750	1
	450050014593	CHARLOTTESVILLE	22902		1551		E	HIGH	ST		GOLDEN SKILLET RESTAURANT	750	1
	450050161435	CHARLOTTESVILLE	22903		1562			DAIRY	RD		CHARLOTTESVILLE SCHOOL SUPT 1S	750	3
	450050006650	CHARLOTTESVILLE	22901		1564			SEMINOLE	TRL		GOODYEAR TIRE	750	1
	45VA99004287	CHARLOTTESVILLE	22901	R	1600			EMMET	ST	N	DAYS INN 2S	750	1
	45VA99004289	CHARLOTTESVILLE	22901		1600			EMMET	ST	N	DAYS INN 3S	750	1
	45VA99004291	CHARLOTTESVILLE	22901	R2	1600			EMMET	ST	N	DAYS INN 3S	750	1
	45VA99148220	CHARLOTTESVILLE	22903	R	1720			CHERRY	AVE		CHERRY AVENUE CHRISTIAN CHURCH 1S	750	1
	450050001825	CHARLOTTESVILLE	22901		1906			EMMET	ST	N	MEINEKE CAR CARE CTR 1S	750	2
	450050001832	CHARLOTTESVILLE	22901		1908			EMMET	ST	N	SPEEDEE OIL CHANGE TUNE UP 1S	750	2
	450050153303	CHARLOTTESVILLE	22903	R	1909			THOMSON	RD		WESLEY MEMORIAL CHURCH ED BLDG 2S	750	1
	45VA66015753	CHARLOTTESVILLE	22902		1915		E	MARKET	ST		MILL HOUSE CONDOS 1 BLDG 3S	750	1
	45VA99002367	CHARLOTTESVILLE	22903		20			ELLIEWOOD	AVE		THE BUDDIST BIKER 2S	750	1
	450050001420	CHARLOTTESVILLE	22903		20			ELLIEWOOD	AVE		ALBRIGHT BLDG - REST BOOK STORE	750	1
	450050008210	CHARLOTTESVILLE	22902		200		W	WATER	ST		MONO LOCO 1S	750	1
	450050009000	CHARLOTTESVILLE	22903		202			10	ST	NW	R02 CATERING 1S	750	1
	450050004200	CHARLOTTESVILLE	22903		2025			IVY	RD		UNIVERSITY GILL 1S	750	1
	450050087701	CHARLOTTESVILLE	22903	R	205			7	ST	SW	META T CHISHOLM BLDG 1S	750	2
	45VA99158039	CHARLOTTESVILLE	22902		206			5	ST	NE	DALGLIESH GILP PAX ARCHITECTS 3S	750	2
	45VA99158040	CHARLOTTESVILLE	22902		208	212		5	ST	NE	MULTI-OCCUPANCY 3 TENANTS 3S	750	2
	450050000315	CHARLOTTESVILLE	22901		2102			ANGUS	RD		FRANK NEOFOTIS MO MERC	750	1
	450050009480	CHARLOTTESVILLE	22901		2104			ANGUS	RD		QUICK PICK-MO 1S	750	1
	450050000520	CHARLOTTESVILLE	22903		2110	2112		BARRACKS	RD		BARRACKS ROAD NORTH SHOP CTR	750	2
	450050000530	CHARLOTTESVILLE	22903		2114			BARRACKS	RD		BARRACKS RD N SHOP CTR-MO	750	2
	450050000540	CHARLOTTESVILLE	22903		2115	2116		BARRACKS	RD		BARRACKS ROAD NORTH SHOP CTR 1S	750	2
	45VA99149605	CHARLOTTESVILLE	22901		2115			HYDRAULIC	RD		HARLOW BUILDING 2S	750	2
	450050000600	CHARLOTTESVILLE	22903		2120	2122		BARRACKS	RD		BARRACKS RD NORTH SHP CTR-LA VOUGE	750	2
	45VA99004660	CHARLOTTESVILLE	22903		2127			IVY	RD		TOYKO ROSE RESTAURANT 1S	750	1
	450050152044	CHARLOTTESVILLE	22902		213			2	ST	SW	BANG 2S	750	1
	450050000620	CHARLOTTESVILLE	22903		2130			BARRACKS	RD		BARRACKS ROAD NORTH SHOP CTR 1S	750	2
	450050014240	CHARLOTTESVILLE	22902		215		E	HIGH	ST		VILLAGE SCHOOL 2S	750	1
	450050003780	CHARLOTTESVILLE	22902		221		E	MAIN	ST		SAL S PIZZA 1S	750	1
	450050015850	CHARLOTTESVILLE	22902		223	225	E	MAIN	ST		CHAPS 2S	750	1
	450050008001	CHARLOTTESVILLE	22903		229			5	ST	NW	HARRIS FURNITURE SHOP 1S	750	1
	45VA99009109	CHARLOTTESVILLE	22901		2340			COMMONWEALTH	DR		PARKER MCELWAIN JACOBS 3S	750	1
	450050154482	CHARLOTTESVILLE	22902		300		E	JEFFERSON	ST		HANCKEL-CITIZENS INSURANCE 2S	750	2
	450050002470	CHARLOTTESVILLE	22902		301		E	HIGH	ST		MULTI OFFICE BLDG 2S	750	2
	45VA99006908	CHARLOTTESVILLE	22902		308			RIDGE	ST		FOOD MASTER 2S	750	1
	45VA99160240	CHARLOTTESVILLE	22902		310			2	ST	SE	MARRACCINI DESIGNS-1 TENANT 1S	750	1
	450050025061	CHARLOTTESVILLE	22903		339	341		11	ST	NW	COVENENT CHURCH OF GOD 1S	750	1
	45VA66007775	**CHARLOTTESVILLE**	**22902**		**350**			**RTE 250**		**W**	**CITY OF CHARLOTTESVILLE FIRE 2S**	**750**	**1**
	450050159857	CHARLOTTESVILLE	22902		400			AVON	ST		FOXES CAFE 1S	750	1
	45VA99160878	CHARLOTTESVILLE	22902		403			AVON	ST		FOXS CAFE 1S	750	1
	450050008600	CHARLOTTESVILLE	22902		404			8	ST	NE	THE MAPLEWOOD BUILDING 3S	750	1
	450050008410	CHARLOTTESVILLE	22902		407			3	ST	NE	MONTICELLO AREA COMM ACTION AGENCY	750	2

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	45VA66016937	CHARLOTTESVILLE	22903		407			12	ST	NW	HABITATIONAL-1 BLDG 3S	**750**	1
	45VA99158877	CHARLOTTESVILLE	22902		409			3	ST	NE	OFFICE PUBLIC DEFENDER 2S	**750**	2
	450050022700	CHARLOTTESVILLE	22902		409		E	HIGH	ST		ALBEMARLE COUNTY-OLD JAIL BLDG	**750**	1
	45VA99159418	CHARLOTTESVILLE	22902		410		E	JEFFERSON	ST		THE 1780 INN AT COURT SQUARE 2S	**750**	2
	450050021000	CHARLOTTESVILLE	22902		415			4	ST	NE	MCCLOURE CALLAHAN ATKINS 3S	**750**	1
	450050008450	CHARLOTTESVILLE	22903		416			4	ST	NW	WENDY S 1S	**750**	1
	45VA99009097	CHARLOTTESVILLE	22903		420		W	MAIN	ST		STATION RESTAURANT 1S	**750**	1
	45VA99147769	CHARLOTTESVILLE	22903		420		W	MAIN	ST		WHITE ORCHID 1S	**750**	1
	45VA99002022	CHARLOTTESVILLE	22902		500			COURT	SQ		MONTICELLO PLAZA 10S	**750**	1
	45VA99147921	CHARLOTTESVILLE	22903		505		W	MAIN	ST		C AND R AUTO SERVICE 1S	**750**	2
	450050008042	CHARLOTTESVILLE	22902		508			STEWART	ST		DOMINO S PIZZA 1S	**750**	1
	450050005100	CHARLOTTESVILLE	22902		512	518	E	MAIN	ST		COLONIAL CAFE	**750**	1
	45VA99005230	CHARLOTTESVILLE	22902		512			RIVES	ST		QUEEN S MARKET 1S	**750**	1
	450050005120	CHARLOTTESVILLE	22902		520	522	E	MAIN	ST		GUARANTY BLDG 2S	**750**	2
	45VA99012661	CHARLOTTESVILLE	22903		600			CHERRY	AVE		SEAFOOD EXPRESS 1S	**750**	1
	450050001140	CHARLOTTESVILLE	22903		601			CHERRY	AVE		CITY DRY CLEANERS	**750**	2
	450050152256	CHARLOTTESVILLE	22903		604	618	W	MAIN	ST		HOFF MOTOR CO-MORRIS TIRE SERVICE	**750**	1
	450050116671	CHARLOTTESVILLE	22903	3R	608			PRESTON	AVE		NAPA MACHINE SHOP	**750**	1
	450050005920	CHARLOTTESVILLE	22903		616		W	MAIN	ST		MORRIS TIRE SERVICE	**750**	1
	450050001100	CHARLOTTESVILLE	22903		701			CHARLTON	AVE		FLYING QUAIL LAND TRUST	**750**	1
	45VA99011421	CHARLOTTESVILLE	22903		706			ROSE HILL	DR		DAVID WILDMAN BUILDING 2S	**750**	1
	45VA99158662	CHARLOTTESVILLE	22903		711		W	MAIN	ST		LABOR READY 2S	**750**	2
	45VA99000314	CHARLOTTESVILLE	22903	R	719		W	MAIN	ST		BRITISH PRECISION SERVICE 1S	**750**	2
	45VA99158207	CHARLOTTESVILLE	22903	1R	719		W	MAIN	ST		BRITISH PRECISION SRVC-OFFICE 1S	**750**	2
	45VA99004692	CHARLOTTESVILLE	22903		814	816		CHERRY	AVE		CHERRY AVE SHOPPING CENTER 1S	**750**	1
	45VA99148721	CHARLOTTESVILLE	22902		815		E	HIGH	ST		TARLETON S OAK FOOD MART 1S	**750**	3
	45VA66016293	CHARLOTTESVILLE	22903		827			CHERRY	AVE		SUN SHINE MINI MART 1S	**750**	1
	450050147590	CHARLOTTESVILLE	22903		830			HARRIS	ST		QUALITY WELDING	**750**	1
	45VA99158552	CHARLOTTESVILLE	22903		832			CHERRY	AVE		GOCO-CONVENIENCE STORE 1S	**750**	1
	450050005441	CHARLOTTESVILLE	22903	ADJ	853		W	MAIN	ST		VIRGINIA BLOOD SVCS CTR 1S	**750**	2
	450050013920	CHARLOTTESVILLE	22903		900			HARRIS	ST		EMERGENCY FOOD BANK 1S	**750**	2
	450050161204	CHARLOTTESVILLE	22902		901		E	MARKET	ST		DOWNTOWN GULF SER STA GARAGE	**750**	2
	45VA99158548	CHARLOTTESVILLE	22903		924			HARRIS	ST		GOCO-CONVENIENCE STORE 1S	**750**	1
	45VA99004395	CHARLOTTESVILLE	22903		939			PRESTON	AVE		STRIPER JOHN S 1S	**750**	1
	450050161498	CHARLOTTESVILLE	22904					MCCORMICK	RD		RIVANNA WTR/SWR-OBSERV WTR TRTMT	**750**	1
	450050161499	CHARLOTTESVILLE	22904					MCCORMICK	RD		RIVANNA WTR/SWR-OBSERV WTR TRTMT	**750**	2
	45VA66016936	CHARLOTTESVILLE	22903		1	6		LATROBE	CT		HABITATIONAL-6 BLDGS 1S	**500**	1
	45VA99007608	CHARLOTTESVILLE	22902		103	107	S	1	ST		THE TERRACES-4 TENANTS 5S	**500**	1
	45VA99159841	CHARLOTTESVILLE	22903		109			14	ST	NW	BASIL MEDITERRANEAN BISTRO 1S	**500**	1
	45VA99151501	CHARLOTTESVILLE	22903	ADJ	1100			HARRIS	ST		VIRGINIA OIL COMPANY 1S	**500**	2
	45VA99004128	CHARLOTTESVILLE	22903	ADJ	1108			FORREST	ST		PACE S TRANSFER SYSTEM 1S	**500**	1
	450050007330	CHARLOTTESVILLE	22901		1160			RIVER	RD		HICKY S WOODWORKING SHOP 2S	**500**	1
	45VA99004347	CHARLOTTESVILLE	22902		1200			5	ST	SW	HOLIDAY INN 6S	**500**	1
	45VA99011370	CHARLOTTESVILLE	22903	ADJ	1200			FORREST	ST		MURRAY HIGH SCHOOL 1S	**500**	2
	45VA99000135	CHARLOTTESVILLE	22903		1229			HARRIS	ST		ASSOCIATED FABRICATORS 1S	**500**	1
	450050002380	CHARLOTTESVILLE	22903		1229			HARRIS	ST		ALLIED REALTY - MO MERC	**500**	1
	450050002381	CHARLOTTESVILLE	22903		1229			HARRIS	ST		ALLIED REALTY CO BLDG A 4	**500**	2
	450050002382	CHARLOTTESVILLE	22903		1229			HARRIS	ST		ALLIED REALTY CO BLDG A 5	**500**	2
	45VA99003956	CHARLOTTESVILLE	22903		1237			PRESTON	AVE		MAUPIN APARTMENTS 3S	**500**	1
	45VA66016780	CHARLOTTESVILLE	22902		1301		E	MARKET	ST		W A HARTMAN MEMORIALS 1S	**500**	1
	45VA99158964	CHARLOTTESVILLE	22902	R	1304		E	MARKET	ST		KUTTNER BLDG-STORAGE BLDG 1S	**500**	2
	450050006190	CHARLOTTESVILLE	22902		1307		E	MARKET	ST		JINX PIT STOP RESTAURANT 1S	**500**	1
	450050005590	CHARLOTTESVILLE	22903		1395		W	MAIN	ST		LEE S GRILL 1S	**500**	1
	45VA99004288	CHARLOTTESVILLE	22901	ADJ	1600			EMMET	ST	N	DAYS INN 2S	**500**	1
	450050012350	CHARLOTTESVILLE	22902		1712			MONTICELLO	RD		WOODLIN IMPORT CAR SERVICE	**500**	2
	450050000178	CHARLOTTESVILLE	22903	ADJ	1717			ALLIED	LN		ALBEMARLE CHILDRENS THEATRE	**500**	2

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	450050000180	CHARLOTTESVILLE	22903		1719			ALLIED	ST		1719A ALLIED ROALITY CORP BLDG	**500**	2
	45VA99159367	CHARLOTTESVILLE	22901		1797			HYDRAULIC	RD		WHOLE FOODS 2S	**500**	1
	45VA99160844	CHARLOTTESVILLE	22902	R	201	213		2	ST	NW	MCGUFFEY ARTS CTR-GALLERIES 1S	**500**	2
	450050008310	CHARLOTTESVILLE	22902		201	213		2	ST	NW	MCGUFFEY ARTS CENTER 3S	**500**	1
	450050153390	CHARLOTTESVILLE	22902	R	205			RIDGE	ST		CITY OF CHARLOTTESVILLE-FIRE TOWER	**500**	2
	450050009500	CHARLOTTESVILLE	22901		2100			ANGUS	RD		ULTIMATE BLISS 1S	**500**	2
	450050000316	CHARLOTTESVILLE	22901		2102			ANGUS	RD		FRANK NEOFOTIS BLDG 1S	**500**	2
	450050000560	CHARLOTTESVILLE	22903		2118			BARRACKS	RD		BARRACKS ROAD NORTH SHOP CTR	**500**	1
	450050014980	CHARLOTTESVILLE	22903		2119			IVY	RD		PASTA PLUS	**500**	1
	450050000580	CHARLOTTESVILLE	22903		2124			BARRACKS	RD		BARRACKS ROAD NORTH SHP CTR	**500**	2
	45VA99147934	CHARLOTTESVILLE	22902		218		W	MAIN	ST		BMD LAN BUILDING 2S	**500**	1
	450050004100	CHARLOTTESVILLE	22903		2203			JEFFERSON PARK	AVE		WAYSIDE TAKEOUT CATERING 1S	**500**	1
	450050161127	CHARLOTTESVILLE	22903		2408			FONTAINE	AVE		JO BOBS RESTAURANT	**500**	1
	450050013280	CHARLOTTESVILLE	22903		2508			FONTAINE	AVE		SLOAN S SUNSET DINER	**500**	1
	45VA99152167	CHARLOTTESVILLE	22903		3			UNIVERSITY	CIR		WATSON MANOR 3S	**500**	1
	45VA99005519	CHARLOTTESVILLE	22903		3020			FONTAINE AVENUE EXTENDED			LAFAYETTE SCHOOL 2S	**500**	1
	45VA99159050	CHARLOTTESVILLE	22903		410		W	MAIN	ST		THE SPICE DIVA 1S	**500**	2
	45VA99149476	CHARLOTTESVILLE	22903		416		W	MAIN	ST		ORZO KITCHEN WINE 1S	**500**	1
	450050016660	CHARLOTTESVILLE	22903		418		W	MAIN	ST		MEDLIN MOTORS CAR PREP BUILDING	**500**	2
	450050151255	CHARLOTTESVILLE	22903		418		W	MAIN	ST		MAIN STREET MARKET 1S	**500**	1
	450050001138	CHARLOTTESVILLE	22903		600			CHERRY	AVE		JRN STORES-KENTUCKY FRIED CHICKEN	**500**	1
	45VA99005397	CHARLOTTESVILLE	22902		609		E	MARKET	ST		MICHIE BUILDING 3S	**500**	1
	45VA66015752	CHARLOTTESVILLE	22903		719		W	MAIN	ST		MEL S RESTAURANT 1S	**500**	1
	45VA99002580	CHARLOTTESVILLE	22902	ADJ	735			PARK	ST		FIRST BAPTIST CHURCH 2S	**500**	1
	45VA99150059	CHARLOTTESVILLE	22902		816			HINTON	AVE		BELLMONT BAR BQ 1S	**500**	1
	45VA99158553	CHARLOTTESVILLE	22903	F	832			CHERRY	AVE		GOCO-GASOLINE FILLING CANOPY 1S	**500**	2
	45VA99002320	CHARLOTTESVILLE	22903		900		W	MAIN	ST		HAMPTON INN 5S	**500**	1
	45VA99002413	CHARLOTTESVILLE	22902		901		E	MARKET	ST		MARKET STREET CAFE/CHEVRON 1S	**500**	2
	45VA99005940	CHARLOTTESVILLE	22901		901			SEMINOLE	TRL		IMPORT THE CAR STORE 1S	**500**	2
	450050161205	CHARLOTTESVILLE	22902		903		E	MARKET	ST		DOWNTOWN GULF STORAGE BLDG	**500**	2
	45VA99158549	CHARLOTTESVILLE	22903	R	924			HARRIS	ST		GOCO-GAS PUMP CANOPY 1S	**500**	2
	45VA99158550	CHARLOTTESVILLE	22903	1R	924			HARRIS	ST		GOCO-DIESEL FILLING CANOPY 1S	**500**	2
	45VA99156462	CHARLOTTESVILLE	22903	R	946			GRADY	AVE		DAVID RAMAZANI FURNITURE MAKER 1S	**500**	1
	45VA99161145	CHARLOTTESVILLE	22902		100			10	ST	NE	TENTH AND MARKET BLDG 4S		4
	450050000945	CHARLOTTESVILLE	22903		105			EMMET	ST	N	BEST WESTERN/CAVALIER INN 5S		4
	45VA99149169	CHARLOTTESVILLE	22902		109	111	W	WATER	ST		WATER STREET STUDIOS BLDG 3S		4
	45VA99004313	CHARLOTTESVILLE	22902		110			AVON	ST		INOVA CORPORATION 3S		4
	45VA99000300	CHARLOTTESVILLE	22901		1145			RIVER	RD		1145 RIVER RD INDUSTRIAL CTR 2S		4
	45VA99009385	CHARLOTTESVILLE	22902		1185			5	ST	SW	SLEEP INN AND SUITES 3S		4
	45VA99002406	CHARLOTTESVILLE	22902		1201			5 STREET	EXT		CHRISTIAN AID MISSION 3S		4
	45VA99008438	CHARLOTTESVILLE	22902		126			GARRETT	ST		AUDREY VIRGINIA BLD 2S		4
	450050001000	CHARLOTTESVILLE	22903		128			CHANCELLOR	ST		UNIVERSITY CHRISTIAN MINISTRIES 4S		4
	45VA99001519	CHARLOTTESVILLE	22902		1304		E	MARKET	ST		KUTTNER BUILDING 1S		4
	450050000740	CHARLOTTESVILLE	22901		1313			BELLEVIEW	AVE		LEWIS BLDG 6TENANTS 2S		4
	45VA99159116	CHARLOTTESVILLE	22902		1317			CARLTON	AVE		SERVICE MASTER-2 TENANTS 2S		4
	45VA99160806	CHARLOTTESVILLE	22902		1333	1335		CARLTON	AVE		BLUE RIDGE PACE 1S		4
	450050161899	CHARLOTTESVILLE	22903		1521	1527		UNIVERSITY	AVE		MINCER BLDG-2 TENANTS 3S		4
	450050001960	CHARLOTTESVILLE	22903		1600			GORDON	AVE		MARTHA JEFFERSON HOUSE 4S		4
	450050007300	CHARLOTTESVILLE	22903		180			RUGBY	RD		VA DELTA UPSILON ALUMNI ASSOC 3S		4
	450050003802	CHARLOTTESVILLE	22901		1801			HYDRAULIC	RD		K-MART PLAZA 1S		4
	450050012500	CHARLOTTESVILLE	22901		1901			EMMET	ST	N	HOLIDAY INN 7S		4
	45VA99160504	CHARLOTTESVILLE	22902		200			GARRETT	ST		THE GLEASON CONDOS 6S		4
	45VA99158565	CHARLOTTESVILLE	22902		200		W	SOUTH	ST		200 SOUTH STREET INN 4S		4
	450050005220	CHARLOTTESVILLE	22902		201	207	W	MAIN	ST		DOWNTOWN GRILL BLD 3S		4
	45VA99157506	CHARLOTTESVILLE	22902		202			DOUGLAS	AVE		BELMONT LOFTS 5S		4
	45VA99158566	CHARLOTTESVILLE	22902		204		W	SOUTH	ST		200 SOUTH ST INN BLDG 2 3S		4

Rev	Risk ID	Postal Community	Zip	Prefix 1	Low No. 1	High No. 1	Direction 1	Thoroughfare Name 1	Type 1	Suffix 1	Building Description	NFF	Rating
	45VA99009807	CHARLOTTESVILLE	22903		210			RIDGE MCINTIRE	RD		DOMINION DIGITAL INC 3S		4
	450050009660	CHARLOTTESVILLE	22903		2101			ARLINGTON	BLVD		MILMONT CENTER 2S		4
	450050015000	CHARLOTTESVILLE	22903		2121			IVY	RD		FOODS OF ALL NATIONS 2S		4
	45VA99150522	CHARLOTTESVILLE	22902		214		E	HIGH	ST		QUEEN CHARLOTTE SQUARE 4S		4
	45VA99159289	CHARLOTTESVILLE	22902		215		E	MAIN	ST		PARAMOUNT THEATER 4S		4
	450050008208	CHARLOTTESVILLE	22902		216	218	W	WATER	ST		THE WATERHOUSE BLDG 6S		4
	45VA99015246	CHARLOTTESVILLE	22901		220			ZAN	RD		GIANT SUPERMARKET 1S		4
	45VA99012698	CHARLOTTESVILLE	22902		230		E	HIGH	ST		QUEEN CHARLOTTE SQUARE 4S		4
	450050004145	CHARLOTTESVILLE	22903		2512			JEFFERSON PARK	AVE		FRY S SPRING BEACH CLUB 2S		4
	450050005255	CHARLOTTESVILLE	22902		255		W	MAIN	ST		FEDERAL BUILDING 4S		4
	45VA99015268	CHARLOTTESVILLE	22902		310			4	ST	NE	GREAT EASTERN BLD 3		4
	45VA99015904	CHARLOTTESVILLE	22902		310			4	ST	NE	COURT SQUARE BUILDING 3		4
	450050000421	CHARLOTTESVILLE	22902		310			AVON	ST		AVON CT BLD A - 2S		4
	450050000422	CHARLOTTESVILLE	22902	R	310			AVON	ST		AVON CT BLD C - 2S		4
	450050000152	CHARLOTTESVILLE	22903		400			ACKLEY	LN		WESTMINISTER CHILD CARE CTR		4
	450050004960	CHARLOTTESVILLE	22902		400	402	E	MAIN	ST		ENTERPRISE PROPERTIES BUILDING 3S		4
	450050005278	CHARLOTTESVILLE	22902		401			MCINTIRE	RD		ALBEMARLE COUNTY OFFICE BLDG 4S		4
	450050008207	CHARLOTTESVILLE	22902		406	418	E	WATER	ST		KING WAREHOUSE MO OFFICES		4
	450050004600	CHARLOTTESVILLE	22902		423		E	MAIN	ST		MASONIC TEMPLE BLDG 3S		4
	450050006575	CHARLOTTESVILLE	22902		501			PARK	ST		HOSPICE OF THE PIEDMONT 3S		4
	45VA99148193	CHARLOTTESVILLE	22902		615			CAMI	LN		JVI BUILDING 2S		4
	45VA99000483	CHARLOTTESVILLE	22901		921			RIVER	RD		TRACTOR SUPPLY 1S		4
	450050001640	CHARLOTTESVILLE	22903		945	1117		EMMET	ST	N	BARRACKS ROAD SHOP CTR- 1S		4
	45VA99015454	CHARLOTTESVILLE	22902		979			2	ST	SE	CHARLOTTESVILLE POLICE BLD 1S		4
	450050003770	CHARLOTTESVILLE	22908					HOSPITAL	DR		UNIVERSITY OF VA HOSP COMPLEX 1S		4
	450050153525	CHARLOTTESVILLE	22903		100			DARDEN	BLVD		UNIVERSITY OF VA-SPONSORS HALL 1S		4
	450050001950	CHARLOTTESVILLE	22902		100	118		GARRETT	ST		H M GLEASON CO		4
	450050005800	CHARLOTTESVILLE	22902		100		W	MAIN	ST		F W WOOLWORTH BLDG		4
	45VA50000030	CHARLOTTESVILLE	22902		1001		E	MARKET	ST		PHOTO		
	45VA50000057	CHARLOTTESVILLE	22907		102			MAIN	ST		PHOTO		
	450050006250	CHARLOTTESVILLE	22903		102			MARION	CT				
	45VA50000070	CHARLOTTESVILLE	22902		103			KEYSTONE	PL		PHOTO		
	450050001650	CHARLOTTESVILLE	22903		1031	1033	N	EMMET	ST		BARRACK RD SHOP CRT 1S M O		1
	45VA50000079	CHARLOTTESVILLE	22902		104			KEYSTONE	PL		PHOTO		
	45VA50000097	CHARLOTTESVILLE	22903		105			14	ST	NW	PHOTO		
	450050005160	CHARLOTTESVILLE	22902		105	107	W	MAIN	ST		THREE NOTCH LAND TRUST BLDG-M O		4
	450050159491	CHARLOTTESVILLE	22902		106		W	SOUTH	ST		M W LAND TRUST/SOUTH STREET REST		4
	450050160211	CHARLOTTESVILLE	22902		1100		E	HIGH	ST		TYLER PROPERTY PARTNERSHIP 2S		4
	450050005990	CHARLOTTESVILLE	22903		1106	1112	W	MAIN	ST		JOHN BARTELT 3S		1
	450050005991	CHARLOTTESVILLE	22903		1107		W	MAIN	ST		WEST MAIN STATION 1S		4
	450050005180	CHARLOTTESVILLE	22902		111	115	W	MAIN	ST		NST PROPERTIES MO 3S		4
	450050001645	CHARLOTTESVILLE	22903		1117			EMMET	ST	N	BARRACKS ROAD SHOPPING CENTER 2S		4
	45VA50000174	CHARLOTTESVILLE	22902		1123		E	MARKET	ST		PHOTO		
	450050072105	CHARLOTTESVILLE	22901		1147			RIVER	RD		RIVER ROAD IND CTR MO 1S		4
	450050161521	CHARLOTTESVILLE	22901		1150			PEPSI	PL		PEPSI COLA BOTTLING CO		4
	450050005840	CHARLOTTESVILLE	22902		118	120	W	MAIN	ST		M O CORP-THE YOUNG MENS SHOP		4
	450050008740	CHARLOTTESVILLE	22903		120			11	ST	SW	CROSSROADS ENTERTAINMENT CORP 1S		4
	45VA50000228	CHARLOTTESVILLE	22903		1200			JEFFERSON PARK	AVE		PHOTO		
	45VA50000233	CHARLOTTESVILLE	22903		1201			CEDARS	CT		PHOTO		
	450050002300	CHARLOTTESVILLE	22903		1222	1226		HARRIS	ST		IVY PROPERTIES		4
	45VA50000274	CHARLOTTESVILLE	22903		1232			EMMET	ST	N	PHOTO		
	450050001060	CHARLOTTESVILLE	22903		129			CHANCELLOR	ST				
	45VA50000335	CHARLOTTESVILLE	22902		1315			CREEKSIDE	DR		PHOTO		
	45VA50000338	CHARLOTTESVILLE	22902		1318			CREEKSIDE	DR		PHOTO		
	450050000900	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				
	450050151088	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				

Rev	Risk ID	Postal Community	Zip	Prefix 1	Low No. 1	High No. 1	Direction 1	Thoroughfare Name 1	Type 1	Suffix 1	Building Description	**NFF**	Rating
	450050151090	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				
	450050151091	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				
	450050151092	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				
	450050151093	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				
	450050151094	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				
	450050151095	CHARLOTTESVILLE	22902		1325			CARLTON	AVE				
	45VA50000351	CHARLOTTESVILLE	22902		1327		E	HIGH	ST		PHOTO		
	450050006680	CHARLOTTESVILLE	22903		134			10	ST	NW	SIMMONS BROTHERS 2S		4
	450050000980	CHARLOTTESVILLE	22902		1400			CARLTON	AVE				
	450050155499	CHARLOTTESVILLE	22902		1400			CARLTON	AVE				
	450050155500	CHARLOTTESVILLE	22902		1400			CARLTON	AVE				
	450050155501	CHARLOTTESVILLE	22902		1400			CARLTON	AVE				
	450050155502	CHARLOTTESVILLE	22902		1400			CARLTON	AVE				
	450050004130	CHARLOTTESVILLE	22903		1400			JEFFERSON PARK	AVE		PARK LANE BLDG - OFFICES		1
	450050006480	CHARLOTTESVILLE	22902		1400			MONTICELLO	RD		AFTER SIX INC		4
	450050005620	CHARLOTTESVILLE	22903		1417			UNIVERSITY	AVE		ANDERSON BUILDING 3S		4
	450050001589	CHARLOTTESVILLE	22903		1418			EMMET	ST	N			
	45VA50000429	CHARLOTTESVILLE	22903		1497			OLD LYNCHBURG	RD		PHOTO		
	450050001591	CHARLOTTESVILLE	22901		1503			EMMET	ST	N			
	450050001980	CHARLOTTESVILLE	22903		1508			GRADY	AVE		TAU KAPPA EPSILON FRATERNITY		4
	450050004325	CHARLOTTESVILLE	22902		1540		E	HIGH	ST		C C SPIVEY - M O BLDG 1S		1
	450050001810	CHARLOTTESVILLE	22901		1615			EMMET	ST	N			
	450050001811	CHARLOTTESVILLE	22901		1617			EMMET	ST	N			
	45VA50000491	CHARLOTTESVILLE	22901		1640			SEMINOLE	TRL		PHOTO		
	450050001815	CHARLOTTESVILLE	22901		1709			EMMET	ST	N			
	45VA50000524	CHARLOTTESVILLE	22911		1782			AIRPORT	RD		PHOTO		
	45VA99004963	CHARLOTTESVILLE	22904		180			MCCORMICK	RD		NEWCOMB HALL 3S		4
	45VA99000030	CHARLOTTESVILLE	22902		1801			BROADWAY	ST		ISO TEMPS RESEARCH 1S		4
	450050001600	CHARLOTTESVILLE	22901		1912			EMMET	ST	N			
	450050001601	CHARLOTTESVILLE	22901		1914			EMMET	ST	N			
	45VA50000597	CHARLOTTESVILLE	22901		200			SEMINOLE	CT		PHOTO		
	45VA50000598	CHARLOTTESVILLE	22901		200			SHOPPERS WORLD	CT		PHOTO		
	450050015100	CHARLOTTESVILLE	22902		201		E	JEFFERSON	ST				
	450050006060	CHARLOTTESVILLE	22902		201		E	MARKET	ST		BUILDING 3S		1
	450050003890	CHARLOTTESVILLE	22903		2015			IVY	RD				
	450050004122	CHARLOTTESVILLE	22901		2018			HOLIDAY	DR		ABERDEEN BARNS INC		4
	45VA99001949	CHARLOTTESVILLE	22901		2035			INDIA	RD		HAMPTON INN OF CHARLOTTESVILLE 5S		4
	450050000970	CHARLOTTESVILLE	22902		210			CARLTON	RD		MARTIN / HORN CORP 2S		4
	45VA50000661	CHARLOTTESVILLE	22901		2100			RIO HILL	CTR		PHOTO		
	450050161898	CHARLOTTESVILLE	22903		211		N	EMMET	ST				4
	450050003985	CHARLOTTESVILLE	22903		2120			IVY	RD		E L KERWICH BLDG 2S		1
	450050153838	CHARLOTTESVILLE	22903		2132			IVY	RD				
	450050000415	CHARLOTTESVILLE	22902		215			AVON	ST				
	45VA50000696	CHARLOTTESVILLE	22911		2151			RICHMOND	RD		PHOTO		
	450050000847	CHARLOTTESVILLE	22901		2202		N	BERKSHIRE	RD		NORTH BERKSHIRE DENTIST LTD 2S		1
	45VA50000745	CHARLOTTESVILLE	22903		2240			IVY	RD		PHOTO		
	45VA50000782	CHARLOTTESVILLE	22911		2345			HUNTERS	WAY		PHOTO		
	45VA50000906	CHARLOTTESVILLE	22903		2851			IVY	RD		PHOTO		
	45VA50000933	CHARLOTTESVILLE	22901		2944			HYDRAULIC	RD		PHOTO		
	45VA50000937	CHARLOTTESVILLE	22903		3			BOARS HEAD	LN		PHOTO		
	45VA50000956	CHARLOTTESVILLE	22902		301		E	JEFFERSON	ST		PHOTO		
	450050153535	CHARLOTTESVILLE	22903	2R	305			4	ST	NW			
	45VA50000985	CHARLOTTESVILLE	22902		309			AVON	ST		PHOTO		
	450050004920	CHARLOTTESVILLE	22902		316		E	MAIN	ST		ROCKFORD CORP - MO 4S		4
	450050160472	CHARLOTTESVILLE	22901		330			SEMINOLE	CT		PEPSI COLA BOTTLING OF CENTRAL VA		4
	450050160868	CHARLOTTESVILLE	22901	R	330			SEMINOLE	CT		PEPSI COLA BOTTLING CO-VEHICLE SHOP		4

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	45VA50001098	CHARLOTTESVILLE	22902		350			PARK	ST		PHOTO		
	45VA50001187	CHARLOTTESVILLE	22903		400			RAY C HUNT	DR		PHOTO		
	45VA50001196	CHARLOTTESVILLE	22902		401			AVON	ST		PHOTO		
	450050008747	CHARLOTTESVILLE	22903		404	500		14	ST	NW			
	45VA50001246	CHARLOTTESVILLE	22902		416		E	MAIN	ST		PHOTO		
	450050008315	CHARLOTTESVILLE	22903		510			17	ST	NW			
	450050006580	CHARLOTTESVILLE	22902		515			PARK	ST		CHVLLE ALBMRL ASSOC/RETARDED CITIZE		4
	45VA50001449	CHARLOTTESVILLE	22901		520			GREENFIELD	TER		PHOTO		
	450050005122	CHARLOTTESVILLE	22902		526	538	E	MAIN	ST		FLOOR FASHIONS OF VA INC		4
	450050004225	CHARLOTTESVILLE	22902		612		E	JEFFERSON	ST				
	450050001880	CHARLOTTESVILLE	22903		614			FORREST	ST				
	45VA50001587	CHARLOTTESVILLE	22902		614		E	HIGH	ST		PHOTO		
	45VA50001604	CHARLOTTESVILLE	22903		629		W	MAIN	ST		PHOTO		
	450050007100	CHARLOTTESVILLE	22902		632			RIDGE	ST				
	450050001885	CHARLOTTESVILLE	22903		706			FORREST	ST				4
	450050002465	CHARLOTTESVILLE	22903		710			HENRY	AVE				
	450050002420	CHARLOTTESVILLE	22903		711			HENRY	AVE				
	45VA50001697	CHARLOTTESVILLE	22903		713			HARRIS	ST		PHOTO		
	450050007335	CHARLOTTESVILLE	22903		719			RUGBY	RD		U-ITARIAN CHURCH 3S		1
	450050006105	CHARLOTTESVILLE	22902		801		E	MARKET	ST				
	450050002125	CHARLOTTESVILLE	22903		810			HARRIS	ST				
	450050155503	CHARLOTTESVILLE	22903		810			HARRIS	ST				
	450050155504	CHARLOTTESVILLE	22903		810			HARRIS	ST				
	450050155505	CHARLOTTESVILLE	22903		810			HARRIS	ST				
	45VA50001903	CHARLOTTESVILLE	22901		90			WHITEWOOD	RD		PHOTO		
	450050001632	CHARLOTTESVILLE	22903		901		N	EMMET	ST		BARRACK RD SHOP CRT 1S BANK		1
	450050007275	CHARLOTTESVILLE	22903		901			ROSE HILL	DR				
	450050006920	CHARLOTTESVILLE	22903		916	920		PRESTON	AVE		ALBEMARLE FARMERS - MO		1
	450050006276	CHARLOTTESVILLE	22904					MCCORMICK	RD		UNIVERSITY OF VA 2S		1

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	450050117899	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1745		BROADWAY	ST	**2,000**	16,000	1	19,300	02/01/2006
	450003000350	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1625		QUAIL	RUN			1	17,280	01/08/2019
	45VA97001655	ALBEMARLE CO FPSA	CROZET	22932	ADJ	5778		THREE NOTCHED	RD	**500**	1,200	1	1,200	01/02/2019
	45VA97001654	ALBEMARLE CO FPSA	CROZET	22932		5778		THREE NOTCH D	RD	**750**	3,000	1	3,000	01/02/2019
	45VA99162514	ALBEMARLE CO FPSA	CROZET	22932		5728		THREE NOTCHED	RD	**2,000**	13,213	1	13,213	01/02/2019
	450003000065	ALBEMARLE CO FPSA	CROZET	22932		5752		THREE NOTCHED	RD	**1,250**	7,350	1	7,350	01/02/2019
	450003000052	ALBEMARLE CO FPSA	CROZET	22932		5730		THREE NOTCHED	RD	**1,750**	9,540	1	9,540	01/02/2019
	45VA97001650	ALBEMARLE CO FPSA	CROZET	22932		5784		THREE NOTCHED	RD	**750**	2,700	2	3,600	01/02/2019
	450003160400	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1405		BRANDLIN	DR	**1,250**	3,472	1	3,472	12/01/1983
	45VA99163009	ALBEMARLE CO FPSA	CROZET	22932		330		CLAREMONT	LN			4	192,620	02/01/2015
	45VA99009157	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		500		GREENBRIER	DR			3	43,565	09/01/2014
	45VA99160737	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2050		BOND	ST			1	19,332	09/01/2016
	45VA99008443	ALBEMARLE CO FPSA		22901		2291		SEMINOLE	LN	**1,250**	8,280	1	8,280	09/01/2016
	45VA99008443	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2291		SEMINOLE	LN	**1,250**	8,280	1	8,280	09/01/2016
	450003000955	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2146		BERKMAR	DR	**1,250**	8,160	2	9,920	09/01/2016
	450003000955	ALBEMARLE CO FPSA		22901		2146		BERKMAR	DR	**1,250**	8,160	2	9,920	09/01/2016
	45VA99000580	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3036		BERKMAR	DR	**1,250**	4,500	1	4,500	09/01/2016
	450003001022	ALBEMARLE CO FPSA		22901		3000		BERKMAR	DR	**2,250**	23,100	1	23,100	09/01/2016
	450003001022	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3000		BERKMAR	DR	**2,250**	23,100	1	23,100	09/01/2016
	450003000950	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2130		BERKMAR	DR	**1,250**	7,500	2	10,000	09/01/2016
	450003000950	ALBEMARLE CO FPSA		22901		2130		BERKMAR	DR	**1,250**	7,500	2	10,000	09/01/2016
	45VA99155480	ALBEMARLE CO FPSA		22911		3441		SEMINOLE	TRL	**1,250**	8,400	1	8,400	09/01/2016
	45VA99155480	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3441		SEMINOLE	TRL	**1,250**	8,400	1	8,400	09/01/2016
	45VA99160841	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		595		MARTHA JEFFERSON	DR			3	92,875	12/01/2013
	45VA99165840	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1926		ABBEY	RD	**1,750**	16,030	1	16,030	07/01/2016
	45VA99165840	ALBEMARLE CO FPSA		22911		1926		ABBEY	RD	**1,750**	16,030	1	16,030	07/01/2016
	45VA99012249	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		100		MYERS	DR	**500**		2	12,412	06/01/2016
	45VA99012247	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		150		MYERS	DR	**750**	5,400	2	6,850	06/01/2016
	450050161521	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1150		PEPSI	PL	**500**		3	14,688	07/01/2016
	45VA99156508	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1421		SACHEM	PL	**1,250**	3,780	2	5,040	03/01/2011
	45VA99156502	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1414		SACHEM	PL	**1,500**	5,490	2	7,320	03/01/2011
	45VA99010150	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		340		GREENBRIER	DR	**2,500**	31,200	1	32,200	07/01/2016
	45VA99003655	ALBEMARLE CO FPSA	EARLYSVILLE	22936		385		REAS FORD	RD	**2,000**	18,168	2	22,044	04/01/2016
	45VA99147826	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	1R	5221		ROCKFISH GAP	TPKE	**2,500**	23,350	1	23,350	04/01/2016
	45VA99147825	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R	5221		ROCKFISH GAP	TPKE	**2,250**	18,600	2	25,700	04/01/2016
	45VA99147824	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		5221		ROCKFISH GAP	TPKE	**2,250**	26,744	2	34,063	04/01/2016
	45VA99165256	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3315		BERKMAR	DR	**1,500**	9,330	2	12,405	04/01/2016
	450003115990	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1740		BROADWAY	ST			1	51,000	04/01/2016
	450003155700	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		199		SPOTNAP	RD			2	13,217	03/01/2016
	45VA99006632	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		722	W	RIO	RD	**1,500**	11,799	2	15,129	03/01/2016
	45VA99164998	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		707		BELVEDERE	BLVD	**3,000**	16,980	1	16,980	03/01/2016
	45VA99162685	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3275		BERKMAR	DR	**1,500**	6,632	1	8,004	03/01/2016
	45VA99156379	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		220	S	PANTOPS	DR	**3,000**	14,520	2	19,360	03/01/2011
	450003155530	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	ADJ	2100	E	MARKET	ST	**2,500**	16,036	2	17,876	03/01/2009
	450003155529	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	ABT	2100	E	MARKET	ST	**2,500**	14,292	1	15,639	01/01/2005
	45VA99150552	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		725		DENALI	WAY	**3,500**	33,000	4	52,800	02/01/2016
	45VA99146673	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2165		SEMINOLE	TRL	**1,750**	8,604	2	10,954	02/01/2016
	45VA99152798	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	3R	200		EDNAM	DR			1	17,780	02/01/2016
	450003000036	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	5R	200		EDNAM	DR	**4,500**	152,256	1	160,951	02/01/2016
	450003000033	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	4R	200		EDNAM	DR			3	62,232	02/01/2016
	450003000032	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	2R	200		EDNAM	DR	**750**	5,420	3	8,130	02/01/2016
	450003000031	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		200		EDNAM	DR	**500**	40,198	3	68,590	02/01/2016
	45VA99014241	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		390		GREENBRIER	DR	**3,000**	15,162	3	22,653	01/01/2016
	45VA99164711	ALBEMARLE CO FPSA	AFTON	22920	F	2797		KACEY	LN	**1,000**	1,152	1	1,536	01/01/2016
	45VA99164695	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	2811		HYDRAULIC	RD	**1,250**	7,200	1	7,200	01/01/2016
	45VA99164694	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2811		HYDRAULIC	RD	**1,250**	11,142	2	12,442	01/01/2016
	45VA99159780	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3042		BERKMAR	DR	**1,250**	5,400	1	5,400	01/01/2016
	45VA99011667	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		460		WESTFIELD	RD	**750**	2,600	1	2,600	11/01/2003

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	45VA99008377	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3210		PROFFIT	RD	3,000	18,621	1	18,621	12/01/2015
	45VA99005603	ALBEMARLE CO FPSA	CROZET	22932		5773		THE SQUARE		1,000	3,522	2	4,472	11/01/2015
	45VA99161584	ALBEMARLE CO FPSA	CROZET	22932		5771		THE SQUARE		1,000	2,368	1	2,368	11/01/2015
	45VA99004783	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		556		DETTOR	RD	4,500	102,312	1	106,462	12/04/2018
	45VA99163958	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2206		IVY	RD	1,000	1,398	1	1,398	11/01/2015
	45VA99002536	ALBEMARLE CO FPSA	EARLYSVILLE	22936		607		EARLYSVILLE FOREST	DR	500	968	1	968	12/01/1997
	45VA99000236	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2800		WHITEWOOD	RD	750	2,000	1	2,000	01/01/1996
	450003161507	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		695		MOORES CREEK	LN	1,250	11,474	3	14,982	09/01/1984
	450003155813	ALBEMARLE CO FPSA	ESMONT	22937				RTE 626		1,500	3,900	1	3,900	02/01/1986
	450003155524	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		695		MOORES CREEK	LN	500	992	1	992	09/01/1984
	450003082261	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901				WHITEWOOD	RD	750	2,000	1	2,000	01/01/1994
	450003000209	ALBEMARLE CO FPSA	EARLYSVILLE	22936		600		EARLYSVILLE FOREST	DR	1,750	15,324	1	15,324	03/01/1986
	450003000148	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902				RTE 720		750	6,985	1	6,985	03/01/1992
	450003005280	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1180		SEMINOLE	TRL			1	498,180	09/01/2015
	450003004043	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2421		IVY	RD	2,000	22,304	3	32,944	03/01/2016
	450003151408	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		442		WESTFIELD	RD	1,000	8,601	1	8,601	09/01/2015
	450003006521	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		300		MYERS	DR	500		1	34,008	06/01/2016
	45VA99010268	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		200		MYERS	DR			1	35,218	06/01/2016
	45VA99163977	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2009		ABBEY	RD	1,750	3,839	1	3,839	08/01/2015
	45VA99007627	ALBEMARLE CO FPSA		22932		5793		THE	SQ	1,250	5,320	2	7,600	04/01/2014
	45VA99007627	ALBEMARLE CO FPSA	CROZET	22932		5793		THE SQUARE		1,250	5,320	2	7,600	04/01/2014
	45VA99163891	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		201		CONNER	DR			1	18,285	07/01/2015
	45VA99163711	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	R	1232		STONEY RIDGE	RD	1,500	13,171	1	15,317	06/01/2015
	45VA99163616	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1962		SNOW POINT	LN	1,500	3,496	1	3,496	05/01/2015
	45VA99163615	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	2R	1575		AVON	ST	1,500	11,640	1	11,640	05/01/2015
	45VA99163614	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	1R	1575		AVON	ST	1,500	11,640	1	11,640	05/01/2015
	45VA99163613	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	R	1575		AVON	ST	1,500	11,543	1	11,543	05/01/2015
	45VA99163612	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1965		SNOW POINT	LN	1,250	3,496	1	3,496	05/01/2015
	45VA99163611	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1975		SNOW POINT	LN	1,500	3,496	1	3,496	05/01/2015
	45VA99145942	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1305		SEMINOLE	TRL	1,750	4,770	1	4,770	09/01/2005
	45VA99154351	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		304		HICKMAN	RD	1,250	2,720	1	2,720	11/01/2009
	45VA99152571	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2029		LOCKWOOD	DR			4	68,145	07/01/2015
	45VA99163748	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1822		BROADWAY	ST			1	12,600	06/01/2015
	450003189348	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1820		BROADWAY	ST	1,250	11,100	1	11,100	06/01/2015
	45VA99005249	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1810		BROADWAY	ST	750	2,990	1	2,990	06/01/2015
	45VA99164677	ALBEMARLE CO FPSA	CROZET	22932		5857		JARMANS GAP	RD	1,000	1,639	2	2,324	01/01/2016
	45VA99150052	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1232		STONEY RIDGE	RD			2	32,418	06/01/2015
	450003160470	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	2325		SEMINOLE	LN	1,000	4,770	1	4,770	06/01/2015
	45VA99163610	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1985		SNOW POINT	LN	1,750	3,496	1	3,496	05/01/2015
	450003000440	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1575		AVON STREET	ST	1,250	11,446	1	11,446	05/01/2015
	450050161578	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1313		RICHMOND	RD	1,000	8,776	1	8,776	10/01/2011
	450050007360	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1195		SEMINOLE	TRL	750	3,100	1	3,100	11/01/2004
	450050007355	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1195		SEMINOLE	TRL	2,000	15,390	1	15,390	11/01/2004
	450050001505	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		105	S	PANTOPS	DR	3,500	14,400	3	20,600	09/01/2001
	450050000790	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1750		BROADWAY	ST	1,000	7,500	1	9,000	06/01/2013
	45VA99163007	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		320		WINDING RIVER	LN	4,000	20,790	3	27,720	02/01/2015
	45VA99162973	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R	1180		BOXWOOD ESTATE	RD	1,500	9,738	2	10,645	02/01/2015
	45VA99162973	ALBEMARLE CO FPSA		22903		1180		BOXWOOD ESTATE	RD	1,500	9,738	2	10,645	02/01/2015
	45VA99162972	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		1180		BOXWOOD ESTATE	RD	1,250	12,518	4	25,950	02/01/2015
	45VA99162972	ALBEMARLE CO FPSA		22903		1180		BOXWOOD ESTATE	RD	1,250	12,518	4	25,950	02/01/2015
	45VA99162686	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		607		WOODBROOK	DR	1,750	13,440	1	13,440	12/01/2014
	45VA99162456	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		505		FAULCONER	DR	2,000	7,344	2	9,792	09/01/2014
	45VA99162455	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		501		FAULCONER	DR	1,750	5,304	3	7,956	09/01/2014
	45VA99162454	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		503		FAULCONER	DR	2,000	6,384	2	12,768	09/01/2014
	45VA99162372	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		5046		SEMINOLE	TRL	750	1,700	1	1,700	09/01/2014
	45VA99162367	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		3846		CARTERS MOUNTAIN	RD	1,500	4,095	1	4,095	09/01/2014
	45VA99162280	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	8R	1625		COUNTRY CLUB	CIR	1,500	3,645	1	3,645	09/01/2014
	45VA99162279	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1946		OLD MILL	RD	750	1,026	1	1,026	09/01/2014

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	45VA99162278	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1940		OLD MILL	RD	**750**	1,680	1	1,680	09/01/2014
	45VA99162277	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1946		OLD MILL	RD	**2,250**	7,021	1	7,021	09/01/2014
	45VA99162276	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1940		OLD MILL	RD	**1,000**	4,464	1	4,464	09/01/2014
	45VA99162275	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	3R	1625		COUNTRY CLUB	CIR	**750**	976	1	976	09/01/2014
	45VA99162274	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	2R	1625		COUNTRY CLUB	CIR	**750**	2,100	1	2,100	09/01/2014
	45VA99162273	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	1625		COUNTRY CLUB	CIR	**750**	3,081	2	3,710	09/01/2014
	45VA99162272	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1920		OLD MILL	RD	**500**		1	22,450	09/01/2014
	45VA99162231	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		154		HANSEN	RD	**3,000**	16,397	2	21,862	08/01/2014
	45VA99162091	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2271		SEMINOLE	LN	**1,000**	4,358	2	8,715	07/01/2014
	45VA99161742	ALBEMARLE CO FPSA	BARBOURSVILLE	22923	F	5548		SEMINOLE	TRL	**500**	576	1	576	05/01/2014
	45VA99161741	ALBEMARLE CO FPSA	BARBOURSVILLE	22923		5548		SEMINOLE	TRL	**750**	1,960	1	1,960	05/01/2014
	45VA99161585	ALBEMARLE CO FPSA	CROZET	22932		5783		THE SQUARE		**1,250**	5,481	2	7,308	04/01/2014
	45VA99161501	ALBEMARLE CO FPSA	BARBOURSVILLE	22923		4370		STONY POINT	RD	**1,000**	1,251	1	1,251	04/01/2014
	45VA99161143	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		107		WHITEWOOD	RD			2	18,443	11/01/2014
	45VA99161135	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	2R	389		ELK	DR	**500**	324	1	324	02/01/2014
	45VA99161134	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	1R	389		ELK	DR	**1,250**	2,030	1	2,030	02/01/2014
	45VA99161133	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	R	389		ELK	DR	**750**	1,123	1	1,123	02/01/2014
	45VA99161014	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	F	1215		SEMINOLE	TRL	**500**	529	1	529	01/01/2014
	45VA99160524	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	2R	1475		WILTON FARM	RD			3	14,508	09/01/2013
	45VA99160523	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	1R	1475		WILTON FARM	RD			4	35,760	09/01/2013
	45VA99160522	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	R	1475		WILTON FARM	RD			3	27,000	09/01/2013
	45VA99160521	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1475		WILTON FARM	RD	**1,000**	1,750	1	1,750	09/01/2013
	45VA99160495	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		943		GLENWOOD STATION	LN	**1,500**	14,412	3	21,618	09/01/2013
	45VA99160449	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2010		BOND	ST			1	6,184	09/01/2013
	45VA99159779	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3046		BERKMAR	DR	**750**	3,892	1	3,892	04/01/2013
	45VA99012849	ALBEMARLE CO FPSA	CROZET	22932		1220		CROZET	AVE	**2,250**	28,210	6	48,360	04/01/2004
	45VA99012699	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		380		GREENBRIER	DR	**1,750**	16,112	1	16,112	03/01/2009
	45VA99012313	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		227		LAMBS	LN			1	24,082	04/01/2008
	45VA99012304	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2045		LAMBS	RD			2	15,712	02/01/2004
	45VA99012031	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		400		SHOPPERS WORLD	CT	**1,750**	13,600	1	13,600	04/01/2010
	45VA99011960	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1570		AVON STREET	EXT	**1,250**	6,200	1	6,200	08/01/2006
	45VA99011499	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3287		WORTH	XING	**1,500**	2,732	1	2,732	10/01/2003
	45VA99011498	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1294		STONY POINT	RD	**1,750**	4,800	1	4,800	10/01/2003
	45VA99011369	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	ADJ	958	N	MILTON	RD	**500**	120	1	120	10/01/2003
	45VA99011366	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	ADJ	958	N	MILTON	RD	**500**	1,000	1	1,000	10/01/2003
	45VA99011365	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		958	N	MILTON	RD	**3,000**	71,100	1	71,100	10/01/2003
	45VA99011346	ALBEMARLE CO FPSA	CROZET	22932	ADJ	5880		ROCKFISH GAP	TPKE	**750**	816	1	816	09/01/2003
	45VA99011345	ALBEMARLE CO FPSA	CROZET	22932	ADJ	5880		ROCKFISH GAP	TPKE	**750**	816	1	816	09/01/2003
	45VA99011344	ALBEMARLE CO FPSA	CROZET	22932	ADJ	5880		ROCKFISH GAP	TPKE	**750**	912	1	912	09/01/2003
	45VA99011343	ALBEMARLE CO FPSA	CROZET	22932	ADJ	5880		ROCKFISH GAP	TPKE	**750**	912	1	912	09/01/2003
	45VA99011342	ALBEMARLE CO FPSA	CROZET	22932		5880		ROCKFISH GAP	TPKE	**3,500**	90,210	1	90,210	09/01/2003
	45VA99011335	ALBEMARLE CO FPSA	CROZET	22932	R4	5941		ROCKFISH GAP	TPKE	**500**	150	2	200	09/01/2003
	45VA99011334	ALBEMARLE CO FPSA	CROZET	22932	R	5941		ROCKFISH GAP	TPKE	**500**	144	1	144	09/01/2003
	45VA99011333	ALBEMARLE CO FPSA	CROZET	22932	R5	5941		ROCKFISH GAP	TPKE	**750**	1,456	1	1,456	09/01/2003
	45VA99011332	ALBEMARLE CO FPSA	CROZET	22932	R6	5941		ROCKFISH GAP	TPKE	**2,250**	32,558	1	32,558	09/01/2003
	45VA99011331	ALBEMARLE CO FPSA	CROZET	22932		5941		ROCKFISH GAP	TPKE	**2,000**	26,676	1	26,676	09/01/2003
	45VA99011330	ALBEMARLE CO FPSA	CROZET	22932	R2	5941		ROCKFISH GAP	TPKE	**1,500**	16,952	1	16,952	09/01/2003
	45VA99011329	ALBEMARLE CO FPSA	CROZET	22932	R3	5941		ROCKFISH GAP	TPKE	**3,500**	74,676	2	111,568	09/01/2003
	45VA99011328	ALBEMARLE CO FPSA	CROZET	22932	R1	5941		ROCKFISH GAP	TPKE	**500**	144	1	144	09/01/2003
	45VA99011289	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	ADJ	3251		MORGANTOWN	RD	**500**	140	1	140	09/01/2003
	45VA99011288	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	ADJ	3251		MORGANTOWN	RD	**500**	200	1	200	09/01/2003
	45VA99011287	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		3251		MORGANTOWN	RD	**2,500**	42,057	1	42,057	09/01/2003
	45VA99011278	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	2775		HYDRAULIC	RD	**750**	720	1	720	09/01/2003
	45VA99011277	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	2775		HYDRAULIC	RD	**750**	720	1	720	09/01/2003
	45VA99011276	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	2775		HYDRAULIC	RD	**750**	720	1	720	09/01/2003
	45VA99011267	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2775		HYDRAULIC	RD	**750**	720	1	720	09/01/2003
	45VA99011266	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	2775		HYDRAULIC	RD	**750**	720	1	720	09/01/2003
	45VA99011265	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2775		HYDRAULIC	RD	**5,000**	264,123	2	311,703	09/01/2003

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	45VA99011243	ALBEMARLE CO FPSA	CROZET	22932	ADJ	1407		CROZET	AVE	**750**	960	1	960	09/01/2003
	45VA99011242	ALBEMARLE CO FPSA	CROZET	22932	ADJ	1407		CROZET	AVE	**750**	960	1	960	09/01/2003
	45VA99011241	ALBEMARLE CO FPSA	CROZET	22932	ADJ	1407		CROZET	AVE	**750**	960	1	960	09/01/2003
	45VA99011240	ALBEMARLE CO FPSA	CROZET	22932		1407		CROZET	AVE			2	54,142	09/01/2003
	45VA99011239	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	210		LAMBS	LN	**500**	504	1	504	09/01/2003
	45VA66016534	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	F	1600	N	SEMINOLE	TRL	**750**	3,400	1	3,400	09/01/2012
	45VA66013329	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		55		ALBEMARLE	SQ	**500**	1,100	1	1,100	03/01/2011
	45VA66013328	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1771		OLD BROOK	RD	**750**	1,600	2	2,100	03/01/2011
	45VA66013312	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	F	1220		SEMINOLE	TRL	**750**	2,400	1	2,400	03/01/2011
	45VA66013311	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1245		SEMINOLE	TRL	**500**	1,200	1	1,200	03/01/2011
	45VA66013310	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	F	1245		SEMINOLE	TRL	**750**	2,100	1	2,100	03/01/2011
	45VA66013309	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1220		SEMINOLE	TRL	**1,500**	3,400	1	3,400	03/01/2011
	45VA66013308	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1245		SEMINOLE	TRL	**1,250**	1,800	1	1,800	03/01/2011
	45VA66007915	ALBEMARLE CO FPSA	CROZET	22932		5652		THREE NOTCH	RD	**1,250**	9,600	1	9,600	07/01/2009
	45VA66007866	ALBEMARLE CO FPSA	SCOTTSVILLE	24590	R	181		IRISH	RD	**750**	1,092	1	1,092	07/01/2009
	45VA66007785	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	R	3827		STONY POINT	RD	**500**	1,800	1	1,800	07/01/2009
	45VA66007784	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3827		STONY POINT	RD	**1,000**	5,624	1	5,624	07/01/2009
	45VA66007782	ALBEMARLE CO FPSA	EARLYSVILLE	22936		283		REAS FORD	RD	**1,500**	13,440	1	13,440	07/01/2009
	45VA66007781	ALBEMARLE CO FPSA	KESWICK	22947		3501		STEAMER	RD	**2,000**	23,432	1	23,432	07/01/2009
	45VA66007780	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3575		INNOVATION	DR	**3,000**	16,896	1	16,896	07/01/2009
	45VA66007779	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3055		BERKMAR	DR	**1,250**	3,105	2	4,140	07/01/2009
	45VA99163526	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		325		RIVANNA PLAZA	DR			1	12,500	05/01/2015
	45VA99163525	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		315		RIVANNA PLAZA	DR	**2,250**	14,364	1	14,364	05/01/2015
	45VA99163524	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		305		RIVANNA PLAZA	DR			1	5,070	05/01/2015
	450003003360	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		210		LAMBS	LN	**4,000**	93,027	1	93,027	09/01/2003
	450003003160	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1625		COUNTRY CLUB	CIR			2	95,926	09/01/2014
	450003003000	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1400		OLD BROOK	RD	**1,250**	10,170	2	13,560	03/01/2011
	450003002540	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		183		SPOTNAP	RD			1	7,762	06/01/2003
	450003002010	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		395		GREENBRIER	DR	**1,000**	5,700	1	5,700	08/01/2006
	450003001980	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		370		GREENBRIER	DR	**1,750**	14,000	1	14,000	05/01/2007
	450003000580	ALBEMARLE CO FPSA	NORTH GARDEN	22959		3901		RED HILL SCHOOL	RD	**2,500**	28,950	1	28,950	09/01/2003
	450003000560	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		4217		RED HILL	RD	**4,000**	98,340	1	98,340	09/01/2003
	450003000430	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1565		AVON STREET	EXT			1	41,850	07/01/2012
	450003000401	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	1R	1501		AVON STREET	EXT	**2,000**	9,840	1	9,840	04/01/2014
	450003000400	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	R	1501		AVON STREET	EXT	**2,000**	10,000	1	10,000	04/01/2014
	450003000220	ALBEMARLE CO FPSA	SCOTTSVILLE	24590		7868		SCOTTSVILLE	RD	**2,250**	30,900	1	30,900	09/01/2003
	450003000142	ALBEMARLE CO FPSA	COVESVILLE	22931		5678		HEARDS MOUNTAIN	RD	**500**	375	1	375	01/01/1982
	450003000042	ALBEMARLE CO FPSA	CROZET	22932		5870		ROCKFISH GAP	TPKE	**3,000**	58,600	1	58,600	09/01/2003
	45VA99148101	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1143		RIO	RD	**1,000**	2,000	1	2,000	05/01/2006
	45VA99148062	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2775		POWELL CREEK	DR	**3,000**	66,089	1	66,089	05/01/2006
	45VA99147939	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2776		HYDRAULIC	RD	**2,000**	7,512	2	10,016	04/01/2006
	45VA99163326	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		705		RIO	RD	**2,500**	42,678	2	62,560	04/01/2015
	45VA99157462	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		77		BARCLAY PLACE	CT	**2,250**	8,800	3	13,200	11/01/2011
	45VA99157437	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		392		PANTOPS SHOPPING	CTR	**500**		1	3,600	11/01/2011
	45VA99157247	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	R	1313		RICHMOND	RD	**1,500**	13,380	1	13,380	10/01/2011
	45VA99156795	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	1R	683		THOMAS JEFFERSON	PKWY	**750**	600	2	800	06/01/2011
	45VA99156760	ALBEMARLE CO FPSA	NORTH GARDEN	22959	2R	2503		RURAL RIDGE	LN	**1,750**	2,820	1	2,820	05/01/2011
	45VA99156759	ALBEMARLE CO FPSA	NORTH GARDEN	22959	1R	2503		RURAL RIDGE	LN	**1,250**	2,304	1	2,304	05/01/2011
	45VA99156758	ALBEMARLE CO FPSA	NORTH GARDEN	22959	R	2503		RURAL RIDGE	LN	**1,250**	1,736	1	1,736	05/01/2011
	45VA99156757	ALBEMARLE CO FPSA	NORTH GARDEN	22959	ADJ	2503		RURAL RIDGE	LN	**1,000**	1,200	1	1,200	05/01/2011
	45VA99156756	ALBEMARLE CO FPSA	NORTH GARDEN	22959		2503		RURAL RIDGE	LN	**1,250**	2,550	1	2,550	05/01/2011
	45VA99156510	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1411		SACHEM	PL	**1,250**	2,484	2	3,312	03/01/2011
	45VA99156509	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1415		SACHEM	PL	**1,250**	3,798	2	5,064	03/01/2011
	45VA99156507	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1441		SACHEM	PL	**1,750**	7,800	2	10,400	03/01/2011
	45VA99156506	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1450		SACHEM	PL	**1,750**	9,207	2	10,815	03/01/2011
	45VA99156504	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1422		SACHEM	PL	**1,250**	3,737	2	4,982	03/01/2011
	45VA99156503	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1412		SACHEM	PL	**2,000**	8,580	2	11,440	03/01/2011
	45VA99156501	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1410		SACHEM	PL	**1,750**	7,167	2	9,556	03/01/2011

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	45VA99156500	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		90		SACHEM	PL	**1,250**	6,750	2	8,061	03/01/2011
	45VA99156483	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	F	1400		OLD BROOK	RD	**1,000**	2,267	2	2,692	03/01/2011
	45VA99156424	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		799		FAULCONER	DR	**3,000**	72,302	2	105,395	03/01/2011
	45VA99156423	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	ADJ	799		FAULCONER	DR	**2,000**	27,091	3	33,312	03/01/2011
	45VA99156195	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		801		FRANKLIN	ST	**5,000**	22,320	2	24,560	01/01/2011
	45VA99155881	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		254		LAKEVIEW	DR	**1,250**	3,184	1	4,144	11/01/2010
	45VA99155528	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2965		IVY	RD			3	66,492	08/01/2010
	45VA99155427	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		108		TOWN COUNTRY	LN	**2,000**	5,130	2	6,840	08/01/2010
	45VA99155246	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1954		RIO HILL	CTR	**1,500**	12,000	1	12,000	06/01/2010
	45VA99155231	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1200		FIVE SPRINGS	RD	**2,250**	11,040	3	16,560	06/01/2010
	45VA99155139	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2001		COMMONWEALTH	DR	**1,750**	3,698	2	4,930	07/01/2014
	45VA99155117	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		404		PEOPLE	PL	**2,000**	21,900	4	43,800	05/01/2010
	45VA99154923	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		605		CAMI	LN	**1,000**	5,120	1	5,120	04/01/2010
	45VA99154919	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		605		CAMI	LN	**1,000**	5,120	1	5,120	04/01/2010
	45VA99154830	ALBEMARLE CO FPSA	CROZET	22932		5794		THREE NOTCHD	RD	**2,250**	6,296	2	8,096	03/01/2010
	45VA99154772	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1410		INCARNATION	DR	**2,250**	23,112	2	30,816	03/01/2010
	45VA99154598	ALBEMARLE CO FPSA	CROZET	22932		1005		HEATHERCROFT	CIR			3	78,330	02/01/2010
	45VA99154362	ALBEMARLE CO FPSA	CROZET	22932		1015		HEATHERCROFT	CIR			3	78,330	03/01/2012
	45VA99154253	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1490		PANTOPS MOUNTAIN	PL			2	15,320	10/01/2009
	45VA99154111	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		590		PETER JEFFERSON	PKWY			3	71,700	09/01/2009
	45VA99154110	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2715		HYDRAULIC	RD	**1,250**	4,092	2	5,456	10/01/2009
	45VA99153959	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R	3825		RED HILL	RD	**750**	816	1	816	08/01/2009
	45VA99153958	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	ADJ	3825		RED HILL	RD	**1,000**	1,296	1	1,296	08/01/2009
	45VA99153957	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		3825		RED HILL	RD	**1,250**	1,820	2	2,080	08/01/2009
	45VA99153881	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1895		WOODBURN	RD			3	14,840	08/01/2009
	45VA99153855	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2214		IVY	RD	**3,500**	19,392	2	25,824	04/01/2015
	45VA99153739	ALBEMARLE CO FPSA		22901		805		GARDENS	BLVD	**1,750**	11,947	1	11,947	06/01/2009
	45VA99153739	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		805		GARDENS	BLVD	**1,750**	11,947	1	11,947	06/01/2009
	45VA99153024	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		375		FOUR LEAF	LN	**3,500**	13,800	2	17,280	01/01/2009
	45VA99152956	ALBEMARLE CO FPSA		22901		1827		SEMINOLE	TRL			3	16,654	01/01/2011
	45VA99152956	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1827		SEMINOLE	TRL			3	16,654	01/01/2011
	45VA99152017	ALBEMARLE CO FPSA	CROZET	22932		6317		ROCKFISH GAP	TPKE	**750**	1,680	2	2,240	05/01/2008
	45VA99152002	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1241		RICHMOND	RD			4	35,040	05/01/2008
	45VA99151993	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1809		BROADWAY	ST	**2,250**	6,768	2	7,088	05/01/2008
	45VA99151818	ALBEMARLE CO FPSA	EARLYSVILLE	22936		395		REAS FORD	RD			1	200,540	02/01/2014
	45VA99151308	ALBEMARLE CO FPSA	AFTON	22920		2693		HEARTWOOD	RD	**750**	1,511	2	1,698	02/01/2008
	45VA99150961	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		630		COUNTRY GREEN	LN	**750**	2,400	1	2,400	10/01/2008
	45VA99150764	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1793		RICHMOND	RD			4	72,154	10/01/2007
	45VA99150551	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		120		YELLOWSTONE	DR	**3,500**	33,000	4	52,800	08/01/2007
	45VA99150551	ALBEMARLE CO FPSA		22903		120		YELLOWSTONE	DR	**3,500**	33,000	4	52,800	08/01/2007
	45VA99150091	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		32		MILL CREEK	DR	**2,000**	13,558	1	13,558	05/01/2007
	45VA99149999	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	R	683		THOMAS JEFFERSON	PKWY	**1,000**	1,176	2	1,568	06/01/2011
	45VA99149888	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		594		PANTOPS	CTR	**750**	3,328	1	3,328	04/01/2007
	45VA99149871	ALBEMARLE CO FPSA	CROZET	22932		5496		REAS CREEK	DR	**2,250**	8,600	1	8,600	04/01/2007
	45VA99149868	ALBEMARLE CO FPSA	CROZET	22932		5496		REAS CREEK	DR	**2,000**	7,160	1	7,160	04/01/2007
	45VA99148802	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1205		STONEY RIDGE	RD	**1,500**	13,680	2	15,360	09/01/2006
	45VA99148627	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1615		EARLYSVILLE	RD	**750**	1,812	1	1,812	08/01/2006
	45VA99148578	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3705		DOBLEANN	DR	**1,000**	8,820	1	8,820	08/01/2006
	45VA99148562	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1240		SEMINOLE	TRL	**1,500**	11,300	1	11,300	07/01/2006
	45VA99148545	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1518		VIOLA	WAY	**1,000**	1,800	1	1,800	07/01/2006
	45VA99146557	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1330		THOMAS JEFFERSON	PKWY	**750**	760	1	760	01/01/2006
	45VA99146297	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		120		RIVERBEND	DR	**1,500**	3,200	1	3,200	12/01/2005
	45VA99146181	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		944		GLENWOOD STATION	LN	**1,500**	16,667	3	25,000	11/01/2005
	45VA99146169	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1413		SACHEM	PL	**1,250**	3,012	2	3,584	11/01/2005
	45VA99146047	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		1565		OLD LYNCHBURG	RD	**1,000**	5,000	1	5,000	10/01/2005
	45VA99016036	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2335		SEMINOLE	LN			2	47,328	09/01/2012
	45VA99016033	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2315		SEMINOLE	LN	**1,000**	4,608	2	6,144	04/01/2009
	45VA99015888	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3322		WORTH	XING	**1,750**	4,612	1	4,612	07/01/2005

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	45VA99015686	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1626		RICHMOND	RD	**1,250**	8,480	1	8,480	12/01/2014
	45VA99015456	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2275		SEMINOLE	LN	**1,000**	6,232	1	7,732	05/01/2005
	45VA99015432	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1949		NORTHSIDE	DR			1	32,162	05/01/2005
	45VA99015272	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		500		CRESTWOOD	DR	**500**		7	279,109	10/01/2014
	45VA99015171	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1869		SEMINOLE	TRL			3	18,172	01/01/2011
	45VA99015171	ALBEMARLE CO FPSA		22901		1869		SEMINOLE	TRL			3	18,172	01/01/2011
	45VA99015170	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1851		SEMINOLE	TRL			1	6,600	01/01/2011
	45VA99015170	ALBEMARLE CO FPSA		22901		1851		SEMINOLE	TRL			1	6,600	01/01/2011
	45VA99014739	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	ABT	1300		RICHMOND	RD	**500**	768	1	768	12/01/2004
	45VA99014738	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1300		RICHMOND	RD	**2,250**	31,848	1	31,848	12/01/2004
	45VA99014466	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1195		SEMINOLE	TRL	**1,250**	3,296	1	3,296	11/01/2004
	45VA99014464	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	R	1357		RICHMOND	RD	**1,000**	7,660	1	7,660	05/01/2012
	45VA99014461	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1357		RICHMOND	RD	**500**		1	30,530	05/01/2012
	45VA99014411	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1381		RICHMOND	RD	**1,750**	11,200	1	11,200	05/01/2012
	45VA99014391	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1550		PANTOPS MOUNTAIN	PL			3	78,195	06/01/2005
	45VA99014098	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1294		STONY POINT	RD	**1,250**	4,956	1	4,956	10/01/2004
	45VA99014096	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		100		SHOPPERS WORLD	CT	**1,500**	3,344	1	3,344	10/01/2004
	45VA99011135	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		100		WOODBROOK	DR	**3,000**	50,366	1	50,366	04/01/2008
	45VA66005860	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		25		MILL CREEK	DR	**3,000**	14,140	1	14,140	07/01/2009
	45VA66005855	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1310		PARHAM	CIR	**1,000**	1,900	1	1,900	04/01/2009
	45VA66005854	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	R	32		MILL CREEK	DR	**750**	1,200	1	1,200	04/01/2009
	45VA66000641	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		650		PETER JEFFERSON	PKWY	**2,500**	43,632	3	65,448	01/01/2008
	450003007825	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1807		SEMINOLE	TRL			2	24,192	05/01/2009
	450003007412	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1636		SEMINOLE	TRL	**750**	2,985	1	2,985	09/01/2002
	450003007077	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1000	E	RIO	RD	**3,000**	56,800	1	56,800	09/01/2003
	450003007055	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		634	W	RIO	RD	**1,000**	3,642	2	4,856	02/01/2003
	450003007022	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1525		RIO ROAD EAST		**2,500**	8,304	1	9,804	04/01/2007
	450003007000	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		355		RIO	RD	**3,000**	13,992	2	18,656	07/01/2009
	450003006220	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		2100	E	MARKET	ST			4	87,933	03/01/2012
	45VA99011134	ALBEMARLE CO FPSA	EARLYSVILLE	22936		185		BUCK MOUNTAIN	RD	**3,500**	49,852	1	49,852	03/01/2008
	45VA99011113	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2740		PROFFIT	RD			1	84,365	09/01/2003
	45VA99011076	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		200		ALBEMARLE	SQ	**1,000**	4,050	1	4,050	07/01/2008
	45VA99010611	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1744		SEMINOLE	TRL			1	15,103	07/01/2003
	45VA99010607	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1860		SEMINOLE	TRL			1	11,200	07/01/2003
	45VA99010604	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1900		SEMINOLE	TRL			1	11,200	07/01/2003
	45VA99010603	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1980		SEMINOLE	TRL			1	78,823	07/01/2003
	45VA99010597	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1800		SEMINOLE	TRL			1	21,393	07/01/2003
	45VA99010553	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		307		RIO	RD	**3,000**	19,035	3	25,758	07/01/2009
	45VA99010432	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2891		SEMINOLE	TRL	**1,000**	2,464	3	3,696	06/01/2003
	45VA99010071	ALBEMARLE CO FPSA	KESWICK	22947		3756		RICHMOND	RD	**1,750**	12,076	1	12,076	06/01/2013
	45VA99009965	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1320		BRANCHLANDS	DR	**3,500**	37,511	4	60,162	02/01/2003
	45VA99009866	ALBEMARLE CO FPSA	CROZET	22932		6550		ROSELAND FARM		**1,000**	4,600	2	5,200	02/01/2003
	45VA99009259	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	518		BARRACKS FARM	RD	**2,000**	4,000	1	4,000	11/01/2002
	45VA99009258	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		518		BARRACKS FARM	RD	**4,500**	21,600	1	21,600	11/01/2002
	45VA99009257	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	518		BARRACKS FARM	RD	**2,500**	43,500	1	43,500	11/01/2002
	45VA99009161	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1792		AIRPORT	RD	**750**	5,000	1	5,000	11/01/2002
	45VA99008884	ALBEMARLE CO FPSA	CROZET	22932		5790		THREE NOTCHED	RD	**1,250**	4,848	2	5,296	09/01/2006
	45VA99008883	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		1066		OLD LYNCHBURG	RD	**750**	576	1	576	09/01/2002
	45VA99008605	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		2030		AVON	CT	**1,750**	16,716	2	21,016	09/01/2004
	45VA99008136	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		375		GREENBRIER	DR	**3,000**	15,600	3	23,400	08/01/2013
	45VA99007737	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1313		THOMAS JEFFERSON	PKWY	**750**	824	1	824	02/01/2002
	45VA99007711	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		220		WAYLES	LN	**1,500**	4,712	1	4,712	02/01/2002
	45VA99007706	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1420		RICHMOND	RD	**1,000**	2,388	1	2,388	02/01/2002
	45VA99007694	ALBEMARLE CO FPSA	CROZET	22932	ADJ	5391		THREE NOTCHED	RD	**2,000**	11,300	1	11,300	05/01/2005
	45VA99007692	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1420		RICHMOND	RD	**1,000**	2,388	1	2,388	02/01/2002
	45VA99007686	ALBEMARLE CO FPSA	CROZET	22932		5391		THREE NOTCHED	RD	**3,500**	63,093	2	80,929	12/01/2012
	45VA99006729	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R	500		CRESTWOOD	DR	**1,750**	12,272	2	16,084	10/01/2014
	45VA99006704	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		5688		ROCKFISH GAP	TPKE	**750**	1,664	1	1,664	08/01/2001

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	45VA99006684	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3064		BERKMAR	DR	**1,250**	3,600	1	3,600	08/01/2001
	45VA99006682	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1590		SEMINOLE	TRL	**2,000**	22,080	1	23,980	05/01/2009
	45VA99006617	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		675		PETER JEFFERSON	PKWY			4	87,904	12/01/2003
	45VA99006614	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1575		STATE FARM	BLVD	**2,500**	9,113	3	13,671	08/01/2001
	45VA99006589	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1061	E	RIO	RD	**1,000**	3,102	1	3,102	05/01/2014
	45VA99006379	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	ADJ	683		THOMAS JEFFERSON	PKWY			2	5,502	06/01/2011
	45VA99006364	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		683		THOMAS JEFFERSON	PKWY			3	10,612	06/01/2011
	45VA99006090	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1017		THOMAS JEFFERSON	PKWY	**500**	200	1	200	05/01/2001
	45VA99006087	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1017		THOMAS JEFFERSON	PKWY	**500**	200	1	200	05/01/2001
	45VA99005935	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2422		RICHMOND	RD	**3,000**	42,196	1	42,196	03/01/2001
	45VA99005867	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3670		DOBLEANN	DR	**1,250**	10,000	1	10,000	03/01/2001
	45VA99005735	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1658		STATE FARM	BLVD	**500**		1	20,208	02/01/2001
	45VA99005608	ALBEMARLE CO FPSA	KESWICK	22947		5445		LOUISA	RD	**1,000**	2,376	3	3,168	01/01/2001
	45VA99005543	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		302		HICKMAN	RD			1	3,634	12/01/2000
	45VA99005484	ALBEMARLE CO FPSA	CROZET	22932		1200		CROZET	AVE	**1,500**	3,600	2	4,800	04/01/2009
	45VA99005456	ALBEMARLE CO FPSA	CROZET	22932		1210		CROZET	AVE	**1,000**	5,640	1	8,460	11/01/2000
	45VA99005231	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1980		SEMINOLE	TRL	**4,000**	80,784	1	80,784	09/01/2000
	45VA99005082	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2055		ABBEY	RD	**1,500**	8,552	1	8,552	08/01/2000
	45VA99004826	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1700		TIMBERWOOD	BLVD	**1,500**	3,208	1	3,208	11/01/2008
	45VA99004104	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1738		SCOTTSVILLE	RD	**2,250**	24,750	1	26,250	09/01/1999
	45VA99004015	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1353		THOMAS JEFFERSON	PKWY	**750**	940	1	940	08/01/1999
	45VA99004014	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1353		THOMAS JEFFERSON	PKWY	**750**	1,580	1	1,580	08/01/1999
	45VA99004013	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1353		THOMAS JEFFERSON	PKWY	**500**	1,440	1	1,440	08/01/1999
	45VA99004011	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1353		THOMAS JEFFERSON	PKWY	**1,250**	4,396	1	4,396	08/01/1999
	45VA99003093	ALBEMARLE CO FPSA	CROZET	22932		5190		SUGAR RIDGE	RD	**1,500**	10,761	3	13,821	07/01/1998
	45VA99002987	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2496		OLD IVY	RD	**1,500**	16,698	3	25,047	03/01/2009
	45VA99002252	ALBEMARLE CO FPSA	BARBOURSVILLE	22923	R	4500		WINERY	LN	**1,250**	2,080	1	2,080	01/01/2011
	45VA99002251	ALBEMARLE CO FPSA	BARBOURSVILLE	22923		4500		WINERY	LN	**1,500**	4,816	2	6,106	01/01/2011
	45VA99001948	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2097		INN	DR	**1,750**	37,995	2	55,200	05/01/2006
	45VA99001147	ALBEMARLE CO FPSA	BARBOURSVILLE	22923		4785		BURNLEY STATION	RD	**2,250**	4,911	2	5,428	08/01/2013
	45VA99000975	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1185		SEMINOLE	TRL			1	11,890	03/01/2011
	45VA99000972	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1321		STONY POINT	RD	**750**	1,800	1	1,800	09/01/2004
	45VA99013692	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2800		HYDRAULIC	RD	**750**	2,080	1	2,080	08/01/2004
	45VA99011238	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	210		LAMBS	LN	**500**	504	1	504	09/01/2003
	45VA99011185	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R1	4217		RED HILL	RD	**750**	912	1	912	09/01/2003
	45VA99011183	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R2	4217		RED HILL	RD	**750**	912	1	912	09/01/2003
	45VA99011176	ALBEMARLE CO FPSA	NORTH GARDEN	22959	ADJ	3901		RED HILL SCHOOL	RD	**750**	912	1	912	09/01/2003
	45VA99011175	ALBEMARLE CO FPSA	NORTH GARDEN	22959	ADJ	3901		RED HILL SCHOOL	RD	**750**	1,056	1	1,056	09/01/2003
	45VA99011173	ALBEMARLE CO FPSA	NORTH GARDEN	22959	ADJ	3901		RED HILL SCHOOL	RD	**750**	912	1	912	09/01/2003
	45VA99011163	ALBEMARLE CO FPSA	SCOTTSVILLE	24590	ADJ	7868		SCOTTSVILLE	RD	**750**	912	1	912	09/01/2003
	45VA99011162	ALBEMARLE CO FPSA	SCOTTSVILLE	24590	ADJ	7868		SCOTTSVILLE	RD	**750**	912	1	912	09/01/2003
	45VA99011159	ALBEMARLE CO FPSA	SCOTTSVILLE	24590	ADJ	7868		SCOTTSVILLE	RD	**750**	912	1	912	09/01/2003
	45VA99011146	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	3201		BERKMAR	DR	**750**	864	1	864	01/01/2009
	45VA99011144	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	ADJ	2775		POWELL CREEK	DR	**750**	768	1	768	05/01/2006
	45VA99011143	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	3201		BERKMAR	DR	**750**	864	1	864	01/01/2009
	45VA99011142	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3201		BERKMAR	DR	**3,000**	69,756	1	69,756	01/01/2009
	45VA99011141	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R2	100		WOODBROOK	DR	**750**	1,080	1	1,080	04/01/2008
	45VA99011140	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R1	100		WOODBROOK	DR	**750**	1,080	1	1,080	04/01/2008
	45VA99011139	ALBEMARLE CO FPSA	EARLYSVILLE	22936		185		BUCK MOUNTAIN	RD	**750**	720	1	720	09/01/2003
	45VA99011136	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	100		WOODBROOK	DR	**750**	1,080	1	1,080	04/01/2008
	45VA99163478	ALBEMARLE CO FPSA	EARLYSVILLE	22936		5854		BUFFALO RIVER	RD	**1,250**	2,607	2	3,012	05/01/2015
	45VA66007865	ALBEMARLE CO FPSA	SCOTTSVILLE	24590		181		IRISH	RD	**1,500**	4,590	2	6,120	07/01/2009
	450003411005	ALBEMARLE CO FPSA	SHADWELL	22947		1750		PIPER	WAY	**500**		3	27,975	09/01/2000
	450003410864	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	1000	E	RIO	RD	**500**	432	1	432	09/01/2003
	450003408441	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2405		IVY	RD	**2,000**	17,368	1	17,368	03/01/2005
	450003250551	ALBEMARLE CO FPSA		22901		1901		COMMONWEALTH	DR	**3,000**	13,344	2	17,728	07/01/2014
	450003250551	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1901		COMMONWEALTH	DR	**3,000**	13,344	2	17,728	07/01/2014
	450003166615	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		160		RIVERBEND	DR	**1,500**	2,709	1	2,709	04/01/2013

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	450003161120	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		389		ELK	DR	**1,500**	12,957	1	12,957	02/01/2014
	450003161030	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	ADJ	220	S	PANTOPS	DR	**500**		1	14,608	03/01/2011
	450003160189	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1610		QUAIL	RUN	**2,250**	20,000	1	20,000	06/01/2007
	450003158399	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1215		SEMINOLE	TRL	**1,250**	5,940	1	5,940	01/01/2014
	450003156267	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1460		SEMINOLE	TRL			1	6,400	07/01/1991
	450003155528	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	ABT	2100	E	MARKET	ST	**1,250**	4,960	1	4,960	01/01/2005
	450003154582	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3893		STONY POINT	RD	**2,250**	38,500	1	38,500	09/01/2003
	450003036673	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1296		CLIFTON INN	DR	**2,000**	5,594	2	9,064	06/01/2013
	450003036589	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		250		PANTOPS MOUNTAIN	RD			5	612,614	12/01/2003
	45VA99163046	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		674		HILLSDALE	DR	**1,750**		2	24,384	02/01/2015
	45VA99159636	ALBEMARLE CO FPSA	EARLYSVILLE	22936	R	6953		MARKWOOD	RD	**500**	464	1	464	04/01/2013
	45VA99159635	ALBEMARLE CO FPSA	EARLYSVILLE	22936		6953		MARKWOOD	RD	**1,250**	3,496	1	3,496	04/01/2013
	45VA99159541	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2075		BOND	ST	**2,500**	35,232	1	35,232	03/01/2013
	45VA99159455	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2613		BARRACKS	RD	**750**	2,055	2	2,490	02/01/2013
	45VA99159191	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		355		ALBEMARLE	SQ	**2,250**	7,252	1	7,252	01/01/2013
	45VA99002764	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		103	S	PANTOPS	DR	**3,000**	13,230	2	17,640	04/01/2015
	45VA99015265	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2955		IVY	RD	**500**		3	65,331	04/01/2015
	45VA99164533	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	R	1835		AVON STREET	EXT	**750**	2,100	1	2,100	12/01/2015
	450003000501	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1835		AVON STREET	EXT	**2,000**	24,626	1	24,626	12/01/2015
	45VA99164554	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	2R	3045		IVY	RD	**750**	1,620	2	2,160	12/01/2015
	45VA99164553	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	1R	3045		IVY	RD	**2,000**	14,717	2	20,113	12/01/2015
	45VA99164552	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R	3045		IVY	RD	**750**	5,796	3	8,694	12/01/2015
	45VA99002406	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1201		5 STREET	EXT			3	35,871	12/01/2015
	45VA99163264	ALBEMARLE CO FPSA		22901		625		BERKMAR	CIR	**1,250**	8,400	2	11,200	03/01/2015
	45VA99163264	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		625		BERKMAR	CIR	**1,250**	8,400	2	11,200	03/01/2015
	45VA99150691	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	ADJ	1125		STONEY RIDGE	RD	**1,750**	14,293	1	14,293	03/01/2015
	45VA99150690	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1125		STONEY RIDGE	RD	**1,250**	6,412	2	8,442	03/01/2015
	450003115880	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		669		GOLD EAGLE	DR			1	54,804	03/01/2015
	45VA99012667	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	F	3103		SCOTTSVILLE	RD	**500**	1,104	1	1,104	03/01/2015
	45VA99012665	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		3103		SCOTTSVILLE	RD	**1,750**	4,620	1	4,620	03/01/2015
	450050153820	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2415		IVY	RD	**2,250**	28,800	1	28,800	02/01/2015
	45VA99014877	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3355		BERKMAR	DR			3	35,480	02/01/2015
	45VA99160127	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1791		RICHMOND	RD			1	7,649	02/01/2015
	45VA99165584	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		3025		IVY	RD	**1,250**	11,359	1	11,359	06/01/2016
	45VA99165994	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		919		GARDENS	BLVD	**1,000**	6,770	1	6,770	08/01/2016
	45VA99165993	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		907		GARDENS	BLVD	**1,500**	10,024	1	10,024	08/01/2016
	45VA99165993	ALBEMARLE CO FPSA		22901		907		GARDENS	BLVD	**1,500**	10,024	1	10,024	08/01/2016
	45VA99165972	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	3R	2215		FOXFIELD	TRAK	**1,750**	2,940	1	2,940	08/01/2016
	45VA99165971	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	2R	2215		FOXFIELD	TRAK	**1,750**	2,940	1	2,940	08/01/2016
	45VA99165970	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	2215		FOXFIELD	TRAK	**1,000**	7,325	1	7,325	08/01/2016
	45VA99165969	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	2215		FOXFIELD	TRAK	**1,500**	2,795	1	2,795	08/01/2016
	45VA99165968	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2215		FOXFIELD	TRAK	**750**	1,344	1	1,344	08/01/2016
	45VA99163576	ALBEMARLE CO FPSA	KESWICK	22947	R	5400		GORDONSVILLE	RD	**1,000**	1,710	1	1,710	05/01/2015
	45VA99163575	ALBEMARLE CO FPSA	KESWICK	22947		5400		GORDONSVILLE	RD	**3,500**	22,425	1	23,325	05/01/2015
	45VA99162956	ALBEMARLE CO FPSA	EARLYSVILLE	22936	3R	4510		MOCKERNUT	LN	**1,250**	1,275	2	1,700	01/01/2015
	45VA99162955	ALBEMARLE CO FPSA	EARLYSVILLE	22936	2R	4510		MOCKERNUT	LN	**750**	1,764	1	1,764	01/01/2015
	45VA99162954	ALBEMARLE CO FPSA	EARLYSVILLE	22936	1R	4510		MOCKERNUT	LN	**2,000**	5,334	2	5,880	01/01/2015
	45VA99162951	ALBEMARLE CO FPSA	EARLYSVILLE	22936		4510		MOCKERNUT	LN	**2,250**	7,776	2	10,368	01/01/2015
	45VA99162949	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		400		WORRELL	DR	**1,250**	6,853	2	8,439	02/01/2015
	45VA99003455	ALBEMARLE CO FPSA		22901		671		BERKMAR	CIR	**1,750**	17,280	1	17,280	02/01/2015
	45VA99003455	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		671		BERKMAR	CIR	**1,750**	17,280	1	17,280	02/01/2015
	45VA99162934	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1800		TIMBERWOOD	BLVD	**1,250**	12,474	1	12,474	02/01/2015
	45VA99158379	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1531		RIO	RD			1	104,102	07/01/2012
	45VA99158353	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2331		SEMINOLE	LN			2	30,306	06/01/2014
	45VA99158206	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R	556		DETTOR	RD	**1,500**	3,494	1	3,494	05/01/2012
	45VA99158062	ALBEMARLE CO FPSA	KESWICK	22947		5412		LOUISA	RD	**1,750**	3,920	1	3,920	04/01/2012
	45VA99157998	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		350		PORTICO	WAY			4	149,332	03/01/2012
	45VA99157929	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1840		ARDEN CREEK	LN	**3,500**	31,345	4	50,152	03/01/2012

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	45VA99157928	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1810		ARDEN CREEK	LN	**2,000**	6,840	2	8,208	03/01/2012
	45VA99164573	ALBEMARLE CO FPSA	EARLYSVILLE	22936	R	395		REAS FORD	RD	**750**	3,554	1	3,554	12/01/2015
	45VA99153342	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1201		FIVE SPRINGS	RD	**1,750**	14,560	1	15,760	04/01/2009
	45VA99153288	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		505		BERWICK	RD	**4,000**	17,780	1	17,780	04/01/2009
	45VA99153288	ALBEMARLE CO FPSA		22901		505		BERWICK	CT	**4,000**	17,780	1	17,780	04/01/2009
	45VA99153268	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3311		WORTH	XING	**2,000**	6,168	1	6,168	04/01/2009
	45VA99153171	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2427		PEYTON	DR	**3,000**	14,000	3	20,000	03/01/2009
	45VA99153170	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		300		COMMONWEALTH	CT	**2,250**	8,000	3	12,000	03/01/2009
	45VA99153027	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1390		RICHMOND	RD	**1,500**	8,882	2	10,696	01/01/2009
	450003145900	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901				RTE 29		**1,000**	1,360	3	3,480	01/01/1990
	45VA66013331	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1000		OLD BROOK	RD	**1,000**	2,295	2	3,060	03/01/2011
	45VA99151038	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		4372		IVY	RD	**1,000**	2,648	1	2,648	10/01/2016
	45VA99158773	ALBEMARLE CO FPSA	CROZET	22932		5888		ST GEORGE	AVE	**1,500**	4,050	2	6,687	09/01/2012
	45VA99158460	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	1193		SEMINOLE	TRL	**750**	3,100	1	3,100	07/01/2012
	45VA99158459	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1193		SEMINOLE	TRL	**750**	3,663	1	3,663	07/01/2012
	45VA99158458	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1193		SEMINOLE	TRL	**2,000**	13,396	1	13,396	07/01/2012
	45VA99158410	ALBEMARLE CO FPSA	EARLYSVILLE	22936		1842		DAVIS SHOP	RD	**1,250**	3,216	2	4,945	07/01/2012
	450003160099	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1180		PEPSI	PL			2	21,780	07/01/2016
	45VA99003917	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2151		RICHMOND	RD	**2,500**	7,800	2	10,400	11/05/2018
	45VA99014452	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1470		PANTOPS MOUNTAIN	PL			2	37,536	11/05/2018
	450003004412	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2000		SEMINOLE	TRL			1	48,576	05/01/1991
	450003003260	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1		CRUTCHFIELD	PARK	**500**		3	41,525	09/01/2016
	450003000140	ALBEMARLE CO FPSA	COVESVILLE	22931		5678		HEARDS MOUNTAIN	RD	**2,000**	21,800	1	21,800	01/01/1982
	450003000140	ALBEMARLE CO FPSA	COVESVILLE	22931		5678		HEARDS MOUNTAIN	RD	**2,000**	21,800	1	21,800	01/01/1982
	45VA99148914	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1510		BROAD CROSSING	RD			1	8,000	10/01/2006
	45VA99002760	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3300		BERKMAR	DR	**1,250**	11,019	2	14,692	02/01/1998
	45VA99000158	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		3045		IVY	RD			3	12,147	12/01/2015
	45VA97001316	ALBEMARLE CO FPSA	NORTH GARDEN	22959		4907		PLANK	RD	**1,000**	6,510	2	7,870	10/11/2018
	45VA97001306	ALBEMARLE CO FPSA	NORTH GARDEN	22959		5022		PLANK	RD	**4,000**	20,735	3	23,790	10/10/2018
	45VA97001289	ALBEMARLE CO FPSA	BATESVILLE	22924		6670		PLANK	RD	**1,000**	4,050	2	4,650	10/01/2018
	45VA99167311	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		4245		FREE UNION	RD	**1,500**	2,132	1	2,132	10/01/2018
	45VA66016806	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		665		OLD LYNCHBURG	RD	**1,250**	2,640	1	2,640	11/01/2012
	45VA66016805	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		1284		SUNSET AVENUE	EXT	**750**	2,560	1	2,560	11/01/2012
	45VA97001249	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		295		MERCHANT WALK	AVE	**1,500**	3,090	1	3,090	09/18/2018
	45VA99167728	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		638		HILLSDALE	DR			3	98,815	09/14/2018
	45VA99006374	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		576		BRANCHLANDS	BLVD			1	9,816	09/14/2018
	45VA66016533	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1600		SEMINOLE	TRL	**750**	1,700	1	1,700	09/01/2012
	45VA66016526	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1295		SEMINOLE	TRL	**750**	2,760	1	2,760	07/01/2012
	45VA66016525	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1265		SEMINOLE	TRL	**1,000**	4,620	1	4,620	07/01/2012
	45VA97001117	ALBEMARLE CO FPSA	COVESVILLE	22931	2R	5861		PIEDMONT APPLE	LN	**750**	5,120	1	5,120	08/13/2018
	45VA97001116	ALBEMARLE CO FPSA	COVESVILLE	22931	3R	5861		PIEDMONT APPLE	LN	**2,250**	7,700	1	7,700	08/13/2018
	45VA97001115	ALBEMARLE CO FPSA	COVESVILLE	22931		5861		PIEDMONT APPLE	LN	**3,000**	41,633	2	42,635	08/13/2018
	45VA99012844	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1646		SEMINOLE	TRL	**1,500**	10,404	1	10,404	04/01/2004
	450003007040	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1445	E	RIO	RD	**3,000**	11,844	3	17,766	02/01/1991
	45VA66005857	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1200		STONEY RIDGE	RD	**2,250**	24,500	1	24,500	04/01/2009
	45VA66005858	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1122		STONEY RIDGE	RD	**2,500**	24,555	1	24,555	04/01/2009
	45VA66005856	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1215		FIVE SPRINGS	RD	**1,250**	2,400	1	2,400	04/01/2009
	45VA99152416	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		3325		LOBBAN	PL	**1,250**	7,200	1	7,200	09/01/2008
	450003000751	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2100		BERKMAR	DR	**1,250**	7,500	1	7,500	05/01/2003
	45VA99003330	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		635		HILLSDALE	DR	**2,000**	23,690	2	24,590	10/01/1998
	450003003701	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		101		RIVERBEND	DR	**750**	4,758	2	5,406	06/01/1993
	45VA97000971	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		3101		FONTAINE AVENUE EXTENDED		**5,000**	46,498	2	54,795	07/02/2018
	45VA97000958	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		425		BURGOYNE	RD	**1,750**	11,074	2	14,298	06/29/2018
	45VA97000957	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		255		SAPONI	LN	**750**	3,540	2	4,390	06/29/2018
	45VA99010822	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1553		DELPHI	DR	**2,000**	7,266	1	7,266	06/28/2018
	45VA97000841	ALBEMARLE CO FPSA	KESWICK	22947		4842		RICHMOND	RD	**1,000**	1,544	2	1,794	05/31/2018
	45VA97000584	ALBEMARLE CO FPSA	CROZET	22932		5721		MEADOWS	DR	**1,250**	3,025	1	3,025	04/09/2018
	45VA97000583	ALBEMARLE CO FPSA	CROZET	22932		5728		MEADOWS	DR	**1,250**	3,025	1	3,025	04/09/2018

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	45VA97000582	ALBEMARLE CO FPSA	CROZET	22932		5735		MEADOWS	DR	**1,000**	2,100	1	2,100	03/28/2018
	45VA97000581	ALBEMARLE CO FPSA	CROZET	22932		5727		MEADOWS	DR	**1,250**	3,025	1	3,025	04/09/2018
	45VA97000580	ALBEMARLE CO FPSA	CROZET	22932		5813		MEADOWS	DR	**1,250**	3,025	1	3,025	04/09/2018
	45VA97000579	ALBEMARLE CO FPSA	CROZET	22932		5821		MEADOWS	DR			2	6,380	04/09/2018
	45VA97000578	ALBEMARLE CO FPSA	CROZET	22932		5722		MEADOWS	DR	**1,250**	3,025	1	3,025	04/09/2018
	45VA97000577	ALBEMARLE CO FPSA	CROZET	22932		5729		MEADOWS	DR	**1,250**	3,025	1	3,025	04/09/2018
	45VA97000562	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		829		MALLSIDE FOREST	CT	**500**		3	81,264	03/27/2018
	45VA99005182	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		670		BERKMAR	CIR	**1,750**	19,352	3	29,028	03/28/2018
	450003008055	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		685		RIO	RD			3	39,192	03/29/2018
	45VA97000518	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1800		RIO HILL	CTR	**500**		1	9,797	03/22/2018
	45VA97000456	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1860		RIO HILL	CTR			1	11,200	03/12/2018
	45VA99167098	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		655		WOODBROOK	DR			4	25,320	03/07/2018
	45VA99167099	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		675		WOODBROOK	DR			3	18,990	03/07/2018
	45VA99167100	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	675		WOODBROOK	DR	**1,250**	3,480	1	3,480	03/07/2018
	45VA99167097	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		635		WOODBROOK	DR			4	25,320	03/07/2018
	450003007861	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3500		SEMINOLE	TRL	**1,500**	7,725	2	9,160	03/01/2000
	45VA99005936	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2424		RICHMOND	RD	**1,250**	10,956	1	10,956	03/01/2001
	45VA97000369	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		375		MERCHANT WALK	SQ			1	31,259	02/22/2018
	45VA97000355	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		5209		BELLAIR FARM		**3,000**	13,820	1	13,820	02/20/2018
	45VA99161077	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1982		SNOW POINT	LN	**1,250**	3,240	1	3,240	02/07/2018
	45VA97000241	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1992		SNOW POINT	LN	**1,750**	3,240	1	3,240	01/23/2018
	45VA97000240	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1972		SNOW POINT	LN	**1,250**	3,240	1	3,240	01/23/2018
	45VA99157509	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	1728		SEMINOLE	TRL	**2,000**	9,200	1	9,200	12/19/2017
	45VA99157513	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	5R	1728		SEMINOLE	TRL	**1,000**	2,616	1	2,616	12/19/2017
	45VA99157510	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	2R	1728		SEMINOLE	TRL	**1,250**	4,950	1	4,950	12/19/2017
	45VA99157511	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	3R	1728		SEMINOLE	TRL	**1,500**	6,660	1	6,660	12/19/2017
	45VA99157507	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1728		SEMINOLE	TRL	**500**	1,584	2	2,112	12/19/2017
	45VA99157514	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	6R	1728		SEMINOLE	TRL	**1,250**	4,200	2	5,600	12/19/2017
	45VA99157512	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	4R	1728		SEMINOLE	TRL	**2,000**	10,140	2	13,520	12/19/2017
	45VA99157515	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	7R	1728		SEMINOLE	TRL	**750**	1,120	1	1,120	12/19/2017
	45VA99157508	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R	1728		SEMINOLE	TRL	**1,500**	7,680	1	7,680	12/19/2017
	45VA99160798	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	R	575		RODES	DR	**750**	1,627	1	1,627	12/19/2017
	45VA99005573	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903	1R	575		RODES	DR	**750**	625	1	625	12/19/2017
	45VA99005572	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		575		RODES	DR	**2,250**	8,304	2	10,332	12/19/2017
	45VA97000155	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2186		RICHMOND	RD	**3,500**	24,765	2	33,020	01/03/2018
	45VA99001585	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		260		PANTOPS	CTR	**1,000**	7,852	1	7,852	12/20/2017
	45VA99168342	ALBEMARLE CO FPSA	GREENWOOD	22943		8312		BROOKSVILLE	RD		5,055	2	6,740	12/01/2017
	45VA99009802	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1885		SEMINOLE	TRL			2	39,810	12/01/2017
	450003007706	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	2150		SEMINOLE	TRL	**750**	2,100	1	2,100	11/27/2017
	450003007705	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2150		SEMINOLE	TRL	**3,000**	49,776	2	51,336	11/27/2017
	45VA99168201	ALBEMARLE CO FPSA	GREENWOOD	22943		465		NEWTOWN	RD	**1,250**	1,800	1	1,800	11/01/2017
	45VA99167391	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		6624		PLANK	RD	**1,500**	3,134	2	3,795	06/01/2017
	450050007986	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2350		SEMINOLE	TRL		1,000	9	175,314	12/01/1997
	450003156277	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1420		SEMINOLE	TRL			1	13,600	04/01/1998
	450003156270	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1450		SEMINOLE	TRL			1	71,408	08/01/1991
	450003008508	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1778		SEMINOLE	TRL			1	9,632	08/01/1992
	450003008500	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1786		SEMINOLE	TRL			2	94,750	01/01/1996
	45VA99167876	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		325		WINDING RIVER	LN	**500**		3	17,700	09/01/2017
	45VA99166191	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		4006		HUNTERSTAND	CT	**1,250**	6,917	1	6,917	09/01/2016
	45VA99166190	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		4004		HUNTERSTAND	CT	**1,750**	12,765	1	12,765	09/01/2016
	45VA99148064	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1980		RIO HILL	CTR			1	80,900	05/01/2006
	45VA99147770	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		218		ALBEMARLE	SQ	**2,250**	17,414	1	17,414	03/01/2006
	45VA99146057	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		300		PANTOPS	CTR	**1,750**	14,688	1	14,688	10/01/2005
	45VA99015243	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		570		PANTOPS	CTR	**2,500**	37,272	1	37,272	04/01/2005
	45VA99015242	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		400		PANTOPS	CTR			1	64,404	04/01/2005
	45VA99015241	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		100	S	PANTOPS	DR	**1,750**	8,256	1	8,256	04/01/2005
	45VA99012047	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R1	600		SHOPPERS WORLD	CT			1	72,974	12/01/2003
	45VA99012040	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1500		SEMINOLE	TRL	**2,250**	14,240	1	14,240	01/01/2003

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	45VA99012036	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		600		SHOPPERS WORLD	CT			1	72,974	12/01/2003
	45VA99012035	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R2	800		SHOPPERS WORLD	CT			1	6,400	12/01/2003
	45VA99012034	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		500		SHOPPERS WORLD	CT			1	10,800	12/01/2003
	45VA99011998	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R3	900		SHOPPERS WORLD	CT	**1,000**	5,200	1	5,200	12/01/2003
	45VA99011669	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1940		SEMINOLE	TRL			1	46,695	11/01/2003
	45VA99011529	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		975		HILTON HEIGHTS	RD			1	119,083	10/01/2004
	45VA99010610	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1774		SEMINOLE	TRL			1	41,080	07/01/2003
	45VA99010601	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2030		SEMINOLE	TRL			1	12,777	07/01/2003
	45VA99010596	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1850		SEMINOLE	TRL			1	25,012	07/01/2003
	45VA99010577	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1790		SEMINOLE	TRL			1	12,000	07/01/2003
	45VA99009690	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	R4	900		SHOPPERS WORLD	CT	**1,000**	5,388	1	5,388	01/01/2003
	45VA99006307	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		300		SHOPPERS WORLD	CT			1	27,800	12/01/2003
	45VA99167504	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		120		WEGMANS	WAY			1	100,002	07/01/2017
	45VA99167503	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		140		WEGMANS	WAY	**3,000**	34,838	1	34,838	07/01/2017
	45VA99167502	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		245		MERCHANT WALK	AVE	**1,250**	8,409	1	8,409	07/01/2017
	45VA99167501	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		250		MERCHANT WALK	AVE	**1,250**	8,715	1	8,715	07/01/2017
	45VA99167500	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		255		MERCHANT WALK	AVE	**750**	2,280	1	2,280	07/01/2017
	45VA99167497	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		265		MERCHANT WALK	SQ	**1,250**	8,340	1	8,340	07/01/2017
	45VA99167494	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		325		MERCHANT WALK	SQ	**2,000**	19,737	1	19,737	07/01/2017
	45VA99167486	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		415		MERCHANT WALK	SQ	**2,000**	9,949	1	9,949	07/01/2017
	45VA99167484	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		425		MERCHANT WALK	SQ	**1,750**	14,107	1	14,107	07/01/2017
	45VA99167483	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		435		MERCHANT WALK	SQ	**1,750**	13,792	1	13,792	07/01/2017
	45VA99167453	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1677		AVON STREET	EXT	**750**	1,722	1	1,722	06/01/2017
	45VA99167437	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		405		MERCHANT WALK	SQ	**1,750**	4,414	1	4,414	06/01/2017
	45VA99167430	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		100		WEGMANS	WAY			1	136,800	06/01/2017
	45VA99167429	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		150		WEGMANS	WAY	**1,750**	18,018	1	18,018	07/01/2017
	45VA99167397	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		315		MERCHANT WALK	SQ	**1,250**	7,200	1	7,200	06/01/2017
	45VA99011171	ALBEMARLE CO FPSA	ESMONT	22937	ADJ	7625		PORTERS	RD	**750**	912	1	912	09/01/2003
	45VA99167681	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3352		BERKMAR	DR	**1,750**	13,200	2	13,880	08/01/2017
	45VA99153244	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		4257		SEMINOLE	TRL			1	86,850	08/01/2017
	45VA99167035	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1675		AVON STREET	EXT	**2,000**	14,580	2	17,065	06/01/2017
	45VA99166901	ALBEMARLE CO FPSA	CROZET	22932	F	5995		ROCKFISH GAP	TPKE	**500**	1,440	1	1,440	02/01/2017
	45VA99166900	ALBEMARLE CO FPSA	CROZET	22932		5995		ROCKFISH GAP	TPKE	**1,500**	3,468	2	4,225	02/01/2017
	45VA99166873	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		930		OLYMPIA	DR	**2,000**	12,708	1	12,708	02/01/2017
	45VA99166738	ALBEMARLE CO FPSA	CROZET	22932	F	6115		ROCKFISH GAP	TPKE	**750**	3,200	1	3,200	01/01/2017
	45VA99166737	ALBEMARLE CO FPSA	CROZET	22932		6115		ROCKFISH GAP	TPKE	**1,750**	3,678	2	4,556	01/01/2017
	45VA99166725	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1389		RICHMOND	RD	**1,500**	13,816	1	13,816	01/01/2017
	45VA99166645	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3008		RICHMOND	RD	**1,500**	3,425	1	3,425	12/01/2016
	45VA99011245	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	1610		OWENSVILLE	RD	**750**	864	1	864	09/01/2003
	45VA99011244	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1610		OWENSVILLE	RD			1	56,450	09/01/2003
	45VA99011170	ALBEMARLE CO FPSA	ESMONT	22937	ADJ	7625		PORTERS	RD	**750**	912	1	912	09/01/2003
	45VA99011169	ALBEMARLE CO FPSA	ESMONT	22937		7625		PORTERS	RD	**2,250**	27,230	1	27,230	09/01/2003
	45VA99148326	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		960		HILTON HEIGHTS	RD	**2,250**	65,217	2	98,254	05/01/2017
	45VA99006891	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		4105		LEWIS N CLARK	DR			4	82,048	04/01/2017
	45VA99008342	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1670		DISCOVERY	DR			2	42,400	04/01/2017
	45VA99152585	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		1		BOARS HEAD POINTE		**500**		3	27,788	04/01/2017
	45VA99152463	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1001		RESEARCH PARK	BLVD			4	92,096	04/01/2017
	45VA99010126	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1000		RESEARCH PARK	BLVD			3	69,768	04/01/2017
	45VA99005941	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	ADJ	3450		SEMINOLE	TRL	**1,500**	9,912	1	9,912	04/01/2017
	450003003836	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2813		HYDRAULIC	RD	**1,000**	7,586	1	7,586	04/01/2017
	450050412056	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		571		BRANCHLANDS	BLVD	**1,000**	5,084	1	5,084	09/01/1995
	450050007503	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1680		SEMINOLE	TRL	**750**	3,272	1	3,272	03/01/1994
	450003410474	ALBEMARLE CO FPSA	KESWICK	22947		4085		KESWICK	RD	**1,250**	4,800	2	6,400	07/01/1995
	450003186900	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1265		RICHMOND	RD	**750**	2,400	1	2,400	11/01/1989
	450003169350	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		201		BOWEN LOOP				2	55,627	03/01/1991
	450003166900	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3001		HOLLYMEAD	DR	**1,750**	4,433	3	5,449	11/01/1987
	450003166620	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		725		RIO	RD	**1,000**	8,190	2	10,920	11/01/1998
	450003166610	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	1R	338		RIO	RD	**2,250**	5,000	1	5,000	03/01/1989

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	450003166568	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		31		BLENHIEM FARM		**500**	120	1	120	04/01/1985
	450003166567	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		31		BLENHIEM FARM		**500**	144	1	144	04/01/1985
	450003166566	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		31		BLENHIEM FARM		**500**	525	1	525	04/01/1985
	450003166565	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		31		BLENHIEM FARM		**2,000**	2,700	2	3,600	04/01/1985
	450003162300	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1585		AVON STREET	EXT	**1,750**	15,000	1	16,500	05/01/2015
	450003161050	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		504		PANTOPS	CTR	**1,250**	8,000	1	8,000	02/01/1993
	450003161049	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		504		PANTOPS	CTR	**2,500**	27,224	1	27,224	02/01/1993
	450003161048	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		504		PANTOPS	CTR	**1,500**	10,400	1	10,400	02/01/1993
	450003161047	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		504		PANTOPS	CTR			1	11,480	02/01/1993
	450003161044	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		392	S	PANTOPS	DR	**750**	3,300	1	3,300	02/01/1993
	450003160190	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1615		QUAIL	RUN	**2,500**	28,800	1	28,800	01/01/1991
	450003159783	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		3680		STOCKTON	RD	**750**	1,175	1	1,175	08/01/1983
	450003159392	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		170	S	PANTOPS	DR	**1,250**	4,400	3	6,600	10/01/1992
	450003156269	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1434		SEMINOLE	TRL			1	10,800	07/01/1991
	450003152403	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2553		PROFFIT	RD	**1,750**	3,500	1	3,500	03/01/1991
	450003152402	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2553		PROFFIT	RD	**2,000**	4,650	1	4,650	03/01/1991
	450003152401	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2553		PROFFIT	RD	**3,000**	8,800	1	8,800	03/01/1991
	450003152400	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2553		PROFFIT	RD	**3,500**	34,450	2	35,425	03/01/1991
	450003150185	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2320		MINOR MILL	RD	**1,250**	3,456	1	3,456	01/01/1986
	450003116560	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1321		OAK TREE	LN	**1,250**	1,800	2	2,400	10/01/1985
	450003115870	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1725		BROADWAY	ST			2	13,661	11/01/1991
	450003100242	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2325		SEMINOLE	LN	**500**		1	24,000	06/01/2015
	450003056900	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1764		SEMINOLE	TRL			1	15,300	08/01/1992
	450003056888	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1772		SEMINOLE	TRL			1	12,000	08/01/1992
	450003056887	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1770		SEMINOLE	TRL			1	42,520	01/01/1996
	450003014984	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		5100		DICKERSON	RD	**750**	5,200	1	5,200	11/01/1998
	450003010800	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		3025		BERKMAR	DR	**2,250**	8,100	3	12,100	06/01/1990
	450003008520	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1774		SEMINOLE	TRL			1	22,480	01/01/1996
	450003008515	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1776		SEMINOLE	TRL			1	26,144	08/01/1992
	450003008510	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1780		SEMINOLE	TRL			1	12,800	08/01/1992
	450003008505	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1784		SEMINOLE	TRL			1	12,000	11/01/1992
	450003008490	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1782		SEMINOLE	TRL			1	46,695	08/01/1992
	450003007882	ALBEMARLE CO FPSA	KESWICK	22947	ADJ	701		CLUB VIEW	DR			3	25,300	09/01/1994
	450003007881	ALBEMARLE CO FPSA	KESWICK	22947		701		CLUB VIEW	DR			4	54,548	09/01/1994
	450003007880	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1416		SEMINOLE	TRL			1	27,200	12/01/1993
	450003007845	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2000		SEMINOLE	TRL	**750**	6,000	1	6,000	01/01/1986
	450003007760	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1500		SEMINOLE	TRL	**2,000**	16,290	1	16,290	08/01/1988
	450003007443	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1646		SEMINOLE	TRL	**750**	3,010	1	3,010	01/01/1993
	450003007025	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1532	E	RIO	RD	**6,000**	255,860	1	255,860	12/01/2000
	450003003834	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2775		HYDRAULIC	RD	**1,250**	8,951	1	8,951	02/01/1982
	450003003703	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	1R	101		RIVERBEND	DR	**500**	1,450	1	1,450	06/01/1993
	450003003660	ALBEMARLE CO FPSA	CROZET	22932		1408		CROZET	AVE	**2,250**	21,392	1	21,392	10/01/1994
	450003003650	ALBEMARLE CO FPSA	CROZET	22932		1407		CROZET	AVE	**2,250**	37,125	2	42,875	04/01/1991
	450003003471	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1070		SEMINOLE	TRL			1	100,000	01/01/1996
	450003003450	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		601		HILLSDALE	DR	**1,250**	6,600	1	6,600	09/01/1992
	450003003340	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		518		BARRACKS FARM	RD	**2,500**	43,500	1	43,500	04/01/1993
	450003003290	ALBEMARLE CO FPSA	SCOTTSVILLE	24590		7414		SCOTTSVILLE	RD	**500**	840	1	840	07/01/1990
	450003002750	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1353		THOMAS JEFFERSON	PKWY	**1,000**	4,525	1	4,525	02/01/1997
	450003002703	ALBEMARLE CO FPSA	CROZET	22932	R	5505		WALNUT LEVEL	RD	**1,250**	1,125	1	1,125	07/01/1988
	450003002700	ALBEMARLE CO FPSA	CROZET	22932		5505		WALNUT LEVEL	RD	**2,250**	4,845	2	5,820	07/01/1988
	450003001766	ALBEMARLE CO FPSA	CROZET	22932		6135		ROCKFISH GAP	TPKE	**1,000**	5,320	1	5,320	04/01/1993
	450003001370	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		2390		HUNTERS	WAY	**500**	1,600	1	20,000	06/01/1988
	450003000299	ALBEMARLE CO FPSA	CROZET	22932		5505		WALNUT LEVEL	RD	**3,000**	8,514	2	9,564	04/01/1989
	450003000141	ALBEMARLE CO FPSA	COVESVILLE	22931		5678		HEARDS MOUNTAIN	RD	**1,000**	4,800	1	4,800	01/01/1982
	450003000078	ALBEMARLE CO FPSA	CROZET	22932		5804		SAINT GEORGE	AVE	**3,500**	21,002	2	23,900	10/01/1994
	450003000064	ALBEMARLE CO FPSA	CROZET	22932		5652		THREE NOTCHED	RD	**1,000**	8,800	1	8,800	11/01/1987
	45VA99012248	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	777		MYERS	DR	**1,000**	7,200	1	7,200	01/01/2004
	45VA99003174	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		475		FRANKLIN	ST			1	9,450	07/01/2013

Rev	Risk ID	Fire Protection Area (FPA)	Postal Community	Zip	Prefix 1	Low No. 1	Direction 1	Thoroughfare Name 1	Type 1	NFF	Eff Area	Stories	Tot Flr Area	Survey Date
	45VA99002928	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		400		WESTFIELD	RD	3,000	11,997	2	15,996	04/01/1998
	45VA99002408	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		3464		WORTH	XING			1	6,440	10/01/1997
	45VA99001712	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1652		HARRIS CREEK	RD	2,250	10,880	2	13,140	08/01/1997
	45VA99000579	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1895		SEMINOLE	TRL	1,750	13,650	2	16,800	04/01/1996
	45VA99000178	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1980		RIO HILL	CTR	1,250	5,390	1	5,390	01/01/1997
	45VA99010350	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		620		BERKMAR	CIR	2,000	19,950	1	19,950	12/01/2014
	45VA99157687	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		615		WOODBROOK	DR	1,750	6,030	1	6,030	03/01/2017
	45VA99162762	ALBEMARLE CO FPSA	EARLYSVILLE	22936		2345		EARLYSVILLE	RD	1,500	4,627	2	5,758	12/01/2014
	45VA99011250	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	1610		OWENSVILLE	RD	500	192	1	192	09/01/2003
	45VA99011249	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	1610		OWENSVILLE	RD	500	192	1	192	09/01/2003
	45VA99011248	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	1610		OWENSVILLE	RD	500	192	1	192	09/01/2003
	45VA99011247	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	1610		OWENSVILLE	RD	500	192	1	192	09/01/2003
	45VA99011246	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901	ADJ	1610		OWENSVILLE	RD	750	864	1	864	09/01/2003
	450003000668	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	2R	1740		TIMBERWOOD	BLVD			1	9,670	02/01/2017
	450003000667	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1740		TIMBERWOOD	BLVD			1	37,972	02/01/2017
	450003000666	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911	3R	1740		TIMBERWOOD	BLVD	1,500	11,440	1	11,440	02/01/2017
	45VA99015500	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1770		TIMBERWOOD	BLVD	1,750	14,838	1	14,838	02/01/2017
	45VA99157463	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2615		HYDRAULIC	RD	2,000	7,200	3	10,800	11/01/2011
	45VA99156505	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1440		SACHEM	PL	1,750	7,452	2	9,936	03/01/2011
	45VA99152209	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1500		RIO	RD	4,000	27,000	2	36,000	07/01/2008
	45VA99014924	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2119		BERKMAR	DR	1,500	4,263	3	6,090	01/01/2005
	45VA99000851	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1525		STONY POINT	RD	1,750	11,364	3	15,008	07/01/2002
	45VA99166345	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902	7R	1501		AVON ST	EXT	2,250	13,000	1	13,000	10/01/2016
	45VA99166280	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		695		BERKMAR	CT	1,250	6,750	1	6,750	10/01/2016
	45VA99166188	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1301		SEMINOLE	TRL	1,250	4,770	1	4,770	09/01/2016
	45VA99166186	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1309		SEMINOLE	TRL	1,250	8,000	1	8,000	09/01/2016
	45VA99166101	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		2120		BERKMAR	DR	1,000	5,425	1	5,425	09/01/2016
	459991022268	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1770		TIMBERWOOD	BLVD	3,500	14,611	1	14,911	06/01/2008
	459991022267	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		1770		TIMBERWOOD	BLVD	3,500	14,611	1	14,911	06/01/2008
	459991017342	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		355		ALBEMARLE	SQ	1,250	2,300	1	2,300	03/01/2011
	459991017341	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		355		ALBEMARLE	SQ	1,250	2,300	1	2,300	03/01/2011
	459991017340	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		355		ALBEMARLE	SQ	1,250	2,300	1	2,300	03/01/2011
	459991017338	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		355		ALBEMARLE	SQ	1,250	2,300	1	2,300	03/01/2011
	459991017205	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		355		ALBEMARLE	SQ	1,250	2,300	1	2,300	03/01/2011
	459991017203	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		55		ALBEMARLE	SQ	500	1,100	1	1,100	03/01/2011
	459991015550	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		300		PANTOPS	CTR	1,750	14,688	1	14,988	10/01/2005
	459991013931	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2214		IVY	RD	3,500	19,916	2	26,012	07/01/2009
	459991013930	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2214		IVY	RD	3,500	19,916	2	26,312	07/01/2009
	459991013929	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2214		IVY	RD	3,500	19,916	2	26,012	07/01/2009
	459991013928	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22903		2214		IVY	RD	3,500	19,916	2	26,312	07/01/2009
	459991013763	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		650		PETER JEFFERSON	PKWY	2,500	43,632	3	65,448	01/01/2008
	459991010468	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1200		STONEY RIDGE	RD	2,500	24,500	1	24,500	04/01/2009
	459991008040	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22902		1200		STONEY RIDGE	RD	2,500	24,500	1	24,500	04/01/2009
	459991006026	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		944		GLENWOOD STATION	LN	1,500	16,667	3	25,000	11/01/2005
	459991005619	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		250		PANTOPS MOUNTAIN	RD			4	217,476	06/01/1991
	459991004676	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1532	E	RIO	RD	6,000	255,860	1	257,560	12/01/2000
	459991002942	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1320		BRANCHLANDS	DR	4,500	37,511	4	117,364	02/01/2003
	459991002941	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1320		BRANCHLANDS	DR	4,500	37,511	4	117,364	02/01/2003
	459991002772	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		376	S	PANTOPS	DR	3,000	40,936	1	39,532	02/01/1993
	459991002771	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22911		376	S	PANTOPS	DR	3,000	40,936	1	39,532	02/01/1993
	459991002770	ALBEMARLE CO FPSA	CHARLOTTESVILLE	22901		1532	E	RIO	RD	6,000	255,860	1	257,560	12/01/2000

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Appendix F

Storage Tanks

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Storage Tanks

1. Development of Future Operating Storage

Utilizing the hourly peaking factor diurnal patterns developed from pump station and tank level monitoring data provided by the RWSA, Michael Baker developed cumulative demand curves for a constant pumping rate on an assumed schedule of 8, 16, 20, or 24 hours. Example cumulative demand curves are presented in Figure 1. The pumping schedule (Table 1) was selected such that pump station delivery did not exceed firm capacity. The difference between the maximum and minimum cumulative demand curves, multiplied by the average daily demand (ADD), represents the volume of operating storage required for the system to be in equilibrium. Pump station delivery rates, firm capacities, ADD, and the resulting required volume of operating storage are presented in Table 2.

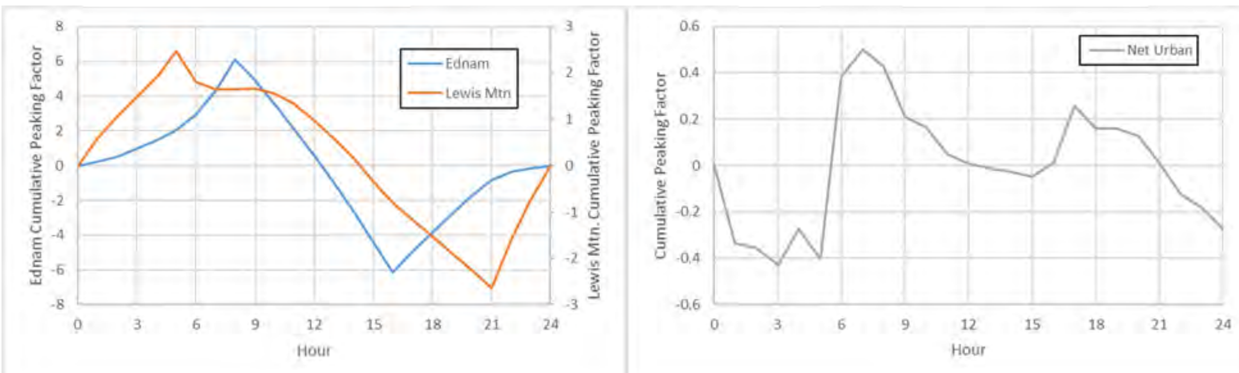

Figure 1. Cumulative Demand Curve with Assumed Pumping Schedule for Ednam PZ.

Table 1. Start and End Times for Assumed Pump Station Schedules

Duration (hours)	Start Time	End Time
8	9 a.m.	5 p.m.
16	6 a.m.	10 p.m.
20	4 a.m.	12 a.m.
24	-	-

Table 2. Pump Station Schedules and Tank Operating Volumes

Pressure Zone	PS Hours On	Cumulative Peaking Factor				ADD (MGD)	Operating Storage (MG)
		Maximum	Minimum	Difference over 24 Hrs	Difference per Hour		
North	16	2.938	-2.473	5.411	0.225	0.90	0.20
Lewis Mountain	16	2.901	-2.783	5.684	0.237	0.60	0.14
Stillhouse	16	2.623	-2.178	4.801	0.200	0.89	0.18
Mosby Mountain	8	6.656	-8.521	15.177	0.632	0.20	0.13
Avon Park	8	6.416	-8.087	14.503	0.604	0.07	0.04
Ednam	8	6.084	-6.146	12.23	0.510	0.07	0.03
Net Urban	24	0.500	-0.430	0.930	0.039	8.62	0.33
Glenmore	20	1.407	-0.548	1.955	0.081	0.22	0.02

2. Customer Meter Impacts on Operating Range

Over time, development has occurred at higher elevations within some PZs, with the HGL associated with adequate customer pressure encroaching on the tank's elevation range. As the elevation of connected services increases, the minimum effective tank level must also increase unless other measures (e.g., installing private pumps) are taken by the retail utility to boost pressure for the retail customer. Increasing the tank's minimum operating level in turn increases average residence time (i.e., water age) as well as the frequency of cycling the tank and its supporting PS. Fire suppression storage (FSS) must be maintained, therefore the only component remaining to adjust is operating storage.

Table 3. Pressure Thresholds and Storage Tank Levels

Tank	Tank Elev. (ft)		Customer Meter Elevation (ft.)		At Highest Meter, HGL (ft.) to Provide:			Meter Elev. (ft.) for 80 psi at Max. Tank Level	At Lowest Meter		PZ Max. Head Range (ft.)
	Base	Top	Highest	Lowest	20 psi / 30 psi / 40 psi				Tank Full psi	HGL for 80 psi	
Piney Mtn.	767	805	692	375*	738	761	784	621	186	410	395
Pantops	612	652	588	316	634	657	680	467	145	351	301
Avon Street	607	653									
Observatory	620	659									
Lewis Mtn.	726	750	673	457	719	742	765	566	127	492	258
Stillhouse	746	795	694	466	740	763	786	611	143	501	294
Ednam	810	880	785	589	831	854	877	695	126	624	256
Mosby Mtn.	720	753	653	442	699	722	745	570	135	477	276
Avon Park	696	750	694	467	740	763	786	565	123	502	248

*Excludes Camelot (served by PRV)

3. Observatory Tank Surcharge

At the Observatory Tank, 0.6 MG (35%) of operating storage is accessible only when the tank is surcharged above the UPZ target HGL of 652 feet. In recent years, the Observatory Tank level exceeded an HGL of 652 feet approximately 1.2% of the time, or on average 17 minutes per day. The tank rarely exceeded an HGL of 654 feet, approximately four minutes per day on average. The highest level exceeded an HGL of 657 feet and occurred on May 21, 2017, when the OBSWTP was off-line for the overnight hours and the Pantops Tank altitude valve appeared to be closed (Figure 2). (An altitude valve is also installed at the Avon Street Tank to prevent loss of water due to overflow when the UPZ HGL is higher than 652 ft.) The history of infrequently surcharging the Observatory Tank supports the approach of not relying on operating storage above the UPZ HGL of 652 ft. for planning purposes.

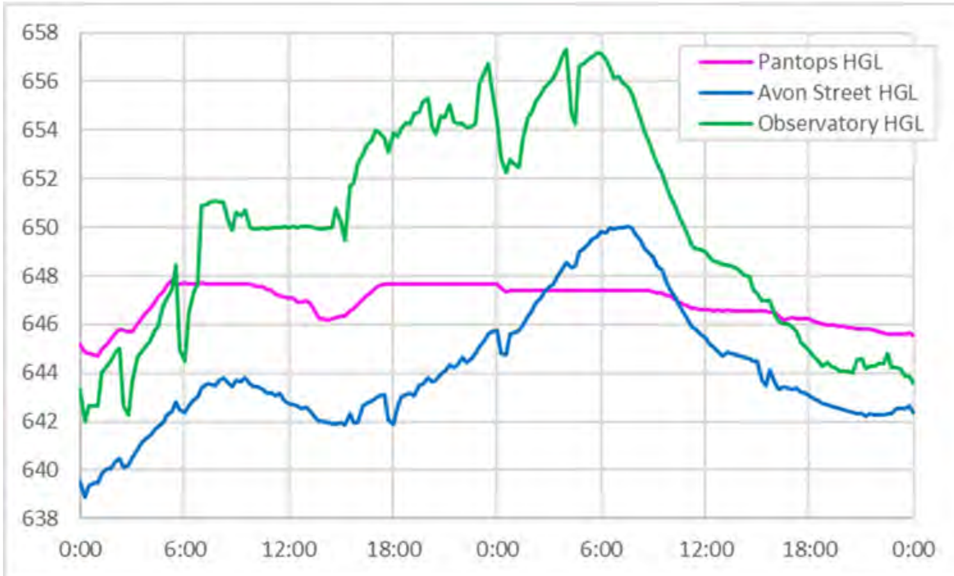

Figure 2. Urban Pressure Zone Storage Tank HGLs for May 20 and 21, 2017.

Tank level data indicates that after the Pantops Tank was closed, water moved to the other UPZ tanks via the City's distribution network, which is better connected hydraulically to the Observatory Waterline and Observatory Tank than to the Southern Loop Waterline and the Avon Street Tank. The Observatory Tank therefore acts as a "shock absorber" when the other UPZ tanks are full and water production exceeds demand.

With construction of the CWL, the Observatory Tank surcharge storage (0.6 MG between 652 feet and 659 feet) may be utilized less often than in the recent past, as water will be able to move east of the OBSWTP more efficiently. As with the current system configuration, however, the Observatory Tank will still provide "overflow" storage when production exceeds demand and the Pantops and Avon Street Tanks are full. In this case, and if the SRWTP is the only source of water, pressure will be reduced in Pantops and the northern UPZ compared to existing conditions: water going to the southern and western areas of the urban system will no longer be required to overcome the higher friction losses associated with flowing through the smaller City distribution mains to reach the Observatory Waterline.

4. Recovery of Under-utilized Storage

In order to achieve the required pressure from a storage tank at all depths, a review of customer elevations and pressure needs is required. Such a detailed review is beyond the scope of this report but is presented here at a cursory level. Given the 30-foot maximum operating range allowed by VDH regulations for storage tanks floating on a PZ, a minimum allowable UPZ HGL of 622 feet for elevation thresholds become apparent for static conditions. Because NFF varies throughout the system, the threshold elevation for adequate pressure will change from one location to another. The key concern is providing NFF to hydrants at higher elevations.

Based on information presented in Table 4, the RWSA can recover over half of UPZ dead storage in the near term by working with the ACSA to identify high-elevation customers to move to a higher existing or new PZ.

Without performing a cost-benefit analysis or detailed cost estimate, and excluding an estimate of the number of individual PRVs required, it is apparent from Table 4 that addressing customers at an elevation above 530 feet enables expanding the UPZ normal operating range from the current 18 feet to the maximum allowable 30 feet (minimum HGL 622 feet) with less than three times the capital investment to address customers above elevation 542 feet and who have less than 40 psi water service for the existing operating range (minimum HGL 634 feet). The number of private pumps to install assumes that small subzones are created from surrounding PZs via PRVs, as shown in Figure 47 of the main report.

Table 4. UPZ Threshold Elevations Given Minimum Operating HGL of 622 Feet

Elev. (feet)	Static Pressure (psi)	Description	No. of UPZ Customers Above Elev.	Customers to Move to Higher PZ	Private Pumps to Install
576	20	Minimum residual for fire flow (HGL 622)	23	19	4
542	40	Minimum allowable pressure (HGL 634)	481	401	80
530	40	Minimum allowable pressure (HGL 622)	951	731	220

The 23 highest-elevation UPZ customers are ACSA retail customers along Avon Street Extension, with assumed meter elevations from 577 to 603 feet. The current minimum HGL for the UPZ is approximately 634 feet, which corresponds to a pressure of 20 psi, the minimum allowed, at the assumed highest-elevation customer meters (elevation 588 feet). The assumed highest-elevation UPZ customer meter is at elevation 603 feet. If not already installed, and depending on whether and when a new PZ is created (see next paragraph) and whether this customer would remain on the UPZ, this customer should be equipped with a double backflow preventer to minimize the potential for customer water to enter the transmission and distribution system when the Avon Street Tank is draining.

The RWSA can recover up to 11 feet (2.80 MG, or just over half of the total 5.2 MG) of dead storage by reducing the minimum operating HGL from 634 feet to 623 feet, if the ACSA creates a new PZ for high-elevation customers along Avon Street Extension. Michael Baker envisions supplying the new PZ from the ACSA's Mill Creek PZ via a PRV vault, accompanied by installation of a water distribution main parallel to the RWSA transmission main, replacement of the ACSA's Avon Park GST with an EST, and any upgrades required at the ACSA's Mill Creek PS. The ACSA would lead this effort to benefit the overall performance of the UPZ, and design criteria include ensuring that support of the new PZ maintains provision of adequate fire flow.

This project would be entirely on the public side and also resolve the ACSA's current challenges in managing its Avon Park Tank.

If the ACSA moves customers along Avon Street Extension to a new PZ, the distribution of highest-elevation customer meters becomes geographically diverse, thus requiring multiple actions to achieve additional recovery of dead storage. Locations are scattered about the UPZ and range from 571 to 575 feet in elevation. These ACSA and City retail customers could be served by a new hydropneumatic tank PZ, a new PZ supplied from the Lewis Mtn. PZ via PRV vault, or a private pump. The retail utility cost per gallon for recovering additional UPZ dead storage is, however, anticipated to be higher than for the Avon Street Extension project, and it will require willing participation from customers to be served by private pumps.

5. 2070 Required Storage

Requirements for operating storage within each PZ are presented in Table 5. Taking firm pump station capacity in excess of ADD into account, the PS may also be able to contribute to fire flow. The Observatory, Avon Street, and Lewis Mtn. Tank sites have space for a second tank. All other locations where an additional or replacement tank is recommended will require property acquisition.

Given projected growth in demand through 2070, existing tank geometries, and assumed meter elevations for existing customers, future storage requirements are presented in Table 5 and Table 6. Operating storage is based on an assumed pump schedule (not to exceed existing PS capacity), projected 2070 ADD, and the diurnal pattern specific to the PZ. Fire suppression storage is calculated based on maximum NFF and its associated duration, less any excess firm capacity at the supporting PS. Where system demand is low compared to NFF, fire suppression storage will be a significant component of total recommended storage, thus contributing to increased water age.

Based on storage calculations, one additional RWSA tank with a diameter of 44 feet and an effective height of 24.5 feet (Lewis Mtn. PZ), and one additional ACSA tank with diameter of 57 feet and an effective height of 10 feet (Avon Park Tank, Mill Creek PZ) would be required by 2030 to provide the 0.5 MG of additional storage volume needed. Assuming GSTs are constructed at the same base elevation as the existing tanks, a total volume of 1.3 MG would be added to the system: 0.3 MG for a second RWSA tank at Lewis Mtn., and 1.0 MG for a second ACSA tank in the Mill Creek PZ (Avon Park Tank).

Table 5. Tank and Pump Station Data

Existing Tank	Base Elev. (ft)	Top Elev. (ft)	Highest Meter Elev. (ft)	HGL for 20 psi at Meter	2070 ADD[1] (MGD)	Max. NFF (gpm)	Pump Station			
							Hours On[2]	Pump Rate (gpm)	Firm Capacity (gpm)	Capacity for Fire (gpm)
Piney Mtn.[3]	767.2	805.5	692	738	0.853	3,000	16	889	1,055	111
Pantops	612	652	588	634	7.620	6,000	24	5,290 (net)	13,680[4]	7,694
Avon Street	607	653								
Observatory	620	659								
Lewis Mtn.	726	750.5	673	719	0.522	4,500	16	544	1,155	530
Stillhouse	745.5	795.5	694	740	0.796	3,000	16	829	1,244	313
Ednam	810	880	785	831	0.039	4,000	8	81	600	461
Mosby Mtn.	720	753	653	699	0.124	1,000	8	258	500	83
Avon Park	696	750.5	694	740	0.061	1,750	8	127		-
Glenmore	375.75	410.75	420	N/A	0.162	1,000	16	167	188	7
TOTAL	-	-	-	-	10.18	-	-	7,720	-	-

1. Includes unmetered water (1.48 MGD), excludes UVA demand (1.39 MGD)
2. Assumed start time: 4 a.m. (20 hours on), 6 a.m. (16 hours on), 7 a.m. (12 hours on), 9 a.m. (8 hours on)
3. Supplied by the RWSA's planned Airport Road Pump Station
4. 19.7 MGD = 13,680 gpm (existing OBSWTP & SRWTP rated capacity)

Table 6. 2070 Storage Volumes by Category

Existing Tank	2070 ADD[1] (MGD)	Assumed Operating Storage (MG)	Highest Meter Elevation (ft)	Storage Above HGL20[2] (MG)	Fire from PS (MG)	Storage Without Sprinklers(MG)		
						Fire Needed	Operating + Net Fire	Add'l Vol. Needed
Piney Mtn.[3]	0.904	0.20	692	0.80	-0.02	0.54	0.72	-
UPZ	8.616	0.33	588	4.57[4]	-	1.44	1.77	-
Lewis Mtn.	0.598	0.14	673	0.52	-0.13	0.84	0.85	0.33
Stillhouse	0.892	0.18	694	0.73	-0.06	0.54	0.66	-
Ednam	0.067	0.03	785	0.21	-0.06	0.23	0.20	-
Mosby Mtn.	0.201	0.13	653	0.19	-0.01	0.18	0.30	0.11
Avon Park	0.066	0.04	694	0.05	-	0.21	0.25	0.20
Glenmore	0.219	0.02	420	0.78	-	0.18	0.20	-
TOTAL	11.564	1.07	-	7.85	-0.28	4.16	4.95	0.64

1. Includes unmetered water, excludes UVA demand (1.390 MGD) and SRWTP backwash water (0.265 MGD)
2. HGL20 is HGL corresponding to 20 psi at highest assumed meter elevation
3. Supplied by the RWSA's planned Airport Road Pump Station
4. Excludes storage above HGL 652 feet

6. Fire Suppression Storage

Model results indicate that existing and planned PS capacities, taking transmission upgrades into account, will be adequate through 2070, provided a PZ's needed FSS is provided within the PZ. Assuming that buildings with high NFF values are not sprinklered, approximately 0.6 MG of additional, accessible storage is required by 2030 to meet existing NFF (compare Table 6 NFF volume to Table 13 in Section 7.3 of the report). This additional storage will meet projected needs through 2070. If, however, all buildings with 3,000 gpm or higher NFF are sprinklered, then only 0.3 MG of additional, accessible storage is required by 2030 (Table 7).

Table 7. 2070 Required Storage with Building Sprinklers

Existing Tank	NFF (gpm)	Duration (hours)	Storage Volume (MG)					
			Oper-ating	Fire Needed	Fire from PS	Operating + Net Fire	Existing Above 20 psi	Needed
Piney Mtn.	2,250	2	0.20	0.27	0.02	0.45	0.80	-
Pantops Avon Street Observatory	2,500	2	0.33	0.30	-	0.63	4.57[5]	-
Lewis Mtn.	2,000	2	0.14	0.24	0.13	0.25	0.52	-
Stillhouse	2,250	2	0.18	0.27	0.06	0.39	0.73	-
Ednam	1,900	2	0.03	0.23	0.06	0.20	0.21	-
Mosby Mtn.	1,500	2	0.13	0.18	0.01	0.30	0.19	0.11
Avon Park	1,750	2	0.04	0.21	-	0.25	0.05	0.20
Glenmore	1,500	2	0.02	0.18	-	0.20	0.78	-
TOTAL	-	-	1.08	1.88	0.28	2.67	7.85	0.31

FSS volumes assume all fire flow is sourced from in-zone storage, with the PS providing a small contribution to fire flow where possible. For the Lewis Mtn. and Ednam PZs, at locations where NFF exceeds the distribution system capacity to deliver NFF on its own, the difference between NFF and AFF is assumed to be met by dry hydrants at the adjacent ponds.

Within the UPZ, water production rates (up to 12,300 gpm at 90% of existing OBSWTP and SRWTP capacity) are significantly higher than maximum NFF (6,000 gpm). Outside the UPZ, however, maximum NFF may exceed the PS design point, therefore some if not all FSS must be provided within the PZ. Minimum in-zone FSS is presented in Table 8, assuming the highest-capacity pump is off-line and that additional pumps for future expansion of PS capacity have not been installed. The City's Lambeth PZ is a closed system without storage; pump capacities are shown for information purposes. The ACSA's Mill Creek PS design point is estimated from model data, with the following assumptions:

- C = 95 for station piping to account for fitting losses
- C = 120 for water mains
- Maximum Avon Park Tank HGL
- Minimum Avon Street Tank HGL

Table 8. Net Available PS Capacity for Fire Suppression Given Constant Pumping

Pressure Zone	Pump Station	Design Flow (gpm)	Design TDH (ft.)	No. of Pumps	Firm Capacity (gpm)	Firm TDH (ft.)	24-Hr Flow Rate (gpm)	
							2070 ADD	Net Avail.
North	ARPS	1055	150	2	1055	150	627	428
Lewis Mtn.	Alderman Road	600 1000	110 118	2 1	1155	121	414	741
Stillhouse	Stillhouse	1244	212	2	1244	212	619	625
Ednam	Ednam	600	190	2	600	190	46	554
Mosby Mtn.	Mosby Mtn.	500	111	2	500	111	139	361
Avon Park	Mill Creek	700	129	2	700	129	46	654
Glenmore	Glenmore	188	172	2	188	172	152	36
Lambeth	Lambeth	450 1530	95 95	2 2	2430	95	159	84

After addressing ADD, excess PS capacity can be utilized to reduce the volume of FSS required within the PZ. Subtracting excess firm capacity from the volume associated with maximum NFF provides the minimum FSS volume required within the PZ. FSS volume is presented in Table 9, along with the required operating height of the existing tank to provide that volume.

Table 9. Minimum In-Zone Fire Suppression Storage for Maximum NFF (No Sprinklers)

Pressure Zone	Pump Station	NFF (gpm)	Available PS Flow (gpm)	Min. FSS Required (gpm)	Fire Flow Duration (hours)	Min. FSS Required (MG)	Tank Diam. (ft.)	Height for FSS Vol. (ft.)
North	ARPS	3,000	428	2,572	3	0.46	60	21.9
Lewis Mtn.	Alderman Road	3,500[1]	741	2,759	4	0.66	60	31.3
Stillhouse	Stillhouse	3,000	625	2,375	3	0.43	50	29.1
Ednam	Ednam	1,900[2]	554	1,346	2	0.16	27	37.7
Mosby Mtn.	Mosby Mtn.	1,500	361	1,139	2	0.14	30.77	24.6
Avon Park	Mill Creek	1,750	654	1,096	2	0.13	28	28.6
Glenmore	Glenmore	1,500	36	1,464	2	0.18	61.5	7.9

1. 4,500 gpm NFF;2,900 gpm AFF; assume rest from dry hydrant; use next highest NFF at 3,500 gpm
2. 4,000 gpm NFF; 2,100 gpm AFF; assume rest from dry hydrant; next highest NFF at 1,250 gpm; use 4,000 – 2,100 = 1,900 gpm

From data provided by the ACSA, the highest NFF within the Lewis Mtn. PZ is 4,500 gpm. NFF information did not indicate whether buildings are sprinklered, which would reduce the NFF, or whether the NFF values provided take sprinkler systems into account. Per NFPA 1, Fire Code, the planning duration for flow rates 4,000 gpm and above is 4 hours, resulting in a total volume of 1.08 MG – more than twice the volume of the existing tank.

For an assumed daily runtime of 16 hours, the firm capacity of the RWSA's Alderman Road PS (1,050 gpm) has approximately 500 gpm excess capacity after meeting projected 2070 ADD. This excess capacity is assumed to contribute to AFF, resulting in a volume of approximately 0.13 MG over four hours (Table 7). The Lewis Mtn. Tank stores approximately 0.36 MG below the alarm level. The existing system can therefore contribute 0.49 MG toward the NFF volume. The remaining fire suppression volume is assumed to be provided by a dry hydrant.

The next-highest Lewis Mtn. PZ NFF is 3,500 gpm at a commercial building near the tank. This location requires a 4-hour fire suppression volume of 0.84 MG, resulting in a net required fire suppression volume of 0.72 MG after taking the Alderman Road PS contribution into account. This volume also exceeds the existing tank-full volume of 0.5 MG, therefore additional storage within the Lewis Mtn. PZ is required by 2030 for adequate fire protection purposes.

7. Operations Recommendations

7.1. Stillhouse Storage

The 0.7 MG Stillhouse Tank is 50 feet tall and 50 feet in diameter, with a current operating range of only eight feet (0.12 MG), between tank levels of 40.5 and 48.5 feet. The estimated required operating storage volume is 0.18 MG. The bottom end of the current operating range provides a water pressure of 40 psi to the assumed highest-elevation customer meter (694 feet). The Stillhouse PS turns off when the tank level is 48.5 feet, 1.5 feet below the tank-full level. Based on SCADA data as well as model simulations for MDD conditions (Figure 3, red graph), the tank cycles several times per day, dropping from full to "pumps on" level in three hours or less during the day. The current system therefore does not meet the RWSA operations criterion of one cycle per day.

Options to improve system resilience and address frequent tank cycling include increasing the operating range of the existing tank, operating the Stillhouse PS at a reduced flow rate to increase the fill time, replacing the existing tank with a larger tank, and adding a second tank. If the operating levels of the existing tank are adjusted to achieve one cycle per day for 2070 MDD conditions (28.5-foot operating range, see Figure 3), the minimum tank level is 20 feet, which leaves approximately 0.28 MG in storage. This does not meet the required fire suppression storage volume (0.48 MG net), therefore additional storage is required to meet the one cycle per day criterion.

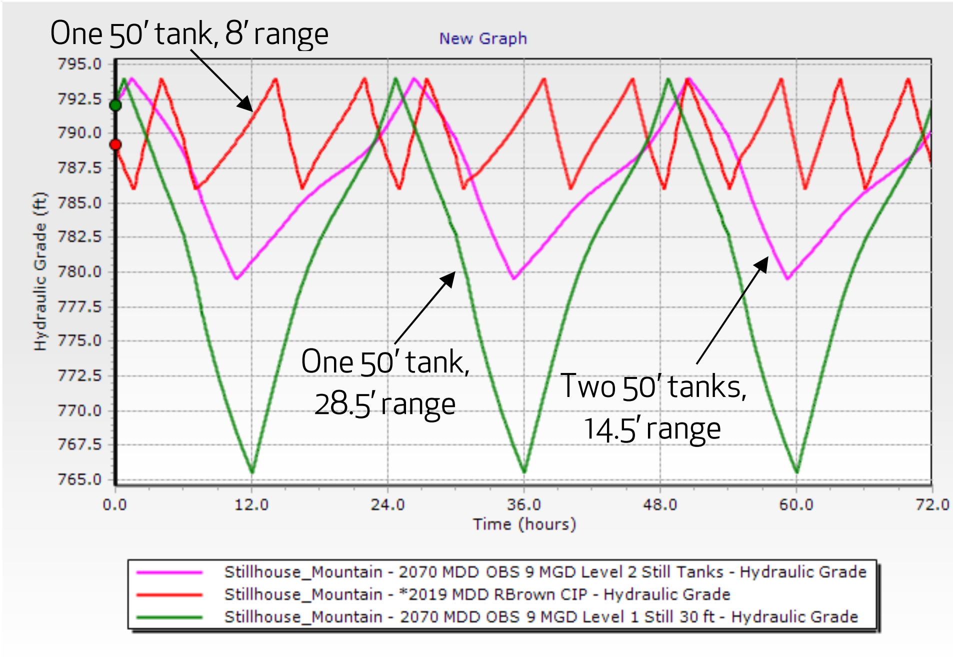

Figure 3. Stillhouse Tank Level for One vs. Two Tanks.

If all buildings with NFF 3,000 gpm and higher have approved automatic sprinkler systems, then NFF is no more than 2,250 gpm, with an associated fire suppression volume of 0.27 MG (two hours duration). Adjusting tank settings to effect an operating range of 28.5 feet then becomes feasible, as the 0.28 MG remaining in storage below the proposed normal minimum operating level would exceed the fire suppression storage required (0.27 MG). In addition, the provision of fire flow would not rely on a contribution from the pump station, thus improving system resilience and redundancy.

To confirm the recommendation of a duplicate tank, a tank sizing and siting study should be conducted and include a review of mode(s) of operating the Stillhouse PS. Installing a second tank adjacent to the existing tank will require property acquisition and site grading to create a level tank pad. Expanding the Stillhouse operating range will require adjustment of PS operating protocols and setpoints.

7.2. Lewis Mtn. Storage

As with the Stillhouse Tank, the Lewis Mtn. Tank has a limited operating range, therefore the tank and Alderman Road PS cycle approximately twice per day, which does not meet the RWSA's preferred one-cycle operations criterion. In addition, the current operating range provides a minimum of 31 psi at the assumed highest-elevation customer meter (elevation 673 feet) but no more than 33.5 psi. Based on type of construction, the highest-elevation customer is assumed to have a private pump installed.

At 660 feet, the assumed next-highest-elevation customer meter is on Ednam Drive. Minimum pressure at this location is 36 psi when the tank is at the alarm level (18 feet, 0.38 MG in storage). By adjusting the pump on/off levels to increase the operating range from 4.5 to 9.5 feet in the near term, the number of cycles can be reduced from two to one per day for 2070 ADD, as shown in Figure 4. Increasing the operating range of the existing tank in this manner results in a minimum pressure of 35 psi at the second-highest customer meter and a minimum tank level of 14.5 feet (0.31 MG in storage), 3.5 feet below the existing alarm level.

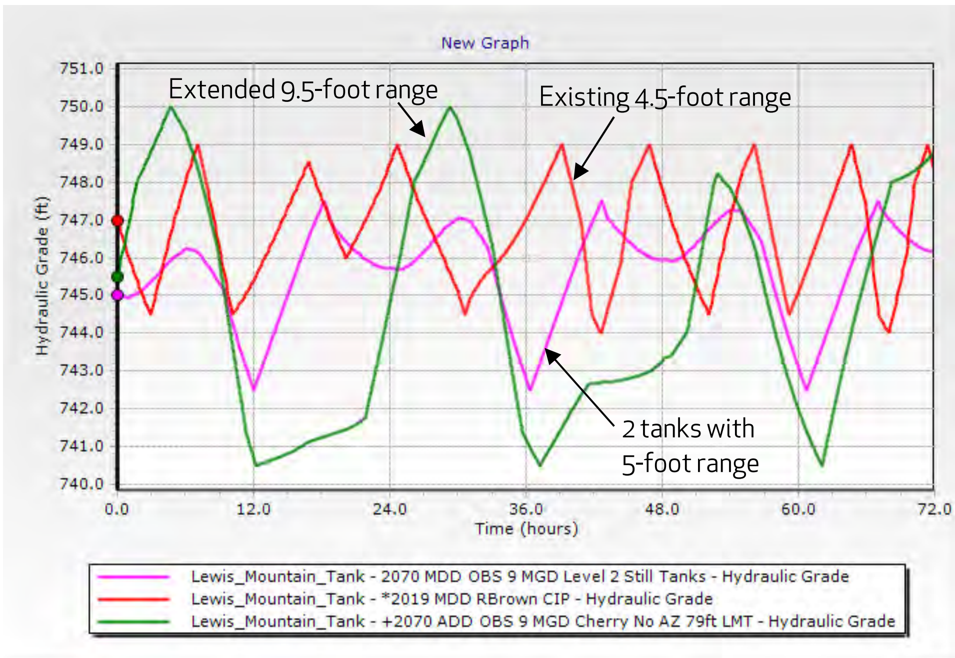

Figure 4. Lewis Mtn. Tank Level for Existing vs. Extended Operating Range.

The maximum NFF, as provided by Albemarle County Fire Rescue, is 4,500 gpm. For this flow rate, NFPA code requires a four-hour fire flow duration, which results in a fire suppression volume of 1.08 MG, over twice the volume of the existing tank. In addition, the local distribution system cannot support a flow rate of 4,500 gpm in this location and maintain a minimum pressure of 20 psi. Modeled AFF is approximately 2,900 gpm, therefore the balance of 1,600 gpm to meet NFF is assumed to be provided via dry hydrants at the ponds adjacent to the building. If, however, the building has an approved automatic sprinkler system, NFF is reduced by 75% to 1,125 gpm. Duration would then be two hours, resulting in a fire suppression volume of only 135,000 gallons, which is well within the storage volume available for the expanded operating range described above. Information on the existence of approved automatic sprinkler systems for buildings with NFF values of 3,000 gpm or higher was not available when preparing the UFWMP.

The next-highest NFF is 3,500 gpm for a commercial building close to the tank. The distribution system can meet NFF. 3,500 gpm for four hours results in a fire suppression volume of 0.84 MG, which exceeds the size of the tank, therefore additional storage would be required unless NFF can be reduced due to the presence of an approved automatic sprinkler system. Assuming a 16-hour pumping schedule, and given the Alderman Road PS firm capacity, the pump station is assumed to contribute 530 gpm toward fire flow (0.13 MG over four hours).

Given current tank operating levels, a two-tank system with a second 60-foot diameter tank will provide the required fire suppression storage (0.84 – 0.13 = 0.71 MG) below the existing alarm level of 18 feet. That level provides 31 psi at the assumed highest-elevation customer meter and 36 psi at the assumed next-highest elevation customer meter. A second tank with the same height as the existing tank provides the estimated operating volume of 0.11 MG in the upper-most 5.5 feet of the tanks. Results from model simulations indicate that the lead pump will run continuously, with the lag pump running once per day but never filling the tank completely (Figure 4, magenta graph), unless the lag pump stop level is increased from its current setting. As system demand increases, operations staff may prefer to utilize the higher-capacity Pump 1 as the lag pump rather than alternating the lower-capacity Pumps 2 and 3 as the lead/lag pumps.

As with Stillhouse, an identical, duplicate tank for the Lewis Mtn. PZ provides the necessary storage volumes while also providing operational flexibility when one tank must be taken off-line for maintenance, and it satisfies the Lewis Mtn. storage need identified in Section 7.6 of the UFWMP Report. One tank by itself will not satisfy the fire suppression storage requirement, therefore redundancies such as opening the UVA interconnection should be planned in case of a significant fire event while one of the tanks is off-line.

Although installing an 82.5-foot diameter GST to replace the existing 60-foot diameter tank has the same fire suppression and operating volumes as two 60-foot diameter tanks, adding a second 0.5 MG tank is recommended. The existing Lewis Mtn. Tank site has already been graded to construct a second, identical tank and does not require property or easement acquisition. A smaller supplemental tank is also less expensive to construct than a larger replacement tank, and it provides redundancy when a tank must be taken out of service temporarily.

Pressure Zone Diurnal Pattern Factors

Hour	North	Lewis Mtn	Stillhouse	Mosby Mtn	Avon Park	Ednam	Net Urban	Glenmore
0	0.724	0.749	0.547	0.603	0.770	0.16	0.727	0.547
1	0.633	0.588	0.462	0.438	0.513	0.209	0.663	0.462
2	0.583	0.466	0.438	0.438	0.513	0.307	0.643	0.438
3	0.541	0.428	0.507	0.438	0.513	0.455	0.570	0.507
4	0.527	0.435	0.543	0.548	0.642	0.474	0.724	0.543
5	0.654	0.550	0.673	0.630	0.770	0.590	0.596	0.673
6	1.202	0.833	1.140	0.959	0.898	0.926	1.383	1.140
7	1.504	1.337	1.582	1.616	1.219	1.399	1.500	1.582
8	1.265	1.512	1.391	1.589	1.348	1.724	1.427	1.391
9	1.181	1.505	1.330	1.288	1.348	1.807	1.210	1.330
10	1.202	1.405	1.273	1.288	1.283	1.628	1.166	1.273
11	1.209	1.268	1.221	1.178	1.283	1.539	1.047	1.221
12	1.131	1.146	1.172	1.041	1.155	1.527	1.009	1.172
13	1.124	1.115	1.119	0.959	1.091	1.421	0.986	1.119
14	1.117	1.062	1.071	1.041	1.027	1.337	0.972	1.071
15	1.040	1.016	1.026	1.014	1.091	1.298	0.952	1.026
16	1.019	1.046	1.103	1.014	1.219	1.213	1.014	1.103
17	1.075	1.115	1.131	1.014	1.091	1.203	1.258	1.131
18	1.139	1.138	1.204	1.123	1.091	1.099	1.161	1.204
19	1.174	1.153	1.209	1.260	1.155	1.079	1.161	1.209
20	1.153	1.138	1.144	1.315	1.155	1.035	1.126	1.144
21	1.054	1.108	1.083	1.205	1.027	0.884	1.012	1.083
22	0.963	1.054	0.945	1.123	0.963	0.497	0.875	0.945
23	0.787	0.833	0.685	0.877	0.834	0.190	0.817	0.685
24	0.724	0.749	0.547	0.603	0.770	0.160	0.727	0.547

(Stillhouse pattern applied to Glenmore.)

Pressure Zone Cumulative Demand Volume

North PZ		PS Flow for	Net Hrly	Cumulative	
Hour		16 Hrs On			
1	0.633		0.633	0.633	
2	0.583		0.583	1.216	
3	0.541		0.541	1.757	
4	0.527		0.527	2.284	
5	0.654		0.654	2.938	
6	1.202	1.5	-0.298	2.64	
7	1.504	1.5	0.004	2.644	
8	1.265	1.5	-0.235	2.409	
9	1.181	1.5	-0.319	2.09	
10	1.202	1.5	-0.298	1.792	
11	1.209	1.5	-0.291	1.501	
12	1.131	1.5	-0.369	1.132	
13	1.124	1.5	-0.376	0.756	
14	1.117	1.5	-0.383	0.373	
15	1.04	1.5	-0.46	-0.087	
16	1.019	1.5	-0.481	-0.568	
17	1.075	1.5	-0.425	-0.993	
18	1.139	1.5	-0.361	-1.354	
19	1.174	1.5	-0.326	-1.68	
20	1.153	1.5	-0.347	-2.027	
21	1.054	1.5	-0.446	-2.473	
22	0.963		0.963	-1.51	
23	0.787		0.787	-0.723	
24	0.724		0.724	0.001	
Delta	(cumulative max – min)			5.411	
Delta / 24				0.225458	
2070 ADD	includes unmetered			903,845	gpd
Operating				203,779	gal
PS MGD				1.36	
PS gpm				944	
PS Design				1055	OK
2070 H/D MDD				1,408,371	gpd
Hours On				24	
PS MGD				1.41	
PS gpm				979	
PS Design				1055	OK

Lewis Mtn. PZ		PS Flow for	Net Hrly	Cumulative	
Hour		16 Hrs On			
1	0.695		0.695	0.695	
2	0.574		0.574	1.269	
3	0.525		0.525	1.794	
4	0.525		0.525	2.319	
5	0.582		0.582	2.901	
6	0.8	1.5	-0.7	2.201	
7	1.188	1.5	-0.312	1.889	
8	1.39	1.5	-0.11	1.779	
9	1.382	1.5	-0.118	1.661	
10	1.285	1.5	-0.215	1.446	
11	1.204	1.5	-0.296	1.15	
12	1.116	1.5	-0.384	0.766	
13	1.083	1.5	-0.417	0.349	
14	1.083	1.5	-0.417	-0.068	
15	1.067	1.5	-0.433	-0.501	
16	1.059	1.5	-0.441	-0.942	
17	1.132	1.5	-0.368	-1.31	
18	1.164	1.5	-0.336	-1.646	
19	1.148	1.5	-0.352	-1.998	
20	1.124	1.5	-0.376	-2.374	
21	1.091	1.5	-0.409	-2.783	
22	1.027		1.027	-1.756	
23	0.913		0.913	-0.843	
24	0.841		0.841	-0.002	
Delta	(cumulative max – min)			5.684	
Delta / 24				0.236833	
2070 ADD	includes unmetered			522,195	598,427
Operating				141,727	gal
PS MGD				0.90	
PS gpm				625	
PS Design				1155	OK
2070 H/D MDD				932,469	gpd
Hours On				24	
PS MGD				0.93	
PS gpm				646	
PS Design				600	Extend

Stillhouse PZ		PS Flow for	Net Hrly	Cumulative	
Hour		16 Hrs On			
1	0.462		0.462	0.462	
2	0.438		0.438	0.9	
3	0.507		0.507	1.407	
4	0.543		0.543	1.95	
5	0.673		0.673	2.623	
6	1.14	1.5	-0.36	2.263	
7	1.582	1.5	0.082	2.345	
8	1.391	1.5	-0.109	2.236	
9	1.33	1.5	-0.17	2.066	
10	1.273	1.5	-0.227	1.839	
11	1.221	1.5	-0.279	1.56	
12	1.172	1.5	-0.328	1.232	
13	1.119	1.5	-0.381	0.851	
14	1.071	1.5	-0.429	0.422	
15	1.026	1.5	-0.474	-0.052	
16	1.103	1.5	-0.397	-0.449	
17	1.131	1.5	-0.369	-0.818	
18	1.204	1.5	-0.296	-1.114	
19	1.209	1.5	-0.291	-1.405	
20	1.144	1.5	-0.356	-1.761	
21	1.083	1.5	-0.417	-2.178	
22	0.945		0.945	-1.233	
23	0.685		0.685	-0.548	
24	0.547		0.547	-0.001	
Delta	(cumulative max – min)			4.801	
Delta / 24				0.200042	
2070 ADD	includes unmetered			892,074	gpd
Operating				178,452	gal
PS MGD				1.34	
PS gpm				931	
PS Design				1244	OK
2070 H/D MDD				1,390,029	gpd
Hours On				24	
PS MGD				1.39	
PS gpm				965	
PS Design				884	Extend

Mosby Mtn. PZ		PS Flow for	Net Hrly	Cumulative	
Hour		8 Hrs On			
1	0.438		0.438	0.438	
2	0.438		0.438	0.876	
3	0.438		0.438	1.314	
4	0.548		0.548	1.862	
5	0.63		0.63	2.492	
6	0.959		0.959	3.451	
7	1.616		1.616	5.067	
8	1.589		1.589	6.656	
9	1.288	3	-1.712	4.944	
10	1.288	3	-1.712	3.232	
11	1.178	3	-1.822	1.41	
12	1.041	3	-1.959	-0.549	
13	0.959	3	-2.041	-2.59	
14	1.041	3	-1.959	-4.549	
15	1.014	3	-1.986	-6.535	
16	1.014	3	-1.986	-8.521	
17	1.014		1.014	-7.507	
18	1.123		1.123	-6.384	
19	1.26		1.26	-5.124	
20	1.315		1.315	-3.809	
21	1.205		1.205	-2.604	
22	1.123		1.123	-1.481	
23	0.877		0.877	-0.604	
24	0.603		0.603	-0.001	
Delta	(cumulative max – min)			15.177	
Delta / 24				0.632375	
2070 ADD	includes unmetered			200,541	gpd
Operating				126,817	gal
PS MGD				0.60	
PS gpm				417	
PS Design				500	OK
2070 H/D MDD				312,483	gpd
Hours On				12	
PS MGD				0.62	
PS gpm				431	
PS Design				500	OK

Avon Park PZ		PS Flow for	Net Hrly	Cumulative	
Hour		8 Hrs On			
1	0.513		0.513	0.513	
2	0.513		0.513	1.026	
3	0.513		0.513	1.539	
4	0.642		0.642	2.181	
5	0.77		0.77	2.951	
6	0.898		0.898	3.849	
7	1.219		1.219	5.068	
8	1.348		1.348	6.416	
9	1.348	3	-1.652	4.764	
10	1.283	3	-1.717	3.047	
11	1.283	3	-1.717	1.33	
12	1.155	3	-1.845	-0.515	
13	1.091	3	-1.909	-2.424	
14	1.027	3	-1.973	-4.397	
15	1.091	3	-1.909	-6.306	
16	1.219	3	-1.781	-8.087	
17	1.091		1.091	-6.996	
18	1.091		1.091	-5.905	
19	1.155		1.155	-4.75	
20	1.155		1.155	-3.595	
21	1.027		1.027	-2.568	
22	0.963		0.963	-1.605	
23	0.834		0.834	-0.771	
24	0.77		0.77	-0.001	
Delta	(cumulative max – min)			14.503	
Delta / 24				0.604292	
2070 ADD	includes unmetered			66,442	gpd
Operating				40,150	gal
PS MGD				0.20	
PS gpm				139	
PS Design					Extend
2070 H/D MDD				103,530	gpd
Hours On				12	
PS MGD				0.21	
PS gpm				146	
PS Design				8	Extend

Ednam PZ		PS Flow for	Net Hrly	Cumulative	
Hour		8 Hrs On			
1	0.209		0.209	0.209	
2	0.307		0.307	0.516	
3	0.455		0.455	0.971	
4	0.474		0.474	1.445	
5	0.59		0.59	2.035	
6	0.926		0.926	2.961	
7	1.399		1.399	4.36	
8	1.724		1.724	6.084	
9	1.807	3	-1.193	4.891	
10	1.628	3	-1.372	3.519	
11	1.539	3	-1.461	2.058	
12	1.527	3	-1.473	0.585	
13	1.421	3	-1.579	-0.994	
14	1.337	3	-1.663	-2.657	
15	1.298	3	-1.702	-4.359	
16	1.213	3	-1.787	-6.146	
17	1.203		1.203	-4.943	
18	1.099		1.099	-3.844	
19	1.079		1.079	-2.765	
20	1.035		1.035	-1.73	
21	0.884		0.884	-0.846	
22	0.497		0.497	-0.349	
23	0.19		0.19	-0.159	
24	0.16		0.16	0.001	
Delta	(cumulative max – min)			12.230	
Delta / 24				0.509583	
2070 ADD	includes unmetered			67,396	gpd
Operating				34,344	gal
PS MGD				0.20	
PS gpm				139	
PS Design				600	OK
2070 H/D MDD				105,016	gpd
Hours On				8	
PS MGD				0.32	
PS gpm				222	
PS Design				600	OK

Net Urban PZ		PS Flow for	Net Hrly	Cumulative	
Hour		24 Hrs On			
1	0.663	1	-0.337	-0.337	
2	0.643	1	-0.357	-0.694	
3	0.57	1	-0.43	-1.124	
4	0.724	1	-0.276	-1.4	
5	0.596	1	-0.404	-1.804	
6	1.383	1	0.383	-1.421	
7	1.5	1	0.5	-0.921	
8	1.427	1	0.427	-0.494	
9	1.21	1	0.21	-0.284	
10	1.166	1	0.166	-0.118	
11	1.047	1	0.047	-0.071	
12	1.009	1	0.009	-0.062	
13	0.986	1	-0.014	-0.076	
14	0.972	1	-0.028	-0.104	
15	0.952	1	-0.048	-0.152	
16	1.014	1	0.014	-0.138	
17	1.258	1	0.258	0.12	
18	1.161	1	0.161	0.281	
19	1.161	1	0.161	0.442	
20	1.126	1	0.126	0.568	
21	1.012	1	0.012	0.58	
22	0.875	1	-0.125	0.455	
23	0.817	1	-0.183	0.272	
24	0.727	1	-0.273	-0.001	
Delta	(cumulative max – min)			2.384	
Delta / 24				0.099333	
2070 ADD	includes unmetered			8,615,919	gpd
Operating				855,848	gal
PS MGD				8.62	
PS gpm	System Total incl. UVA, unmetered			11,354	
PS Design	(Existing)			12,312	OK
2070 H/D MDD				25,476,196	gpd
Hours On				24	
PS MGD				25.48	
PS gpm				17,694	
PS Design	(Upgraded)			16,249	Extend

Glenmore PZ		PS Flow for	Net Hrly	Cumulative	
Hour		16 Hrs On			
1	0.462		0.462	0.462	
2	0.438		0.438	0.9	
3	0.507		0.507	1.407	
4	0.543		0.543	1.95	
5	0.673		0.673	2.623	
6	1.14	1.5	-0.36	2.263	
7	1.582	1.5	0.082	2.345	
8	1.391	1.5	-0.109	2.236	
9	1.33	1.5	-0.17	2.066	
10	1.273	1.5	-0.227	1.839	
11	1.221	1.5	-0.279	1.56	
12	1.172	1.5	-0.328	1.232	
13	1.119	1.5	-0.381	0.851	
14	1.071	1.5	-0.429	0.422	
15	1.026	1.5	-0.474	-0.052	
16	1.103	1.5	-0.397	-0.449	
17	1.131	1.5	-0.369	-0.818	
18	1.204	1.5	-0.296	-1.114	
19	1.209	1.5	-0.291	-1.405	
20	1.144	1.5	-0.356	-1.761	
21	1.083	1.5	-0.417	-2.178	
22	0.945		0.945	-1.233	
23	0.685		0.685	-0.548	
24	0.547		0.547	-0.001	
Delta	(cumulative max – min)			4.801	
Delta / 24				0.200042	
2070 ADD	includes unmetered			219,458	gpd
Operating				43,901	gal
PS MGD				0.26	
PS gpm				181	
PS Design				188	OK
2070 H/D MDD				341,959	gpd
Hours On				24	
PS MGD				0.34	
PS gpm				236	
PS Design				188	Extend

13 Stillhouse customer meters requiring private pump to accommodate 30-foot tank operating range: 795 ft. top of tank – 30 ft. – 92 ft. (40 psi @ 2.3 ft. head / psi) = 795 – 122 = 673 ft.

ID	Label	Associated Element	Demand (gpd)	Elevation (ft)
154112	9235020	ACSA_P_ 4005	89.13	693.5
154113	9235030	ACSA_P_ 4005	331.52	693.4
154114	9235040	ACSA_P_ 4004	1,270.63	692.0
154111	9235015	ACSA_P_ 4005	777.86	686.9
154115	9235050	ACSA_P_ 4004	312.77	685.0
142925	2411390	ACSA_P_ 5292	258.97	684.7
154110	9235010	ACSA_P_ 4005	414.13	684.7
142924	2411380	ACSA_P_ 5292	647.01	684.2
154109	9235000	ACSA_P_ 4006	1.63	681.3
142923	2411370	ACSA_P_ 5290	50.82	679.2
142922	2411360	ACSA_P_ 5290	73.64	676.5
142926	2411400	ACSA_P_ 5292	250.82	674.2
142921	2411350	ACSA_P_ 5290	425.27	674.1

22 Lewis Mtn. customer meters requiring private pump to accommodate 9-foot tank operating range: 726 ft. bottom of tank + 15.4 ft. (min. op. level) – 92.4 ft. (40 psi @ 2.31 ft. / psi) = 649 ft.

ID	Label	Associated Element	Demand (gpd)	Elevation (ft)
140923	1410263	ACSA_N_109-1-7	2,301.88	672.6
140924	1410264	ACSA_N_109-1-7	10,946.14	672.6
140926	1410266	ACSA_P_ 3221	1,170.45	667.6
143149	2440840	ACSA_P_ 4060	762.47	659.7
143154	2440882	ACSA_P_ 4060	647.91	657.7
143152	2440870	ACSA_P_ 4060	737.44	655.5
143151	2440860	ACSA_P_ 4060	414.24	655.3
143153	2440880	ACSA_P_ 4060	502.25	655.1
141139	1411360	ACSA_P_ 1524	5,469.41	654.1
144083	3425260	ACSA_P_ 3204	27.55	651.9
144084	3425265	ACSA_P_ 3204	42.92	651.5
144085	3425270	ACSA_P_ 3204	119.48	651.4
144081	3425250	ACSA_P_ 3204	61.94	651.0
144082	3425255	ACSA_P_ 3204	54.38	651.0
144080	3425245	ACSA_P_ 3204	7.56	650.9
144077	3425230	ACSA_P_ 3204	94.37	650.6
144086	3425275	ACSA_P_ 3204	176.30	650.3
144078	3425235	ACSA_P_ 3204	29.26	650.2
144079	3425240	ACSA_P_ 3204	94.12	650.2
144087	3425280	ACSA_P_ 3204	84.13	650.1
144076	3425225	ACSA_P_ 3205	141.19	649.7
144075	3425220	ACSA_P_ 3205	69.01	649.6

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Appendix G

Analysis of North Zone Pressure Surge Data

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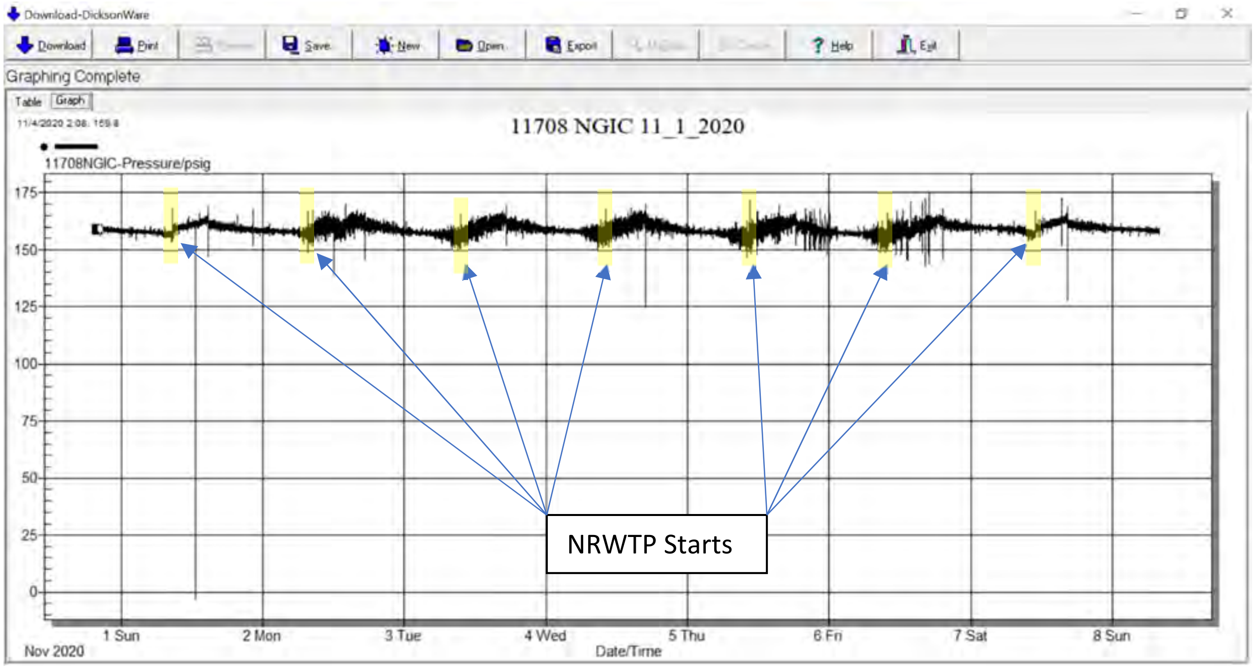
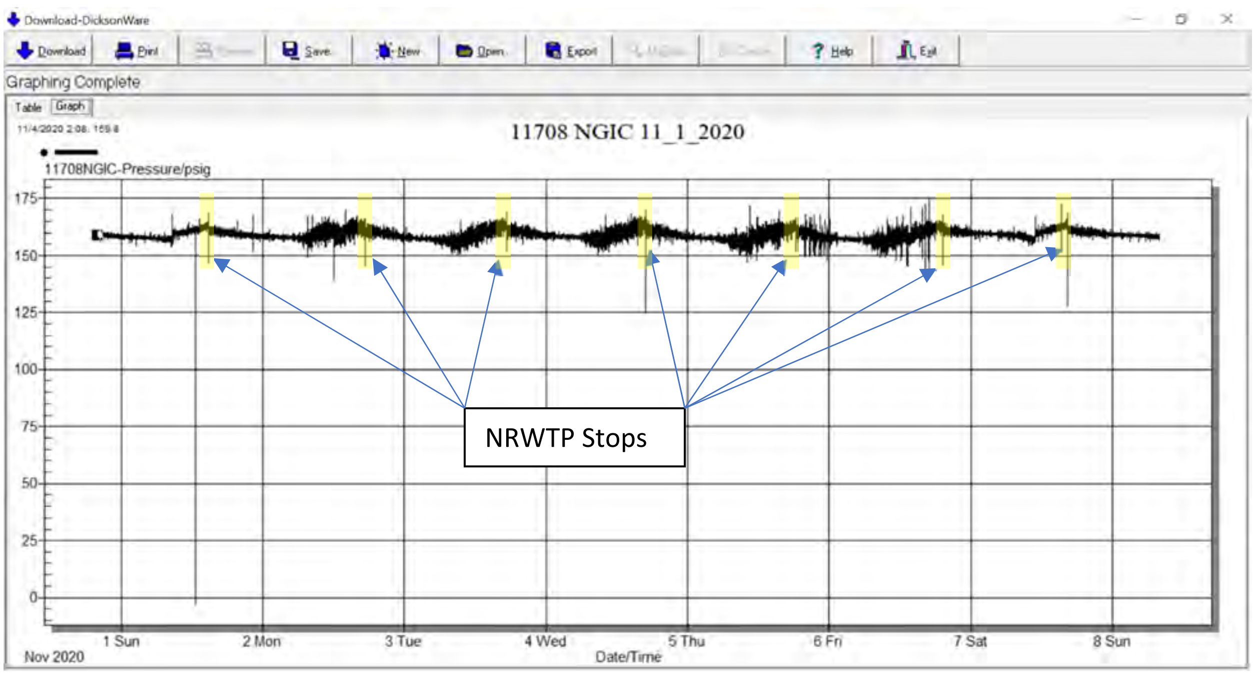
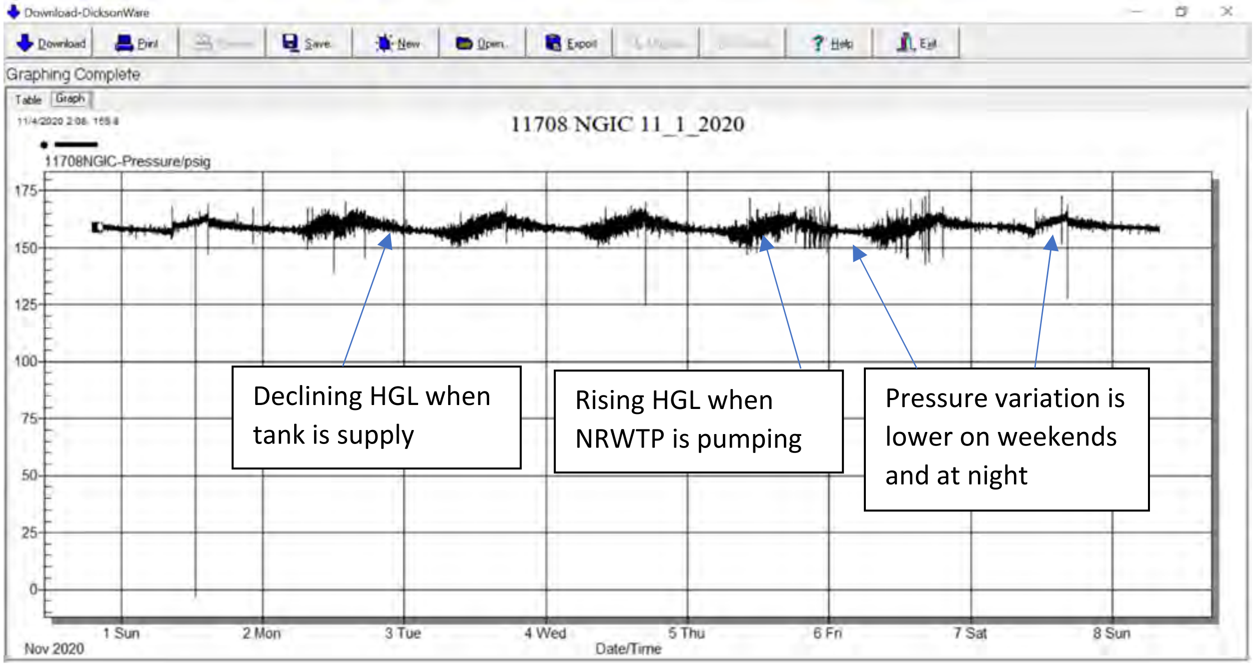
Analysis of ACSA North Zone Pressure Surge Data

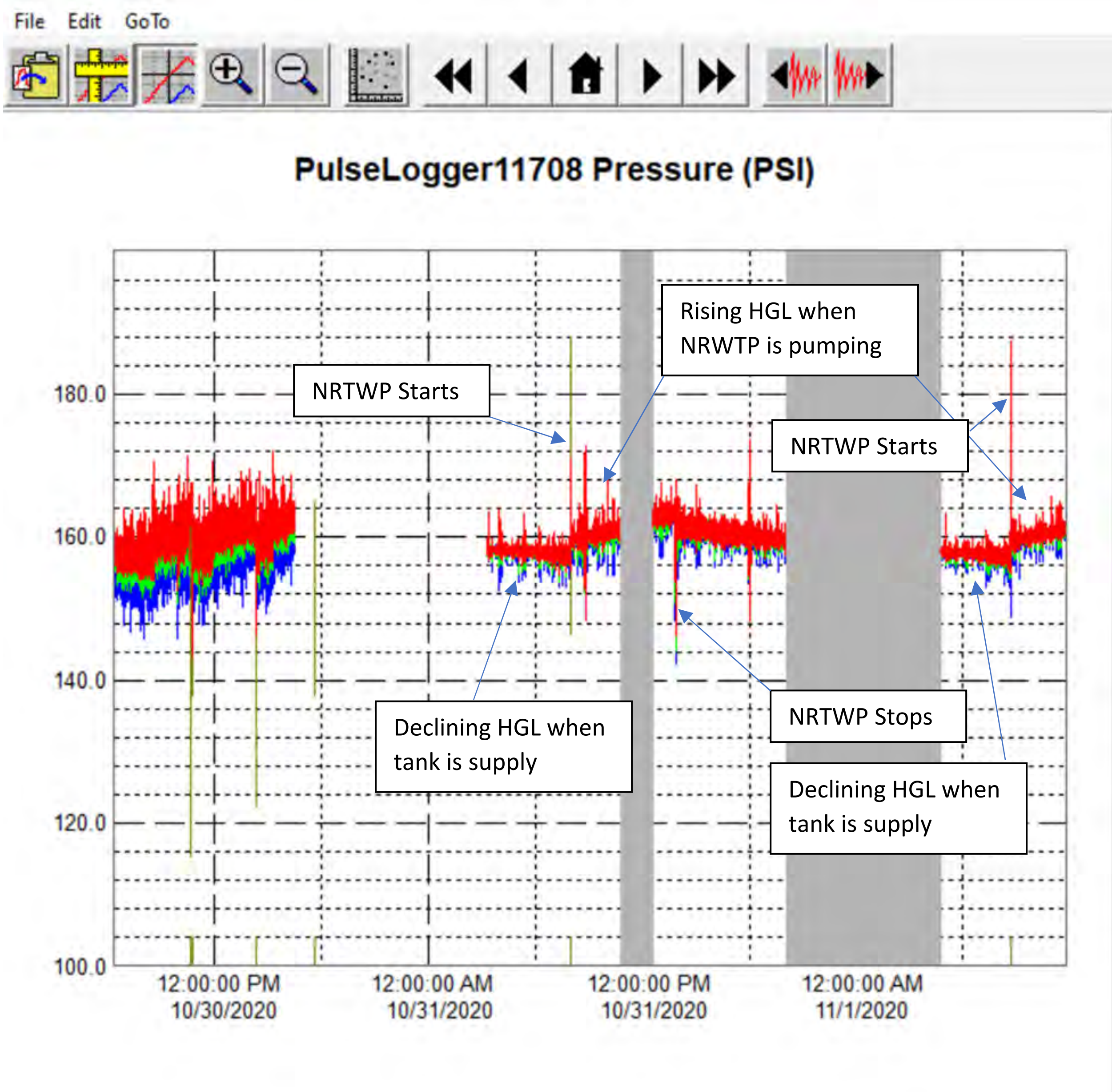
October/November 2020





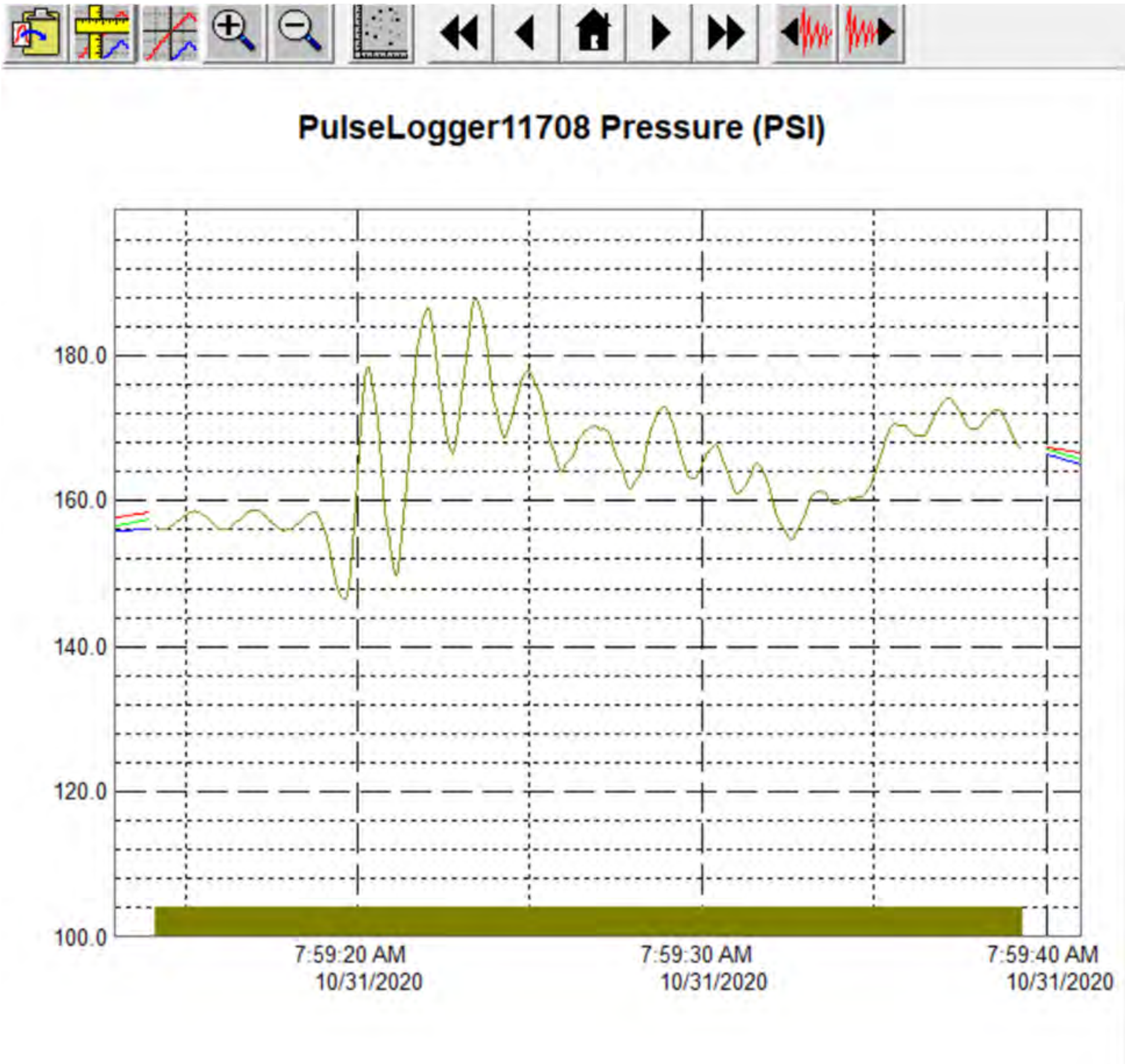


Due to lower frequency of sampling pressure, this monitoring data often does not include highest peaks and lowest troughs. Higher-frequency sampling is required to capture the extreme pressures – see following pages.



It can be seen that the highest pressure spikes coincide with start-up of the NRWTP. Pressure drops coincide with NRWTP shut-down.

Other customer actions also cause pressure drops, such as pumps starting up or valves opening quickly. For pressure drops, consider discussing hydrant operations with Albemarle County Fire Rescue, e.g., regarding training/maintenance activities. The City of Virginia Beach Fire Department trains its employees on hose use to minimize creating pressure surges (ref.: Chief Jon McIvor).



Close-up of pressure spike associated with NRWTP start-up. Wave frequency is approximately 1.3 seconds. Amplitude is approximately 30 psi initially, dampened by Piney Mtn. Tank.

Appendix H

Estimated Costs

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Item	Quantity	Unit	Unit Cost	Total Cost
Lewis Mtn. Tank (Short-Term)				
Contruction - Private Pumps	22	EA	$3,500	$77,000
Contractor Overhead & Profit (15%)	1	LS	$11,550	$11,550
Mobilization / Demobilization (10%)	1	LS	$7,700	$7,700
Contsruction Subtotal				*$96,250*
Engineering Design	1	LS	$20,000	$20,000
Legal/Miscellanious (3%)	1	LS	$2,888	$2,888
Permitting (3%)	1	LS	$2,888	$2,888
RWSA Construction Contingency for COs (10%)	1	LS	$9,625	$9,625
Construction Administration	1	LS	$10,000	$10,000
Engineering Contingency (10%)	1	LS	$9,625	$9,625
Subtotal				*$151,275*
Contingency (30%)				$46,000
Total				$197,275
Use				$200,000
South Rivanna River Second Crossing				
24" DIP (Restrained Joint)	3,600	LF	$850	$3,060,000
24" DIP River Crossing Surcharge	250	LF	$1,700	$425,000
24" Mainline Isolation Butterfly Valve	2	EA	$35,000	$70,000
Contractor Overhead & Profit (15%)	1	LS	$533,250	$533,250
Mobilization / Demobilization (5%)	1	LS	$178,000	$178,000
Construction Subtotal				*$4,266,250*
Engineering Design	1	LS	$272,000	$272,000
Legal/Miscellaneous (3%)	1	LS	$128,000	$128,000
Real Estate Services	1	LS	$20,000	$20,000
Property Acquisition	1	LS	$50,000	$50,000
RWSA Construction Services for COs (10%)	1	LS	$426,625	$427,000
Construction Adminstration/Inspection	1	LS	$154,000	$154,000
Engineering Contingency (10%)	1	LS	$426,625	$426,625
Subtotal				$5,743,875
Use				$5,800,000
Central Waterline				
30" DIP	9,200	LF	$800	$7,360,000
24" DIP	14,200	LF	$750	$10,650,000
30" DIP RR Crossing Surcharge	100	LF	$2,000	$200,000
24" DIP RR Crossing Surcharge	200	LF	$1,875	$375,000
Contractor Overhead & Profit (15%)	1	LS	$2,787,750	$2,787,750
Mobilization / Demobilization (5%)	1	LS	$929,250	$929,250
Construction Subtotal				*$22,302,000*
Engineering	1	LS	$1,688,000	$1,688,000
Real Estate Services	1	LS	$200,000	$200,000
Property Acquisition	1	LS	$1,100,000	$1,100,000
Legal/Miscellaneous (3%)	1	LS	$670,000	$670,000
Permitting	1	LS	$900,000	$900,000
Construction Administration/Inspection (6%)	1	LS	$1,339,000	$1,339,000
Construction Contingency (10%)	1	LS	$2,230,200	$2,230,200
Engineerng Contingency	1	LS	$284,091	$284,091
Subtotal				$30,713,291
Use				$31,000,000

Item	Quantity	Unit	Unit Cost	Total Cost
Stillhouse Tank				
Ground Storage Tank (0.73 MG Capacity)	1	LS	$730,000	$730,000
Site Work (concrete pad, driveway, etc.)	1	LS	$200,000	$200,000
Contractor Overhead & Profit (15%)	1	LS	$139,500	$139,500
Mobilization / Demobilization (5%)	1	LS	$46,500	$46,500
Construction Subtotal				*$1,116,000*
Engineering	1	LS	$90,000	$90,000
Legal/Miscellaneous (3%)	1	LS	$33,000	$33,000
Permitting (3%)	1	LS	$33,000	$33,000
Insurance Bonds (2.1%)	1	LS	$20,000	$20,000
Construction Administration/Inspection (6%)	1	LS	$67,000	$67,000
Construction Contingency (10%)	1	LS	$112,000	$112,000
Engineering Contingency (10%)	1	LS	$112,000	$112,000
Subtotal				$1,583,000
Contingency (10%)				$159,000
Total				$1,742,000
Use				$1,700,000
North Rivanna Waterline Reinforcement				
12" DIP	6,000	LF	$400	$2,400,000
12" DIP River Crossing Surcharge	200	LF	$800	$160,000
Contractor Overhead & Profit (15%)	1	LS	$384,000	$384,000
Mobilization / Demobilization (5%)	1	LS	$128,000	$128,000
Construction Subtotal				*$3,072,000*
Engineering (8%)	1	LS	$245,760	$245,760
Legal/Miscellaneous Services (3%)	1	LS	$92,000	$92,000
Permitting (3%)	1	LS	$92,000	$92,000
Construction Administration/Inspection (6%)	1	LS	$185,000	$185,000
Construction Contingency (10%)	1	LS	$307,000	$307,000
Engineering Contingency (10%)	1	LS	$307,000	$307,000
Subtotal				$4,300,760
Use				$4,300,000
North Rivanna River Second Crossing				
12" DIP	400	LF	$525	$210,000
12" DIP River Crossing Surcharge	200	LF	$1,050	$210,000
12" Mainline Isolation Gate Valve	4	EA	$50,000	$200,000
Contractor Overhead & Profit (15%)	1	LS	$93,000	$93,000
Mobilization / Demobilization (5%)	1	LS	$31,000	$31,000
Construction Subtotal				*$744,000*
Engineering (8%)	1	LS	$59,520	$59,520
Easement Acquisition	0.03	AC	$250,000	$7,000
Legal/Miscellaneous Services (3%)	1	LS	$22,320	$22,320
Permitting (3%)	1	LS	$22,320	$22,320
Construction Administration/Inspection (6%)	1	LS	$53,000	$53,000
Construction Contingency (10%)	1	LS	$74,000	$74,000
Engineering Contingency (10%)	1	LS	$74,000	$74,000
Subtotal				$1,056,160
Contingency (10%)				$106,000
Total				$1,162,160
Use				$1,200,000

Item	Quantity	Unit	Unit Cost	Total Cost
Emmet / Seminole WL Observatory to Hydraulic				
24" DIP	8,550	LF	$550	$4,702,500
30" DIP	6,750	LF	$650	$4,387,500
30" DIP RR Crossing Surcharge	100	LF	$1,300	$130,000
Contractor Overhead & Profit (15%)	1	LS	$1,383,000	$1,383,000
Mobilization / Demobilization (5%)	1	LS	$461,000	$461,000
Construction Subtotal				*$11,064,000*
Engineering (8%)	1	LS	$885,000	$885,000
Easement Acquisition	1.05	AC	$250,000	$264,000
Legal/Miscellaneous Services (3%)	1	LS	$331,920	$331,920
Permitting (3%)	1	LS	$331,920	$331,920
Construction Administration/Inspection (7%)	1	LS	$774,000	$774,000
Construction Contingency (10%)	1	LS	$1,106,400	$1,106,400
Engineering Contingency (10%)	1	LS	$1,106,400	$1,106,400
Subtotal				$15,863,640
Contingency (10%)				$1,587,000
Total				$17,450,640
Use				$18,000,000
Alderman Rd PS Discharge Inter-connection				
8-inch Bi-directional Flow Meter and Vault	1	LS	$225,000	$225,000
Contractor Overhead & Profit (15%)	1	LS	$33,750	$33,750
Mobilization/Demobilization (10%)	1	LS	$22,500	$22,500
Construction Subtotal				*$281,250*
Engineering (8%)	1	LS	$23,000	$23,000
Legal/Miscellaneous Services (3%)	1	LS	$8,438	$8,438
Construction Administration (7%)	1	LS	$20,000	$20,000
Constuction Contingency (10%)	1	LS	$28,125	$28,125
Engineering Contingency (10%)	1	LS	$28,125	$28,125
Subtotal				$388,938
Use				$400,000
Single-Feed Bypasses				
Fire Hydrant Assembly on 12" WM	11	EA	$15,000	$165,000
24" x 16" Tapping Tee	1	EA	$16,000	$16,000
16" Gate Valve	1	EA	$110,000	$110,000
16" Tee	2	EA	$10,000	$20,000
16" Blind Flange	3	EA	$3,000	$9,000
Concrete vault 6' X 12' X 6'	15	CY	$7,000	$105,000
12" Mainline Isolation Gate Valve	9	EA	$50,000	$450,000
14" Mainline Isolation Gate Valve	1	EA	$90,000	$90,000
Planning / Administration / Permitting (3%)	1	LS	$29,000	$29,000
General Requirements (8%)	1	LS	$77,000	$77,000
Contractor Overhead & Profit (15%)	1	LS	$145,000	$145,000
Insurance Bonds (2.1%)	1	LS	$20,000	$20,000
PER (3%)	1	LS	$29,000	$29,000
Engineering (8%)	1	LS	$77,000	$77,000
Construction Administration/Inspection (7%)	1	LS	$68,000	$68,000
Mobilization / Demobilization (5%)	1	LS	$48,000	$48,000
Subtotal				$1,033,000
Contingency (30%)				$310,000
Total				$1,343,000
Use				$1,300,000

Item	Quantity	Unit	Unit Cost	Total Cost
Rivanna River Second Crossing				
16" DIP	4,200	LF	$450	$1,890,000
16" DIP River Crossing Surcharge	400	LF	$900	$360,000
16" Mainline Isolation Gate Valve	1	EA	$110,000	$110,000
10" Meter Isolation Gate Valve	2	EA	$45,000	$90,000
10" Flow Meter and Vault	1	EA	$250,000	$250,000
Contractor Overhead & Profit (15%)	1	LS	$405,000	$405,000
Mobilization / Demobilization (5%)	1	LS	$135,000	$135,000
Construction Subtotal				*$3,240,000*
Engineering (8%)	1	LS	$259,200	$259,200
Legal/Miscellaneous Services (3%)	1	LS	$97,000	$97,000
Easement Acquisition	0.29	AC	$250,000	$73,000
Construction Administration/Inspection (7%)	1	LS	$18,144	$18,144
Construction Contingency (10%)	1	LS	$324,000	$324,000
Enginering Contingency (10%)	1	LS	$324,000	$324,000
Subtotal				$4,335,344
Contingency (10%)				$434,000
Total				$4,769,344
Use				$4,800,000
Lewis Mtn. Tank				
Ground Storage Tank (0.5 MG Capacity)	1	LS	$500,000	$500,000
Contractor Overhead & Profit (15%)	1	LS	$75,000	$75,000
Mobilization / Demobilization (5%)	1	LS	$25,000	$25,000
Construction Subtotal				$600,000
Preliminary Engineering Report (3%)	1	LS	$18,000	$18,000
Engineering (8%)	1	LS	$48,000	$48,000
Legal/Miscellaneous Services (3%)	1	LS	$18,000	$18,000
Construction Administration/Inspection (7%)	1	LS	$42,000	$42,000
Construction Contingency (10%)	1	LS	$60,000	$60,000
Engineering Contingency (10%)	1	LS	$60,000	$60,000
Subtotal				$846,000
Contingency (10%)				$85,000
Total				$931,000
Use				$900,000
Avon Street Waterline				
20" DIP	10,100	LF	$350	$3,535,000
20" Mailine Isolation Butterfly Valve	2	EA	$30,000	$60,000
12" Gate Valve	3	EA	$50,000	$150,000
Construction Subtotal				*$3,745,000*
Engineering (8%)	1	LS	$300,000	$300,000
Easement Acquisition	0.70	AC	$250,000	$174,000
Legal/Miscellaneous Services (3%)	1	LS	$112,350	$112,350
Permitting (3%)	1	LS	$112,350	$112,350
Construction Administration/Inspection (7%)	1	LS	$262,000	$262,000
Construction Contingency (10%)	1	LS	$374,500	$374,500
Engineering Contingency (10%)	1	LS	$374,500	$374,500
Subtotal				$7,964,000
Contingency (30%)				$2,390,000
Total				$10,354,000
Use				$10,300,000

Item	Quantity	Unit	Unit Cost	Total Cost
South Rivannal WL Rio to Hydraulic (All CIP Option - No Betterment)				
24" DIP	9,000	LF	$550	$4,950,000
Contractor Overhead & Profit (15%)	1	LS	$743,000	$743,000
Mobilization / Demobilization (5%)	1	LS	$248,000	$248,000
Construction Subtotal				$5,941,000
Engineering (8%)	1	LS	$475,000	$475,000
Legal/Miscellaneous Services (3%)	1	LS	$178,000	$178,000
Easement Acquisition	0.62	AC	$250,000	$155,000
Construction Administration/Inspection (7%)	1	LS	$415,870	$415,870
Construction Contingency (10%)	1	LS	$595,000	$595,000
Engineering Contingency (10%)	1	LS	$594,000	$594,000
Subtotal				$8,353,870
Contingency (15%)				$1,254,000
Total				$9,607,870
Use				$9,600,000
Airport Road Pump Station (ARPS) (Costs Provided by the RWSA)				
Pump Station	1	LS	$4,000,000	$4,000,000
Waterline Phase 1	1	LS	$6,000,000	$6,000,000
Waterline Phase 2	1	LS	$1,400,000	$1,400,000
Total				$11,400,000
OBS WM Cast Iron Replacement (OBSWTP to Alderman Rd PS, Emmet St to Lambeth PS)				
18" DIP	2,100	LF	$475	$997,500
Contractor Overhead & Profit (15%)	1	LS	$150,000	$150,000
Mobilization / Demobilization (5%)	1	LS	$50,000	$50,000
Construction Subtotal				*$1,197,500*
Engineering (8%)	1	LS	$95,800	$95,800
Legal/Miscellaneous Services (3%)	1	LS	$36,000	$36,000
Easement Acquisition	0.14	AC	$250,000	$37,000
Construction Administration/Inspection (7%)	1	LS	$83,825	$83,825
Construction Contingency (10%)	1	LS	$120,000	$120,000
Engineering Contingency (10%)	1	LS	$120,000	$120,000
Subtotal				$1,690,125
Contingency (10%)				$170,000
Total				$1,860,125
Use				$1,900,000
South Rivanna Replacement on Rio Road				
24" DIP	13,300	LF	$600	$7,980,000
30" DIP	8,700	LF	$720	$6,264,000
Contractor Overhead & Profit (15%)	1	LS	$2,137,000	$2,137,000
Mobilization / Demobilization (5%)	1	LS	$712,000	$712,000
Construction Subtotal				$17,093,000
Engineering (8%)	1	LS	$1,367,000	$1,367,000
Legal/Miscellaneous Services	1	LS	$513,000	$513,000
Easement Acquisition	1.52	AC	$250,000	$379,000
Construction Administration/Inspection (7%)	1	LS	$1,196,510	$1,196,510
Construction Contingency (10%)	1	LS	$1,710,000	$1,710,000
Engineering Contingency (10%)	1	LS	$1,709,000	$1,709,000
Subtotal				$23,967,510
Contingency (15%)				$3,596,000
Total				$27,563,510
Use				$27,600,000

Item	Quantity	Unit	Unit Cost	Total Cost
North Rivanna Cast Iron Replacement (outside limits of North Rivanna Reinforcement)				
12" DIP	15,200	LF	$375	$5,700,000
Contractor Overhead & Profit (15%)	1	LS	$855,000	$855,000
Mobilization / Demobilization (5%)	1	LS	$285,000	$285,000
Construction Subtotal				*$6,840,000*
Engineering (8%)	1	LS	$547,200	$547,200
Legal/Miscellaneous Services (3%)	1	LS	$205,000	$205,000
Easement Acquisition	1.05	AC	$250,000	$262,000
Construction Administration/Inspection (7%)	1	LS	$478,800	$478,800
Construction Contingency (10%)	1	LS	$684,000	$684,000
Engineering Contingency (10%)	1	LS	$684,000	$684,000
Subtotal				$9,701,000
Contingency (10%)				$971,000
Total				$10,672,000
Use				$10,600,000
Pantops and Avon Street Tank Replacements				
Pantops Ground Storage Tank (5.0 MG Capacity)	1	LS	$2,500,000	$2,500,000
Site Work for new Pantops GST	1	LS	$500,000	$500,000
Avon Elevated Storage Tank (2.0 MG Capacity)	1	LS	$1,500,000	$1,500,000
Contractor Overhead & Profit (15%)	1	LS	$675,000	$675,000
Mobilization / Demobilization (5%)	1	LS	$225,000	$225,000
Construction Subtotal				$5,400,000
Engineering (8%)	1	LS	$432,000	$432,000
Legal/Miscellaneous Services	1	LS	$162,000	$162,000
Property Acquisition	1.00	AC	$250,000	$250,000
Construction Administration/Inspection (7%)	1	LS	$378,000	$378,000
Construction Contingency (10%)	1	LS	$540,000	$540,000
Engineering Contingency (10%)	1	LS	$540,000	$540,000
Subtotal				$7,702,000
Contingency (15%)				$1,156,000
Total				$8,858,000
Use				$8,900,000
Airport Road Tanks				
Ground Storage Tanks (1.0 MG Capacity)	2	EA	$750,000	$1,500,000
Contractor Overhead & Profit (15%)	1	LS	$225,000	$225,000
Mobilization / Demobilization (5%)	1	LS	$75,000	$75,000
Construction Subtotal				$1,800,000
Preliminary Engineering Report (3%)	1	LS	$54,000	$54,000
Engineering (8%)	1	LS	$144,000	$144,000
Legal/Miscellaneous Services (3%)	1	LS	$54,000	$54,000
Construction Administration/Inspection (7%)	1	LS	$126,000	$126,000
Construction Contingency (10%)	1	LS	$180,000	$180,000
Engineering Contingency (10%)	1	LS	$180,000	$180,000
Subtotal				$2,538,000
Contingency (10%)				$254,000
Total				$2,792,000
Use				$2,800,000

Item	Quantity	Unit	Unit Cost	Total Cost
Investigations / Studies				
Waterline Condition Assessment				$800,000
Pressure Surge Investigation / Mitigation				$800,000
Pumping Facility Condition Assessment				$200,000
Water Model - Hydraulic Calibration				$180,000
Water Model - Water Quality Calibration				$220,000
Storage Evaluation				$263,000
Operations Evaluation				$137,000
Total				$2,600,000
Total				***$155,300,000***

SAY ***$155.3 Million***