RECLAIMED WATER MASTER PLAN UPDATE

September 2021

Final Report

TOWN OF CARY

CDM Smith

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Section 1

Project Background and Objectives

1.1 Reclaimed Water System Overview

The Town of Cary (Town) began operation of its reclaimed water system in 2001 and was the first utility in North Carolina to deliver reclaimed water for beneficial uses to homes and businesses to meet irrigation and cooling demands. Reclaimed water is a critical piece of the Town's overall water resources, serving the following goals:

- Reducing the peak demands on the potable water system to decrease or defer water treatment plant expansion
- Reducing wastewater treatment plant discharge and loads into receiving waters
- Assisting the Town's efforts to reduce per capita potable water use
- Reducing interbasin transfer (IBT)

The reclaimed water system was initially implemented with two service areas: 1) the "North" service area which includes approximately 14.4 miles of reclaimed water pipeline from the North Cary Water Reclamation Facility (NCWRF) to provide irrigation, cooling water, and toilet flushing for commercial customers and lawn irrigation for single- and multi-family homes, and 2) the "South" service area which includes approximately 4.6 miles of reclaimed water pipeline from the South Cary Water Reclamation Facility (SCWRF) to provide irrigation for residential areas, irrigation of recreational areas, and toilet flushing at a Town-owned park. Both water reclamation facilities provide tertiary wastewater treatment and ultraviolet disinfection, along with reclaimed water storage, pumping, followed by hypochlorite feed to maintain a disinfection residual in the reclaimed water distribution system.

In 2012, the Town expanded its reclaimed water system into a third service area through joint implementation of the Jordan Lake Water Reclamation and Reuse project (JLWRP) with Durham County and Wake County. This project provided reclaimed water from Durham County's Triangle Wastewater Treatment Plant (TWWTP) to a third, "West" service area to serve customers in the Wake County portion of Research Triangle Park and to the Town of Cary's Thomas Brooks Park, site of the USA Baseball national training center, as well as new subdivisions and developing portions of northwestern Cary. The West service area includes approximately 42.6 miles of reclaimed water pipeline.

Figures 1-1 through 1-3 show the existing reclaimed water system for the West, North, and South service areas, respectively. Figures 1-1 through 1-3 also show the installed reclaimed water pipes that are temporarily supplied with potable water until they can be connected to the reclaimed water system, as discussed further in Section 1.1.1.

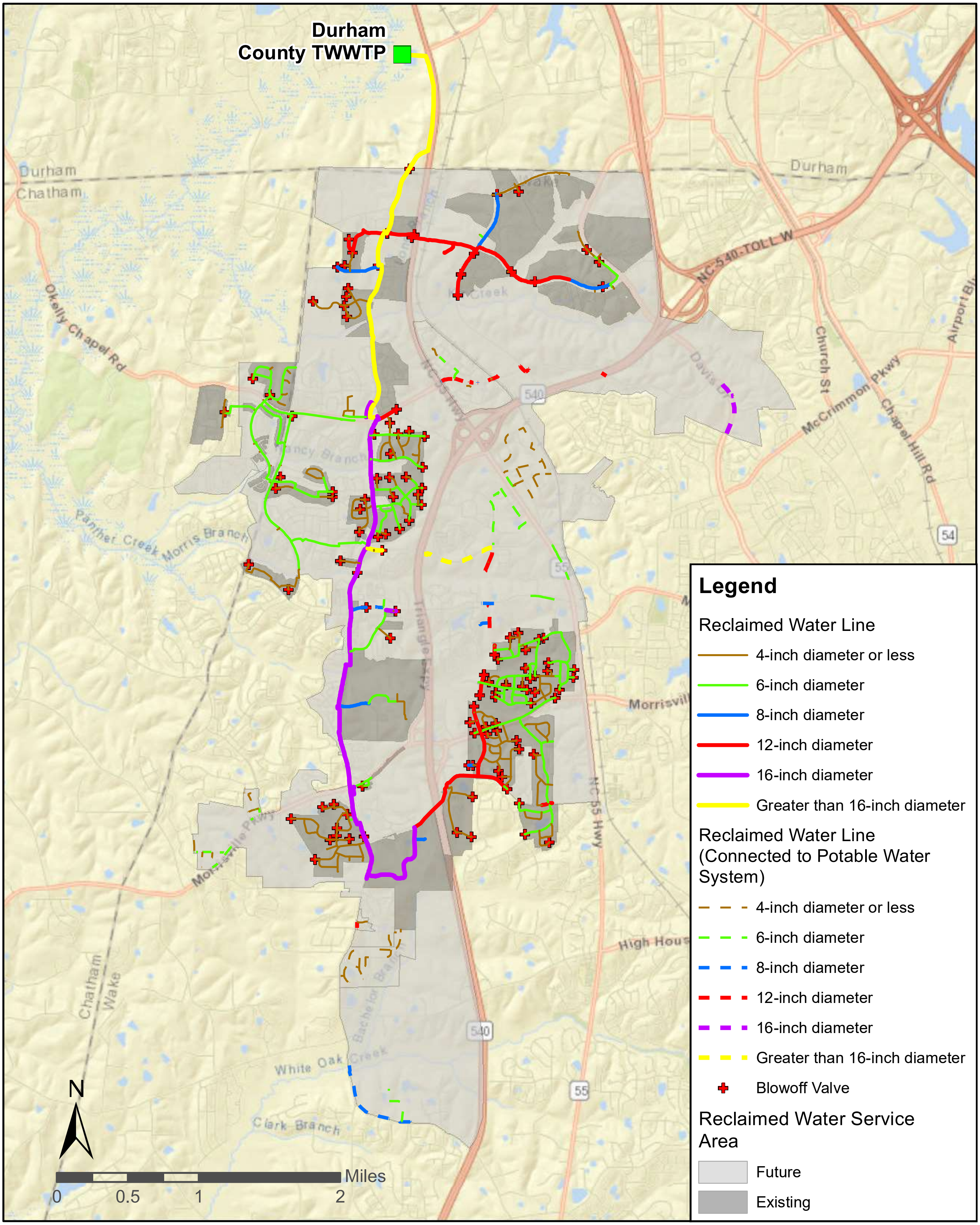

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Figure 1-1
Existing Reclaimed Water System West Service Area

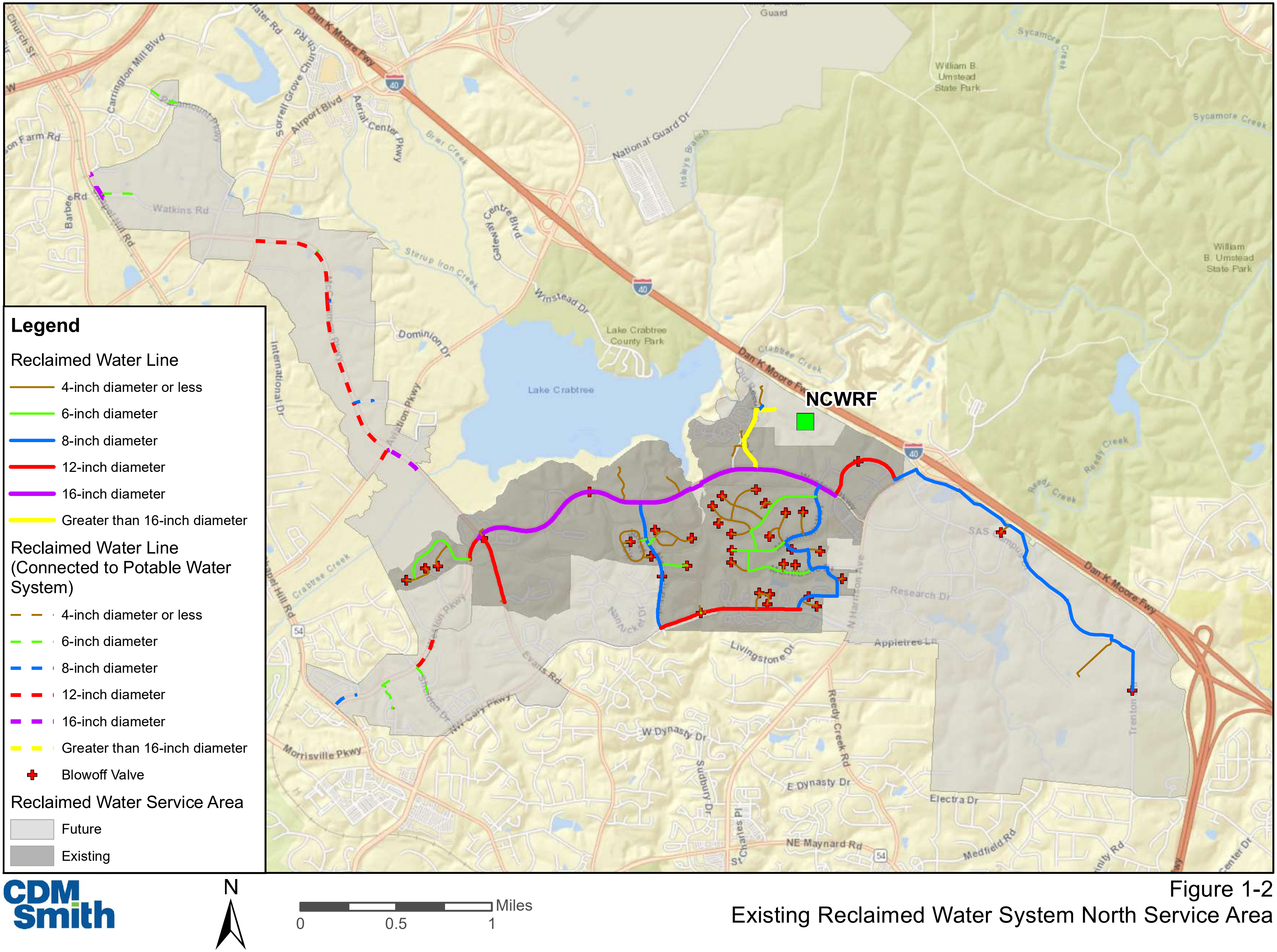

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Figure 1-2
Existing Reclaimed Water System North Service Area

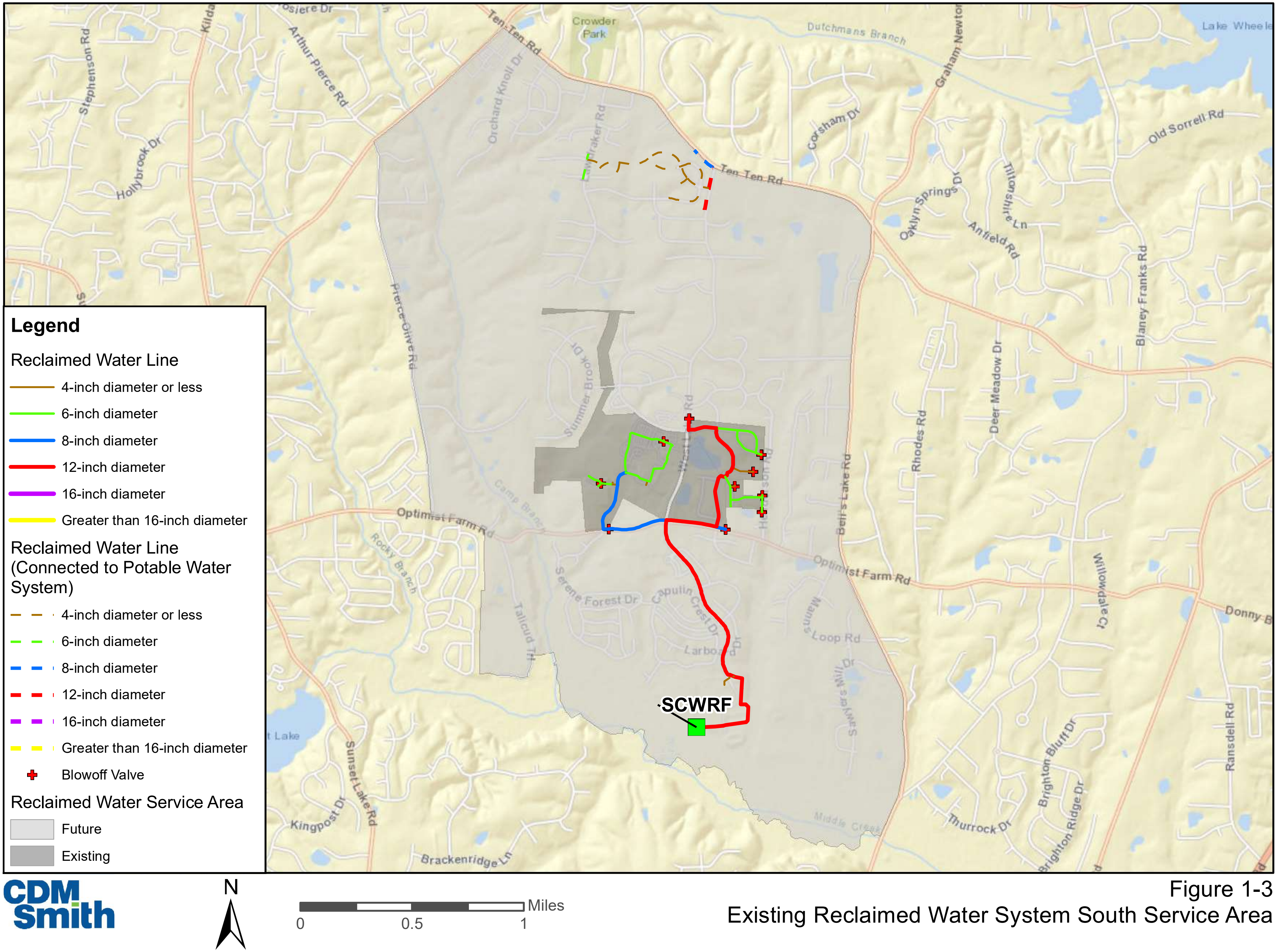

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Figure 1-3
Existing Reclaimed Water System South Service Area

1.1.1 Reclaimed Water Policy

The Town adopted an official policy, set forth in Policy Statement 132, to ensure the continued orderly expansion and effective utilization of the reclaimed water system. This policy defines the three reclaimed water service areas (shown on Figures 1-1 through 1-3). For new development occurring within those service areas, the developers are required to extend the reclaimed water system to the development and to install reclaimed water infrastructure for secondary water use facilities for landscape and ground irrigation systems, where available. All other secondary water use facilities, such as cooling towers, are encouraged to utilize reclaimed water, where available. If reclaimed water is not available to the site at the time of development, the secondary water use facilities may be temporarily supplied with potable water until reclaimed water is available, at which time they will be converted to the reclaimed water system. This policy is periodically updated to reflect planning updates for the reclaimed water system.

1.1.2 Regulatory Standards

The reclaimed water system is designed to meet the North Carolina Department of Environmental Quality (NCDEQ) mandatory treatment standards. The Town's reclaimed water system permits specify the water quality standards listed in **Table 1-1**, which corresponds to Type I reclaimed water.

Table 1-1. Minimum Reclaimed Water Quality Standards

Parameter	Daily Maximum	Maximum Monthly Average
Turbidity (NTU)	10	--
BOD_5 (mg/L)	15	10
Total Suspended Solids (mg/L)	10	5
Ammonia (NH_3) (mg/L)	6	4
Fecal Coliform (#/100 mL)	25	14
pH*	6.0 – 9.0	--

*Daily minimum pH is 6.0, daily maximum pH is 9.0

1.1.3 Reclaimed Water Rates

Reclaimed water usage is metered by the Town. A flat per-gallon reclaimed water rate is currently set at $3.90/1,000 gallons for irrigation use and $1.00/1,000 gallons for non-irrigation use including cooling towers. Potable irrigation rates range from 1.7 to 4.9 times the reclaimed water rate. Therefore, reclaimed water represents a significant savings over the potable irrigation rates. Potable non-irrigation rates are 5.3 to 8.0 times the reclaimed water rate. Reclaimed water customers are also exempt from the Town's alternate day watering restrictions.

1.1.4 Bulk Reclaimed Water

Bulk reclaimed water is provided at no charge to approved customers who complete a training course. The NCDEQ restricts uses of bulk reclaimed water. Allowable uses are listed in the reclaimed water system permits and include irrigation, road construction, dust control, sewer flushing, and street cleaning.

1.1.5 Reclaimed Water Supply

The North and South service areas are supplied with reclaimed water from the treatment and pumping facilities at the Town's NCWRF and SCWRF, respectively. The West service area is supplied with reclaimed water from Durham County's TWWTP through an interlocal agreement. The Town pays Durham County a monthly volume charge based on the volume of reclaimed water metered at the point of delivery near the Durham County line. This volume charge compensates Durham County for the portion of the County's costs for management, administration, operations, maintenance, compliance monitoring, and reporting for the reclaimed water production facilities. The volume charge is currently fixed at $2.94/1,000 gallons for the first 100 million gallons (MG) metered and reduces to $2.06/1,000 gallons for any volume metered above and beyond 100 MG each fiscal year.

1.1.6 Reclaimed Water System Operations

Operations for the Town's reclaimed water system include the following items.

Blow-offs

Long residence times in the reclaimed water distribution systems can lead to degradation of chlorine residual and overall water quality as well as internal pipeline corrosion and buildup issues. As part of the standard operating procedures, the Town has set a target chlorine residual of at least 0.5 mg/L at sampling points in the distribution system. To maintain chlorine residual in low demand areas of the distribution system, the Town flushes reclaimed water through blow-off valves at the extremities of the distribution system. Further discussion of blow-off locations and volumes is included in Section 2 of this report.

Minimum System Pressure

The Town adopted a minimum pressure policy (Policy Statement 129), which establishes a minimum water supply pressure to be provided through the potable and reclaimed water distribution systems of 40 psi during average and maximum day conditions, and 30 psi during peak hour conditions. Operation of the high service pumps and hydropneumatic tanks at the NCWRF and SCWRF are set to provide this pressure to the highest points in the distribution system.

Reclaimed Water Holiday

Each year in February, the Town conducts a reclaimed water "holiday" when all of the reclaimed water systems are temporarily shut down. The holiday allows staff to perform maintenance on the components of the system including inspection, cleaning, and repair, as necessary. The annual holiday is usually performed over 10 days assuming no significant repair issues arise during the system inspection. The holiday is conducted during the historically lowest reclaimed water demand period of the year to minimize disruption to customers.

Cross-Connections

Cross-connection control between the reclaimed water system and potable water system is important to protect public health. The Town has adopted cross-connection control ordinances and requires backflow preventers on the potable water system where reclaimed water and potable water are supplied to the same structure or facility. Backflow preventers are provided on the reclaimed water system where potable water is to be temporarily supplied until reclaimed water is available to the site. To prevent cross-connections, reclaimed water meters and meter boxes are distinguished from potable water meters with reverse threads and purple colored lettering stating "Reclaimed Water – Do Not Drink".

Temporary Potable Water Connections

In areas where reclaimed water pipes are installed with new development but cannot be directly supplied with reclaimed water until the system is expanded, the pipes are temporarily connected to the potable water system to keep the rubber gaskets from drying out or rotting. The installation requires a reclaimed water irrigation meter and a backflow preventer to protect the potable water system from cross-connection.

The process for disconnecting the temporary potable water connection to supply reclaimed water to the pipes includes the following sequence:

1. Isolate and turn off the potable water valve charging the backflow preventer
2. Remove the backflow preventer above ground
3. Cap standpipes attached to the backflow preventer 3 feet below grade
4. Abandon the potable and reclaimed water valves; remove the top part of the valve box and fill the bottom part of the valve box with stone
5. Allow reclaimed water to charge the reclaimed water pipe only after backflow preventer abandonment has been completed

1.2 System Planning

The last Town of Cary Reclaimed Water Master Plan Update, prepared by CDM Smith in 2013, focused on maximizing the Town's use of reclaimed water and combining the North/West service areas. In 2017, an addendum was added to the Master Plan report based on updated demands and the assumption that the TWWTP would supply the North/West reclaimed system in the near-term but by buildout it would be supplied entirely by the NCWRF.

In 2018, the Town completed updates to the Long-Range Water Resources Plan (LRWRP). The LRWRP provides strategic planning to meet the Town's water resource needs through development of a Water Resources Portfolio, including reclaimed water. In 2019, following the LRWRP, a Business Case Evaluation was performed that ultimately recommended keeping the West and North service areas separate. In June 2020, the Town updated the service areas defined in Policy Statement 132 to reflect the recommendation for separate West and North service areas. A copy of Policy Statement 132 is included in **Appendix A**.

This Reclaimed Water Master Plan Update is being performed to reflect the revised assumptions for future reclaimed water demands, as adjusted from the LRWRP forecast by Town staff to account for changes in reclaimed water boundaries and specific insight for future development, and to incorporate revised boundaries for the West and North service areas.

1.3 Project Objectives

The objectives for the Reclaimed Water Master Plan Update include the following:

- Convert the reclaimed water hydraulic model to Innovyze InfoWater Pro software and update the model to reflect existing system conditions, including demands on the system experienced in recent years.
- Incorporate updated future reclaimed water demand projections through year 2065, as provided by the Town, to develop future planning scenarios. Demand projections include customer consumption as well as non-revenue and flushing water.
- Evaluate alternative scenarios for future expansion of the reclaimed water system within the updated service area boundaries in Policy Statement 132. Identify proposed transmission mains, tanks, booster pump stations, and other major facilities needed to support future growth.
- Develop a phased plan of improvements to support a Capital Improvements Plan.

1.4 Report Format

To present the evaluation, results, and recommendations developed during the master planning process, the remainder of the report is organized into the following sections:

Section 2 – Reclaimed Water Demands

Section 3 – Hydraulic Model Updates and Evaluation Criteria

Section 4 – Future Reclaimed Water Alternatives Evaluation

Section 5 – Recommended Capital Improvement Program

An overview of key project highlights and next steps is summarized in Section 5.5.

Section 2

Reclaimed Water Demands

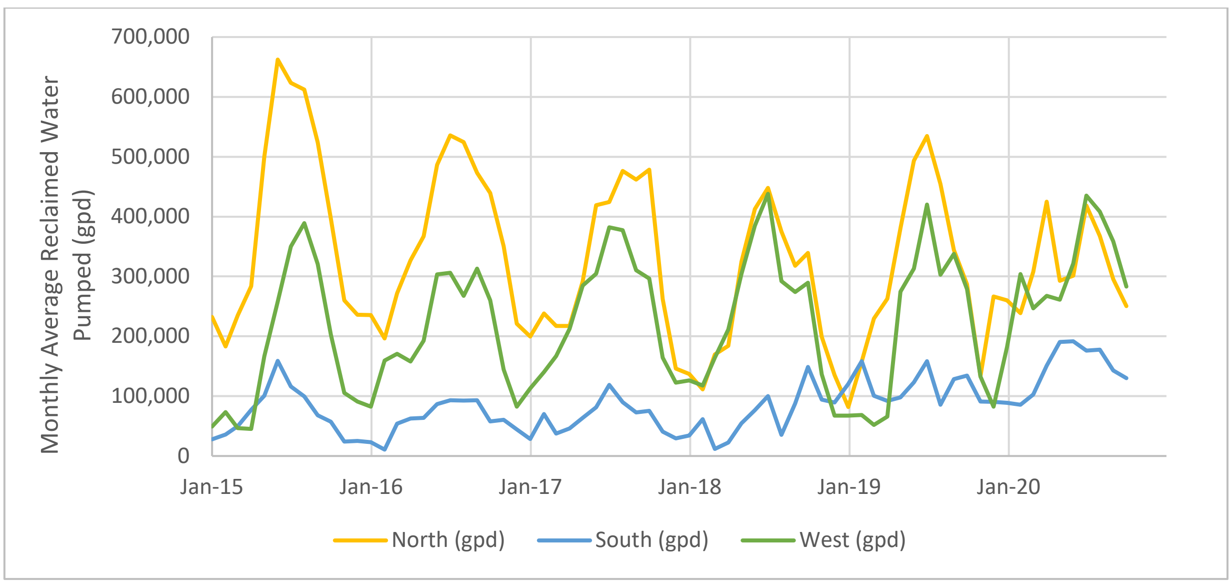
2.1 Existing Demands

Historical reclaimed water billing and pumping records and individual customer metering data from January 2018 through October 2020 were analyzed to determine the characteristics of the current demands on the reclaimed water system as well as peaking factors related to seasonal and diurnal variations in reclaimed water usage. The diurnal variations and peaking factors discussed in this section will be applied to future demand scenarios.

2.1.1 Average Annual Demand

Demands on the reclaimed water system are seasonal in nature since they are primarily for irrigation and cooling water. Demands peak during the summer months and drop to a minimum during the winter months. **Figure 2-1** shows the monthly trends in water pumped from the treatment facilities to the North, South and West distribution systems. The demands presented in this report do not include on-site use of reclaimed water at the NCWRF or SCWRF.

Figure 2-1. Monthly Reclaimed Water Pumped to the Distribution System by Service Area



The system is not typically operated at an average annual flow; the seasonal and daily maximum/minimum flows are more important to consider for the evaluation of the reclaimed water facilities. However, the average annual demand (AAD) is used as a basis for projecting future demands on the system and for determining total annual revenue generated by the system.

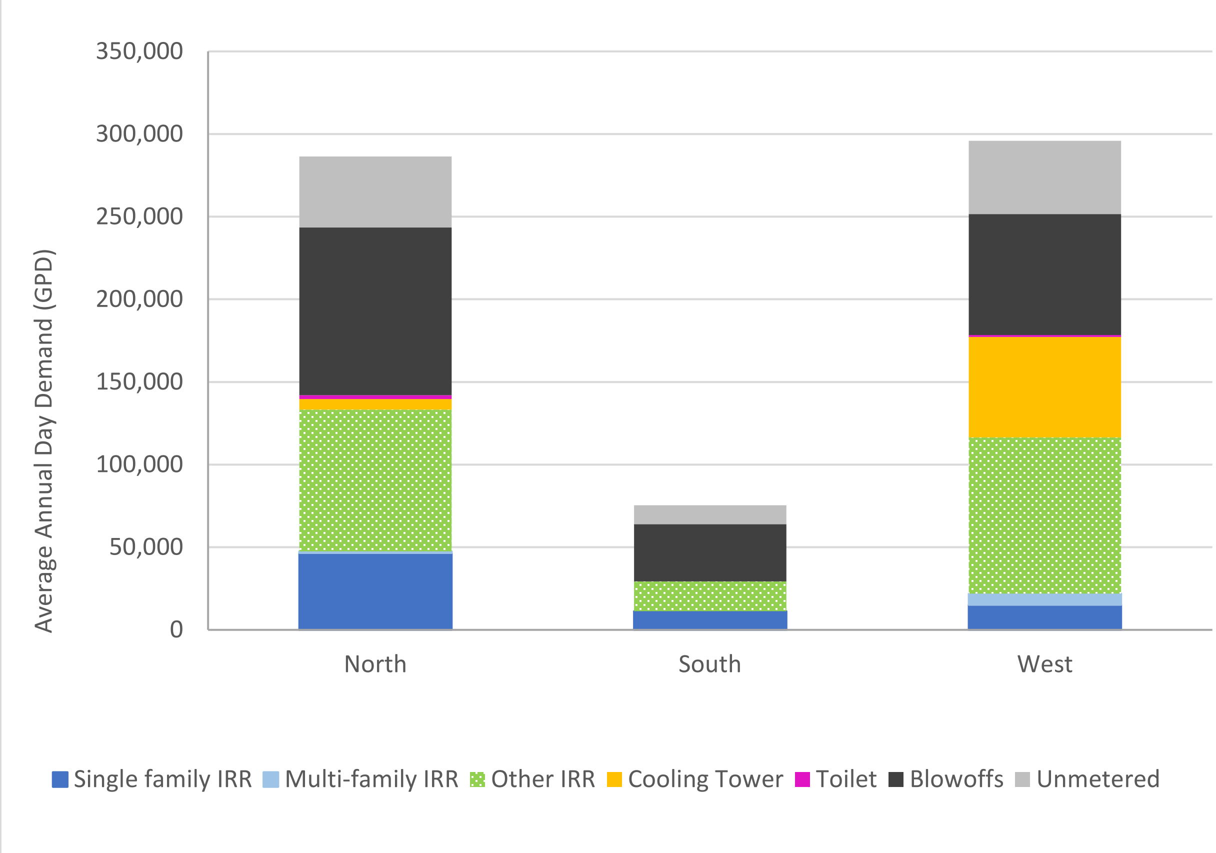
The 2018 through 2020 customer meter billing data served as a baseline for projecting future demand as well as allocating customer demands in the hydraulic model. According to records at the Raleigh-Durham International Airport, the summer seasonal precipitation (defined as the months of May through October) was 7.8 inches above average in 2018, 4.2 inches below average in 2019, and 4.7 inches above average in 2020. Although 2019 was the driest year of the three, there is less confidence in the individual meter data for 2019. Therefore, 2018 and 2020 were primarily relied upon to determine existing demands.

Figure 2-2 shows a breakdown of the resulting AAD in each service area by the following use categories:

- Single-Family Residential Irrigation
- Multi-Family Residential Irrigation
- Other Irrigation – this category includes irrigation of commercial, industrial, office, parks, schools and other institutional facilities.
- Cooling Towers
- Toilet Flushing for non-residential facilities
- Blowoffs – blowoff of water from the distribution system is performed year-round to maintain water quality. Blowoffs are metered by the Town and generally run constantly throughout the day.
- Unmetered Water – determined by comparing the water use metered in the categories above to the water pumped to the distribution system in each service area. Based on review of 2018 through 2020 data, it is assumed that 15 percent of the water pumped to the system is unmetered. Since the pipes and meters in the reclaimed water system are relatively new, it is assumed that water loss in the system is relatively low. Therefore, the unmetered water is assumed to be primarily attributable to uncertainty in reporting of the blowoff volumes.

In general, a significant portion of the distributed reclaimed water is used for blowoffs to maintain water quality. Metered use that is billed to customers (metered billable demand) represents only approximately 50 percent of the total water distributed to the North service area, approximately 40 percent of the total water distributed to the South service area, and approximately 60 percent of the total water distributed to the West service area.

Figure 2-2. Existing Annual Average Reclaimed Water Demand by Service Area and Use Category



2.2 Peaking Factors

The following sections describe the development of peaking factors that will be applied to the annual average reclaimed water projections and used for evaluation and design of reclaimed water facilities.

2.2.1 Seasonal Peaking Factors

Figure 2-1 shows the typical seasonal variation in total reclaimed water distributed to each service area. The Town's reclaimed water usage is generally highest from May to October. However, based on review of monthly billing and pumping data, the blowoff and unmetered portion of the reclaimed water flow shows an opposite trend with higher blowoffs in the winter season (November to April) needed to maintain water quality during low demand months. The blowoff portion of the demand has the effect of diluting the seasonal and maximum day peaking factors attributed to the customer demand. To account for this, only the metered billable data was used to determine seasonal and maximum month peaking factors.

Separate peaking factors were determined for irrigation, cooling tower, and toilet flushing use categories across all three service areas. The peaking factors determined from analysis of the 2018 to 2020 billing data are similar to those determined in the 2013 Master Plan. **Table 2-1** gives the seasonal 'summer' (May through October) and 'winter' (November through April) peaking factors expressed as a ratio to the AAD. The maximum month to AAD peaking factor is also presented for use category. Applying these seasonal and maximum month factors to future AAD projections provides an estimate of the customer-related flows that the reclaimed water system must sustain on a long-term basis.

Table 2-1. Seasonal and Maximum Daily Reclaimed Water Peaking Factors by Use Category

Use Category	Winter Average: AAD Peaking Factor[1] (November-April)	Summer Average: AAD Peaking Factor [1] (May-October)	Max Month: AAD Peaking Factor[1]	Max Day: AAD Peaking Factor[2]
Irrigation	0.4	1.6	2.4	3.4
Cooling Tower	0.8	1.2	1.5	2.5
Toilet Flushing	1.0	1.0	1.0	1.0

1. Seasonal peaking factors determined from metered billing data for customer uses. Expressed as a ratio to the average annual day demand (AAD).
2. Maximum day peaking factors determined by applying the maximum day: maximum month peaking factor observed in the pumping data to the maximum month from metered data. Expressed as a ratio to the AAD.

2.2.2 Maximum Daily Peaking Factor

The maximum day to average annual demand ratio (or max day peaking factor) is a key parameter for evaluating the reclaimed water system. Major elements of the distribution system are typically sized to deliver the maximum day demand reliably and consistently. In addition, reclaimed water supply is typically limited by the amount of water available to satisfy the maximum day demand, with hourly demands in excess of the maximum day satisfied through system storage.

Since meter billing data is only available on an aggregate monthly basis, the maximum day peaking factor was determined by applying the maximum day: maximum month peaking factor observed in the pumping data to the maximum month from metered data. The peaking factors determined from analysis of the 2018 to 2020 billing data are similar to the those determined in the previous Master Plan. Therefore, for consistency, the same peaking factors are used as in the previous Master Plan. Table 2-1 gives the maximum day peaking factors expressed as a ratio to the AAD.

2.2.3 Diurnal Variations and Hourly Peaking Factors

Peak hour demand is the highest rate of reclaimed water consumption to occur during any one-hour period during a given year. Peak hour demand is often expressed as the ratio to the AAD. The reclaimed water facilities are sized to convey peak hour flow and storage tanks are typically sized to equalize the system demand for all demand in excess of the maximum day, including the peak hour demand. If there is no system storage, the supply of reclaimed water and the reclaimed water pumping capacity must be sufficient to meet this demand.

Since reclaimed water usage patterns vary significantly among individual customers, hourly reclaimed water usage was obtained from the Town's Aquastar advanced metering infrastructure

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(AMI) data for the months of July and August 2020. Data was obtained from 13 of the largest reclaimed water users, representing customers in all three service areas and all three reclaimed water use categories (irrigation, cooling towers, and toilet flushing), as listed in **Table 2-2**. These users represent 48 percent of the total reclaimed water metered billable usage during July and August 2020. **Figure 2-3** shows the unit diurnal usage patterns determined for the 9 individual irrigation customers. **Figure 2-4** shows the unit diurnal usage patterns for the 3 individual cooling tower customers and one toilet flushing customer. The three types of reclaimed water usage patterns are described below.

Table 2-2. Hourly Peaking Factors for Individual Customer Meters

Meter #	Service Area	Use Category	Customer	July/August 2020 Average Use (gpd)	Peak Hour: Avg Hour Daily Peaking Factor
180818	North	Irrigation	AERC OF NC, LP	11,000	5.1
154603	North	Irrigation	HIGHWOODS PROPERTIES	14,000	4.1
136121	North	Irrigation	JOHN DEERE U.S. AG	17,000	4.6
195592	North	Irrigation	METROPOLITAN LIFE INSURANCE CO	17,000	3.1
218600	North	Irrigation	WESTON AT LAKESIDE	8,000	3.4
210509	North	Cooling Tower	WINSTEAD	12,000	1.4
151600	South	Irrigation	TOWN OF CARY (Middle Creek Park)	4,000	6.7
210489	West	Cooling Tower	CISCO SYSTEMS 1	41,000	1.3
210488	West	Cooling Tower	CISCO SYSTEMS 2	23,000	1.4
117177	West	Irrigation	CISCO SYSTEMS 3	12,000	3.7
209039	West	Toilet Flushing	CREDIT SUISSE	1,000	2.8
130418	West	Irrigation	NETAPP	13,000	3.5
129246	West	Irrigation	TOWN OF CARY (Thomas Brooks Park)	63,000	3.2
			Total	**236,000**	**n/a**

Figure 2-3. Irrigation Unit Diurnal Patterns (July-August 2020)

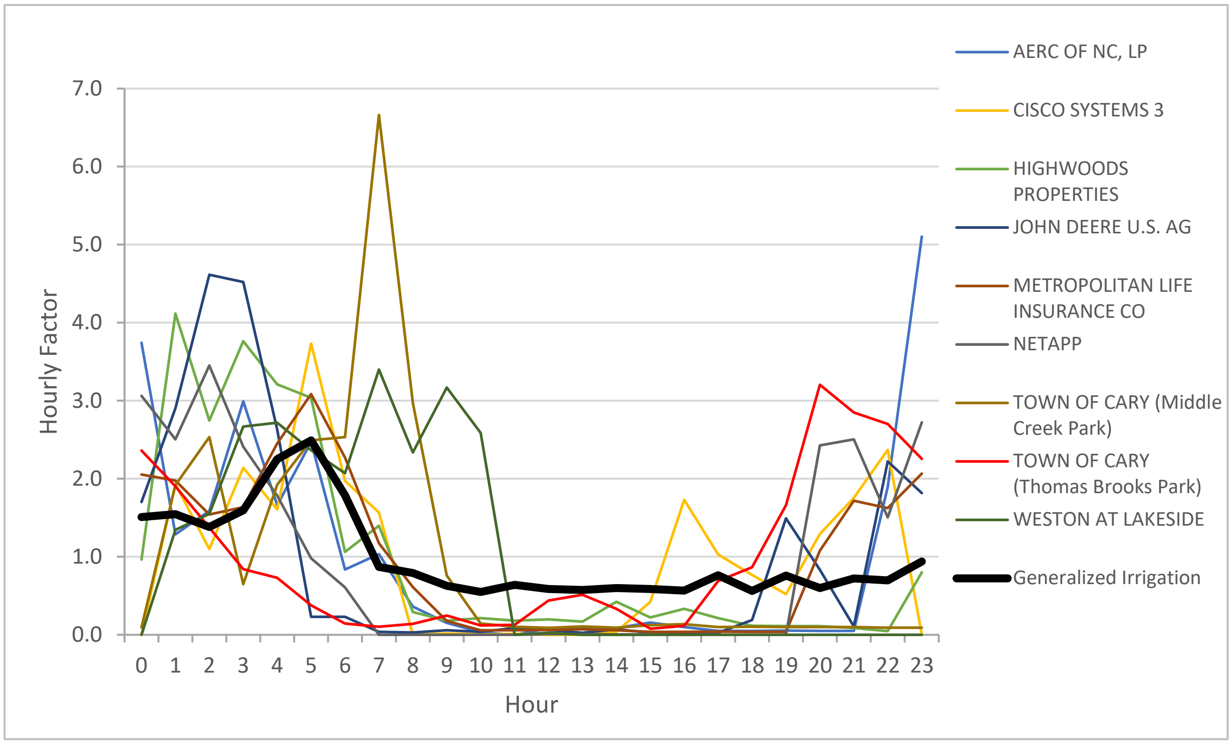
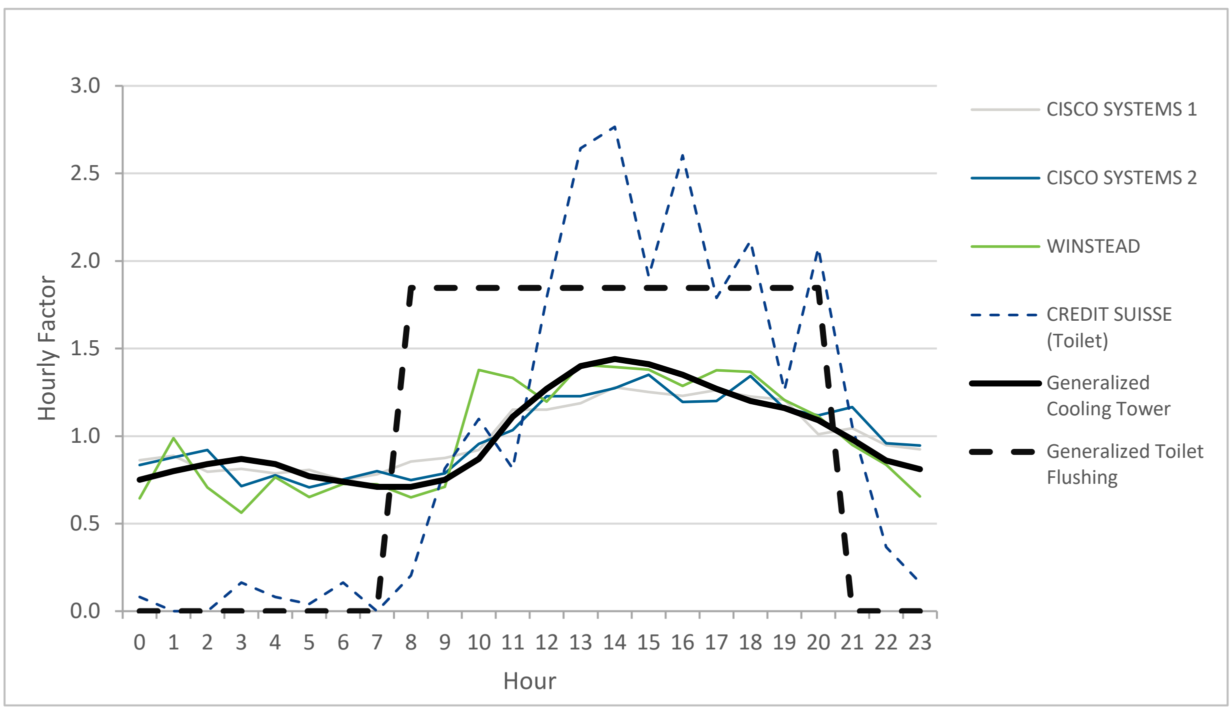


Figure 2-4. Cooling Tower and Toilet Flushing Unit Diurnal Patterns (July-August 2020)



Irrigation

In general, irrigation usage peaks between 8 p.m. and 5 a.m. and is minimal between 11 a.m. and 6.p.m, as shown in Figure 2-3. For the remaining irrigation reclaimed water users for which customer-specific patterns were not obtained, a generalized pattern was developed based on hourly pumped flows recorded by SCADA. Hourly SCADA was only available for the NCWRF, so this analysis was only performed for the North service area.

The hourly metered usage for the North service area customers presented in Table 2-2 were subtracted from the hourly pumped flows. Additionally, the generalized cooling tower and toilet flushing patterns (described in the following section) were applied to the cooling tower/toilet flushing customers for which customer-specific patterns were not obtained. Those uses were also subtracted from the pumped flows along with the constant blowoff flows. The remaining hourly flows were used to determine a unit diurnal pattern that represents general irrigation use, which is shown in Figure 2-3. It should be noted that this pattern is very similar to the irrigation pattern developed for the previous Master Plan, which validates the use of this pattern for the Town's reclaimed water system.

Table 2-2 summarizes the peak hour factors for each of the irrigation patterns. The diurnal curves and peak hour factors are applied to the maximum day demands for the hydraulic modeling scenarios, as discussed in Section 3.

Cooling Towers

The cooling tower users presented in Figure 2-4 show a remarkably consistent pattern. Usage is relatively constant over the entire day, peaking at 2 p.m. in the afternoon. The individual unit diurnal patterns are also very similar to the generalized cooling tower pattern developed for the previous Master Plan, which validates the use of this pattern for the Town's reclaimed water system.

Table 2-2 summarizes the peak hour factors for each of the cooling patterns. The diurnal curves and peak hour factors are applied to the maximum day demands for the hydraulic modeling scenarios, as discussed in Section 3.

Toilet Flushing

The one toilet flushing user presented in Figure 2-4 had fairly low usage during July and August 2020, likely due to reduced office work force during the Covid-19 shut downs. Therefore, the generalized toilet flushing pattern developed for the previous master plan is applied to all future reclaimed water toilet flushing uses. This pattern assumes constant use from 8 a.m. to 8 p.m. since toilet flushing is only applicable for commercial/industrial customers. This diurnal pattern is applied to the maximum day demands for the hydraulic modeling scenarios, as discussed in Section 3.

2.3 Future Demand Projections

The Town's most recent LRWRP recommended a targeted expansion of the reclaimed water system. Per the LRWRP Appendix D – Reclaimed Water Business Case Evaluation, the following criteria define targeted expansion:

- Fulfill current commitments:
  - Continue service to existing customers in North and West Service Areas
  - Extend reclaimed water service to "future reclaimed" customers who have existing reclaimed water infrastructure by not reclaimed water service
- Consider targeted reclaimed water service expansions in the future, such as new high-value commercial developments with year-round demand
- Durham County continues to supply West Service Area
- Current equipment and systems should meet commitments
- No additional storage needed
- No chlorine boosting anticipated
- Water pressure is desirable under current reclaimed service conditions
- CIP projects to be added in future for operational effectiveness and efficiency – (looping mains)

This approach differs from the previous approach to maximize expansion of the reclaimed water system. As a result, Town staff revised service area boundaries, which are more limited than previous boundaries, and revised future demand estimates to align with the targeted expansion approach.

As part of this effort, Town staff performed a parcel-level evaluation of buildout demands on the reclaimed water system. The buildout estimates are associated with year 2065. Parcels with potential to connect to the reclaimed water system were identified and a demand assigned based on the following categories:

- Existing Reclaimed Water Customers – Existing customers are assumed to continue using reclaimed water at the current amounts.
- Future Connection of Existing Potable Customers – These are customers that are served by a reclaimed water line that is currently connected to the potable water system since reclaimed water service has not been extended to that area yet. These customers are assumed to use the same amount of water as they currently do but, in the future, they will be connected to the reclaimed water system instead of potable. Existing usage is taken from the potable water meter billing database.
- Future Cooling Tower – Parcels identified by Town staff as having potential for future cooling towers. Assumed AAD is approximately 16,620 gpd/parcel based on analysis of current usage for similar parcels already connected to the reclaimed water system.
- Future Toilets – Parcels identified by Town staff as having potential for future toilet flushing use. Assumed AAD is approximately 5,570 gpd/parcel based on analysis of current usage for similar parcels already connected to the reclaimed water system.
- Future Field – Parcels identified by Town staff as having potential for future recreational fields that would be irrigated with reclaimed water, including parks and sports facilities.

Assumed AAD is approximately 72 gpd/acre based on analysis of current usage for similar parcels already connected to the reclaimed water system.

- Future Frontage – Commercial, office, institutional, or neighborhood parcels identified by Town staff as having potential for future irrigation of road/entry frontage landscaping with reclaimed water. Assumed AAD is approximately 50 gpd/acre based on analysis of current usage for similar parcels already connected to the reclaimed water system.
- Future Single-Family Residential – Single family residential parcels identified by Town staff as having potential for landscape irrigation. Assumed AAD is approximately 94 gpd/acre based on analysis of current usage for similar parcels already connected to the reclaimed water system.

An additional 5 percent is added to the future demands in all categories to account for miscellaneous system losses attributable to the new demands.

Table 2-3 presents a summary of the existing and future buildout reclaimed water demands by category and service area. **Figure 2-5** shows the categorization of parcels within the North and West reclaimed water service area boundaries, as defined by the Town Policy Statement 132. Future demands are allocated spatially in the hydraulic model as described in Section 3.

Table 2-3. Summary of Existing and Future Buildout Reclaimed Water Demands

	North (gpd)		South (gpd)		West (gpd)	
	Existing	Future[1]	Existing	Future[1]	Existing	Future[1]
Single-Family Irrigation	47,000	47,000	11,000	33,000	15,000	69,000
Existing Multi-Family Irrigation	1,000	1,000	0	0	7,000	7,000
Other Irrigation – Existing	86,000	86,000	18,000	18,000	94,000	94,000
Future Field Irrigation	0	0	0	0	0	2,000
Future Frontage Irrigation	0	42,000	0	0	0	89,000
Cooling Tower	6,000	44,000	0	0	61,000	96,000
Toilet Flushing	2,000	7,000	0	0	1,000	1,000
Future Connection of Existing Potable	0	25,000	0	5,000	0	43,000
Blowoffs & Unmetered Water[2]	144,000	0	46,000	0	118,000	0
AAD	**286,000**	**252,000**	**75,000**	**56,000**	**296,000**	**401,000**
Summer Avg Demand	**368,000**	**381,000**	**92,000**	**90,000**	**378,000**	**603,000**
MDD	**617,000**	**800,000**	**145,000**	**190,000**	**666,000**	**1,275,000**

1. Future demands assume existing customers continue using reclaimed water at the current amounts.
2. Metered blowoffs and unmetered water are given for the existing system. Unmetered water is assumed to be 15 percent of the total water distributed and is primarily associated with uncertainty in the metered blowoffs. Although blowoffs are expected to be needed in the future, the estimated blowoff amounts are not presented. Further discussion of future blowoffs is presented in Section 4. The future customer demands include an additional 5 percent to account for miscellaneous system losses attributable to the new demands.

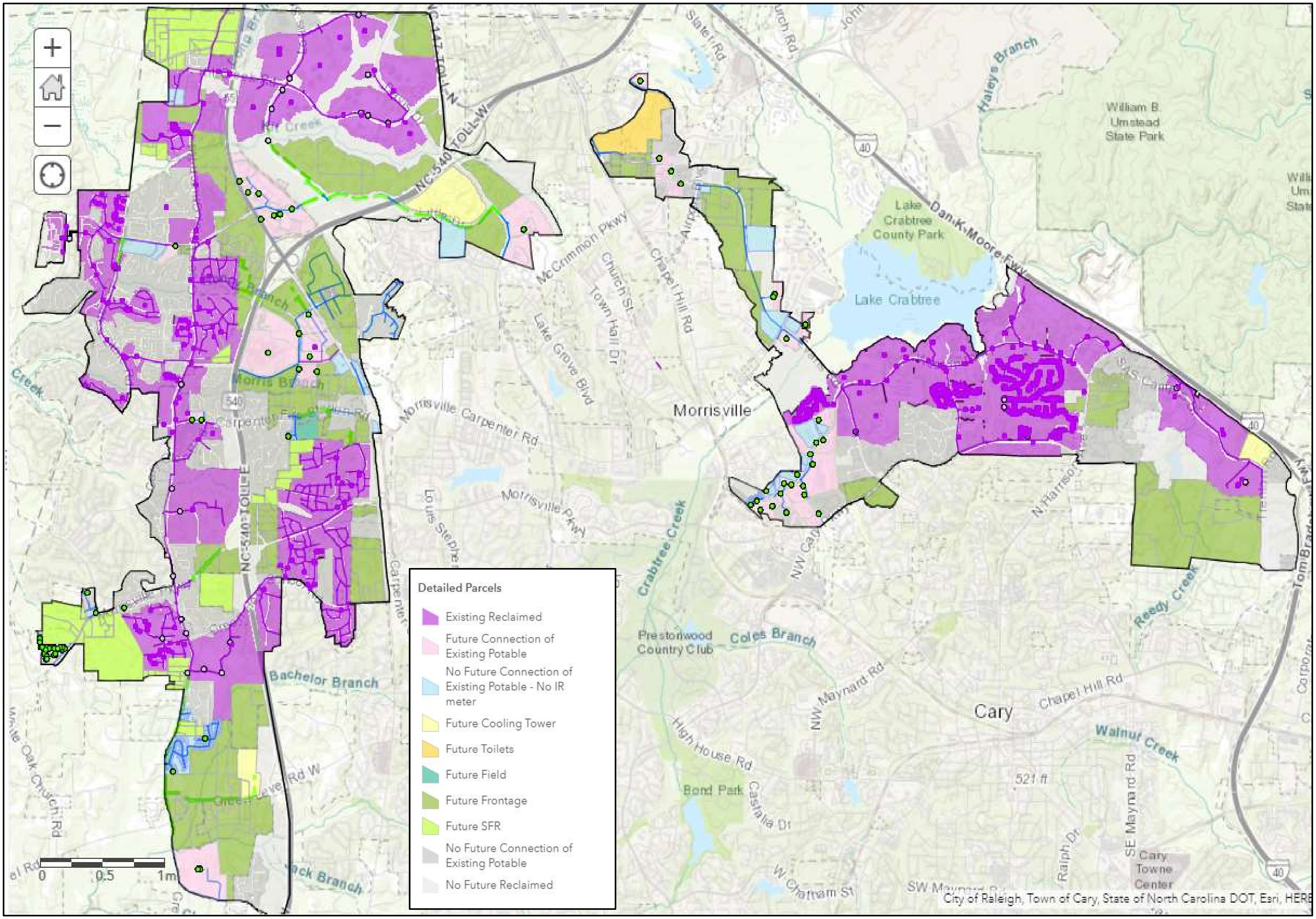


Figure 2-5
Demand Projection Categories by Parcel – North and West Service Area

It is assumed that blowoffs will continue to be needed in the future. Evaluation of blowoffs and water age is presented in Section 4. However, the impact of blowoff volume relative to the growth of demand from the metered billable customer uses can be seen in **Figures 2-6 through 2-8**. These figures show the growth in metered billable demand between existing and buildout for the North, South, and West service areas, respectively. The largest growth is seen in the West service area, at about 125 percent. The South service area growth is approximately 93 percent from existing to buildout, and the North service area growth is approximately 77 percent. For the North and South service areas, the current blowoffs are greater than the customer demand growth projected for those service areas.

Figure 2-6. Projected Reclaimed Water Demand Growth – North Service Area

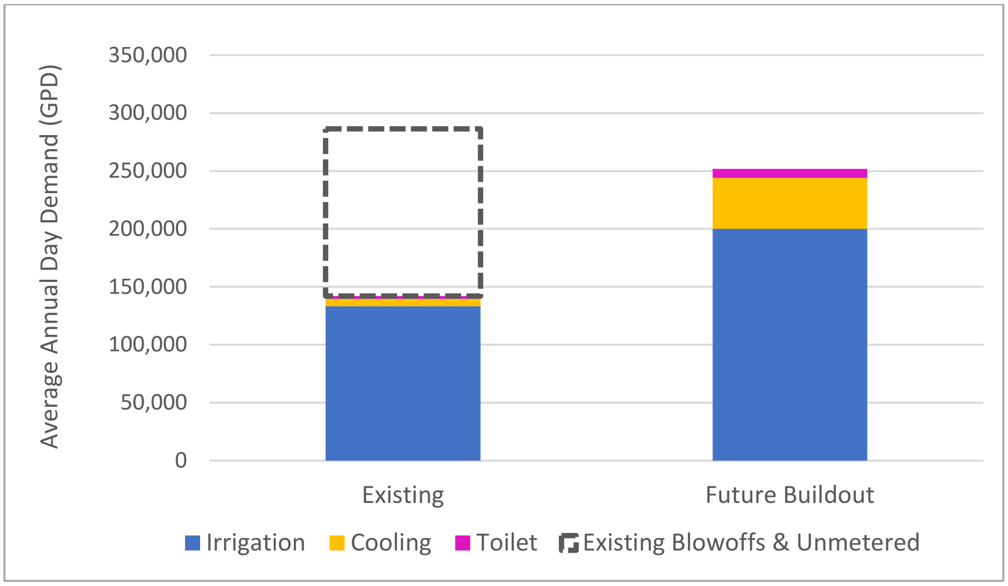


Figure 2-7. Projected Reclaimed Water Demand Growth – South Service Area

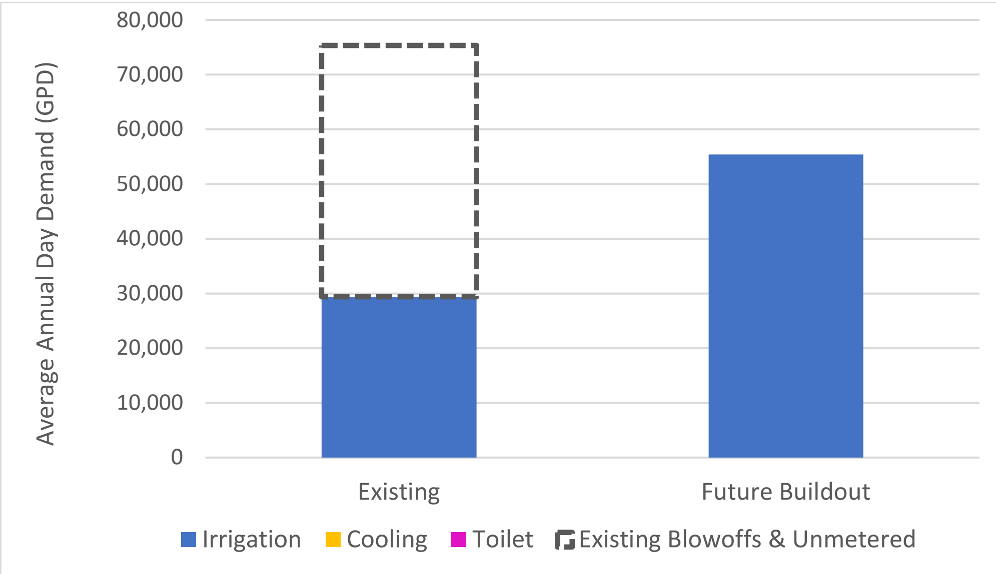
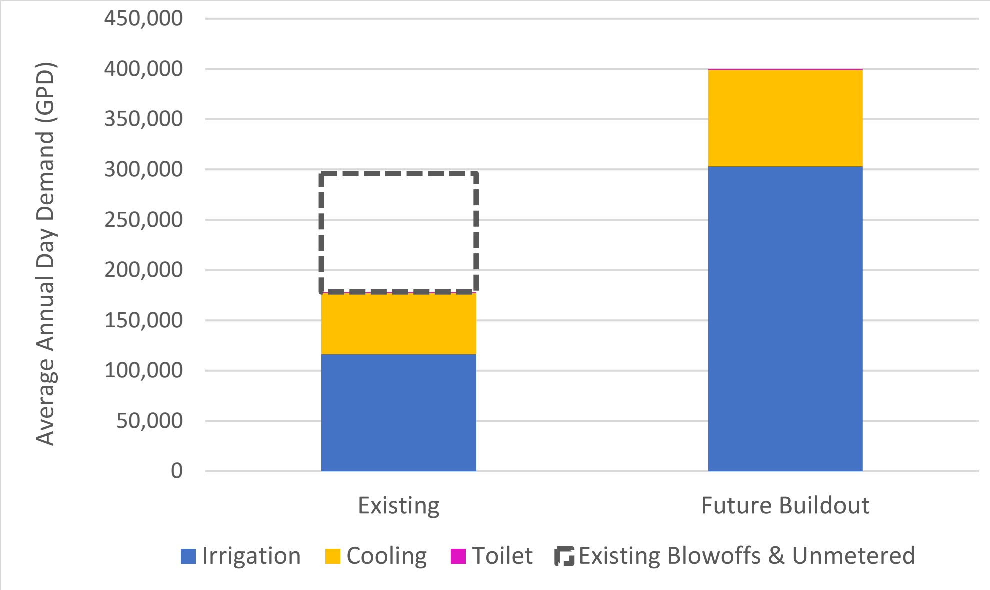


Figure 2-8. Projected Reclaimed Water Demand Growth – West Service Area



Section 3

Hydraulic Model Updates and Evaluation Criteria

The hydraulic evaluation conducted to develop this master plan was performed using a computer model of the reclaimed water distribution system. This section provides a discussion of the evaluation criteria, computer model development, and verification. Hydraulic modeling results for the existing system are also presented.

3.1 General Evaluation Criteria

The evaluation approach discussed in this section focuses on meeting key criteria under projected conditions such as maximum day demands and peak hour demands. The key criteria for evaluation of the adequacy of the reclaimed water system include system pressures, velocity, headloss, and storage requirements. Criteria for modeling of new proposed pipelines are also discussed.

3.1.1 System Pressures

The adequacy of a reclaimed water distribution system is evaluated based on its ability to provide the volume of water required to satisfy the demands of the customers in the service area at adequate system pressures. The Town adopted a Policy Statement 129 which establishes a minimum water supply pressure to be provided through the potable and reclaimed water distribution systems of 40 psi during average and maximum day conditions, and 30 psi during peak hour conditions. Pressures are greater than 120 psi in some portions of the reclaimed water system. Although there are no maximum pressure requirements, the Town requires pressure reducing valves be installed with all connections to the reclaimed water system.

3.1.2 Velocity and Headloss

There are no specific standards for velocity and headloss in reclaimed water distribution systems. Therefore, the guidelines for potable water distribution systems were used in this analysis. For transmission mains, AWWA recommends a maximum design velocity of 10 feet per second (fps), with velocities less than 5 fps as the desirable range. AWWA recommends limiting headloss in transmission mains to 10 ft/1,000 ft with headlosses limited to 3 ft/1,000 ft for pipe sizes greater than 16 inches in diameter. These criteria were considered in the evaluation based on the role of the transmission main and its effectiveness in improving the hydraulics of the system. This analysis was based on a maximum design velocity of 10 fps, with velocities less than 5 fps as the desirable range. The analysis was also based on a maximum headloss of 10 ft/1,000 ft with headloss less than 5 ft/1,000 ft as the desirable range.

3.1.3 Storage Volume Requirements

Storage requirements for the reclaimed water system can be classified as follows:

- **Short-Term (Operating) Storage** – Provided to balance hourly variations in supply and demand that occur daily. Operating storage can also include emergency/reserve storage if the reclaimed water system has uses that can tolerate only brief outages (cooling towers, toilets, industrial customers, etc.). Operating storage is usually provided by steel or concrete tanks (elevated or ground) similar to those used for potable water storage.

- **Long-Term (Seasonal) Storage** – Provided to balance variations between seasonal summer and winter demands, with water produced during periods of low demand stored for an extended period of time (months) for subsequent withdrawal during periods of high demand. Long-term storage is usually provided in reservoirs, lakes, quarries, or surface impoundments.

The minimum supply/demand equalization storage volume requirement is typically determined by comparing the 24-hour diurnal reclaimed water supply pattern on the minimum wastewater flow day with the 24-hour diurnal demand pattern on the maximum reclaimed water demand day. Since the minimum supply of reclaimed water at the NCWRF, SCWRF, and TWWTP all significantly exceed the peak hour demands projected for buildout of the North, South, and West service areas respectively, storage is not required to meet an hourly deficit in supply.

The reliability required in the Town's reclaimed water system is not as great as that required in the potable water system since the potable system may serve as a back-up to customers which need an uninterrupted supply. However, the Town would like to maintain some operating reserve storage within the reclaimed water system. For this master plan, a reserve storage volume equal to 2 hours of max month demand was assumed. Even at buildout, the volume of storage available at the NCWRF, SCWRF, and TWWTP provide greater than the minimum operating reserve storage for the North, South, and West service areas, respectively.

Since the Town's capacity to produce reclaimed water exceeds the buildout demands, seasonal storage was not considered for the scenarios evaluated in this master plan.

3.2 Model Updates

CDM Smith originally developed a hydraulic model of the reclaimed water distribution system using Innovyze InfoWorks WS computer modeling software as part of the 2013 Master Plan. Three distinct model networks were developed – one for the North Cary service area, one for the South Cary service area, and one for the West Cary service area. For this Master Plan Update, the model was converted to Innovyze InfoWater Pro, which is the Town's currently preferred software. Updates to the model network and demands were also made to reflect the condition of the existing reclaimed water systems.

3.2.1 Physical Model

The existing system physical model was updated based on the Town's GIS data. All reclaimed water pipes 3 inches in diameter and greater in the GIS database were modeled, with each pipe characterized in the model by length, diameter, and a Hazen-Williams roughness coefficient (C value) assigned based on the diameter and material of construction of the pipe. The majority of the original reclaimed water pipes in the North and South service areas are ductile iron pipe. The more recently constructed portions of the North and South service areas, as well as the majority of the West service area reclaimed water pipes are PVC.

For future reclaimed water system scenarios, new pipelines were added into the hydraulic model to simulate system extensions and improvements. In general, pipes were located along existing or proposed transportation thoroughfares as identified in *The Cary 2040 Community Plan* adopted in January 2017. Pipes less than 18 inches in diameter are assumed to be polyvinyl chloride pipe (PVC) and are assigned a C value of 140. Pipes 18 inches in diameter and greater are assumed to be ductile iron pipe (DIP) and are assigned a C value of 130. Where possible, pipes were connected to create loops to increase efficiency of the system and provide redundancy.

For hydraulic modeling purposes, nodes are used to represent locations where pipes are connected and locations at which water is withdrawn from the system. The ground elevations were assigned to each node that was added to the model based on Town of Cary topographic contour data (2-foot interval).

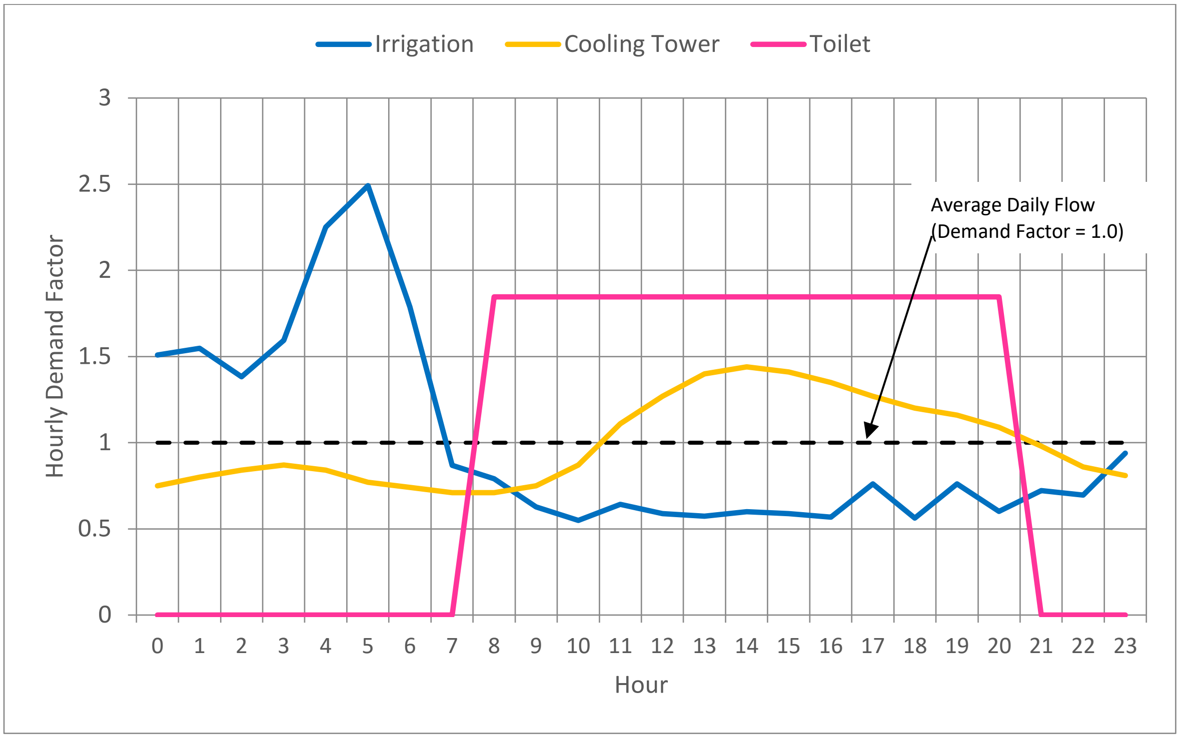
The reclaimed water high service pumps are set to maintain a target discharge pressure to the distribution system. The model operations and discharge pressures at the NCWRF, SCWRF, and delivery point from Durham County were verified with SCADA data for summer 2020.

3.2.2 Demand Allocation

Current and future average annual day demands were developed on an individual meter or parcel basis. These demands were assigned to the nearest pipe in the model, and then allocated to the appropriate node at the pipe end. Peaking factors specific to the reclaimed water end use (as discussed in Section 2) were used in the model to adjust the average annual day water usage to maximum day demand conditions. The unmetered portion of the existing reclaimed water demand was assigned proportionally to the existing blowoff locations since unmetered water is assumed to be primarily attributable to uncertainty in reporting of the blowoff volumes, as discussed in Section 2.1.1. For future scenarios to size new pipes, the blowoffs and unmetered water assigned to the blowoffs were removed from the model.

Diurnal curves representing the hourly variation in demand over a day were input into the model to account for peak hour and minimum hour demand conditions. The generalized diurnal curves for each end use are given in **Figure 3-1** and are based on the demand analysis presented in Section 2. Where existing customer-specific diurnal curves were determined based on analysis of AMI data, those were input into the model for the appropriate customers (see Figure 2-3 and 2-4).

Figure 3-1. Unit Diurnal Reclaimed Water Use Patterns



3.2.3 Model Verification

Once the model was converted to InfoWater Pro software, the updated model was run and results compared to the previous model version to verify consistent results.

In addition, the model was verified to SCADA pressure data from the high service pump discharge at the NCWRF and SCWRF and the pressure at the meter from Durham County for the West service area.

3.3 Existing System Evaluation

3.3.1 Hydraulic Evaluation

The existing reclaimed water system was evaluated under current maximum day demand conditions using the updated hydraulic model. An extended period simulation (EPS) was performed and the resulting pressures are shown on **Figure 3-2** for the North, South, and West Cary distribution systems. The existing system meets all pressure, velocity, and headloss criteria presented in Section 3.1.

Future scenario evaluation is presented in Section 4.

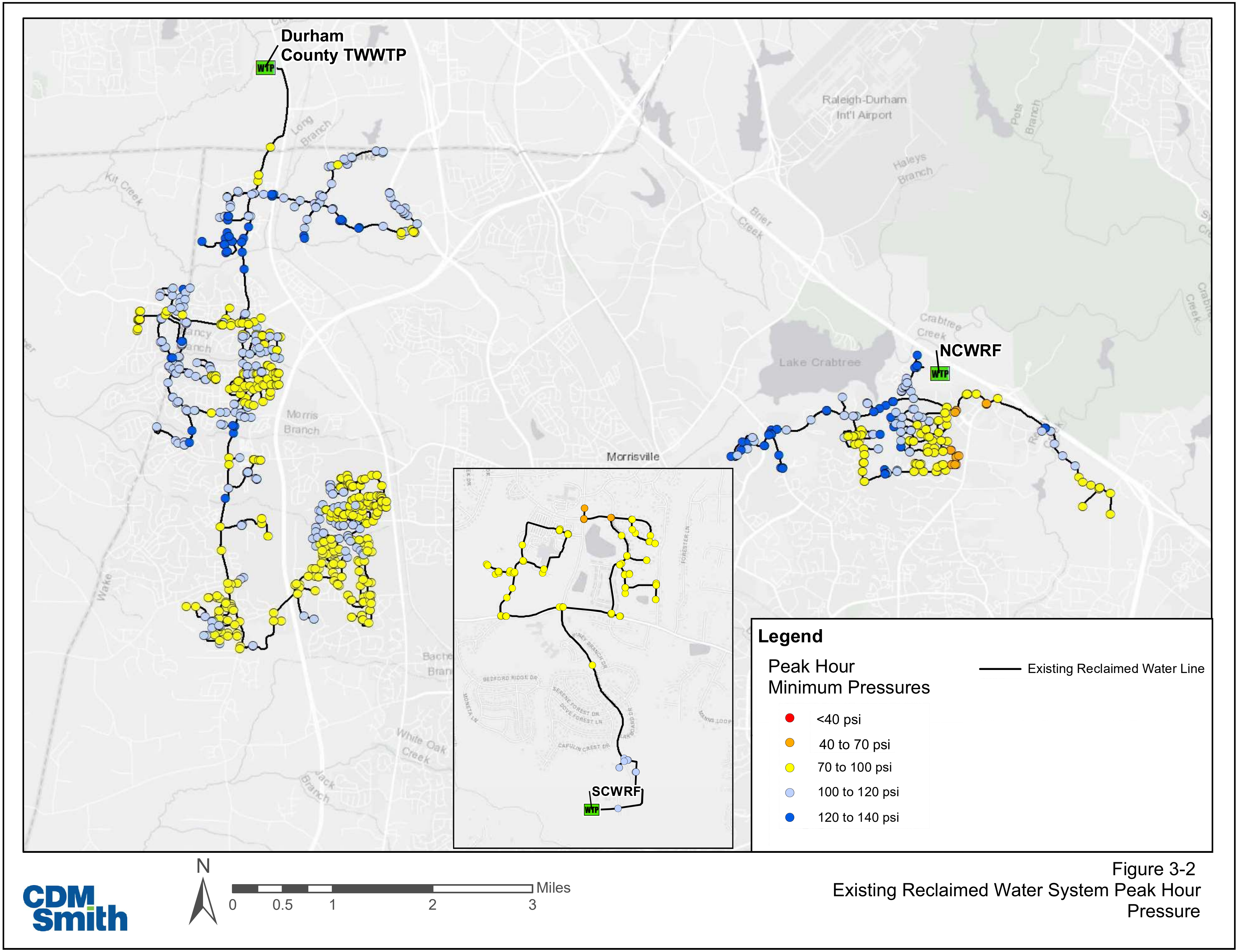


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Figure 3-2
Existing Reclaimed Water System Peak Hour Pressure

3.3.2 Water Age Evaluation

Blowoffs and associated unmetered water accounts for approximately 40 to 60 percent of the reclaimed water pumped to the Town's distribution systems. The blowoffs are performed at the extremities of the distribution system to maintain the target chlorine residual of at least 0.5 mg/L at sampling points in the distribution system. To determine the impact of the blowoffs, water age model simulations were run with and without the blowoff flows.

The water age simulations were run for a duration of 20 days at a 1-hour hydraulic time step to reach equilibrium. The average water age at each model node was determined using the final 24 hours of the model simulation. Average water age represents the travel time from the water source through the system. Dead-end nodes that had no demand associated with them were excluded from the analysis since the travel time at these locations is not accurately represented in the model.

Figure 3-3 shows the impact of blowoffs in the North service area. In general, for AAD demands, the blowoffs reduce average water age to less than 3 days in all but a few small areas.

Figure 3-4 shows the impact of blowoffs in the South service area. In general, for AAD demands, the blowoffs reduce average water age to less than 3 days in all but a dead-end area.

Figure 3-5 shows the impact of blowoffs in the West service area. For AAD demands, the blowoffs reduce average water age to less than 5 days along the 16-inch diameter main on Green Level Church Road. However, there are significant areas, including the Carpenter Village area that still have water age in excess of 10 days due to low usage of the reclaimed water system.

Total chlorine sampling data was obtained for sample sites in the West service area for March 2020 (after the annual reclaimed water holiday) through January 2021. The sample sites and corresponding water age are shown in **Figure 3-6**. A plot of total chlorine data at the sample sites is given in **Figure 3-7**. The figures show a general trend of decreasing chlorine residual with increasing water age. The chlorine at the Wake/Durham County line is generally highest, with the sites furthest from the TWWTP (413 Mills Park and 170 Brooks Park) generally with the lowest chlorine. The site with the highest water age (approximately 5 days) at 170 Brooks Park still shows a chlorine residual of the target 0.5 mg/L or greater. Based on this data, a target water age of 5 days or less is established to maintain the desired chlorine residual for the future evaluations.

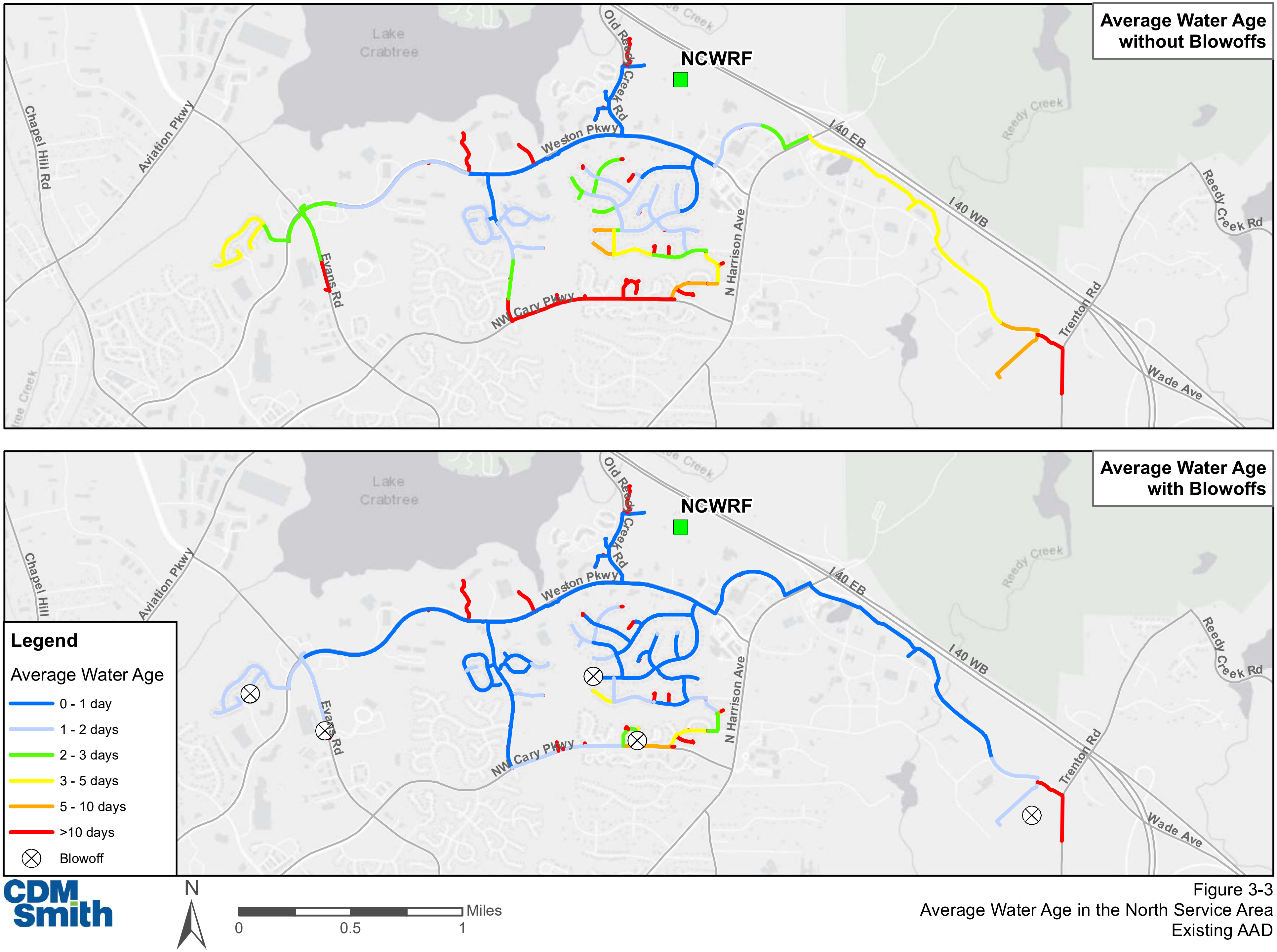

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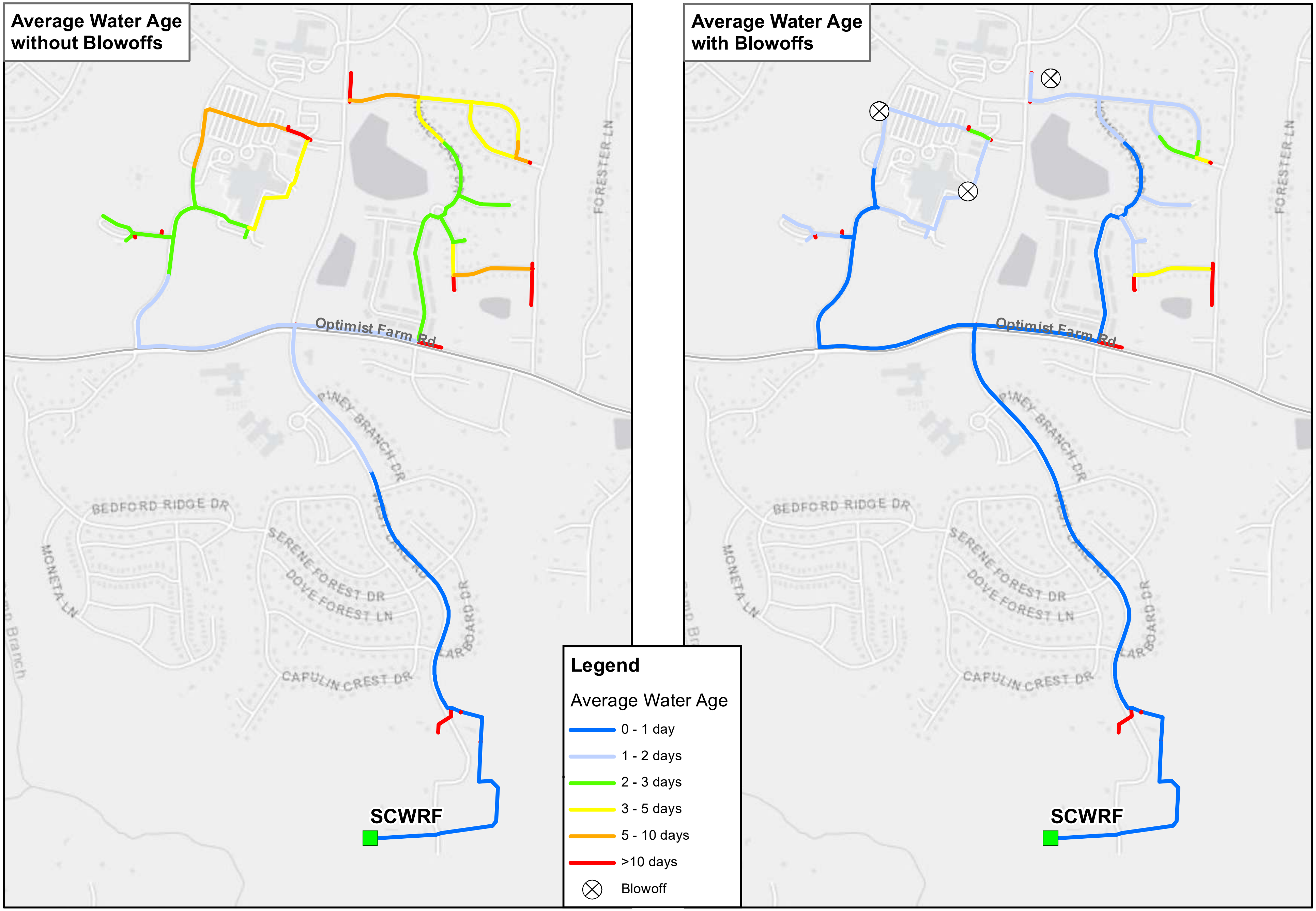
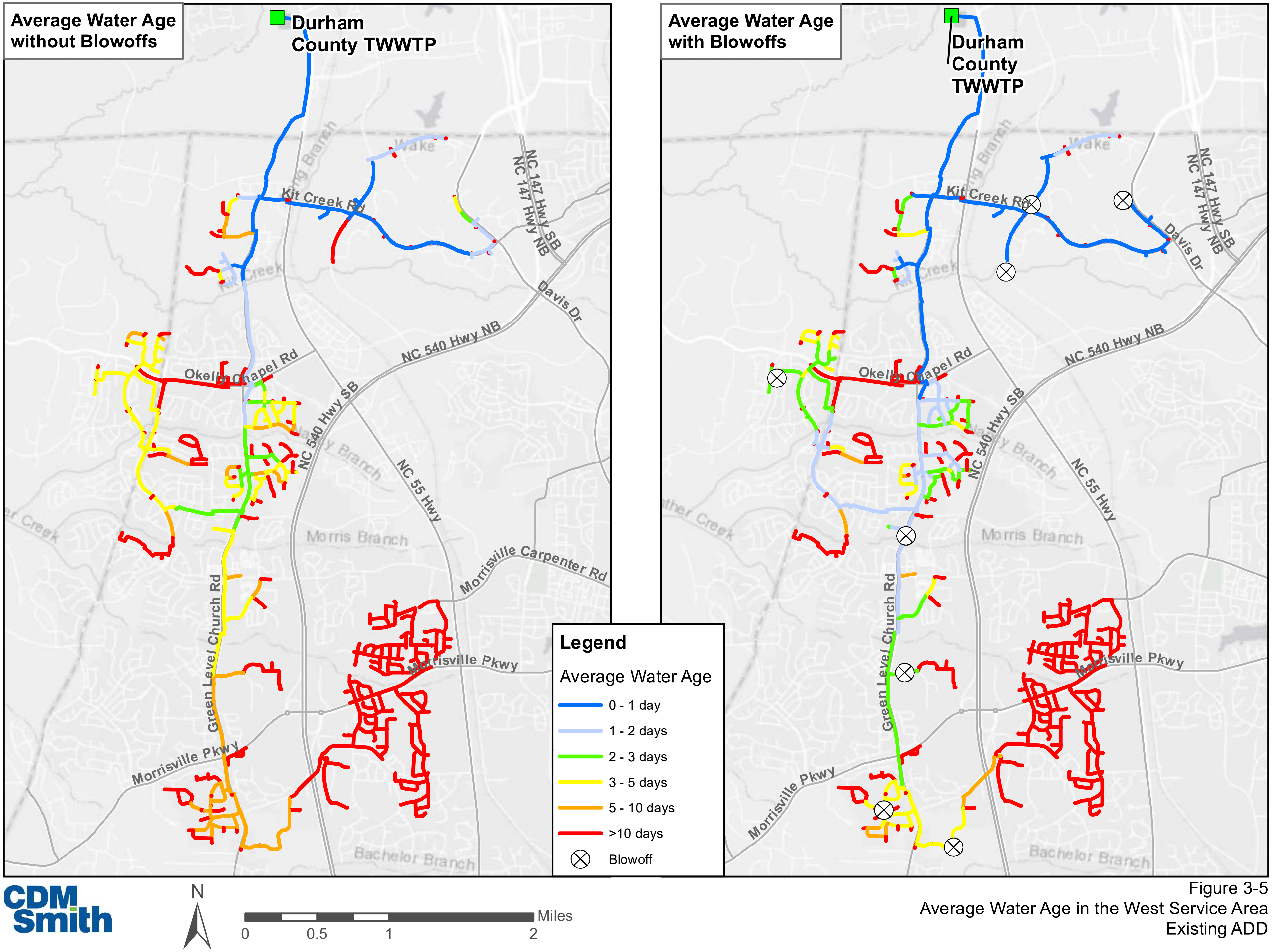
Figure 3-3
Average Water Age in the North Service Area
Existing AAD



CDM Smith

Figure 3-4
Average Water Age in the South Service Area
Existing ADD



CDM Smith

Figure 3-5
Average Water Age in the West Service Area
Existing ADD

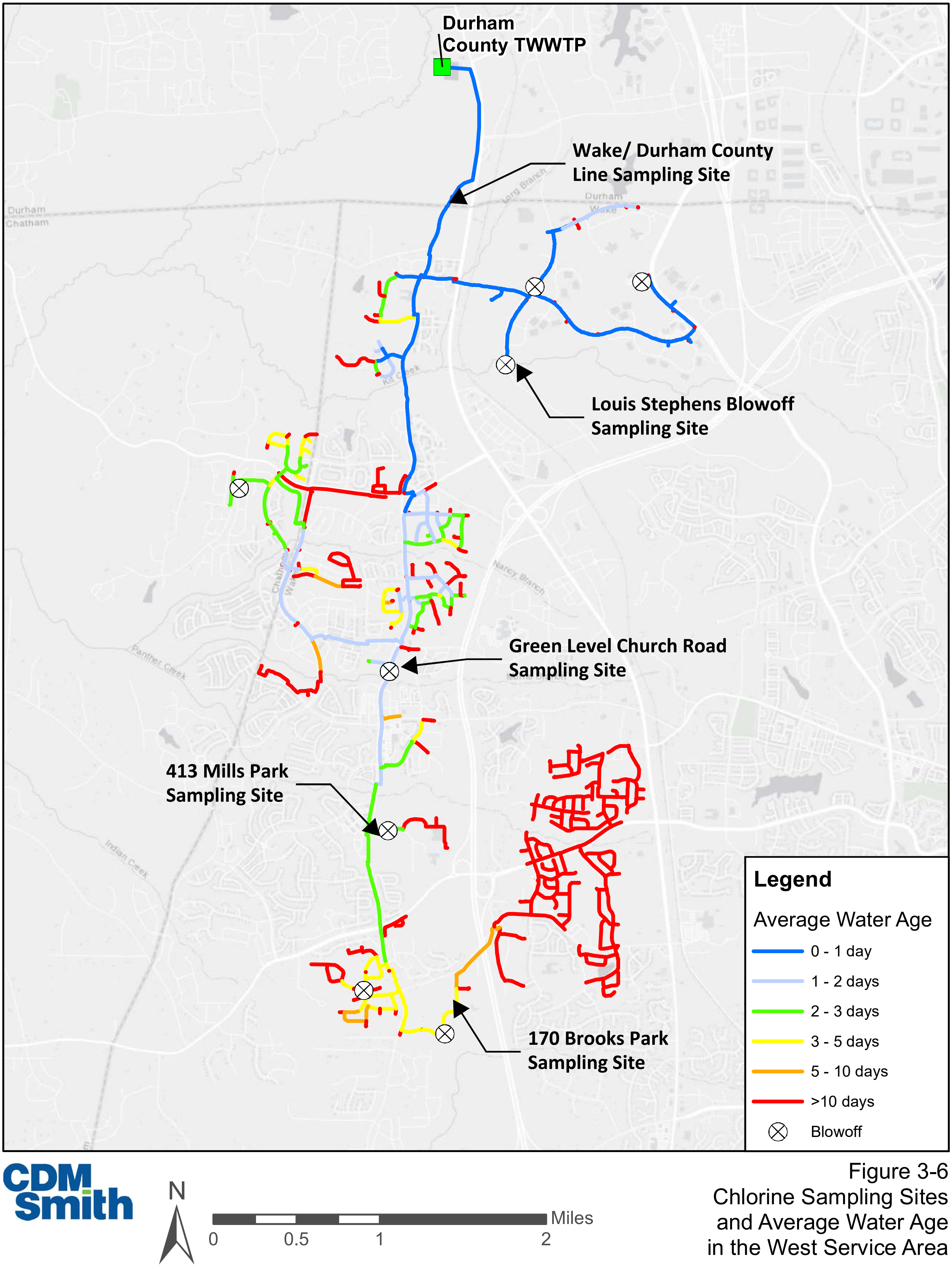


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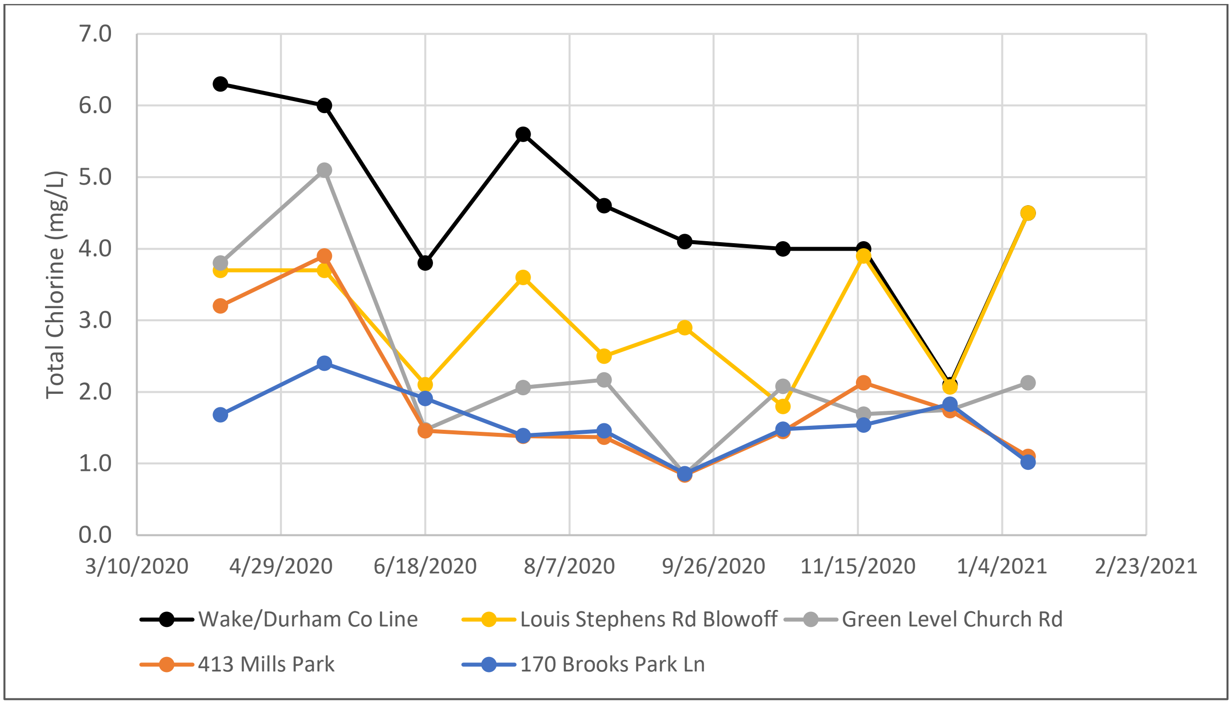
Figure 3-6
Chlorine Sampling Sites
and Average Water Age
in the West Service Area

Figure 3-7. Total chlorine sampling data over time at locations shown in Figure 3-6



Section 4

Future Reclaimed Water Alternatives Evaluation

Based on review of the reclaimed water demand projections and discussions with Town staff, alternatives were established for evaluation of the future reclaimed water system expansion. The alternatives primarily focus on improving operations of the system as expansion occurs and right-sizing pipes for the updated demand projections. The evaluation was conducted with the following approach:

1. **Develop Base Scenario -** As a first step, skeletonized improvements, including reclaimed water pipes required to serve future demands, were routed and sized to meet the minimum evaluation criteria for the buildout (2060) planning year. This serves as the base scenario for optimizing the improvements to meet water age or other criteria.

   Pipes are routed along existing or proposed roadways to the edge of the parcel with proposed development. Pipes are sized for the future customer demands only without blowoff to avoid oversizing pipes and exacerbating water quality issues. Since the existing pipes were sized based on assumptions of much higher ultimate demand on the system, in some cases, this results in a smaller new pipe adjacent to a larger diameter existing pipe.

2. **Optimize Future Improvements for Water Age -** Water age or travel time analysis represents a cursory analysis to flag potential water quality issues. Water age is a primary factor that influences a system's ability to maintain disinfection residuals. As water age increases, disinfection residual tends to decrease. The Town of Cary targets a chlorine residual of 0.5 mg/L or greater which corresponds to an average water age of 5 days or less as illustrated in Section 3.

   Optimal pipe sizes for buildout are chosen based on evaluating the impact to average water age with minimum pipe size to meet hydraulic criteria (from the base scenario) versus sizing with consistent upstream/downstream pipes. Looping was also evaluated to reduce water age in specific areas. Where water age still exceeds the target of 5 days, blowoff locations are evaluated and recommended to reduce water age.

3. **Identify Oversized Existing Pipes along NCDOT Roads -** Since the existing pipes were sized based on assumptions of much higher ultimate demand on the system, some existing pipes may be oversized for the projected buildout demands. Evaluation was performed to see if existing reclaimed water pipes that are located along a North Carolina Department of Transportation (NCDOT) route could be downsized in coordination with a future road project to improve water age.

The evaluation of the alternatives and results are discussed in the following sections for the West, North, and South service areas. Recommendations were categorized as infrastructure improvements, operational improvements, and NCDOT-coordination-related improvements.

4.1 West Service Area

The West service area is the Town's largest reclaimed water service area with the most potential for growth. This service area also has the highest water age due to some neighborhoods with low demands. Results of the base scenario and optimized scenario for future water age (including NCDOT-coordination-related improvements) are presented in the following subsections. In addition, several specific alternatives were evaluated for the West service area only. These include:

- Optimize Blowoffs for Existing Demands
- Apple Campus Demand Sensitivity – Perform sensitivity analysis to determine maximum demand that could be served to the proposed Apple campus in near-term
- Booster Chlorination – Conceptual feasibility evaluation to determine if booster chlorination might be an option for improving water quality in the West service area since this service area has the greatest distance from the reclaimed water source to the end of the distribution system

Figure 4-1 shows the location and relative amount of demand at buildout of the West service area. The purple circles indicate existing reclaimed water demands. The blue circles indicate existing customers that are served by a reclaimed water line that is currently connected to the potable water system but will be converted to the reclaimed water system in the future. The green circles indicate demand from future development of parcels. The dotted lines indicate where new reclaimed water pipes will be required to meet buildout demands. The reclaimed water pipes that are currently on the potable water system but will be converted once the reclaimed water system expands are shown as blue pipes on Figure 4-1.

4.1.1 Base Scenario

Figure 4-2(a) and Table 4-1 summarize the proposed size of the new reclaimed water pipes for the base scenario. Pressures, velocities, and headloss are all within the minimum evaluation criteria discussed in Section 3. The base scenario includes several areas of inconsistent pipe sizing where new smaller pipes are recommended between larger existing pipes.

No upsizing of existing pipes is required in the West service area to meet buildout demands. The buildout peak hour demand is 2.2 mgd (without blowoff). The peak hour supply contractually available to the Town from the TWWTP is 3.6 mgd, therefore additional supply capacity or pumping is not needed in the future. Due to the already high water age in the system and the adequacy of the existing facilities to meet peak future demands, additional distribution system storage is not recommended in the West service area.

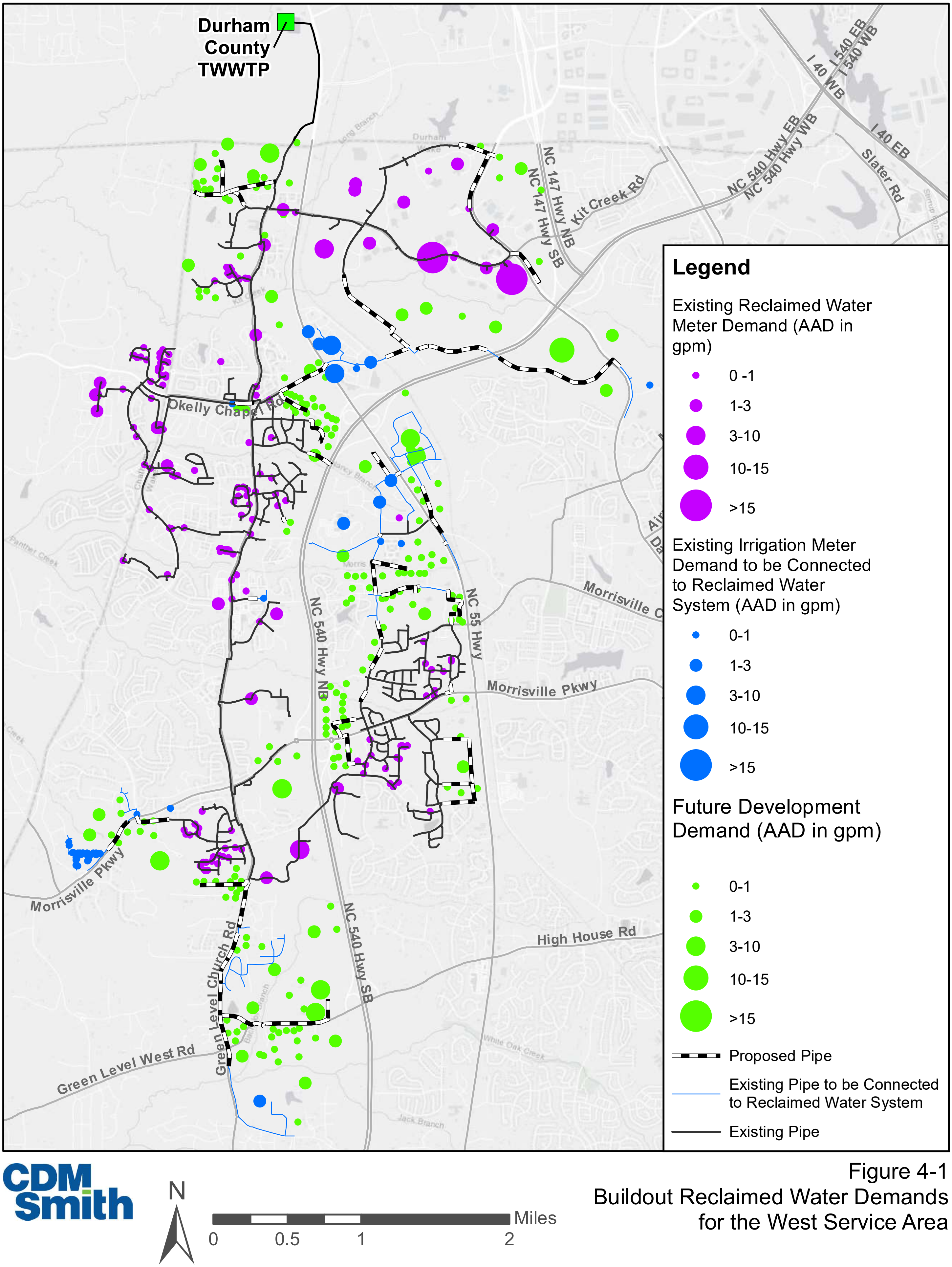


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Figure 4-1
Buildout Reclaimed Water Demands for the West Service Area

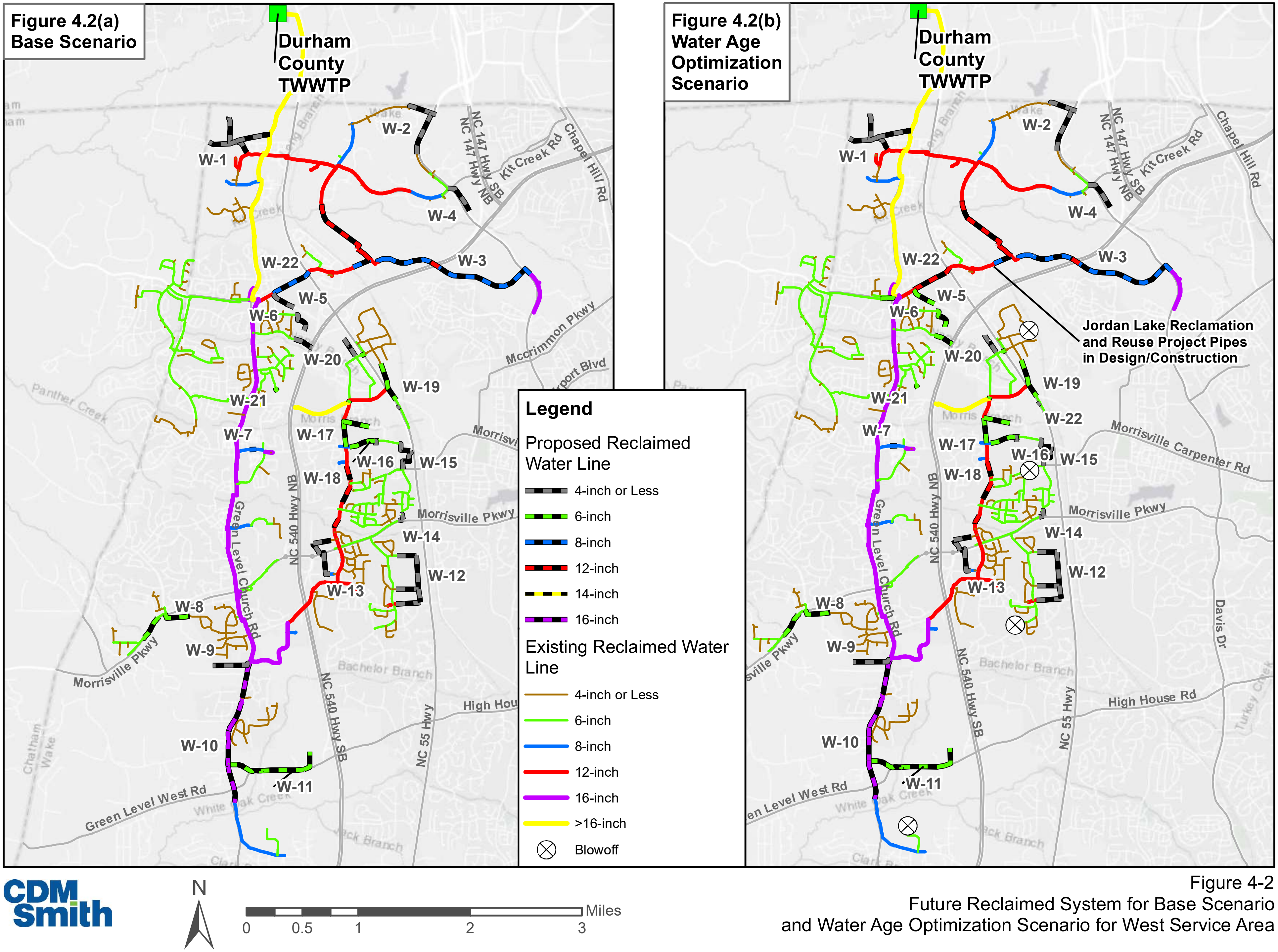

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Figure 4-2
Future Reclaimed System for Base Scenario
and Water Age Optimization Scenario for West Service Area

Table 4-1. Base Scenario Pipe Size for the West Service Area

Diameter	Proposed Pipe Length (ft)
4-inch	28,300
6-inch	14,000
8-inch	10,700
12-inch	6,200
16-inch	700
Total	**59,900**

4.1.2 Future Water Age Optimization

Neighborhoods in the extremities of the existing system are currently experiencing average water age that exceeds 5 days for AAD. Even with the existing flushing, the neighborhoods east of I-540 are still experiencing older water due to low demand (**Figure 4-3(a)**). As demands increase in the future, the water age along the main pipeline improves, however the neighborhoods east of I-540 and a few isolated neighborhoods west of the main pipeline are still older than 5 days for the future base scenario (without flushing) as illustrated in **Figure 4-3(b)**.

While the base scenario met the evaluation criteria for minimum pressure, headloss, and velocities, it did not address water age and also included instances of inconsistent pipe sizes between upstream/downstream pipes. Hydraulic model simulations were performed to optimize pipe sizing, looping and blowoffs for buildout of the West service area while minimizing water age. If larger sized pipes consistent with upstream/downstream existing pipes did not contribute to excessive water age, the preference is to keep consistent sizing. An average water age of less than 5 days is targeted for the majority of the system, excluding small dead-end mains.

Optimizing Pipe Sizes

Based on the water age analysis results, optimized pipe sizes that differ from the base scenario include:

- W-5 – Increasing the proposed connection pipeline along O'Kelly Chapel Road between Alston Avenue and NC 55 Hwy from an 8-inch to a 12-inch diameter provided consistent pipe sizing and decreased average water age to less than 5 days.
- W-6– Increasing the proposed pipe size from 4-inch to 6-inch diameter provided consistent pipe sizing with the existing upstream reclaimed water pipes while maintaining an average water age of less than 5 days.
- W-14 and W-15 – Increasing the proposed pipe size from 4-inch to 6-inch diameter provided consistent pipe sizing to complete a loop and also helps to slightly decrease water age.

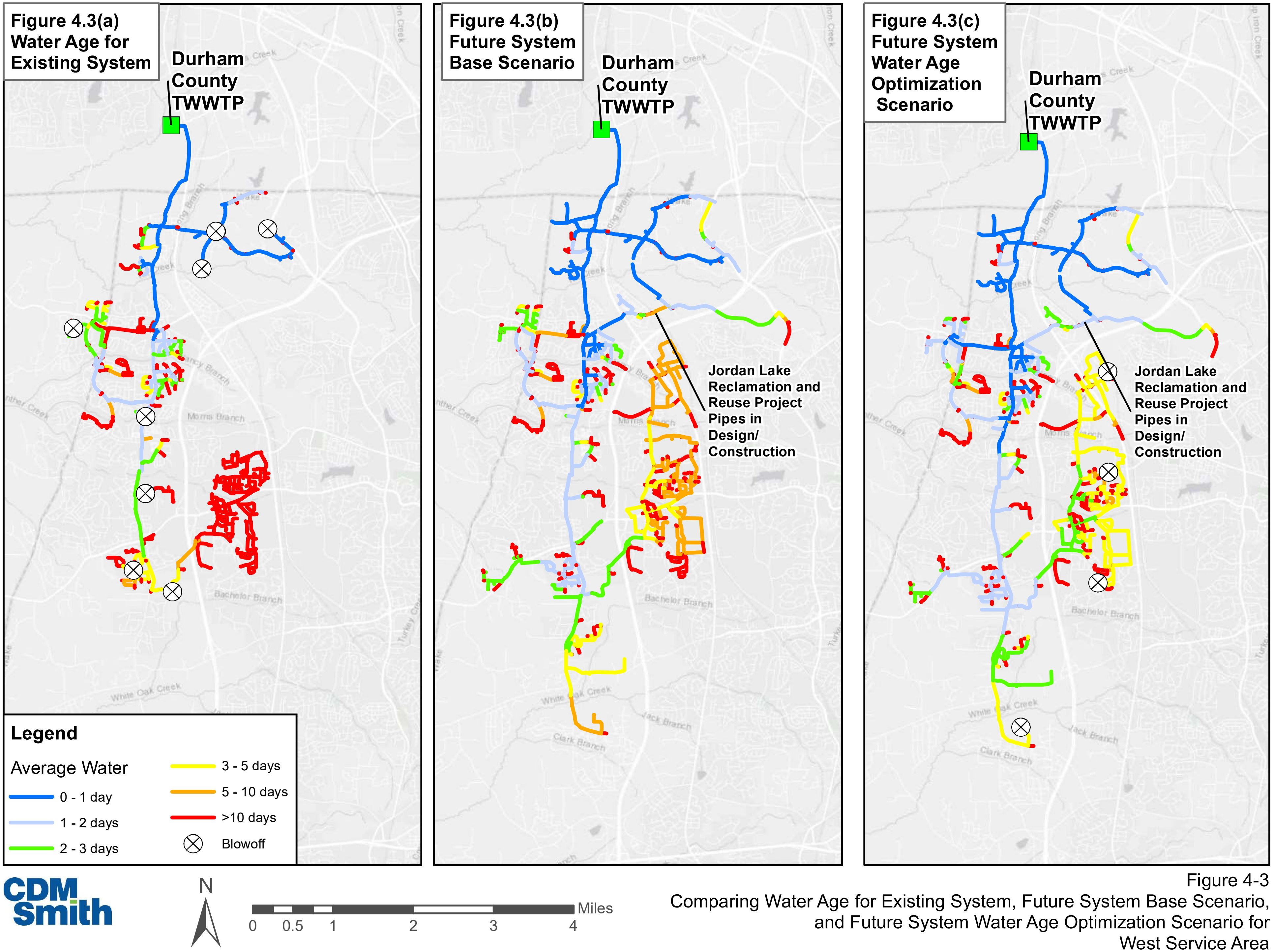

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Figure 4-3
Comparing Water Age for Existing System, Future System Base Scenario, and Future System Water Age Optimization Scenario for West Service Area

Looping

The following neighborhoods with high water age were investigated for looping improvements:

- O'Kelly Chapel Road, west of the main pipeline on Green Level Church Road
- Catalina Grande Avenue
- East of I-540

Initial model results showed high water age (>10 days) on the dead end along O'Kelly Chapel Road, west of the main pipeline on Green Level Church Road. Adding a connecting pipeline (W-Loop1) to the main pipeline on Green Level Church Road improved water age on O'Kelly Chapel Road from 11 days to less than 1 day.

While a loop was investigated to connect Catalina Grande Ave to Yates Store Road to improve water age in a dead-end neighborhood located in the western portion of the service area, the addition of this loop caused the water age to increase along O'Kelly Chapel Road and was therefore not recommended.

Even with higher demands projected in the area east of I-540, the average water age remains above 5 days. Two options for looping were considered along the following roads:

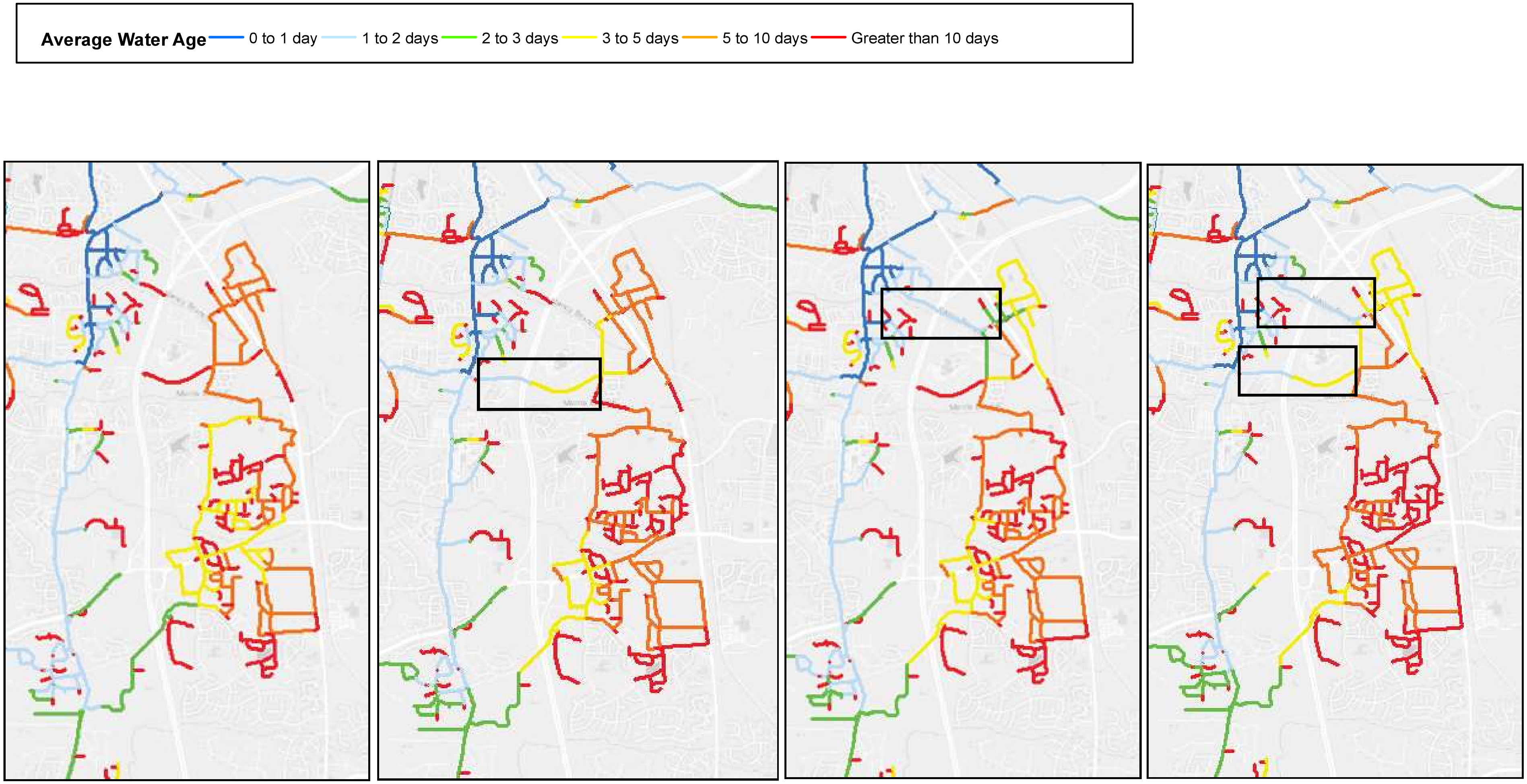
- McCrimmon Pkwy
- NCDOT Proposed Throughfare from Hortons Creek Road to Highcroft Drive

Figure 4-4 presents the improvement in water age for the various looping options under I-540. Even with looping there are still neighborhoods with old water that would require flushing. Looping improves water age in the neighborhood north of McCrimmon Parkway but moves the areas of concern with higher water age to the south. Therefore, looping does not decrease overall water age or eliminate areas with water age greater than 5 days. Due to cost associated with a pipeline under I-540, a new looping is not currently recommended unless it can be coordinated with a NCDOT project in the future.

Future Blowoffs

Figure 4-4 illustrated that, for the buildout of the West service area, looping alone will not improve the water age to less than 5 days for the area east of I-540. Instead of looping, flushers are recommended in three locations east of I-540 once the system is built-out: Mahal Avenue, Indian Wells Road near Ansley Stream Lane, and Sears Farm Road/Cozy Oak Lane.

Project W-10 includes converting an existing 16-inch wastewater force main into a reclaimed water main. Because the recommendation from the Town is to use this force main and not slipline to reduce diameter, an additional flusher is recommended at Green Level High School to improve water age at the end of Green Level Road. Flushing approximately 10,000 gallons per day at each location reduces the water age to less than 5 days for most pipes with the exception of a few dead-end pipes.



Water Age - No Looping

Water Age - Looping along McKimmon Parkway

Water Age - Looping along Proposed Throughfare

Water Age - Looping at Both I-540 Crossings

Figure 4-4
West Service Area
Average Water Age Comparison for Looping Options in Neighborhoods West of I-540

Recommendations

Implementing the infrastructure and operational improvements outlined below and shown in Figure 4-2(b) resulted in an improved water age at buildout of the West service area. A comparison of water age between the base scenario and optimized scenario is shown in Figure 4-3.

- Infrastructure Improvements – Approximately 11.8 miles of new 4-inch through 16-inch diameter reclaimed water pipes to connect existing reclaimed water lines and serve additional properties. In addition to the reclaimed water pipes recommended in the base scenario, a 6-inch new reclaimed water pipe looping project was recommended to improve water age. **Table 4-2** summarizes the recommended size of the reclaimed water pipes for optimization of water age in the West service area.
- Operational Improvements – Flushing a total of 30,000 gpd split across three locations in the area east of I-540, and an additional 10,000 gpd at Green Level High School.
- NCDOT Coordination – There are no potential NCDOT coordination projects recommended at this time. Downsizing of existing pipes along NCDOT roadways in the West service area does not eliminate the need for flushing or provide significant improvements to water age.

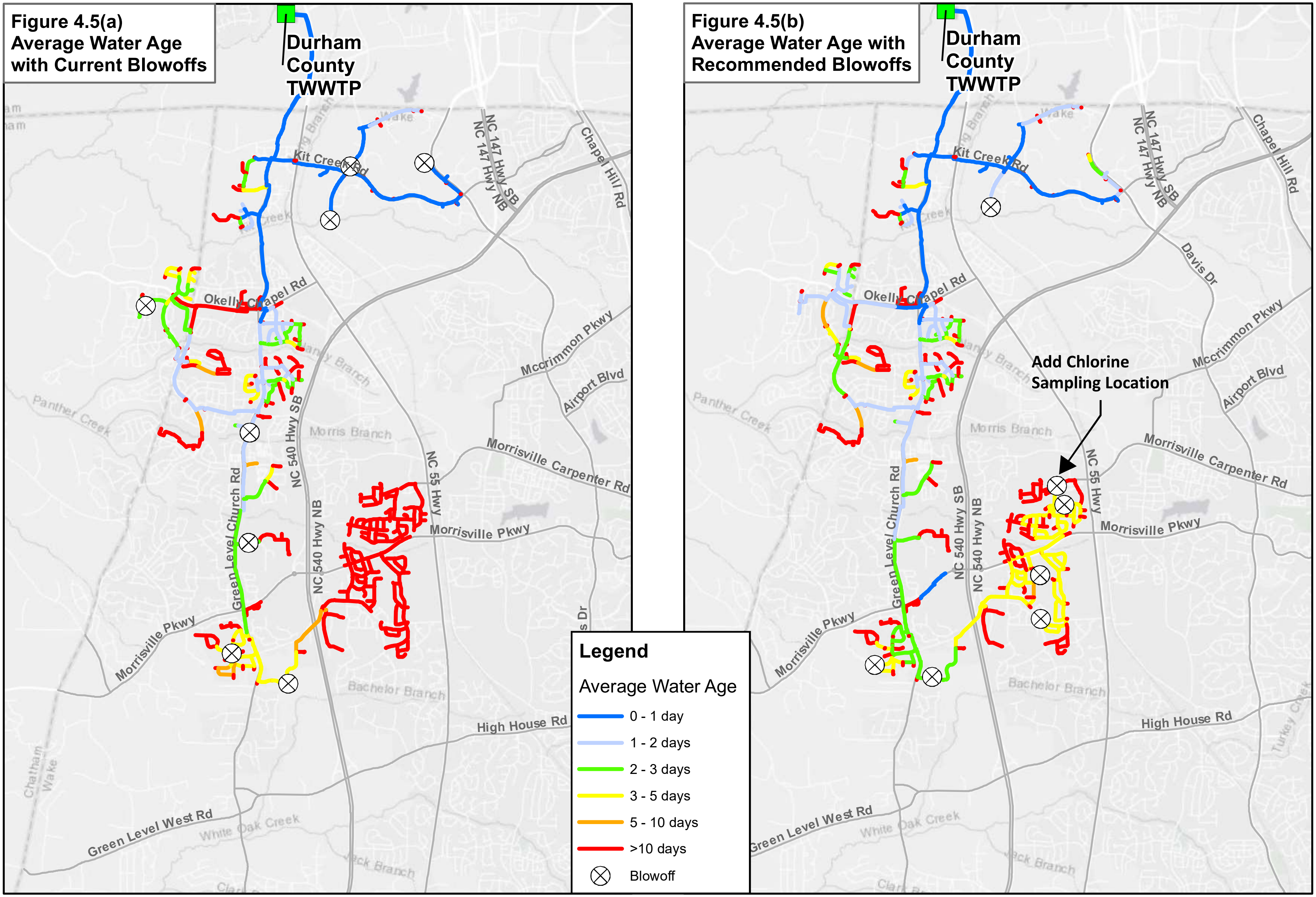
Table 4-2. Recommended Pipe Size for the West Service Area (Water Age Optimization Scenario)

Diameter	Proposed Pipe Length (ft)
4-inch	22,800
6-inch	20,200
8-inch	8,700
12-inch	8,300
16-inch	700
Total	**60,700**

4.1.3 Existing Water Age Optimization

In the West Service area, blowoffs and associated unmetered water accounts for approximately 40 percent of the existing reclaimed water pumped to the Town's distribution system. The blowoffs are performed at the extremities of the distribution system to maintain the target chlorine residual of at least 0.5 mg/L at sampling points in the distribution system. To determine the impact of the blowoffs, water age model simulations were run varying the location and quantities of the blowoffs.

Figure 4-5(a) shows the impact of the current flushing in the West service area. For AAD demands, the flushing at blowoffs reduces average water age to less than 5 days along the 16-inch diameter main on Green Level Church Road. However, there are significant areas, including the Carpenter Village area that still have water age in excess of 10 days due to low usage of the reclaimed water system. For this reason, an alternative was evaluated to optimize the location and quantity of flushing for the West Service area during existing AAD. **Figure 4-5(b)** shows the impact of the recommended flushing. The location and approximate quantity of the recommended flushing for the existing system is outlined below:



N

0 0.5 1 2 3 Miles

Figure 4-5
Average Water Age for Current and Recommended Blowoffs for West Service Area during AAD

- Louis Stephens Drive – 4,000 gpd
- Green Hope Church Road – 5,000 gpd
- Thomas Brooks Park – maintain current flushing rate at 32,000 gpd
- Place the following 4 flushers in the neighborhood east of I-540:
  - Corner of Green Hope School Road/Sears Farm Road – 15,000 gpd
  - Sienna Hill Place – 4,000 gpd
  - Hayes Hill Place – 15,000 gpd
  - Indian Wells Road – 15,000 gpd

The recommended flushing rates listed above will reduce the overall blowoff quantity by approximately 25 percent. When comparing Figures 4-5(a) and 4-5(b) the following operational and infrastructure are recommended:

- Remove two of the blowoffs in the vicinity of Kit Creek Road and Louis Stephens Drive that are near the Cisco Cooling Tower and Credit Suisse users. Based on water age simulations these flushers are not needed.
- Reduce the blowoff rate at the end of Louis Stephens Drive. In addition, if the Apple Campus is built and uses reclaimed water, the need for flushing along Louis Stephens Road should be re-evaluated in the future.
- Remove the following flushers: Abbey View Way (in the neighborhood west of Green Valley Church Road), 10304 Green Level Church Road, and Mills Park Drive. Based on water age simulation, these flushers are not needed.
- In the near-term, construct W-Loop1 to improve water age to less than 2 days along O'Kelly Chapel Road.
- Move and increase the flushing rate for the flusher in the neighborhood south of Morrisville Parkway and west of Green Level Church Road to the end of Green Hope School Road.
- Place four new flushers in the neighborhood east of I-540 to improve water age in the Carpenter Village area.

In addition to modifying the current blowoff locations, it is recommended that a chlorine sampling location be added in the area of highest water age east of I-540, on Indian Wells Road, to monitor disinfectant residuals in this area. Existing chlorine sampling locations are shown on Figure 3-6 and the recommended additional location is shown on Figure 4-5(b).

4.1.4 Apple Campus Demand Sensitivity

After North Carolina offered a large job grant, Apple announced it would be investing $552 million to create a new campus in the Research Triangle Park located off Louis Stephens Drive and Little Drive. The new campus is proposed to include 1 million square feet run entirely by renewable energy. As part of the job grant requirements, Apple must hire a minimum of 126 workers in 2023, increasing to 1,350 employees in 2026 and 2,700 in 2032(1). Due to the potential for high reclaimed water use, the Town wanted to know the maximum amount of reclaimed water that could be provided to the campus. **Figure 4-6** shows the location of the future Apple campus in blue as well as the reclaimed water pipes to serve this area. The campus will be located in the RTP where a proposed reclaimed pipeline is currently in design/construction as part of the Jordan Lake Reclamation and Reuse project (W-3). No additional proposed pipeline projects outlined in this memo would be required prior to serving the Apple Campus.

EPS model runs were performed to determine the maximum supply that could be provided while maintaining the minimum hydraulic criteria in the 8-inch pipe along Little Drive that would be the limiting pipeline. The demands modeled for this scenario included the following:

- Existing system MDD for the West service area (666,000 gpd)
- Buildout MDD from the Town's reclaimed water projections for the parcels in blue in Figure 4-6 as well as the parcels along Davis Drive that will be served through the proposed W-3 pipeline (99,500 gpd)

Based on modeling with demands presented above, an additional 468,000 gpd could be served to the location of the Apple Campus on a maximum day. This would correspond to a peak hour reclaimed water demand of up to 455 gpm. For comparison, the projected future MDD through pipe W-3 without the Apple Campus is 99,500 gpd, with a peak hour demand of 73 gpm.

4.1.5 Booster Disinfection

Booster disinfection was discussed as a potential alternative to improve water quality in sections of the West service area with high water age. Since the reclaimed water system does not have any in-system storage, adding booster disinfection would generally require identifying a site along the reclaimed water line that is appropriate for a storage shed to house sodium hypochlorite storage and feed equipment, piping and appurtenances. The space would require heating and ventilation. In addition, process monitoring and a static mixer would be required to mix the sodium hypochlorite solution in the existing pipeline.

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[1] Stradling, R. & Eanes, Zachery. (2021, June 22). After Apple picked Austin, NC sweetened its offer to the company records show. *The News & Observer*. Retrieved from https://www.newsobserver.com/article252282568.html

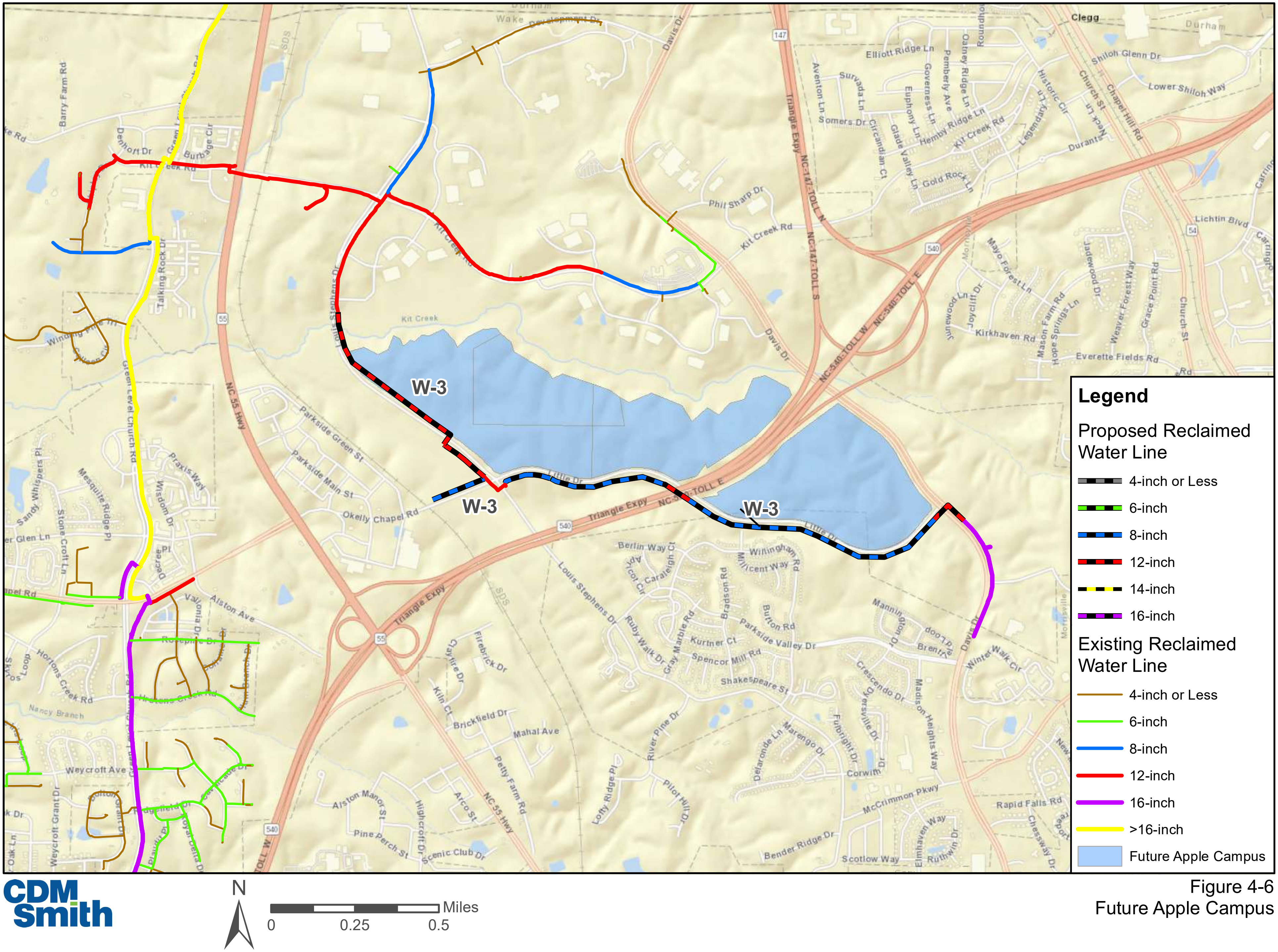

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Figure 4-6
Future Apple Campus

The following are considerations for booster disinfection in the West service area:

- In general, booster disinfection stations should be located in areas of high water age and low disinfectant residuals. Data from the chlorine sample sites in the West service area presented in Figures 3-6 and 3-7 show a total chlorine residual of at least 0.5 mg/L (the minimum target for the reclaimed water system) at all sampling locations, with some locations closer to the TWWTP showing total chlorine residual of up to 4.0 mg/L or higher. Durham County is contractually obligated to provide a chlorine residual of at least 2.0 mg/L at the entry point to Cary's system at the county line. Based on available data, booster disinfection would not be recommended upstream of the sample sites in Figure 3-6 with the current flushing operations.
- Chlorine sampling should be performed in the areas of highest water age east of I-540 to confirm low disinfectant residuals in these areas. Evaluate if moving flushing to the extremity of the system helps increase disinfectant residual in these areas.
- If flushing were discontinued, the average water age in the portion of the service area beyond the intersection of Green Level Church Road and Mill Park Drive is increased to 5 days or more (Figure 3-5). The high water age is related to lack of demand on the southern portion of the system. A booster station at this location would increase disinfectant residual, however the boosted chlorine residual would still dissipate over time with low usage on the system. Therefore, flushing would still be required to move water through the system after booster disinfection.
- Dosing of sodium hypochlorite in the distribution system would need to be closely monitored as the presence of residual organic nitrogen and dissolved organic carbon in the reclaimed water exert chlorine demand and form organic chloramines. Bench-scale testing would need to be conducted to determine disinfectant demand and disinfectant decay curves along with evaluating the effect of seasonal variation on both.

Based on the above considerations, booster disinfection is not recommended at this time for the West service area.

4.2 North Service Area

The North service area has potential for expansion to the northwest and southeast. **Figure 4-7** shows the location and relative amount of demand at buildout of the North service area. The purple circles indicate existing reclaimed water demands. The blue circles indicate existing customers that are served by a reclaimed water line that is currently connected to the potable water system but will be converted to the reclaimed water system in the future. The green circles indicate demand from future development of parcels. The dotted lines indicate where new reclaimed water pipes will be required to meet buildout demands. The reclaimed water pipes that are currently on the potable water system but will be converted once the reclaimed water system expands, are shown as blue pipes on Figure 4-7.

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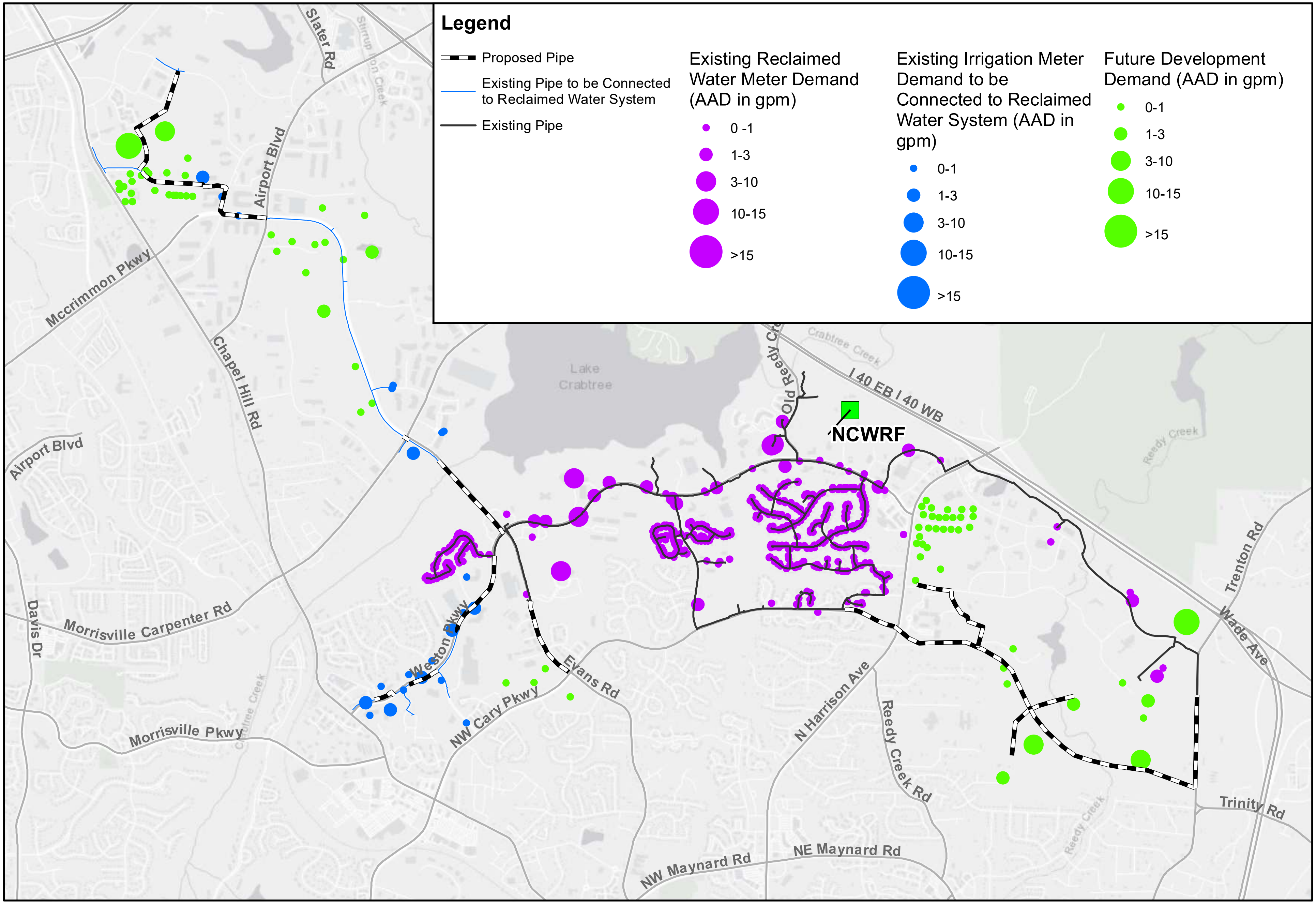

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N

0 0.5 1 Miles

Figure 4-7
Buildout Demands for the North Service Area

4.2.1 Base Scenario

Figure 4-8(a) and Table 4-3 summarize the proposed size of the new reclaimed water pipes for the base scenario to meet the minimum pressures, velocities, and headloss evaluation criteria discussed in Section 3.

Table 4-3. Base Scenario Pipe Size for the North Service Area

Diameter	Proposed Pipe Length (ft)
4-inch	4,700
6-inch	27,300
12-inch	2,700
Total	**34,700**

No upsizing of existing pipes is required in the North service area to meet buildout demands. The buildout peak hour demand is 1.5 mgd (without blowoff). The existing pumping capacity at the NCWRF is 8.3 mgd, therefore additional supply capacity or pumping is not needed in the future. Due to the already high water age in the system and the adequacy of the existing facilities to meet peak future demands, additional distribution system storage is not recommended in the North service area.

4.2.2 Future Water Age Optimization

In the North service area, only the extremities of the system are experiencing average water age that exceeds 5 days. These areas include: the pipe serving SAS, the pipe along Evans Road, and the pipes along NW Cary Parkway. Existing flushing provides improvement in water age for all of these areas, as shown in **Figure 4-9(a)**. As demands increase in the future, the majority of average water age remains below the 5-day target value with only a section along SAS loop, a small section along NW Cary Parkway and the far extremity of the system on Weston Parkway having average water age greater than 5 days (without flushing) as seen in **Figure 4-9(b)**.

While the base scenario met the evaluation criteria for minimum pressure, headloss, and velocities, it did not address water age and recommended several instances of inconsistent pipe sizes between upstream/downstream pipes. Hydraulic model simulations were performed to optimize pipe sizing, looping and blowoffs for buildout of the North service area while minimizing water age. If larger sized pipes consistent with upstream/downstream existing pipes did not contribute to excessive water age, the preference is to keep consistent sizing.

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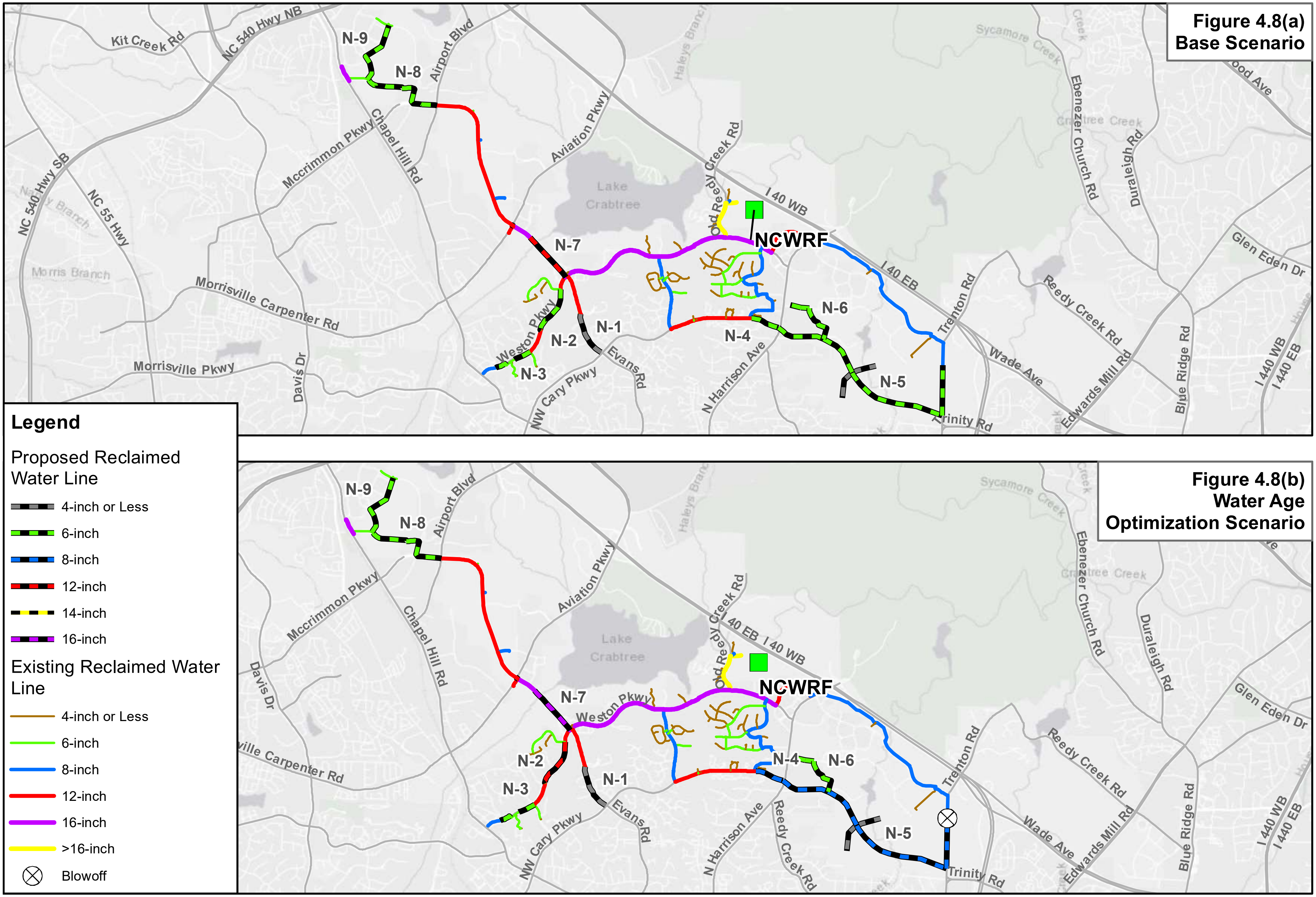

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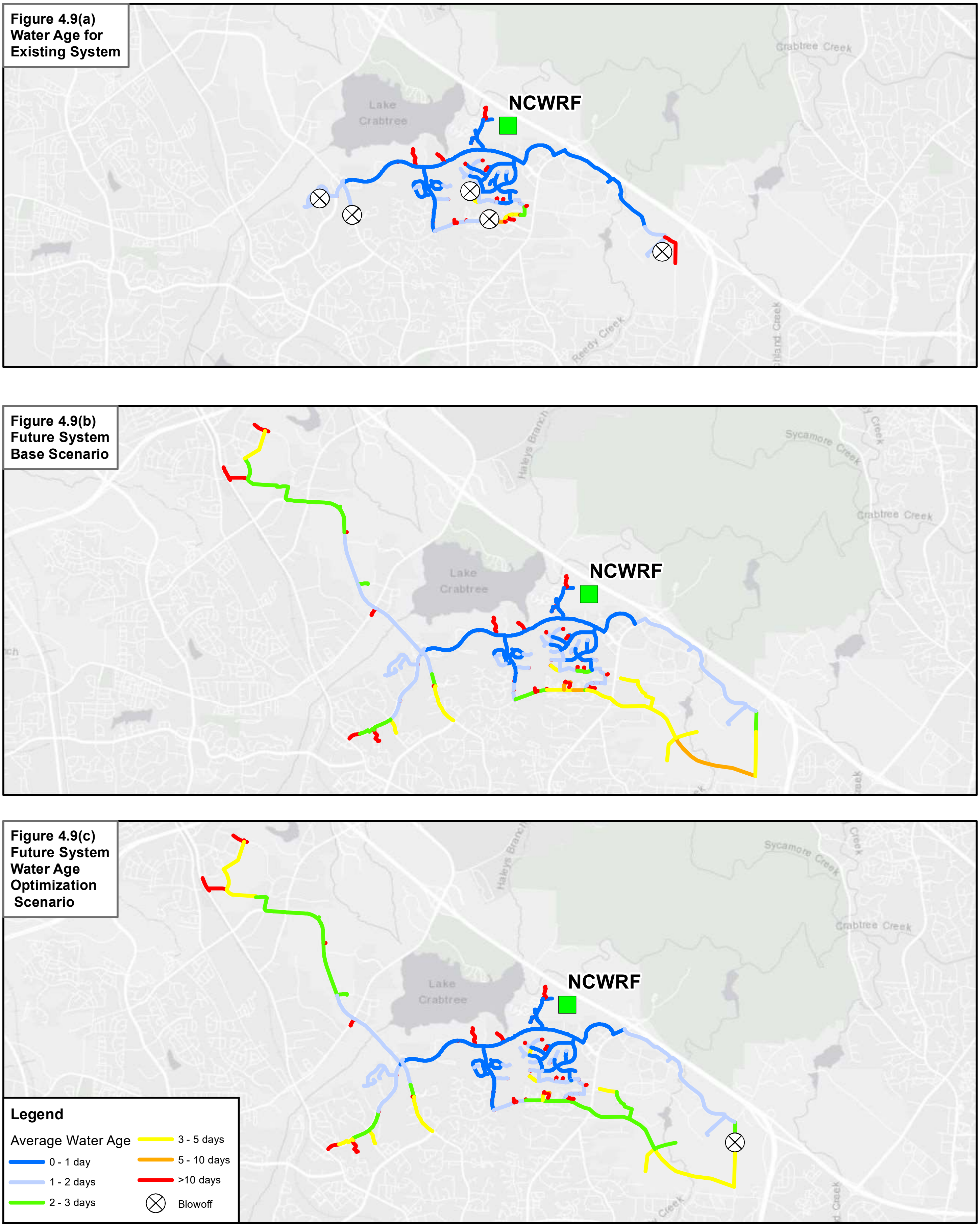
N

0 0.5 1 2 3 Miles

Figure 4-8
Future Reclaimed System for Base Scenario
and Water Age Optimization Scenario for North Service Area



N

0 0.5 1 2 Miles

Figure 4-9
Comparing Water Age for Existing System, Future System Base Scenario, and Future System Water Age Optimization Scenario for North Service Area

Optimizing Pipe Sizes

Based on the water age analysis results, optimized pipe sizes that differ from the base scenario include:

- N-1 – Although upsizing the proposed reclaimed water pipe along Evans Road from the base scenario to 12-inches in diameter would provide consistency with the existing 12-inch reclaimed water pipe, it would result in an average water age of 6days. A 6-inch pipe provides water age just under 4 days while a 4-inch diameter pipe results in a water age of just over 3 days. Therefore, the 4-inch diameter recommendation from the base scenario was maintained.
- N-2– Increasing the proposed connection pipeline along Weston Parkway between the existing reclaimed water pipes from a 6-inch in the base scenario to a 12-inch diameter provides consistent pipe sizing along Weston Parkway while only increasing the average water age by approximately 1 day (from 2 days to 3 days).
- N-7 - Increasing the pipe size from 12-inch in the base scenario to 16-inch diameter provides consistent pipe sizing on Evans Road running north of Weston Parkway with the existing pipelines upstream of these new reclaimed water mains while maintaining similar water age.

Looping

The SAS loop located in the southeastern portion of the system was recommended for the base scenario (improvement N-4). Optimization of this looping was further investigated to provide consistent pipe sizing with the existing reclaimed water pipes and to address water age along the SAS loop. Upsizing to an 8-inch diameter pipe provided consistent pipe sizing for the loop and improved the average water age from 5 days to 4 days along NW Cary Parkway. However, the water age remained greater than 5 days on the eastern portion of the SAS loop. For this reason, an 8-inch diameter pipe with flushing was further considered for this area.

Future Blowoffs

One flusher is recommended for future buildout of the North service area at the corner of the SAS loop as shown in **Figure 4-8(b)** to address older water seen in this area. Flushing approximately 10,000 gallons per day reduces the water age to less than 5 days.

Recommendations

Implementing the infrastructure and operational improvements outlined below and shown in Figure 4-8(b) resulted in an improved water age in the North service area at buildout. A comparison of water age between the base scenario and optimized scenario is shown in Figure 4-9.

- Infrastructure Improvements – Approximately 6.6 miles of new 4-inch through 16-inch diameter reclaimed water pipes to connect existing reclaimed water lines and serve additional properties. **Table 4-4** summarizes the recommended size of the reclaimed water pipes for optimization of water age in the North service area.

- Operational Improvements – Flushing a total of 10,000 gpd at the eastern side of the future SAS loop.
- NCDOT Coordination – Potential areas of coordination with future NCDOT projects:
  - The existing 12-inch diameter reclaimed water pipe along NW Cary Parkway is currently oversized. Reducing this to an 8-inch diameter reclaimed water pipe would improve water age along NW Cary Parkway and also in the SAS loop area. Flushing would still be required in the future in the SAS area even with downsizing the 12-inch diameter reclaimed water pipe.
  - The existing 16-inch diameter reclaimed water pipe along Chapel Hill Road is currently oversized. Reducing this from a 16-inch to a 6-inch diameter will slightly improve water age (less than 1 day) and provide consistent pipe sizing in this area.

Table 4-4. Recommended New Pipes for North Future Water Age Optimization Scenario

Diameter	Proposed Pipe Length (ft)
4-inch	4,700
6-inch	11,700
8-inch	13,300
12-inch	2,500
16-inch	2,500
Total	**34,700**

4.3 South Service Area

The South service area has limited potential for targeted expansion. The potential for expansion in the vicinity of Pierce Olive Road was considered, however, based on the criteria developed for targeted expansion (listed in Section 2.3) it was determined that this area would not be included in the future extension of the South reclaimed water system. **Figure 4-10** shows the location and relative amount of demand at buildout of the South service area. The purple circles indicate existing reclaimed water demands. The blue circles indicate existing customers that are served by a reclaimed water line that is currently connected to the potable water system but will be converted to the reclaimed water system in the future. The green circles indicate demand from future development of parcels. The dotted lines indicate where new reclaimed water pipes will be required to meet buildout demands. The reclaimed water pipes that are currently on the potable water system but will be converted once the reclaimed water system expands are shown by the blue pipes on Figure 4-10.

It should be noted that the projected buildout demand north of the existing system at Middle Creek Park only comprises an AAD of approximately 24,000 gpd. The reclaimed water pipes that are currently on the potable system at the far northwest near Lawdraker Road do not have any projected demand. Therefore, it is recommended that these pipes are not connected to the reclaimed water system.

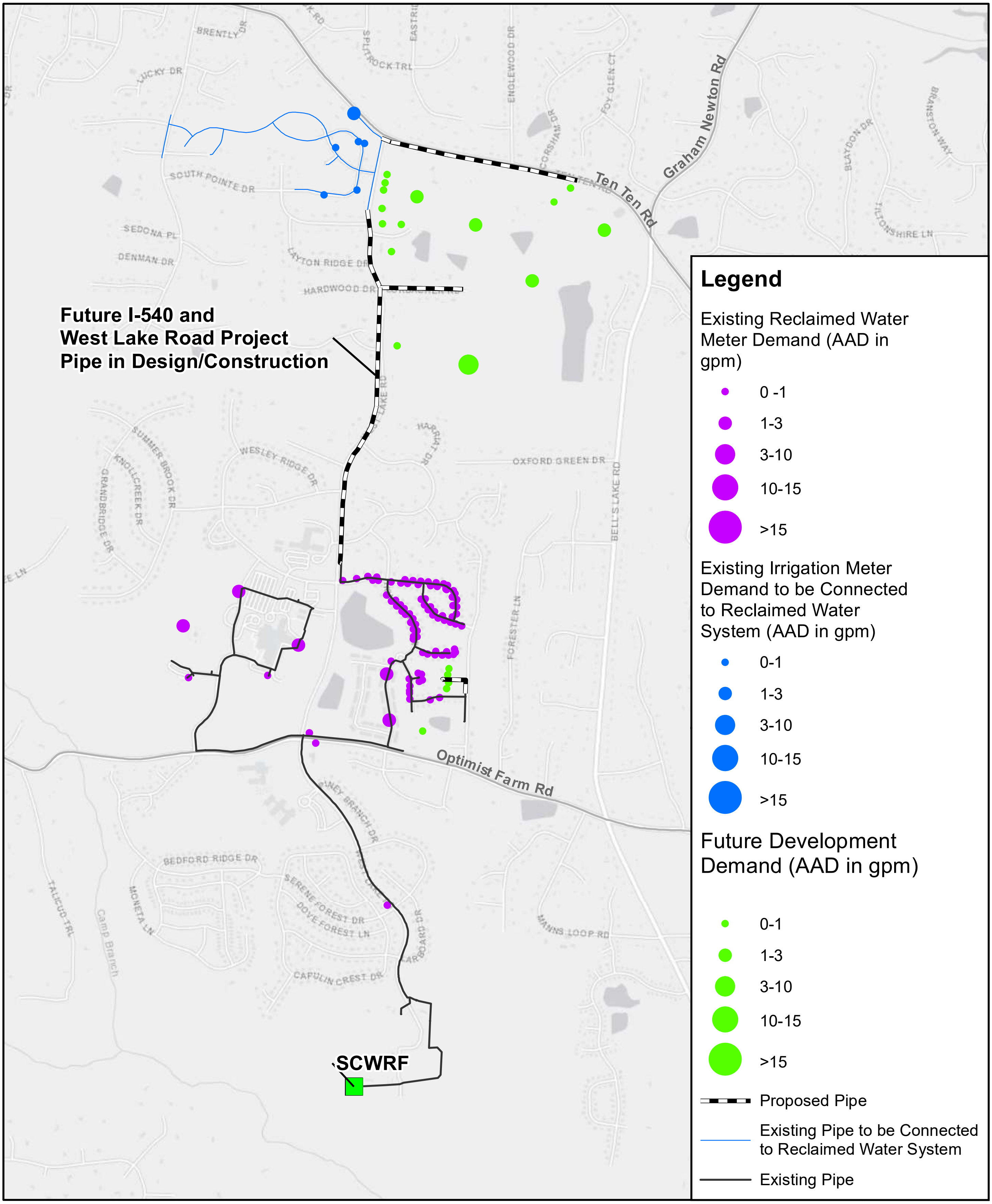


Figure 4-10
Buildout Reclaimed Water Demands
for the South Service Area

4.3.1 Base Scenario

Figure 4-11 shows the minimum pressures at buildout for the South service area expansion. The topography of the South Cary service area increases in elevation to the north, with the SCWRF at the lowest elevation. With the current pumping set points, pressures north of the proposed I-540 corridor are just below the minimum desired pressure of 40 psi due to higher elevations.

An additional approximately 10 feet of head is required at the SCWRF high service pumps to maintain pressures greater than 40 psi during peak hour in the northern portion of the South service area. Based on review of the pump curves and current operations, this increase in head can be achieved with the current pumps by increasing the discharge pressure set point at the hydropneumatic tank from approximately 120 psi to 125 psi. This operational adjustment would be required to serve all future projected growth in the South service area except a small 4-inch diameter pipeline off of Henderson Road and an additional parcel picked up along Field Glow Lane which adds approximately 1,000 gpd AAD total to the South service area.

The buildout peak hour demand for the South service area is 0.39 mgd (without blowoff). The existing firm pumping capacity at the SCWRF is 0.70 mgd. Since August 2020, the on-site plant water used at the SCWRF has been supplied from the potable system. Assuming plant water continues to be supplied from the potable system in the future (and is not converted back to the reclaimed water system via the reclaimed water pumps), additional supply or pumping capacity is not needed in the future.

Figure 4-12(a) and Table 4-5 summarize the proposed size of the new reclaimed water pipes to meet the minimum evaluation criteria presented in Section 3, assuming pumping operational adjustments are made to maintain minimum pressures in the section north of the I-540 corridor. Pressures, velocities, and headloss are all within the minimum evaluation criteria discussed in Section 3.

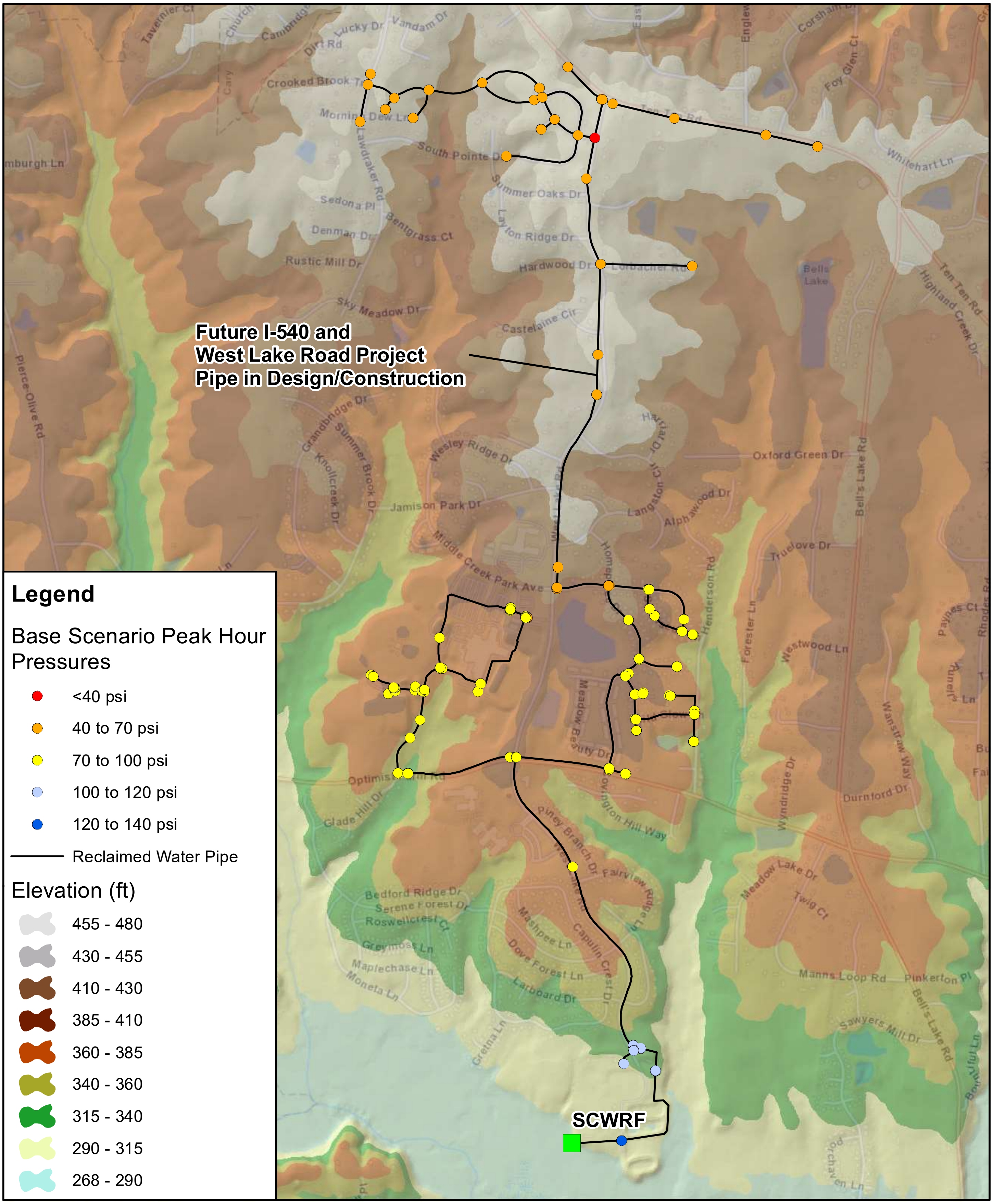
Table 4-5. Base Scenario Pipe Size for the South Service Area

Diameter	Proposed Pipe Length (ft)
4-inch	4,500
8-inch	4,600
14-inch[1]	500
Total	**9,600**

1. The planned reclaimed water pipe under the future I-540 corridor is in design/construction as a 14-inch diameter pipe.

4.3.2 Future Water Age Optimization

In the South service area, average water age is greater than 5 days near Middle Creek High School and at the northern portion of the system on West Lake Road. Existing flushing provides improvement in water age for all these areas (**Figure 4-13(a)**). As demands increase in the future, the majority of average water age remains below the 5 day target value with only the area around Middle Creek High School exceeding the average water age target of 5 days as shown in **Figure 4-13(b)**.



N

0 0.45 0.9 Miles

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Figure 4-11
Minimum Pressures at
Buildout for the South
Service Area Expansion

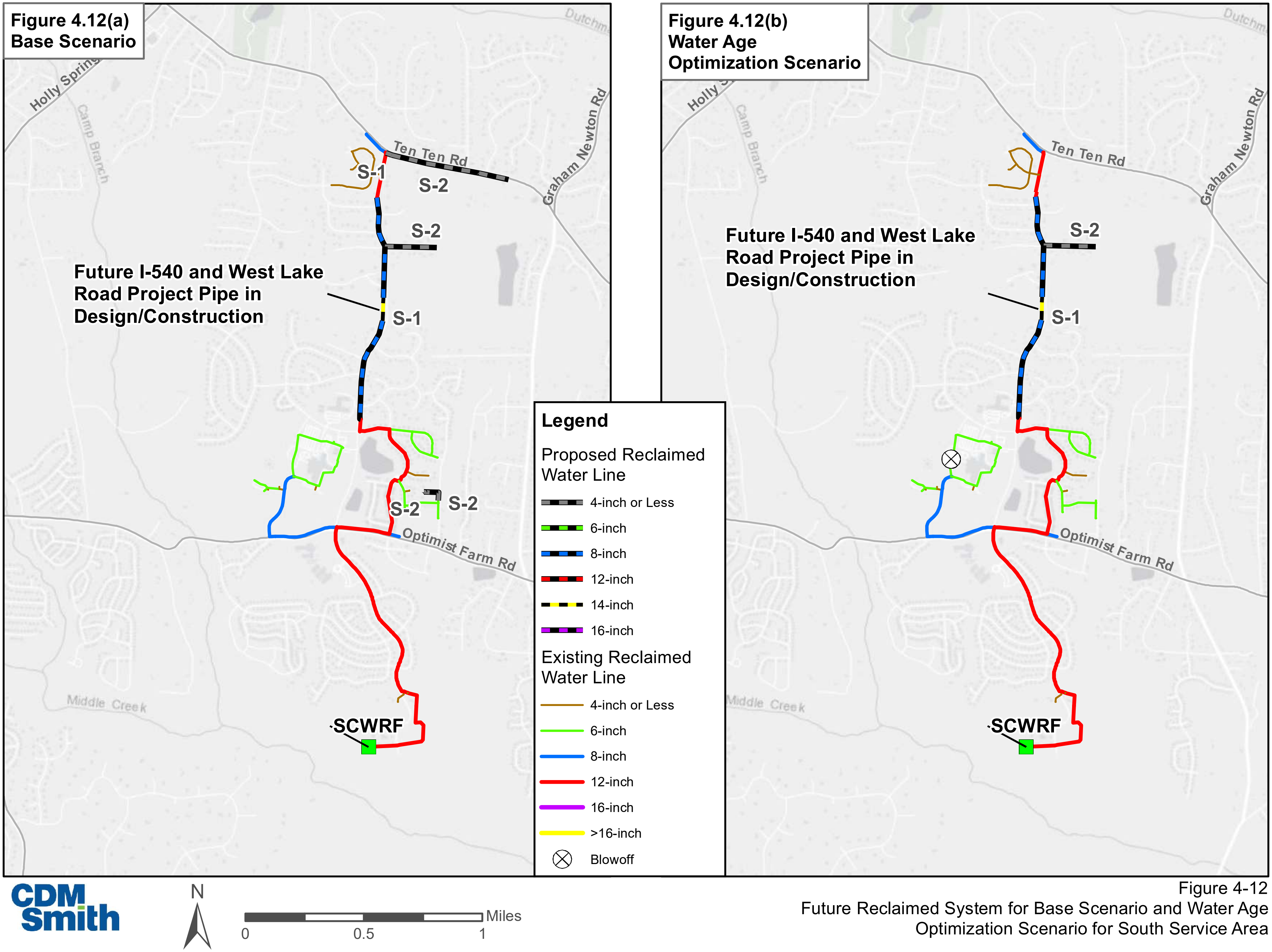

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Figure 4-12
Future Reclaimed System for Base Scenario and Water Age Optimization Scenario for South Service Area

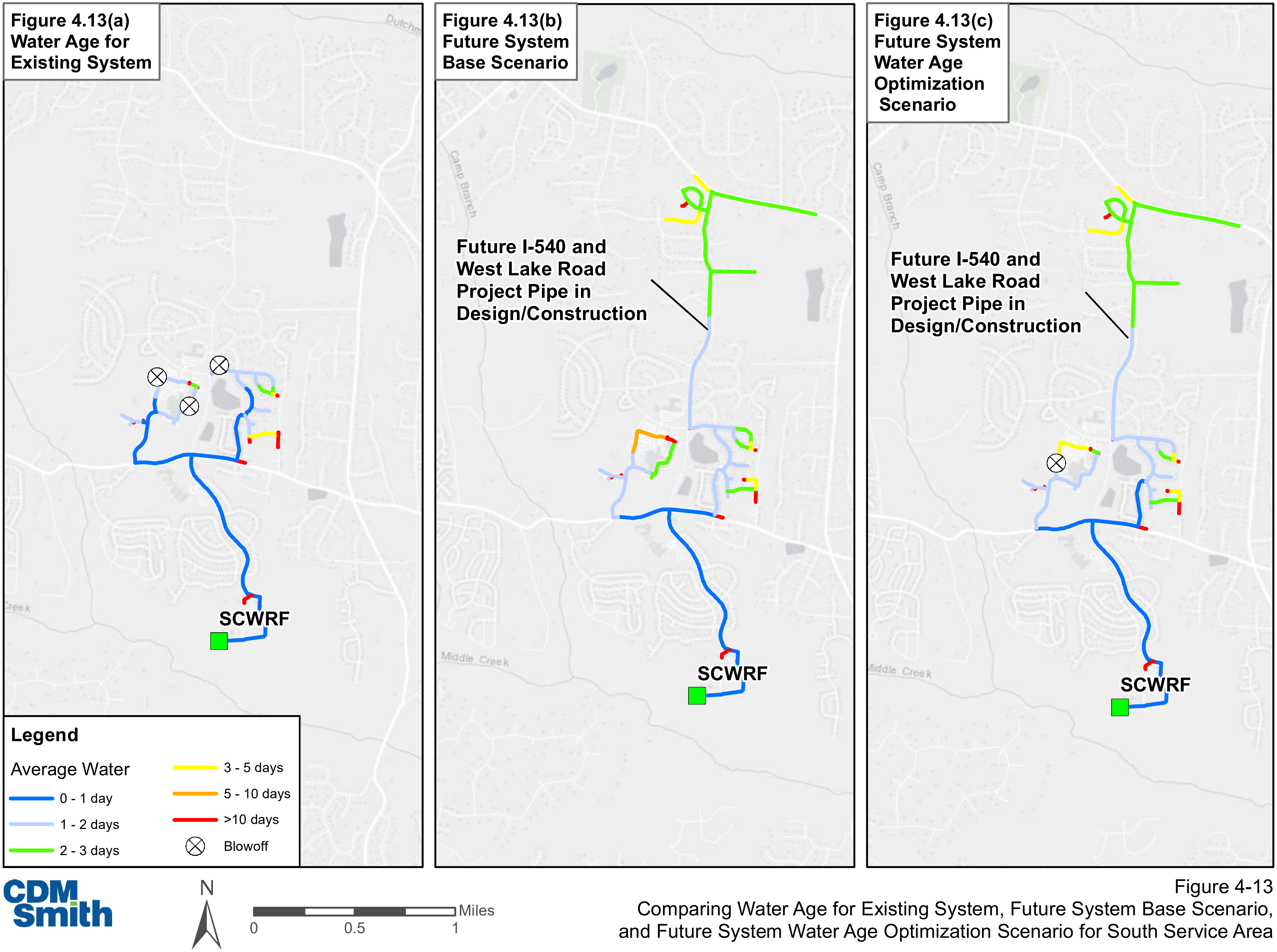

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Figure 4-13
Comparing Water Age for Existing System, Future System Base Scenario, and Future System Water Age Optimization Scenario for South Service Area

While the base scenario met the evaluation criteria for minimum pressure, headloss, and velocities, it did not address water age and recommended inconsistent pipe sizes between upstream/downstream pipes along West Lake Road. Hydraulic model simulations were performed to optimize pipe sizing, looping and blowoffs for buildout of the South service area while minimizing water age. If larger sized pipes consistent with upstream/downstream existing pipes did not contribute to excessive water age, the preference is to keep consistent sizing.

Optimizing Pipe Sizes

The proposed reclaimed water pipe running along West Lake Road was originally recommended as an 8-inch diameter pipe for the base scenario. A portion of this pipe is currently in design/construction as part of the future I-540 and West Lake Road project and is sized to be 14-inches in diameter. While 14-inch diameter was considered for this pipeline, the water age at the most northern portion of the system is 4 days. A 12-inch pipeline would provide consistency with the upstream/downstream pipes but also resulted in a water age of 4 days. An 8-inch diameter pipeline provides average water age improvement to under3 days and is therefore recommended.

Looping

No additional looping improvements were investigated for the South service area.

Future Blowoffs

One future flusher is recommended for buildout of the South service area at Middle Creek High School, as shown in **Figure 4-12(b)**. Flushing approximately 4,000 gallons per day reduces the average water age from approximately 6 days to 4 days.

Recommendations

The infrastructure and operational improvements outlined below and shown in Figure 4-12(b) result in an improved water age in the South service area at buildout. A comparison of water age between the base scenario and optimized scenario is in Figure 4-13.

- Infrastructure Improvements – Approximately 1.8 miles of new 4-inch through 14-inch diameter reclaimed water pipes to connect existing reclaimed water lines and serve additional properties. **Table 4-6** summarizes the recommended size of the reclaimed water pipes for optimization of water age in the South service area.
- Operational Improvements
  - Increase the discharge pressure set point at the SCWRF pumps/hydropneumatic tank from approximately 120 psi to 125 psi to maintain pressures greater than 40 psi during peak hour in the northern portion of the South service area.
  - Flushing 4,000 gpd at Middle Creek High School.
- NCDOT Coordination – There are no potential NCDOT coordination projects recommended at this time. Downsizing of existing pipes along NCDOT roadways in the South service area does not eliminate the need for flushing or provide significant improvements to water age.

Table 4-6. Recommended New Pipes for North Future Water Age Optimization Scenario

Diameter	Proposed Pipe Length (ft)
4-inch	4,500
8-inch	4,600
14-inch[1]	500
Total	**9,600**

1. The planned reclaimed water pipe under the future I-540 corridor is in design/construction as a 14-inch diameter pipe.

Section 5

Recommended Capital Improvement Program

A Capital Improvement Program (CIP) was developed for implementing the recommended reclaimed water system improvements discussed in Section 4.

The CIP only includes projects that are recommended to serve the targeted expansion opportunities in the West, North, and South service areas. The phasing of improvements is dependent on the timing of projected development. While looping recommendations presented in Section 4 may be completed in the near-term to help with existing water age issues, the remaining improvements to expand the reclaimed water system are dependent on when development will occur. Some of the project phasing may also be programed to closely match the planned construction of major transportation thoroughfares when the schedule for transportation improvements is refined. Construction of new reclaimed waterlines in conjunction with roadway construction, where possible, would be advantageous in terms of cost and ease of construction.

5.1 Cost Estimates

The American Association of Cost Estimators (AACE) recommends four levels of accuracy for construction cost estimating. The level of cost estimation is dependent upon the stage and scope of the project. The four major categories are shown in **Table 5-1**. The construction cost estimates prepared for this report are at the "Conceptual Estimate" level (Category 1).

Table 5-1. Level of Cost Categories

Category Level	Accuracy
Category 1 – Conceptual Estimate	+50% to -30%
Category 2 – Study Estimate	+30% to -20%
Category 3 – Preliminary Estimate	+20% to -10%
Category 4 – Detailed Estimate	+15% to -5%

Cost estimates for the improvements presented in the CIP were prepared using previous estimates for similar projects, historical data from comparable work, and estimating guides and equipment costs. Factors such as competitive market conditions, actual site conditions, and implementation schedule cannot be quantified at the current level of detail but can significantly impact the project cost.

The following assumptions are used in developing costs for reclaimed water improvements:

- All pipes and pumps are sized for buildout maximum day and peak hour demands.
- Reclaimed water pipes are assumed to be PVC installed by open cut methods. Major road and water crossings are assumed to be HDPE installed by directional drilling methods. Costs include appurtenances and pavement along the pipe trench, where applicable.

- Land acquisition costs are not included.
- Total construction cost is estimated by applying 30 percent contingency to the cost of pipeline and pumping improvements. Capital cost is estimated by applying 25 percent to the total construction cost for engineering, legal, and administrative fees.

Projecting costs into the future is speculative, as inflation rates for energy prices, building materials, and construction labor fluctuate constantly. A "constant dollar" approach was used in developing capital costs for the primary alternatives. All costs shown are in 2021 values and reference an Engineering News Record (ENR) Construction Cost Index (CCI) for June 2021 of 12112. Care should be taken during future updates to index costs for each year based on the inflation rate experienced over the update year. Project sizing and costs should be refined during the design phase.

5.2 Capital Improvement Program

The CIP is presented in **Table 5-2** (at the end of Section 5). A description of the recommended improvements is provided by phase in the following sections. The location of each project is shown color coded by diameter on **Figure 5-1**. Projects are labeled by service area (W = West service area, N = North service area; S = South service area).

The costs presented in the CIP are for distribution/transmission mains along transportation thoroughfares and do not include the cost of smaller diameter neighborhood pipelines. For new development, it is assumed that the neighborhood pipes and service connections would be installed by the developer, per the Town's Policy Statement 132. However, the ultimate cost of providing reclaimed water service to customers within existing neighborhoods would include installation of smaller service lines.

5.2.1 Phase 1

Phase 1 projects are those that may benefit the existing system by reducing water age or increasing demand on the extremities of the reclaimed water system in the near-term.

Project WLoop-1 – Loop on O'Kelly Chapel Road

Construct a pipeline loop connection of approximately 690 LF of 6-inch diameter pipeline along O'Kelly Chapel Road connecting the existing pipeline east and west of Green Level Church Road. This loop improves modeled water age in the existing system on O'Kelly Chapel Road from 11 days to less than 1 day in the West service area.

Engineer's Conceptual-Level Opinion of Probable Cost: $236,000.

Project W-3 – Louis Stephens Drive and Little Drive

Construct a pipeline connection of approximately 8,400 LF of 8-inch and 4,260 LF of 12-inch diameter pipeline creating a loop along Louis Stephens Drive and extending service along Little Drive. This project spans between existing 12-inch and 16-inch diameter pipelines. This pipeline is part of the planned Jordan Lake Water Reclamation and Reuse Project by Wake County.

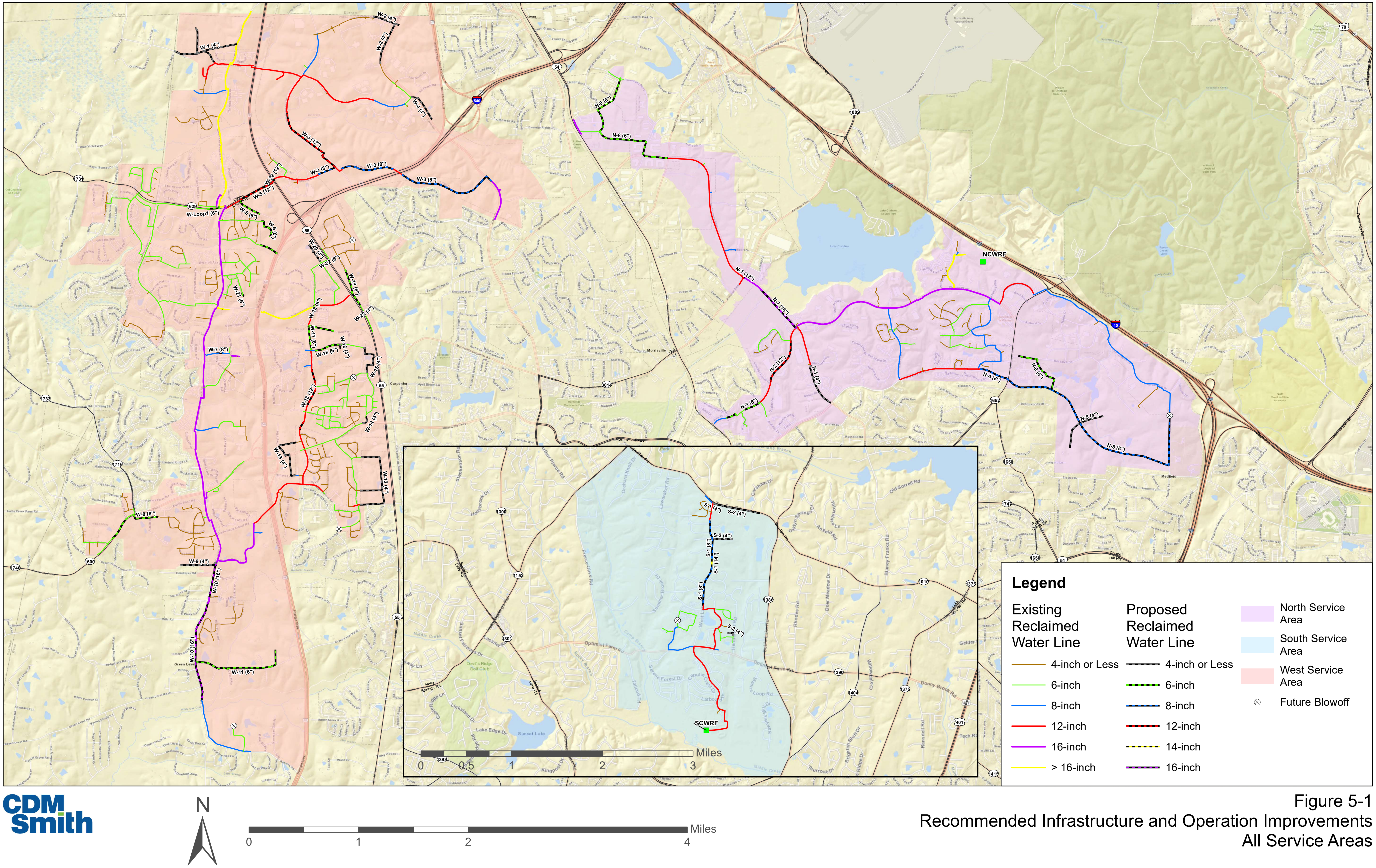

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Figure 5-1
Recommended Infrastructure and Operation Improvements
All Service Areas

This project will extend the West service area to serve the existing Parkside Town Commons and Fujifilm customers and proposed Apple campus and areas of RTP South. The Apple campus is proposed at 1 million square feet of building area that is projected to be constructed over the next 5 years. Assuming the Apple campus will use reclaimed water for building cooling and irrigation, this project is recommended as higher priority to increase demands in the West service area. Additionally, the project will connect existing reclaimed water pipes that are currently on the potable system in the Parkside development.

Engineer's Conceptual-Level Opinion of Probable Cost: $3,163,000.

Project N-7 – Evans Road connection

Construct a pipeline connection of approximately 170 LF of 12-inch diameter and 2,540 LF of 16-inch diameter pipeline on Evans Road between Weston Parkway and NW Cary Parkway. This pipeline will be between existing 12-inch diameter pipelines.

This project, along with Project N-7 will extend the reclaimed water service to the Wake Technical Community College RTP campus, which intends to use reclaimed water for cooling towers. The campus plan includes 975,000 square feet of buildings by buildout, with 415,000 square feet over the next 10 years.

Engineer's Conceptual-Level Opinion of Probable Cost: $1,504,000.

Project N-8 – Watkins Road connection

Construct a pipeline connection of approximately 4,240 LF of 6-inch diameter pipeline along Watkins Road connecting McCrimmon Parkway with Chapel Hill Road. This pipeline will be between existing 16-inch, 12-inch, and 6-inch diameter pipelines.

This project, along with Project N-6 will extend the reclaimed water service to the Wake Technical Community College RTP campus, which intends to use reclaimed water for cooling towers. The campus plan includes 975,000 square feet of buildings by buildout, with 415,000 square feet over the next 10 years.

Engineer's Conceptual-Level Opinion of Probable Cost: $1,008,000.

Project N-9 – Paramount Parkway and Chapel Hill connection

Construct a pipeline connection of approximately 3,180 LF of 6-inch diameter pipeline connecting Paramount Parkway with Chapel Hill Road. This pipeline will be between existing 16-inch and 6-inch diameter pipelines.

This project, along with Project N-8 will extend the reclaimed water service to the Wake Technical Community College RTP campus, which intends to use reclaimed water for cooling towers. The campus plan includes 975,000 square feet of buildings by buildout, with 415,000 square feet over the next 10 years.

Engineer's Conceptual-Level Opinion of Probable Cost: $621,000.

Project N-2 – Weston Parkway connection

Construct a pipeline connection of approximately 2,320 LF of 12-inch diameter pipeline on Weston Parkway between Kennicott Avenue and Cascade Pointe Lane.

This project, along with Project N-3 will connect existing reclaimed water pipes (with existing irrigation demands) that are currently on the potable system to be supplied with reclaimed water from the North service area.

Engineer's Conceptual-Level Opinion of Probable Cost: $660,000.

Project N-3 – Weston Parkway/Sheldon Drive connection

Construct a pipeline connection of approximately 1,440 LF of 6-inch diameter pipeline on Weston Parkway near intersection of Sheldon Drive. This pipeline will be between existing 12-, 8- and 6-inch diameter pipelines.

This project, along with Project N-2 will connect existing reclaimed water pipes (with existing irrigation demands) that are currently on the potable system to be supplied with reclaimed water from the North service area.

Engineer's Conceptual-Level Opinion of Probable Cost: $383,000.

5.2.2 Phase 2

Phase 2 includes the remainder of the projects for which phasing of improvements is dependent on the timing of projected development and/or roadway construction. These projects are presented for the West, North, and South service areas, respectively.

Project W-1 – Wake Road, Barry Farm Road, and proposed thoroughfare expansion

Construct a pipeline extension of approximately 5,050 LF of 4-inch diameter pipeline along Wake Road, Barry Farm Road, and proposed thoroughfare to serve future growth. This pipeline will be extending from an existing 20-inch and 12-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $976,000.

Project W-2 – Davis Drive and Development Drive connection

Construct a pipeline connection of approximately 3,490 LF of 4-inch diameter pipeline to complete loop on Davis Drive and Development Drive. This pipeline will be between existing 4-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $795,000.

Project W-4 – Davis Drive extension

Construct a pipeline extension of approximately 1,600 LF of 4-inch diameter pipeline on Davis Drive to serve future growth.

Engineer's Conceptual-Level Opinion of Probable Cost: $286,000.

Project W-5 – O'Kelly Chapel Road connection

Construct a pipeline connection of approximately 1,740 LF of 12-inch diameter pipeline along O'Kelly Chapel Road between Alston Ave and NC 55 Hwy. This pipeline will be between existing 12-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $496,000.

Project W-6 – Alston Ave, Rosepine Drive, and Hortons Creek Road extensions

Construct pipelines consisting of approximately 3,270 LF of 6-inch diameter pipeline extending along Alston Ave, Rosepine Drive, and off Hortons Creek Road along the proposed thoroughfare for serving future development.

Engineer's Conceptual-Level Opinion of Probable Cost: $638,000.

Project W-7 – Carpenter Fire Station Road connection

Construct a pipeline connection of approximately 330 LF of 8-inch diameter pipeline along Carpenter Fire Station Road. This pipeline will be between existing 8-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $74,000.

Project W-8 – Morrisville Parkway connection

Construct a pipeline connection of approximately 2,590 LF of 6-inch diameter pipeline connecting Morrisville Parkway to the existing pipeline on Cobalt Ridge Way. This pipeline will be between existing 6-inch and 4-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $679,000.

Project W-9 – Bigelow Road

Construct a pipeline connection of approximately 1,800 LF of 4-inch diameter pipeline along Bigelow Road to serve future development.

Engineer's Conceptual-Level Opinion of Probable Cost: $321,000.

Project W-10 – Green Level Church Road

Convert approximately 5,950 LF of 16-inch existing wastewater force main to reclaimed water main along Green Level Church Road. Construct a pipeline connection of approximately 650 LF of 16-inch diameter pipeline along Green Level Church Road between the existing 16-inch diameter wastewater force main that is being converted into reclaimed water main and the existing 8-inch on Green Level Church Road.

Engineer's Conceptual-Level Opinion of Probable Cost: $301,000.

Project W-11 – Green Level West Road

Construct a pipeline extension of approximately 4,790 LF of 6-inch diameter pipeline along Green Level West Road to serve future demand.

Engineer's Conceptual-Level Opinion of Probable Cost: $935,000.

Project W-12 – Green Hope School Road to Schooner Drive connections

Construct pipeline connections of approximately 5,380 LF of 4-inch diameter pipeline along Green Hope School Road and through the future development off of Green Hope School Road to create loops to Schooner Drive and Misty Rise Drive.

Engineer's Conceptual-Level Opinion of Probable Cost: $963,000.

Project W-13 – Morrisville Parkway to Stockwell Lane Loop

Construct a pipeline loop of approximately 3,980 LF of 4-inch diameter pipeline on Morrisville Parkway to Stockwell Lane Loop along Twyla Road to serve future development.

Engineer's Conceptual-Level Opinion of Probable Cost: $785,000.

Project W-14 – Morrisville Parkway loop

Construct a pipeline loop of approximately 510 LF of 6-inch diameter pipeline on Morrisville Parkway to serve future demand.

Engineer's Conceptual-Level Opinion of Probable Cost: $99,000.

Project W-15 – Indian Wells Road to Carpenter Fire Station Road loop

Construct a pipeline loop of approximately 2,070 LF of 6-inch diameter pipeline extending from Indian Wells Road to serve future demand.

Engineer's Conceptual-Level Opinion of Probable Cost: $448,000.

Project W-16 – Carpenter Fire Station Road connection

Construct a pipeline connection of approximately 290 LF of 4-inch and 1,420 LF of 6-inch diameter pipeline as an extension along Howard Road (4-inch) and along Carpenter Fire Station Road (6-inch). This pipeline will be between existing 8-inch and 6-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $329,000.

Project W-17 – Howard Road to Highcroft Drive extension

Construct a pipeline connection of approximately 2,570 LF of 6-inch diameter pipeline along proposed thoroughfare for Highcroft Drive north of Carpenter Fire Station Road connecting to Howard Road, and along Highcroft Drive crossing McCrimmon Parkway to connect existing 6- and 12-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $574,000.

Project W-18 – Highcroft Drive connection

Construct a pipeline connection of approximately 1,980 LF of 12-inch diameter pipeline along proposed thoroughfare for Highcroft Drive. This pipeline will be between existing 12-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $564,000.

Project W-19 – Petty Farm Road connection

Construct a pipeline connection of approximately 1,890 LF of 6-inch diameter pipeline along Petty Farm Road. This pipeline will be between existing 6-inch and 4-inch diameter pipelines.

Engineer's Conceptual-Level Opinion of Probable Cost: $369,000.

Project W-20 – Off Mahal Avenue extension

Construct a pipeline extension of approximately 1,050 LF of 4-inch diameter pipeline off Mahal Avenue to serve future development.

Engineer's Conceptual-Level Opinion of Probable Cost: $320,000.

Project W-21 – Royal Delta Drive extension

Construct a pipeline extension of approximately 210 LF of 6-inch diameter pipeline along Royal Delta Drive to serve future demands.

Engineer's Conceptual-Level Opinion of Probable Cost: $41,000.

Project W-22 – NC55 Crossings

Construct a pipeline connection of approximately 150 LF of 4-inch diameter pipeline crossing NC55 at Petty Farm Road, 180 LF of 6-inch diameter pipeline crossing NC55 at Mahal Avenue, and 270 LF of 12-inch diameter pipeline crossing NC 55 at O'Kelly Chapel Road.

Engineer's Conceptual-Level Opinion of Probable Cost: $694,000.

Project N-1 – Evans Road extension south

Construct an extension of approximately 2,170 LF of 4-inch diameter pipeline along Evans Road between Weston Parkway and NW Cary Parkway to serve future growth.

Engineer's Conceptual-Level Opinion of Probable Cost: $389,000.

Project N-4 – NW Cary Parkway West of N Harrison Ave

Construct a pipeline connection of approximately 1,370 LF of 8-inch diameter pipeline along NW Cary Parkway between N Harrison Avenue and Beechtree Drive. This pipeline will be between an existing 12-in diameter pipeline and the proposed 8-inch SAS loop.

Engineer's Conceptual-Level Opinion of Probable Cost: $301,000.

Project N-5 – SAS Loop East of N Harrison Ave

Construct a pipeline connection of approximately 2,570 LF of 4-inch diameter and 11,890 LF of 8-inch diameter pipeline along the proposed throughfare from the intersection of NW Cary Parkway and N Harrison Avenue to Trinity Road near SAS. This pipeline will be between existing 8-inch diameter pipeline and the proposed project N-4 8-inch pipeline.

Engineer's Conceptual-Level Opinion of Probable Cost: $3,278,000.

Project N-6 – Charger Lane to Research Drive connection

Construct a pipeline of approximately 2,860 LF of 6-inch diameter pipeline along Charger Lane to Research Drive to serve future development.

Engineer's Conceptual-Level Opinion of Probable Cost: $558,000.

Project S-1 – West Lake Road extension

Construct a pipeline extension of approximately 4,570 LF of 8-inch diameter pipeline on West Lake Road and 140 LF of 4-inch diameter crossing West Lake Road to connect to Ten Ten Road development. There is one section of approximately 510 LF of 14-inch diameter pipeline currently in construction/design as part of the I-540 and West Lake Road Project. This extension is dependent upon operational adjustments at the SCWRF reclaimed water pump station to provide adequate pressures in the reclaimed water system north of the I-540 corridor.

Engineer's Conceptual-Level Opinion of Probable Cost: $2,111,000.

Project S-2 – Ten-Ten extension, Lorbacher Road extension, and Henderson Road extension

Construct pipeline extensions of approximately 1,160 LF of 4-inch diameter pipeline off of Lorbacher Road from project S-1, 550 LF of 4-inch off Henderson Road, and 2,650 LF of 4-inch on Ten Ten. This extension is dependent upon operational adjustments at the SCWRF reclaimed water pump station to provide adequate pressures in the reclaimed water system north of the I-540 corridor.

Engineer's Conceptual-Level Opinion of Probable Cost: $780,000.

5.3 Operational Considerations

5.3.1 Existing System Operations

As discussed in Section 4, to maintain water quality and decrease water age in the extremities of the systems, particularly during demands less than average annual conditions, it is recommended the Town continue flushing at blowoffs until demands at the end of the system are sufficient to maintain the 0.5 mg/L chlorine residual. Based on model simulations of water age, the following operational measures are recommended for the existing system:

West Service Area

Modifications to the current flushing locations are recommended to reduce the overall blowoff quantity by approximately 25 percent and address water age greater than 5 days in the Carpenter Village area.

- Discontinue use of two of the blowoffs in the vicinity of Kit Creek Road and Louis Stephens Drive that are near the Cisco Cooling Tower and Credit Suisse users. Based on water age simulations these flushers are not needed.
- Reduce the blowoff rate at the end of Louis Stephens Drive. In addition, if the Apple Campus is built out and uses reclaimed water, the need for flushing along Louis Stephens Road should be re-evaluated in the future.

- Discontinue use of the following flushers: Abbey View Way (in the neighborhood west of Green Valley Church Road), 10304 Green Level Church Road, and Mills Park Drive. Based on water age simulation, these flushers are not needed.
- In the near-term, construct W-Loop1 to improve water age to less than 2 days along O'Kelly Chapel Road.
- Move and increase the flushing rate for the flusher in the neighborhood south of Morrisville Parkway and west of Green Level Church Road to the end of Green Hope School Road.
- Place four new flushers in the neighborhood east of I-540 to improve water age in the Carpenter Village area.
- Add a chlorine sampling location in the area of highest water age east of I-540, on Indian Wells Road, to monitor disinfectant residuals in this area.

North Service Area

Flushing operations should continue at the current locations to maintain water age less than the target 5 days with the exception of the blowoff at SAS. It is recommended that the SAS blowoff location be moved to the end of the existing 8-inch pipe on Trenton Road.

South Service Area

Flushing operations should continue at the current locations on West Lake Road and at the Middle Creek school to maintain water age less than the target 5 days. Based on water age simulation, only one flushing location is needed along the Middle Creek school loop. Therefore, the second flushing location can be discontinued.

5.3.2 Buildout System Operations

Pumping

The existing reclaimed water pumping and supply capacity is adequate for buildout demands, as summarized in **Table 5-3**.

Table 5-3. Summary of Pumping Capacity vs. Buildout Demands

	Existing Pumping Capacity(1) (mgd)	Buildout Peak Hour Demand (excluding blowoffs) (mgd)
West Service Area	3.6 (2)	2.2
North Service Area	8.3	1.5
South Service Area	0.7	0.4

1. Firm capacity with one pump out of service
2. Capacity of supply to the West service area is based on the peak hour supply stipulated in the contractual agreement with Durham County.

Before the South service area is expanded north of the I-540 corridor, it is recommended that the discharge pressure set point at the SCWRF pumps/hydropneumatic tank in increased from approximately 120 psi to 125 psi to maintain pressures greater than 40 psi during peak hour in the northern portion of the South service area.

CDM Smith

Blowoffs

Although increased demands in the future will improve water age and water quality in sections of the reclaimed water systems, flushing is still recommended in the future for areas with projected low demand. The following operational measures are anticipated to be needed based on modeling of buildout ADD conditions:

West Service Area

At buildout, flushing is recommended at four locations, as shown in Figure 5-1. Flushers are recommended in the area east of I-540 along Mahal Avenue, Indian Wells Road near Ansley Stream Lane, and Sears Farm Road/Cozy Oak Lane. An additional flusher is recommended at Green Level High School to improve water age at the end of Green Level Road. Based on modeling of AAD, flushing approximately 10,000 gallons per day at each location reduces the average water age to less than 5 days for most pipes with the exception of a few dead-end pipes.

Flushing at these future locations should be implemented as soon as the system is extended to reach the recommended blowoffs. The Town should then monitor chlorine residual to evaluate whether existing upstream flushing locations can be discontinued with increased system demands as development occurs.

North Service Area

At buildout, one flusher is recommended at the corner of the SAS loop to address projected water age issues, as shown in Figure 5-1. Flushing approximately 10,000 gpd reduces the average water age to less than 5 days. This location corresponds to a recommended existing system blowoff location. As the system is extended and demands increase, the Town should then monitor chlorine residual to evaluate whether existing flushing locations can be discontinued.

South Service Area

At buildout, one flusher is recommended at Middle Creek High School, as shown in Figure 5-1. Flushing approximately 4,000 gpd reduces the average water to less than 5 days.

5.4 NCDOT Coordination Considerations

Optimizing sizing of new and existing infrastructure along NCDOT roads should be coordinated with future NCDOT projects. Construction of new reclaimed waterlines in conjunction with roadway construction, where possible, would be advantageous in terms of cost and ease of construction. In some instances, there are oversized pipelines along NCDOT routes that could be considered for downsizing in the future. The following pipelines should be re-evaluated when performing work along these NCDOT roads.

- West Service Area - There are no potential NCDOT coordination projects recommended at this time. Downsizing of existing pipes along NCDOT roadways in the West service area does not eliminate the need for flushing or provide significant improvements to water age.
- North Service Area
  - The existing 12-inch diameter reclaimed water pipe along NW Cary Parkway is currently oversized. If replacement is necessary, reducing this to an 8-inch diameter reclaimed water pipe would improve water age along NW Cary Parkway and along the

SAS loop. Flushing would still be required in the future in the SAS area even with downsizing the 12-inch diameter reclaimed water pipe.

- The existing 16-inch diameter reclaimed water pipe along Chapel Hill Road is currently oversized. If replacement is necessary, reducing the pipe diameter from 16 inches to 6 inches will provide consistent pipe sizing in this area.

- South Service Area - There are no potential NCDOT coordination projects recommended at this time. Downsizing of existing pipes along NCDOT roadways in the South service area does not eliminate the need for flushing or provide significant improvements to water age.

5.5 Project Summary and Next Steps

The patterns of reclaimed water use for irrigation, cooling, and toilet flushing within the Town's three service areas, including seasonal and daily peaking factors and diurnal usage patterns, have remained consistent since the system first started operations. However, the growth in number of customers using the system for non-potable water has not been as great as was projected in past planning efforts. As a result, areas with low demand have necessitated flushing of the system through blowoffs to the sanitary sewer to maintain water quality and disinfectant residual in the reclaimed water system. Metered use that is billed to customers represents approximately 50 percent of the total water distributed to the North service area, approximately 40 percent of the total water distributed to the South service area, and approximately 60 percent of the total water distributed to the West service area.

The Town's most recent LRWRP recommended a targeted expansion of the reclaimed water system that resulted in revised service area boundaries and future demand estimates to only expand the system to serve new high-value customers with year-round demand. With the adjusted targeted expansion approach, the largest potential for growth is seen in the West service area. Customer demands are projected to increase by 125 percent from existing to buildout of the West service area. The South service area growth is approximately 93 percent from existing to buildout, and the North service area growth is approximately 77 percent. The buildout maximum day customer demand in all three service areas combined is estimated at approximately 2.1 mgd.

Based on these projections, the reclaimed water supply and existing infrastructure is adequate for buildout demands and only pipeline extensions are needed to serve future reclaimed water demands in the North, West, and South service areas.

Although increased demands in the future will improve water age, which serves as an indicator of water quality, in sections of the reclaimed water systems, some areas with low demand are still projected to have water age higher than the target of 5 days. Various configurations of pipe sizing and looping were evaluated to minimize future water age to the extent feasible. Even with these, flushing through blowoffs in some limited areas with low demand is still anticipated in the future.

Since water age and water quality issues in the reclaimed water system are driven by low demand, opportunities to increase demand at the ends of the system or terminate the dead-end pipes at a location of larger demand would be beneficial for water quality in the reclaimed water system. Near-term projects that may benefit the existing system by reducing water age or increasing demand on the extremities of the reclaimed water system include the following:

- Looping existing pipes at O'Kelly Chapel Road and Green Level Church Road (Project WLoop-1)
- Implementation of the Jordan Lake Water Reclamation and Reuse Project to extend the West reclaimed water system to serve the proposed Apple campus (Project W-3)
- Extending the North reclaimed water system to serve the Wake Technical Community College RTP campus, which intends to use reclaimed water for cooling towers (Projects N-6 and N-7)
- Pipeline extensions along Weston Parkway to connect existing reclaimed water pipes (with existing irrigation demands) that are currently on the potable system to be supplied with reclaimed water from the North service area (Projects N-2 and N-3)

The CIP developed as part of the Reclaimed Water System Master Plan Update provides improvements to extend reclaimed water service to customers throughout the three main service areas. Because unforeseen events affecting projected growth and expansion may occur, it is recommended that the reclaimed water system improvements implementation plan summarized in this master plan be reviewed and updated periodically, at least every 5 years, to ensure that the system improvements and associated funding are being cost-effectively spent on pace with growth and development patterns. Factors such as right-of-way acquisitions and new roadway construction or existing roadway repaving/repairs may also affect the implementation schedule and should be considered in updating the implementation plan.

Table 5-2. Town of Cary Reclaimed Water System Capital Improvements Program

Project Number	Project Name	Phase	Diameter (inches)	Total Length (ft)	Total Capital Cost (in 2021 Dollars)
Phase 1 - West Service Area					
WLoop-1	Loop on O'Kelly Chapel Rd	1	6	690	$236,000
W-3	Louis Stephens Drive and Little Drive	1	8	8,400	$3,163,000
			12	4,260	
Phase 1 - North Service Area					
N-7	Evans Road connection	1	12	170	$1,504,000
			16	2,540	
N-8	Watkins Road connection	1	6	4,240	$1,008,000
N-9	Paramount Parkway and Chapel Hill Connection	1	6	3,180	$621,000
N-2	Weston Parkway connection	1	12	2,320	$660,000
N-3	Weston Parkway/Sheldon Drive connection	1	6	1,440	$383,000
Phase 2 - West Service Area					
W-1	Wake Road, Barry Farm Road, and proposed thoroughfare expansion	2	4	5,050	$976,000
W-2	Davis Drive and Development Drive connection	2	4	3,490	$795,000
W-4	Davis Drive extension	2	4	1,600	$286,000
W-5	O'Kelly Chapel Road connection	2	12	1,740	$496,000
W-6	Alston Ave, Rosepine Drive, and Hortons Creek Road extensions	2	6	3,270	$638,000
W-7	Carpenter Fire Station Road connection	2	8	330	$74,000
W-8	Morrisville Parkway connection	2	6	2,590	$679,000
W-9	Bigelow Road	2	4	1,800	$321,000
W-10	Green Level Church Road	2	16	650	$301,000
W-11	Green Level West Road	2	6	4,790	$935,000
W-12	Green Hope School Road to Schooner Drive connections	2	4	5,380	$963,000
W-13	Morrisville Parkway to Stockwell Lane loop	2	4	3,980	$785,000
W-14	Morrisville Parkway loop	2	6	510	$99,000
W-15	Indian Wells Road to Carpenter Fire Station Road loop	2	6	2,070	$448,000
W-16	Carpenter Fire Station Road connection	2	4	290	$329,000
			6	1,420	

Project Number	Project Name	Phase	Diameter (inches)	Total Length (ft)	Total Capital Cost (in 2021 Dollars)
W-17	Howard Road to Highcroft Drive extension	2	6	2,570	$574,000
W-18	Highcroft Drive connection	2	12	1,980	$564,000
W-19	Petty Farm Road connection	2	6	1,890	$369,000
W-20	Off Mahal Avenue extension	2	4	1,050	$320,000
W-21	Royal Delta Drive extension	2	6	210	$41,000
W-22	NC-55 Crossings	2	4	150	$694,000
			6	180	
			12	270	
Phase 2 - North Service Area					
N-1	Evans Road extension south	2	4	2,170	$389,000
N-4	NW Cary Parkway West of N Harrison Ave	2	8	1,370	$301,000
N-5	SAS Loop East of N Harrison Ave	2	4	2,570	$3,278,000
			8	11,890	
N-6	Charger Lane to Research Drive connection	2	6	2,860	$558,000
Phase 2 - South Service Area					
S-1	West Lake Road extension	2	4	140	$2,111,000
			8	4,570	
			14	510	
S-2	Ten-Ten extension, Lorbacher Road extension and Henderson Road Extension	2	4	4,360	$780,000
			TOTAL	**104,940**	**$25,679,000**

Appendix A

Policy Statement 132

CDM Smith

RECLAIMED WATER SYSTEM, EFFECTIVE UTILIZATION

POLICY STATEMENT 132

EFFECTIVE UTILIZATION OF RECLAIMED WATER SYSTEM

PREPARED BY: Jamie Revels, P.E., Director of Utilities
SUPERSEDES: 10/30/14
ADOPTED BY COUNCIL: 6/11/20
EFFECTIVE: 6/11/20

Purpose and Background

Cary developed a reclaimed water system that went online June 22, 2001. Reclaimed water is an integral part of Cary's water resources strategy for meeting long-term water demand requirements. This policy has been adopted to ensure the continued orderly expansion and effective utilization of the reclaimed water system.

Policy

Residents and businesses within the reclaimed water service area shall utilize Cary's reclaimed water system for secondary water use facilities including irrigation systems, cooling towers, and other potential uses as determined to be feasible by the Director of Utilities. Secondary water use facilities for landscape and ground irrigation systems shall be required to use reclaimed water, where available. All other secondary water use facilities, such as cooling towers, shall be encouraged to utilize reclaimed water, where available.

Cary has designated a reclaimed water service area, as shown in Figure 1, where reclaimed water will be provided according to the Reclaimed Water Master Plan. For development within the reclaimed water service area the developer shall install, and shall be responsible for the full cost of, reclaimed water infrastructure along the entire site frontage as well as any required reclaimed water infrastructure within the site. The developer shall extend the reclaimed water system to the development and shall be responsible for the full cost of this infrastructure. If reclaimed water is unavailable, the developer shall install a temporary interconnection with the potable water system and all on-site secondary water use facilities identified for reclaimed water shall be designed to be readily converted to use reclaimed water when reclaimed water supply is available to the site. Cary may provide potable water supply to secondary water use facilities until reclaimed water is available to the site and connection to the Cary's reclaimed water system is possible. The potable water supply shall be isolated by suitable backflow prevention as required by the Cary Code of Ordinances (Chapter 36, Utilities) and the Standard Specifications and Details manual. Once reclaimed water is available to the site, permanent disconnection from the potable water system and connection to the reclaimed water system is required.

There may be limited circumstances in which strict adherence to this Policy is not feasible or desirable. In these circumstances, the Director of Utilities may approve development which does not conform to the standards set forth in this policy if such development (i) will not adversely impact Cary infrastructure, and (ii) will maintain the intent and purpose of the Policy.

See Figure 1, the reclaimed water service area.

RELATED POLICY STATEMENTS:

Other policy statements include provisions related to this policy statement, including but not limited to: Utility System Extension and Connection Policy, Policy Statement 23.

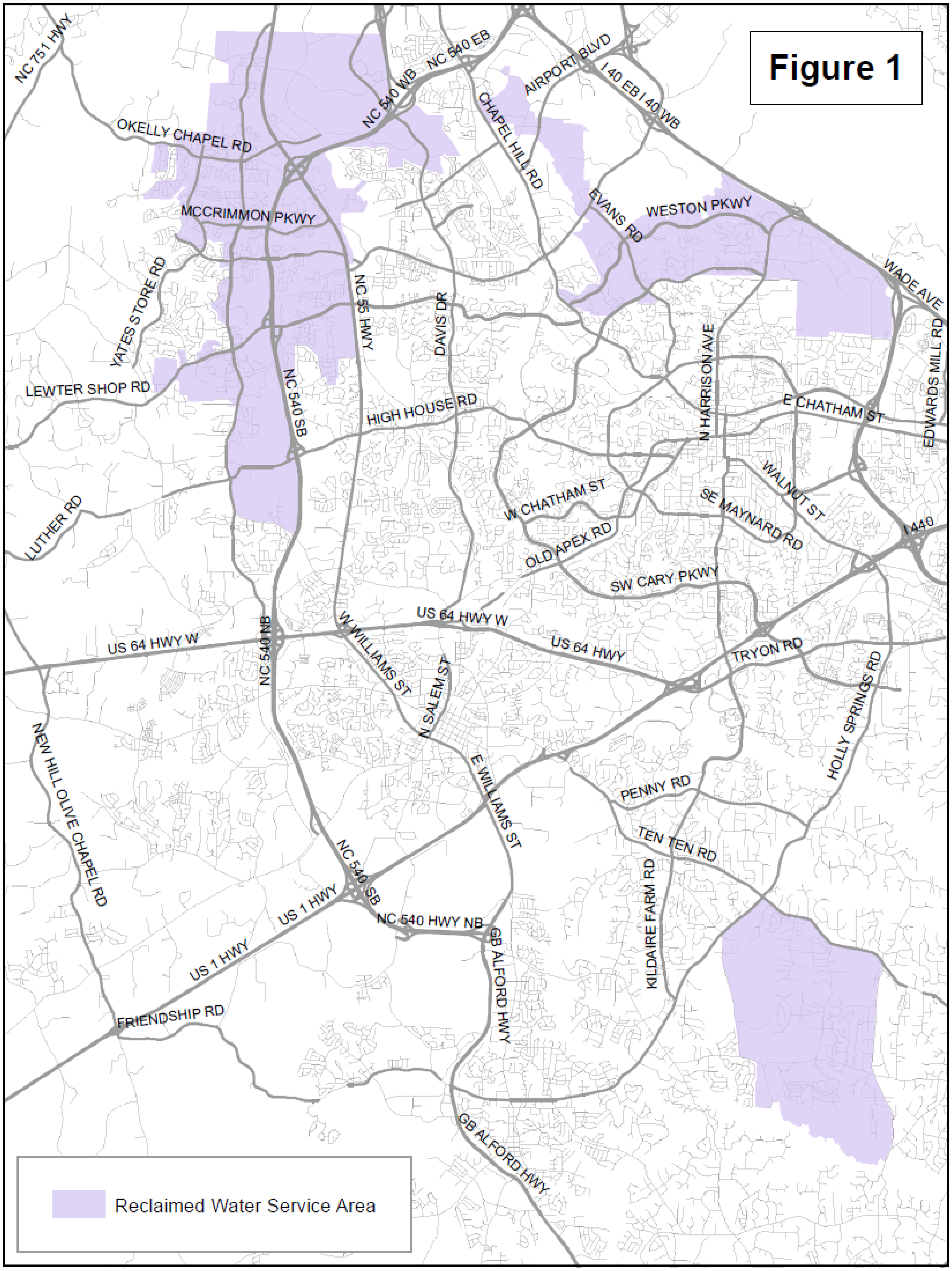
Figure 1
Reclaimed Water Service Area
NC 751 HWY
NC 540 WB
NC 540 EB
AIRPORT BLVD
I 40 EB
I 40 WB
OKELLY CHAPEL RD
CHAPEL HILL RD
MCCRIMMON PKWY
EVANS RD
WESTON PKWY
YATES STORE RD
NC 55 HWY
DAVIS DR
WADE AVE
EDWARDS MILL RD
LEWTER SHOP RD
NC 540 SB
N HARRISON AVE
HIGH HOUSE RD
E CHATHAM ST
WALNUT ST
W CHATHAM ST
SE MAYNARD RD
LUTHER RD
OLD APEX RD
I 440
SW CARY PKWY
US 64 HWY W
US 64 HWY W
NC 540 NB
W WILLIAMS ST
US 64 HWY
TRYON RD
N SALEM ST
HOLLY SPRINGS RD
NEW HILL OLIVE CHAPEL RD
E WILLIAMS ST
PENNY RD
TEN TEN RD
NC 540 SB
US 1 HWY
NC 540 HWY NB
KILDAIRE FARM RD
US 1 HWY
GB ALFORD HWY
FRIENDSHIP RD
GB ALFORD HWY

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