SECTION 3

Existing Water System Operations

This section documents the current operation of the Town of Cary water distribution system and provides key information about the following infrastructure components: elevated and ground storage tanks (ET and GST), water mains, pump stations, control valves, and master meters. This information serves as the basis for the subsequent system analysis.

The major system facilities that make up the Town of Cary's water distribution system are shown in Figure 3-1. These facilities are discussed in detail in the following subsections:

- Pressure zones
- Primary supply sources
- Emergency interconnections
- Storage facilities
- Pump stations
- Control valve stations
- Master meters
- Transmission and distribution pipelines

3.1 Pressure Zones

Water systems are commonly divided into separate hydraulic regions, known as pressure zones (PZs), to maintain adequate pressures throughout the distribution system regardless of topographical variation. A reference pressure, referred to as the hydraulic grade line (HGL), is typically identified for each PZ to indicate the elevation of the maximum pressure expected during low demands. In a PZ with an elevated storage tank, the high water level in the tank may be identified as the HGL. In a PZ without an elevated storage tank, the HGL may be specified based on the discharge pressure from a booster pump station (BPS), groundwater well, pressure-regulating valve station, or other water supply facility. Water conveyed to a high pressure zone must be pumped, and water conveyed to a lower-pressure zone must be regulated through a valve, such as a pressure reducing valve (PRV). Therefore, pumps and valves are usually the boundary points that separate PZs.

The Town's service area ranges in elevation from approximately 251 feet above mean sea level (msl) in the western portion of the water system to about 520 feet msl in the central portion of the system. Based on this range of elevations, the water system has been divided into three PZs: Western, Central, and Southern (Figure 3-1). Table 3-1 provides details on each PZ.

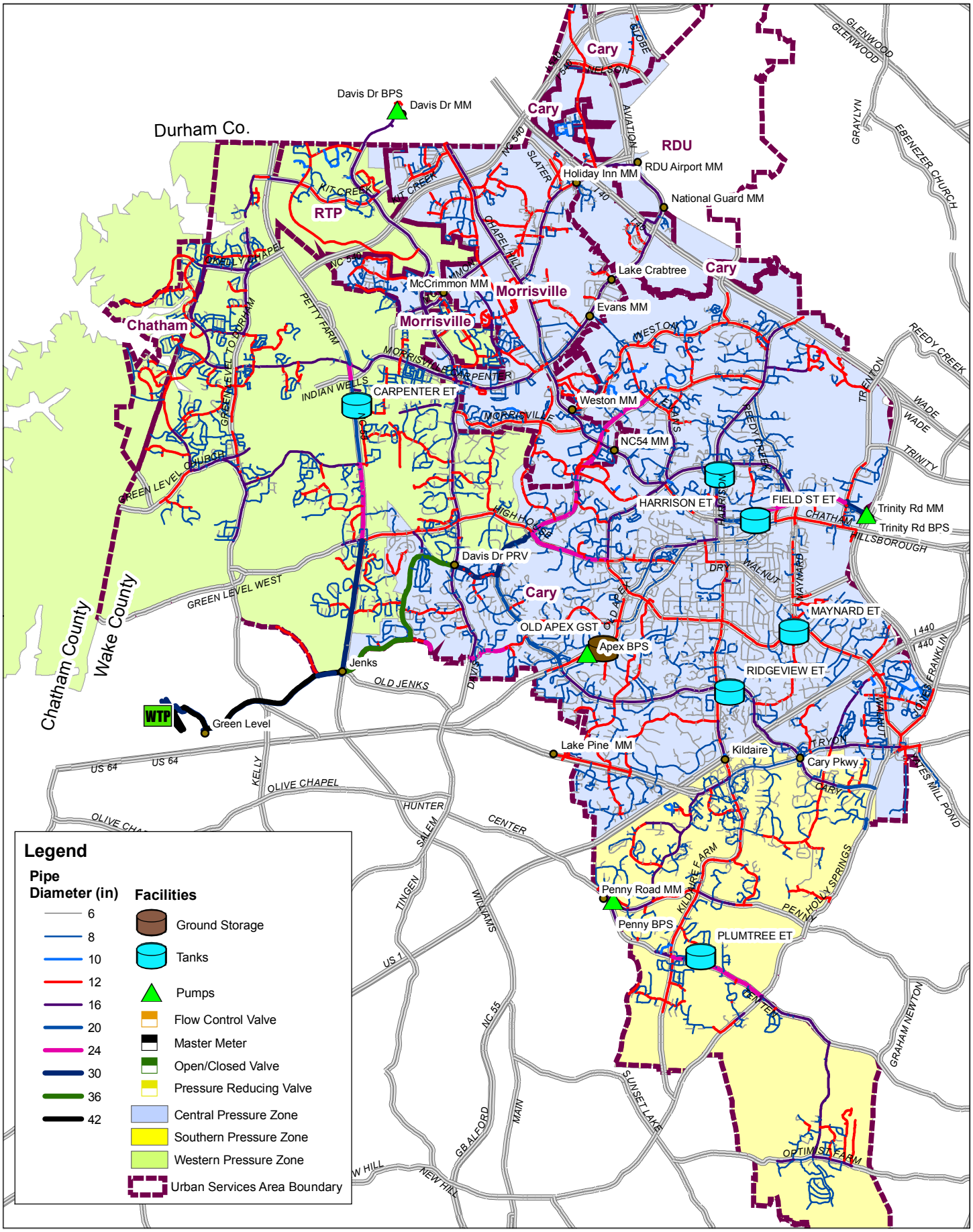

FIGURE 3-1
Town of Cary Distribution System

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TABLE 3-1
Pressure Zone Details

Pressure Zone	HGL (ft msl)	Elevations Served (ft msl)	Pressure Range[a] (psi)	Water System Facilities[e]		
				Pump Stations[b]	Storage Tanks	Control Valves
Western (WPZ)	540	251-435	125-45	Cary/Apex Water Treatment Plant High Service Pump Station (HSPS) Davis Drive BPS	Carpenter ET	Davis Drive PRV
Central (CPZ)	641	280-520	156-52	Cary/Apex Water Treatment Plant (WTP) HSPS Trinity Rd. BPS Old Apex BPS Station	Harrison ET Field Street ET Maynard ET Ridgeview ET Old Apex GST	Old Apex Tank Fill Low Zone PRV[c]
Southern (SPZ)	595	330-488	115-46	Penny Rd BPS	Plumtree ET	Kildaire Farm Road OCV Cary Parkway OCV[d]

[a] Pressure range is calculated as (HGL-Elevation)/2.31. Actual pressures vary depending on tank level, localized demand, and hydraulic effect of control valves and pump stations.

[b] Three booster pumping facilities in the water system are characterized as "emergency supplies" as shown in Table 3-2 (Davis Drive, Trinity Road, and Penny Road BPSs). The Old Apex BPS located in the CPZ is utilized for re-pumping stored water from the Old Apex GST.

[c] A small low pressure zone in the Morrisville area in the vicinity of Church Street, Chapel Hill Road, and Aviation Parkway is supplied by the CPZ through a PRV (pressure setting not known at time of study).

[d] Kildaire Farm Road and Cary Parkway control valves are manually operated fully open/fully closed valves (OCV). The valves do not operate based on a flow or pressure set-point; flow is monitored via Supervisory Control and Data Acquisition (SCADA) system.

[e] Green Level PRV and Jenks flow control valve (FCV) supply Town of Apex. See Table 3-5 for details.

3.2 Primary Supply Sources

Jordan Lake supplies raw water to the Cary/Apex WTP, which is the raw water supply to the Town of Cary. The WTP currently has a total capacity of 40 million gallons per day (mgd) and plans to expand the plant to at least 56 mgd are underway. The Cary/Apex WTP and high service pump station (HSPS) are located on Wimberly Road and supply the WPZ and CPZ through two transmission parallel mains (30-inch diameter and 42-inch diameter) that are 2.9 miles and 2.8 miles in length, respectively. The CPZ supplies the SPZ via the Kildaire Farm Road and Cary Parkway control valves. The Town of Apex is supplied by the 42-inch transmission main through two active master meter control valves located at Jenks Road and Green Level Road.

3.3 Emergency Interconnections

Water distribution systems are often connected to neighboring water systems to allow the sharing of supplies to meet peak demands, during short-term emergencies, or during planned shutdowns of a primary supply source. For most systems, emergency interconnections are not typically used during normal operations of the water system.

The Town of Cary system has three available emergency interconnections, one each with the City of Durham, City of Raleigh, and Town of Apex. These interconnections are located at the Davis Drive BPS, the Trinity Road BPS, and the Penny Road BPS, respectively. The Penny Road BPS serves as a connection between the Town of Cary's SPZ and the Town of Apex. The Trinity Road BPS and Penny Road BPS are considered emergency connections only. These three interconnections are further detailed in Tables 3-2 and 3-4. The Davis Drive BPS can also be used to supply water to Durham from Cary. At the Trinity Road BPS interconnection, Cary can supply water to Raleigh by gravity. There is an additional emergency interconnection with the Town of Apex at Lake Pine Drive which was not considered in this Master Plan at the direction of the Town.

TABLE 3-2
Emergency Interconnections

Interconnection Name/Location	Agency	Firm Pumping Capacity (mgd)[a]	Total Pumping Capacity (mgd)	Notes
Davis Drive BPS	City of Durham	2.8	5.6	To WPZ from Durham via BPS *(and to Durham by pumping)*
Trinity Road BPS	City of Raleigh	8.0	12.0	To CPZ via BPS *(and to Raleigh by gravity)*
Penny Road BPS	Town of Apex	1.5	3.0	To SPZ from Town of Apex via BPS

[a] Firm capacities of Trinity Road BPS and Penny Road BPS are based on manufacturer's pump curve data, not field-derived pump test data or modeling analysis. Additional information on Davis Drive BPS capacity is provided in Table 3-4.

3.4 Storage Facilities

Water distribution systems rely on stored water to help equalize fluctuations between supply and demand, to supply sufficient water for firefighting, and to meet short-term demands during an emergency or an unplanned outage of a major source of supply. The Town has six ETs and one GST. The locations of these storage facilities are shown in Figure 3-1. Table 3-3 lists the storage tanks as well as their total volume and "usable" volume.

"Usable" volume addresses equalization, fire flow, and emergency volumes. It is based on the minimum water level in an elevated tank that is necessary to provide approximately 30 psi (pounds per square inch) to all areas within the pressure zone. The "usable" volume is not the same as the daily "operational" volume that is utilized for equalization purposes.

Additionally, there are two 3-MG clearwells and one 2-MG clearwell (8 MG total) located at the Cary/Apex WTP. These provide additional storage for the Cary system. However, the clearwells are not operated below half-full (11 feet) in order to ensure adequate chlorine contact time before distribution. For this reason, the "usable" volume for storage allocation in the clearwells is only 4 MG.

TABLE 3-3
Water Storage Tanks

Pressure Zone	Tank	Bottom of Bowl Elevation (ft msl)	High Water Elevation (ft msl)	Approx. Tank Height (ft)	Max Tank Diameter (ft)	Total Volume (MG)	Usable Volume[a] (MG)
Western	Carpenter	500	540	167	100	2.0	2.0
Central	Old Apex[b]	464	487	23	150	3.0	1.75
	Ridgeview	601	641	167	74	1.0	1.0
	Maynard	608.8	646	166	50	0.5	0.5
	Harrison	606	641	163	75	1.0	1.0
	Field Street	601	641	170	64	0.75	0.75
Southern	Plumtree	555	595	141	74	1.0	1.0
					Elevated and Re-Pumped Storage	**9.25**	**8.00**
					Clearwell Storage at the Cary/Apex WTP[c]	**8.0**	**4.0**
					Total System Storage	**17.25**	**12.03**

[a] The "usable" volume is based on the minimum level in an elevated tank that provides at least 30 psi static pressure to all areas within the pressure zone. Refer to Section 5 for pressure criteria.

[b] Operational volume of Old Apex GST is 1.75 MG based on high water alarm of 13.5-ft and "pump stop" set-point of 5.5-ft. The Town may be able to increase operational volume by altering tank level set-points.

[c] Approximately half of the clearwell storage is required for chlorine contact time and cannot be allocated for storage.

3.5 Pump Stations

The Town's system includes one HSPS at the Cary/Apex WTP serving both the CPZ and WPZ, and four BPSs. Table 3-4 provides detailed information about each pump station in the Town of Cary system.

BPSs are required to convey water from GSTs into the distribution system or from lower-pressure zones into higher-pressure zones. Pump stations typically consist of two or more individual pumps. The capacity of the station with the largest pump out of service is typically referred to as the "firm" capacity of the pump station.

For this analysis, the capacity of the HSPS was based on the intersection of the system curve in the model with the pump curves provided by the Town. This resulted in a total capacity of approximately 41 mgd and a firm capacity of approximately 37 mgd based on the

modeling analysis described in Section 6.4. Since the CPZ pumps can supply the WPZ, the firm capacity of the HSPS was determined with one of the large CPZ pumps out of service.

Three of the BPSs are used only during emergencies: the Davis Drive BPS, Trinity Road BPS and Penny Road BPS. The Old Apex BPS operates in conjunction with the Old Apex GST and can be used for both peak demand and emergency situations.

TABLE 3-4
Pump Station Data

Facility	Suction/Discharge Description	Design Flow (gpm)	Design Flow (MDG)	Head (ft)	Manufacturer/Model Number/ Serial Number	Pump Function	Operation & Control
Cary/Apex WTP HSPS WPZ Pumps[a,e]	Two pumps draw from two 3-MG and one 2-MG clearwells and convey flow to the WPZ through a 30" main	3,825	5.5	305	Ingersoll-Dresser 16ENL-4 SN: 0010MS001203-1	Primary supply to the WPZ	Manual observation of Carpenter Tank level
		3,825	5.5	305	Ingersoll-Dresser 16ENL-4 SN: 0010MS001203-2		
Cary/Apex WTP HSPS CPZ Pumps[a,e]	Five pumps draw from two 3 MG clearwells and convey flow to the CPZ and Town of Apex through a 42" main	2,808	4.0	450	Fairbanks Morse 18EKL-4 SN: 0010MS001201-1,2	Primary supply to the CPZ and SPZ and Town of Apex	Manual observation of Maynard Tank level
		2,808	4.0	450			
		6,255	9.0	450	Fairbanks Morse 25KKL-4 SN: 0010MS001200-1,2		
		6,255	9.0	450			
		6,255	9.0	450	Fairbanks Morse 25KKL-4 SN: 0010MS001202-1		
Davis Drive BPS[b]	One pump to Durham from WPZ	2,430	3.5	175	Floway 23009-1-3 (4-stage)	Emergency interconnection	Manual
	One pump to WPZ from Durham	1,940[c]	2.8[c]	60[c]	Floway 23009-1-2 (1-stage)		
	One pump to WPZ from Durham	1,940[c]	2.8[c]	60[c]	Floway 23009-1-1 (1-stage)		
Trinity Road BPS[e]	Three pumps convey flow to the CPZ from the City of Raleigh	2,750	4.0	100	Fairbanks Morse 15H(7000W)	Emergency interconnection	Manual
		2,750	4.0	100			
		2,750	4.0	100			
Penny Road BPS[d]	Two pumps convey flow to SPZ from the Town of Apex	1,050	1.5	36	Fairbanks Morse 11M (7000) K3M2-054986-0,1	Emergency interconnection	Manual
		1,050	1.5	36			

TABLE 3-4
Pump Station Data

Facility	Suction/Discharge Description	Design Flow (gpm)	Design Flow (MDG)	Head (ft)	Manufacturer/Model Number/ Serial Number	Pump Function	Operation & Control
Old Apex BPS Station[e]	Three pumps convey water from Old Apex GST to the CPZ	2,315	3.3	195	Fairbanks Morse 204460-0,1,2	Used seasonally to provide additional system storage to aid in peak hour demand management or emergency operation	Tank fill start: 11PM Tank fill stop: 6 AM or high water level (HWL) alarm of 13.5-ft Pump on: 6AM Pumps off: 12-2PM or low water level LWL=5.5-ft Pumps/tank fill valve inactive: 2PM-11PM
		2,315	3.3	195			
		2,315	3.3	195			

[a] Refer to Figure 6-5 for Cary/Apex WTP HSPS pump and system curve information.

[b] Water System Interconnection Study evaluated Durham pump station capacities under various flow regimes (Hazen and Sawyer, 2008).

[c] Can also gravity flow from Durham to Cary WPZ at lower flow.

[d] Penny Road BPS capacity taken from pump name plate values, not actual operating points.

[e] Cary/Apex WTP HSPS, Trinity Road BPS and Old Apex BPS pump capacities are taken from manufacturer pump curves, not actual operating points.

3.6 Control Valve Stations

Pressure regulating and flow control valve stations allow distribution systems to transfer water in a controlled manner from a higher PZ to a lower PZ or into an ET or GST. There are six types of control valves that are commonly used in water distribution systems:

- **Pressure reducing valve (PRV):** A PRV modulates to maintain a preset downstream pressure setting. Typically, the pressure setting is adjusted locally in the vault using a small pilot valve and analogue pressure gauge, but a PRV can also be controlled using a digital pressure indicating transmitter (PIT) and controller. A PRV works by opening until the downstream pressure matches the pressure set-point. The only functioning PRVs in the Town of Cary system are the Davis Drive and Green Level PRVs. The Davis Drive PRV conveys flow from the CPZ to the WPZ and operates at a setting of 78 psi (570 ft head). The Davis Drive PRV is used only during peak demand or emergencies. The Davis Drive PRV was utilized in 2007 during peak summer demands but was not used in 2008 because peak summer demands were lower than in 2007. (With the addition of a third WPZ pump, described in Section 6, the Davis Drive PRV will primarily be utilized in the future as an emergency supply rather than to supply peak demands.) The Green Level PRV is used to convey flow from the CPZ 42-inch transmission main to the Town of Apex water system. The Green Level PRV setting was not necessary during this study because this connection was simulated as a junction demand in the computer model. An open/close valve (OCV) is also located at the Green Level PRV vault as described below.

- **Open/close valve (OCV):** An OCV does not utilize a flow or pressure setting to regulate flow. Rather, the valve is opened or closed to achieve a desired output such as tank level or pressure change in the downstream system. Typically, this type of valve is opened remotely via the SCADA system. The Town of Cary's OCVs are operated remotely via SCADA. An OCV can be either a fully open/fully closed valve or a partially open/fully closed valve. The Cary Parkway and Kildaire Farm Road control valves are fully open/fully closed OCVs which are used to provide a desired turn-over in the Plumtree ET in the SPZ. During peak summer demands, both the Cary Parkway and Kildaire Farm Road OCVs are open all day and closed only for a few hours to force turn-over of the Plumtree ET. The Old Apex tank fill valve is a partially open/fully closed OCV which is used to fill the Old Apex GST in the CPZ. The Green Level OCV is a fully open/fully closed OCV and is used in conjunction with the Green Level PRV to regulate flow to the Town of Apex system along with the Jenks Road FCV. The functionality of the Green Level supply was simulated as a junction demand in the computer model. For this reason, the control settings for the Green Level OCV and PRV were not needed for this study.

- **Pressure sustaining valve (PSV):** A PSV modulates to maintain a preset minimum upstream pressure setting; if the upstream pressure drops, then the valve will close until the upstream pressure matches the pressure setting. No PSVs are currently located in the Town of Cary system.

- **Maximum Pressure relief valve (MPRV):** An MPRV opens when the upstream pressure exceeds a preset maximum pressure setting. An MPRV is commonly used at pump

stations to limit dangerously high surge pressures. MPRVs are located only at pump stations in the Town of Cary distribution system.

- **Flow control valve (FCV):** A FCV modulates to maintain a preset flow rate through the valve regardless of pressure. This typically requires a flow meter, but some manufacturers provide control modules that interpolate the valve position and pressure drop across the valve to derive the flow rate. The only functioning FCV in the Town of Cary system is the Jenks Road FCV, which uses a physical flow meter. Operations staff typically set the Jenks FCV at a constant flow rate for the day or season and then remotely open or close the Green Level OCV to convey the necessary flow to the Town of Apex system. The Old Apex tank fill valve is specified as a rate of flow controller (ROFC) but is operated as an OCV and is throttled at a constant position.
- **Altitude Valve (AV):** An AV is commonly used at elevated tanks to prevent overflow. The AV works by throttling closed upon reaching a pressure set-point, which is equivalent to the overflow head of the tank. All elevated tanks in the Town of Cary system have AVs.

A summary of the six active control valves used in the Town of Cary system is provided in Table 3-5.

TABLE 3-5
Active Control Valves

Name/Location	Pressure Zone		Valve Type	Valve Diameter (in)	Valve Setting	SCADA Control
	Upstream	Downstream				
Davis Drive	Central	Western	PRV	16	570-ft m.s.l.	Open/close
Kildaire Farm Rd.[a]	Central	Southern	OCV	10	Fully Open	Open/close
Cary Parkway[a]	Central	Southern	OCV	10	Fully Open	Open/close
Old Apex Tank Fill[b]	Central	Central	OCV	16	Partially Open	Open/close
Jenks Road[c]	Central	Town of Apex	FCV	18	0.5-1.0 mgd	Open/close
Green Level[c]	Central	Town of Apex	PRV	24	Information not Available	Open/close

[a] Both valves were designed as PRVs but utilized as fully open/fully closed OCVs.

[b] The Old Apex tank fill valve is simulated as a flow control valve in the computer model.

[c] The Jenks Road and Green Level control valves are simulated as a junction demand in the computer model.

3.7 Master Meters

Master meters in the Town of Cary system are flow meters between two neighboring utilities or jurisdictions which may or may not have a control valve to control flow. There are 13 master meters in the Cary system, 6 of which are related to the former Morrisville district. Table 3-6 lists the relevant data for these meters, including: name and meter size, pressure zone and location, meter function and location, flow meter type and status, control valve type, and SCADA capabilities.

TABLE 3-6
Master Meter Supplies to Neighboring Jurisdiction

Name and Meter Size	Pressure Zone and Location	Master Meter Function and Location	Flow Meter Type[a]	Status of Master Meter[b]	Control Valve Type	SCADA Monitor & Control
Jenks Road (18")	Central (on 42")	Supply to Town of Apex; Jenks Road & NC 55	P	Open - SM	FCV	Yes
Green Level (24")	Central (on 42")	Supply to Town of Apex; Intersection of Jenks & Green Level Church Road	M	Open - SM	PRV & OCV	Yes
Lake Pine (Size N/A)	Central (Apex Boundary)	Emergency Supply to Apex; US 64 and Lake Pine Drive	N/A	Closed – MR	N/A	No
Weston (8")	Central (Morrisville Boundary)	Supply to Morrisville; Weston Parkway east of NC 54	M	Open - NM	None	No
Evans (8")	Central (Morrisville Boundary)	Supply to Morrisville; Evans Rd south of Aviation Parkway	TS	Open – NM	Check Valve	No
Highway 54 (10")	Central (Morrisville Boundary)	Supply to Morrisville; Chapel Hill Road near Wilson Rd	M	Open – NM	None	No
McCrimmon (6")	Western (Morrisville Boundary)	Supply to Morrisville; McCrimmon & Davis Drive Road	M	Closed – NM	None	No
Lake Crabtree (8")	Central (Near Airport)	Supply leaving Morrisville; Aviation Parkway	TS	Open – NM	Check Valve	No
Holiday Inn 1 & 2 (both 8")	Central (Near Airport)	Supply leaving Morrisville; Airport Boulevard	TS	Open – NM	Check Valve	No
National Guard 1, 2 & 3 (4" and 8")	Central (Near Airport)	Supply to National Guard; Aviation Parkway (Sheetz Gas Station)	TC	Open – MR	None	No
RDU Airport (8")	Central (Near Airport)	Supply to RDU Airport; Near the airport terminal entrance	TS	Open – MR	None	No
Trinity Road Pump Station (16")	Central (Raleigh Boundary)	Current study to reverse meter orientation to allow Central 641 PZ flow to Raleigh 588 PZ	T	Closed – NM	None	No
Penny Road (two 8")	Southern	Emergency Supply to/from Apex; Penny & Ten Ten Roads	T	Closed – MR	OCV	No

[a] Meter Types (P = Propeller; M = Magnetic, TS = Turbine Single, TC = Turbine Compound, V = Venturi)

[b] Meter Status (SM = Meter monitored from SCADA; NM = Meter not monitored from SCADA or manually read; MR = Manually read for customer billing)

N/A = Information not available

3.8 Transmission and Distribution Pipelines

The Town of Cary system dates to the 1960s, with pipe installations occurring periodically over the last 50 years, and includes over approximately 800 miles of pipelines ranging from 2- to 42-inches in diameter. Pipelines 12-inches in diameter and larger are considered transmission mains, and the smaller pipes are considered distribution mains. Table 3-7 lists the estimated footage of pipelines by diameter and material.

The majority of the pipelines, about 62 percent, are made of ductile iron. Asbestos cement pipes comprise the second largest group at 23 percent. The remaining pipe is comprised of polyvinyl chloride at 13 percent and unknown material at less than 3 percent. Approximately 30 percent of the pipelines are trunk mains (12-inches and greater) and the remaining 70 percent are distribution mains (smaller than 12-inches).

TABLE 3-7
Pipes by Size and Material Based on GIS Data

Diameter (in)	Length of Pipe by Material (ft)				Total Length (ft)	Total Length (%)
	AC[a]	PVC[b]	DIP[c]	Unknown[d]		
4	-	-	438	-	438	0.01%
6	456,058	184,516	516,972	24,658	1,182,203	27.94%
8	294,590	242,295	1,163,555	22,079	1,722,520	40.71%
10	3,601	2,700	23,771	361	30,433	0.72%
12	141,845	76,630	542,228	18,630	779,332	18.42%
14	-	-	53		53	0.00%
16	34,867	24,752	291,825	13,803	365,247	8.63%
20	5,009	5,182	15,430	468	26,089	0.62%
24	5,509	11,674	28,201	2,367	47,752	1.13%
30	724	2,328	30,949	4,605	38,607	0.91%
36	14,726	893	-	-	15,619	0.37%
42	-	-	13,962	9,077	23,039	0.54%
Totals (ft)	**956,928**	**550,971**	**2,627,384**	**96,049**	**4,231,332**	
Totals (miles)	**181**	**104**	**498**	**18**		
Percent (%)	**22.6%**	**13.0%**	**62.1%**	**2.3%**		

[a] AC: Asbestos cement

[b] PVC: Polyvinyl chloride

[c] DIP: Ductile iron pipe

[d] Unknown: Material type unclassified