Wingate Water and Wastewater System Master Plan

Submitted to:

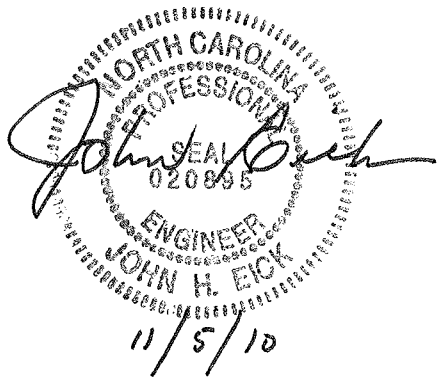
Town of Wingate
North Carolina

November 2010

STEARNS & WHELER PLLC
A GHD-Affiliated Company

Water and Wastewater System Master Plan

November 5, 2010
Final



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Section 1 Executive Summary

1.1 Background

Recently, the Town of Wingate completed a comprehensive land use planning project designed to position the town for growth over the next ten years. This plan, known as Wingate 2020, embraces Wingate's history as a college town and supports a pedestrian-friendly town with a vibrant retail downtown.

During the same time frame, the town retained Stearns & Wheler, PLLC, a GHD-affiliated company, to develop a 10-year water and wastewater master plan. This plan is an extension of the comprehensive land use plan and will incorporate the planned growth defined by it. It will also provide an evaluation of the existing water and wastewater systems, provide up-to-date maps and hydraulic models of each system, and provide a prioritized planning-level capital improvement program for both the rehabilitation of the existing system and new improvements required to address planned growth.

Located in Union County, North Carolina, the town has grown around Wingate University. The town is influenced by the City of Charlotte and the nearby City of Monroe, yet it remains a small college town. Wingate's non-student population is estimated to be 3,084 with an additional 1,140 part-time and full-time students.

Per the Wingate 2020 plan, the town's population is expected to increase to 6,480 people by 2020 including students. This will increase to around 7,900 people by 2030.

1.2 Scope of Work

This study focused primarily on the ability of the distribution and collection systems to reliably fulfill their intended purposes. The scope did not include evaluations of source water quantity or quality, future regulations, or intergovernmental agreements between the town and adjacent jurisdictions. Stearns & Wheler did not conduct systematic field inspections to assess facility condition. Cost opinions are based upon recent similar projects, and taken together should provide an accurate picture of future capital programs. However, the costs for any single capital project could vary significantly from those shown in the study based upon site-specific factors beyond the scope of this evaluation. For this reason, cost opinions should be updated immediately prior to appropriating budget for specific projects.

1.3 Water System Recommendations

Wingate currently provides retail water service to its citizens and the University. Union County, in turn, provides wholesale water service to the town. Wingate's water system is comprised of over 90,000 feet of pipe sized from ¾-inch to 12-inches and one elevated water tank. The system was constructed in the 1960s and much of the smaller sized pipe (primarily galvanized steel pipe) is in poor condition.

A distribution system network hydraulic model was recently prepared by others and updated as part of this plan. The model was used to simulate how the system would respond under stress. A fire flow condition was modeled during high flow days (i.e., during the hot summer months).

The results of the fire flow analysis under existing conditions revealed that areas of the distribution system, including the central area of town, were able to sustain high flows when stressed. Other areas showed deficiencies with respect to available fire flow. Areas of town served by 2-inch pipe failed the fire flow analysis, as did areas with incomplete looping of the distribution system. Under future flow conditions, the response to fire flow conditions was exacerbated.

In order to provide adequate fire flow to all areas of the town, it is recommended that several water improvement projects be undertaken in the near future. This includes upsizing existing 6-inch pipe at various locations with 12-inch water mains. The cost of these improvements total approximately $3.5 million. It is recommended that an additional $2.1+ million be spent over the next 20 years to prepare for future growth and replace aging galvanized pipe.

The majority of the improvements recommended to address the aforementioned deficiencies under current conditions involve increasing pipe sizes to accommodate the higher flow rates required for fire protection. These improvements have the added benefit of increasing the robustness of the water distribution system and thereby increasing its ability to cope with the projected water demands of 2020 and 2030.

1.4 Wastewater System Recommendations

As with the water system, Wingate provides retail wastewater service to its citizens and the University. Union County provides wholesale wastewater service to the town.

The majority of Wingate's wastewater collection system was constructed in the mid-1970s. The system consists of primarily vitrified clay pipe (VCP) and polyvinyl chloride pipe (PVC). The collection system also contains a small amount of ductile iron pipe (DIP) and cast iron pipe (CIP). The town maintains Diane Street pumping station. The privately-owned Forest Hills

High School, Trellis and Jail Pumping Stations utilize the town's collection system at various points.

A collection system network hydraulic model was developed as part of this plan. The model was used to simulate how the system would respond under dry and wet weather flows.

The town's collection system is currently sized to handle the normal flows that would be seen by a town of this size, both under existing and 2030 conditions. However the system is aged and experiencing a high level of infiltration (groundwater that enters the gravity sewers through cracks, open joints, and damaged pipe) and inflow (surface water that enters the gravity sewer through damaged or exposed manhole or pipe openings or illegal surface drain connections). This results in the collection system operating above capacity during wet weather events. Wastewater overflows have occurred throughout the system during storm events.

The town has been working to rehabilitate the collection system, and has recently rehabilitated the sewers and manholes serving the Dianne Street pumping station. In addition, improvements to that pumping station have been made. Plans are in place to investigate the remaining system, prioritize the needed improvements, and continue to rehabilitate the system. It is recommended these plans be implemented and improvements made.

To help quantify the efforts, Stearns & Wheler made an inventory of the remaining vitrified clay pipe (VCP) that would most likely need to be rehabilitated. The cost of rehabilitating the remaining pipe and manholes is approximately $4.6 million.

1.5 Capital Improvements Program

Table 1-1 provides a listing of projects with planned expenditures over the next twenty years. Note that there are some recommendations in Section 5 that are not necessarily considered capital improvements or that can not be quantified. They are not included in the Capital Improvement Projects table but remain an important aspect of system sustainability.

Table 1-1 Capital Improvements Program

	Project	Capital Cost, $Million											
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	By 2030	Total
W-1	Replace 6 in. and 8 in. pipe along and across Highway 74 with 12 in. PVC pipe	1.10											1.10
W-2	Replace 6 in. pipe on Elm St. with 12 in. PVC pipe Extend Bivens St. pipe south towards Highway 74 with 12 in. PVC pipe and interconnect to the Union County main for redundancy	0.16	0.73										0.89
W-3	Replace 2 in. galvanized pipe on College St. with 6 in. PVC pipe Install connection at College St. and Jerome St. with 6 in. PVC pipe to complete loop		0.06	0.55									0.61
W-5	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Elm St., and south of Faculty Dr.		0.04	0.31									0.35
S-1	Rehabilitation of 62,000 feet of VCP and manholes in wastewater collection system.	0.44	1.04	1.04	1.04	1.04							4.60
W-4	Replace 2 in. galvanized pipe on Circle Dr. with 6 in. PVC pipe.				0.18								0.18
W-6	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Faculty Dr								0.03	0.27			0.30
W-7	Replace 6 in. pipe on Maye St. with 8 in. PVC pipe.								0.09	0.74			0.83
W-8	Replace 6 in. cast iron and 2 in. galvanized pipe on S. Main St. with 8 in. PVC pipe											0.48	0.48
W-9	General replacement of galvanized pipe with PVC pipe of same size.						0.27	0.27	0.27	0.27	0.29		1.37
	TOTAL	1.70	1.87	1.90	1.22	1.04	0.27	0.27	0.39	1.28	0.29	0.48	10.71

Section 2 Water and Sewer Master Plan Overview

In 2009, the Town of Wingate embarked on a comprehensive land use planning project designed to position the town for growth over the next ten years. The planning process was led by GHD Consulting, Inc. The recently completed Wingate 2020 plan embraces Wingate's history as a college town and supports a pedestrian-friendly town with a vibrant retail downtown.

During the same time frame, the town retained Stearns & Wheler, PLLC, a GHD-Affiliated Company, to develop a 10-year water and wastewater master plan. This plan is an element of the comprehensive land use plan and will incorporate the planned growth defined by it. It will also provide an evaluation of the existing water and wastewater systems, provide up-to-date maps and hydraulic models of each system, and provide a prioritized planning-level capital improvement program for both the rehabilitation of the existing system and new improvements required to address planned growth.

2.1 Background

The Town of Wingate is located in Union County, North Carolina, just east of the City of Monroe. The town was built around Wingate University (formerly Wingate College), which was founded in 1896. Although influenced by the City of Monroe and the City of Charlotte located in neighboring Mecklenburg County, Wingate has remained a small college town. Wingate's non-student population is estimated to be 3,084 with an additional 1,140 part-time and full-time students attending the college in the 2011 school year.

The town does not own or operate treatment plants for either the water or sewer systems. Thus the Wingate systems are considered satellite systems. The town owns and operates the collection and distribution systems only. There are areas that are served with water but remain on septic and conversely some have public sewer but use wells.

2.1.1 Existing Water System

Wingate currently provides retail water service to its citizens and the University. Union County, in turn, provides wholesale water service to the town. Union County treats surface water for delivery to the majority of the western portion of the county. They also purchase treated surface water from Anson County. Potable water delivered to Wingate originates at the Anson County Water Treatment Plant (WTP).

Union County has major water lines, 8-inch and 12-inch, that bisect the town in a north-south manner along Bivens and South Main Streets and in an east-west manner along Highway 74. Wingate receives its water from Union County near the intersection of Highway 74 and Bivens Street where the master meter is located. The town has a 500,000 gallon elevated storage tank near Jerome and Camden Streets. Some smaller water lines are tapped directly into the Union County 12-inch main that extends along Highway 74. There are no booster pump or pressure relief stations within the town's distribution system. There are approximately 75 hydrants and system valves.

Wingate's water distribution system was constructed in the 1960s and consists primarily of 2-inch galvanized steel pipe, 6-inch asbestos cement pipe (AC) and ductile iron pipe (DIP). Table 2-1 is an inventory of the distribution piping.

Table 2-1 Distribution System Inventory

Diameter (in)	AC	CIP	Copper	Ductile Iron	Galvanized	PVC	Grand Total
0.75			732				732
1			1,083				1,083
2					21,208	11,636	32,844
3					100		100
4						285	285
6	9,176	10,630		3,822	183	36,480	60,291
8	280	2,936					3,216
12	961			326		1,062	2,349
Total	10,417	13,566	1,815	4,148	21,491	49,463	100,900

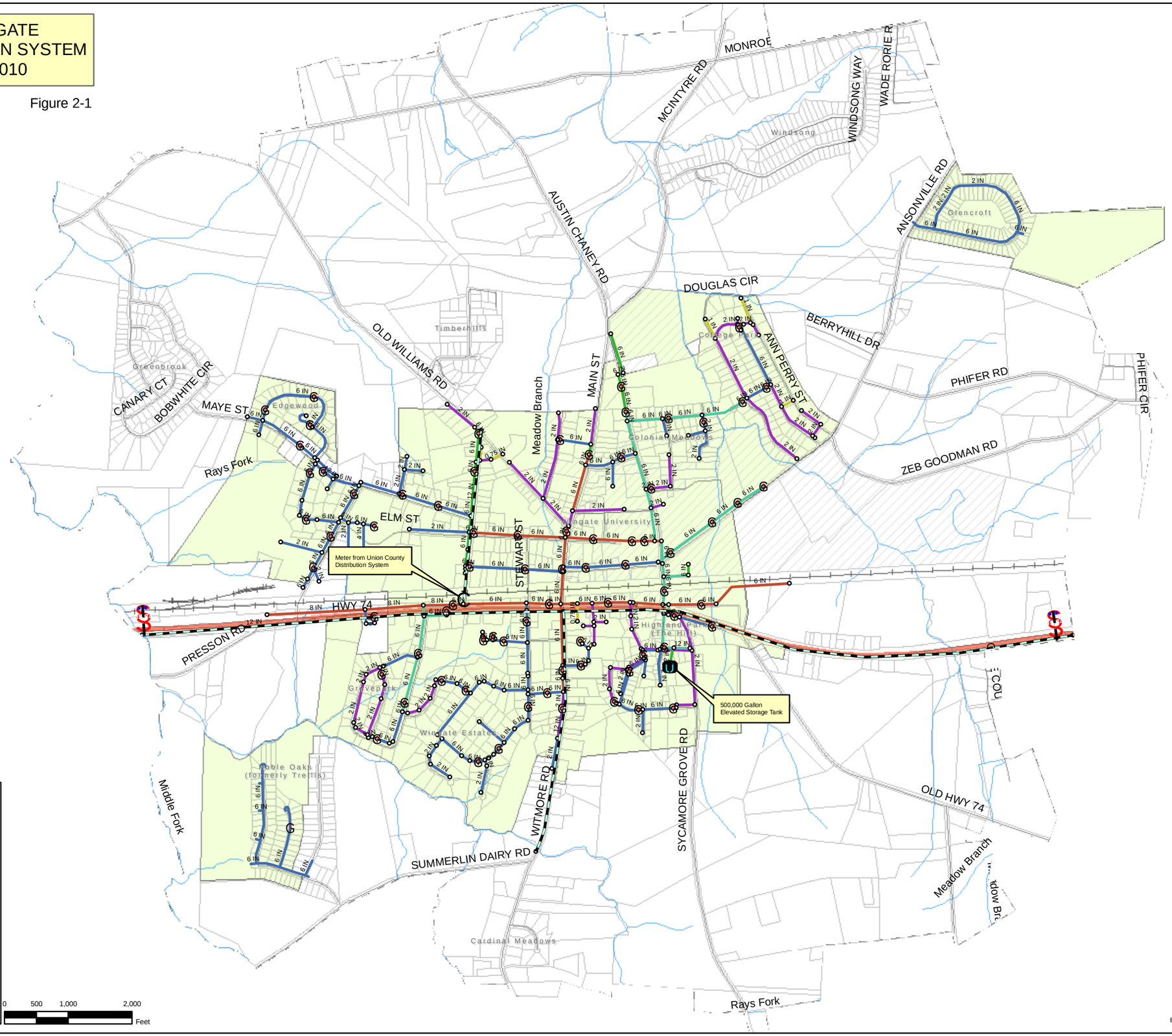
The 50-year old galvanized steel pipe has exceeded its design life of 20 to 30 years. The system has subsequently experienced water line breaks. In addition, Wingate is concerned that some areas of the town have undersized water lines and do not have adequate fire protection.

Wingate has begun rehabilitating its water distribution system. In 2010, the town replaced aging water lines along Bivens Street. In general, the town reports that 6-inch DIP lines are in good condition, 6-inch AC lines are in acceptable condition, and the 2-inch galvanized lines are in very poor condition.

In 2001, a Water System Management Plan was developed that included recommendations for adding additional hydrants, looping the system and increasing line size. Many of these recommendations are still valid.

TOWN OF WINGATE
WATER DISTRIBUTION SYSTEM
NOVEMBER 2010

Figure 2-1



HISTORY:

Wingate's water distribution system was constructed in the 1960s and consists primarily of 2-inch galvanized steel pipe. 6-inch asbestos cement pipe (AC) and ductile iron pipe (DIP) also exists. The 50-year old galvanized steel pipe has exceeded its design life of 20 to 30 years. Water lines have recently been replaced along Bivens Street.

The hydrant locations are approximate and based upon existing maps.

Legend

- Meter
- Hydrants
- Tanks
- Union County Water Main
- Junctions

Pipes

MATERIAL

- AC
- CIP
- Copper
- Ductile Iron
- Galvanized
- PVC
- University_owned_parcels
- ETJ
- Wingate_Town_Limits

STEARNS & WHELER PLLC
A GHD-Affiliated Company

Map created by Stearns & Wheler, PLLC in 2010 as part of the Town of Wingate Water & Sewer Master Plan

Existing data provided by the Town of Wingate was utilized. Its accuracy is not verified.

2.1.2 Existing Wastewater System

As with the water system, Wingate provides retail wastewater service to its citizens and the University. Union County provides wholesale wastewater service to the town.

The majority of Wingate's wastewater collection system was constructed in the mid-1970s. The system consists of primarily vitrified clay pipe (VCP) and polyvinyl chloride pipe (PVC). The collection system also contains a small amount of ductile iron pipe (DIP) and cast iron pipe (CIP). There are approximately 537 manholes in the gravity collection system. The town maintains Diane Street pumping station. The privately-owned Forest Hills High School, Trellis and Jail Pumping Stations utilize the town's collection system at various points. Table 2-2 shows the existing collection system inventory.

Table 2-2 Collection System Inventory

Diameter (in)	Cast Iron CIP** (ft)	Ductile Iron DIP (ft)	PVC* (ft)	Steel (ft)	VCP (ft)	All Materials (ft)
8	517	79	46,836		56,374	103,806
10	92		5,591		668	6,351
12		28	1,134	223	6,326	7,711
15			1,351			1,351
6" force main			5,455			5,455
Total	609	107	60,367	223	63,368	124,674
Manholes						537
Pumping Stations			Diane Street			1

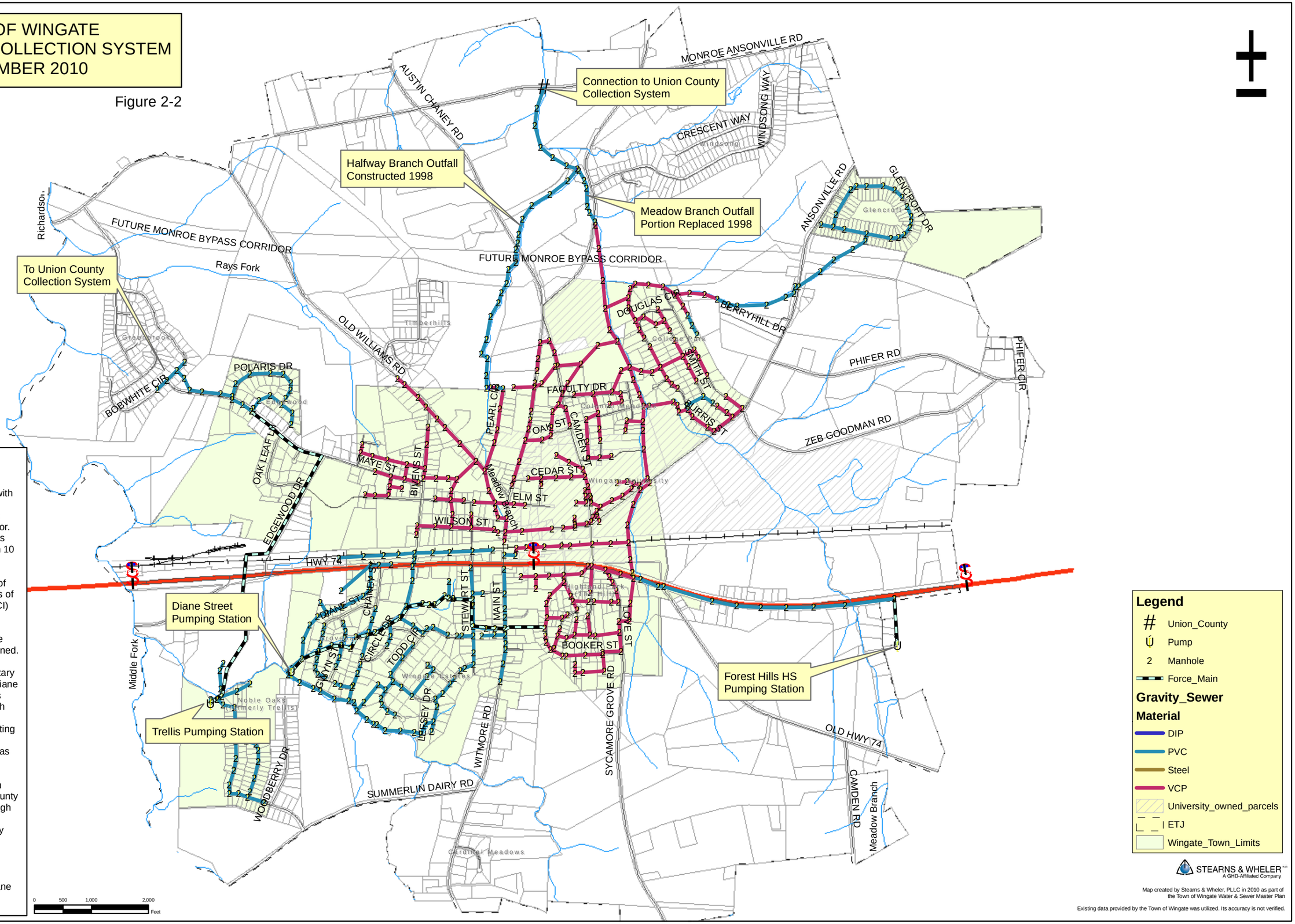
* The Diane Street Basin (Basin 2) sewers are currently being rehabilitated and are included as PVC.

**CIP was used during construction of the original system for creek crossings and where shallow cover exists. It is not shown in the comprehensive collection system map (Figure 2-2).

Figure 2-2 shows the town's existing wastewater collection system. There are several "high priority" areas in the collection system, as deemed by the North Carolina Department of Environment and Natural Resources (15A NCAC 2T .0400). High priority sewers would include any visible sewers, sewers contacting surface waters and sewers subject to undermining by erosion (i.e., near a creek or with minimum cover under a creek). Table 2-3 presents a list of high priority sewers. These areas are required to be inspected once every six months. Referenced manholes refer to those shown on Figure 2-2.

TOWN OF WINGATE
WASTEWATER COLLECTION SYSTEM
NOVEMBER 2010

Figure 2-2



HISTORY:

The majority of the collection system was designed in 1974 with the exception of the Wingate University system and Meadow Branch outfall which existed prior. All collector sewers are 8-inches with larger outfalls ranging from 10 - 15 inches.

Original pipe materials consist of vitrified clay (VC) and segments of ductile iron (DI) and cast iron (CI) where needed. Newer and rehabilitated portions are constructed of polyvinyl chloride (PVC) or cured-in-place (CIP) lined. Several manholes have been rehabilitated since a 2000 Sanitary Sewer Evaluation Study. The Diane Street Pumping Station basin is currently being rehabilitated with CIP and is approximately 40% complete. Additional smoke testing and manhole inspections are currently underway in other areas of the system as well.

Trellis and Edgewood collection systems discharge to Union County to the northwest. Forest Hills High School Pumping Station is maintained by the Union County school system. Trellis Pumping Station is maintained by Union County Public Works. The only pumping station under Town of Wingate responsibility is on Diane Street.

Table 2-3 High Priority Sewers

From Manhole Number	To Manhole Number	Type
3-39	3-40	Aerial Sewer – 36' 8" CIP
2-24	2-25	Aerial Sewer – 18' 10" CIP
2-107	2-108	Aerial Sewer – 72' 8" CIP
2-110	2-111	Shallow Cover – 180' 8" CIP
4-8	4-9	Aerial Sewer through Box Culvert – 273' 12" Steel
MB-R6	MB-R7	Aerial Sewer - 28' 12" DIP
HB-30	HB-31	Shallow Cover over Rip Rap Drainage Ditch – 18' 8" DIP

The town's Diane Street pumping station is a duplex submersible pumping station. Its typical operating point is 275 gallons per minute at 116 feet Total Dynamic Head. The station discharges into a one-mile long 6-inch PVC force main that discharges into Manhole 4-67. At the time of this plan, replacement pumps were being procured for the station. The operating point of the replacement pumps is 292 gallons per minute at 131 feet Total Dynamic Head.

Wastewater collected by the town's system flows by gravity to the Union County wastewater system, where it is pumped and ultimately treated by the City of Monroe's Wastewater Treatment Plant. Both Union County and Monroe have the ability to accept or reject wastewater flow from Wingate's system if it exceeds contractual flow rates.

A majority of the town's wastewater flow ultimately ends up in the town's Meadow Branch interceptor before entering the Union County Pumping Station No. 2 on Monroe-Ansonville Road. This interceptor existed prior to the rest of the system and was thought to originally be constructed to serve Wingate University. Once the remainder of the collection system was constructed, a small treatment system that received the flow was taken offline and the town connected the sewers to Union County's collection system. In the late 1990's, another interceptor, the Halfway Branch interceptor, was constructed which connects to the Meadow Branch interceptor. The Meadow Branch interceptor was also replaced between McIntyre Road and Monroe-Ansonville Road with upsized pipe from the point of connection with the Halfway Branch interceptor downstream. Developments on the west side of town such as Noble Oaks and Edgewood enter the Union County collection system at a point west and are not part of the larger and older town collection system.

The Wingate wastewater collection system is aged and experiencing a high level of infiltration (groundwater that enters the gravity sewers through cracks, open joints, and damaged pipe) and inflow (surface water that enters the gravity sewer through damaged or exposed manhole openings or illegal surface drain connections). This results in the collection system operating above capacity during wet weather events. Wastewater overflows have occurred throughout the system during storm events. The town suspects surcharging of the Meadow Branch and Halfway Branch Interceptors from the connection with Union County well upstream. Many manhole covers are bolted down and the manholes have separated in the past due to hydraulic pressure.

The town has performed some rehabilitation on its wastewater collection system. A Sanitary Sewer Evaluation Study (SSES) was performed by Hydrostructures, Inc. in 2000. This study identified areas of the collection system that were contributing to high levels of infiltration and inflow (I/I). As a result of this work, several manholes throughout the system were rehabilitated. The collection system feeding the Diane Street pumping station is currently being rehabilitated with a Cured-In-Place Pipe (CIPP) lining system. In addition the Diane Street pumping station was rehabilitated within the last ten years. At this time, additional manhole inspections and smoke testing are being performed on the system to help identify areas and methods of additional rehabilitation.

2.2 Master Plan Development

Development of this plan and its components were based on existing documentation and knowledge from several sources including town staff, studies conducted in the past for the town by others, available as-built water and sewer drawings, development plan drawings, billing and flow records, and information contained in the recently issued Town of Wingate 2020 Comprehensive Land Use Plan.

The planning horizon for this document is through 2020. However, since the 2030 population projection was developed through the Comprehensive Master Plan, the hydraulic models include the 2030 population scenario.

The two main components of this water and sewer master plan are the comprehensive maps and the hydraulic models. The plan does not include evaluation of the distribution system storage tank or collection system pumping station condition or performance.

2.2.1 Distribution and Collection System Maps

The town's last wastewater collection system base map was created in 2000 as part of the Hydrostructures, Inc. Sanitary Sewer Evaluation Study. Several developments and repairs have occurred since that time. A comprehensive map that includes pipe materials, diameter, pumping station locations, and system history was created from digitizing this existing base map in AutoCAD v.2008, adding new extensions from development plans, and then importing it into both the hydraulic model and into ArcGIS v.9.3. Within ArcGIS, attribute tables were populated with pipe, pump, force main and manhole information. This allows the map to be manipulated to depict certain features such as pipe size and material.

The existing comprehensive water distribution maps consisted of a 1974 map showing existing and new extensions and a map created in 2000 as part of a Water System Management Plan. Both of these maps, along with the base model recently prepared by another consultant, were used to prepare the comprehensive map presented in this document. The map is stored electronically in ArcGIS v.9.3. As with the collection system map, physical attribute data tables were updated which allows the map to be manipulated to depict various features.

2.2.2 Hydraulic Modeling

Modern technology has taken computerized hydraulic modeling to a new and ever changing level of sophistication. The software packages available along with their options are numerous, but there are two basic types of hydraulic models: steady state and dynamic.

A steady state model uses pipe flow equations to route flow through a system. The flow that enters the upstream end is routed to the downstream end (i.e., flow in equals flow out). The available storage in the pipe is not accounted for and the momentum term is neglected. This type of model gives a "snapshot" of the system in time. A dynamic model accounts for available storage in a pipe as well as the momentum term.

Computer hydraulic models are used in the analysis and planning of wastewater collection and distribution systems by simulating the capacity and operation of the systems. Models simulate the routing of flows through pipes and other hydraulic structures in a network to determine system deficiencies in existing infrastructure and capacity requirements for future infrastructure.

The hydraulic model includes nodes and links connected together to represent a collection or distribution system. In a collection system model, nodes represent manholes, wet wells or other hydraulic structures, and the links represent pipes. In a distribution system model, nodes represent junctions where multiple pipes come together, hydrant and valve locations (if not added separately) and similar to the collection system, links are the pipes. Additionally, storage tanks, reservoirs, booster stations, valves and other system features can be input into the model.

In either system, hydraulic analyses are performed over a certain simulation time frame to assess system performance under steady state or dynamic situations. The analyses are based upon more than the physical data. They include measured information about water demand and wastewater flow for a typical day and for events that strees the system. For a wastewater collection system, the system is stressed under wet weather conditions. Site specific rainfall data and wet weather flows are selected to model and model calibration to a significant storm event is performed. A water distribution system model is stressed during dry summer months.

Once physical and hydraulic data is input, the model is validated to check for connectivity and missing information and/or potential errors. The model is then calibrated to reflect measured field conditions.

Section 3 Existing and Future Service Requirements

3.1 Population Projections

Wingate's population and growth patterns were evaluated as part of the Wingate 2020 comprehensive plan. The data and information presented here reflects this work.

Table 3-1 Total and Households 1970-2008[1]

	1970	1980	1990	2000	2008
Population					
Municipal Limit Total	2,569	2,615	2,821	2,406	4,225
Households					
Total Households	398	518	646	751	-
Persons per HH	3.3	2.89	2.79	2.46	-
1 person HH	78	118	113	206	-
1 person HH 65+	43	40	61	94	-

Wingate's population grew steadily from 1970 to 1990, as shown in Table 3-1. From 1990 to 2000 the town lost 415 people – almost 15% of its total population. By 2008, Wingate's state-estimated population was a significantly higher 4,225 – a 176% increase. This higher number reflects newly annexed areas of the town, newer subdivisions, and growth of the Wingate University student population.[1]

Table 3-2 Population Projections for the Town of Wingate[1]

	2010		2020		2030	
	#	%	#	%	#	%
Union County Projected Growth Rate	-	-	-	42.10%	-	32.08%
Projected non-Student Population	3,084	-	4,382	42.10%	5,788	32.08%

Population projections are available from the State of North Carolina at the county level. Local population projections must be extrapolated from county growth patterns. Historically, the Town of Wingate has not mirrored the growth patterns of Union County as the western reaches of the county grew due to proximity and accessibility to employment centers in Charlotte. The State is implementing a Monroe Bypass toll road designed to reduce

[1] Wingate 2020 Comprehensive Land Use Plan, GHD Consulting Inc., October 2010.

travel times to employment centers in Charlotte. As a result of this, growth patterns in Wingate may begin to match those of Union County as a whole.

As such, the population projections for the Town of Wingate shown in Table 3-2 are based on Union County's projected growth rates. The state's 2008 estimate of 4,225 is used as the base total population for 2010 as little new housing has come online since 2008. Non-student population is used for this projection to remove the influence of the Wingate University population on the town's residential growth projections.

The student population for 2009-2010 is reported to be approximately 1,140. Although the student population will not grow per the Union County projected growth rates, the University does plan to grow in its enrollment. For the purposes of this study, the student population is estimated to grow to 2,100 by the year 2020.

In summary, Wingate is expected to have a permanent population of 4,382 people and a student population of 2,100 by the year 2020.

3.2 Land Use

Wingate's existing and future land uses were evaluated as part of the Wingate 2020 comprehensive plan. The land use information presented here reflects that work.

Figure 3-1 illustrates Wingate's existing land use. The town's business and commercial district is located along US Highway 74. The University area (shown in light blue) is centered along Camden Street. The remainder, and majority, of the land within the town limits and extraterritorial jurisdiction (ETJ) is intended for residential use. Most of the residential development in Wingate has been single-family, detached homes on ½-acre and one-acre lots.

Figure 3-2 illustrates Wingate's future land use vision. The vision is centered on a Town Center located at the intersection of Main Street and US Highway 74. This area represents a mix of land uses including curb-front stores, offices, and residential uses on the upper levels of the buildings.

The majority of residences will be in the Town Residential, Village Residential, and Outer Village land uses. Development is planned to occur at the following densities:

- Town Residential – 1/6-acre maximum
- Village Residential – 1/5- to 1/3-acre
- Outer Village – 1-acre

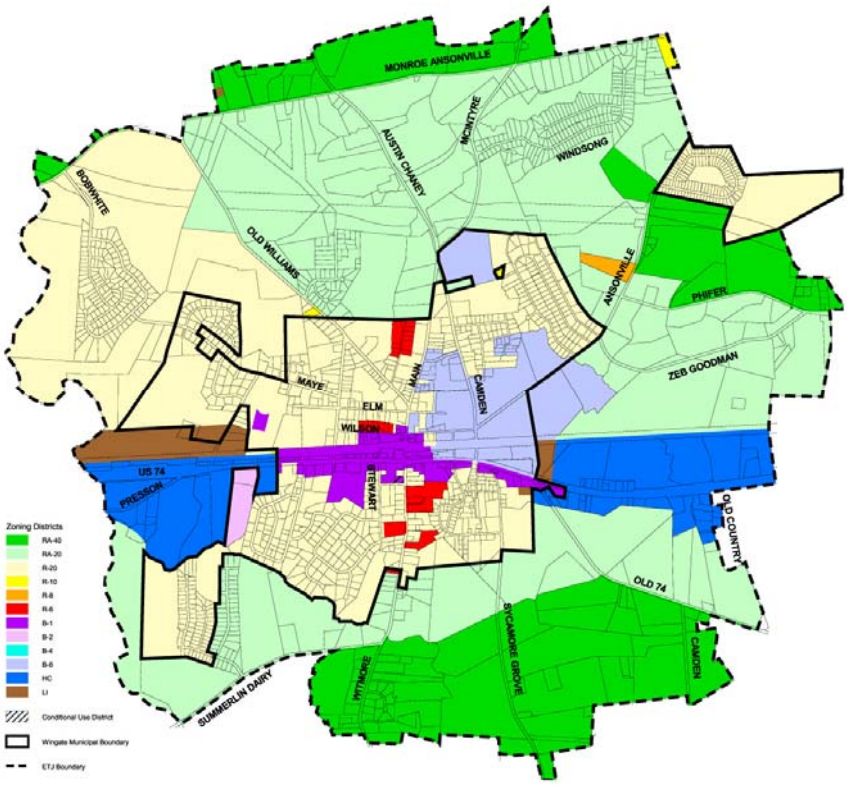


Figure 3-1 Town of Wingate Existing Land Use

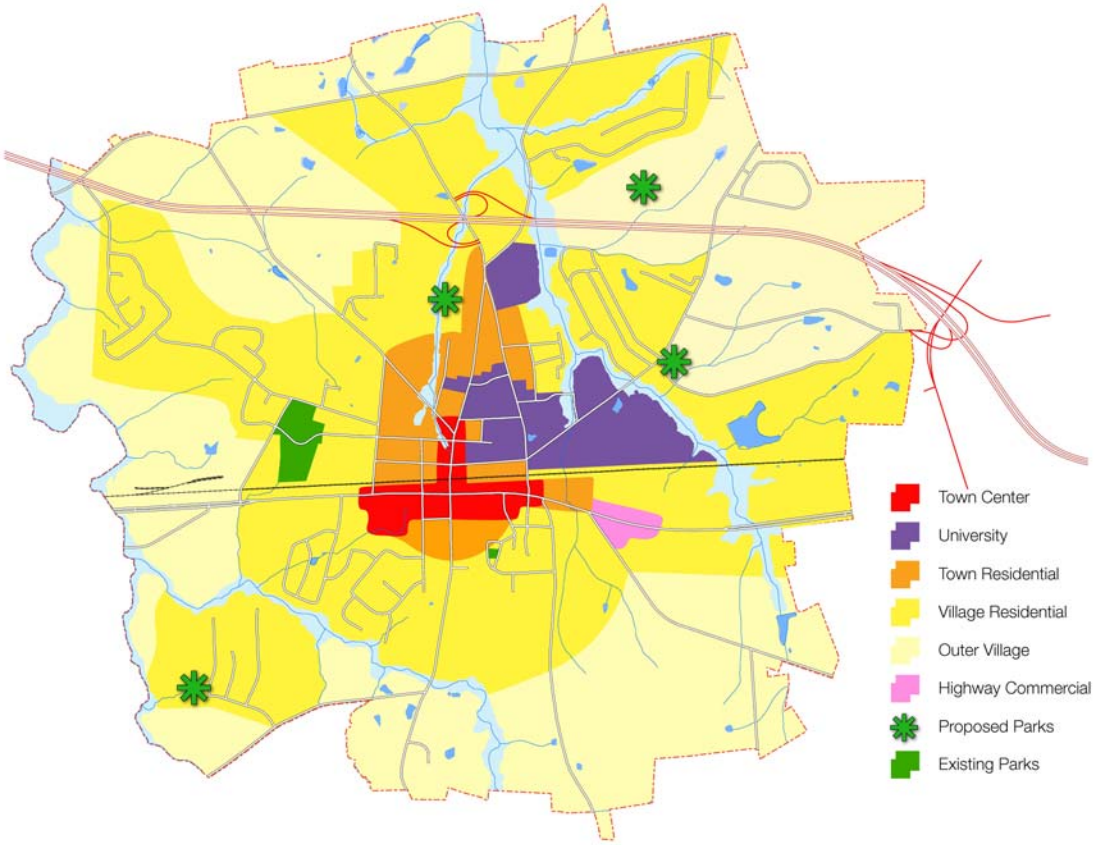


Figure 3-2 Town of Wingate Future Land Use Vision

3.3 Water Demands

Wingate's current water demands are estimated using billing data provided by the town. Data is available for the period from March 1, 2009 through February 28, 2010. Billing data represents the volume of water sold to the town's customers. This data is represented in Figure 3-3.

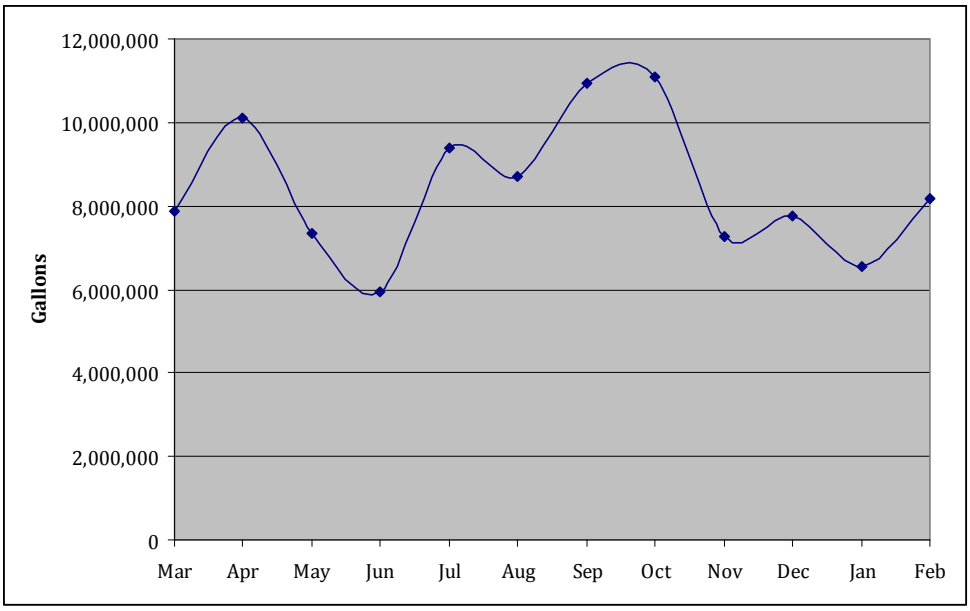


Figure 3-3 Average Monthly Demand 2009-2010

Water use varies depending on the time of year and the time of day. To account for these variations, peaking factors are commonly used in evaluating water system operating characteristics. Peaking factors are multipliers that are applied to the average day demand to approximate other peak water demands. The definitions used in discussing and planning water demand are as follows:

- *Average Daily Demand (ADD):* The average water demand over the entire year. This is usually expressed in terms of million gallons per day (mgd) or gallons per minute (gpm). ADD is also expressed in terms of gallons per capita per day (gpcd) to estimate future demands. Peaking factors are applied to the ADD to estimate the other peak demands.

- *Diurnal Demand:* Fluctuation of water demands over a 24-hour period.
- *Fire Flow:* Additional flow added to the demand to provide for fire fighting. This additional flow is often dictated by fire code.
- *Maximum Day Demand (MDD)*: The highest consumption day in the year. The MDD peaking factor is the ratio of MDD to ADD.

- *Maximum Hour Demand (MHD)*: The one hour in the year when water consumption is the highest. The MHD peaking factor is the ratio of MHD to ADD. This factor is usually estimated based on engineering judgment, since it is difficult to determine the actual maximum hour demand in the system.

The total water use for the billing year provided was approximately 101 million gallons. Based on the account descriptions, approximately 6.3 million gallons (20,000 gallons per day) could be for irrigation use. The ADD is approximately 280,000 gallons per day (192 gallons per minute). The MDD occurred on July 17, 2009 with a total water demand of 479,000 gallons (332 gpm). The resulting MDD factor is 1.7. Data were unavailable to determine the MHD. Typically, the MHD is 3 times that of the ADD. In this case, it is estimated at 840,000 gallons per day (577 gallons per minute).

The current per capita demand is 65.5 gpcd (including the student population). Future water demands are projected in Table 3-3.

Table 3-3 Water Demand Projections

	Population	Demand	Average Daily Demand		Maximum Hourly Demand	
	#	Gpcd	gpd	gpm	gpd	gpm
Current – 2010	4,230	65.5	277,000	192	831,000	577
Future – 2020	6,480	65.5	424,000	295	1,273,000	885
Future – 2030	7,900	65.5	517,000	359	1,552,000	1,080

The added average demand was included in the model and discussed in more detail in Section 4.

3.4 Wastewater Flows

Existing wastewater flow rates are estimated from data provided by a Union County meter. This meter records the wastewater flow leaving the Wingate system through the Meadow Branch interceptor in 15-minute increments. The data from March 2009 to March 2010 is represented in Figure 3-4.

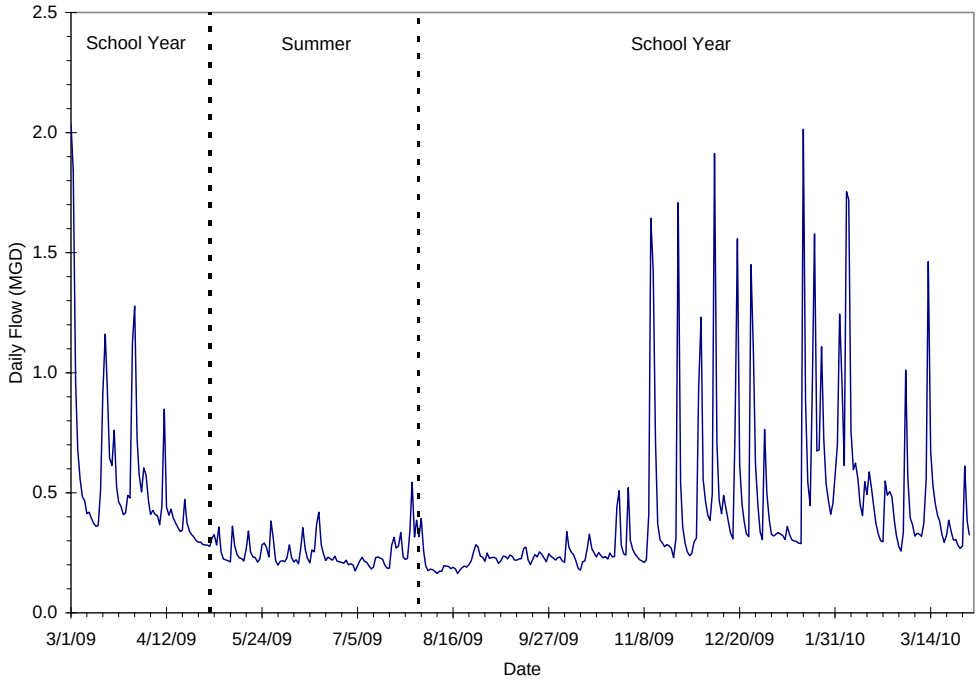


Figure 3-4 Annual Wastewater Flow 2009-2010

As evidenced in Figure 3-4, there are large fluctuations in wastewater flow between late October and early April. This signifies either a large increase in water use during the school year or significant I/I, or both. It is known that the town's collection system experiences high flows during wet-weather.

There are many ways to evaluate wastewater flow and there are standard definitions when discussing wastewater flow that must be defined:

- *Average Daily Flow (ADF):* The average wastewater flow over the entire year.
- *Average Dry Weather Flow (ADWF):* Average dry weather flow is average daily flow expected with no response to wet weather. This includes typical generation by users and normal groundwater infiltration (GWI).
- *Diurnal Flow:* Fluctuation of wastewater flows over a 24-hour period.
- *Infiltration/Inflow (I/I):* The wastewater component caused by rainfall-dependent infiltration/inflow (RDI/I) and groundwater infiltration (GWI).
- *Peak Dry Weather Flow (PDWF*): The highest measured hourly flow that occurs on a dry weather day.
- *Peak Wet Weather Flow (PWWF)*: The highest measured hourly flow that occurs during wet weather.
- *Peak Factor (PF):* Peak factor is PWWF/ADWF.

- *Rainfall-Dependent Infiltration/Inflow (RDI/I):* Rainfall that enters the collection system through direct connections (roof leaders, manholes, etc.) and through cracked pipes, deteriorated joints from high groundwater and causes an almost immediate increase in wastewater flow.

A dry period of August 5 – 10, 2009 was selected to evaluate ADWF. The ADWF over the measured period is approximately 174,600 gallons per day. The minimum flow experienced was 60,700 gallons per day.

Over the same time period, a diurnal flow curve was developed. This is depicted in Figure 3-5. The diurnal curve reflects a typical flow pattern as evidenced by a peak in usage in the mornings and evenings before and after work and school and low usage in the overnight hours when most people are asleep.

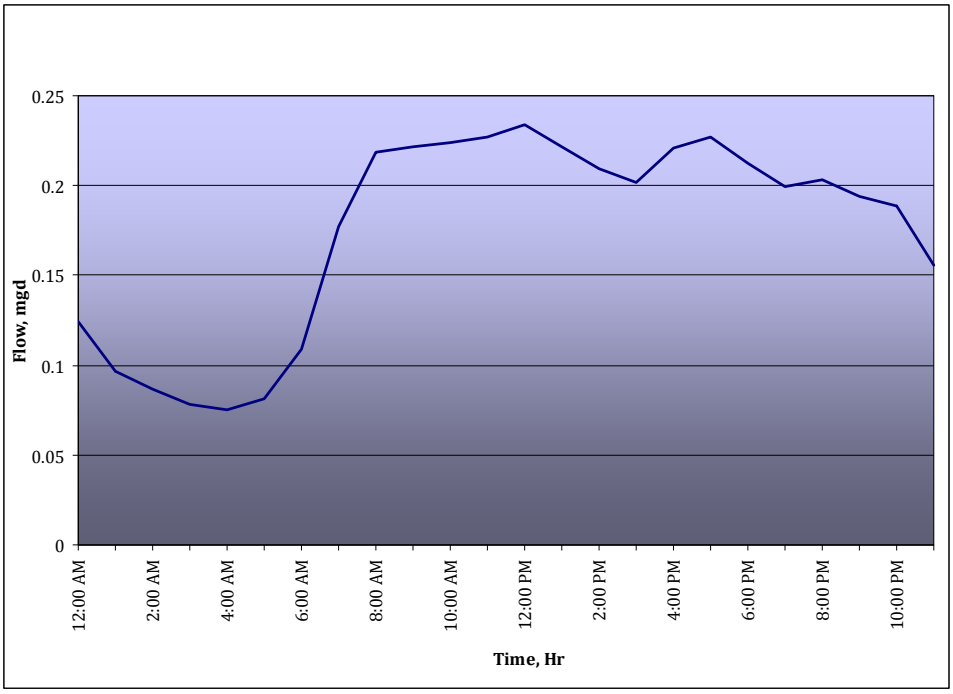


Figure 3-5: Wastewater Diurnal Curve

ADF for the year was 400,000 gallons per day. This value relates well to the ADF of 347,500 gallons per day calculated from meter readings from 1998 to 1999 as part of the Sanitary Sewer Evaluation Study. The average peak flow reached over the flow metering evaluation period is 2.04 million gallons per day (that averaged over the 15-minute readings for the highest flow day).

Flow can also be evaluated on an hourly basis. The data reveals the following information related to hourly sewer flow (Table 3-4).

Table 3-4 Existing Wastewater Hourly Flow

	Hourly Wastewater Flow
During Rain Events (PWWF)	2.5 mgd
During Dry Weather (PDWF)	0.67 mgd
Average Dry Weather Flow (ADWF)	0.18 mgd
Average Dry Weather Day to Peak Dry Hour	3.8
Average Dry Weather Day to Peak Wet Hour (PF)	14.2

Peak hourly flow is used when designing new or replaced sewers and pumping stations as the sizing must be adequate to handle these peaks. As an example, the minimum peaking factor required for sewer design by North Carolina is 2.5. Peaking factors can also be based on a population formula. The smaller the population, the larger the peaking factor. The PF for Wingate's system for dry weather is within normal ranges, yet it is very high under wet weather conditions.

To account for future growth, the ADWF (175,000 gpd) was divided by the current population to obtain a per capita wastewater flow. This per capita flow is 41 gallons per day. To estimate future average dry weather flow for year 2020 and year 2030, the per capita flow was multiplied by the projected populations for those years. Table 3-5 shows these values. The populations are again taken from the Wingate 2020 Comprehensive Plan.

Table 3-5 Wastewater Flow Projections

	Population	Demand	Average Dry Weather Flow	Maximum Peak Hourly Flow
	#	gpcd	gpd	gpd
Current – 2010	4,230	41.3	175,000	669,000
Future – 2020	6,480	41.3	266,000	1,009,000
Future – 2030	7,900	41.3	326,000	1,240,000

3.5 Demand and Flow Discussion

Potable water is used for various purposes including irrigation and domestic use. Therefore, some of the potable water will not enter the gravity sewers. In theory, the wastewater entering a collection system will be of less volume than the potable water leaving a distribution system, given an equal customer base. By comparing wastewater flow and water demand we can get a picture of the tightness of the collection system.

Figure 3-6 depicts the collected data from the wastewater flow meter from March 2009 to March 2010 and water demand data from March 2009 through February 2010. Water demand rises above the sewer flows in summer and fall planting season when irrigation demand is high and when the students return to school. During the wetter months, the wastewater flows rise well above water demand, indicating a response to wet weather events within the collection system. The wastewater flows are low and steady during the dry summer months when rainfall is scarce and groundwater levels are normal.

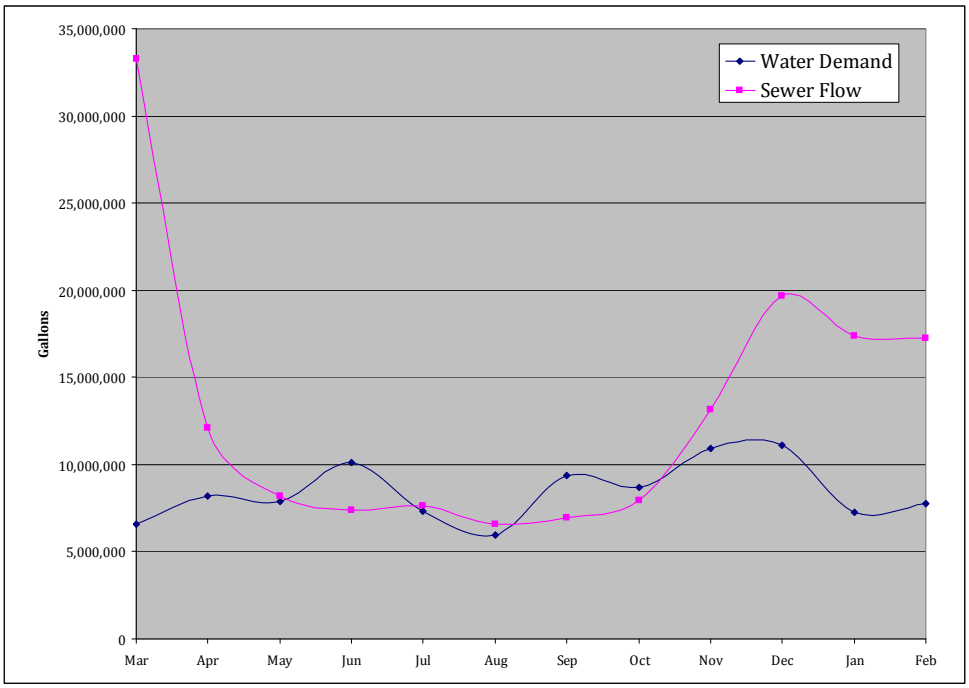


Figure 3-6: Water Demand Versus Wastewater Flow 2009-2010

Figure 3-6 is typical for an aged collection system, and indicates excessive infiltration into the system. Excessive I/I, along with stoppages and collapses in aged collection systems, robs capacity and negatively affects operation of the entire system. This problem eventually comes to the attention of the general public in the form of sewer overflows, sewer backups, equipment failures, facility expansion needs or denial of growth, permit violations, and increases in operating costs and thus, user fees.

Sections 4 and 5 discuss the modeling and evaluation of the water distribution system and the wastewater collection system, respectively.

Section 4 Water Distribution System Evaluation

4.1 Hydraulic Modeling

In 2010, Orion Engineering completed the development of a network hydraulic model of the Town of Wingate's water distribution system. The model was developed using EPANet, a public domain software modeling program. This base model was used for the evaluations presented herein.

The model was converted to Bentley WaterGEMS in order to overlay the pipe network on the town's base mapping. This model also provides more advanced user options than EPANet offers. The water demands presented in Section 3 were loaded into the model.

4.1.1 Modeled Demand Distribution

Daily demands from the top 14 water users were provided by Orion Engineering. The demands were loaded into the model at the closest node to the physical address. These demands are presented in Table 4-1.

Table 4-1 Top 14 Water Users

Address	Closest Node	Total (gpm)
E Wilson Apartments	62	11.35
309 E Wilson St. / Helms Dorm	203	10.05
205 Edgewood Dr. / Feed Mill	230	8.29
204 E Wilson / Harris Dining Hall	58	5.77
207 N. Camden St. / Cannon Hall	73	4.18
205 S. Main St	63	4.09
Main & Oak St	146	3.80
205 S. Main St	271	3.68
3702 US Hwy 74 E	161	3.11
301 Bivens St. / Wingate Elem.	275	1.93
125 Pearl Cir	240	1.90
3821 US Hwy 74 E	123	1.46
105 Oak Dr. / Apartments	136	1.33
226 Cedar St. / Alumni Dorm.	152	1.25
TOTAL:		62.19

As presented in Section 3, the average daily demand is estimated to be approximately 280,000 gallons per day (192 gpm) per the town's 2009-2010 billing records. The remainder of the water demand was distributed evenly across the remaining nodes in the hydraulic model.

4.1.2 Fire Flow Analysis

A water distribution system also needs to be able to respond to fire flow conditions. The hydraulic network model is therefore run under a fire flow scenario to evaluate how the water distribution system will respond.

The analysis determines the fire flow available given certain pressure, velocity, and flow constraints. The automated analysis does not determine the length of time for which the specified flow is available; it only determines the flow available and resulting residual pressure. Variation of available fire flow across a water distribution system is due to head losses limiting flow to areas that are farther from water storage tanks or water sources, and served by smaller diameter pipes. The fire flow values obtained from a hydraulic model do not represent the amount of flow that can be observed flowing from a fire hydrant. The flows represent *theoretically available* fire flow via the water distribution system in a given location. By examining the results from the analysis, it is possible to determine areas of the water distribution system where adequate fire flow is unavailable and improvements are necessary.

Standard modeling protocol suggests that the fire flow should be evaluated when the system is operating at maximum day demands. Therefore, the peak demand for the baseline model was set to 327 gpm.

Wingate does not have a minimum fire flow requirement. Thus supplementary constraints were selected to mimic the requirements of most municipalities. The required minimum pressure was set to 20 psi and a velocity constraint was not used. The minimum required fire flow was set to 500 gpm. Any node unable to achieve such a flow or pressure would fail the fire flow analysis.

4.2 Existing Facilities and Condition

The ability of the existing water distribution system to meet current water demands and fire flow requirements was analyzed using twice the average daily demand, or peak demand. Static pressures and available fire flows were then reviewed at each distribution node to identify the deficient portions of the water distribution system.

The Town of Wingate receives potable water from the Union County water distribution system via a 12-inch water main connection near the intersection of Bivens Street and Highway 74. There is no booster pumping station at the point of connection to deliver water from Union County. Wingate relies on the hydraulic grade of the Union County system, which is 722 feet, to maintain water distribution system pressures. The town maintains one water storage tank with a nominal volume of 500,000 gallons and an overflow elevation 720.8 feet.

In general, it is desirable to maintain pressures within a range of 35 to 80 psi, though 20 psi is generally considered the threshold below which a system is considered deficient. Model simulations indicate the existing water distribution system is in good condition with regards to static pressures. Across Wingate, static pressures range from 48.6 to 86.7 psi, with an average water distribution system pressure of 69.5 psi, assuming a water storage tank hydraulic grade of 720.5 feet.

Water distribution system pressures do not fall significantly when the water storage tank is empty. Model simulations indicate that pressures range between 40.6 to 86.3 psi when the tank water level is 1 foot above the tank base elevation (701.8 ft). The average water distribution system pressure at this tank level is 63.4 psi. The stability of static pressures throughout Wingate is due to the hydraulic grade at the connection to the Union County water distribution system. A review of the water distribution system uncovered that the water storage tank overflow elevation is two feet below the hydraulic grade of the Union County water distribution system. Any improvements to facilitate water delivery to the water storage tank by reducing or removing existing hydraulic restrictions may also result in the frequent overflows of the tank and resulting water loss.

4.2.1 Fire Flow Analysis under Existing Conditions

Further analysis revealed deficiencies in the water distribution system with respect to available fire flow. The majority of the water distribution system in Wingate is comprised of 6-inch diameter cast iron and ductile iron pipe, though a sizeable amount is comprised of 2-inch diameter or less galvanized pipe. All of the portions of the water distribution system served by 2-inch diameter galvanized pipe failed the fire flow analysis because there was not enough capacity in a 2-inch pipe to deliver 500 gpm in addition to peak demands.

The system-wide minimum and average available fire flows are 5 gpm and 637 gpm, respectively. Only 46 percent of nodes within the model were able to achieve fire flows of 500 gpm or greater. When discounting the 2-inch or smaller diameter galvanized pipe within the water distribution system, 64 percent of the nodes were able to achieve fire flows.

In more detail, the analysis indicates that areas farthest away from the water storage tank and the connection to Union County were deficient in terms of available fire flow despite being served by larger diameter pipes of higher quality materials. For example, communities along Maye Street are served by 6-inch diameter ductile iron and polyvinyl chloride pipe and were unable to achieve fire flows of 500 gpm in model simulations. Sections to the east, along Faculty Drive and Smith Street were also unable to achieve 500 gpm of available fire flow despite being served by 6-inch diameter pipe.

The fire flow analysis demonstrated that the community closest to the water storage tank also could not achieve fire flows. The water distribution system in this section of the town is comprised of an incomplete loop of 2-inch diameter galvanized pipe and 6-inch diameter polyvinyl chloride pipe. Flow from the water storage tank is delivered to the community via two, 2-inch diameter galvanized pipes that severely limit the amount of fire flow available to the community.

Even though a significant portion of the water distribution system was deficient with regards to available fire flow, other areas were able to achieve fire flows in excess of 2000 gpm, primarily near the connection to the Union County system near the town center.

Previous studies have identified areas of the town that currently do not have fire protection. The sections identified include Creekview Lane, Lowery Drive, and Lefsey Drive which are all currently served by 2-inch diameter pipe. Also, fire hydrants were recommended to be added in other sections along with and other improvements, in particular the replacement of galvanized pipe. Those sections include Anne Perry Street, Burris Street, North Camden Street, Diane Street, West Elm Street, Faculty Drive, Love Street, Old Williams Road, Smith Street, and Todd Circle. To add fire protection to these portions of the distribution system, pipes will need to be increased in size to a minimum pipe diameter of 6 inches.

4.3 Future Conditions

The current per capita demand is calculated at 65.5 gallons per day. Future water demands are projected in Table 4-2.

Table 4-2 Water Demand Projections

	Population	Demand Per Capita (gpd/person)	Average Daily Demand (gpd)	Maximum Day Demand (gpd)
Current - 2010	4,230	65.50	277,000	479,000
Future – 2020	6,480	65.50	424,000	722,000
Future - 2030	7,900	65.50	517,000	880,000

Using the assumption that redevelopment, not new development, is anticipated in the town center, none of the water demands associated with growth were applied there. All new water demands were applied at the periphery of the water distribution system where new development is projected to occur. The nodes to which additional demands were applied are Nodes 253, 268, 78, and 11. Table 4-3 presents the future demand loading distribution applied for 2020 and 2030.

Table 4-3 Future Loading Distribution.

Address	Node	Current ADD (gpm)	2020 ADD (gpm)	2030 ADD (gpm)
Northwest: Maye Street & Polaris Drive	253	0.47	25.5	41.7
North: Camden St & North Main Street	268	0.47	25.5	41.7
South: South Main Street	78	0.47	25.5	41.7
East: Highway 74 East	11	0.47	25.5	41.7

Under the projected 2020 maximum day demands, model simulations indicate static pressures are not significantly impacted. For 2020, simulated pressures range between 31.7 to 86.6 psi, assuming a water storage tank hydraulic grade of 720.5 feet. The average water distribution system pressure at this tank level is 68.2 psi. The minimum pressure is below 35 psi, but higher than the minimum threshold of 20 psi.

When modeling the system under Year 2030 maximum day demands, negative pressures result at two nodes connected to a 2-inch diameter galvanized pipe along South Main Street. One is Node 78, where one of the 2030 future demands was applied. The other simulated negative pressure was located at Node 83, a node adjacent to the applied future 2030 demand. Discounting the negative pressures, static pressures range between 34.5 to 86.6 psi, assuming a water storage tank hydraulic grade of 720.5 feet. The average water distribution system pressure at this tank level is 66.6 psi.

4.3.1 Fire Flow Analysis under Future Conditions

As discussed above, a significant portion of the Wingate water distribution system cannot provide adequate fire flow (greater than or equal to 500 gpm) under current conditions. Thus the increase in water demands anticipated by 2020 further increases the portion of the system that is deficient with regards to fire flow. In addition to those areas of the water distribution system identified as deficient under current conditions, the following areas are affected under the 2020 scenario:

- The community centered around Todd Circle cannot achieve available fire flow of 500 gpm or greater given the proximity to the anticipated growth areas to the south of the town center.
- Available fire flow in the town center is reduced from a range of 1000 to 3500 gpm to a range of 500 to 1000 gpm.

The additional increase in water demands anticipated by 2030 further strains the water distribution system with respect to available fire flow.

Without any improvements to the system, model simulations indicate that no node can achieve available fire flow under the 2030 scenario using the modeling constraints described in Section 4.1.2.

4.4 Alternatives

The analysis of the existing facilities under current conditions using the hydraulic model did not identify any sections of the distribution system that were deficient with respect to static pressures. There were, however, significant deficiencies with respect to available fire flow. Additional deficiencies with respect to both static pressures and available fire flow were uncovered when reviewing the water distribution system's ability to meet demands anticipated for 2020 and 2030.

The alternatives available to the town to address these problems are:

- Do nothing and no longer maintain fire protection as a service provided by the distribution system, or
- Complete improvements necessary to do the following:
    - Bring currently available fire flow to within acceptable ranges, and
    - Increase the robustness of the distribution system to cope with future projected water demands.

To do nothing would further limit the ability of the water distribution system to provide adequate fire protection over time due to demands associated with anticipated growth. This alternative would have a negative impact on public health and safety, and is not recommended.

The majority of the improvements recommended to address the aforementioned deficiencies under current conditions involve increasing pipe sizes to accommodate the higher flow rates required for fire protection. These improvements have the added benefit of increasing the robustness of the water distribution system and thereby increasing its ability to cope with the projected water demands of 2020 and 2030.

It should be noted that there are inherent drawbacks to such improvements that may be realized, such as impacts to water age and quality. It is for that reason that not all improvements are recommended to be implemented now, and should be implemented when the increases in demands are anticipated to occur.

4.5 Recommended Improvements

Recommended improvements were developed to address the identified deficiencies. Each recommended improvement is categorized based on priority determined by the type of deficiency being addressed. Three priority levels were applied to the improvements:

- *Critical* – Improvement is needed to address existing deficiencies that pose immediate risk to health and safety (i.e., fire flow),

- *Moderate* – Improvement is needed to address existing deficiencies that do not pose an immediate risk to public safety (i.e., pipe condition), or
- *Future* – Improvement is needed to address anticipated deficiencies associated with the projected growth for 2020 and 2030.

The recommended improvements to the Wingate water distribution system are presented in Table 4-4 and in Figure 4-1.

Table 4-4 Recommended Water System Improvements

Improvement	Description	Probable Construction Cost	Priority
W-1	Replace 6 in. and 8 in. pipe along and across Highway 74. with 12 in. PVC pipe	$1,100,000	Critical
W-2	Replace 6 in. pipe on Elm St. with 12 in. PVC pipe Extend Bivens St. pipe south towards Highway 74 with 12 in. PVC pipe and interconnect to the Union County main for redundancy	$886,000	Critical
W-3	Replace 2 in. galvanized pipe on College St. with 6 in. PVC pipe Install connection at College St. and Jerome St. with 6 in. PVC pipe to complete loop	$605,000	Critical
W-4	Replace 2 in. galvanized pipe on Circle Dr. with 6 in. PVC pipe.	$175,000	Moderate
W-5	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Elm St., and south of Haskins Dr.	$345,000	Critical
W-6	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Haskins Dr.	$300,000	Future (2020)
W-7	Replace 6 in. pipe on Maye St. with 8 in. PVC pipe.	$829,000	Future (2020)
W-8	Replace 6 in. cast iron and 2 in. galvanized pipe on S. Main St. with 8 in. PVC pipe	$481,000	Future (2030)
W-9	General replacement of galvanized pipe with PVC pipe of same size.	$1,370,000	Moderate

Four of the nine recommended improvements are *critical* because they address existing deficiencies related to fire flow. Two recommended improvements are *moderate*, while the remaining three recommended improvements address *future* deficiencies. The estimate of probable construction cost is also presented above, with costs ranging from $175,000 to $1,370,000.

Of the recommended improvements, Improvement W-1 is the most critical because it addresses the inadequacies of the water distribution main that interconnects Wingate's water source (interconnection with Union County) with the water storage tank. Currently consisting of 6-inch and 8-inch water segments, the water distribution main delivers water to the 12-inch water segment that connects to the water storage tank, the only storage structure within Wingate. The 12-inch water distribution main along Highway 74, and proposed as part of Improvement W-1, creates a "backbone" for the water distribution system that increases its strength with regards to static pressures and fire protection.

A result of Improvement W-1 will be the removal of the hydraulic restrictions impeding the delivery of water to the water storage tank. However, it is possible the water storage tank may experience overflows due to the difference in hydraulic grade between the tank overflow apparatus (720.8 feet) and the connection to the Union County water distribution system (722 feet). To remedy this, the town may need to adjust the pressure reducing valves or other flow control device to reduce the hydraulic grade at the point of connection. Further investigation is required prior to implementation of Improvement W-1.

Improvement W-2 is almost as critical as Improvement W-1 as it facilitates the delivery of water from the 12-inch water distribution main along Highway 74 to the periphery of the system, where available fire flow is at its lowest. A feature of this improvement is the extension of the water line that interconnects the Wingate water distribution system with the Union County water distribution system to create redundancy in the event of a water distribution main break along Highway 74.

The distribution system along College Street and Jerome Street is characterized by fire flow deficiencies due to 2-inch galvanized pipe and incomplete water service loops. Improvement W-3 is intended to address the fire flow deficiencies in this community by replacing the 2-inch galvanized pipe with 6-inch polyvinyl chloride pipe and by also installing a 6-inch polyvinyl chloride connection between the water distribution mains at the intersection. By upsizing the pipe and completing the water distribution loop, the available fire flow will be increased to a range of 1,000 to 2,000 gpm. This is a significant improvement.

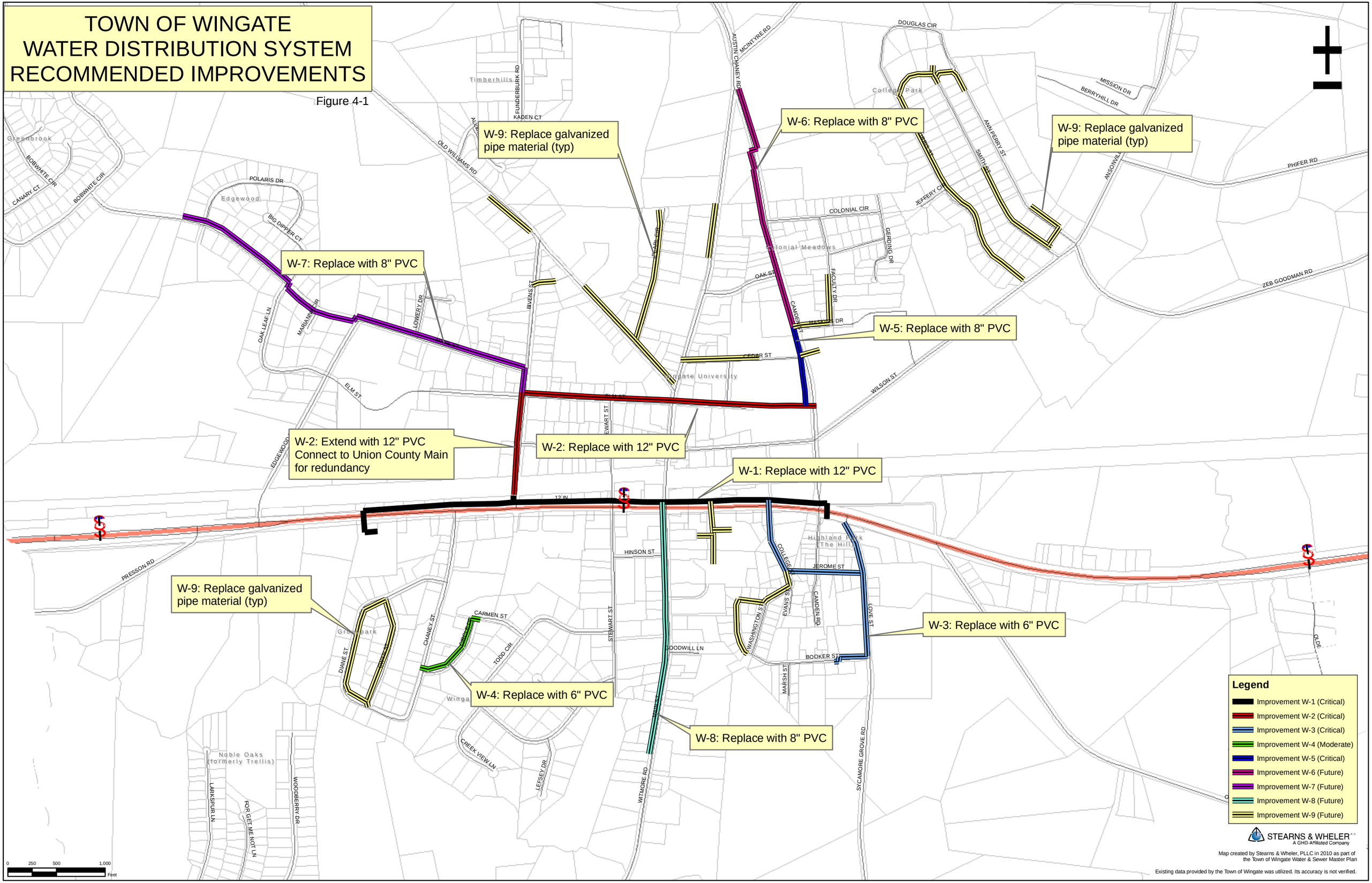
Similar to Improvement W-2, Improvement W-5 is intended to facilitate the delivery of water from the 12-inch water distribution main along Highway 74 to the communities along Anne Perry Street and Burris Street.

The remaining improvements are intended to improve the reliability and strength of the water distribution system by addressing current and future deficiencies yet they do not pose a significant risk to public health or safety.

The critical improvements should be handled chronologically. That is, Improvement W-3 assumes that Improvements W-1 and W-2 have been completed.

TOWN OF WINGATE
WATER DISTRIBUTION SYSTEM
RECOMMENDED IMPROVEMENTS

Figure 4-1



Section 5 Wastewater Collection System Evaluation

5.1 Hydraulic Modeling

The Town of Wingate did not have a wastewater collection system model prior to the development of this study. Stearns & Wheler developed the collection system hydraulic network model using SewerGEMS v8i. The heart of the physical model was formed from digitizing an existing wastewater system map prepared in 2000 that showed pipes, pipe sizes, manholes, the pumping station and force main. Collection system extensions or modifications constructed after 2000 were added to this base model. Pipe sizes, manhole rims and invert elevations were verified and entered based on the town's existing drawings. Information regarding the Diane Street pumping station was provided by the town.

5.1.1 Modeled Flow Distribution

As presented in Section 3 and Figure 3-5, a diurnal curve was created which simulates wastewater flow patterns throughout the day. This pattern was input into the model. Also presented in Section 3 was the average dry weather flow of 175,000 gallons per day, the average daily flow of 400,000 gallons per day, and the peak flow of 2.04 million gallons per day.

5.1.2 Model Assumptions and Limitations

Where drawing records conflicted, the town's staff identified the correct data where possible. Areas where information was lacking are shown on the map, but inactivated for modeling purposes. Examples of these areas are mainly within Wingate University. Other areas include newer developments such as Glencroft where the survey datum between the existing and newer information could not be verified, and some small miscellaneous extensions throughout the system. Additionally, portions of the collection system not entering the Meadow Branch interceptor were not included in modeling. These areas include the Trellis and Edgewood developments which connect with the Union County collection system at a point west of the town.

Some areas, such as the oldest part of Meadow Branch interceptor, had no manhole rim or invert data except where future extensions tie into it. This interceptor is critical for modeling. Thus, rim and invert data was back-calculated and may not be as accurate as other parts of the model.

Wastewater flow data was generally distributed equally throughout the manholes in model (i.e., dividing the total average dry-weather flow by each active manhole in the model). This resulted in an average flow per manhole of 0.25 gallons per minute. Where areas were inactivated due to lack of

available information or differing elevation datums, the nearest manhole was loaded with the additional estimated wastewater flow based on the number of inactive manholes (85) in those areas. Such instances are summarized in Table 5-1.

Table 5-1 Adjusted Wastewater Loading

Deactivated Manholes		Added to Average (gpm)	Added at Manhole	Value (gpm)
28	Glencroft	6.985	3-7f	7.235
5	Trailer Park	1.247	3-7d	1.497
4	3-7a, 3-7b, 3-7b1, 3-7b2	0.998	3-7	1.247
3	1-98a, 1-98b, 1-98-c	0.748	1-98	0.998
1	1-104a	0.249	1-104	0.499
35	A,B,C MHs	8.732	4-1	8.981
2	2-133D, 2-133C	0.499	2-133b	0.748
1	2-79aa	0.249	2-79	0.499
1	1-39a	0.249	1-39	0.499
1	1-38d	0.249	1-38c	0.499
4	1-36d - 1-36a	0.998	1-36	1.247

For the 2020 and 2030 scenarios, the additional wastewater generation was added to areas where the land use plan identified future growth. The manholes selected to apply the additional wastewater in the model are Manhole Nos. 1-50C (Northwest: Old Williams Road), 1-79 (North: North Main Street), 2-135 (South: South Main Street) and 4-9f (Southeast: Highway 74 East).

In addition to the dry-weather model scenarios, one wet-weather scenario was incorporated in the model. The data to load the wet-weather scenario is 2005 data provided from four temporary flow meters that were installed and monitored by another consultant (Frazier Engineering). The location of the four meters was near Manholes 2-22, 2-68, MB-7-R and HB17 as referenced in the comprehensive map in Section 2. The flow meters measured wastewater at the installed points in 15-minute increments. No site-specific rainfall data was measured. The consultant indicates the significant rainfall event used in their analysis was April 12-13, 2005. The rainfall measurements used in the model are daily values from a US Geological Survey rain gauge in northeast Union County that equated to a 1.6 inch total rainfall depth. The wet-weather event is applied over 17 catchment areas. Catchment areas are delineated in the model that identifies one point of inflow from sections of the collection system area. The model simulates the rainfall and the system capacity by pipe segment, manhole and wetwell over the evaluation period, 72-hours. The results only indicate performance immediately upstream of the flow meter locations. Not all potential overflows may manifest in the model due to the small number and location of meters installed.

A formal I/I evaluation would include flow metering and site-specific rainfall measurements in 15-minute increments that capture several rain events so that accurate model calibration can occur. In this instance, the wet-weather data is not complete enough to perform accurate calibration thus the wet-weather scenario evaluated will provide conceptual results, at best.

5.2 Existing Facilities and Condition

The model shows no capacity deficiencies under the current dry-weather scenario except for the area near Manholes MB-1 to MB-3, and MB-4 and MB-5 to MB-3. However, the rim and inverts in these areas were estimated and the results should be discounted until better data is obtained. There are several segments of sewers that experience low velocities (below 2 feet/second). This is because an 8-inch sewer at a minimum design slope of 0.4 percent can convey almost 500,000 gallons per day yet several segments serve only a handful of connections. A routine cleaning and root control program can assist with reducing grease and debris build-up that could occur in low flow sections and cause odor or blockage.

Under wet-weather conditions, the model results indicate pipe surcharging or overflow in some segments based on the 2005 information. These areas are located as follows.

- From Manhole 2-25 to the Diane Street Pumping Station
- From Manhole 2-68 to the Diane Street Pumping Station
- Diane Street Pumping Station Wetwell
- From Manhole 2-75 to 2-76
- From Manhole 4-2 to MB-3, including MB-4 to MB-5. It should be noted again that the rim and inverts on this section were estimated based on other nearby rim and invert data. Thus the results in this area are suspect.
- From Manhole 3-1 to Manhole MB-12-A. Again, manhole rim and inverts in this area were estimated. Results could be different if more accurate information were obtained.

Sanitary Sewer Overflows (SSO) have been experienced in a few distinct areas after significant rain events over the past several years: at Diane Street Pumping Station and immediately upstream, Manhole 1-22 and Manhole 3-25 (Meadow Branch interceptor). Surcharging and overflows had been occurring on the interceptor upstream of the Union County connection.

The town does not suspect there are many illicit connections to the collection system such as downspouts, yard drains and sump pumps. From discussion with town staff, review of past smoke testing studies, and past experience evaluating collection systems, the main source of I/I is suspected to be groundwater infiltrating into the system through main line joints and

from lateral connections. Several manholes along Halfway Branch and Meadow Branch are in the floodplain and their covers are bolted down. There has been little rehabilitation of the sewers since originally constructed except for the current work occurring in the Diane Street pumping station basin. Thus, the original VCP sewers likely have cracks and defective joints.

The main difference between overflow occurrences and modeled results is at Manhole 1-22. Wastewater from this manhole enters Manhole 1-51 and must makes two sharp turns against natural flow path. It is suspected by town staff that the angle of the turn could possibly cause surcharge up the line during heavy flow conditions. Reworking of the sewer connection near the intersection of Pearl Street and Old Williams Road could alleviate this problem.

5.3 Future Conditions

As presented in Section 3, future flows were projected as follows:

Table 5-2 Wastewater Flow Projections

	Population	Demand Per Capita (gpcd)	Average Dry Weather Flow (gpd)
Current - 2010	4,230	41.3	175,000
Future – 2020	6,480	41.3	266,000
Future - 2030	7,900	41.3	326,000

These additional flows were added to the model at certain manholes near the outskirts of town where development is expected to occur. The model was run under the 2020 and 2030 dry weather scenarios results. Under dry weather conditions, the collection system model does not identify surcharging or overflows under projected flows (discounting the area mentioned under the current scenario near MB-1 to MB-5).

The wet-weather scenario was not performed under future conditions.

5.4 Alternatives

The collection system is sized to handle the Town of Wingate's existing and projected dry weather flows. However, the physical condition of the collection system is resulting in high wet weather flows and resulting sewer overflows.

There are three alternatives for improving the wastewater collection system:

- Do nothing
- Place large pipe to accommodate rainfall induced I/I (RDI/I), or
- Rehabilitate and replace to remove RDI/I

As evidenced by the wet-weather SSOs experienced within the collection system, doing nothing is an environmental and health threat. Even though the model demonstrates that the system is adequately sized for future growth under normal conditions, the consequences of leaving the system in its current state will result in continued SSOs, structural failure, and potential regulatory compliance issues. Town resources will be stretched by operating the system in a reactive mode. Most importantly, wastewater resulting from future growth will not be accepted by Union County (i.e., a sewer moratorium will be placed) if the system is not rehabilitated. The "do nothing" alternative is not recommended.

There are two alternatives to address I/I:

(1) Upsize the downstream facilities to handle rainfall from some identified storm event or,

(2) Repair what has failed to remove a realistic amount of I/I (I/I can never be completely removed).

5.5 Recommended Improvements

Modeling demonstrates the collection system is sized appropriately to handle future growth under dry weather. The town has already begun to address I/I with the rehabilitation of the Diane Street Pumping Station basin. The Town Board has recently approved another area for additional smoke testing, manhole inspections and Closed Circuit Television Inspection (CCTV). It is recommended the town continue to investigate and prioritize areas for wastewater collection system rehabilitation. The model and system inventory developed as part of this plan can be used as tools towards developing a Capital Program.

Table 5 shows recommended activities to improve the collection system. Included is a capital project designed to rehabilitate the remaining VCP and associated manholes in the system. The preliminary opinion of construction cost for this pipe assumes all sewers are of a condition to accept cured-in-place pipe and no other excavation and replacement of sewers occurs. Also included are projects designed to identify future capital improvements or sustain the system until capital improvements can be performed. Costs for these projects are not included in this capital plan.

As in Section 4, the activities are ranked critical, moderate or future. The rehabilitation project is considered critical as it impacts the public safety, environmental health, and future growth of the town. There is an outstanding concern about surcharging in the outfalls during wet weather that could continue even if Wingate rehabilitates the entire system. This issue needs to be discussed with the neighboring utilities for resolution. It is ranked as critical to the environmental sustainability of the town. Improvement S-1 is shown in Figure 5-1.

Table 5-3 Recommended Collection System Improvements and Activities

Improvement	Description	Probable Construction Cost	Priority
S-1	Rehabilitate remaining VCP pipe and manholes in the system.	$4,600,000	Critical
S-2	Work with Union County and Marshville to address surcharging issues	-	Critical
S-3	Survey Meadow Branch Outfall manholes to verify if slope is causing modeled surcharging under dry weather conditions (update the model)		Moderate
S-4	Implement a root control program	-	Moderate
S-5	Continue expansion and update of the CIP and hydraulic model	-	Future
S-6	Develop an Asset Management Plan	-	Future
S-7	Develop/expand design standards and ordinances for sewer construction	-	Future
S-8	Maintain the comprehensive map	-	Future

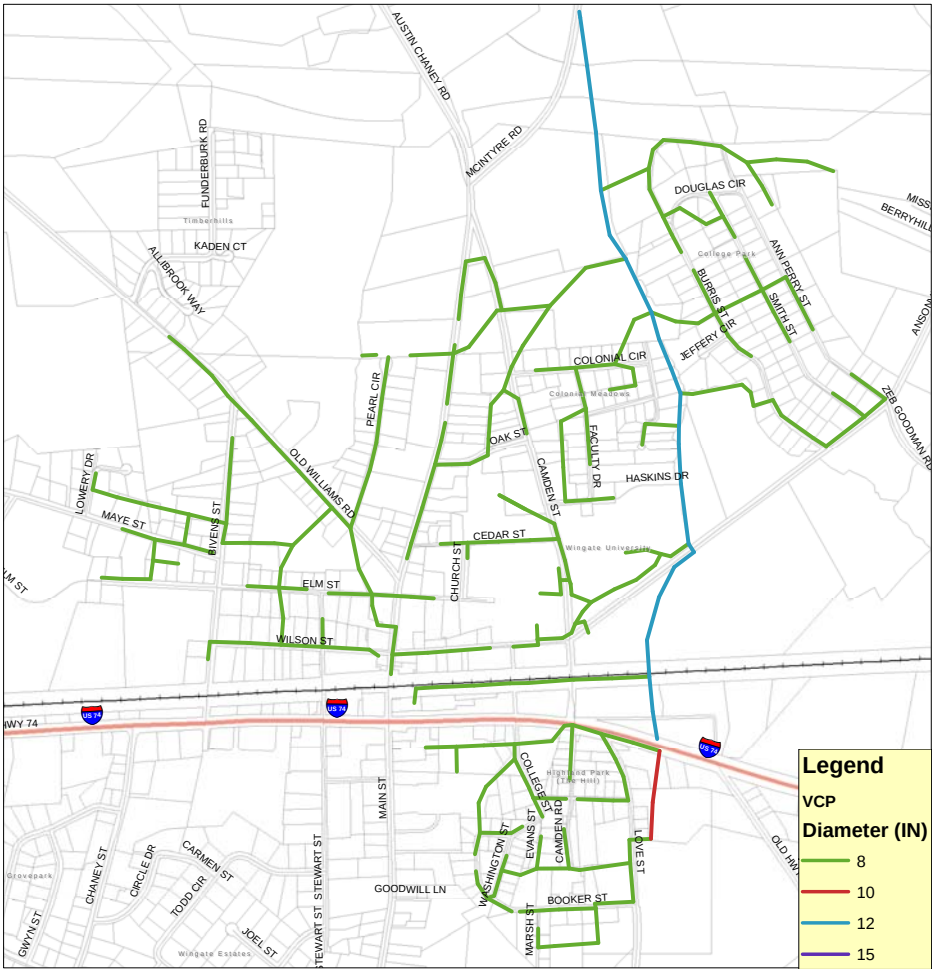


Figure 5-1 Recommended Rehabilitation Improvement S-1

Section 6 Capital Improvement Program

6.1 Recommended Program

Recommended improvements were discussed in Sections 4 and 5 for the water distribution and wastewater collection systems, respectively. Section 4 provided specific projects designed to improve fire flow and provide a more robust water distribution system. Section 5 included one preliminary opinion of probable construction cost for rehabilitation of certain sewers and manholes and many recommendations for which detailed costs can not yet be formulated.

Table 6-1 summarizes the recommended water and wastewater improvement projects, the estimated present day capital cost of the project, and the recommended year of implementation.

Table 6-1 Capital Improvement Projects

Improvement	Description	Probable Construction Cost	Priority/Year
W-1	Replace 6 in. and 8 in. pipe along and across Highway 74. with 12 in. PVC pipe	$1.100,000	Critical 2011
W-2	Replace 6 in. pipe on Elm St. with 12 in. PVC pipe Extend Bivens St. pipe south towards Highway 74 with 12 in. PVC pipe and interconnect to the Union County main for redundancy	$886,000	Critical 2012
W-3	Replace 2 in. galvanized pipe on College St. with 6 in. PVC pipe Install connection at College St. and Jerome St. with 6 in. PVC pipe to complete loop	$605,000	Critical 2013
W-5	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Elm St., and south of Haskins Dr.	$345,000	Critical 2013
S-1	Rehabilitation of 62,000 feet of VCP and manholes in wastewater collection system.	$4,600,000	Critical 2015
Subtotal	Critical Improvements (2011 – 2015)	$7,536,000	
W-4	Replace 2 in. galvanized pipe on Circle Dr. with 6 in. PVC pipe.	$175,000	Moderate 2014
W-6	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Faculty Dr.	$300,000	Future (2020) 2019
W-7	Replace 6 in. pipe on Maye St. with 8 in. PVC pipe.	$839,000	Future (2020) 2019
W-8	Replace 6 in. cast iron and 2 in. galvanized pipe on S. Main St. with 8 in. PVC pipe	$481,000	Future (2030)
W-9	General replacement of galvanized pipe with PVC pipe of same size.	$1,370,000	Moderate
Subtotal	Future Improvements (2014-2030)	$3,165,000	

As seen in Table 6-1, it is recommended the town implement $2.9 million in water distribution system improvements and $4.6 million in wastewater collection system improvements in the very near future, for a total of $7.5 million. This is to provide fire flow protection to underserved areas of the town. An additional $3.2 million in water improvements is required to position the town for planned growth and replace failing 2-inch galvanized steel water lines. Additional wastewater improvements may be identified by investigative studies currently being performed by others.

Table 6-2, overleaf, suggests a breakdown of annual revenue needed to perform the improvements over the next twenty years.

6.2 Funding Options

A next step in refinement of the Capital Improvement Program will be to prepare more detailed estimates and schedules for implementation, design and construction of individual projects. An important extension of the program will be to evaluate current revenues and expenses and identify potential funding sources for each project and implement a financial plan.

Consider revenues, debt obligation, operation and maintenance costs, and affects on user rates when selecting a funding source for each project. Ideally, the town should support system improvements through its own revenues from applicable taxes, bonds, and fund reserves. However many utilities of this size cannot perform the scope of necessary work without implementing significant water and sewer rate increases.

There are a range of state and federal funding programs available. Table 6-3 summarizes some of the common funding programs used for water and sewer improvements in North Carolina as identified by the University of North Carolina – Chapel Hill Environmental Finance Center.

Much of the funding provided by the agencies listed in Table 6-3 is dependent on user rates. If rates have not been evaluated recently, the town should also plan for a rate study to compliment the Capital Improvement Program.

Table 6-2 Annual Revenue Suggestions

	Project	Capital Cost, $Million											
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	By 2030	Total
W-1	Replace 6 in. and 8 in. pipe along and across Highway 74. with 12 in. PVC pipe	1.10											1.10
W-2	Replace 6 in. pipe on Elm St. with 12 in. PVC pipe Extend Bivins St. pipe south towards Highway 74 with 12 in. PVC pipe and interconnect to the Union County main for redundancy	0.16	0.73										0.89
W-3	Replace 2 in. galvanized pipe on College St. with 6 in. PVC pipe Install connection at College St. and Jerome St. with 6 in. PVC pipe to complete loop		0.06	0.55									0.61
W-5	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Elm St., and south of Faculty Dr.		0.04	0.31									0.35
S-1	Rehabilitation of 62,000 feet of VCP and manholes in wastewater collection system.	0.44	1.04	1.04	1.04	1.04							4.60
W-4	Replace 2 in. galvanized pipe on Circle Dr. with 6 in. PVC pipe.				0.18								0.18
W-6	Replace 6 in. pipe on N. Camden St. with 8 in. PVC pipe north of Faculty Dr.								0.03	0.27			0.30
W-7	Replace 6 in. pipe on Maye St. with 8 in. PVC pipe.								0.09	0.74			0.83
W-8	Replace 6 in. cast iron and 2 in. galvanized pipe on S. Main St. with 8 in. PVC pipe											0.48	0.48
W-9	General replacement of galvanized pipe with PVC pipe of same size.						0.27	0.27	0.27	0.27	0.29		1.37
	TOTAL	1.70	1.87	1.90	1.22	1.04	0.27	0.27	0.39	1.28	0.29	0.48	10.71

Table 6-3 Typical Water and Wastewater Funding Sources[1]

Agency	Grant/Loan Program	Purpose
North Carolina Department of Commerce, Division of Community Assistance (DCA)	Community Development Block Grants (CDBG) (HUD funds)	To improve housing and economic development for low and moderate income communities
USDA Rural Development	Water and Wastewater Loans and Grants	Funds are for eligible community water, sewer, storm sewer, and solid waste projects. Applications received year round.
Economic Development Administration, Department of Commerce	Public Works and Development Facilities Grant Program	These grants support projects that promote economic development in economically distressed areas.
NC Division of Environmental Health	Public Water Supply Section -Drinking Water SRF Loan Program	Planning, designing, and construction for the purpose of upgrading, expanding, extending, rehabilitating or consolidating water systems.
Clean Water Management Trust Fund (CWMTF) Grants		Grants fund projects to protect and restore surface water quality, such as stormwater management, stream restoration, wetland acquisition, and improvements or repairs to wastewater treatment systems.
North Carolina Division of Water Quality - Construction Grants and Loans Section	Clean Water State Revolving Fund	The CWSRF program is available to fund a wide variety of water quality projects.
NC Rural Economic Development Center	Supplemental Grants Program, Capacity Building Grants Program	The Rural Center administers grant programs to help rural communities develop the water and sewer systems they need to support local economic growth and ensure a reliable supply of clean water.
Economic Infrastructure Grants	Grant funds are used to generate new jobs in rural or urban, economically distressed communities through water and wastewater improvement projects.	Pre-applications taken on a rolling basis.

The Capital Improvement Program is a working document. To be useful for financial stability, the program should be evaluated and prioritized annually, specify funding sources for projects, and contain supplementary justifications with priority rankings. Changes should be adopted by the Board and implemented. The program for the distribution and collection system could also be incorporated into a Town-wide program.

[1] Compiled by University of North Carolina – Chapel Hill Environmental Finance Center

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