FINAL REPORT FOR

REUSE WATER SYSTEM MASTER PLAN

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Prepared for:

City of Raleigh Public Utilities Department

Submitted by:

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REUSE WATER SYSTEM MASTER PLAN

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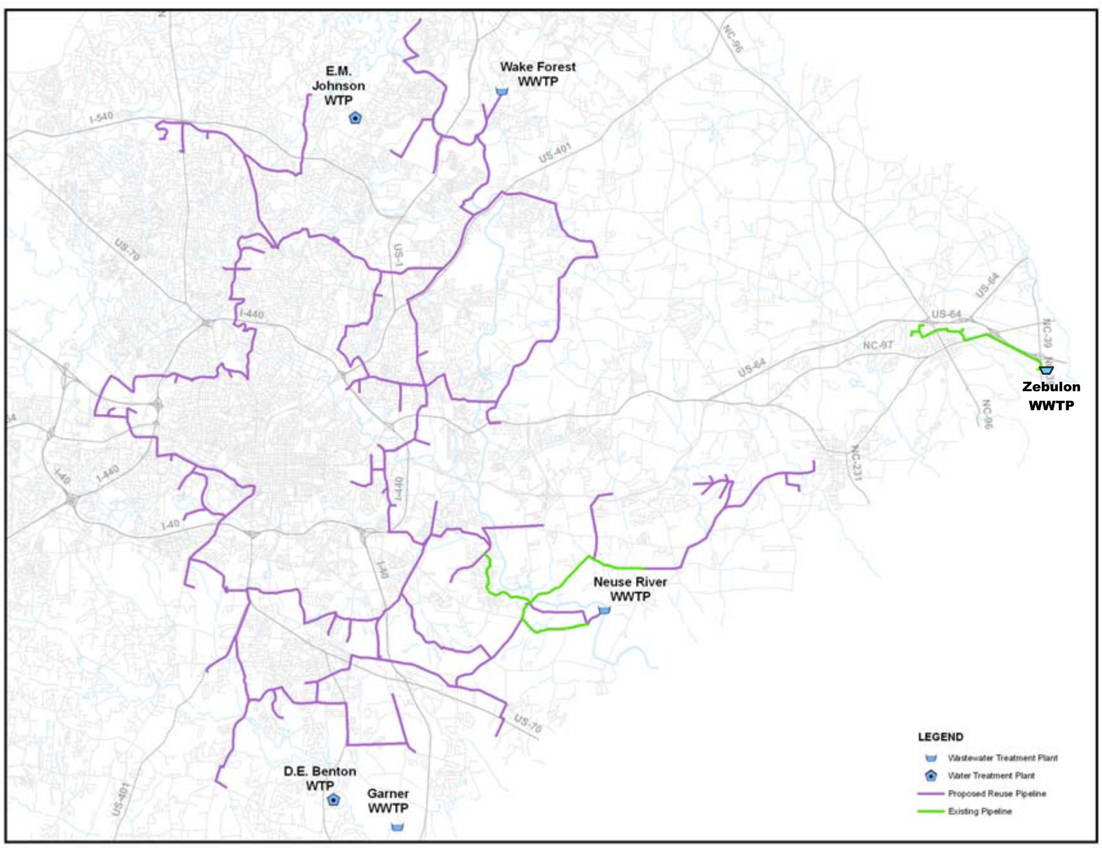
ES. EXECUTIVE SUMMARY

The City of Raleigh (City) encourages the beneficial use of the State's water resources concurrent with the protection of public health and the environment. As such, the City encourages the use of reuse water for any approved purpose when economically and technically feasible. The City's goal is to provide a regional reuse water system that satisfies non-potable water demands with high quality reclaimed water.

Existing Facilities

The existing facilities within the reuse service area include four existing wastewater plants, two existing water treatment plants, and the existing reuse system. The four existing wastewater plants include the City of Raleigh's Neuse River Wastewater Treatment Plant (WWTP), the City of Raleigh's Garner WWTP, the Wake Forest Smith Creek WWTP, and the Zebulon Little Creek WWTP. The water plants include the City of Raleigh's E.M. Johnson Water Treatment Plant (WTP) and the G.G. Hill WTP. The City is currently designing the new D.E. Benton WTP in the southern part of the service area. *Figure ES-1* indicates the location of the existing facilities.

Figure ES-1: Location of Existing Facilities



The City's Neuse River WWTP reuse system was placed in service in January 2000 and consists of a sodium hypochlorite feed system, an effluent reuse pumping station, and approximately 10 miles of 6-inch through 16-inch pipeline. The current system was designed to take effluent from the Neuse River WWTP to serve agricultural fields adjacent to the Neuse River WWTP and the plant's non-potable water system, with capacity to serve the nearby River Ridge Golf Course upon permit approval.

In 2003, the Town of Zebulon began constructing their first phase of reclaimed water distribution system to provide water for cooling tower make-up and for irrigation. The reclaimed water distribution system consists of a new pumping station, a 0.25 MG elevated storage tank, and approximately 4,500 LF of 12-inch reclaimed water piping. The reclaimed water system currently supplies water to US Foods for cooling tower water, the Five County Stadium for irrigation, and to the WWTP for non-potable plant uses. An expansion to the reclaimed water system is currently underway to supply reuse water to several other customers identified including GlaxoSmithKline, Aimet Technologies, Alliance Concrete Inc., Illinois Tool Works, East Wake Academy, and Zebulon Middle School.

The E.M. Johnson WTP is permitted to distribute reuse water to bulk tanker trucks.

Demands

Demands were estimated by surveying potential customers, evaluating existing potable water irrigation use, and interviewing prospective customers. Demands were divided into 8 different categories. A total of 233 users were identified throughout the City and surrounding areas with an annual average flow of 3.86 MGD. *Table ES-*1 summarizes the total demand for each reuse category.

Table ES-1: Total Identified Users

User Categories	Number of Identified Users	ADF	MDF	MHF
Golf Course	24	1,227,400	3,769,600	11,143,200
Commercial	23	283,000	849,000	2,834,000
Industry	33	383,750	579,500	1,397,150
Institution	37	397,510	1,069,821	2,804,816
Recreation	45	247,173	1,246,019	3,019,730
School	40	107,800	810,600	2,298,500
Residential	14	1,030,000	1,280,000	3,400,000
Nursery	17	184,000	368,000	1,364,000
TOTAL	233	3,860,634	9,972,540	28,261,397

Hydraulic Analysis

A new hydraulic model was developed in H2Onet Analyzer, Version 3.1 for the proposed distribution system at ultimate build-out. Sizing the required facilities at ultimate build-out ensured initial facilities were adequate to serve initial demands and projected future demands. Hydraulic analyses were conducted to identify piping, storage, pumping, and booster pumping facilities necessary to meet projected reuse demands through the system build-out while meeting established design goals. Parameters used to develop the reuse program included the establishment of appropriate service demands and maintaining appropriate system pressures. Various combinations of improvements were evaluated to determine the most appropriate system configuration to meet the projected reuse demands.

Several goals were established for design of the hydraulic model. The goals included the following:

- Provide a similar pressure to the potable water system to maintain the level of service for existing customers.
- The minimum system pressure was set at 25 psi during peak hour flows.
- Distribution and transmission piping would be sized for maximum headloss of 5 feet per thousand feet of pipeline.

Scenarios were developed for maximum hour, maximum day, and average day with replenishment for system storage.

Model Results

Of the 233 identified potential users added to the hydraulic model, 128 users were served based on the selected routing. Although this only accounts for service to 55% of the identified users, these users represent 79% of the total projected reuse demand. Table ES-2 summarizes the percentages of users served based on the total number of users and projected demand for the selected routing of the distribution system.

Table ES-2: Percentage of Users Served with Selected Routing

Parameter	Total Identified	Total Served	Percent Served
Number of Users	233	128	55%
Avg. Daily Demand	3.86 mgd	3.05 mgd	79%

The hydraulic model of the proposed reuse distribution system included a total of three elevated storage tanks, two pumping facilities, two in-line booster pumping stations, 253 pipes, and 226 nodes, representing the proposed system at ultimate build-out. The pipes in the model represent approximately 166 miles of reuse pipeline.

System Phasing

Seven general areas of the proposed reuse system at build-out were identified during development of the hydraulic model. These areas were named Southeast Raleigh, Wake Forest, East Wake, Northeast Raleigh, Garner, West Raleigh, and Northwest Raleigh. Figure 4-4 illustrates the proposed distribution system by phase.

Recommended Facilities

The Southeast Raleigh phase is recommended as the first phase of construction, including a new storage tank on Sunnybrook Road. The Neuse River WWTP is within the Southeast Raleigh service area.

The Wake Forest Phase is recommended as the second phase of construction and contains the Wake Forest WWTP. The Wake Forest Phase can be operated independently of the overall distribution system due to the availability of the reuse flow source from the Wake Forest WWTP.

The third phase of construction is recommended to be the East Wake Phase. Several miles of existing pipelines can be utilized for this phase of the reuse system thus reducing pipeline costs and the location of the phase is in close proximity to the Neuse River WWTP.

The Northeast Raleigh service area is located between Southeast Raleigh and Wake Forest phases. It is recommended as the fourth phase of construction.

The Garner service areas are located adjacent to the Southeast Raleigh service area and are recommended for the fifth phase of construction. The Garner phase is important in the delivery of water to the future West Raleigh phase, which is recommended as the sixth phase of construction. The Northwest Raleigh is recommended as the final phase of construction. Construction of the Northwest Raleigh phase will join the Northeast Raleigh and West Raleigh service areas, thereby completing the loop of the reuse distribution system.

Probable Costs

The probable costs of each recommended phase is shown in Table ES-3.

Table ES-3: Probable Costs of Recommended Facilities

Facility	Probable Cost ($)
Southeast Raleigh Phase	
Reuse Transmission Mains	4,800,000
Sunnybrook Road Elevated Storage Tank	1,500,000
Subtotal	6,300,000
Engineering and Contingency	1,900,000
Total	8,200,000
Wake Forest Phase	
Reuse Transmission Mains	5,200,000
Smith Creek Reuse PS	1,000,000
Subtotal	6,200,000
Engineering and Contingency	1,900,000
Total	8,100,000
East Wake Phase	
Reuse Transmission Mains	3,800,000
Subtotal	3,800,000
Engineering and Contingency	1,100,000
Total	4,900,000

Facility		Probable Cost ($)
Northeast Raleigh Phase		
Reuse Transmission Mains		15,200,000
	Subtotal	15,200,000
	Engineering and Contingency	4,500,000
	Total	19,700,000
Garner Phase		
Reuse Transmission Mains		12,700,000
	Subtotal	12,700,000
	Engineering and Contingency	3,800,000
	Total	16,500,000
West Raleigh Phase		
Reuse Transmission Mains		11,700,000
Carter Finley Elevated Storage Tank		1,500,000
Tryon Road Booster Pumping Station		800,000
	Subtotal	14,000,000
	Engineering and Contingency	4,200,000
	Total	18,200,000
Northwest Raleigh Phase		
Reuse Transmission Mains		6,300,000
Baileywick Elevated Storage Tank		1,000,000
Spring Forest Road Booster Pumping Station		800,000
	Subtotal	8,100,000
	Engineering and Contingency	2,400,000
	Total	10,500,000

Rate Analysis

Several rate structures were reviewed to determine the most appropriate structure for reuse water rates. A uniform rate structure was chosen for the reuse system. Reuse water rates were estimated based on a 30-year and 60-year buildout scenarios.

Table ES-4 shows the estimated break-even reuse rate for the next 30 years as well as the estimated potable water rate for each year. The estimated potable water rates are based on 9 percent annual increases until 2015. Beyond 2015, the rate was assumed to escalate at the same rate as the anticipated inflation of 3 percent.

Table ES-4: Rates for Option 1 Phasing, 30-Year Build-out Scenario

Years	2006	2011	2016	2021	2026	2031	2036
Phase	SE Raleigh	Wake Forest	East Wake	SE Raleigh	Garner	West Raleigh	NW Raleigh
Rate per ccf	$ 3.12	$ 3.54	$ 3.84	$ 5.14	$ 4.99	$ 7.34	$ 7.87
Estimated Potable Water Rate per ccf	$ 1.56	$ 2.40	$ 3.49	$ 4.04	$ 4.69	$ 5.43	$ 6.30

Table ES-5 shows the estimated break-even reuse rate for the next 60 years as well as the estimated potable water rate for each year. The estimated potable water rates are based on 9 percent annual increases until 2015. Beyond 2015, the rate was assumed to escalate at the same rate as the anticipated inflation of 3 percent.

Table ES-5: Rates for Option 1 Phasing, 60-Year Build-out Scenario

Years	2006	2016	2026	2036	2046	2056	2066
Phase	SE Raleigh	Wake Forest	East Wake	SE Raleigh	Garner	West Raleigh	NW Raleigh
Rate per ccf	$2.94	$3.43	$3.73	$6.37	$6.65	$10.66	$11.63
Estimated Potable Water Rate per ccf	$1.56	$3.49	$4.69	$6.30	$8.46	$11.37	$15.29

The City of Raleigh's current annual budget includes an allocation of $0.5 million for the construction of the Raleigh Reuse System. This willingness to invest capital has a significant impact on the break-even reuse rates. To assess the impact, the rate model was adjusted to reflect varying levels of capital investment from the City. Table ES-6 shows the adjusted reuse rates based on the annual investments of $0.5 million, $1.0 million, and $1.50 million. The rates are based on the 30-year buildout of the system.

Table ES-6: Rates for Option 1 Phasing, 30-Year Build-out Scenario

Years	2006	2016	2026	2036	2046	2056	2066
Phase	SE Raleigh	Wake Forest	East Wake	SE Raleigh	Garner	West Raleigh	NW Raleigh
Rate per ccf, w/ no investment	$ 3.12	$ 3.54	$ 3.84	$ 5.14	$ 4.99	$ 7.34	$ 7.87
Rate per ccf, w/ $0.5 M	$2.39	$2.78	$2.95	$4.51	$5.69	$6.78	$7.29
Rate per ccf, w/ $1.0 M	$1.66	$2.02	$2.06	$3.88	$5.09	$6.22	$6.72
Rate per ccf, w/ $1.5 M	$0.92	$1.27	$1.17	$3.25	$4.48	$5.66	$6.14
Estimated Potable Water Rate per ccf	$1.56	$3.49	$4.69	$6.30	$8.46	$11.37	$15.29

Satellite Reuse Facilities

Certain portions of the proposed distribution system are located too far from the reuse water sources to be cost-effectively supplied by conventional reuse systems. The West Raleigh, Garner, and Northwest Raleigh phases include a number of potential reuse customers, with an estimated average demand exceeding 1 mgd. Satellite water reclamation facilities (SWRF) utilizing membrane bioreactor (MBR) technology were evaluated as an alternative to allow this reuse demand to be served more cost-effectively and much sooner than a conventional approach could accomplish.

Twenty potential satellite service areas were developed and screened in a workshop with City staff. In the screening workshop, seven alternative systems were selected for further evaluation. Two systems for the N.C. State University area were selected, including a small system to serve only the new Centennial Campus, and a larger system serving both campuses as well as the area surrounding the football stadium. Two golf courses, the Carolina Country Club and the Brier Creek Country Club were selected because of their high demand in dry periods. The Downtown South system is centered around a high water using industry and would position the City to serve new development in the southern portions of the downtown area. The Downtown North system is centered around the government complex in the northern section of downtown and also includes a potential stream restoration component for an urban stream which is listed on the 303d list of impaired streams. The final alternative was a system for a single large commercial building, such as the one currently being planned for the Crabtree Valley mall area.

Table ES-7 provides the demand and estimated cost for each proposed satellite system. Table ES-8 provides the break-even reuse water rates for each alternative.

Table ES-7 – Potential Satellite Reuse Service Areas

Satellite System Name	Average Demand, gpd	Total Cost
NCSU Centennial	127,000	$ 2,800,000
West Raleigh	243,000	$ 8,700,000
Carolina Country Club	90,000	$ 1,500,000
Brier Creek	140,000	$ 4,400,000
Downtown South	90,000	$ 1,500,000
Downtown North	TBD	$ TBD
High-Rise Commercial Bldg	37,000	$ 1,500,000

Table ES-8 - Rates for Proposed Satellite Systems

	Projected Breakeven Rate, per ccf	
Satellite System Name	**0 to 5 years**	**6 to 10 years**
NCSU Centennial	$ 4.73	$ 4.24
West Raleigh	$ 7.44	$ 6.29
Carolina Country Club	$ 4.17	$ 3.75
Brier Creek	$ 6.21	$ 5.52
Downtown South	$ 3.72	$ 3.36
Downtown North	$ TBD	$ TBD
High-Rise Commercial Bldg	$ 8.34	$ 7.38

The Downtown South and Carolina Country Club alternatives are recommended for further development as they provide the ability to serve significant reuse demand at a cost comparable to the initial phases of the reuse distribution system. These satellite alternatives also provide the opportunity to reach these customers much faster than the conventional distribution system.

Administrative Programs

Developing a reuse system requires many administrative programs. Several of these are explored in later chapters of this report. A new reuse ordinance was developed to give the City the authority to implement a reuse system. The ordinance addresses the basic issues associated with connecting to the system, extensions of the system, enforcement of the ordinance, requirements of the existing reuse permit, and the anticipated requirements for obtaining delegated authority from the Department of Environment and Natural Resources. As the system continues to develop, the City may need to add additional provisions into the ordinances.

Reuse standards were developed to provide information to the development community in what is required for the construction of reuse water systems. The standards follow the existing water standards closely, with modifications to address specific issues associated with reuse water.

Reuse is a relatively new resource, and public education is a vital component to safely and effectively operate the system. On-going public education features include a reuse brochure, information on the City website, and a booth at the annual WaterFest event.

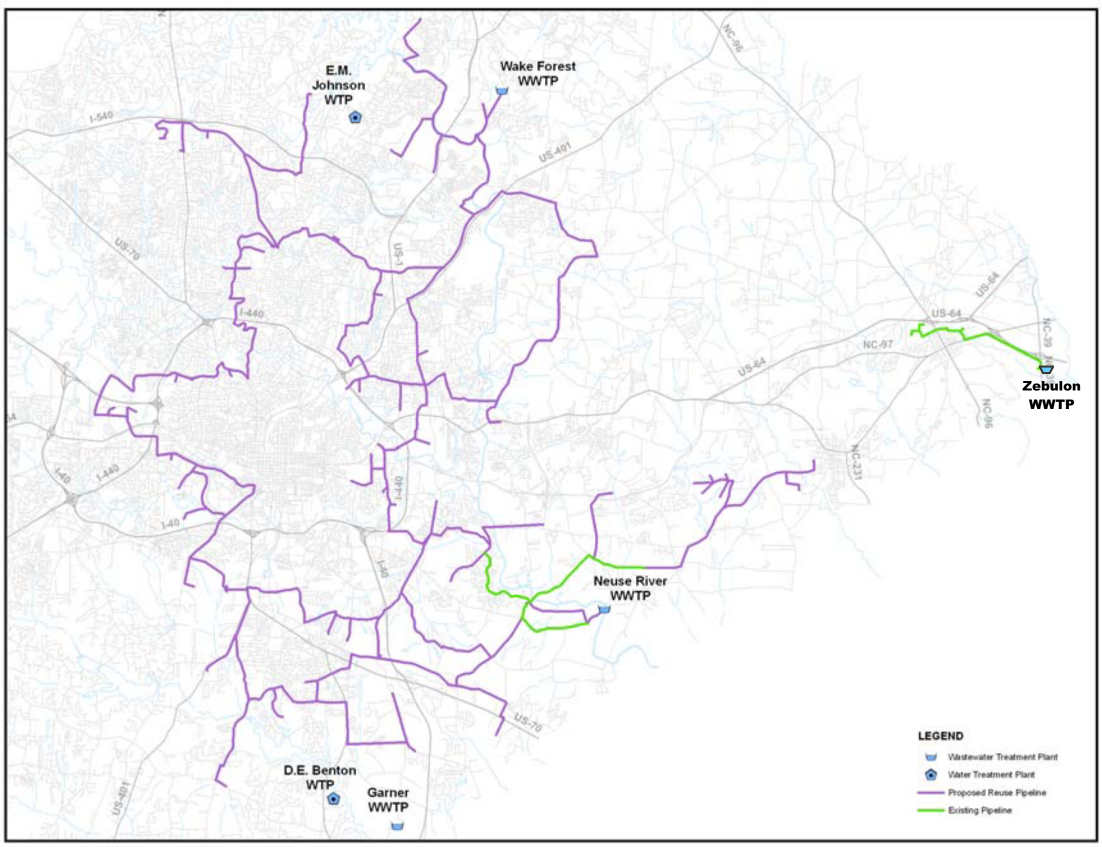
Environmental Assessment

An environmental assessment is included in this report to demonstrate the minimal impact reuse systems have on the environment, particularly when compared to the benefits of reuse. The environmental assessment is for typical projects and does not include specific environmental features. As the system is developed, additional field work analyzing the specific routes may be required to supplement the environmental information contained in this report.

2. EXISTING FACILITIES

The existing facilities within the reuse service area include four existing wastewater plants, two existing water treatment plants, and the existing reuse system. The four existing wastewater plants include the City of Raleigh's Neuse River Wastewater Treatment Plant (WWTP), the City of Raleigh's Garner WWTP, the Wake Forest Smith Creek WWTP, and the Zebulon Little Creek WWTP. The water plants include the City of Raleigh's E.M. Johnson Water Treatment Plant (WTP) and the G.G. Hill WTP. The City is currently designing the new D.E. Benton WTP in the southern part of the service area. Detailed descriptions of these facilities are provided below. Figure 2-1 indicates the location of the existing facilities.

Figure 2-1: Location of Existing Facilities



Neuse River Wastewater Treatment Plant

The Neuse River WWTP is located in Wake County, approximately 12 miles southeast of Raleigh, near the Johnston County line. The plant was originally placed into service in 1976 with a capacity of 30 million gallons per day (mgd). Subsequent upgrades to the plant have increased capacity to 60 mgd, the current capacity of the plant. Plans are being developed to expand the plant to 75 mgd. On average, the plant currently treats 45 mgd of wastewater.

The Neuse River WWTP consists of the following treatment steps: primary treatment, activated sludge secondary treatment with biological nutrient removal, tertiary filtration, and ultraviolet disinfection. A summary of the effluent water quality from the Neuse River WWTP from May 2004 to May 2005 is provided in Table 2-1 below. This data was provided by HDR Engineering Inc. of the Carolinas in the *Preliminary Engineering Report for the Neuse River Wastewater Treatment Plant Facility Biosolids Farm Spray Irrigation System* dated July 2005.

Table 2-1: Neuse River WWTP Effluent Water Quality Parameters from 2004-2005

Parameter	Average Value	Permit Limit
BOD_5	0.1mg/l	10mg/l
NH_3	0.1mg/l	4mg/l
TSS	0.7mg/l	5mg/l
Fecal	1.7mg/l	14mg/l
TN	2.8mg/l	N/A
TP	1.2mg/l	N/A

As can be seen by comparing the water quality parameters provided in Table 1-1 and Table 2-1, the Neuse River WWTP meets all the requirements set forth for reuse water distribution. In the event that the quality of the reuse water does not meet the reuse requirements, the reuse water service will be discontinued until the water quality characteristics are in conformance.

Reuse System

The City's existing reuse system was placed in service in January 2000 and consists of a sodium hypochlorite feed system, an effluent reuse pumping station, and approximately 10 miles of 6-inch through 16-inch pipeline. The current system was designed to take effluent from the Neuse River WWTP to serve agricultural fields adjacent to the Neuse River WWTP and the plant's non-potable water system, with capacity to serve the nearby River Ridge Golf Course upon permit approval. The sodium hypochlorite feed system is used to provide a chlorine residual in the reuse water.

The effluent reuse pumping station consists of four vertical turbine pumps with the following capacities: 250 gallons per minute (gpm), 500 gpm, 1000 gpm, and 2000 gpm. The total capacity of the station is approximately 5 mgd. The firm capacity of the station with the largest pump out of service is 1,750 gpm (approximately 2.5 mgd). The initial reuse water demand for the system was approximately 0.9 mgd.

Currently, the effluent reuse pumping system is being upgraded to provide additional capacity for the irrigation of the on-site agricultural fields and for increased demands on the plant's non-potable water system.

Garner Wastewater Treatment Plant

The Garner WWTP is located in Wake County, near the Johnston County line. Currently, the plant has a capacity of 1 mgd and consists of treatment lagoons, a chlorine contact chamber, and a spray irrigation system. In March of 2001, the Garner WWTP was merged into the

Raleigh wastewater system. Upon completion of a new transfer pumping station all of Garner's wastewater will be diverted to the Neuse River WWTP. The Garner WWTP will subsequently be abandoned as a treatment facility. The plant's spray fields will be used to dispose of washwater from the proposed new D.E. Benton WTP. Because the City plans to abandon the Garner WWTP and utilize the spray fields for the disposal of the D.E. Benton WTP wash water, it was not evaluated as a source or demand for reuse water.

Smith Creek Wastewater Treatment Plant

The Smith Creek WWTP is located on Ligon Mill Road one mile east of Capital Boulevard and was previously operated as part of the Town of Wake Forest utility department. On July 1, 2005, the City of Raleigh and the Town of Wake Forest merged their utility systems and the City of Raleigh took over operation of the Smith Creek WWTP.

The Smith Creek WWTP is an advanced tertiary, biological nutrient removal (BNR) plant with a treatment capacity of 2.4 mgd. The plant currently treats an annual average of 0.7 mgd of wastewater. The Smith Creek WWTP was identified as a potential source of reuse water in the model.

The City is currently planning improvements to the Smith Creek WWTP and the influent pumping facilities. A new pumping station is planned to allow the City to divert flow to the Smith Creek WWTP or away from it. This will allow the City to control the influent flow into the plant much like a satellite treatment facility.

E. M. Johnson Water Treatment Plant Filter Wash Water

The E. M. Johnson Water Treatment Plant (WTP) can produce up to 78 mgd of potable water and currently treats an average of 47 mgd. The treatment process includes coagulation, sedimentation, filtration, and disinfection. Filter wash water, produced from backwashing of the filters, was identified as a potential source of reuse water. In 1997, a total of 2.4 mgd of filter wash water was produced from the E. M. Johnson WTP. The City has obtained a permit to distribute reuse water from the E. M. Johnson WTP to bulk containers. The City is also investigating the potential to recycle the treated washwater into the raw water storage basins.

Little Creek Wastewater Treatment Plant & Reuse System

The Town of Zebulon currently operates the Little Creek WWTP. The plant has been in operation since 1993 and has a treatment capacity of 1.85 mgd. In 2002, the Town upgraded the WWTP to include biological nutrient removal capability to meet more stringent effluent limits and to satisfy the North Carolina Department of Environment and Natural Resources (NCDENR) Reclaimed Water Standards. In 2003, the Town began constructing their first phase of reclaimed water distribution system to provide water for cooling tower make-up and for irrigation. The reclaimed water distribution system consists of a new pumping station, a 0.25 MG elevated storage tank, and approximately 4,500 LF of 12-inch reclaimed water piping. The reclaimed water system currently supplies water to US Foods for cooling tower water, the Five County Stadium for irrigation, and to the WWTP for non-potable plant uses. An expansion to the reclaimed water system is currently underway to supply reuse water to several other customers identified including GlaxoSmithKline, Aimet Technologies, Alliance Concrete Inc., Illinois Tool Works, East Wake Academy, and Zebulon Middle School. For the purposes of this master planning report, the reuse system for the Town of Zebulon is considered existing and has been shown on several figures for informational purposes.

3. REUSE DEMAND ALLOCATION

Demands

A utility must be able to supply reuse water at flow rates that fluctuate over a wide range. Yearly, monthly, weekly, daily, and hourly variations in water use are to be expected. Water use is typically higher during dry years since more water is used for irrigation and lawn watering. Parameters most important to the design and operation of a reuse system are average day (AD), maximum day (MD), and maximum hour (MH) uses. These flow factors can vary widely based on size of the utility, as well as regional and climactic variables. For potable water, maximum day factors can vary from 1.5 to 3.5 over the average day flow, while maximum hour factors can vary from 2.0 to 7.0 over the average day flow [Water Treatment Principles and Design, J. Montgomery, 1985]. Because of the nature of reuse water usage, factors associated with reuse are expected to be significantly higher than potable.

Average day use is the yearly total reuse water use divided by the number of days in the year. This rate is used for developing supply, treatment, and pumping costs.

Maximum day use is the maximum quantity of water used on any day of the year. The maximum day rate is used to size reuse supply and treatment facilities to ensure that these facilities are capable of producing an adequate quantity of water.

The greatest demands on a reuse system are generally experienced for short periods of time during the maximum demand day. These peak demands are referred to as maximum hour demands or peak hour demands because they seldom extend over a period of more than a few hours. Although the duration of these extreme demands is relatively short, the rate of consumption during the maximum hour period often taxes the capabilities of the pumping facilities, transmission and distribution mains, and system storage. Instantaneous peak demands are generally met by a combination of discharge from the treatment plant and flow from strategically located storage facilities. The use of system storage minimizes the required capacity of transmission mains and permits a more uniform and economical operation of the supply, treatment, and pumping facilities. Due to the diurnal nature of use, peak hour demands were evaluated for two peak periods, referred to as “day peak” and “night peak” demands.

Existing Demands

The existing reuse system serves a limited number of users: the WWTP’s non-potable water system and portions of the City’s agricultural fields near the plant. The preliminary system, 5MGD total capacity pumping station, was also designed to serve the River Ridge Golf Course adjacent to the WWTP, but this use is not currently permitted. It is expected that the River Ridge Golf Course reuse irrigation system will be permitted and operational by the end of 2006.

Future Demands

The City of Raleigh provided Black & Veatch with a list of potential customers. Many of these were commercial irrigation users, as well as residential developments, industrial, and institutional users. In addition to these users, Black & Veatch identified other potential reuse customers in other areas of the City and expanded the list to include eight categories. These categories and their corresponding symbols include golf course (GC-XX), commercial

(COM-XX), industry (IND-XX), institution (INST-XX), recreation (REC-XX), school (SCH-XX), residential (RES-XX), and nursery (NUR-XX). These users were evaluated to determine their projected demand for reuse water including average daily, maximum daily, and peak hourly flows. The most valuable information on the location and magnitude of demands throughout the system was collected from the utility's meter reading and billing system. Black & Veatch evaluated the water meter sales for all large water meters (1 ½-inch and larger) for the years 1999-2000 and 2004-2005. The data was segregated by potable water meters and irrigation meters. The latest 2004-2005 data included nearly 5,700 users with an average daily demand of 20.6 mgd. Approximately 600 irrigation and hydrant meters registered an average daily demand of 1.4 mgd. The top water users near the WWTP were identified by their zip code. City staff and Black & Veatch team members also identified various potential large water users to survey, including all the golf courses in the area. Written surveys were mailed to the top 50 water users (potable and irrigation), top 25 irrigation users, top water users with a 27610 zip code (potable and irrigation), and the other users identified by the project team. Although approximately 70 surveys were mailed with pre-stamped, pre-addressed envelopes, less than 10 were returned. Follow-up telephone interviews were conducted with the water users that did not complete the surveys and with additional water users identified by the City.

A total of 233 users were identified throughout the City and surrounding areas with an annual average flow of 3.86 MGD. Table 3-1 summarizes the total demand for each reuse category.

Table 3-1: Total Identified Users

User Categories	Number of Identified Users	ADF	MDF	MHF
Golf Course	24	1,227,400	3,769,600	11,143,200
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TOTAL	233	3,860,634	9,972,540	28,261,397

Black & Veatch utilized electronic maps to locate the identified potential users on the system map. Subsequently, those consumption values are correlated to demand points in the model. The majority of the identified users for the reuse system have current demands. In certain cases, where residential or commercial development construction plans were in the near future, an estimated demand was calculated and these future developments were included in the hydraulic model.

Demand Categories

Golf course irrigation was identified early in the project as a large customer base. Twenty-four golf courses were identified in the reuse service area contributing to approximately 32% of the potential identified average daily reuse demand. Telephone surveys were conducted with these golf course users to determine each course's potential reuse requirements. Overall, the majority of golf courses were very interested in reuse as a stable alternative to their current climate-dependent irrigation systems. Several courses could not meet their irrigation demand with their existing facilities and were primarily interested in augmenting their existing irrigation ponds. The surveys indicated that golf course irrigation varies widely from course to course depending on the size and irrigation characteristics of the golf course. For example several golf courses surveyed only irrigate the greens, which only account for approximately 5% of the total golf course acreage. Another characteristic of golf course irrigation is nocturnal reuse demand. This nightly demand is due to irrigation limitations associated with typical golf course usage.

Commercial users account for approximately 7% of the total average day demand for the reuse system. The majority of the commercial reuse demand is generated by landscape irrigation for business parks and cooling water for office buildings. The commercial demand was estimated with the metered water sales data and telephone surveys. Considering that the majority of business parks irrigate with potable water, several local property developers were surveyed to gauge their interest in reuse service. Every property developer contacted was very interested in reuse service and its potential to reduce irrigation costs. Assumptions regarding reuse demand were made by analyzing the information gathered from the surveys and the data calculated from collected information regarding potable water usage over known office space square footage. It was determined that an average of 82 gpd per 1,000 square feet of building space can be assumed for landscape irrigation and 15 gpd per 1,000 square feet of building space can be assumed for cooling water for business parks. Commercial users will provide an early morning demand peak for the reuse system.

Industrial demand is generated by a wide variety of manufacturing facilities. These industrial users use reuse water as process water, rinse water, cooling water, and irrigation water. Approximately 33 industrial users were identified in the service area accounting for about 10% of the total average day demand for the reuse system. Overall, the majority of the industrial users surveyed were interested in reuse service but were concerned about the water characteristics of the reuse water. Most of the surveyed industrial users were interested in learning more information about the reuse service and reuse water parameters. The reuse water demand for industrial users will be site specific. For this report it was assumed that all industrial users would have a daytime peak use.

Institutional users account for approximately 10% of the total average day reuse demand identified. Institutional users include hospitals, universities, colleges, correctional institutions, cemeteries and a retirement home. Reuse water has many different uses for institutional customers ranging from cooling water for boilers to irrigation of landscape and agricultural fields. The majority of institutional users surveyed was interested in reuse service to minimize their potable water costs but would like more information regarding the water characteristics of the reuse water. The majority of institutional reuse water demand were assumed to peak during the daytime except for the demands generated by the cemetery's which are expected to peak nightly.

Approximately 6% of the total average day reuse demand is generated by recreational users. Reuse demand at these facilities is generated by the irrigation of ball fields, soccer fields and in some cases park land. Wherever possible, irrigation meter data was utilized to determine the potential reuse demand for the user, however only 13 irrigation meter readings were available for 45 recreational users. These irrigation meter values ranged widely from 15 gpd to 23,400 gpd, and provided no consistent value for estimating average recreational reuse demand. Therefore, assumptions were made regarding the reuse demand for each recreational user. The major reuse demand for recreational users was determined to be the irrigation of ball fields, therefore the number of ball fields located at each recreational facility was determined. It was assumed that each ball field requires 1,500 gpd of average day flow. The recreational users surveyed were very interested in reuse water service and its potential to lower monthly water bills. Nocturnal peaks are a characteristic of recreational user demand because irrigation must be performed during periods in which the facilities are not in use.

The lowest demand for reuse water is generated by school users. Although 40 schools were located in the service area, the percentage of the total average day demand for reuse water is only about 3%. Wherever possible, irrigation meter data was utilized to determine the potential reuse demand for the user, however only 13 irrigation meter readings were available for 40 school users. These irrigation meter values ranged widely from 500 gpd to 12,550 gpd, and provided no consistent value for estimating average school reuse demand. Therefore, assumptions were made regarding the reuse demand for each school user. It was assumed that one and two ball fields would be located at every middle school and high school, respectively. Each ball field was assumed to require 1,500 gpd of average day flow. School users tend to generate daytime peaks for the reuse distribution system by irrigating the ball fields early in the morning.

Approximately 27% of the total average day reuse demand for the reuse distribution system is created by the 14 identified and potential residential developments. Of these fourteen residential users, nine are proposed residential developments located in the northeastern Raleigh area, New Hope Road area, and the Brier Creek area. Several assumptions had to be made regarding the potential reuse demand for each user, such as home sites per development, acreage per home sites, water usage per acre and percentage of reuse participation. Considering that the majority of the residential landscape irrigation water usage is from potable sources, it was assumed that at least 50 to 100 percent of the home site owners would be interested in reuse service and its potential to lower current water bills. The irrigation usage for each community was determined based on the community size and home and lot square footage. Residential users generate diurnal peaks for the reuse system due to early morning irrigation.

Seventeen plant nurseries were located in the Raleigh reuse service area. These nurseries account for 5% of the total average day reuse flow. Plant irrigation generates the majority of the reuse demand generated by nursery users. The majority of the nursery users were surveyed to accurately determine their potential reuse demand. Overall, most of the nurseries were very interested in reuse service as an alternative to their existing climate-dependent irrigation systems. The information gathered from the telephone surveys was used to make relative assumptions to estimate the reuse demand of the non-surveyed nurseries. The largest nursery reuse user is Taylor’s Nursery. This nursery is located in the southeast portion of Raleigh. Nursery users were assumed to create daytime peaks for the reuse distribution system. Reuse demand is also expected to be more consistent throughout the year due to greenhouse irrigation demands.

4. HYDRAULIC ANALYSIS

Hydraulic analyses were performed using H2Onet Analyzer, Version 3.1. The software links a graphical editing environment and a traditional database environment with a hydraulic analysis algorithm to provide a wide array of analysis options. The software can be utilized to evaluate steady-state and extended period simulations. For this study, several steady-state scenarios were prepared to evaluate the performance of the system under a variety of operating conditions, as described further below.

A new hydraulic model was developed for the proposed distribution system at ultimate build-out. Sizing the required facilities at ultimate build-out ensured initial facilities were adequate to serve initial demands and projected future demands. Hydraulic analyses were conducted to identify piping, storage, pumping, and booster pumping facilities necessary to meet projected reuse demands through the system build-out while meeting established design goals. Parameters used to develop the reuse program included the establishment of appropriate service demands and maintaining appropriate system pressures. Various combinations of improvements were evaluated to determine the most appropriate system configuration to meet the projected reuse demands.

Hydraulic Model Design Goals

Several goals were established for design of the hydraulic model. The goals included the following:

- Provide a similar pressure to the potable water system to maintain the level of service for existing customers.
- The minimum system pressure was set at 25 psi during peak hour flows.
- Distribution and transmission piping would be sized for maximum headloss of 5 feet per thousand feet of pipeline.

Demand Nodes

The eight categories of users identified during the development of the demands included golf courses (GC), commercial (COM), industrial (IND), institutional (INST), recreational (REC), schools (SCH), residential (RES), and nurseries (NUR). Each identified user was assigned a category-based identification number (e.g., GC-01) and added as nodes to the hydraulic model. Street addresses were used to locate all of the users. Nodes for residential users were added to the model near the center of the corresponding residential area. For all other types of users, nodes were added to the model based on the street address of each user. Demand data, including average day, maximum day, and maximum hour demands, were associated with each user node, along with estimated ground elevations at each site. Ground elevations were estimated from 100K DLG topographic electronic files using the software package Topo Depot on CD, version 2.0.23 dated 10/9/2001 and the latest USGS maps. Demands were estimated for a total of 233 identified users.

Preliminary Pipeline Routing

Preliminary model pipeline routing was performed to meet several identified goals. Preliminary routing was chosen to supply water to as many reuse customers as practical. Where possible, routing was selected along existing roadways or proposed roadway projects identified by City staff and the Department of Transportation. Where practical, piping was connected to create hydraulic loops that increase hydraulic efficiency of the system and improve reliability. A corridor analysis was performed that considered several factors, including the level of existing development, constructability, potential for future development, number of potential users along the route, and identified roadway projects. The results of the corridor analysis were presented to City staff and modified appropriately.

A number of factors were used to determine if the reuse system would extend to a particular customer, including the user's projected demand, length of pipe required to reach the user, engineering judgement, and results of the corridor analysis. The routing could not be chosen to serve all of the identified users. Several of the users were relatively isolated, and routing could not be justified based on projected demands and required length of piping. Some highly developed areas were not served based on the low demand projections and constructability issues.

Physical Model

The physical characteristics of the reuse distribution system included ground topography; reservoir elevations and capacities; pump characteristics; and the diameter, length, and interior roughness of each section of pipe being modeled.

In the Hazen-Williams empirical equation for pipe flow, interior roughness is expressed in terms of a coefficient referred to as the C-value. Higher C-values represent greater flow capacities in pipes due to a reduced frictional head loss. The C-value is a function of pipe material and age, type of pipe lining, cross-sectional area of the pipe, amount of tuberculation on the pipe wall, and other factors. Since the reuse distribution system will primarily be new construction with smooth walled PVC pipes, a C-factor of 130 was assigned to the modeled pipes. The existing ductile iron pipes near the Neuse River WWTP were assigned a C-factor of 120.

To analyze a distribution system, it is usually neither practical nor necessary to model every pipe in the system. For planning level studies, "skeletonized" models are typically utilized that include only large diameter pipes. For typical water and reuse systems, the influence of small diameter mains on flow capacity is relatively insignificant and is usually compensated in the model calibration. However, the proposed Raleigh reuse system has a significant amount of pipes with small diameter mains, with approximately one-third of the mains having a diameter of 8 inches or less. To accurately model the proposed system, it was necessary to provide more detail than that of a skeletonized model. In general, all proposed reuse transmission mains were included in the model, with diameters ranging in size from 4-inch to 24-inch. Transmission mains that supply water to the storage tanks throughout the system were sized to insure adequate capacity to replenish the storage tanks within a 6 to 8-hour period, as well as provide system delivery pressures that meet or exceed the minimum criteria of 25 psi during peak hour demands. Other mains were sized to meet or exceed the minimum pressure and flow requirements for the assumed demand scenarios. The existing reuse system, which includes 10 miles of pipeline and a 5-mgd pumping station facility at the Neuse River WWTP, was not input into the model since the reuse distribution system and the existing reuse system will serve different demands and will operate independently. Where possible, existing pipelines were utilized to connect service areas. Existing 12-inch pipelines leaving the Neuse WWTP were utilized to serve the Southeast phase and an existing 16-inch pipeline routed along Auburn Knightdale Road and Grasshopper Road was utilized to serve the East Wake Phase. However, this line will not be available for reuse until approximately 2011 when a new sewer outfall will be constructed.

Application of Model

Network analysis programs make use of engineering equations and mathematical algorithms to determine the flows and pressures that would exist in a distribution system under a specified set of conditions. In general, the flow and gradient patterns depend upon the magnitude and location of system supplies and demands, and the characteristics of the mains in the distribution network. The head loss through each main is a function of the flow rate, pipe diameter, pipe length, and interior pipe roughness. The available pressure, or head, as predicted by the model at any point in the network is the difference between the calculated hydraulic gradient and the ground elevation as entered into the model at the given location.

Using the hydraulic model, alternative system configurations were evaluated to determine the most appropriate layout to meet projected water demands, while meeting established goals. In general, analyses were performed for four basic system conditions: maximum hour demand (for both day peak and night peak), maximum day demands, and average day demand.

Maximum Hour Scenarios – Day Peak and Night Peak

Maximum hour scenarios were utilized to confirm the ability of the system to maintain minimum pressures during periods of maximum demand. The system was configured to match typical operating characteristics at the end of the maximum hour period. Due to the high peaking factors associated with reuse systems and the usage patterns typically associated with reuse, users were separated into two peak-hour categories: day peak and night peak. For example, golf courses typically irrigate during periods that golfers are not utilizing the grounds. The maximum hour demands for golf courses were therefore assigned as night peak demands. Maximum hour scenarios were modeled for both day peak demands and night peak demands with the following considerations:

- The model was developed to satisfy a 6-hour night peak demand followed by a 6-hour day peak demand.
- Tank levels were set 15-ft below their overflow elevations to evaluate the systems ability to maintain pressures. This condition simulates the end of a maximum hour period when tanks have been significantly depleted.
- High service and booster pumping stations were operated at firm capacity. Pumping capacity was added, as required, to meet demands and maintain system pressures. Grade at the high service and booster pumping stations was controlled to maintain the reuse system at a hydraulic grade corresponding to the potable water system hydraulic grade where practical. Some areas of the reuse system deviate from this criterion due to their proximity to booster pumping stations, elevated storage tanks, and locations within the reuse distribution pressure zones. Boosting pressure to meet the potable water pressures in certain areas was not practical and would require additional booster pumping stations and elevated tanks

- For this study, a minimum system pressure goal of 25 psi was established.

Maximum Day Scenarios

Maximum day scenarios were utilized to confirm the ability of the system to maintain storage in elevated tanks during periods of maximum day demand. The system was configured to match typical operating characteristics on the maximum day prior to the maximum hour (night peak and day peak) period. Maximum day scenarios were modeled with the following considerations:

- Elevated tank levels were set to full based on the assumption that the tanks are full and prepared to satisfy the peak demand period.
- High service and booster pumping stations were operated to meet demands and maintain system pressures. Where necessary, booster pump operation was adjusted to maintain the water levels in the elevated tanks. Grade at high service and booster pumping stations was controlled to maintain the reuse system at the corresponding potable water system hydraulic grade, where practical. Some areas of the reuse system deviate from this criterion due to their proximity to booster pumping stations, elevated storage tanks and locations within the reuse distribution pressure zones. Boosting the pressures to meet the potable water pressure in certain areas was not practical and would require additional booster pumping stations and elevated storage tanks.
- System pressures were maintained at the minimum of 25 psi throughout the system.

Average Day Scenarios with Replenishment

Average day scenarios with replenishment were utilized to confirm the ability of the system to refill storage facilities during periods of average demand. The system was configured to match typical operating characteristics on the average day. Average day scenarios were modeled with the following considerations:

- The average day demand period was assumed to have a minimum 8 hours duration. The performance of the reuse system was evaluated to verify the available replenishment rate. Tank levels were assumed to be 15-ft depleted to determine the average replenish rate.
- High service and booster pumping stations were operated to meet demands, maintain system pressures and replenish the storage tanks during the 8-hour average day demand period. Grade at high service and booster pumping stations was controlled to maintain the reuse system at the corresponding potable water system hydraulic grade. Some areas of the reuse system deviate from this criterion due to their proximity to booster pumping stations, elevated storage tanks and locations within the reuse distribution pressure zones. Boosting the pressure to meet the potable water pressures in certain areas was not practical and would require additional booster pumping stations and elevated storage tanks.
- System pressures were maintained at the minimum of 25 psi throughout the system.

Correlation to Water System Pressure Zones

Analysis of the reuse system hydraulic model indicated a strong correlation between the reuse system and the City's potable water system. The water system pressure zones relate to several characteristics of the reuse distribution system, including relative pressure levels, pipeline elevations, and storage requirements. There are four potable water pressure zones in the City of Raleigh: the 495-foot, 595-foot, 605-foot, and 655-foot pressure zones. The Garner service area has a separate 532-foot pressure zone. The Wake Forest service area has a separate 523-foot pressure zone, and the Wake service area has two separate pressure zones, the 467-foot pressure zone and 497-foot pressure zone. These zones provide acceptable water pressures in the potable water system and are defined by the overflow elevations of storage tanks. Combinations of supplies, storage, and pumping facilities supply these zones. The locations of the potable water pressure zones and corresponding hydraulic grades are provided in Figure 4-1.

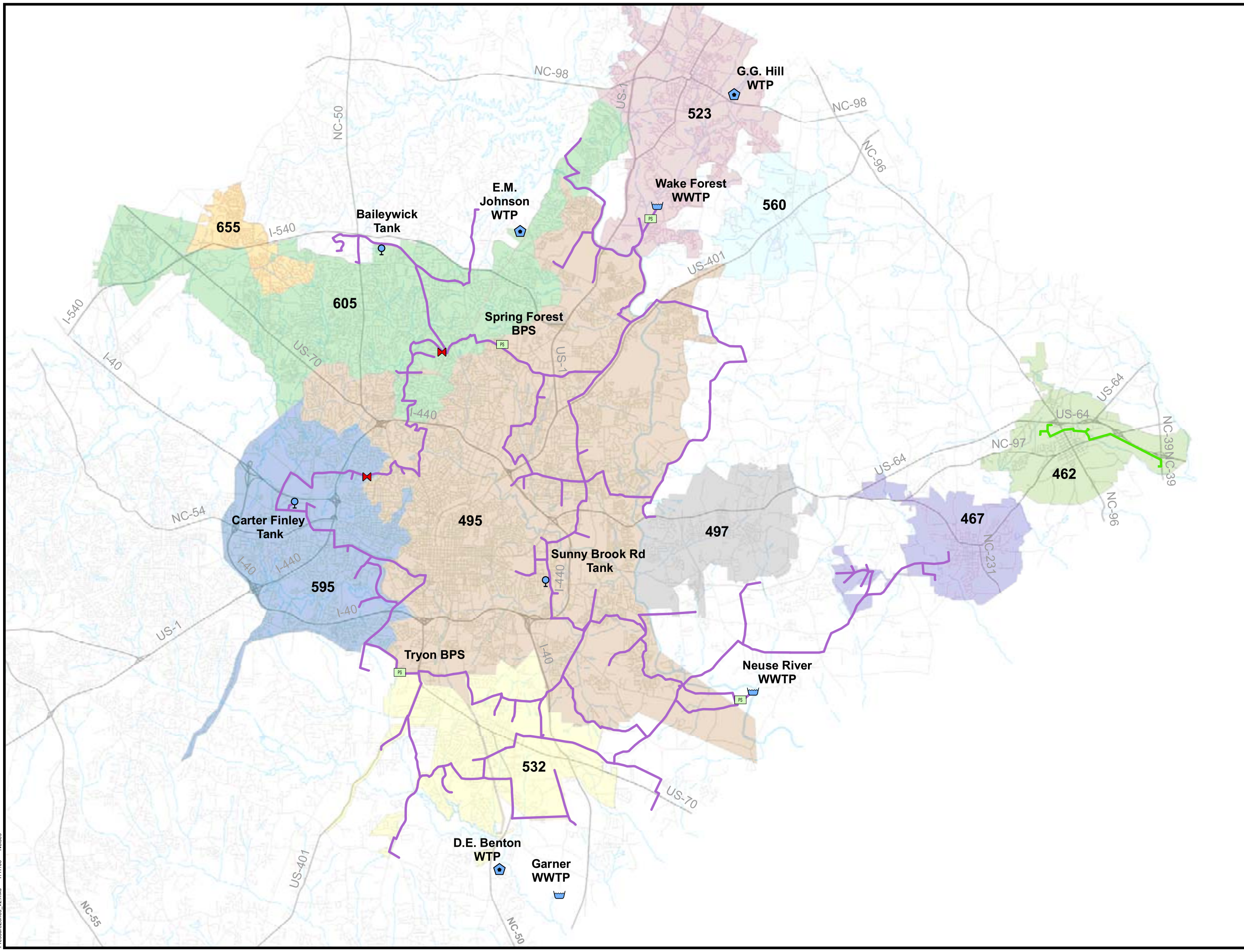
The Raleigh Reuse Distribution System hydraulic grade closely mirrors the City's potable water system hydraulic grade along the 605-foot, 595-foot and 495-foot pressure zones. The reuse system design goal was to maintain the pressure within the reuse distribution system to that of the potable water system, where practical. Therefore, two pressure zones were identified for the reuse system: the 595-foot and the 495-foot pressure zones. As previously stated, some areas of the reuse system deviate from this criterion due to their proximity to booster pumping stations, elevated storage tanks, and locations within the reuse distribution pressure zones. Boosting the pressure to meet the potable water pressures in some areas was not practical and would require additional booster pumping stations and elevated storage tanks.

The 495-foot reuse pressure zone corresponds to the 495-foot potable water pressure zone that serves central, north, and east Raleigh. The 595-foot reuse pressure zone corresponds to the 595-foot and 605-foot potable water pressure zones serving west and south Raleigh. The 532-foot potable water pressure zone in Garner was determined to be adequately served by the 495-foot reuse pressure zone based on the locations and elevations of the identified potential reuse users. The reuse distribution system as proposed does not extend to the 655-foot potable water pressure zone. The locations of the reuse water pressure zones and corresponding hydraulic grades are provided in Figure 4-1A.

City of Raleigh
Reuse Master Plan

Potable Water Pressure Zones

Figure 4-1



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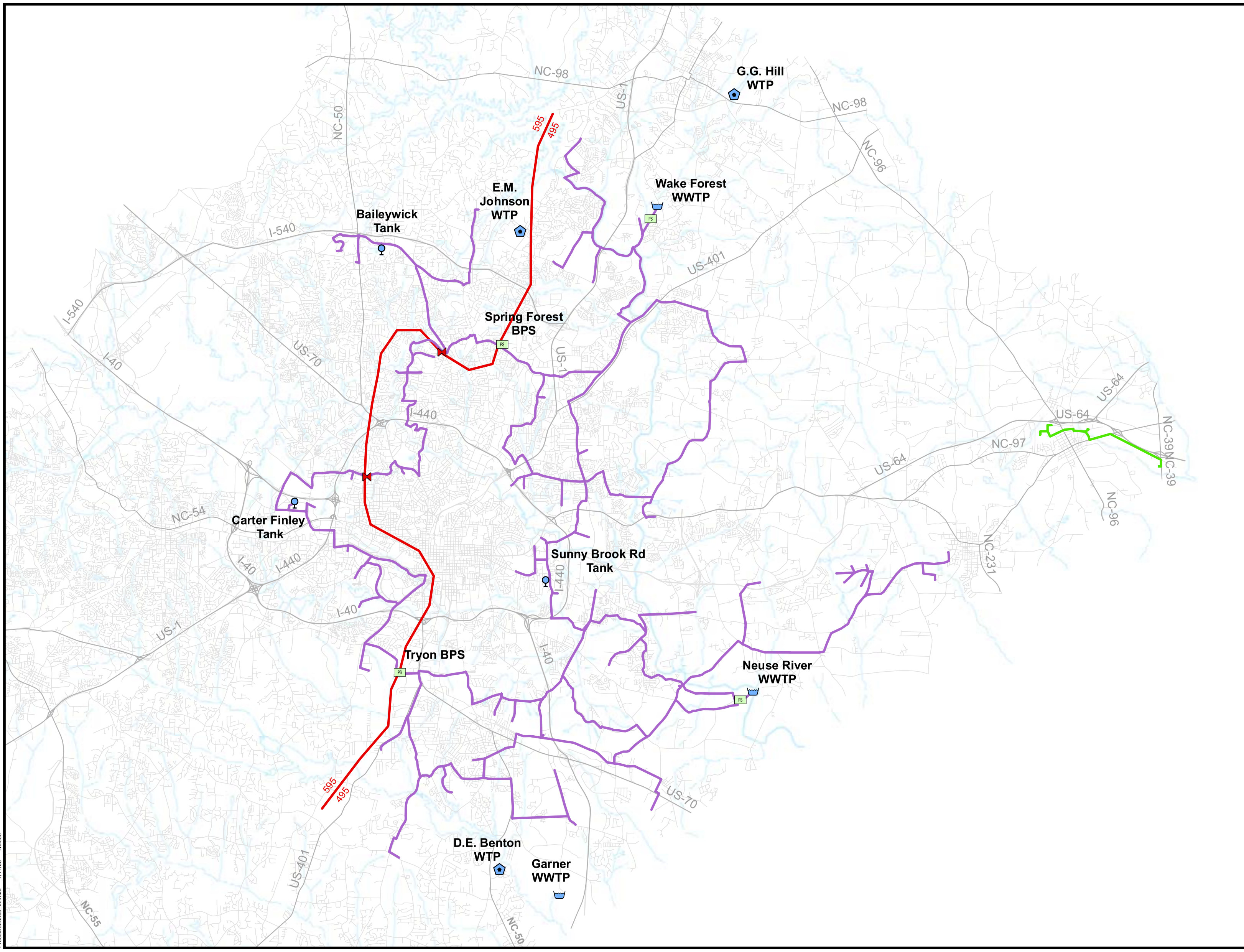

City of Raleigh
Reuse Master Plan

Reuse Water Pressure Zones

Figure 4-1-A

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Hydraulic Model Results

Of the 233 identified potential users added to the hydraulic model, 128 users were served based on the selected routing. Although this only accounts for service to 55% of the identified users, these users represent 79% of the total projected reuse demand. Table 4-1 summarizes the percentages of users served based on the total number of users and projected demand for the selected routing of the distribution system.

Table 4-1: Percentage of Users Served with Selected Routing

Parameter	Total Identified	Total Served	Percent Served
Number of Users	233	128	55%
Avg. Daily Demand	3.86 mgd	3.05 mgd	79%

The hydraulic model of the proposed reuse distribution system included a total of three elevated storage tanks, two pumping facilities, two in-line booster pumping stations, 253 pipes, and 226 nodes, representing the proposed system at ultimate build-out. The pipes in the model represent approximately 166 miles of reuse pipeline.

The locations of the each of the identified customers to be served by the system are shown on the Reuse Distribution System Customers map attached in the Appendix. Each Customer/Map ID number corresponds to an identified customer and is listed in the Reuse System Customers Table also attached in the Appendix. The estimated flows are also provided for each customer.

Storage Facilities

Storage facilities in a distribution system serve a number of purposes, including flow equalization, water pressure stabilization, and pipe size optimization. Storage facilities that store water at the system hydraulic gradient, such as elevated tanks, can also be used to govern pump operation.

Without storage facilities, supply and transmission facilities would need to be sized to meet projected instantaneous demands acting on the system. However, by constructing appropriately sized reservoirs at strategic locations, the required capacity of the other major system components can be reduced, thereby reducing overall system costs.

The amount of equalization storage needed is a function of an area's demand characteristics and the capacities of the major system components. It is generally most economical to size supply, pumping, and transmission facilities to meet the maximum day demand rate and to provide equalizing storage to meet peak demands in excess of this rate. Thus, on a maximum demand day, storage facilities will contribute water when demands are greater than the maximum daily rate and will refill when demands are less than the maximum daily rate.

Determining the appropriate size and location of storage facilities is an important part of a reuse water system study. Factors considered in evaluating the storage requirements in the Raleigh Reuse system included the following:

- The ratio of the maximum hour demand rate to the maximum day demand rate.
- The relative economics of constructing additional pumping and transmission facilities versus additional system storage facilities.
- The degree of system reliability desired by the City.

In an effort to determine whether the Raleigh Reuse distribution system would require supply storage, an analyses was performed to determine the relationship between the minimum hourly flow from the Neuse River WWTP and the Wake Forest WWTP and the maximum hour demand for the reuse system. It was determined that the maximum hour reuse demand for the entire distribution system is 21.4 mgd at buildout of the system. The minimum hourly flows at the Neuse River WWTP and the Smith Creek WWTP are 15 mgd and 0.3 mgd respectively. These minimum hour flows are expected to increase significantly over the project planning period. Using a flat 3 percent increase per year for 20 years, the minimum hourly flows would be 27 and 0.5 mgd respectively, which can adequately supply the maximum hour reuse demand. Therefore, supply storage is not necessary, but some storage may be considered to facilitate reuse pumping.

During the initial development of the Wake Forest Reuse Service area, the maximum hour demand may exceed the minimum hour demand at the Smith Creek WWTP, which will require storage to able to meet the reuse demand at all times. However, the flows at the Smith Creek WWTP may change significantly over the short-term as the City considers transferring additional flow to the Smith Creek WWTP. It is unclear at this time how much storage will be required as the influent flows to the Smith Creek WWTP is uncertain. For the purpose of this report, we have assumed that the Smith Creek WWTP will produce a flow of 2.4mgd at system buildout and will contribute reuse water into the reuse system to provide flow for customers in other service areas.

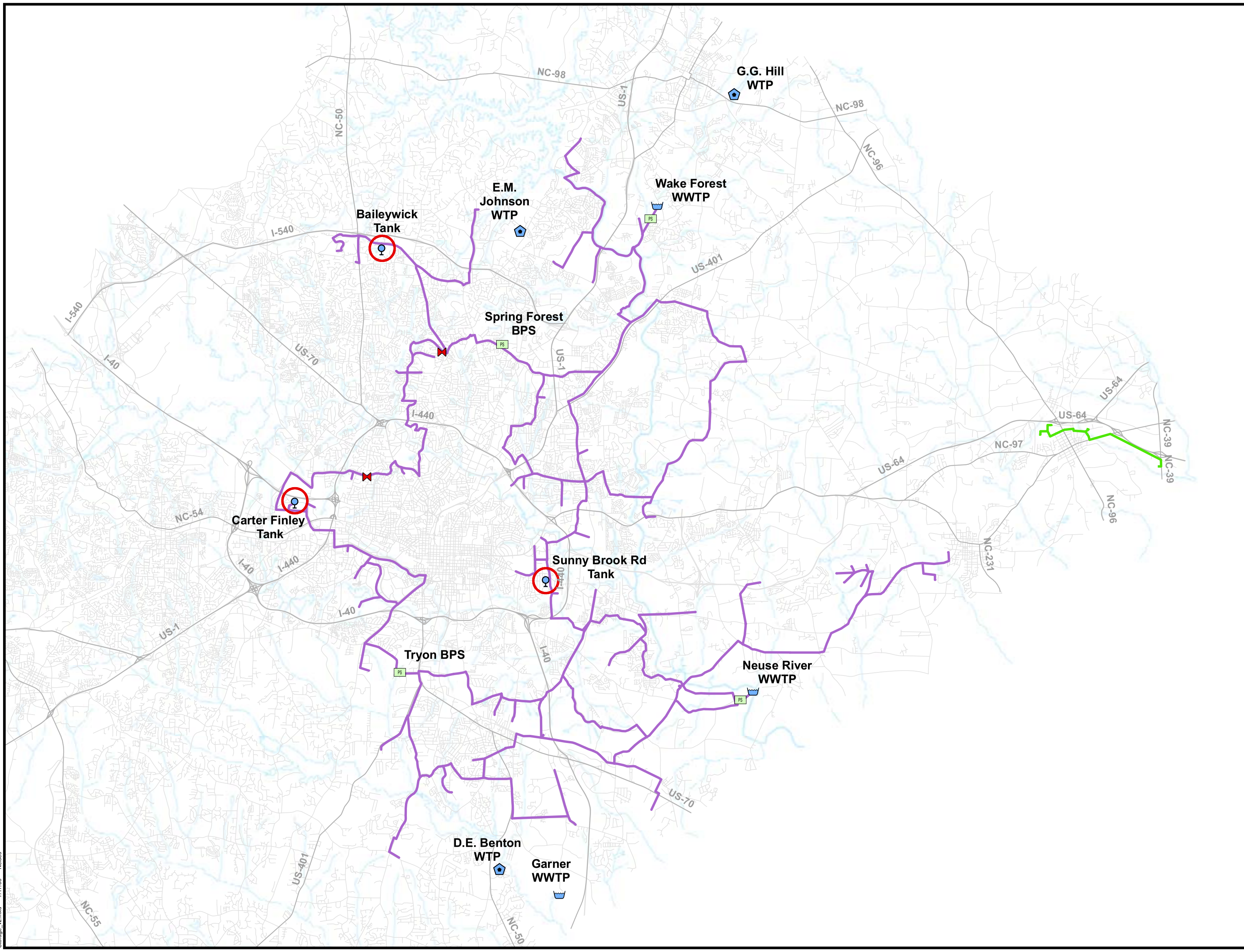
However, due to the large service area and varied pressure requirements within the system, distribution storage requirements were evaluated to reduce capacity of the other major system components and provide suitable system pressures. Analyses of the hydraulic model were performed to evaluate locations for potential future storage facilities in the distribution system. These results were used to determine the most hydraulically efficient locations for the storage facilities within the different service areas. Hydraulic model results for peak hour flows for the different service areas were used to determine the required elevated storage tank volumes. The elevated storage tanks were sized to provide 6 hours of night peak flow and 6 hours of day peak flow for a total of twelve hours of peak flow.

Three elevated storage tanks were identified. Two elevated storage tanks are located in the 595-foot reuse water pressure zone and one elevated storage tank is located in the 495-foot reuse water pressure zone. The locations of the proposed storage facilities are provided in Figure 4-2.

City of Raleigh
Reuse Master Plan

Reuse Distribution System Storage

Figure 4-2



LEGEND

- Elevated Tank
- Pump Station
- PRV
- Wastewater Treatment Plant
- Water Treatment Plant
- Pipe Network
- Zebulon Reuse System

N

0 2 4 Miles
1 inch equals 2.75 miles

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Table 4-2 summarizes the proposed storage facility characteristics at system buildout. The peak hourly demands used to determine the required size of the tank are provided, along with associated system pressures at the base of each tank.

Table 4-2: Storage Facilities Characteristics

Storage Facility	Night Peak Flow (MGD)	Day Peak Flow (MGD)	Overflow Elevation (feet)	Pressure (psi)	Volume (MG)	
					Reuse Volume	Tank Size
Sunnybrook Road Elevated Storage Tank	2.0	0.5	495	87	0.63	0.75
Carter Finley Elevated Storage Tank	1.4	1.4	595	66	0.70	0.75
Baileywick Elevated Storage Tank	1.2	0.2	595	74	0.35	0.50

As previously mentioned, the 495-foot reuse water pressure zone contains one elevated storage tank, the Sunnybrook Road Tank. This tank works to equalize and stabilize the flows in the 495-foot pressure zone and is described in further detail below.

The Sunnybrook Road elevated storage tank is located approximately off Sunnybrook Road at the site that has been purchased by the City. The flow out of the tank during the 6-hour night peak demands is expected to be approximately 2.0 mgd, and the flow from the tank during the 6-hour day peak demands is approximately 0.5 mgd. Thus, the tank would be required to hold at least 0.63 MG to meet peak-hour demands over the total 12-hour peak period. Therefore, a 0.75-million gallon (MG) elevated storage tank is recommended for this site. When the system experiences average day demands the tank replenishes at a rate of approximately 1.9 mgd, refilling a volume of 0.63 MG in approximately 8 hours. The Sunnybrook Road tank levels are directly impacted by the operation of the Tryon Road booster pumping station to supply water to the West, Northeast and Northwest phases of the reuse system.

The 595-foot reuse water pressure zone contains two elevated storage tanks, the Carter Findley Tank and the Baileywick Tank. These tanks work to equalize and stabilize the flows in the 595-foot pressure zone and are described in further detail below.

The Carter Findley elevated storage tank is required to serve the West Raleigh phase of the system and will be located off Trinity Road near Carter Stadium. The night and day peak hour flows expected for this location are 1.4 and 1.4 mgd, respectively. Thus, the tank would be required to hold a minimum of 0.70 MG to meet peak-hour demands over the total 12-hour peak period. Therefore, a 0.75-MG elevated storage tank is recommended to serve the 595-foot pressure zone. When the system experiences average day demands the tank replenishes at a rate of approximately 2.1 mgd, refilling a volume 0.70 MG in approximately 8 hours.

The Baileywick elevated storage tank is required to serve the Northwest Raleigh phase of the system and will be located off Baileywick Road. The night and day peak hour flows expected for this location are 1.2 and 0.2 mgd, respectively. Thus, the tank would be required to hold a minimum of 0.35 MG to meet peak-hour demands over the total 12-hour peak period. Therefore, a 0.50-MG elevated storage tank is recommended to serve the 595-foot pressure zone. When the system experiences average day demands the tank replenishes at a rate of approximately 1.05 mgd, refilling a volume 0.35 MG in approximately 8 hours.

Pumping Facilities

In distribution system planning, pumping facilities are designed to meet the maximum anticipated pumping requirement with the largest pumping unit out of service (firm capacity). The city-wide Raleigh Reuse Distribution System will utilize two plant pumping stations and construct two in-line booster pumping stations located in select service areas. Refer to Figure 4-3 for the locations of the pumping facilities.

At system buildout, the reuse pumping facility at the Neuse River WWTP will require a firm pumping capacity of 5 mgd and the Wake Forest WWTP will require a firm pumping capacity of 2.4 mgd to supply the demands for the reuse distribution system. Several different operating scenarios were evaluated for determining the pumping capacity of the Wake Forest WWTP. The construction phasing sections discusses the various flow scenarios for the Wake Forest WWTP.

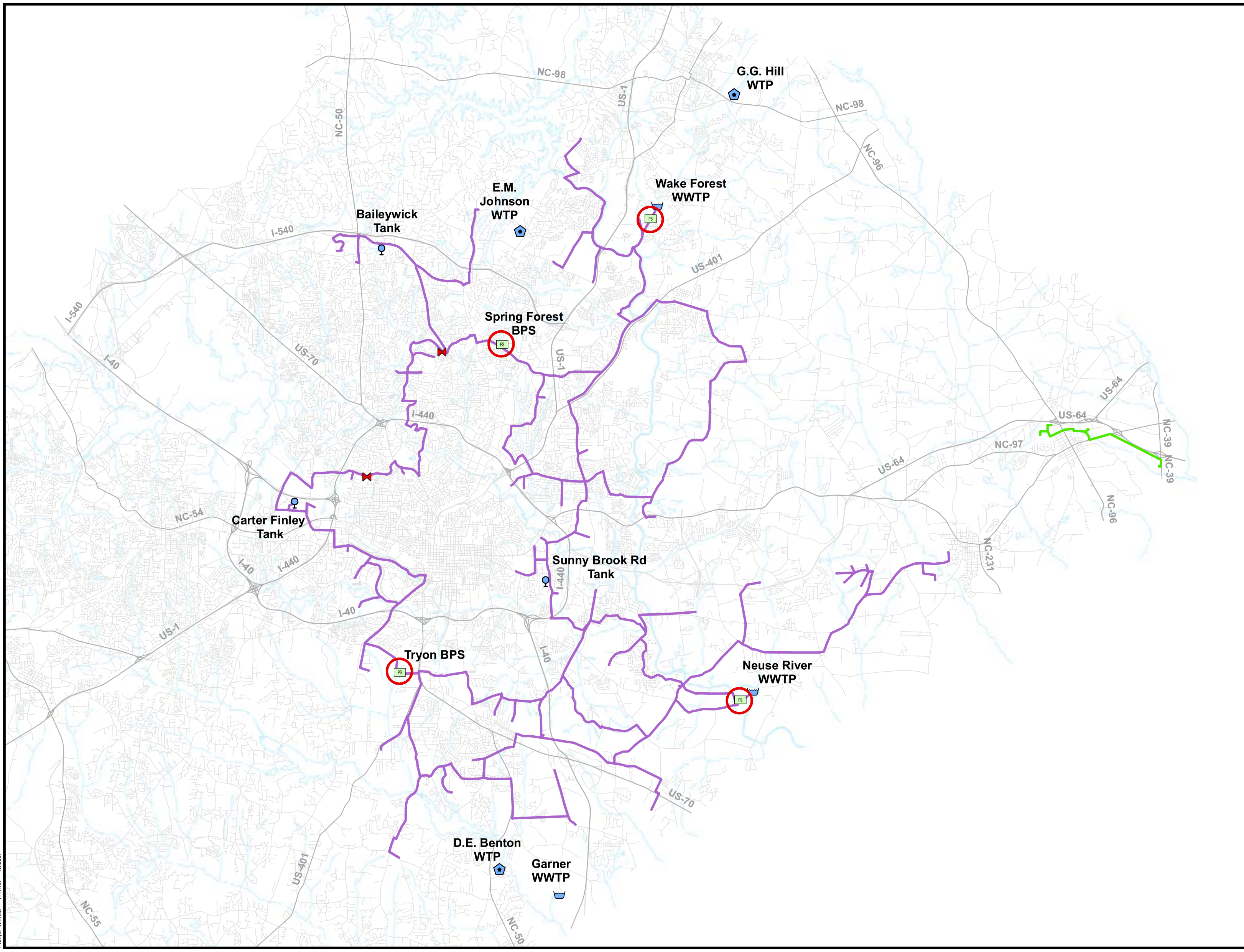
Based on analyses of the hydraulic model, it was determined that two in-line, variable speed booster pumping stations were needed to increase the water pressure in the distribution system. Variable speed pumps are required at each location due to the varying flow and head requirements for the range of anticipated demand conditions. System demands and elevated tank levels will dictate the operation of these pumps to insure the minimum delivery pressure to all points in the system. Table 4-3 summarizes the booster pump station characteristics during the maximum demand on the booster station, and the corresponding upstream and downstream water pressures.

Table 4-3: Booster Pumping Station Characteristics

Booster Pumping Stations	**Maximum Demand on Booster Station**	**Flow (MGD)**	**Head (ft)**	**Power[1] (hp)**	**Pressure (psi)**	
					Up-stream	**Down-stream**
Tyron	Average Day (replenishment)	2.4	174	100	68	143
Spring Forest	Average Day (replenishment)	1.1	149	40	56	120

Note: 1. Power requirement assumes a 75% pump efficiency and a 95% motor efficiency.

The hydraulic analyses indicated that an in-line booster pumping station was needed on Tryon Road to boost water from the 495-foot pressure zone into the 595-foot pressure zone. The 2.4-mgd pumping station will increase downstream reuse water pressure by approximately 75 psi during an average day demand period. The station will include two variable speed 100-hp pumps, each rated at 174 feet of head at 2.4 mgd. The Tryon Road



City of Raleigh
Reuse Master Plan

Pumping Facilities

Figure 4-3

LEGEND

- Elevated Tank
- Pump Station
- PRV
- Wastewater Treatment Plant
- Water Treatment Plant
- Pipe Network
- Zebulon Reuse System

N

0 2 4 Miles

1 inch equals 2.75 miles

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booster station is necessary to meet or exceed the minimum design pressures in west Raleigh and to provide replenishment of the Carter Finley elevated storage tank.

A second in-line booster pumping station will be located on Spring Forest Rd. approximately 0.7 miles east of the Falls of the Neuse Rd. intersection. The pumping station will also boost water from the 495-foot pressure zone into the 595-foot pressure zone, but will be hydraulically isolated from the Carter Finley tank due to pressure reducing valves that supply water to the 495-foot pressure zone between Lynn Road and Lake Boone Trail. The 1.1-mgd pumping station will increase the downstream reuse water pressure by approximately 64 psi during the night peak demand period. The pumping station will be equipped with two variable speed 40-hp pumps, each rated at 149 feet of head at 1.1 mgd. This pumping station is necessary to meet or exceed the minimum design pressures in northwest Raleigh.

Distribution System

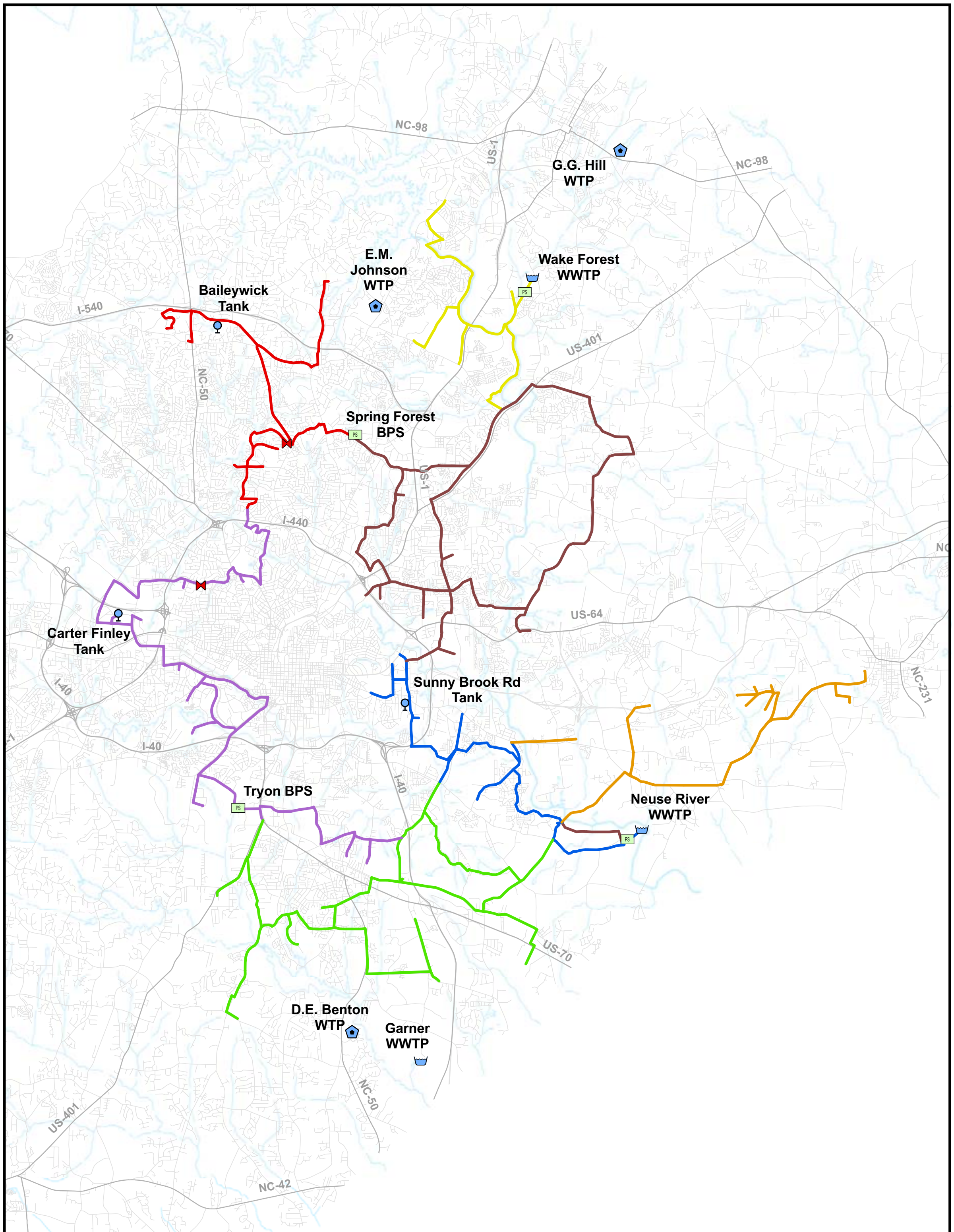
The proposed distribution system at ultimate build-out will include 166 miles of pipes, ranging in size from 4-inches to 24-inches. Table 4-4 includes a summary of the proposed distribution system as entered into the model.

Table 4-4: Summary of Distribution System at Ultimate Build-out

Pipe Diameter	# of Pipes in model	Total Length (ft)
4-inch	30	75,964
6-inch	14	49,694
8-inch	45	150,649
10-inch	14	43,457
12-inch	38	194,251
14-inch (existing)	2	2
16-inch	97	347,923
18-inch	3	112
20-inch	5	12,157
24-inch	3	12
Misc. (for modeling)	2	111
TOTAL	253	874,332

Construction Phasing

Seven general areas of the proposed reuse system at build-out were identified during development of the hydraulic model. These areas were named Southeast Raleigh, Wake Forest, East Wake, Northeast Raleigh, Garner, West Raleigh, and Northwest Raleigh. Figure 4-4 illustrates the proposed distribution system by phase.



LEGEND

- East Wake
- Garner
- Northeast Raleigh
- Northwest Raleigh
- Southeast Raleigh
- Wake Forest
- West Raleigh

N

0 5 Miles

1 inch equals 2.5 miles

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City of Raleigh
Reuse Master Plan

Reuse Distribution System Phasing

Figure 4-4

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Construction phasing of the seven service areas was evaluated based on physical location relative to sources, projected demand, and cost-effectiveness. The ordering of phasing is discussed further in the Rate Analysis Section of this report with all phases expected to be constructed within the 30-year planning period. Summaries of the seven general service areas are provided below.

Southeast Raleigh Phase

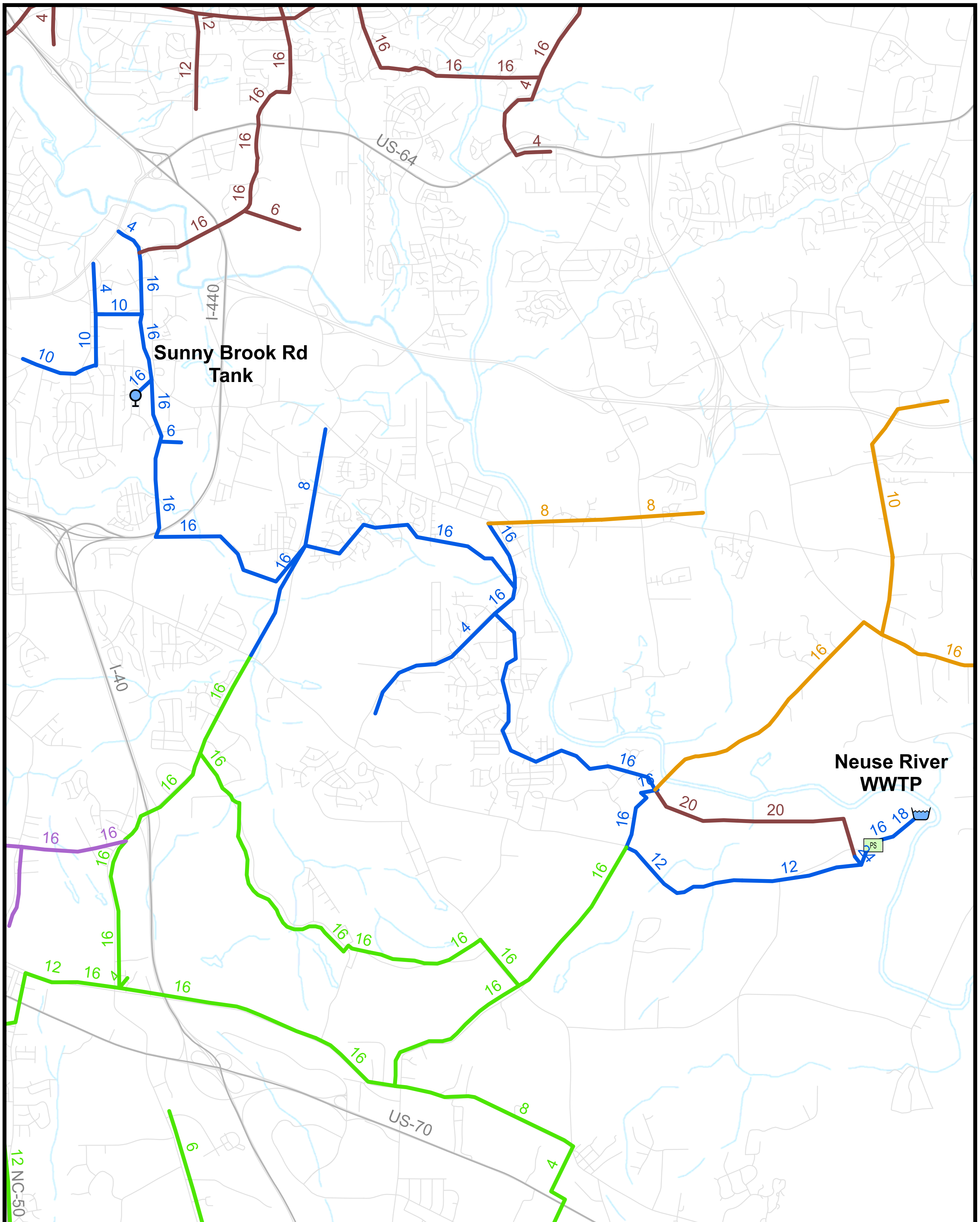
The Southeast Raleigh service area was identified as the first phase of construction because of its proximity to the Neuse River WWTP. The system will connect to the existing reuse system and extend approximately 10 miles throughout southeastern Raleigh. The proposed service area is bounded to the north by New Bern Avenue, to the south by Interstate 40, to the west by the intersection of Poole Road and Martin Luther King Boulevard, and to the east by Old Milburnie Road and the Neuse River. All of the proposed service area falls within the 495-foot reuse water pressure zone.

The Southeast Raleigh phase includes approximately 88,900 feet of distribution piping, the Sunnybrook Road Elevated Storage Tank and the existing reuse pumping station at the site of the Neuse River WWTP. The major transmission mains for this system include an existing 12-inch main that extends from the Neuse River WWTP to Auburn-Knightdale Road and tie in to a 16-inch main routed along Auburn-Knightdale Road and along the Neuse River connecting Barwell Road to Auburn-Knightdale Road and then along the Walnut Creek Interceptor corridor. Approximately 2.5 miles of the 16-inch loop is existing pipeline that will be utilized for the extension of the reuse pipeline. This existing 16-inch pipeline is located along the Neuse River extending from Auburn-Knightdale Road to Barwell Road. Another 16-inch pipeline extends this major transmission main west along the Walnut Creek Sewer Interceptor to Sunnybrook Road, where it turns north. Several extensions will be routed off the major transmission mains to serve identified potential reuse customers. The sizes and locations for the distribution system that serves this phase are provided in Figure 4-5.

Hydraulic model runs were conducted for the Southeast Phase system only and for the system at ultimate build-out for each of the four basic system conditions (peak hour day, peak hour night, maximum day, and average day demands). Since this phase is adjacent to the Neuse River WWTP, system build-out will include a future 20-inch transmission pipeline from the Neuse River WWTP. The model runs were performed to verify adequate flows and pressures will be maintained in the Southeast phase of the system both before the future system improvements and after the system is expanded to ultimate build-out.

Potential Reuse Customers Identified

Twelve potential reuse customers were identified in the Southeast Raleigh service area. These customers account for approximately 18% of the total modeled reuse demand. The flows for this service area are as follows: Average Daily Flow is 553,500 gpd, Maximum Daily Flow is 1.74 mgd, and the Maximum Hour Flow is 4.89 mgd. Three golf courses, 5 institutional users, 2 parks, 1 school, and 1 residential development were located within this service area.



LEGEND

- East Wake
- Garner
- Northeast Raleigh
- Northwest Raleigh
- Southeast Raleigh
- Wake Forest
- West Raleigh

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City of Raleigh
Reuse Master Plan

Southeast Raleigh Phase

Figure 4-5

Phases.mxd 7/17/06 Neises

Wake Forest Phase

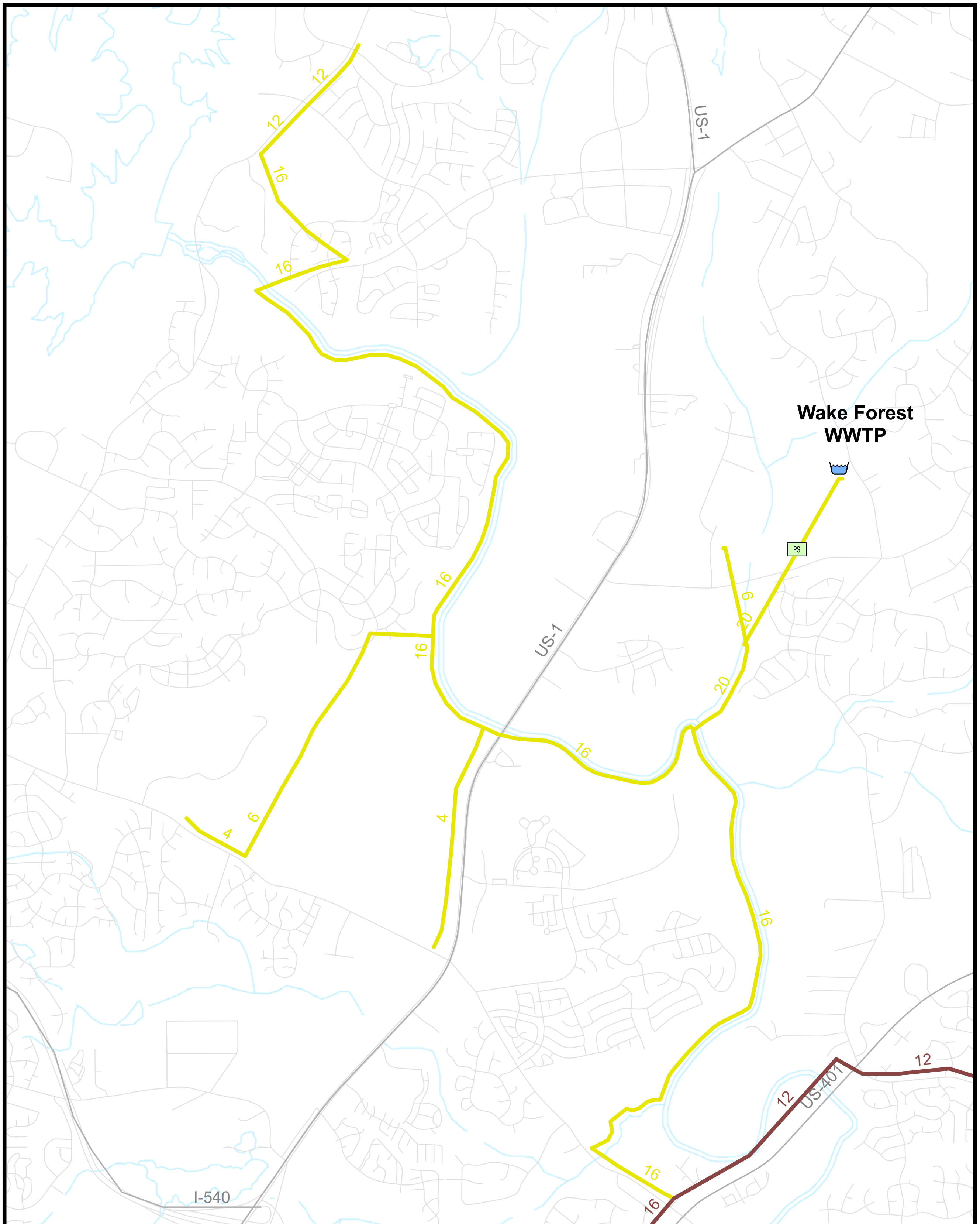
The Wake Forest service area was identified as the second phase of construction. The system will extend approximately 13 miles throughout the Wake Forest area. The proposed service area is bounded to the north Old Highway 98, to the south by the intersection of Perry Creek Road and Highway 401, to the west by Falls of Neuse Road, and to the east by the Wake Forest Smith Creek WWTP. All of the proposed service area falls within the 495-foot reuse water pressure zone.

All of the proposed service area for the Wake Forest Phase lies within the 495-foot reuse water pressure zone. This same service area lies within the 605-foot and 523-foot potable water pressure zone. It is expected that the reuse water distribution system pressures will be less than the current potable water system pressures that customers in this area are currently experiencing. However, each customer identified in the reuse system model has a minimum pressure of 25 psi, as noted previously in the report. To maintain higher system pressures in this area and to accommodate future users that maybe located at higher elevations than those currently identified, the installation of a hydro-pneumatic tank is recommended. A hydro-pneumatic tank would provide flexibility in the control of the system pressure for the Wake Forest phase, a cost effective alternative to elevated storage, and can be used to create a separate pressure zone for the Wake Forest phase in combination with pressure reduction valve for the interconnection into the overall system.

The Wake Forest service area is unique to the reuse distribution system because it can be operated independently of the Neuse WWTP reuse supply and because the future minimum supply of reuse water is uncertain. Due to the system characteristics, several scenarios were evaluated for the operation of the Wake Forest phase of reuse distribution system. City staff indicate that future plans include the construction of a pumping station that can be utilized to transfer additional flow to the Wake Forest WWTP. For the basis of this master plan report, it was assumed that these future plans would be implemented and the Wake Forest WWTP would pump approximately 2.4mgd of reuse flow into the reuse distribution system. This effluent flow rate minimizes the need for additional booster pump stations in the system and maximizes the use of the Wake Forest WWTP as a reuse supply source. This plan accounts for system build-out and the connection of the Wake Forest phase with the Northeast Raleigh phase and the overall reuse distribution system.

The major transmission mains for this system include a 16-inch transmission main routed along the Neuse River Interceptor easement from the intersection of Perry Creek Road and Highway 401 to the Wake Forest WWTP and from the WWTP to Falls of Neuse Road. Several extensions will be routed off the major transmission mains to serve identified potential reuse customers. The sizes and locations for the distribution system that serves this phase are provided in Figure 4-7.

During the initial construction, prior to connection to the over all reuse distribution system, the Wake Forest phase will be operated as an isolated reuse system. During this period, it is possible that a combination of ground and tank storage will be needed to supply the system flow and pressure demands. Presently, the reuse flow from the Wake Forest WWTP at the time of the phase construction is uncertain. Therefore, sizing the storage required for the system is not practical. If the transfer of flow from the future planned pumping station is coordinated with the phases reuse demand, storage would not be needed for the Wake Forest Phase.



LEGEND

- East Wake
- Garner
- Northeast Raleigh
- Northwest Raleigh
- Southeast Raleigh
- Wake Forest
- West Raleigh

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City of Raleigh
Reuse Master Plan

Wake Forest Phase

Figure 4-6

Phases.mxd 7/17/06 Neises

The third operating scenario evaluated the overall reuse system impacts if the Wake Forest WWTP did not supply a minimum of 2.4mgd of reuse flow into the system during the overall system buildout. It was determined that an additional booster pump station would be required in the New Hope Road area to boost the water into the Northeast and Wake Forest phase of the reuse system. The New Hope Road booster pump station would need to be rated at a capacity of approximately 4mgd with approximately 55 feet of head. Depending on the flow rate from the Wake Forest WWTP, the pipeline routed from the Sunnybrook Tank may need to be increased from 16-inch to 20-inch to reduced head loss.

Potential Reuse Customers Identified

Nine potential reuse customers were identified in the Wake Forest service area. These customers account for approximately 14% of the total modeled reuse demand. The flows for this service area are as follows: Average Daily Flow is 430,400 gpd, Maximum Daily Flow is 824,400 gpd, and the Maximum Hour Flow is 1.786 mgd. One golf course, 3 industries, 1 recreational user, 3 schools and 1 residential development were located within this service area.

East Wake Phase

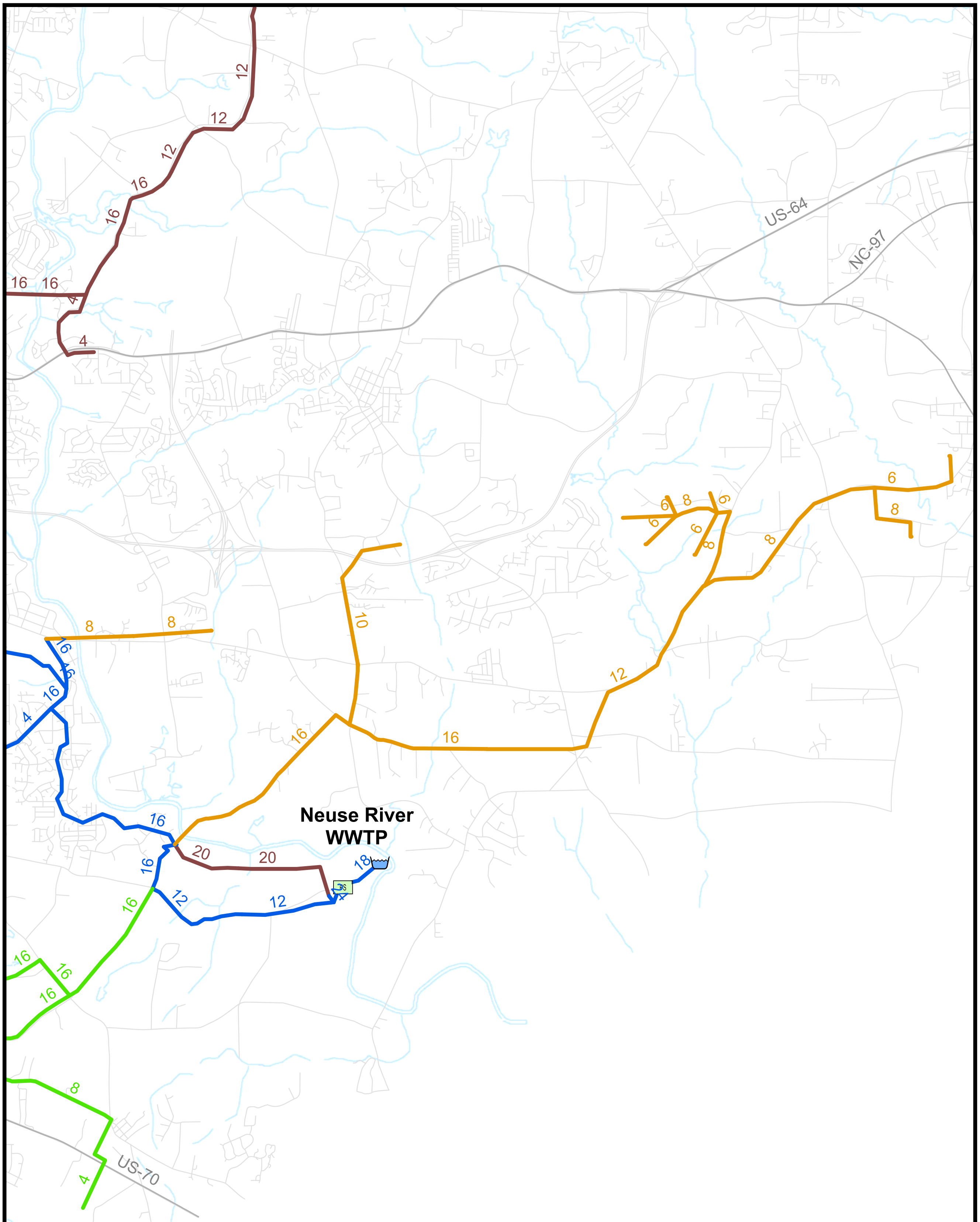
The East Wake service area was identified as the third phase of construction. The system will connect to the existing reuse system and extend approximately 18 miles throughout Eastern Wake County through Knightdale and Wendell. The proposed service area is bounded to the north by Crabtree Creek, to the south by Hodge Road and Auburn Knightdale Road, to the west by Poole Road, and to the east by Holly Brook Road. All of the proposed service area falls within the 495-foot reuse water pressure zone.

The East Wake phase includes approximately 93,500 ft of distribution piping routed east towards the existing Wendell Pumping Station and the proposed Wendell Falls development. Approximately 3.7 miles of 16-inch distribution piping included in the East Wake distribution piping is existing and is currently being utilized by the City as a sewer forcemain. Plans have been discussed that will abandon this 16-inch pipeline once a new sewer outfall is installed in the future around year 2011, therefore the 16-inch pipeline may be available for use in supplying reuse water to the East Wake phase after that time. Also, approximately 2.23 miles of 10-inch pipeline is included in the model that is considered existing for the reuse distribution system due to proposed plans by the Cypress Falls development to install a temporary 10-inch force main connecting to the existing 16-inch sewer interceptor which will be abandoned in the future once the new sewer outfall is constructed.

The major transmission mains for this system include a 16-inch transmission main routed along Auburn Knightdale Road and Grasshopper Road and an 8-inch that continues along Grasshopper Road to Major Slade Road and Poole Road. A 10-inch transmission main also extends from the intersection of Grasshopper Road and Bethlehem Road north to serve the Cypress Falls and Poplar Village development. Several extensions will be routed off the major transmission mains to serve identified potential reuse customers. The sizes and locations for the distribution system that serves this phase are provided in Figure 4-6.

Potential Reuse Customers Identified

Ten potential reuse customers were identified in the East Wake service area. These customers account for approximately 6% of the total modeled reuse demand. The flows for this service area are as follows: Average Daily Flow is 169,000 gpd, Maximum Daily Flow is 583,000 gpd, and the Maximum Hour Flow is 1.7 mgd. One golf course, 1 institutional user, 1 recreational user, 3 schools and 4 residential developments were located within this service area.



LEGEND

- East Wake
- Garner
- Northeast Raleigh
- Northwest Raleigh
- Southeast Raleigh
- Wake Forest
- West Raleigh

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Reuse Master Plan

East Wake Phase

Figure 4-7

Phases.mxd 7/17/06 Neises

Northeast Raleigh Phase

The Northeast Raleigh service area will initially connect to the Southeast Raleigh and Wake Forest service areas and in the future to the Northwest Raleigh phase of system development. The Northeast Raleigh reuse distribution system extends approximately 36 miles across the northeastern portion of Raleigh bounded to the south by Sunny Brook Road, to the north by Highway 401, to the east by Old Crews Road, and to the west by Falls of Neuse Road.

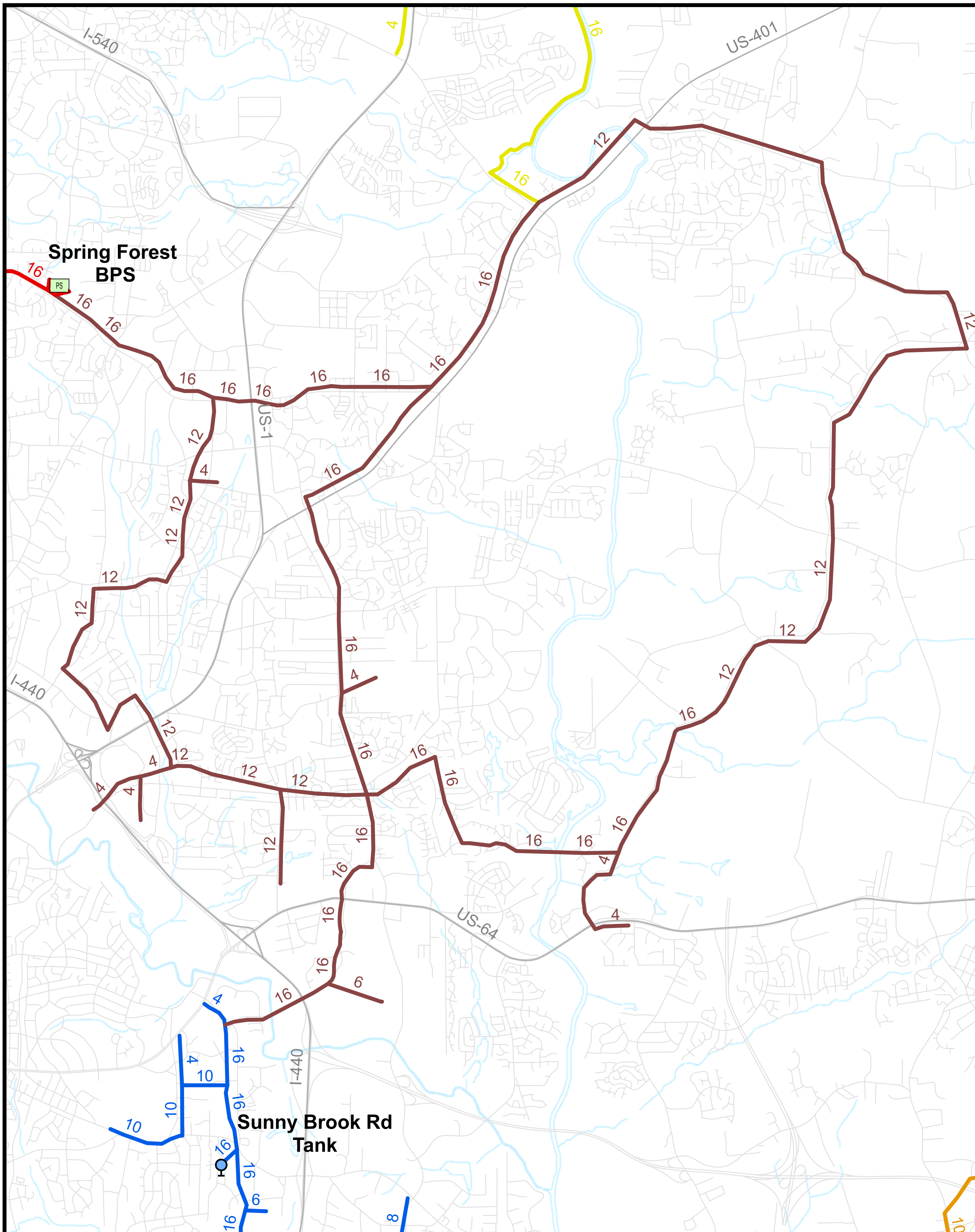
The Northeast Raleigh phase includes approximately 36 miles of distribution system piping. The pipelines for this phase of the system were sized to accommodate the expected demands of the Northwest Raleigh phase of system development.

The major 16-inch transmission main for this portion of the reuse system will connect to the 16-inch southeast Raleigh major transmission main along Corporation Parkway and New Hope Road and extend north where it will form a loop with the 16-inch and 12-inch mains in Old Milburnie Road and Mitchell Mill Road. The 16 inch main also forms a loop with the 12-inch and 16-inch mains along Skycrest Drive, New Hope Church Road, Green Road, and Spring Forest Road. Several extensions will be routed off this major transmission main to identified potential reuse customers. The sizes and locations for the pipes in this service area are shown in Figure 4-8.

In addition to the piping within this phase, a new 20-inch transmission main is required to reinforce the 12-inch main between the Neuse River WWTP and Auburn-Knightdale Road.

Potential Reuse Customers Identified

Twenty-eight potential reuse customers were identified in the Northeast Raleigh service area. These customers account for approximately 28% of the total modeled reuse demand. The flows for this service area are as follows: Average Daily Flow is 852,000 gpd, Maximum Daily Flow is 1.183 mgd, and the Maximum Hour Flow is 4.153 mgd. Two golf courses, 5 commercial users, 5 industries, 2 institutional users, 4 recreational users, 4 schools, 3 residential developments, and 3 nurseries are located within this service area.



LEGEND

- East Wake
- Garner
- Northeast Raleigh
- Northwest Raleigh
- Southeast Raleigh
- Wake Forest
- West Raleigh

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City of Raleigh
Reuse Master Plan

Northeast Raleigh Phase

Figure 4-8

Phases.mxd 7/17/06 Neises

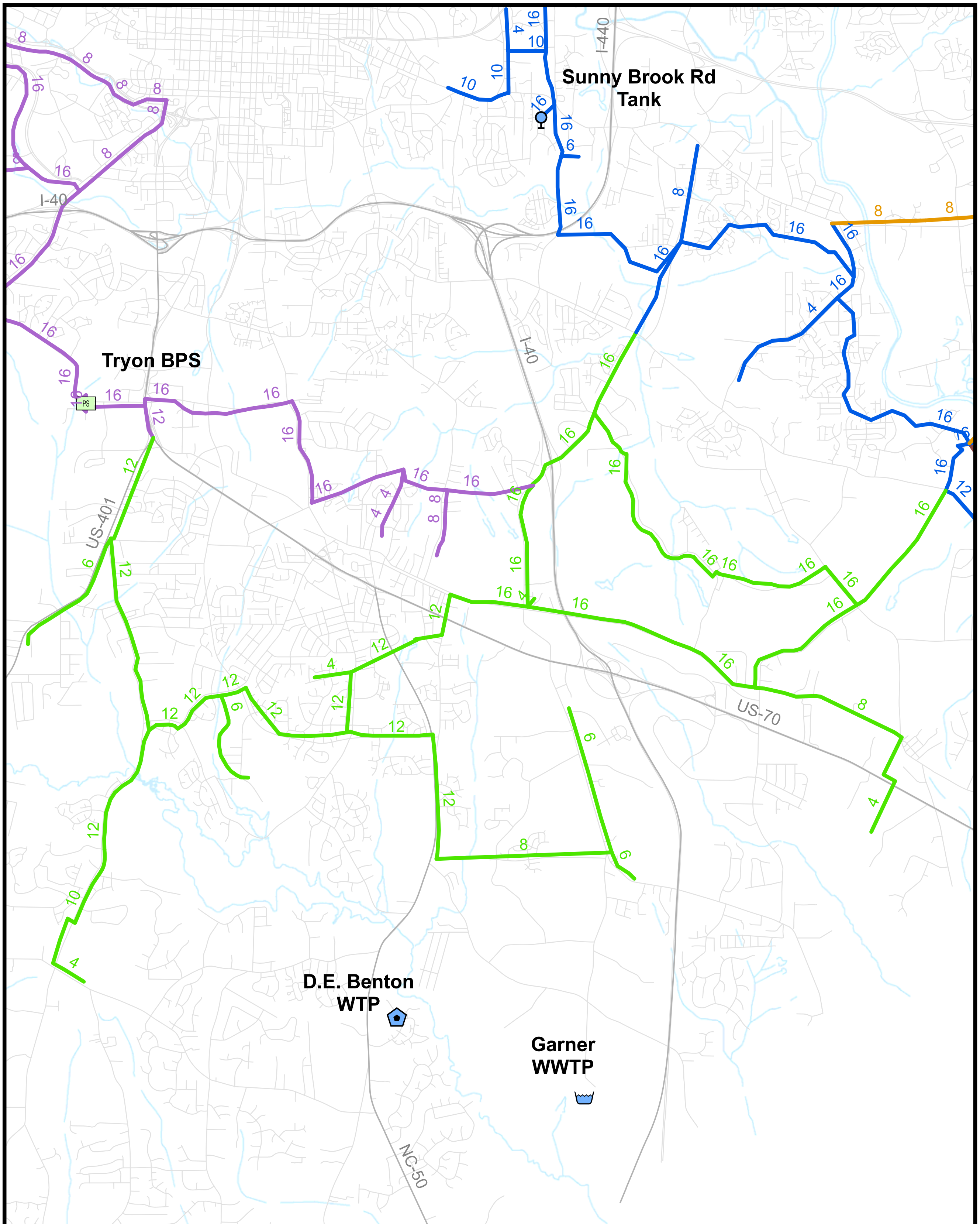
Garner Phase

The Garner distribution system will connect to the Southeast Raleigh distribution system utilizing the Neuse WWTP as the source for reuse water. The Garner distribution system is located in the 495-foot pressure zone. The Garner system includes approximately 33 miles of distribution system piping.

The Garner transmission main extends approximately 174,000 feet from the Neuse River WWTP throughout Garner. The major transmission main for this service area connects to the 20-inch and 12-inch Neuse River WWTP discharge and extends approximately 1.5 miles as a 16-inch main until the intersection of Auburn-Knightdale Road and Rock Quarry Road. At this intersection two 16-inch mains spur off the 20-inch line, one serving Wall Store Road and Auburn Church Road and one serving East Garner Road. These two 16-inch spurs create a loop connecting the Garner service area with the Southeast Raleigh service area and the West Raleigh service area. A 12-inch main also extends from the 16-inch main in the West Raleigh service area at the intersection of Tryon Road and Fayetteville Road and is routed along Old Stage Road. Several extensions are routed off this main transmission main to serve identified potential reuse customers. Refer to Figure 4-9 for the reuse pipeline sizes and locations in this area.

Potential Reuse Customers Identified

Eighteen potential reuse customers were identified in the Garner service area. These customers account for approximately 14% of the total modeled reuse demand. The flows for this service area are as follows: Average Daily Flow is 414,500 gpd, Maximum Daily Flow is 1.324 mgd, and the Maximum Hour Flow is 2.728 mgd. Five golf course users, 1 commercial user, 2 industry users, 1 institutional user, 5 recreational user, 1 school users, and 3 nursery users were located within this service area.



LEGEND

- East Wake
- Garner
- Northeast Raleigh
- Northwest Raleigh
- Southeast Raleigh
- Wake Forest
- West Raleigh

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City of Raleigh
Reuse Master Plan

Garner Phase

Figure 4-9

Phases.mxd 7/17/06 Neises

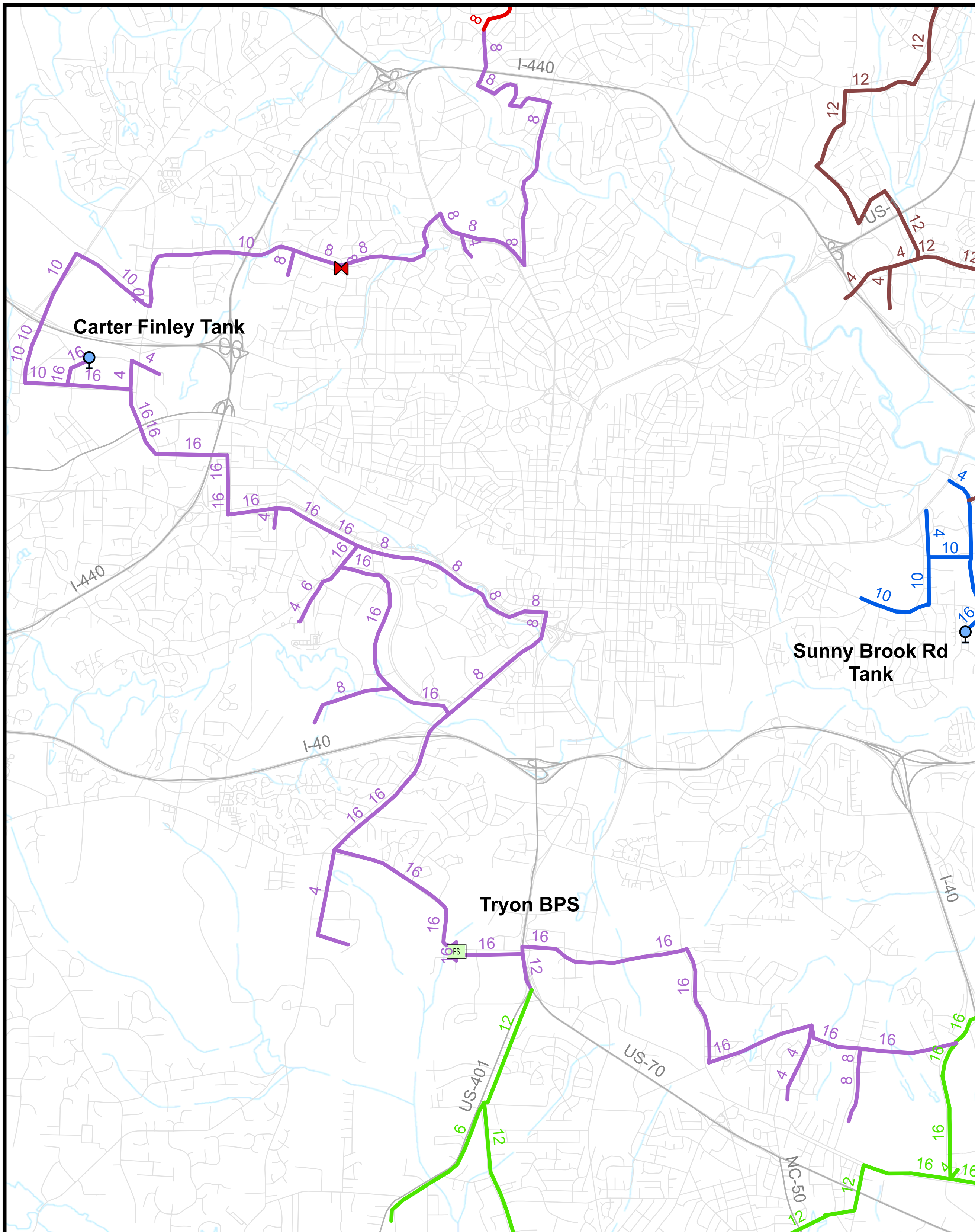
West Raleigh Phase

The West Raleigh service area is contained in both the 495-foot and 595-foot service areas and is supplied water by a two 16-inch transmission main that tie into the Garner Phase at the intersection of Auburn Church Road and Jones Sausage and Jones Sausage Road and White Oak Drive. The Tryon Road booster pumping station takes reuse water from the 495-foot pressure zone and pumps into the 595-foot pressure zone. A pressure reducing valve lets water down into the 495-foot pressure zone in the northwestern section of this phase. The Carter Finley tank is located in the 595-foot service area and is included in the West Raleigh phase of the system.

The West Raleigh reuse distribution system extends approximately 31 miles from the intersection of Interstate 40 and Jones Sausage Road to western Raleigh. The 16-inch major hydraulic pipeline for the project area extends approximately 15 miles across southern Raleigh to the Carter Finley Tank in West Raleigh. . The remaining extension of the major transmission main in this service area includes approximately 3.9 miles of 10-inch pipe and approximately 9.7 miles of 8-inch pipe. The 8-inch transmission main crosses east back into the 495-foot pressure zone and will require a pressure-reducing valve on the main to avoid over pressurization in this area. The 8-inch line will connect to an 8-inch line in the Northwest Raleigh Phase of the system, completing a loop around the City of Raleigh. However, water will not be able to flow from the Northwest Raleigh phase of the system to the 595-foot West Raleigh phase of the system due to the pressure reducing valves required on the 8-inch line to accommodate the 495-foot pressure zone. Several extensions will be routed off the major transmission main to serve identified potential reuse customers in the West Raleigh phase. Refer to Figure 4-10 for the reuse pipeline sizes and locations in this area.

Potential Reuse Customers Identified

Thirty-five potential reuse customers were located in the West Raleigh service area. These customers account for approximately 16% of the total modeled reuse demand. The flows for this service area are as follows: Average Daily Flow is 487,000 gpd, Maximum Daily Flow is 1.528 mgd, and the Maximum Hour Flow is 4.424 mgd. Three golf course users, 5 commercial users, 2 industrial users, 11 institutional users, 8 recreational users, 5 school users, and 1 nursery user were located within this service area.



LEGEND

- East Wake
- Garner
- Northeast Raleigh
- Northwest Raleigh
- Southeast Raleigh
- Wake Forest
- West Raleigh

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City of Raleigh
Reuse Master Plan

West Raleigh Phase

Figure 4-10

Phases.mxd 7/17/06 Neises

Northwest Raleigh Phase

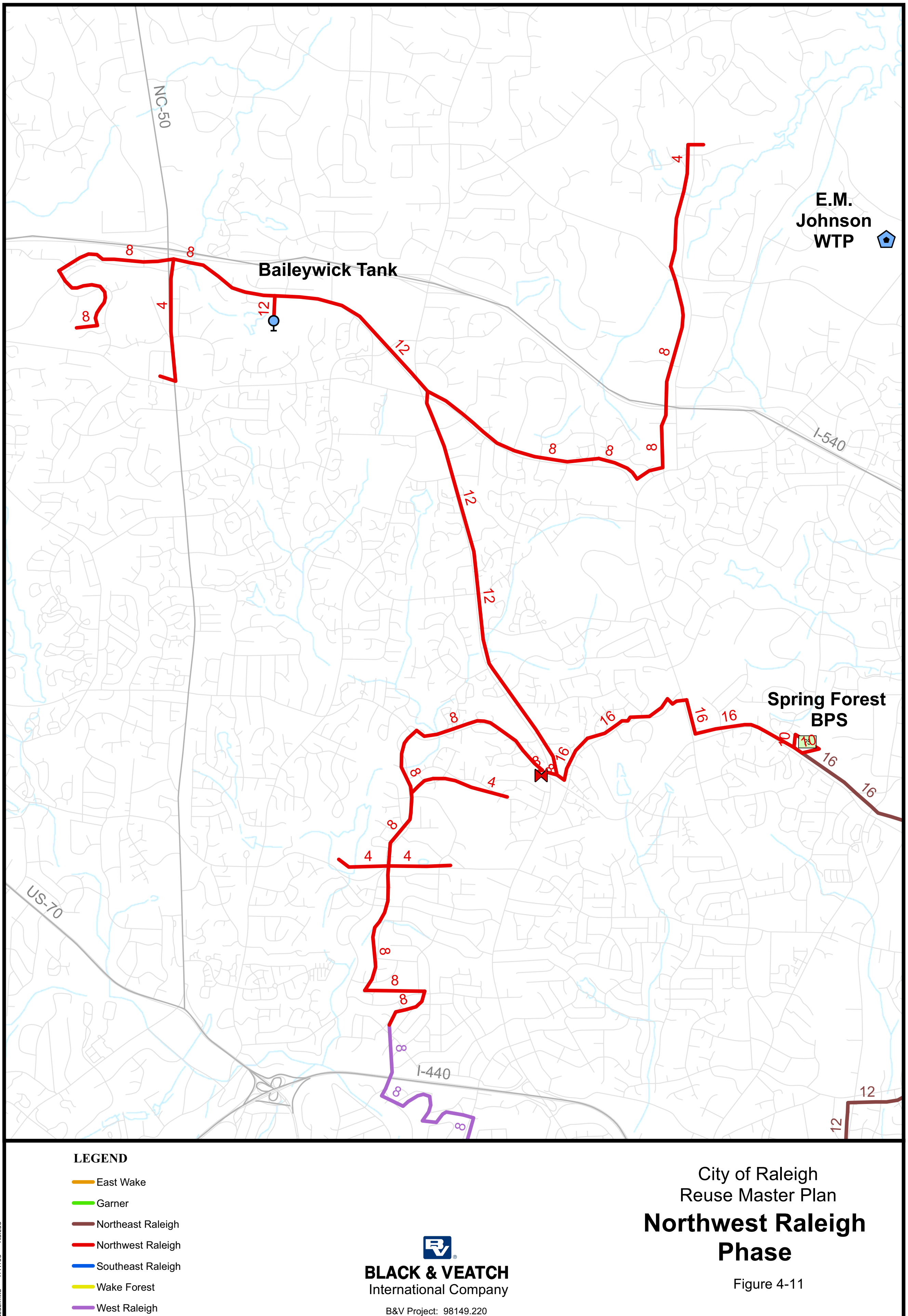
The Northwest Raleigh service area will connect to both the Northeast Raleigh service area and the West Raleigh service area, completing the hydraulic loop of the system. The Spring Forest Road booster pumping station increases the hydraulic grade of the reuse water from Northeast Raleigh to serve Northwest Raleigh. Since Northeast Raleigh supplies water to Northwest Raleigh, the Tryon Road Booster Pumping Station provides water for both phases of development. Pipelines and pumps for the Northeast Raleigh phase of development were sized to accommodate the demands of the Northwest Raleigh phase of development.

The northwest Raleigh pipeline route extends approximately 19 miles across northwestern Raleigh bounded to the north by Honeycutt Road, to the south by Interstate 440, to the west by Ray Road, and to the east by the Spring Forest booster pump station. Completion of this phase will complete a loop around the City of Raleigh; however, water will not be able to flow from the Northwest Raleigh phase to the 595-foot West Raleigh phase of the system due to pressure reducing valves needed when the pipeline crosses into the 495-foot pressure zone.

The major transmission main for this area connects to Northeast Raleigh via the 16-inch main along Spring Forest Road at the Spring Forest booster pump station. A 16-inch main continues from the discharge of the pump station for approximately 2 miles, where it splits into a 12-inch main to the north along Six Forks Road and into a 8-inch line with a pressure reducing valve to the west along Lynn Road. The pressure reducing valve reduces the hydraulic grade in the 8-inch line to avoid over pressurization of the system in the 495-foot pressure zone. The 12-inch main along Six Forks Road extends north for approximately 2.7 miles where it splits into a 12-inch pipeline along Bailywick Road and an 8-inch pipeline along Strickland Road. The 12-inch line along Baileywick Road connects to the Baileywick Tank that serves this service area. Several extensions are routed off this major transmission main to serve identified potential reuse customers. Refer to Figure 4-11 for the reuse pipeline sizes and locations in this area.

Potential Reuse Customers Identified

Thirteen potential reuse customers were located in the Northwest Raleigh service area. These customers account for approximately 5% of the total modeled reuse demand. The flows for this service area are as follows: Average Daily Flow is 147,073 gpd, Maximum Daily Flow is 515,619 gpd, and the Maximum Hour Flow is 1.732 mgd. Two golf course users, 1 commercial user, 5 recreational users, 2 school users, and 3 nursery users were located within this service area. It is expected that future demand for reuse water will increase in this area.



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City of Raleigh
Reuse Master Plan

Northwest Raleigh Phase

Figure 4-11

Phases.mxd 7/17/06 Neises

5. FACILITY RECOMMENDATIONS

The facility recommendations for the Reuse Master Plan study included an analysis of a reclaimed water system in which no satellite facilities were evaluated and a system in which satellite facilities were evaluated and sited for use. This Facility Recommendations discussion includes individual recommendations for each type of system and an overall recommendation for the recommended system based on construction feasibility, system operation evaluations, and cost and rate analysis.

Reuse Water Distribution System

Reuse Water Sources

Neuse River Wastewater Treatment Plant and Reuse Pumping Station

The existing Neuse River Wastewater Treatment Plant (WWTP) has a capacity of 60 MGD, with current plans to increase capacity to 75 MGD. The plant consists of the following treatment steps: primary treatment, waste activated sludge secondary treatment, tertiary filtration, and ultraviolet disinfection. At ultimate build-out of the reuse system, supply of reuse water from the Neuse River WWTP should far exceed demand. Existing facilities are capable of meeting specified effluent permit limits for reuse. For these reasons, no improvements to the Neuse River WWTP are recommended at this time.

The City's effluent reuse pumping station has a current design capacity of 2.5 mgd and is currently in the process of being upgraded. The upgraded facility will serve the reuse water needs for the on-site plant irrigation and non-potable water needs. A new 3,500 gpm pumping station should be added to the Neuse River WWTP to serve the build-out flows for the reuse distribution system. A capacity of 1000 gpm is required for the first phase of flows for the Southeast Raleigh service area. Additional expansions of the pumping station will be necessary for future phases of the reuse system as additional customers are served and reuse demand continues to increase.

Wake Forest Smith Creek WWTP

The Wake Forest Smith Creek WWTP has a treatment capacity of 2.4 mgd and was identified as a potential source of reuse water. Utilization of the Wake Forest WWTP as a source of reuse water for the Raleigh Reuse System greatly improves system hydraulics and efficiency, and is recommended. Multiple sources are preferred for several reasons. If one of the sources is disrupted, the other source can still supply reuse water to the system. The remote location of the Wake Forest WWTP to the Neuse River WWTP is beneficial to prevent pumping over long distances from the Neuse River WWTP to serve northern Raleigh. The reuse water supply from the Wake Forest plant was included in the reuse distribution system model. A new reuse pumping station with a firm capacity of 2.4 mgd is recommended at the Wake Forest WWTP. Although not required, some storage is to be considered to improve operational flexibility. Pressure in this area should be maintained with a hydro-pneumatic tank.

Storage Facilities

There are currently no existing storage facilities within the Raleigh Reuse System. While no supply storage is necessary, storage facilities to minimize supply and transmission facility sizes while serving instantaneous demands and maintaining system pressure were evaluated.

Three elevated storage tanks are recommended. The recommended storage facilities are summarized in Table 1.

Table 1. Recommended Storage Facilities

Storage Facility	Volume (MG)	
	Reuse Volume Required	Tank Size
Sunnybrook Road Elevated Storage Tank	0.63	0.75
Carter Finley Elevated Storage Tank	0.70	0.75
Baileywick Elevated Storage Tank	0.35	0.50

A 0.75 gallon elevated tank is recommended on Sunnybrook Road approximately 1,500 feet west of the Sunnybrook Road intersection. The reuse water will flow by gravity from the elevated storage tank to the 16-inch major transmission main that serves the Southeast Raleigh service area. The Poole Road Elevated Storage Tank will serve the 495-foot pressure zone.

A 0.75-million gallon elevated storage tank is recommended between Trinity Road and Wade Avenue (the Carter-Finley Elevated Storage Tank). The reuse water will flow by gravity from the elevated storage tank to the 16-inch major transmission main that serves the West Raleigh service area. The Carter-Finley Elevated Storage Tank will serve the 595-foot pressure zone.

Another 0.5-million gallon elevated storage tank is recommended between Baileywick Road and Strickland Drive in Northwest Raleigh. The reuse water will flow by gravity into the 12-inch major transmission main that serves the Northwest Raleigh service area. The Baileywick Road Elevated Storage Tank will serve the 595-foot pressure zone.

Pumping Facilities

Pumping facilities were designed to meet the maximum anticipated pumping requirement with the largest pumping unit out of service (firm capacity). A 5 mgd firm capacity pumping station should be added to the Neuse River WWTP to provide flow for the reuse distribution system at system build-out. A pumping capacity of 1.4mgd is required for the first phase of construction for the Southeast Raleigh service area. As the demand for reuse water increases, the reuse pumping station at the Neuse River WWTP will need to be upgraded further as needed.

A firm pumping station capacity of 2.4 mgd should be available at the Wake Forest WWTP site to serve sections of the Wake Forest service area and portions of the Northeast service area.

A 2.4-mgd in-line booster pumping station is recommended on Tryon Road to boost water from the 495-foot pressure zone into the 595-foot pressure zone. The station should include two 90-hp pumps, each rated at 174 feet of head at 2.4 mgd.

A 1.1-mgd in-line booster pumping station is recommended on Spring Forest Rd. approximately 0.7 miles east of the Falls of the Neuse Rd. intersection. The pumping station will boost water from the 495-foot pressure zone into the 595-foot pressure zone. The pumping station should be equipped with two 40-hp pumps, each rated at 149 feet of head at 1.1 mgd.

Distribution System

Distribution system routing was selected to meet several identified goals. These goals included:

- Supplying water to as many reuse customers as practical
- Selecting routing along existing roadways or proposed roadway projects
- Creating hydraulic loops in the system to increase hydraulic efficiency of the system
- Performing a corridor analysis
- Serving areas identified as having significant potential for future development
- Serving identified potential users if cost-effective

The proposed distribution system routing by phase is provided in Figure 4-4 of the Hydraulic Analysis Section of this report.

System Phasing

Seven general areas of the proposed reuse system at build-out were identified during development of the hydraulic model. These areas were Southeast Raleigh, Wake Forest, East Wake, Northeast Raleigh, Garner, West Raleigh, and Northwest Raleigh.

The order of phasing was determined based on location and demand. The Southeast Raleigh phase is recommended as the first phase of construction. The Neuse River WWTP is within the Southeast Raleigh service area. The Wake Forest Phase is recommended as the second phase of construction and contains the Wake Forest WWTP. The Wake Forest Phase can be operated independently of the overall distribution system due to the availability of the reuse flow source from the Wake Forest WWTP. The third phase of construction is recommended to be the East Wake Phase. Several miles of existing pipelines can be utilized for this phase of the reuse system thus reducing pipeline costs and the location of the phase is in close proximity to the Neuse River WWTP. The Northeast Raleigh and Garner service areas are located adjacent to the Southeast Raleigh service area. The projected average day demand was estimated at 0.852 mgd for Northeast Raleigh and 0.414 mgd for Garner. Since the revenue collected by the City of Raleigh through reuse fees would be greater for Northeast Raleigh than with Garner and since the Northeast Raleigh Phase allows for better interconnectivity of the reuse system phasing, therefore the Northeast Raleigh phase is recommended as the fourth phase of construction, followed by Garner phase as the fifth phase. West Raleigh has a much higher demand than Northwest Raleigh, and is therefore recommended as the sixth phase of construction. Northwest Raleigh is recommended as the final phase of construction. Construction of the Northwest Raleigh phase will join the Northeast Raleigh and West Raleigh service areas, thereby completing the loop of the reuse distribution system.

6. PROBABLE COSTS

An important part of any master plan is the probable cost of implementing the proposed modifications and constructing the recommended facilities. This section discusses the assumptions used in determining the probable construction costs for the recommended distribution system presented in this report.

As discussed throughout this report, the proposed distribution system presented in this report is the recommended system based on current information. It is impossible to predict the layout of the entire reuse system at ultimate build-out at this time. The layout of the distribution system, phasing of construction, and components of the system will likely be modified and refined as the system is being built over the 30-year planning period. There are numerous factors that will likely impact the design and timing of the actual reuse system. Some of these possible factors include actual consumer utilization of the reuse system, development patterns throughout the City, identification of new potential users, removal of identified potential users, changes in projected demands, identification of future roadway projects, experience gained from expanding and operating the reuse system, City budgeting, and the desires of the City.

The information presented in this section is intended to provide the City with budget costs for financial planning purposes. All costs are based on 2006 construction prices, with no attempt to predict future price levels. The probable costs include allowances of 15 percent for contingencies and 15 percent for legal, engineering, and administrative expenses. The costs do not include allowances for land or right-of-way acquisition. All of the cost opinions are subject to refinement during final design and build-out of the system. As exact routes are determined for individual pipelines, the cost projections can be adjusted to reflect actual conditions, if desired by the City.

To assist the City in its planning and budgeting process, recommended improvements have been grouped by construction phases. It should be noted, however, that the phasing of construction will be decided by the City as the project progresses. The factors discussed will affect timing and components of the reuse system. Table 6-1 summarizes the proposed costs for all of the recommended facilities by phase.

Probable Costs

Table 6-1: Probable Costs of Recommended Facilities

Facility	Probable Cost ($)
Southeast Raleigh Phase	
Reuse Transmission Mains	4,800,000
Sunnybrook Road Elevated Storage Tank	1,500,000
Subtotal	6,300,000
Engineering and Contingency	1,900,000
Total	8,200,000
Wake Forest Phase	
Reuse Transmission Mains	5,200,000
Smith Creek Reuse PS	1,000,000
Subtotal	6,200,000
Engineering and Contingency	1,900,000
Total	8,100,000
East Wake Phase	
Reuse Transmission Mains	3,800,000
Subtotal	3,800,000
Engineering and Contingency	1,100,000
Total	4,900,000
Northeast Raleigh Phase	
Reuse Transmission Mains	15,200,000
Subtotal	15,200,000
Engineering and Contingency	4,500,000
Total	19,700,000
Garner Phase	
Reuse Transmission Mains	12,700,000
Subtotal	12,700,000
Engineering and Contingency	3,800,000
Total	16,500,000
West Raleigh Phase	
Reuse Transmission Mains	11,700,000
Carter Finely Elevated Storage Tank	1,500,000
Tryon Road Booster Pumping Station	800,000
Subtotal	14,000,000
Engineering and Contingency	4,200,000
Total	18,200,000
Northwest Raleigh Phase	
Reuse Transmission Mains	6,300,000
Baileywick Elevated Storage Tank	1,000,000
Spring Forest Road Booster Pumping Station	800,000
Subtotal	8,100,000
Engineering and Contingency	2,400,000
Total	10,500,000

A breakdown of the costs by phase are provided in the sections that follow.

Southeast Raleigh Phase

The Southeast Raleigh Phase includes a major transmission facilities up to the Sunnybrook Road Tank. This phase builds upon the existing reuse distribution system, including the 12-inch main between the Neuse River WWTP and Auburn-Knightdale Road and the 16-inch main between Auburn-Knightdale Rd and Barwell Road. The reuse pumping facilities are currently being designed and are considered existing for the purposes of this master plan.

It is important to note that much of the capacity planned for this phase of the distribution system is planned for future development. The Sunnybrook Road Tank and the 16-inch transmission main are sized to accommodate the entire 495 reuse pressure zone.

A breakdown of the costs for the facilities included in the Southeast Raleigh Phase are included in Table 6-2.

Table 6-2: Probable Costs for Southeast Raleigh Phase

Description	Length	Unit Cost	Total Cost
4-inch main	10,000	$ 35	$ 350,000
6-inch main	900	$ 50	$ 45,000
8-inch main	4,800	$ 60	$ 288,000
10-inch main	7,000	$ 67	$ 469,000
16-inch main	40,200	$ 90	$ 3,618,000
Sunnybrook Road Tank	0.75 MG	$ 1,500,000	$ 1,500,000
Subtotal			**$ 6,300,000**
Contingency & Engineering			$ 1,900,000
Total			**$ 8,200,000**

Wake Forest Phase

The Wake Forest Phase includes a new reuse pumping station at the Smith Creek WWTP. Plans are currently underway for influent pumping modifications that will allow Smith Creek WWTP to be operated as a satellite treatment facility. No costs have been included in this master plan for those improvements.

This phase initially will operate independently of the Neuse River WWTP Reuse Pumping Station. Therefore, facilities are required to maintain the system pressure. Costs for a hydropneumatic tank to maintain pressure are included in the costs for the proposed Smith Creek WWTP Reuse Pump Station.

The pumping station capacity as well as some of the transmission mains are over-sized to provide water into Northeast Raleigh in future phases.

A breakdown of the costs for the facilities included in the Wake Forest Phase are included in Table 6-3.

Table 6-3: Probable Costs for Wake Forest Phase

Description	Length	Unit Cost	Total Cost
4-inch main	7,200	$ 35	$ 252,000
6-inch main	10,300	$ 50	$ 515,000
12-inch main	3,800	$ 75	$ 285,000
16-inch main	43,000	$ 90	$ 3,870,000
20-inch main	2,500	$ 115	$ 287,500
Smith Creek WWTP Reuse PS	2.4 mgd	$ 1,000,000	$ 1,000,000
Subtotal			**$ 6,200,000**
Contingency & Engineering			$ 1,900,000
Total			**$ 8,100,000**

East Wake Phase

The East Wake Phase includes new transmission facilities from Southeast Raleigh. The costs assume an existing 16-inch sewer force main serving Wendell and a proposed 10-inch sewer force main serving the Cypress Landing development will be converted to reuse service after the new Poplar Creek Outfall is constructed. Converting these mains saves considerable capital costs for this phase.

Pressure in this phase will be maintained by the Sunnybrook Road Tank, so no additional storage has been provided. Flow will come from the Neuse River WWTP Reuse Pump Station. No additional pumping stations are required for this phase.

A breakdown of the costs for the facilities included in the East Wake Phase are included in Table 6-4.

Table 6-4: Probable Costs for East Wake Phase

Description	Length	Unit Cost	Total Cost
6-inch main	15,200	$ 50	$ 760,000
8-inch main	31,000	$ 60	$ 1,860,000
12-inch main	16,100	$ 75	$ 1,207,500
Subtotal			**$ 3,800,000**
Contingency & Engineering			$ 1,100,000
Total			**$ 4,900,000**

Northeast Raleigh Phase

The Northeast Raleigh Phase includes major transmission facilities from Southeast Raleigh and Wake Forest. Pressure in this phase will be maintained by the Sunnybrook Road Tank, so no additional storage has been provided. Flow will come from both the Neuse River WWTP Reuse Pump Station and the Smith Creek WWTP Reuse Pumping Station. No additional pumping stations are required for this phase.

In addition to the transmission piping within this area, the cost for a new 20-inch transmission main near the Neuse River WWTP has also been included in this phase to allow higher flows from the Neuse River WWTP Reuse Pump Station.

A breakdown of the costs for the facilities included in the Northeast Raleigh Phase are included in Table 6-5.

Table 6-5: Probable Costs for Northeast Raleigh Phase

Description	Length	Unit Cost	Total Cost
4-inch main	13,700	$ 35	$ 479,500
6-inch main	2,300	$ 50	$ 115,000
12-inch main	80,200	$ 75	$ 6,015,000
16-inch main	82,600	$ 90	$ 7,434,000
20-inch main	9,700	$ 115	$ 1,115,500
Subtotal			**$ 15,200,000**
Contingency & Engineering			$ 4,500,000
Total			**$ 19,700,000**

Garner Phase

The Garner Phase includes major transmission facilities from Southeast Raleigh. Although the potable water zone in Garner is higher than the 495 reuse pressure zone, the demand does not justify the expense of the storage and pumping required to provide a separate, higher reuse pressure zone. Therefore, only the transmission piping is include in the costs for the Garner Phase.

Much of the transmission piping in the Garner Phase has been significantly over-sized to allow transmission of reuse water through Garner to West Raleigh.

A breakdown of the costs for the facilities included in the Garner Phase are included in Table 6-6.

Table 6-6: Probable Costs for Garner Phase

Description	Length	Unit Cost	Total Cost
4-inch main	11,800	$ 35	$ 413,000
6-inch main	21,000	$ 50	$ 1,050,000
8-inch main	16,300	$ 60	$ 978,000
10-inch main	4,300	$ 67	$ 288,100
12-inch main	57,700	$ 75	$ 4,327,500
16-inch main	63,100	$ 90	$ 5,679,000
Subtotal			**$ 12,700,000**
Contingency & Engineering			$ 3,800,000
Total			**$ 16,500,000**

West Raleigh Phase

The West Raleigh Phase includes a new booster pumping station to supply the 595 reuse pressure zone from the Southeast Raleigh and Garner phases and a new elevated storage tank to regulate the system operating pressure.

A breakdown of the costs for the facilities included in the West Raleigh Phase are included in Table 6-7.

Table 6-7: Probable Costs for West Raleigh Phase

Description	Length	Unit Cost	Total Cost
4-inch main	16,200	$ 35	$ 567,000
8-inch main	51,300	$ 60	$ 3,078,000
10-inch main	20,300	$ 67	$ 1,360,100
12-inch main	1,600	$ 75	$ 120,000
16-inch main	73,400	$ 90	$ 6,606,000
Tryon Road Booster Pump Station	2.4 mgd	$ 800,000	$ 800,000
Carter-Finley Elevated Storage Tank	0.75 MG	$ 1,500,000	$ 1,500,000
Subtotal			**$ 14,000,000**
Contingency & Engineering			$ 4,200,000
Total			**$ 18,200,000**

Northwest Raleigh Phase

The Northwest Raleigh Phase includes a new booster pumping station to supply the 595 reuse pressure zone from the Northeast Raleigh phase and a new elevated storage tank to help regulate the system operating pressure.

A breakdown of the costs for the facilities included in the Northwest Raleigh Phase are included in Table 6-8.

Table 6-8: Probable Costs for Northwest Raleigh Phase

Description	Length	Unit Cost	Total Cost
4-inch main	17,100	$ 35	$ 598,500
8-inch main	47,300	$ 60	$ 2,838,000
12-inch main	24,600	$ 75	$ 1,845,000
16-inch main	10,800	$ 90	$ 972,000
Spring Forest Road Booster Pump Station	1.1 mgd	$ 800,000	$ 800,000
Baileywick Rd Elevated Storage Tank	0.50 MG	$ 1,000,000	$ 1,000,000
Subtotal			**$ 8,100,000**
Contingency & Engineering			$ 2,400,000
Total			**$ 10,500,000**

7. RATE ANALYSIS

Introduction

The development of an adequate rate structure to support water reuse is a function of a number of factors including City Council policy, economic considerations, and a variety of practical, engineering-driven considerations. Black & Veatch has prepared the rate recommendations for consideration by the City of Raleigh who will make the final decisions pertaining to the financial rates and fees associated with the reuse system.

Several goals were identified in collaboration with the City of Raleigh staff for consideration during the development of the proposed reuse rate structure:

- Promote the beneficial use of reuse water as a vital resource
- Reflect the City's potable water rate structure to the extent possible
- Allow consumers to pay less for reuse water than for potable water
- Create a sustainable reuse system
- Provide a stable revenue stream
- Promote maximum utilization of the reuse system

A variety of rate strategies were considered to recover all or a portion of the capital and maintenance costs necessary to supply reuse water. Each rate structure was analyzed to determine the rates required for 100 percent cost recovery. The rates were compared to the current and projected City potable water rates.

Potential Rate Structures

Selecting an appropriate rate structure is vital to promote efficient use of the communities water resources while providing a sustainable, cost-effective system. The City of Raleigh currently uses a uniform rate for their potable water. Based on Black & Veatch's experience, and in consultation with the City of Raleigh staff, several rate structure alternatives were evaluated for the reuse system. The rate structures considered included:

- Uniform Rates
- Seasonal Rate
- Increasing-Block Rate
- Declining-Block Rates

Uniform Rate

A uniform rate charges a constant unit price year-round for all metered water consumed. There are two general types of uniform rates: a true uniform rate or a uniform rate by class. Uniform rates are typically used when:

- Customer classes exhibit similar usage patterns
- Rate variations by customer classes might be perceived as inequitable

- Simplicity and customer understanding are considered important
- Conservation is not a primary issue and rate uniformity adequately addresses conservation
- Cost and usage data by customer or class are not available or too costly to develop

Several advantages result from a uniform rate structure. A uniform rate is easily understood and implemented because customers all pay the same rate. It is often perceived as being equitable and encourages conservation over other potential rate structures, including the existing declining-block rate used for potable water. A uniform rate structure tends to provide a stable revenue stream.

There are several disadvantages commonly associated with uniform rate structures. Large volume users benefit less from a uniform rate structure than with a declining-block structure. Conservation is encouraged less with a uniform rate structure than with an increasing-block structure.

Seasonal

Seasonal rates vary by time period, with higher rates charged during peak demand season. Seasonal rates are typically used to better match price and cost recovery with demand patterns and to encourage conservation during peak use periods. There are two basic approaches to seasonal rates: on-peak/off-peak (e.g., summer rate, winter rate) and an excess-use approach. The excessive use approach is seasonal, but charges a higher rate only when use is above a set amount for each billing cycle. Seasonal rates are typically used when:

- Substantial variations in demand exist between peak and off-peak periods, often due to such use patterns as lawn watering
- The utility is capacity-constrained during peak periods
- The system experiences seasonal fluctuations in the number or types of customers served

Seasonal rates can be perceived as equitable because the rates increase as the cost-of-service increases. Seasonal rates are also considered as a very effective means to promote conservation.

There are several disadvantages typically associated with seasonal rates. Customers must understand when rates change, which may require an extensive public education program. Seasonal rates can have a negative effect on customers with high peak-to-average demands, particularly those who heavily utilize irrigation systems in the summer months. Seasonal rates may be complicated to implement because peak periods must be identified and associated costs determined. As noted previously, an effective public education program must be implemented to assure that customers are adequately informed.

Increasing-Block Rate

An increasing-block rate structure charges increasing volumetric rates for increasing consumption. This type of rate structure is gaining popularity in water scarce regions where conservation is one of the primary defining goals of a rate structure. An increasing-block rate should be considered when:

- There are distinguishable customer classes

- Block rates can be designed to include a rigorous definition of the amount of water sold per block and potential demand responses to differential rate impacts
- System capacity constraints exist or a utility is facing system expansion and is seeking to defer capital expenditures
- A utility wants to send a strong conservation signal

Although increasing-block rate structures encourage conservation more than any other rate structure, there are many disadvantages associated with its use. Increasing-block structures are very complicated to implement because they require extensive information on water sales by block of consumption. Implementation requires judgment and policy procedures to determine the number of blocks, beginning and ending points of blocks, and relatives price levels of blocks. The rate structure also is often considered inequitable and may result in a seasonal, unstable revenue stream. Increasing-block structures require an effective public education program to effectively communicate the rate structure to customers. An increasing-block structure was not considered based on the recommendations of the City of Raleigh staff.

Declining-Block Rate

Currently, the City of Raleigh employs a declining-block rate structure for potable water, although this is proposed to change to a uniform rate by 2003. A declining-block rate structure charges a unit price of each succeeding block at a lower unit rate than previous blocks. Although prevalent with potable water utilities in the past, many utilities are shifting away from declining-block rate structures because of inequity perceptions, cost justifications for its use, and conservation considerations. Declining-block rate structures are typically used when:

- A single volume-based rate structure is used for all customer classes
- Individual classes have highly varied usage from customer to customer
- Production costs decline with increased production (economies of scale)
- The system is dependant on large users remaining on the system

Several advantages result from a declining-block rate structure. A declining-block rate is fairly simple to understand and administer. A declining-block can capture economies of scale by balancing actual costs of production with charges. The two significant disadvantages commonly associated with declining-block rate structures include the perception that the rate structure is inequitable and the reality that it discourages conservation.

Other Rate Structures

Other rate structures that were not evaluated for the reuse system included flat monthly, base plus volume, and time-of-day based rates. These rates were deemed inappropriate for meeting the established goals of the reuse system and were thus eliminated from consideration.

Proposed Rate Structure

Assumptions

Several assumptions were necessary to calculate the many possible revenue streams from the proposed rate structures.

- Revenue bonds were assumed as the source of capital funding for the project. A bond amortization of 30 years and a bond interest rate of 5% were selected for use.
- A depreciation period of 50 years was assumed for the new capital assets.
- A 3% inflation factor was assumed for both capital and operation and maintenance costs.
- Only one rate was considered both inside and outside the City limits.
- The City may consider incentive programs such as providing reuse water at no charge for the first five years to promote development of the reuse system and encourage consumers to connect to the reuse system. The impact of these incentives are not included in this analysis.

These assumptions were input as variables in the model and can be changed to reflect other rate scenarios.

Selected Rate Structure

A uniform rate structure was chosen for the reuse system because it can be developed to meet all of the established goals for the reuse system and will be consistent with the proposed potable water rate structure. A uniform rate will be structured to promote the beneficial use of reuse water. A uniform rate will be simple for customers to understand, while adequately addressing conservation. Because both the potable water rate and the reuse water rate will be uniform, the cost saving between the two resources will be fixed and known throughout the year. A uniform rate can also be structured to allow the City to recover as much of the true costs associated with the construction and operation of the reuse system as deemed appropriate. Because the reuse system will be new, cost and usage data by customer or class are not available. Nevertheless, a uniform rate structure can be developed without such cost and usage data. A uniform rate structure also provides a stable revenue stream, and is easily understood and implemented because customers all pay the same rate.

Although large volume users benefit less from a uniform rate structure than with a declining-block structure, there are not many large water users within the City's service area. A uniform rate encourages conservation more than a flat rate or a declining-block rate. While conservation is not as much of an issue with the reuse system, the utilization of the reuse system reduces potable water demand.

Rate Model

A rate analysis model was created to allow the inclusion of various costs and revenue streams, allow a variety of assumptions, and provide different phasing scenarios. These factors, combined with the variables noted in the Assumptions section above, provided an opportunity to evaluate a variety of rate scenarios.

The rate model included the following costs:

- Capital costs for construction
- Interest on debt
- Depreciation
- Energy for pumping and for booster pumping stations
- Sodium hypochlorite for required disinfection associated with reuse

Inflation was applied to all future costs, including capital costs and operation and maintenance costs. Capital costs for construction were estimated for all reuse facilities, including pipelines, pumping stations, booster pumping stations, and storage facilities. The addition of sodium hypochlorite to the treated effluent is the only wastewater treatment cost considered for the reuse system, as this is the only additional treatment that is required for reuse. All other costs associated with wastewater treatment would be required in the absence of a reuse system.

Certain unknown costs were identified and presented to City staff, but ultimately were not included in the rate analysis. These costs included direct labor costs associated with administration of the reuse system (such as billing and customer service), direct labor costs associated with operation and maintenance of the reuse system, and an allocation of administrative overhead costs.

Potential revenue sources and benefits were also identified and presented to the City, but not included in the rate analysis. These benefits and revenues included:

- Connection fees associated with reuse
- Grant funding
- Reduced discharges to the Neuse River

Reuse connection fees had not been established at the time of this report, and were therefore not included. It was assumed that such fees would be used to offset the administrative costs of the reuse system. Subsidies from the City were not included because of the desired goal to develop a sustainable reuse system.

Identification of specific grant funds was not included in the scope of this master plan. As no source of grant funding had been specifically identified at the time of this report, grant funding was not included in the rate analysis. However, a list of potential sources the City of Raleigh might consider includes the following:

- Clean Water Management Trust Fund
- Funding from the US Congress for infrastructure improvements (pending)

Although the costs and benefits described above were identified but not included in the rate model, the model was designed with sufficient flexibly to allow the City to easily add these unknown costs and revenues into model as they become better quantified.

Rate Scenarios

Three uniform rate structures were considered based on build-out assumptions: a 30-year build-out of the reuse system, a 60-year build-out of the reuse system, and a build-out assuming only $0.5 million per year was available for funding the capital expansion. For the 30-year build-out scenario, each phase would successively be built over a 5-year period. For the 60-year build-out scenario, each phase would successively be built over a 10-year periods. For the rate model, it was assumed all costs would occur during the first year of each phase to generate conservative rates.

30-Year Build-out

For the 30-year build-out scenario, each of the seven phases described in the Hydraulic Analysis section of this report would be built over a five-year period. The order of phasing was determined based on location and demand. The Southeast Raleigh and Wake Forest phases were the first two phases because they included the two WWTPs. The system was then expanded in geographical sequence throughout the service area. The phases were ordered as follows: Southeast Raleigh, Wake Forest, East Wake, Northeast Raleigh, Garner, West Raleigh, and Northwest Raleigh. Based on this phasing, the following rates were estimated for each of the five-year construction periods.

Table 7-1 shows the estimated break-even reuse rate for each of the next five years as well as the estimated potable water rate for each year. The estimated potable water rates are based on 9 percent annual increases until 2015. Beyond 2015, the rate was assumed to escalate at the same rate as the anticipated inflation of 3 percent.

Table 7-1: Rates for Option 1 Phasing, 30-Year Build-out Scenario

Years	2006	2011	2016	2021	2026	2031	2036
Phase	SE Raleigh	Wake Forest	East Wake	SE Raleigh	Garner	West Raleigh	NW Raleigh
Rate per ccf	$ 3.12	$ 3.54	$ 3.84	$ 5.14	$ 4.99	$ 7.34	$ 7.87
Estimated Potable Water Rate per ccf	$ 1.56	$ 2.40	$ 3.49	$ 4.04	$ 4.69	$ 5.43	$ 6.30

60-Year Build-out

For the 60-year build-out scenario, each of the seven phases would be built over a ten-year period. The same order of phasing was used as in the 30-year build-out scenario. The first option considered ordering the phases as follows: Southeast Raleigh, Northeast Raleigh, Garner, West Raleigh, and Northwest Raleigh. Based on this phasing, the following rates were estimated for each of the ten-year construction periods.

Table 7-2 shows the estimated break-even reuse rate for each of the next five years as well as the estimated potable water rate for each year. The estimated potable water rates are based on 9 percent annual increases until 2015. Beyond 2015, the rate was assumed to escalate at the same rate as the anticipated inflation of 3 percent.

Table 7-2: Rates for Option 1 Phasing, 60-Year Build-out Scenario

Years	2006	2016	2026	2036	2046	2056	2066
Phase	SE Raleigh	Wake Forest	East Wake	SE Raleigh	Garner	West Raleigh	NW Raleigh
Rate per ccf	$2.94	$3.43	$3.73	$6.37	$6.65	$10.66	$11.63
Estimated Potable Water Rate per ccf	$1.56	$3.49	$4.69	$6.30	$8.46	$11.37	$15.29

Capital Investment

The City of Raleigh's current annual budget includes an allocation of $0.5 million for the construction of the Raleigh Reuse System. This willingness to invest capital has a significant impact on the break-even reuse rates. To assess the impact, the rate model was adjusted to reflect varying levels of capital investment from the City. Table 7-3 shows the adjusted reuse rates based on the annual investments of $0.5 million, $1.0 million, and $1.50 million. The rates are based on the 30-year buildout of the system.

Table 7-3: Rates for Option 1 Phasing, 30-Year Build-out Scenario

Years	2006	2016	2026	2036	2046	2056	2066
Phase	SE Raleigh	Wake Forest	East Wake	SE Raleigh	Garner	West Raleigh	NW Raleigh
Rate per ccf, w/ no investment	$ 3.12	$ 3.54	$ 3.84	$ 5.14	$ 4.99	$ 7.34	$ 7.87
Rate per ccf, w/ $0.5 M	$2.39	$2.78	$2.95	$4.51	$5.69	$6.78	$7.29
Rate per ccf, w/ $1.0 M	$1.66	$2.02	$2.06	$3.88	$5.09	$6.22	$6.72
Rate per ccf, w/ $1.5 M	$0.92	$1.27	$1.17	$3.25	$4.48	$5.66	$6.14
Estimated Potable Water Rate per ccf	$1.56	$3.49	$4.69	$6.30	$8.46	$11.37	$15.29

8. SATELLITE REUSE FACILITIES

Certain portions of the proposed distribution system are located too far from the reuse water sources to be cost-effectively supplied by conventional reuse systems. The West Raleigh, Garner, and Northwest Raleigh phases include a number of potential reuse customers, with an estimated average demand exceeding 1 mgd. Satellite water reclamation facilities (SWRF) were evaluated as an alternative to allow this reuse demand to be served more cost-effectively and much sooner than a conventional approach could accomplish.

Satellite systems include a new wastewater treatment facility located near the reuse water customers. Typically, the biosolids produced at the SWRF is discharged back into the sewer to be transported to a regional wastewater treatment facility. The cost of constructing a new facility is offset by the reduction in reuse water transmission costs. A SWRF requires a viable wastewater supply, land for the treatment facility, consistent reuse demands, and adequate storage to supply the daily and seasonal variations in demand.

Technology

Although any wastewater treatment technology can be used at a SWRF, membrane bioreactor (MBR) technology is emerging as an optimal solution. MBR systems produce a higher quality effluent suitable for reuse applications, have excellent reliability, are compact, and can be designed to have minimal impact on the surrounding environment. MBR systems include a suspended growth biological reactor with membranes for solids separation. The membranes are submerged in an aeration tank in direct contact with the mixed liquor. A vacuum pump draws clear water through the membranes. The membranes provide a positive barrier to any solids that are greater than the pore sizes, typically in the 0.1 micron size. Removing solids to this level produces a very clean effluent with turbidities less than 0.1 NTU. MBR treated effluent can meet all existing reuse water standards including California Title 22. The higher water quality is an excellent benefit for reuse applications.

The membranes provide a positive barrier to solids which is more reliable than traditional clarifiers and filters, which may allow solids to pass through the system. If the membranes fail, the effluent turbidity will raise and the operations staff will be notified of the problem. The biological component of the system is also more stable than traditional activated sludge systems because of the higher mixed liquor concentrations. Where traditional systems will typically have mixed concentrations around 3,000 mg/l, MBR systems operate between 8,000 – 12,000 mg/l. The high mixed liquor solids help buffer changing wastewater characteristics, providing a more stable biological system.

MBRs are more compact than traditional systems because they do not require clarifiers or filters, and the higher mixed liquor concentrations allow for smaller aeration tanks. MBR systems can be constructed in an area $1/4^{th}$ of a traditional treatment plant. Many smaller MBR systems are completely enclosed inside a building.

The characteristics of MBR systems allow the SWRF to be located in populated areas near the potential reuse customers. The compact footprint allows for the SWRF to be located on smaller lots. The buildings can be architecturally designed to blend in with the surrounding environements. Because there are no primary or secondary clarifiers, the odor emissions are lower for MBR systems. Furthermore, when the MBR is enclosed in a building, the odors can be easily controlled.

Membrane bioreators have been in service for many years. Recently, the costs of the membranes have fallen, making the systems more cost-effective. In certain scenarios, satellite systems using MBR technology can be the most cost-effective alternative to meeting reuse water demands.

Facility Screening

The demand analysis prepared for the reuse master plan was reviewed to determine potential satellite service areas that could be served by a new SWRF. The results of the economic evaluation showed that the Garner, West Raleigh, and Northwest Raleigh phases were the least cost-effective. Twenty potential satellite service areas were developed and screened in a workshop with City staff. Table 8-1 shows the list of service areas that were developed.

Table 8-1 – Potential Satellite Reuse Service Areas

Potential Service Areas	
NCSU Main Campus	**NCSU Centennial Campus**
NCSU Main and Centennial Campus	Stadium Area
West Raleigh	Tyron Road Area
Dorothea Dix	**Downtown South**
Downtown South and Dorothea Dix	**Downtown North**
Wendell	Northwest Raleigh
Carolina Country Club	**Brier Creek**
Eagle Ridge	East Raleigh
Mallinckrodt	**Crabtree High-Rise**
Downtown High-Rise	Glaxo Smith Kline

In the screening workshop, seven alternative systems were selected for further evaluation. Those systems are highlighted in bold in table 8-1. Two systems for the N.C. State University area selected, including a small system to serve only the new Centennial Campus, and a larger system serving both campuses as well as the area surrounding the football stadium. Two golf courses, the Carolina Country Club and the Brier Creek Country Club were selected because of their high demand in dry periods. The Downtown South system is centered around a high water using industry and would position the City to serve new development in the southern portions of the downtown area. The Downtown North system is centered around the government complex in the northern section of downtown and also includes a potential stream restoration component for an urban stream which is listed on the 303d list of impaired streams. The final alternative was a system for a single large commercial building, such as the one currently being planned for the Crabtree Valley mall area.

Alternatives Development

Each of the seven alternatives was further refined to determine the components of a complete system, estimate construction costs, and determine the economic viability. Each system was analyzed to determine reuse demands, facility capacity, storage requirements, wastewater supply, and estimated project costs. A summary of each proposed alternative is presented in Table 8-2. For more detailed information on each alternative, see the technical memoranda located in the Appendices.

Table 8-2 – Potential Satellite Reuse Service Areas

Satellite System Name	Average Demand, gpd	Total Cost
NCSU Centennial	127,000	$ 2,800,000
West Raleigh	243,000	$ 8,700,000
Carolina Country Club	90,000	$ 1,500,000
Brier Creek	140,000	$ 4,400,000
Downtown South	90,000	$ 1,500,000
Downtown North	TBD	$ TBD
High-Rise Commercial Bldg	37,000	$ 1,500,000

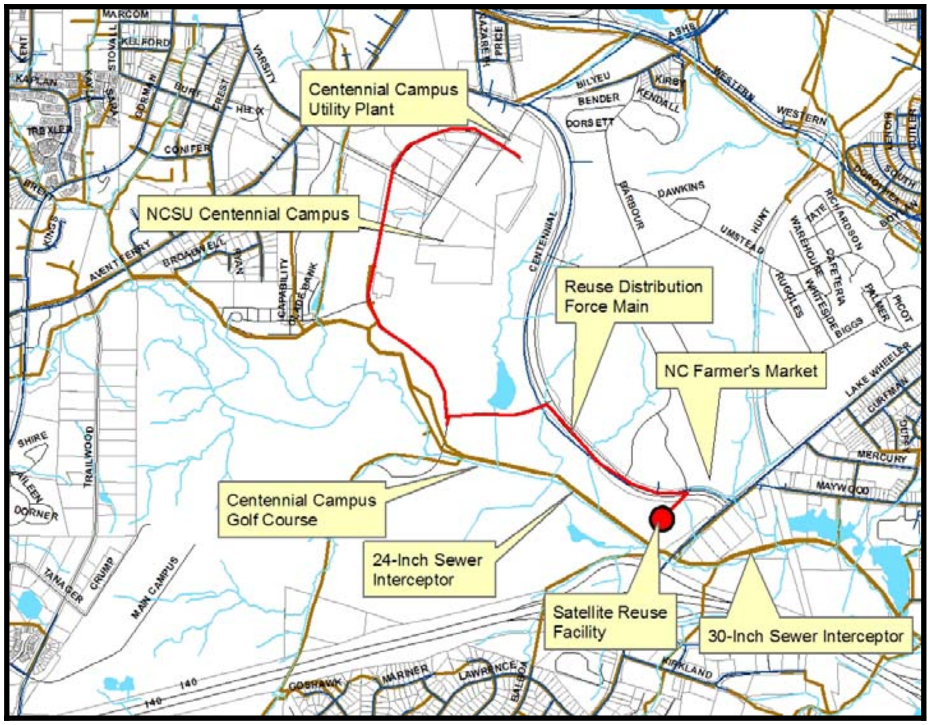
NCSU Centennial Campus

N.C. State has started an ambitious building campaign to develop the new Centennial Campus into a premier research center. The user's include Golf Course irrigation; campus, residential housing, and middle school practice field irrigation; and the reuse water demand associated with the operation of the utility plant. The users have a combined average daily demand of 126,500 gallons per day and a maximum daily demand of approximately 624,500 gallons per day. The reuse pipeline is routed along Main Campus Drive as shown in Figure 8-1.

Wastewater would be supplied from the Walnut Creek interceptor, which should have adequate capacity for the projected demands. One potential location for the SWRF would be on undeveloped land near the intersection of Lake Wheeler Rd and Centennial Parkway, although NCSU officials indicated the land has been designated for other uses.

Centennial Campus is an ideal location for the implementation of a reuse system due to the concentration of reuse demands which maximizes usage and minimizes pipeline costs. Also, due to the location of the golf course, storage options can be efficiently addressed due to the incorporation of course irrigation and storage ponds. Additional meetings with NC State staff are recommended to fully explore providing a full Centennial Campus Reuse system including providing dual plumbing for new buildings along with meeting their irrigation and utility plant reuse demands.

Figure 8-1 – Alternative #2 Western Raleigh / NCSU Service Area

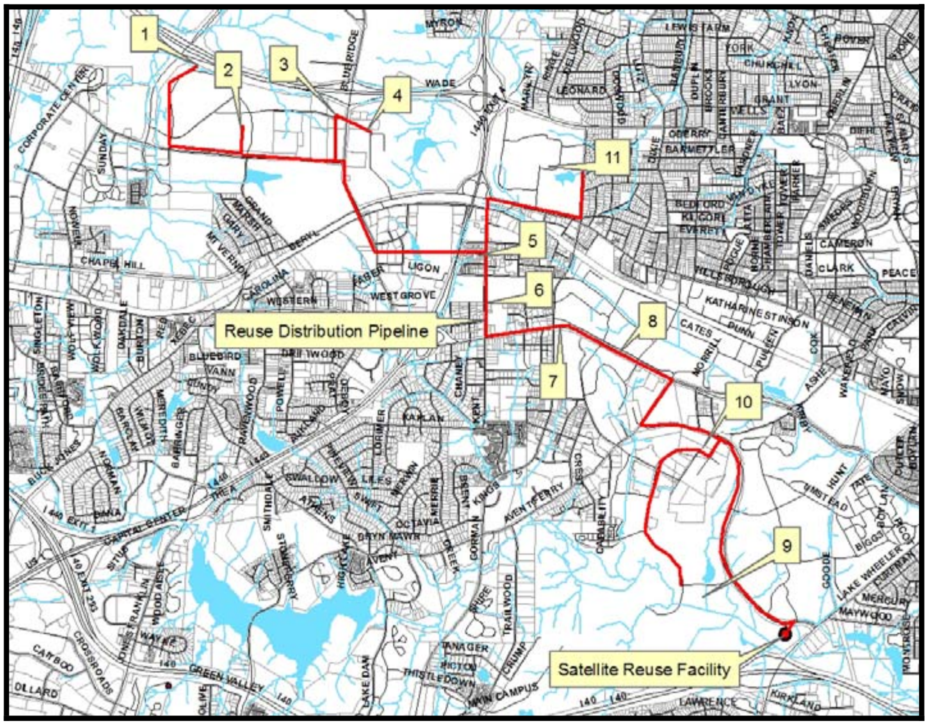


West Raleigh

The West Raleigh service area consists of the area along the western side of Raleigh along the corridor between the North Carolina State Farmer's Market and Carter Findley Stadium. Several potential reuse customers have been identified in this area including boiler and cooling tower demands for North Carolina State University (NC State), irrigation and wash down water demands for NC State's Veterinary School and barn, irrigation demands for Cardinal Gibbons High School ball fields, irrigation demand for Method Park, irrigation water demand for Westchase Office Buildings, demands for NC State's future Centennial Campus Golf Course, and irrigation and utility plant demands for Meredith College. The largest user identified for this area is the projected golf course irrigation demand for the Centennial Campus Golf Course. NC State's Centennial Campus is a 1,334 Acre campus developed to combine scientific and technological innovations and is home to over 100 large and small companies, government agencies, collegiate and business research centers, academic facilities and residential housing facilities.

The potential reuse customers are shown in Figure 8-2. The users have a combined average daily demand of 243,000 gallons per day and a maximum daily demand of approximately 951,500 gallons per day. The reuse pipeline route is also shown on Figure 8-2.

Figure 8-2 – Alternative #1 Western Raleigh / NCSU Service Area



Wastewater would be supplied from the Walnut Creek interceptor, which should have adequate capacity for the projected demands. One potential location for the SWRF would be on undeveloped land near the intersection of Lake Wheeler Rd and Centennial Parkway, although NCSU officials indicated the land has been designated for other uses.

The West Raleigh system would be the largest of all the proposed service areas and has the widest variety of potential reuse customers. It also has the largest capital costs.

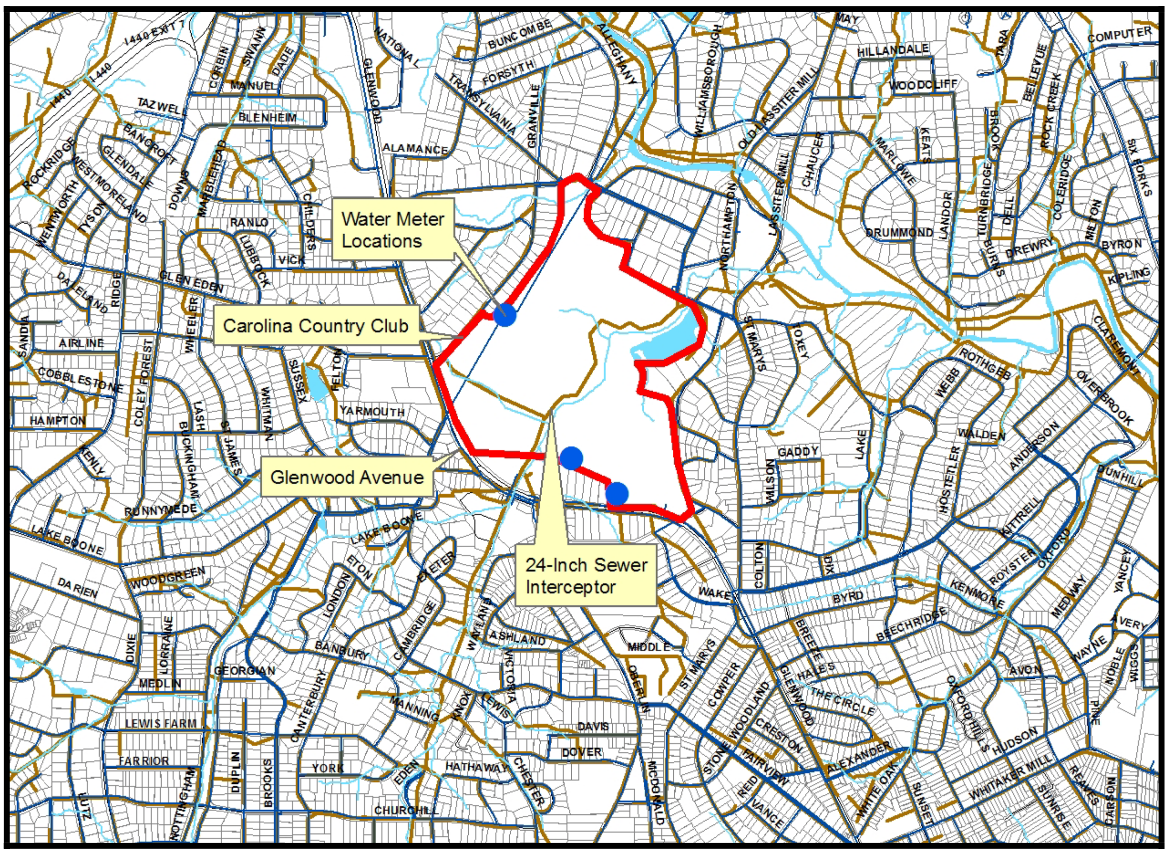
Carolina Country Club

Carolina Country Club is an 18-hole traditional style golf course located off Glenwood Avenue in Raleigh. The property encompasses approximately 172 Acres and was opened in 1910. The course currently irrigates with potable water from the City of Raleigh's water system and has been significantly affected by the water conservation measures enacted during severe drought periods. The Carolina Country Club uses approximately 90,000 gpd of potable water on a yearly average day basis. The majority of this water usage is during the summer months of June, July, August, September and October when the Golf Course is irrigating the fairways and greens. Water consumption depends heavily on rainfall conditions and golf course irrigation can range from every night under hot and dry conditions to every third night with moderate rainfall. The course irrigates approximately 500,000 gal per night during a time frame from 7 am to 7 pm.

Storage is a critical element for any golf course system to be able to keep the facility capacity low while meeting the high flow requirements during irrigation. After discussion with the golf course, it was determined that a concrete storage tank near the maintenance shed was the most viable option. The concrete storage tank would be sized at 1.2 million gallons and would be approximately 100 foot diameter and 20 feet tall. This option would involve significant effort in minimizing the impacts of the tank on the aesthetics of the golf course.

Since Satellite Reuse Facilities utilize wastewater as their influent source, the availability of adequate wastewater flow must be determined before siting a Satellite Reuse Facility. A 24-inch gravity sewer connecting to the Crabtree Interceptor is routed through the Carolina Country Club property. City staff has indicated that adequate wastewater flow is available in the interceptor for the location of the Satellite Reuse Facility. Figure 8-3 denotes the location of the Carolina Country Club site and the 24-inch gravity sewer pipeline.

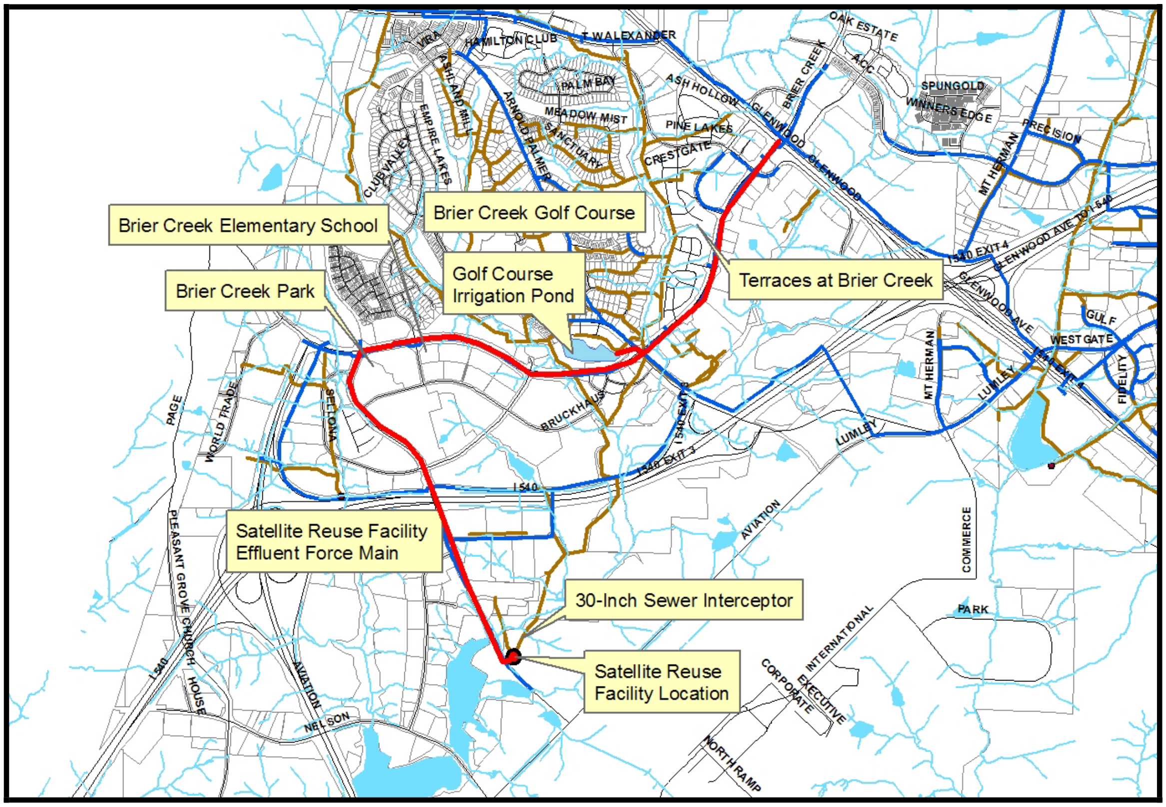
Figure 8-3 – Carolina Country Club Location Map



Brier Creek

The Brier Creek service area includes providing reuse water service to the irrigation water users identified along Brier Creek Parkway. These users include the Brier Creek Elementary School, the Brier Creek Park, the Brier Creek Country Club, the Terraces @ Brier Creek apartments, and retail irrigation water uses which total an annual average day demand of approximately 140,000 gallons per day with a maximum daily demand of 740,000 gallons per day. The reuse pipeline is routed north along Globe Road crossing I-540 and turning east along Brier Creek Parkway to the intersection with Glenwood Avenue as shown in Figure 8-4. A 100,000 gallon storage tank would be provided on the Satellite Facility property to accommodate the peak hour demand resulting for the non golf course irrigation users.

Figure 8-4 –Brier Creek Service Area



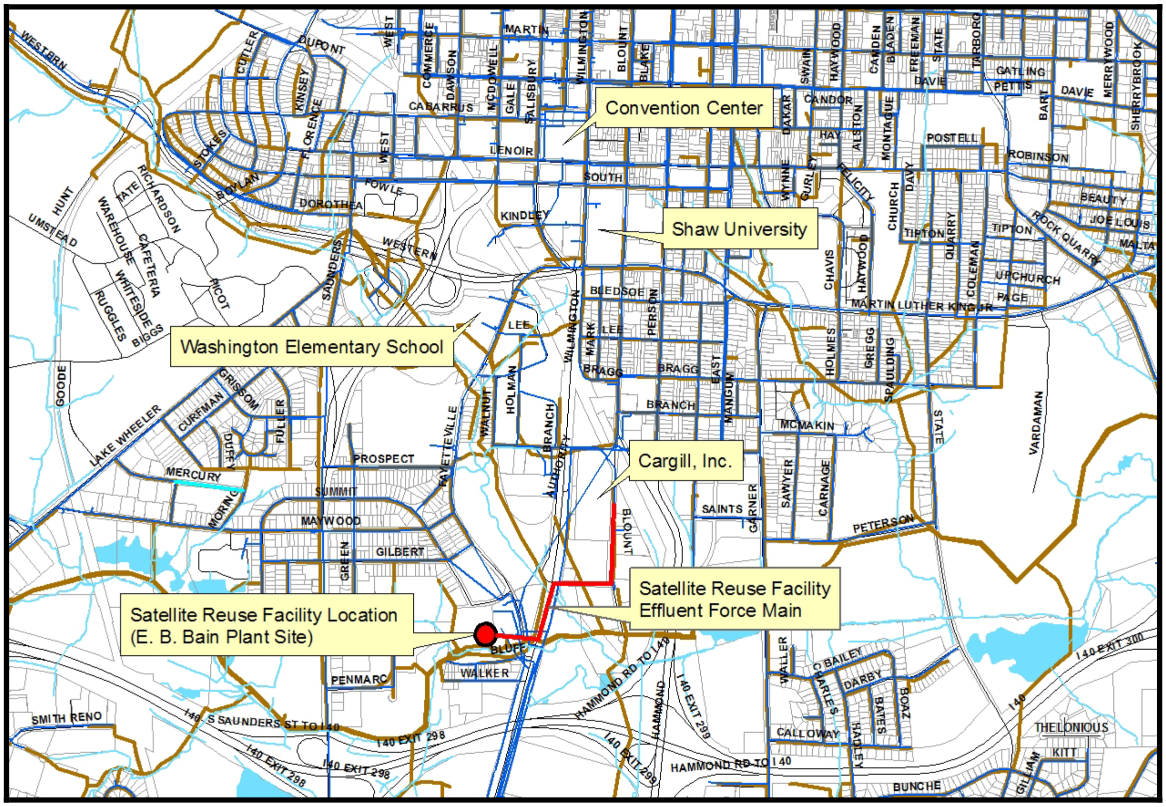
The Brier Creek Pump Station receives wastewater from the 30-inch interceptor serving the Brier Creek area. Not only does the facility provide easy access to the necessary wastewater flow, but the site has adequate space available for the location of the Satellite Reuse Facility.

Downtown South

The Downtown South service area includes providing reuse water service to the largest water user identified for the service area, Cargill, Inc. This water usage includes the 90,000 gallons per day demand of the facilities cooling towers. Since the facility operates continuously, the cooling tower water demand is constant and not subject to the widely varying peaks typically seen with irrigation water usage. The Downtown South service area is depicted in Figure 8-5.

An 18-inch, a 24-inch, a 36-inch, and a 42-inch gravity sewer interceptor are located in the Downtown South service area. Each one of these sewer interceptors will likely have adequate flow for serving the demands of the satellite facility. Since the Downtown South service area is significantly developed and many of the areas that are adjacent to the 18-inch, 24-inch and 36-inch sewer interceptor will likely not have adequate space for the siting of the Downtown South Satellite Reuse Facility, the E.B. Bain Plant site was evaluated for the site of the Satellite Reuse Facility. The 42-Inch sewer interceptor runs through the E.B. Bain Plant site and city staff has indicated that the site has adequate space available for the location of the Satellite Reuse Facility.

Figure 8-5 –Downtown South Service Area



Having a customer with a constant year-round demand allows the SWRF to operate near its rated capacity throughout the year. This helps maximize the revenue generated per gallon of capacity. Serving other customers in the area should be considered as this option is further explored. Although the analysis shows a larger service area is less cost-effective, it would provide a larger system and maximize the reuse potential in the area.

Downtown North

The Downtown North service area includes a new chiller plant constructed by the State of North Carolina, Peace College, the City garage, irrigation around the State Government Complex, and potentially the boiler facility operated by the State. Another potential option would be to provide flow to Pigeon House Branch, which is an urban stream that is currently listed as impaired on the 303d list. The stream has very high flows during rain events, then quickly reverts to a low-flow condition. The MBR technology could provide a very high quality effluent that could provide the stream a steady flow of clean water. This clean water along with other restoration strategies could provide significant benefits and improve the health of the stream. It would also improve the aesthetics of the stream.

Preliminary discussions with the Department of Natural Resources indicate that they would be receptive to allowing a discharge of reuse water into the stream as part of a larger plan to restore the stream.

City staff evaluated the wastewater flow in the 24-inch interceptor adjacent to Pigeon House Branch on the City garage property. The flow recorded in a relatively dry period was 1.3

mgd. This indicates the wastewater available may be the limiting factor at this location. The facility may need to be located further downstream to have adequate wastewater supply.

To further develop this option, the City needs to develop a comprehensive restoration strategy. As part of that strategy, the available wastewater supply needs to be determined at multiple downstream locations. Environmental studies need to be conducted to determine the optimal flow-rates for improving the health of the stream.

High-Rise Commercial Building

With the current development and re-development taking place around the City, the potential for small, dedicated use satellite facilities is becoming more feasible. A small satellite facility installed within the structure or on the property of a high-rise development could be utilized for the supply of reuse water for toilet flushing, cooling tower water, and irrigation water and would reduce the demands on the potable water system. Dual plumbing could be installed throughout the building to supply all of the reuse water demands from the dedicated use satellite reuse water system, a localized satellite reuse water system installed in the area, or from a more regionalized reuse water system.

Multiple scenarios were evaluated to determine the cost effectiveness of these systems. The analysis revealed that the larger buildings are more cost-effective. However, providing a system for a 600,000 sf commercial building was not considered cost-effective. Demands for that system were estimated to be 37,000 gpd.

Economic Analysis

To determine the economic feasibility, a rate analysis model was created to determine the break-even reuse water rate for the proposed system. The model allows the inclusion of various costs and revenue streams and allows for a variety of assumptions. The rate model included the following costs:

- Capital costs for construction
- Treatment costs for operating MBR system
- Interest on debt
- Depreciation
- Energy for pumping and for booster pumping stations
- Sodium hypochlorite for required disinfection associated with reuse

Inflation was applied to all future costs, including capital costs and operation and maintenance costs. Capital costs for construction were estimated for all reuse facilities, including pipelines, pumping stations, booster pumping stations, and storage facilities. All other costs associated with wastewater treatment would be required in the absence of a reuse system.

Table 8-3 shows the estimated break-even reuse rate for each of the next five years as well as the estimated potable water rate for each year. The current potable water rate is $1.56 per hundred cubic feet (ccf), and it is expected to escalate 9 percent each year until 2015. The resulting 2015 potable water rate is $3.39 per ccf.

Table 8-3 - Rates for Proposed Satellite Systems

	Projected Breakeven Rate, per ccf	
Satellite System Name	**0 to 5 years**	**6 to 10 years**
NCSU Centennial	$ 4.73	$ 4.24
West Raleigh	$ 7.44	$ 6.29
Carolina Country Club	$ 4.17	$ 3.75
Brier Creek	$ 6.21	$ 5.52
Downtown South	$ 3.72	$ 3.36
Downtown North	$ TBD	$ TBD
High-Rise Commercial Bldg	$ 8.34	$ 7.38

Recommendations

The Downtown South option has the lowest cost per ccf of all the options evaluated. The system has an anchor customer that would maximize the use of the facility year-round. Although the reuse cost is not currently cost-competitive with potable water, the cost in 10 years is expected to be less than the potable water rate, showing the system has the ability to be cost-effective in the long-term.

Although the analysis showed a system only serving one customer was the most cost-effective, the facility should be planned to expand to serve other potential downtown customers. It is also possible that the facility could be expanded to serve the NCSU Centennial Campus. In addition, the City should monitor the redevelopment of the Dorothea Dix property to determine if significant reuse potential will result.

The Carolina Country Club option should also be developed further. Like the Downtown South option, the projected reuse rate is not currently cost-competitive with potable water. However, future reuse rates will be comparable to the potable water rates in approximately 15 years. Although this system is very seasonal in nature, it is important to recognize the benefits of reducing potable water demand during dry portions of the year. This benefit relieves demand on the water system when it is at its peak demands.

9. REUSE ORDINANCE

An important consideration with any utility is the establishment of ordinances that govern that utility. With a new reuse utility in the City of Raleigh, the development of a reuse ordinance was included in this Master Plan to set the City's policies governing the reuse system. The ordinance set policies related to providing reclaimed water inside the City limits, as well as areas in the extraterritorial jurisdiction outside the City limits.

The City of Raleigh Code of Ordinances was reviewed to determine the backdrop for the City's reuse ordinance. A new reuse ordinance was developed for the City as a stand-alone ordinance to be inserted within the existing Code of Ordinances. Reuse ordinances from communities in Arizona, California, Florida, and North Carolina were reviewed to ensure a thorough and well-organized ordinance. Although the ordinances varied greatly, many of the same provisions concerning reuse were common throughout all of the ordinances reviewed.

Specific requirements for the reuse system, such as cross-connection measures and labeling requirements, were incorporated into the ordinance. The ordinance also included a rate structure to allow the City to recover capital and operating costs.

Relationship with Existing Ordinances

The existing City ordinances were reviewed to determine the existing provisions related to the authority of the City, the existing policies for other utilities, and the general format of the ordinances. Summaries of the relevant portions of the ordinances are provided in this section, along with recommended changes.

The authority for the City to operate utilities is included in DIVISION I – CHARTER. Section 2.14 of the Charter gives the City the authority to regulate and construct public utilities. This section was considered generic enough to not require modification for application to reuse. Sections 6.28 through 6.33 specifically outline the role of the Public Utilities Department and specifically identifies light, water, and sewer utilities. Although there are some references to "other utilities", this section is geared more to specific utilities. Consideration should be given to modify these sections to reflect the reuse facility.

DIVISION II – CODE OF GENERAL ORDINANCES is divided into fourteen parts. Part 8 includes the ordinances pertaining to Public Utilities. This part is further divided into chapters, articles, divisions, and sections. The draft reuse ordinance was developed as a new article, Article E, to be inserted at the end of Chapter 2 – Water and Sewer Service. There are several provisions within the existing ordinances that may impact the reuse ordinance.

- Chapter 1 – The Department of Public Utilities identifies the administrative components, functions, and duties of the department. Section 8-1002 identifies the specific utilities that are administered by the department. Consideration should be given to modifying this section to include the reuse utility.
- Section 8-2008 allows for wells to be installed. These wells may provide an alternative irrigation water supply for prospective reuse customers. Consideration should be given to deleting or modifying this provision to require reuse for irrigation and other non-potable service.
- Section 8-2063 requires that outside extensions must include water and sewer. Consideration should be made to requiring reuse as well.

- Article D of Chapter 2 concerns cross-connection control for the potable water system. This article can be modified to include the cross-connection issues associated with the reuse system. Alternatively, the reuse ordinance can cross-reference this article to ensure the cross connection features are uniform.

Reuse Ordinance Outline

The reuse ordinance was developed as a stand-alone ordinance as new Article E in Part 8, Chapter 2 of the Code of Ordinances. Article E was prepared with the following five divisions:

- Division 1 – General Provisions
- Division 2 – Connection to the Reuse Water System
- Division 3 – Public Extensions of Reuse Water System
- Division 4 – Private Extensions of Reuse Water System
- Division 5 – Discontinuation of Service

The content in each of the five divisions is summarized below.

Division 1 – General Provisions

Division 1 included sections related to the purpose and policy, definitions, enforcement, and other policies for reuse. The requirements specifically required by the State regulations were also included in this section.

Division 2 – Connection Policies

Division 2 included many of the same sections included in the existing water section. It defined the individual customer requirements to connect to the reuse system, including meter requirements.

Divisions 3 and 4 – Extension Policies.

Divisions 3 and 4 defined the requirements and guidelines for the City to extend service to new areas. These divisions were developed to be similar to the existing water and sewer extension policies. Division 3 included provision for public extensions and Division 4 included provision for private extensions.

These policies were developed to recover costs associated with the utilities. The reuse ordinance was essentially a duplication of the extension policies in the water and sewer ordinance.

Division 5 – Discontinuation of Service.

The responsibility for improper use of reuse water will ultimately fall back to the City. Therefore, Division 5 was developed to identify the City’s right to terminate service.

Adopted Ordinance

The City adopted a reuse ordinance in October 2007. The ordinance was developed to include the minimum requirements to satisfy existing reuse permits, including the Zebulon reuse permit, which was transferred to the City of Raleigh in October 2007. A copy of the ordinance is included in Appendix E.

Other Administrative Programs

In several instances, the ordinance allows the City to implement other programs or procedures to operate the reuse water system effectively and efficiently. For instance, the ordinance requires that a special tool be used to operate all reuse water valves. The specifications will be provided in the Public Utilities Handbook.

Also, when delegated authority to issue permits is granted to the City, they will be able to address site specific issues in the permits that are issued to the individual users. The permit will define in more specific terms how the reuse water may be used on a specific site.

10. REUSE STANDARDS

The City of Raleigh publishes the City of Raleigh Public Utilities Department Handbook (Handbook) to summarize the policies, standards, and specifications of the Department in one document. Specific information on design, material, construction, and standard detail drawings used by CORPUD are included. The Handbook was developed based on CORPUD's responsibility for operating, maintaining, and expanding the water and sewer systems of the City of Raleigh. The Handbook was designed to facilitate understanding by developers, engineers, contractors, and the citizens of Raleigh of how CORPUD conducts business both inside the City limits and in the City's extraterritorial jurisdiction.

The Handbook was last updated in October of 2000. The Handbook contained the following four sections: Introduction, General Policies/Regulations, Water, and Sewer. Standard Water and Sewer Details follow at the end of those sections. As part of this Master Plan effort, the entire Handbook was reviewed and updated, and a separate Reuse section was prepared. The Water Section of the existing Handbook was used as the base to create the Reuse section.

Although each of the sections of the Handbook included many changes, only the significant charges are outlined here. Many minor changes such as grammatical changes, spelling errors, and clarifications will not be discussed.

Section 1 – Introduction

Revisions to Section 1 were minor. Section 1 was revised to indicate that reuse was included in the Handbook

Section 2 – General Policies and Regulations

Section 2 had several revisions of significance, including the addition of fees for reuse and the City's delegated authority to issue reuse permits on behalf of NCDENR. The section regarding irrigation well permits was amended to prohibit irrigation wells where reuse was available. Language was added to the Handbook that mandated reuse for all irrigation and that both new developments and existing systems would be required to connect to reuse, where reuse was available. For existing systems, CORPUD will provide a stub-out connection. For new developments, developers will be required to provide dual systems when a reuse main is within 1500 feet of the development.

Section 3 – Water

Revisions to Section 3 were minor. A 10-foot minimum horizontal and 18-inch minimum vertical separation between water and reuse lines was added.

Section 4 – Sewer

Revisions to Section 4 were minor. The reuse paragraph was removed.

Section 5 – Reuse

A new section for reuse was modeled after the water section. Significant differences between the water and reuse section included:

- Valves for reuse were only required on legs of intersections.
- No maximum lengths for reuse mains were required.
- Fire hydrants were not allowed on reuse.
- Pipe materials for reuse were allowed as C900 PVC or ductile iron.
- Locator tape was specified for PVC piping.
- Backflow preventors were not required for reuse.
- A new blow-off detail for reuse was added.
- Identification requirements for reuse mains and appurtenances were added.
- Cross-connection control measurements were added.
- Specifications for items unique to reuse were added.

It is recommended that the City provide electronic copies of the standards on CD and via the CORPUD internet site. It is recommended the electronic versions are provided as Adobe portable document format (pdf) files to prohibit altering and to ensure consistent formatting.

11. PUBLIC EDUCATION

Because reuse was considered a relatively new concept in North Carolina, public education was a key component of the City's reuse program. Irrigation of parks and school grounds were among the many reuse opportunities identified in Raleigh. Therefore, public acceptance of reuse water was critical to ensure availability of these potential reuse sites. The public education effort included several different aspects to reach as many members of the community as possible. These effort included creating a public education brochure, providing information regarding reuse for the City's website, including reuse discussions and information in presentations to the community, trade organizations, and festivals, developing a water curriculum to be taught in the public schools, and identifying other reuse education opportunities that the City may participate in the future.

Reuse Brochure

Public education began early in the master plan effort. A brochure was developed for distribution to educate the general public on key aspects of reuse. The brochure, entitled "Reuse Water: New Services to Meet Your Needs" was designed to promote the benefits of this resource, while alleviating potential concerns of the public. The brochure was included with all demand surveys that were mailed. It will also be available at each of the major reuse facilities. In addition, the brochure materials will be used for site-specific educational opportunities. A copy of the reuse water brochure is attached in the Appendix.

The brochure was targeted to address many of the common questions often associated with reuse water. It included a description of reuse water, including definitions of common terms used to describe reuse water. Reasons for using reuse water were provided, including noting that drinking water is a limited resource that discharges to rivers are reduced, and that reuse water can cost less than potable water. Lists of both potential and prohibited uses were provided, along with a list of reuse systems already in operation. The North Carolina regulations for reuse usage including notification of the public through signage and purple-colored equipment, treatment of reuse water to more stringent standards than treated wastewater, and continuous monitoring requirements were discussed as safeguards for public health. The US Environmental Protection Agency reuse water website and the City of Raleigh's website were provided for those interested in finding additional information.

Reuse Website

Development of the webpage content was another aspect of the public education component of the master plan. The website contained the same basic information as the brochure, with a little more detail. As progress is made, the website should be updated. A copy of the information developed for the City's website is attached in the Appendix.

Ongoing Public Education

The public education effort also included identification of on-going public education programs to increase the awareness of the City's reuse water system. Presentations at community and trade organizations were a significant component of the public education program, and are expected to continue to be so in the future. WaterFest, an annual event for Wake County elementary and middle school students conducted by the City of Raleigh, has been utilized since 2001 to educate young citizens on the importance of Reuse Water. Games, exhibits, and demonstrations are used to highlight the major influence and importance of water in our lives. Depending on the location of the WaterFest event, tours of the water treatment plant, wastewater treatment plant, and Falls Lake Dam are offered. A water curriculum will also be developed for public schools which will incorporate aspects of reuse water, water conservation, and watershed protection into the students school routine. Reuse seminars are also recommended for City staff to provide education related to the reuse system to various departments within the City.

Future Public Education Opportunities

A Speaker's Bureau can be developed to discuss the important issues surrounding reuse service. A reuse Speaker's Bureau would consist of experts in the field of reuse that are willing to speak to civic groups to help describe the benefits of reuse water within the community. The City could develop a user newsletter to highlight direct benefits to the user and the environment. The newsletter could contain information tracking the cost savings for reuse users and the changes in river water quality. Demonstration sites should be considered to illustrate the benefits of reuse water over potable water for growing plants and could include two small gardens, one irrigated with reuse water and one irrigated with potable water.