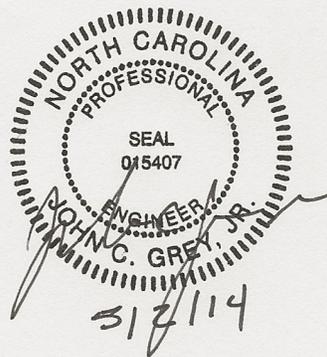


# County of Davie

## Eastern Davie Sewer Area Proposed Wastewater Treatment Facility

Engineering Alternatives Analysis (EAA)/  
Environmental Impact Document (EID)

5/2/2014



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**Eastern Davie Sewer Area (EDSA) Wastewater Treatment Facility  
Engineering Alternatives Analysis (EAA)  
Environmental Impact Document (EID)**

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## **1.0 Executive Summary**

The Eastern Davie Sewer Area (EDSA) is shown in **Figure 1** relative to the rest of Davie County. It occupies approximately 7.6% of the County and includes the Town of Bermuda Run (BR). The EDSA has historically been a high growth area for the County. The Office of State Budget and Management (OSBM) estimated the Davie County population at 41,310 persons in 2010. A block level analysis of the census for that year shows that the population of the planning area was 10,706 or 26% of the County total. With 26% of the County population residing in 7.6% of the County's area in or near the Winston Salem Metropolitan Statistical Area (WSMSA) adjacent to Clemmons and Lewisville, it is clear that growth in that area is governed by growth patterns for the WSMSA and not the more rural and distributed overall Davie County area. It is further clear that the EDSA is poised for additional growth with the construction of the Ashley Furniture facility, the Wake Forest Baptist Health complex, and visionary Bermuda Run master planning that was recently completed.

**Figure 2** is a graphic overview of the two public sewer systems serving the area:

1. Davie County collects wastewater and pumps it into the Winston-Salem/Forsyth City County (CCUC) System at the Tanglewood Pump Station.
2. BR owns and operates a treatment facility permitted at 0.193 MGD that discharges into the Yadkin River in an impaired reach approximately 1.9 miles above the CCUC water intake near Idols Dam.

Also shown in **Figure 2** is the prevalence of soils with severe limitations for septic disposal. Many subdivisions with on-site septic systems are located in the EDSA. A review of Environmental Health records shows that approximately 1/3 to 1/2 of the on-site systems in such subdivisions, as Creekwood/ Davie Gardens have required repair. It is often difficult to find additional drain field area on residential lots to accommodate multiple repairs.

Several factors are motivating Davie County (the County) and Bermuda Run (the Town) to take action:

1. The County's sewer fees for the area have not kept pace with increasing charges from CCUC. The Eastern Davie Sewer area lost \$225,000 in 2010, \$311,000 in 2011 and \$410,000 in 2012 according to certified audits.
2. The County has an agreement with CCUC to accept 550,000 gpd (which has been substantially allocated) into the Tanglewood pump station and has accepted a short-term agreement for an additional 200,000 gpd which must be either removed by 2018 or a fee of \$1,000,000 paid for increased CCUC upgrade expenses.
3. The package treatment facility owned by the Town serving its older portion inside the gates and east of Hwy 801 was previously owned when it was installed in 1984 and it is in need of significant maintenance. Additionally, the State is poised to set new effluent limits governing nutrient discharge for facilities upstream of High Rock Lake that will require this plant to be expanded and its processes rebuilt. The Town requested that CCUC examine the feasibility of accepting its wastewater (independent of Davie County) and decommissioning the Town's treatment facility. Highfill Infrastructure Engineering, PC investigated the possibility for CCUC and published Draft results of its findings on 9/23/13. That report is included in an appendix hereto and indicates that the least capital intensive alternative for the Town to pump to CCUC would cost approximately

\$3,000,000 and then the Town would need to continue to own and operate its own collection system while paying CCUC for treatment.

4. If the Town elects to rebuild its treatment facility to new standards, it will need to comply with current floodway management regulations, acquire new property and expect to pay a construction cost in excess of \$3,000,000.
5. The capital cost of the Town's participation in the EDSA sewer project is estimated to be approximately \$1,000,000. Future sewer rates are estimated to be lower than those charged by CCUC to the County and a strategy for the County to assume the operation and maintenance of the BR collection system is being developed.

#### Eastern Davie Sewer Area Regional System

On February 11, 2014, the Bermuda Run Town Board voted unanimously to support the EDSA NPDES application and agreed to remove its discharge in the Yadkin River upstream of the CCUC intake in order to join the EDSA Regional Sewer system under terms previously discussed.

#### Practical Alternatives Considered for the area

1. Provide a gravity interceptor along Smith and Carter Creeks to the new County owned treatment facility designed to current nutrient removal standards.
2. Provide a gravity interceptor along Smith and Carter to a pump station instead of a treatment facility and pump the wastewater to the CCUC Muddy Creek Interceptor.

#### Economic Analysis

Capital costs for each alternative are as follows (costs include allowances for professional services and 20% contingency):

1. Smith/Carter Interceptor Yadkin and Smith Pump Station revisions, Town Pump Station and forcemain and WWTP removal along with 1 MGD treatment facility expanded to 2 MGD after 10 years **\$6,750,000**  
(Includes approximately \$1M for Town Pump Station, Forcemain and WWTP decommissioning)
2. New 1 MGD WWTP meeting current nutrient removal limits with discharge to the Yadkin River below Idols Dam... **\$9,100,000**
3. Forcemain and Pump Station construction to convey wastewater from the Idols Creek Dam area to the Muddy Creek Interceptor... **\$8,100,000**  
(Includes a major pump station and 26,500 lf of 18" diameter forcemain)

The State requires a Present Worth Analysis of feasible alternatives using an approved discount factor (4.75%) and considering operation and maintenance costs over a 20-year time frame. Table 1 shows a 20 year analysis assuming current flows with very modest annual increases (1%), CCUC fees based on current experience (\$2.5/kgal) and operational costs based on Davie County's experience at Cooleemee with a 25% increase for contingencies.

It can be seen from **Table 13** that the **Present Worth of Costs** for the alternatives is as follows:

- |  |                     |
|--|---------------------|
| 1. Eastern Davie WWTP and Yadkin River Discharge | <b>\$45,000,000</b> |
| 2. Land Application ...                          | <b>\$55,000,000</b> |
| 3. Pump to CCUC...                               | <b>\$96,000,000</b> |

The financial analysis is driven by the cost of CCUC fees representing a **\$50,000,000** additional Present Worth Cost when compared with Davie County's ability to operate its own facility.

### **Conclusion**

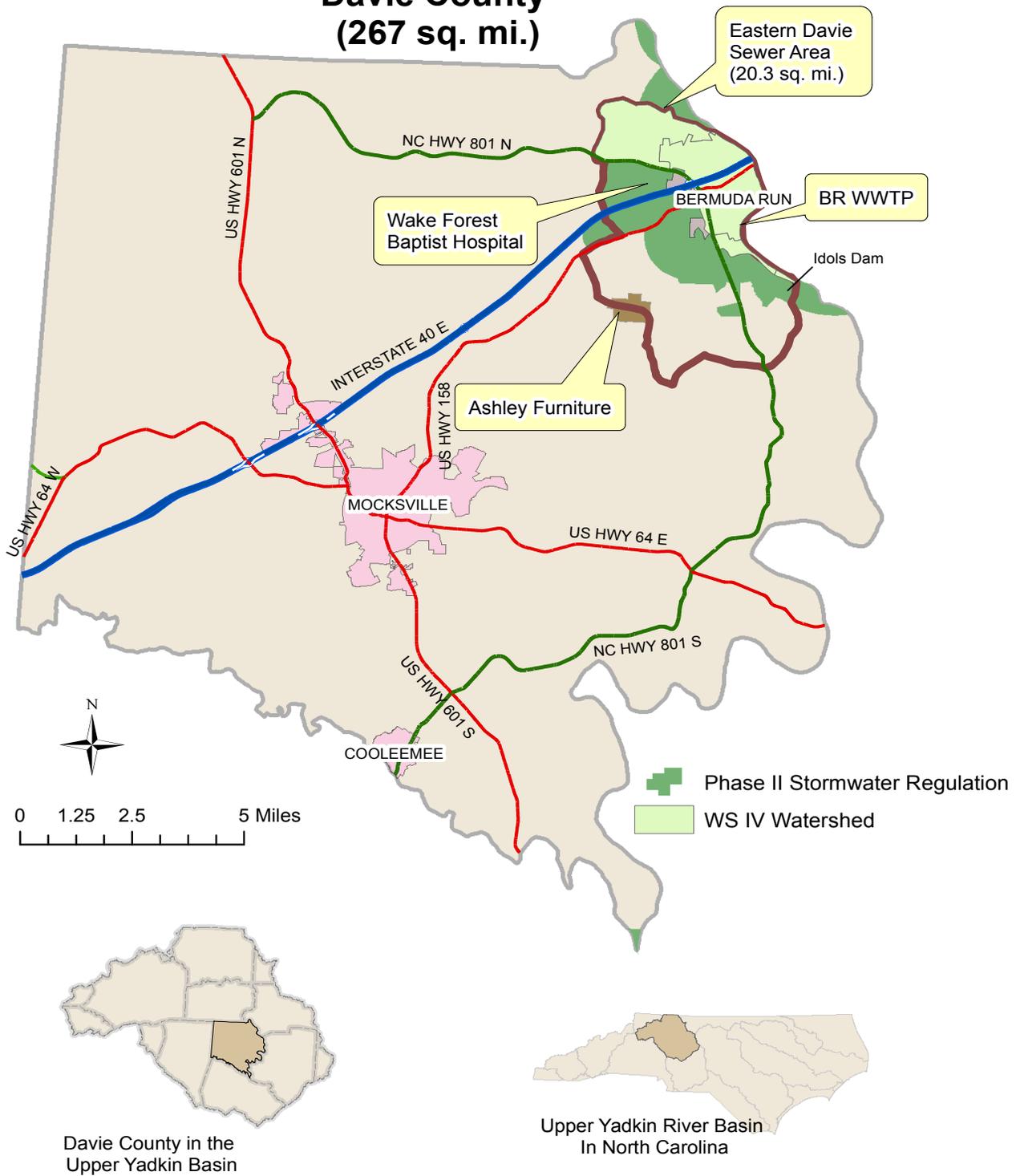
NCDENR has drafted speculative discharge limits for the County's proposed Eastern Davie WWTP that, because of EPA requirements, depends upon removal of the Bermuda Run wastewater discharge. This effectively means that BR must join the County in its endeavor in order for the County to obtain permission to build a new facility.

It has been proposed to Bermuda Run that it will control the allocation of capacity within 1 mile of its Town limits (subject to financial agreements) and that Davie County will be interested in taking over the Town's sewer system where the components meet basic requirements and have clear easements. This offers Bermuda Run a pathway to "get out" of the sewer business and remove the treatment plant from its Town limits.

The least cost alternative based on current information is to construct an Eastern Davie Wastewater treatment facility with an initial capacity of 1 MGD and future expansion potential to 2 MGD.

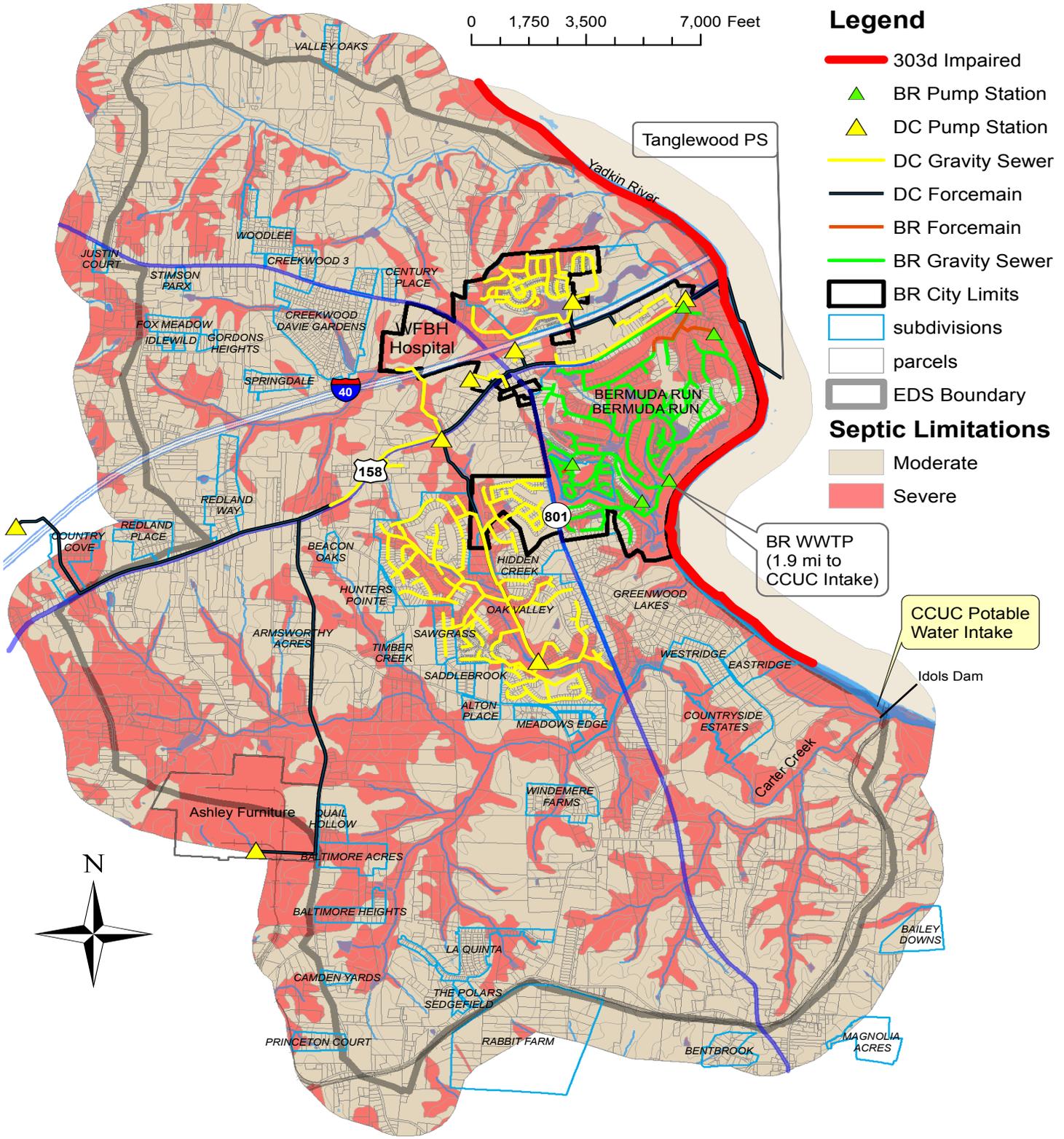
Environmental Note: It can be seen from **Figure 1** that much of the EDSA is covered under Phase 2 Stormwater regulations administered by the State. The County should anticipate extension of the regulated area to include all of the EDSA as the area continues to urbanize in response to availability of additional wastewater disposal options become available.

# Davie County (267 sq. mi.)



C. Jones  
Grey Engineering, Inc.

**Figure 1: Eastern Davie Sewer Area Vicinity Map**



Eastern Davie Sewer ER/EID  
 Grey Engineering, Inc.  
 C. Jones

**Figure 2: Eastern Davie Sewer Area Overview**

## **2.0 Current Situation**

### **2.1 EDSA Overview and Background**

The Davie County and the Eastern Davie Sewer Area (EDSA) are shown in regional context in **Figure 1**. The EDSA occupies approximately 20.3 sqmi of Davie County's 267 sqmi and is largely contained in the Winston Salem Metropolitan Statistical Area (WSMSA). Because of that, a large portion of the planning area is covered under Phase II Stormwater regulations. Further, it can be seen that a significant portion of the area west of Hwy 801 contains a WS IV watershed generated by the CCUC water intake near Idols Dam.

In 2010, the area covered 7.6% of Davie County (20.3 sqmi) and contained 26% (10,706 cap) of its population.

**Figure 2** provides an overview of the area showing the Town and County wastewater collection systems. It can be seen in this figure that much of the soil in the area has severe septic limitations while all other soils are at least moderately limited. It may also be seen that the section of the Yadkin River receiving the Town discharge is classified as **Impaired** in the State's 303d program. That figure also shows parcel and subdivision development in the planning area.

In **Figure 2**, the Davie County collection system is shown in yellow and the Bermuda Run collection system is shown in green. The Town owns the collection system East of NC 801 and West of US Hwy 158, which flows to its wastewater treatment plant. The County owns the collection system serving areas West of NC 801 and North of US Hwy 158. The County system pumps wastewater to the CCUC Tanglewood pump station. Newer portions of the Town are sewered by the County system.

Carter Creek and its tributaries drain the planning area except for those portions East of Hwy 801 that drain into the Yadkin River. Carter Creek empties into the Yadkin River just below Idols Dam at the Norfolk Southern railway bridge.

### **2.2 EDSA Wastewater Collection and Disposal Systems**

#### **2.2.1 Bermuda Run Systems**

##### **2.2.1.1 Bermuda Run Overview**

The Town of Bermuda Run is served by two sewer systems. Areas inside the original gates (South of Hwy 158 and East of Hwy 801) are served by a collection system and treatment facility owned by the Town. Areas outside the original gates are served by the County's system. The Town's system serves approximately 1,469 residents, whereas the County system serves approximately 1,031 residents of the Town (Based upon 2012 census estimate of 2,500 residents with corrections for areas served by the County).

The Bermuda Run wastewater collection and treatment system was originally installed by the Bermuda Center Sanitary District and then assumed by the Town of Bermuda Run when it was incorporated in 1999. The Town system includes a wastewater collection system and a treatment plant permitted to discharge 193,000 gpd at secondary limits.

##### **2.2.1.2 Bermuda Run WWTP**

The Bermuda Run Wastewater Treatment Plant was constructed in 1984 and operates under NPDES Permit # NC0055158, **Appendix A**, requiring treatment to secondary

levels (30 mgI-BOD, 30 mgI-TSS). The facility is an extended aeration process and the physical structure is a steel package plant that was previously in service in a coastal area.

The facility was constructed in a Yadkin River Regulated FEMA Floodway prior to enforcement of current regulations. While the structure is not flood prone, if significant modifications are performed, current regulations will require the plant to be relocated.

### 2.2.1.3 Bermuda Run Wastewater Collection System

The Bermuda Run collection system consists of:

1. 4 pump stations (not including the WWTP influent pump station or LPS units);
2. 3,500 lf of forcemain;
3. 3,474 lf (0.658 mi) of 6" gravity sewer;
4. 62,838 lf (11.901 mi) of 8" gravity sewer;
5. And 4,314 lf (0.817 mi) of 18" gravity sewer.

### 2.2.1.4 Bermuda Run Wastewater Flows

The average daily discharge from the Bermuda Run WWTP in 2013 was 125,000 gpd according to monthly DMR records. The Maximum daily flow for that year was 390,000 gpd.

**Table 1 - Bermuda Run WWTP Average and Per Capita Flows for 2013**

Month	Average flow (MGD)	Per capita Flow (gpcpd)
January	0.141	96
February	0.133	91
March	0.124	84
April	0.131	89
May	0.125	85
June	0.133	91
July	0.130	88
August	0.128	87
September	0.114	78
October	0.102	69
November	0.103	70
December	0.139	95
Maximum Day	0.390	265

### 2.2.1.5 Bermuda Run Infiltration and Inflow (I&I)

Since average daily flows are less than 120 gpcpd and maximum flows daily flows are less than 275 gpcpd, the Bermuda Run system does **not have excessive I&I** in accordance with guidelines set forth in EPA publication EPA/625/6/-91/030, Sewer System Infiltration Analysis and Rehabilitation Handbook, page 7.

### 2.2.1.6 Bermuda Run Alternatives

Facing challenges resulting from an aging treatment facility located in the Yadkin River floodway and expecting nutrient limits to be levied by 2019, Bermuda Run assessed its options by requesting that CCUC perform an analysis of costs associated with pumping Bermuda Run wastewater into the CCUC system without participation in the Eastern Davie Regional project as well as its costs to participate in the Eastern Davie Project. The Highfill Engineering analysis for CCUC is shown in **Appendix B**.

### **2.2.1.7 Bermuda Run Alternatives Comparison**

In summary, Bermuda Run's options include:

- a. Join the Eastern Davie Regional project at a capital cost of approximately \$1,000,000, and then prepare its sewer system to be assumed into the Davie system, transferring operation and maintenance responsibilities to the County.
- b. Construct a pump station and forcemain to deliver wastewater to the CCUC system at a capital cost of approximately \$3,000,000. Then continue to operate and maintain the BR collection system.
- c. Construct a new wastewater treatment facility at a capital cost greatly in excess of \$3,000,000 and relocate that facility closer to residences and away from the Yadkin River floodway. Continue to operate and maintain the Town's collection and treatment system.

On February 11, 2014, the Bermuda Run Town Board voted unanimously to pursue its most economical option and join the support the Eastern Davie Project. A copy of Board's resolution is in **Appendix C**.

## **2.2.2 Davie County Sewer Systems Serving the EDSA**

### **2.2.2.1 Davie County EDSA Overview**

**Figure 2** illustrates elements of the Eastern Davie wastewater collection system.

The system was initially constructed in 1998 to convey wastewater the CCUC Tanglewood pump station under an agreement formed in 1996 allowing Davie to the discharge of 275,000 gallons per average day. The agreement was later amended to provide for the discharge of up to 550,000 gallons per day of wastewater.

The agreement was further amended on January 13, 2014 to allow for the discharge of up to 750,000 gallons per day and included provisions for payment to CCUC if Davie County does not remove its wastewater from the Tanglewood system.

In 2013, the Eastern Davie Sewer system served approximately 1270 residential households for an estimated 3,175 individuals.

### **2.2.2.2 Eastern Davie Collection System**

The Eastern Davie collection system consists of a daisy chain of pump stations that convey wastewater under the HWY 158 Bridge and into the CCUC Tanglewood pump station. The system is composed of: 8 pump stations; 12.1 miles of forcemain; 19.80 miles of 8" gravity sewer; 1.69 miles of 10" gravity sewer; and 0.63 miles of 18" gravity sewer.

### **2.2.2.3 Eastern Davie Wasteflows**

The average daily wastewater flow through the Yadkin River pump station into the CCUC system is approximately 267,000 gallons per day according to pump station flow meter records for the period from June, 2013 through January, 2014.

**Table 2 - Eastern Davie Average and Per Capita Wastewater Flows to CCUC**

Month	Average flow (MGD)	Per capita Flow (gpcpd)
June (2013)	0.266	84
July (2013)	0.257	81
August (2013)	0.255	80
September (2013)	0.256	81
October (2013)	0.248	78
November (2013)	0.257	81
December (2013)	0.295	93
January (2014)	0.299	94
<b>Maximum Daily</b>	0.696	219

**Note:** A new flow meter and SCADA system were installed in 2013 for more accurate daily records. These data are shown above.

**2.2.2.4. Eastern Davie Infiltration and Inflow (I&I)**

Since average daily flows are less than 120 gpcpd and maximum flows daily flows are less than 275 gpcpd, the Eastern Davie system does **not have excessive I&I** in accordance with guidelines set forth in EPA publication EPA/625/6/-91/030, Sewer System Infiltration Analysis and Rehabilitation Handbook, page 7.

**2.2.2.5 Unsewered Areas**

**Figure 2** illustrates development throughout the planning area and shows that many areas are unsewered. Many of the subdivisions shown have had failing septic systems requiring repairs in marginal soils.

The 2010 US Census, when examined at the block level calculates that approximately 10,706 persons lived in the EDSA at that time or 11,126 persons in 2014. Since the Town system serves approximately 1,479 persons and the County system serves approximately 3,175 persons, it is estimated that public sewer serves about 42% of the Eastern Davie Area.

**2.2.2.6 Cost of Collection System Operations**

According to audited financial statements, annual operating costs for the Eastern Davie collection System (not including treatment fees) based on flow were:

<b>2010</b>	\$1.11/kgal;
<b>2011</b>	\$1.14/kgal;
<b>2012</b>	\$1.29/kgal;
<b>2013</b>	\$1.28/kgal

**2.2.3 Winston/Forsyth City County Utility Commission (CCUC) Systems**

**2.2.3.1 Overview**

In 1996, the CCUC agreed to receive Davie County wastewater into its Tanglewood pump station in amounts not to exceed 275,000 gallons on the average day. Later that amount was increased to 550,000 gallons per day and then, in 2014 the agreement was further amended to allow Davie County to discharge up to 750,000 gallons per day with a provision that Davie would pay a portion of the cost of Tanglewood upgrade design and construction if Davie County's flow remains in the station after 2018.

### **2.2.3.2 Tanglewood Pump Station Limitations**

The CCUC Tanglewood pump station is nearing its capacity based upon flow commitments and I&I according to CCUC representatives. The pump station was the subject of a Technical Memorandum issued by Highfill Engineering, P.C. revised on 2/3/11, see **Appendix D**. Another analysis was later performed in response to a Bermuda Run request to the CCUC that was previously referenced and is included in **Appendix B**. These reports indicate that wastewater from Davie County should be conveyed to CCUC's Muddy Creek Interceptor.

### **2.2.3.3 CCUC Muddy Creek Interceptor**

**Figure 3** on the next page shows the CCUC Muddy Creek Interceptor and illustrates a feasible route from Idols Dam to the interceptor. Each option requires approximately 5 miles of at least 18" (for 1 MGD average daily flow) or 24" (for 2 MGD average daily flow) pipeline and a rock bore under the Yadkin River.

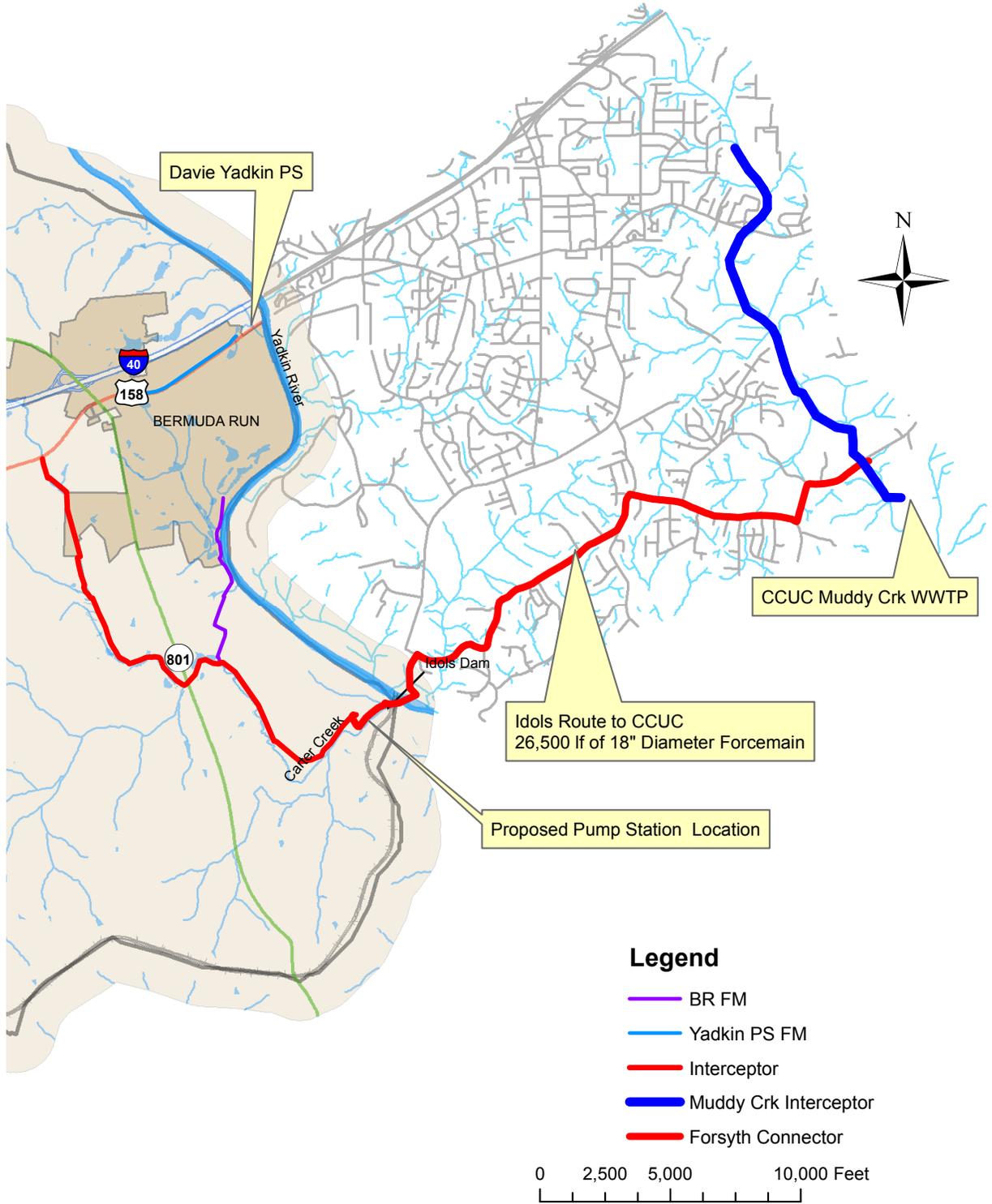
### **2.2.3.4 Current CCUC Pricing and Financial Arrangements**

Under its agreement with CCUC, Davie pays twice the inside county rate for wastewater treatment services. For the service period from 3/15/2013 through 4/17/2013, CCUC received 1,289,670 cubic feet of wastewater from Davie and charged a total of \$75,412.84 for the month.

Unit prices for that time were:

Consumption Charge	\$5.06/hundred cubic feet;
BOD surcharge	\$422/thousand pounds;
TSS Surcharge	\$322/thousand pounds.

CCUC fees have increased steadily at rates between 8% and 10% per year. Davie representatives were advised in a meeting with the CCUC Utilities Director that future increases would likely be 7% per year through 2019. 5% per year from 2020 through 2025, and 3% per year after 2025. CCUC is expecting substantial capital expenses resulting from anticipated nutrient limits for dischargers in the Yadkin River above High Rock Lake.



Eastern Davie Sewer ER/EID  
 Grey Engineering, Inc  
 C. Jones

**Figure 3: Connection to CCUC  
 Muddy Crk Interceptor**

## 2.2.4 Current EDSA Population

The 2010 US Census block diagram for the planning area. Population for each block from Census Bureau records was summed to obtain a 2010 planning area population of 10,706 persons. Since the area is largely contained within the Winston Salem Metropolitan Statistical Area and contains a disproportionate concentration of the Davie County population (7.6% of County area and 26% of County population), annual growth estimates provided by the NC office of Budget and Management for Forsyth County were utilized to project growth in the planning area.

The 2013 population of the planning area is estimated to be approximately 11,013 persons with 4,644 of those benefiting from public sewer service.

## 2.2.5 Current Wasteflows and Commitments

### 2.2.5.1 Actual Flows

For the eight months from June first, 2013 through January 2014, daily Yadkin River pump station flow records indicate that the average flow through the pump station was 267,000-gpd and the peak flow during that time was 696,000-gpd. The County has committed approximately 130,000 gpd of flow to various concerns and retains approximately 100,000-gpd of unallocated flow from its previous 550,000-gpd agreement with CCUC.

Of special concern are future flows from the newly constructed Ashley Furniture complex and the new Wake Forest Baptist Medical Center. The Ashley Furniture has requested water and sewer capacities to serve up to 3,000 employees and the hospital has requested wastewater capacities to serve a 25-bed addition and medical and commercial outparcels.

The Town's Treatment facility is currently permitted at 193,000-gpd and averages approximately 125,000-gpd. While the entire Town is sewered, some residences have not yet joined the system and remain connected to on-site septic service. Flows at the treatment facility will increase as these residences join the system.

### 2.2.5.2 Permitted Flows and Flow Commitments

The Town has performed detailed community master planning and will require access to substantial additional treatment capacity in order to meet its goals.

Current flow requirements are reasonably taken as the combination of the existing permit levels and the expected growth of Ashley Furniture and the Wake Forest/Baptist Medical (WFBM) complex as follows:

Current BR NPDES permitted flow	193,000 gpd
Current Davie/CCUC contractual flow	550,000 gpd
Future Ashley Furniture Flow (1)	60,000 gpd
WFBM flows (2)	<u>150,000 gpd</u>
<b>Total</b>	<b>953,000 gpd</b>

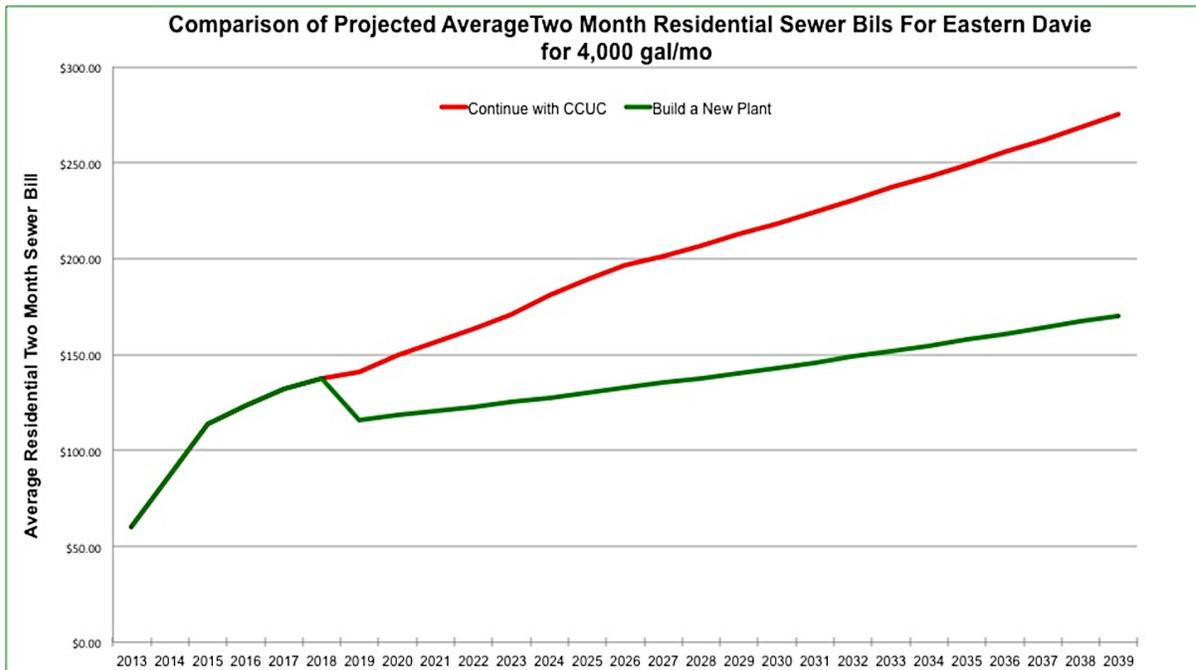
Notes:

- (1) Ashley Furniture has projected growth to 3,000 jobs
- (2) WFBM includes planned medical offices, 25-bed emergency access hospital, and commercial outparcels.

### 2.2.6 Current EDS Financial Considerations

The County's sewer fees for the area have not kept pace with increasing charges from CCUC. The Eastern Davie Sewer area lost \$225,000 in 2010, \$311,000 in 2011 and \$410,000 in 2012 according to certified audits. Davie County has been forced to raise sewer rates to cover its expenses in the Eastern Davie Sewer Area.

The following graph represents the cost of continuing to discharge to CCUC if sufficient sewer use fees are charged to cover collection system and treatment costs based upon rate increases suggested by CCUC.

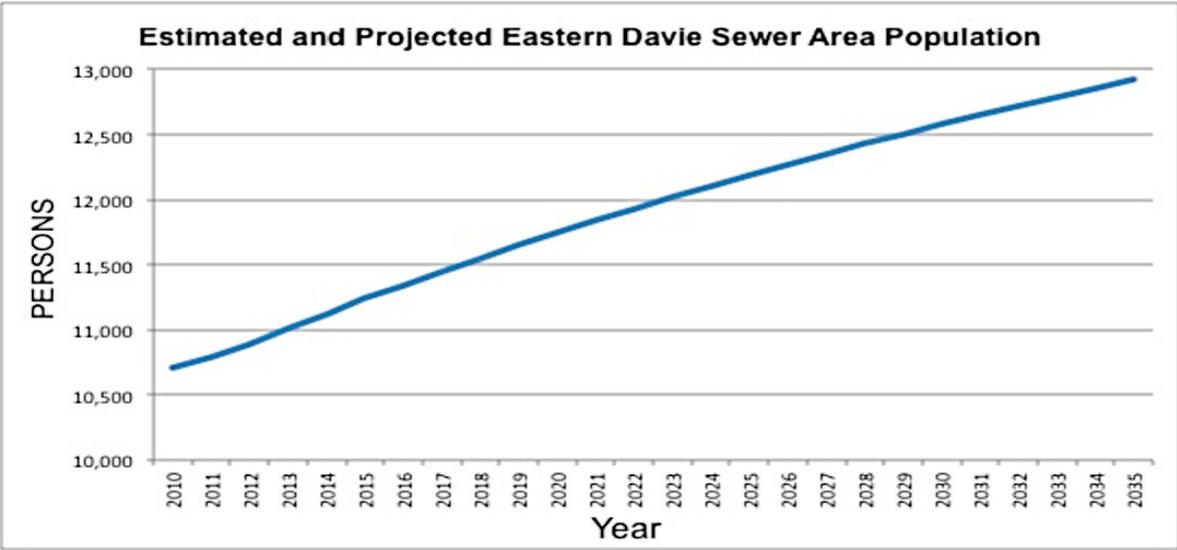


It can be seen from the graph above that some economical alternative to purchasing treatment capacity from CCUC is needed.

### 3.0 Future Situations

#### 3.1 Population Projections

Utilizing US Census data from 2010 and GIS mapping, the Eastern Davie population was estimated to be approximately 10,706 persons at that time. It is noted that the Eastern Davie area occupies only 7.6% of Davie County but contains approximately 26% of its population. Eastern Davie is largely contained within or adjacent to the Winston Salem SMSA. Growth patterns in the area are driven by growth patterns in Forsyth County, where the majority of Eastern Davie residents work. The figure shown below is a graph of those results. The data table is shown on the following page.



**Table 3 - Estimated and Projected Eastern Davie Population**

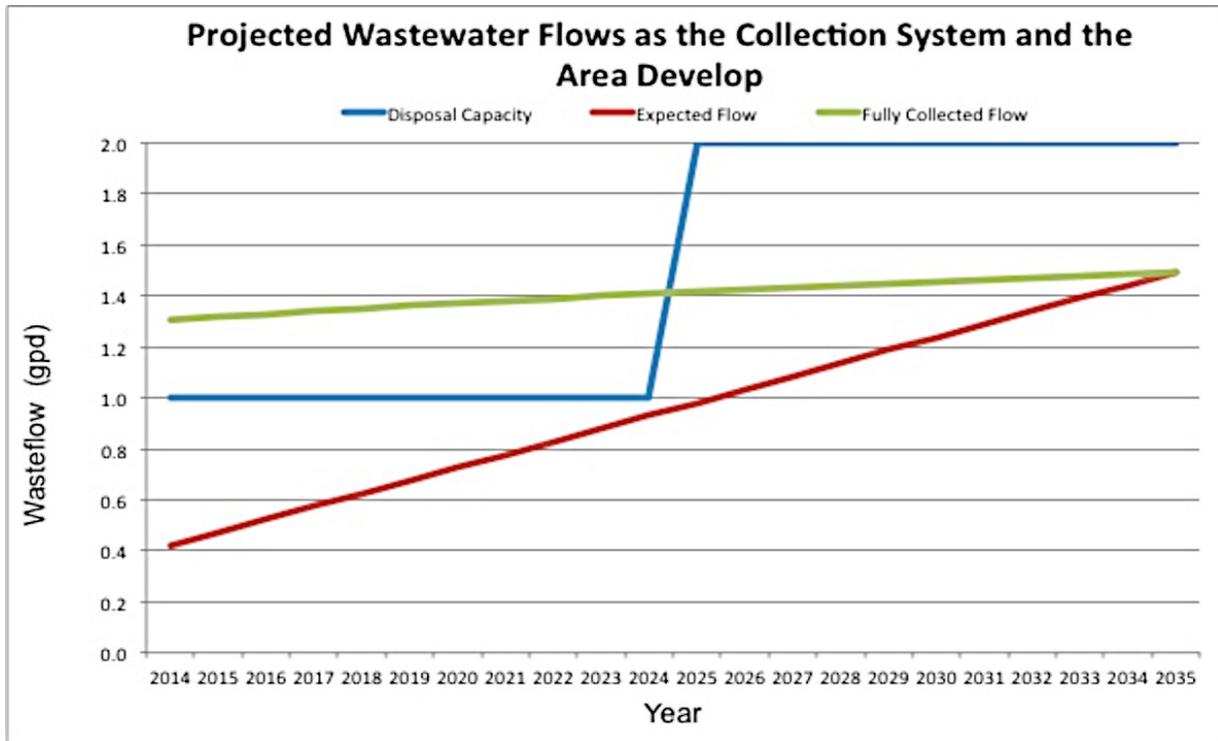
Year	Estimated Area Population	Forsyth Growth Rate	Year	Estimated Area Population	Forsyth Growth Rate
2010	10,706		2023	12,019	0.744%
2011	10,785	0.741%	2024	12,105	0.717%
2012	10,892	0.988%	2025	12,189	0.695%
2013	11,013	1.114%	2026	12,271	0.670%
2014	11,126	1.029%	2027	12,350	0.649%
2015	11,237	0.991%	2028	12,428	0.627%
2016	11,344	0.955%	2029	12,503	0.606%
2017	11,448	0.921%	2030	12,576	0.586%
2018	11,550	0.887%	2031	12,648	0.568%
2019	11,649	0.856%	2032	12,717	0.549%
2020	11,745	0.826%	2033	12,785	0.531%
2021	11,839	0.797%	2034	12,853	0.531%
2022	11,930	0.770%	2035	12,921	0.531%

Sources: US Census Bureau Website  
 NC Office of State Budget and Man. Website  
 NC One Portal Website

### 3.2 Wasteflow Projections

Utilizing the population projections shown above and the assumptions shown in the table below, the theoretical wasteflow projection was developed for the Eastern Davie area can be found on the next page. This projection below considers the required capacity to serve the projected population with a very modest industrial reserve.

Year	Population (Persons)	Residential (gpd)	Commercial (gpd)	Industrial (gpd)	Institutional (gpd)	Subtotal (gpd)	I&I (gpd)	Total (gpd)
2010	10,706	749,420	160,590	120,000	67,448	1,097,458	164,619	1,262,076
2011	10,785	754,976	161,781	120,000	67,948	1,104,704	165,706	1,270,410
2012	10,892	762,434	163,379	120,000	68,619	1,114,432	167,165	1,281,597
2013	11,013	770,925	165,198	120,000	69,383	1,125,506	168,826	1,294,332
2014	11,126	778,855	166,897	120,000	70,097	1,135,849	170,377	1,306,226
2015	11,237	786,571	168,551	120,000	70,791	1,145,913	171,887	1,317,800
2016	11,344	794,083	170,161	120,000	71,467	1,155,711	173,357	1,329,067
2017	11,448	801,394	171,727	120,000	72,125	1,165,247	174,787	1,340,034
2018	11,550	808,500	173,250	120,000	72,765	1,174,515	176,177	1,350,693
2019	11,649	815,421	174,733	120,000	73,388	1,183,542	177,531	1,361,073
2020	11,745	822,159	176,177	120,000	73,994	1,192,330	178,849	1,371,179
2021	11,839	828,715	177,582	120,000	74,584	1,200,881	180,132	1,381,013
2022	11,930	835,096	178,949	120,000	75,159	1,209,204	181,381	1,390,584
2023	12,019	841,307	180,280	120,000	75,718	1,217,304	182,596	1,399,900
2024	12,105	847,343	181,573	120,000	76,261	1,225,177	183,777	1,408,953
2025	12,189	853,229	182,835	120,000	76,791	1,232,854	184,928	1,417,783
2026	12,271	858,945	184,060	120,000	77,305	1,240,310	186,046	1,426,356
2027	12,350	864,516	185,253	120,000	77,806	1,247,576	187,136	1,434,712
2028	12,428	869,935	186,415	120,000	78,294	1,254,644	188,197	1,442,841
2029	12,503	875,207	187,544	120,000	78,769	1,261,520	189,228	1,450,749
2030	12,576	880,335	188,643	120,000	79,230	1,268,208	190,231	1,458,439
2031	12,648	885,332	189,714	120,000	79,680	1,274,725	191,209	1,465,934
2032	12,717	890,192	190,755	120,000	80,117	1,281,065	192,160	1,473,225
2033	12,785	894,923	191,769	120,000	80,543	1,287,235	193,085	1,480,320
2034	12,853	899,678	192,788	120,000	80,971	1,293,438	194,016	1,487,453
2035	12,921	904,459	193,813	120,000	81,401	1,299,673	194,951	1,494,625
Notes:		Per capita Residential wasteflow			70 gpcpd			
		Per Capita Commercial wasteflow			15 gpcpd			
		Industrial Wastewater Reservation			120,000 gpd			
		Institutional Flow Allowance			9%			
		I&I Flow Wasteflow Allownce			15%			



**Table 5 - Expected Wastewater Flows Over Time**

Year	Theoretical Flow (MGD)	Expected as Percent of Theoretical	Expected Flow (MGD)	Design Capacity (MGD)	Expected as Percent of Design
2014	1.306	32%	0.420	1.0	42%
2015	1.318	36%	0.471	1.0	47%
2016	1.329	39%	0.522	1.0	52%
2017	1.340	43%	0.573	1.0	57%
2018	1.351	46%	0.624	1.0	62%
2019	1.361	50%	0.675	1.0	68%
2020	1.371	53%	0.726	1.0	73%
2021	1.381	56%	0.777	1.0	78%
2022	1.391	60%	0.828	1.0	83%
2023	1.400	63%	0.879	1.0	88%
2024	1.409	66%	0.930	1.0	93%
2025	1.418	69%	0.982	2.0	49%
2026	1.426	72%	1.033	2.0	52%
2027	1.435	76%	1.084	2.0	54%
2028	1.443	79%	1.135	2.0	57%
2029	1.451	82%	1.187	2.0	59%
2030	1.458	85%	1.238	2.0	62%
2031	1.466	88%	1.289	2.0	64%
2032	1.473	91%	1.341	2.0	67%
2033	1.480	94%	1.392	2.0	70%
2034	1.487	97%	1.443	2.0	72%
2035	1.495	100%	1.495	2.0	75%

#### **4.0 Purpose and Need**

The Eastern Davie Sewer Area faces several compelling challenges:

1. The current wastewater treatment arrangement with CCUC is very costly and capacity is limited. Most of the current 550,000-gpd allocation is committed and will not support expected expansions and growth from existing manufacturing (Ashley Furniture), healthcare (Wake Forest/Baptist Hospital development) and planned growth by the Town of Bermuda Run.
2. The septic systems of 58% of the area's population are housed in marginal soils. Areas such as Creekwood and Davie Gardens subdivisions will require public sewer in the near future as on-site repair areas are depleted and housing values fall.
3. The Bermuda Run wastewater treatment plant is an aging package plant located in a regulated floodway and discharging into an impaired section of the Yadkin River 1.9 miles upstream of a major potable water intake for the City of Winston Salem at Idols Dam. Further, compliance with nutrient limits expected for all dischargers to the Yadkin River above High Rock Lake will be very costly, requiring a complete relocation and reconstruction of the facility.

#### **5.0 Alternatives Analysis**

**5.1 Alternatives Descriptions:** The investigated / discussed alternatives include:

1. No action
2. Optimum operation of existing facilities
3. Connection to an existing wastewater treatment system
4. Land Application
5. Wastewater Reuse
6. Treatment and Discharge to the Yadkin River
7. Combinations of Alternatives shown above

##### **5.1.1 No Action Alternative:**

Taking no action on this serious environmental issue will likely have the following consequences:

1. Industrial (Ashley Furniture), Institutional (Wake Forest Baptist Medical Center), Commercial and municipal (BR) growth in the area will be stalled.
2. The Bermuda Run wastewater treatment plant will need to be replaced (either by a new treatment facility or a pumping station to an adjoining system) at a much higher cost without the probability of surrendering collection system operations to Davie County.
3. Continued failure of on-site septic systems will result in increasing rates of environmental degradation.
4. Eastern Davie sewer fees will continue to rise at alarming rates.

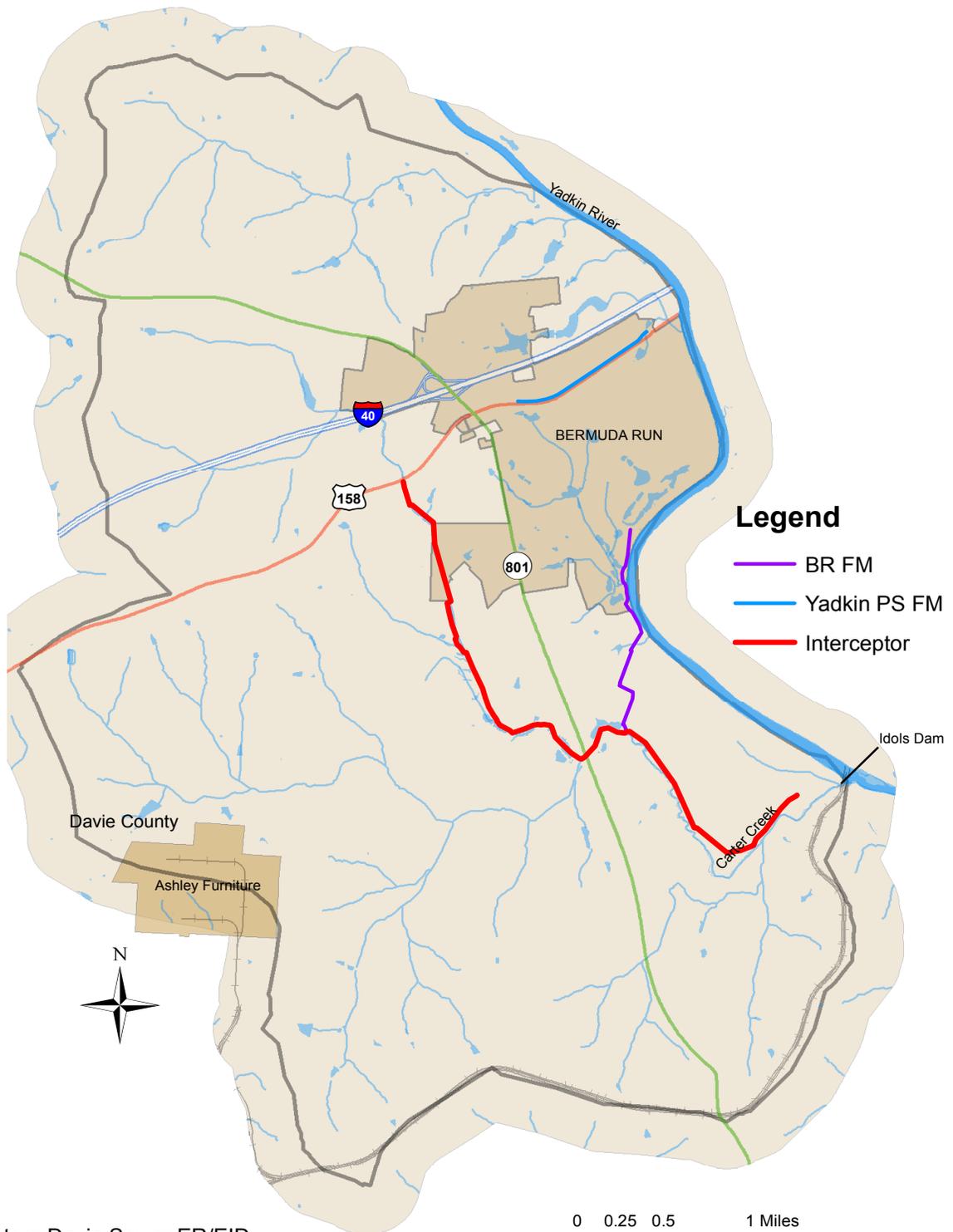
This is not a viable alternative.

##### **5.1.2 Optimum Operation of Existing Facilities:**

The only treatment facility in the area is the Bermuda Run wastewater treatment facility and it is not designed to meet the expected nutrient limits.

##### **5.1.3 Connection to an Existing Wastewater Treatment System Alternative:**

In order to sewer the Eastern Davie Area, a new interceptor must be constructed along Smith and Carter's Creek as shown in **Figure 4** on the next page. A preliminary plan and profile of the required interceptor is shown in **Appendix E**. Construction of this interceptor with modifications to the Yadkin River Pump station along with construction of the Bermuda Run pump station and demolition of its wastewater treatment plant are common elements of all the remaining alternatives.



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**Figure 4: Proposed Interceptor System**

Collectively, these constructions are referred to as the Collection System. The cost of the system is estimated below. The estimated construction cost for the Collection System required to bring area wastewater to a point where either a pumping station or a treatment facility would be built is approximately **\$6,750,000**.

<b>Table 6 - Collection System Construction Cost Estimate</b>							
<b>Gravity Interceptor Piping</b>					<b>Gravity Interceptor Manholes</b>		
<b>Pipe</b>		<b>Units</b>	<b>Unit</b>	<b>Extension</b>	<b>Units</b>	<b>Unit</b>	
<b>Dia.</b>	<b>Depth</b>	<b>If</b>	<b>Cost (\$)</b>	<b>\$</b>	<b>ea</b>	<b>Cost</b>	
						<b>Extension</b>	
						<b>\$</b>	
18"	6-8	3,573	89	317,997	12	1,960	23,520
	8-10	5,022	93	467,046	18	2,450	44,100
24	10-12	4,865	98	476,770	19	2,940	55,860
	12-14	3,024	133	402,192	11	3,430	37,730
	14-16	2,898	148	428,904	9	3,920	35,280
	10-12	1,798	157	282,286	7	3,540	24,780
	18-20	382	267	101,994	1	5,900	5,900
	28-30	206	517	106,502	1	8,850	8,850
	<b>Sub Total</b>	21,768		<b>\$2,584,000</b>	78		<b>\$236,000</b>
	Gravity Interceptor					\$2,820,000	
	Yadkin River PS & 5,000 lf, 8" FM					\$625,000	
	BR PS & WWTP decommissioning					\$700,000	
	BR FM (7,000 lf,8")					\$245,000	
	Easements					\$100,000	
	Rock					\$200,000	
	Road Bores					\$300,000	
	Erosion Control					\$200,000	
	Sub Total					\$5,190,000	
	Professional and Contingency (30%)					\$1,560,000	
	Total					<b>\$6,750,000</b>	

In addition to the Collection System that will transfer the wastewater to a point below Idols Dam, a pumping station and 23,000 lf of forcemain must be constructed to convey wastewater to the CCUC's Muddy Creek Interceptor. Construction costs for Phase 1 (1 MGD) of that alternative (using a peaking factor of 3.5) include a pump station; rock bore under the Yadkin River, and 26,000 lf of 18" diameter forcemain with various valves and appurtenances.

That cost is estimated in the table below to be approximately **\$8,100,000**.

**Table 7 - Phase 1 Construction Cost to Pump To CCUC**

Item	Quantity	Units	Unit Cost (\$)	Extension
Forcemain (18" dia)	26,000	lf	130	3,380,000
Road Bores	1	ls	300,000	300,000
River Crossing Rock Bore	1,100	lf	950	1,045,000
Additional FM Rock	1		200,000	200,000
Pump Station:				
Wet well	1	ls	200,000	200,000
Pumps and Screening	1	ls	400,000	400,000
Electrical and Controls	1	ls	250,000	250,000
Site Work	1	ls	175,000	175,000
Easements	1	ls	100,000	100,000
Erosion Control	1	ls	150,000	150,000
			<b>Sub Total</b>	<b>\$6,200,000</b>
Professional and Contingency (30%)				1,900,000
<b>Total</b>				<b>\$8,100,000</b>

It is estimated that Phase 2 of the system would be constructed 10 years after the initial construction and entail duplication of the Phase 1 forcemain, river crossing, pumping systems and electrical upgrades for an estimated cost similar to the initial construction.

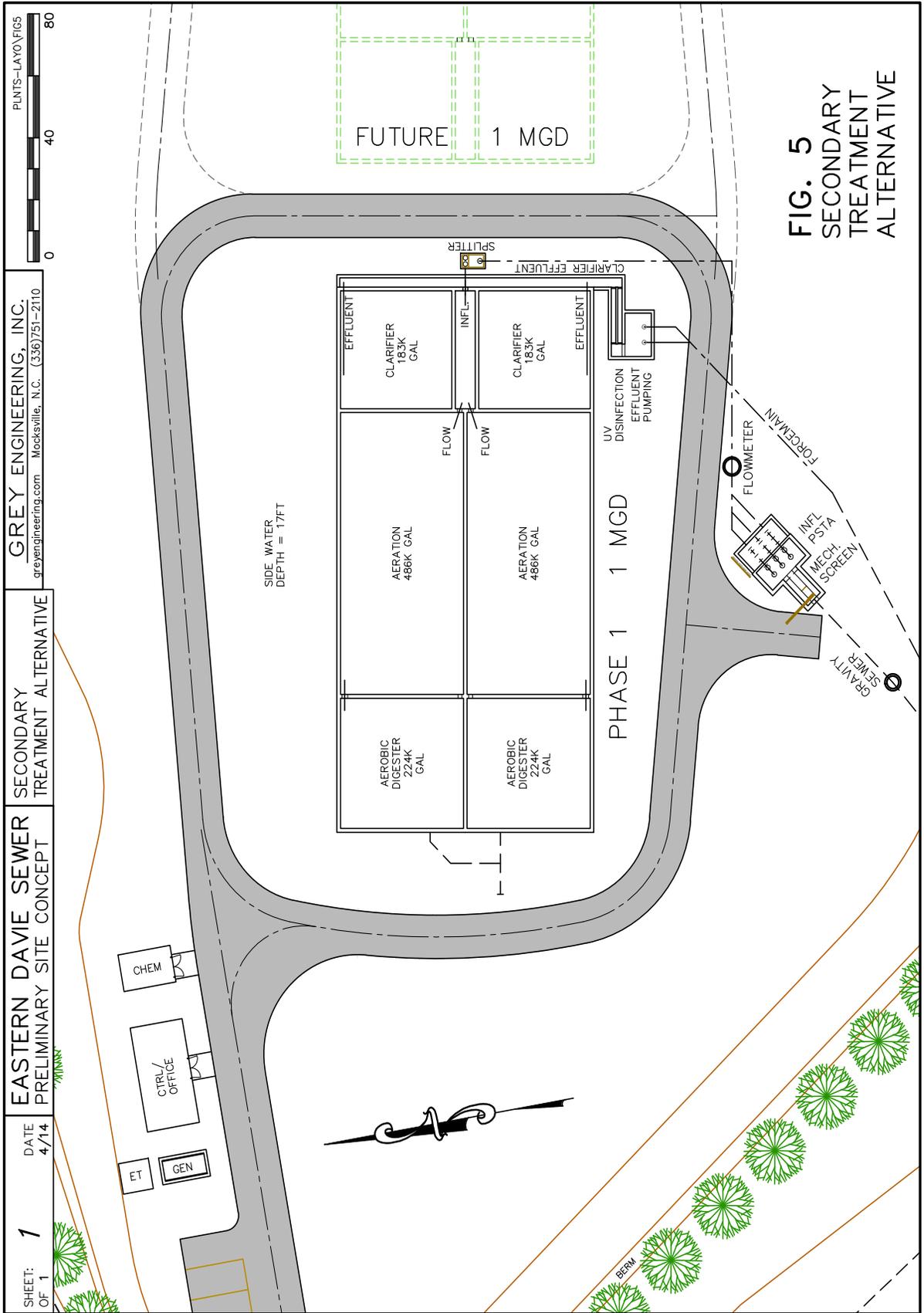
The Combined capital cost of a Phase 1 (1 MGD) pumping system to CCUC from property near Idols Dam is approximately \$14,850,000.

**5.1.4 Land Application**

Requirements for this alternative include the collection system, treatment to secondary standards (<30 BOD and <30 TSS), disinfection, conveyance to the lagoon, and 30 days of storage prior to spray Irrigation on suitable soils.

Collection System: This is the gravity interceptor described and estimated above at a capital cost of approximately **\$6,750,000**.

Secondary Treatment: A preliminary layout for an extended aeration secondary treatment facility is shown in **Figure 5** on the next page.



**FIG. 5**  
**SECONDARY**  
**TREATMENT**  
**ALTERNATIVE**

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**SECONDARY**  
**TREATMENT ALTERNATIVE**

**EASTERN DAVIE SEWER**  
**PRELIMINARY SITE CONCEPT**

**1**  
 SHEET:  
 OF 1

DATE  
 4/14

The initial Phase 1 construction cost is estimated to be approximately **\$7,800,000** and is detailed in the table below.

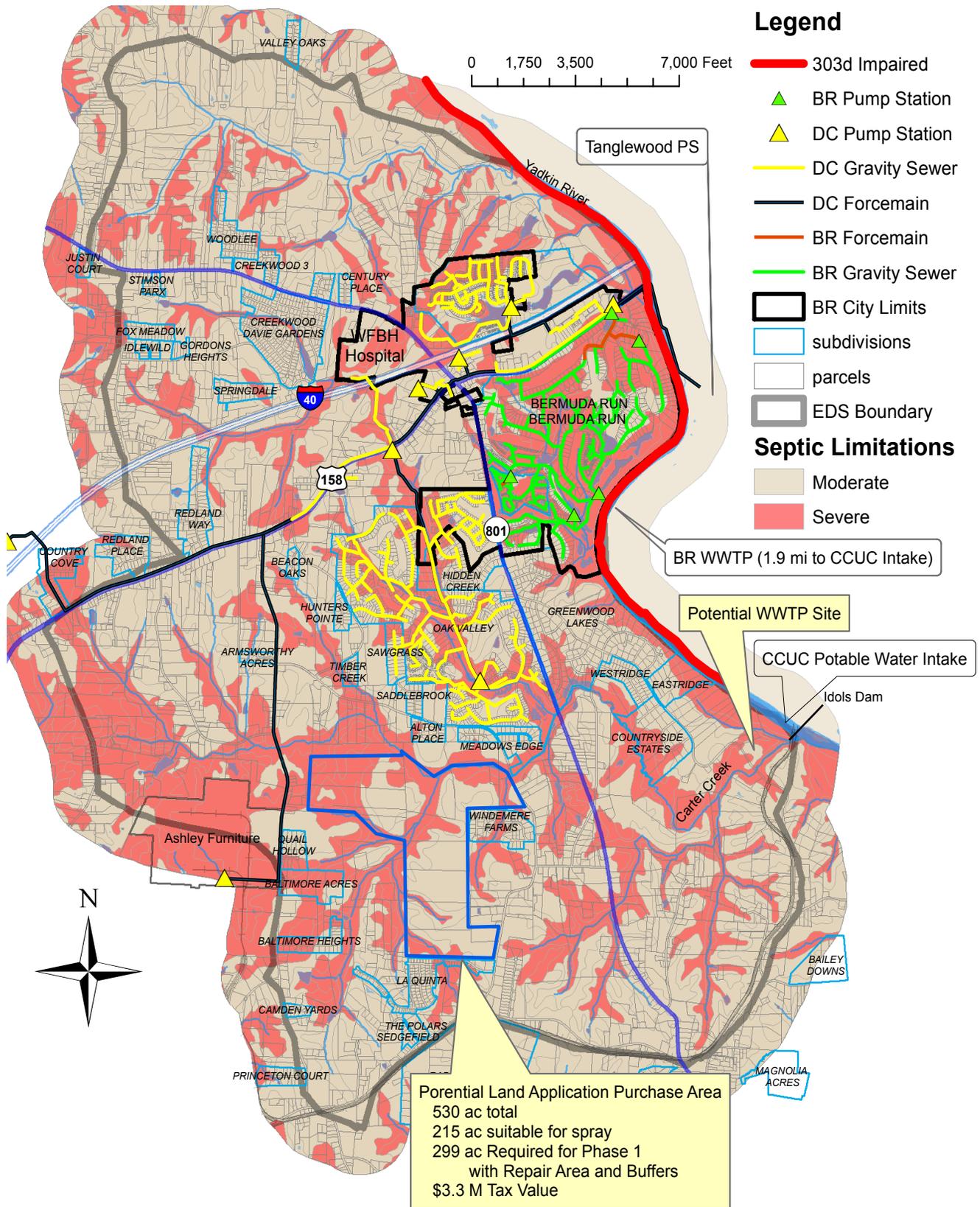
	<b>Phase 1</b>	<b>Phase 2</b>
Electrical	\$600,000	\$200,000
Wet Well	\$600,000	\$0
Infl Pumps, Controls and Screening	\$500,000	\$200,000
Biological Treatment, Settling and Aerobic Digestion	\$1,500,000	\$1,500,000
Effluent UV	\$300,000	\$200,000
Effluent Pumping	\$250,000	\$250,000
Effluent Piping	\$1,400,000	\$700,000
Phase 1- 14,000 lf, 18"		
Site Work, Office, Misc. Chem	\$450,000	\$50,000
Erosion Control	\$150,000	\$50,000
Land Acquisition	\$250,000	\$0
<b>Sub Total</b>	<b>\$6,000,000</b>	<b>\$3,150,000</b>
Professional and Contingency (30%)	\$1,800,000	\$950,000
<b>Phase Total</b>	<b>\$7,800,000</b>	<b>\$4,100,000</b>

This estimate includes approximately 14,000 lf of 18" effluent forcemain. Without the effluent forcemain, but including design and contingencies, the unit cost of this Phase 1 treatment is approximately \$6.00 per gallon day.

Phase 2 secondary treatment costs are estimated to be approximately **\$4,100,000** to occur 10 years from the initial construction as described above.

Lagoon and Land Application:

A 30 million gallon lagoon, 2,000 feet long, 1,000 feet wide, 15 feet deep with 3:1 side slopes covering approximately 60 acres will be required for each phase. Better area soils will support a long-term acceptance rate (LTAR) of approximately 0.2 gpsfpd. Poorer, flooded, and/or steep (15%) soils are not candidates for spray irrigation. While the ratings for septic disposal are not absolute for spray irrigation (some amount of irrigation may take place on loamy soils with severe septic limitations), poorer soils for septic disposal are usually poorer soils for spray irrigation. **Figure 6**, on the next page, presents a detailed topographic and soils view of the potential Phase 1 field area.



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**Figure 6: Potential land Application Overview**

With an average application rate of 0.2 gpsfpd, approximately 115 ac of active field is required. Additionally, an equal repair area must be set aside along with allowances for buffers and maintenance. With a 30% allowance for buffers maintenance areas, Phase 1 Land Application site should include approximately 299 acres on relatively good soils. This assumes that the 60-acre lagoon may be constructed on soils less suited for irrigation.

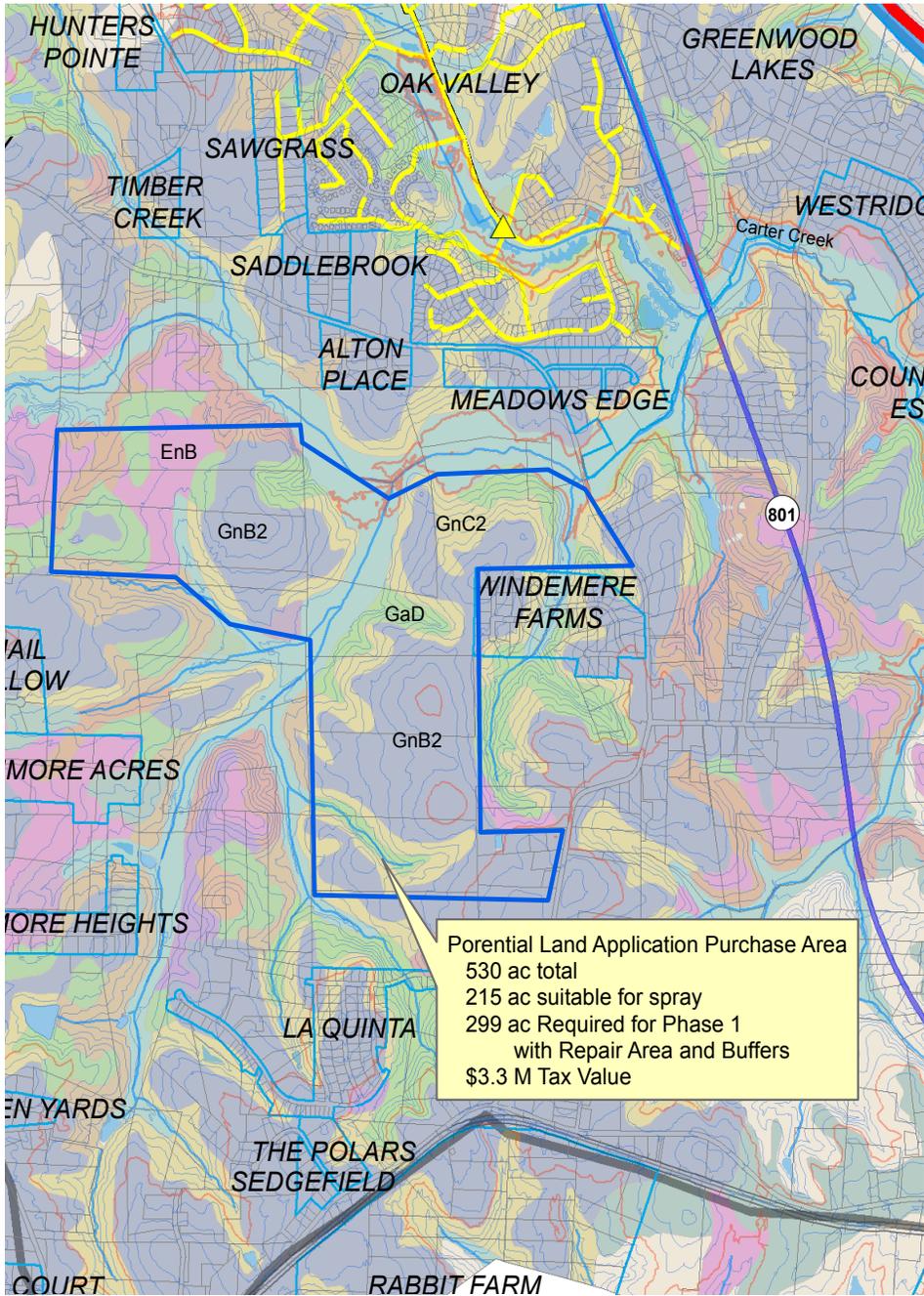
**Figure 7**, on the next page, delineates the only candidate site for a large land application project in the planning area. Note that out of 530 acres, only about 215 acres of GnB2 are certainly suitable (other areas possibly may be used at lower application rates). Utilizing the Davie County GIS database, the estimated real market value of the included properties is approximately \$3.3 M dollars or about \$5,660/acre. Even if this land application site is used for Phase 1, there is no reasonable candidate site for Phase 2 in the area.

For the purpose of economic analysis, it is assumed that a suitable Phase 2 site would be available under the same conditions as the Phase 1 site.

Process	Equip.	Install.	Conc.	Earthwork	Pipe & Valves	Controls	Totals
Secondary Treatment							6,000,000
Effluent Lagoon	200,000	200,000	75,000	772,430	200,000	75,000	1,522,430
Spray System	280,000	200,000				50,000	530,000
Misc Sitework	100,000	150,000		250,000		40,000	540,000
<b>Sub Total</b>							<b>\$8,592,430</b>
Land Acquisition @7.000/acre Phase 1 -500 acres							3,300,000
<b>Sub-Total</b>							<b>\$11,892,430</b>
Design and Legal @30%							3,567,729
<b>Total</b>							<b>\$15,460,159</b>
Notes:							
1) Extended aeration secondary treatment.							
2) 30 MG Storage Pond (55 ac surface area, 1,000'X2,000' 15' deep)							
3) Graymac center swivel spray systems on 115 active acres							
4) Access roads security fencing, field prep, etc.							

The overall Phase 1 land application construction cost is shown in **Table 9** above as **\$15,460,159**.

The Phase 2 wastewater treatment upgrade cost is shown in **Table 8** as **\$4,100,000**. For the purposes of this analysis, the application site development cost is taken as equal to the first phase costs for a total Phase 2 cost with contingencies and professional services of **\$11,755,159**.

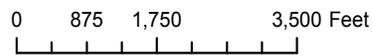


**Legend**

parcels

**Soils**

- ChA
- EnB
- EnC
- GaD
- GnB2
- GnC2
- IrB
- MaB
- MrB2
- MrC2
- MsB
- MsC
- MsD
- PcB2
- PcC2
- RwA
- SeB
- Ud
- Ur



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USGS Contours at 10 feet

**Figure 7: Potential Land Application Property**

**5.1.5 Wastewater Reuse**

There are a variety of golf courses in the area including, Bermuda Run Country Club, Bermuda Run West and Oak Valley. Unfortunately, with respect to reuse, these areas irrigate either from the Yadkin River or various creeks and streams. Additionally they are located at least 2.6 miles from the proposed treatment site.

There are no large-scale industrial water users in the County at this time. Wastewater reuse does not seem to be a feasible alternative at this time.

**5.1.6 Direct Discharge to the Yadkin River Below Idols Dam**

Direct discharge requires the following elements:

Collection System Construction: at a price of approximately **\$6,750,000** as described in Table 6 above.

Treatment and Discharge: these systems include influent pumping and screening, biological treatment, clarification, membrane filtration, UV disinfection, post aeration, effluent pumping and diffusion and aerobic digestion with ancillary facilities such as a control building and emergency power generation. These systems and associated cost estimates are shown in the table below.

<b>Item</b>	<b>Phase 1</b>	<b>Phase 2</b>
Electrical	\$600,000	\$200,000
Wet Well	\$600,000	\$0
Infl Pumps, Controls and Screening	\$500,000	\$200,000
Biological Treatment and Aerobic Digestion	\$2,600,000	\$2,400,000
Effluent Filters	\$350,000	\$200,000
Effluent UV	\$300,000	\$200,000
Effluent Pumping	\$250,000	\$100,000
Effluent Piping	\$950,000	\$0
Site Work, Office, Misc. Chem	\$450,000	\$50,000
Erosion Control	\$150,000	\$50,000
Land Acquisition	\$250,000	\$0
<b>Sub Total</b>	<b>\$7,000,000</b>	<b>\$3,400,000</b>
Professional and Contingency (30%)	\$2,100,000	\$1,020,000
<b>Phase Total</b>	<b>\$9,100,000</b>	<b>\$4,420,000</b>

Phase 1 Tertiary treatment construction is estimated to cost approximately **\$9,100,000**. Phase 2 of that work is estimated to cost approximately **\$4,420,000**

**5.1.7 Combinations of Alternatives**

Remembering the goal of eliminating the Bermuda Run discharge above the Winston Salem water intake while minimizing disposal costs and providing for reasonable growth in an area

dominated by poor soils, it is difficult to envision a collection of combinations that would be reasonable. Every option conveying only a portion of the wastewater to an adjoining system will involve making a capital investment, buying treatment services at historic and published rates and reducing the cash flow to a more economical alternative.

The wide disparity of present worth of costs between each alternative does not suggest that mingling the less expensive alternative with a dramatically more expensive one will be economical in this case.

Combining alternatives is not a viable option for this project.

## 5.2 Present Worth Analysis

### 5.2.1 Analysis Description and Assumptions

A 20-year present worth analysis of each alternative was performed utilizing the current federal discount rate of 4.75%. Flows for each system were taken to be in accordance with **Table 5** and the second phase for each treatment / disposal alternative was scheduled to be constructed 10 years after construction of the first phase.

The operation and maintenance costs were estimated in the basis of flow in \$/kgal and can be found in the table below.

Index	Year	Flow MGD	CCUC	Collect.	Tertiary	Second.	Land	Treat/	Treat/	Pump to
			Fees \$/kgal	System \$/kgal	WWTP \$/kgal	WWTP \$/kgal	App \$/kgal	Disch. \$/kgal	Land \$/kgal	CCUC \$/kgal
0	2015	0.471	8.52	1.59	2.65	2.23	0.27	4.24	4.08	10.11
1	2016	0.522	9.11	1.64	2.73	2.29	0.27	4.37	4.21	10.75
2	2017	0.573	9.75	1.69	2.81	2.36	0.28	4.50	4.33	11.44
3	2018	0.624	10.43	1.74	2.90	2.43	0.29	4.64	4.46	12.17
4	2019	0.675	11.17	1.79	2.99	2.51	0.30	4.78	4.60	12.96
5	2020	0.726	11.72	1.84	3.07	2.58	0.31	4.92	4.74	13.57
6	2021	0.777	12.31	1.90	3.17	2.66	0.32	5.07	4.88	14.21
7	2022	0.828	12.93	1.96	3.26	2.74	0.33	5.22	5.02	14.88
8	2023	0.879	13.57	2.02	3.36	2.82	0.34	5.38	5.17	15.59
9	2024	0.930	14.25	2.08	3.46	2.91	0.35	5.54	5.33	16.33
10	2025	0.982	14.96	2.14	3.56	2.99	0.36	5.70	5.49	17.10
11	2026	1.033	15.41	2.20	3.67	3.08	0.37	5.87	5.65	17.61
12	2027	1.084	15.87	2.27	3.78	3.18	0.38	6.05	5.82	18.14
13	2028	1.135	16.35	2.34	3.89	3.27	0.39	6.23	6.00	18.69
14	2029	1.187	16.84	2.41	4.01	3.37	0.40	6.42	6.18	19.25
15	2030	1.238	17.35	2.48	4.13	3.47	0.41	6.61	6.36	19.83
16	2031	1.289	17.87	2.55	4.26	3.58	0.43	6.81	6.55	20.42
17	2032	1.341	18.40	2.63	4.38	3.68	0.44	7.01	6.75	21.03
18	2033	1.392	18.95	2.71	4.52	3.79	0.45	7.22	6.95	21.66
19	2034	1.443	19.52	2.79	4.65	3.91	0.47	7.44	7.16	22.31
20	2035	1.495	20.11	2.87	4.79	4.02	0.48	7.66	7.38	22.98

**Notes:**

- 1) CCUC expected ann. fee increases per CCUC administration:  
2014-2019 7% 2020-2025 5% 2025-2035 3%
- 2) Davie ann. cost increases: 3%
- 3) Davie collection and treatment fees based upon historic audits.

The unit operations and maintenance cost for secondary treatment were estimated using the audited cost of operating Davie County's 1.5 MGD Cooleemee facility. The initial operating

cost for the Tertiary treatment facility was taken to be 25% more than the unit cost for a secondary facility. Details for viable alternatives are captured in the table below.

Index	Year	Flow	Tertiary	Tertiary	Land App	Land App	To CCUC	To CCUC
			O&M	PW	O&M	PW	O&M	PW
			\$	\$	\$	\$	\$	\$
0	2015	0.471	729,578	729,578	702,219	702,219	1,738,052	1,738,052
1	2016	0.522	832,870	795,103	801,637	765,286	2,049,046	1,956,130
2	2017	0.573	941,703	858,234	906,389	826,051	2,393,059	2,180,948
3	2018	0.624	1,056,317	919,035	1,016,705	884,571	2,773,177	2,412,768
4	2019	0.675	1,176,960	977,564	1,132,824	940,906	3,192,760	2,651,857
5	2020	0.726	1,303,890	1,033,882	1,254,994	995,111	3,596,274	2,851,561
6	2021	0.777	1,437,378	1,088,044	1,383,476	1,047,243	4,030,960	3,051,296
7	2022	0.828	1,577,701	1,140,109	1,518,537	1,097,355	4,498,904	3,251,087
8	2023	0.879	1,725,149	1,190,130	1,660,456	1,145,500	5,002,323	3,450,956
9	2024	0.930	1,880,025	1,238,162	1,809,524	1,191,731	5,543,571	3,650,929
10	2025	0.982	2,043,226	1,284,624	1,966,605	1,236,451	6,126,905	3,852,129
11	2026	1.033	2,214,527	1,329,189	2,131,482	1,279,344	6,640,575	3,985,762
12	2027	1.084	2,394,267	1,371,905	2,304,482	1,320,459	7,179,551	4,113,854
13	2028	1.135	2,582,798	1,412,824	2,485,943	1,359,843	7,744,889	4,236,554
14	2029	1.187	2,780,486	1,451,992	2,676,218	1,397,543	8,337,686	4,354,007
15	2030	1.238	2,987,712	1,489,458	2,875,672	1,433,603	8,959,080	4,466,352
16	2031	1.289	3,204,868	1,525,266	3,084,685	1,468,069	9,610,254	4,573,728
17	2032	1.341	3,432,365	1,559,462	3,303,651	1,500,982	10,292,435	4,676,270
18	2033	1.392	3,670,627	1,592,090	3,532,978	1,532,387	11,006,898	4,774,109
19	2034	1.443	3,920,095	1,623,192	3,773,092	1,562,323	11,754,965	4,867,374
20	2035	1.495	4,181,228	1,652,811	4,024,432	1,590,831	12,538,011	4,956,191
<b>Accumulated O&amp;M Present Worth</b>			<b>\$26,262,656</b>		<b>\$25,277,806</b>		<b>\$76,051,914</b>	

<b>Table 13 - 20 Year Present Worth Summary</b>							
<b>Index yr</b>	<b>Capital Item</b>	<b>Tertiary Cost \$</b>	<b>Tertiary PW \$</b>	<b>Land App Cost \$</b>	<b>Land App PW \$</b>	<b>To CCUC Cost \$</b>	<b>To CCUC PW \$</b>
<b>Phase 1 Construction</b>							
0	Collection	6,750,000	6,750,000	6,750,000	6,750,000	6,750,000	6,750,000
0	Disposal	9,100,000	9,100,000	15,460,159	15,460,159	8,100,000	8,100,000
<b>Phase 2 Construction</b>							
10	Disposal	4,420,000	<u>2,778,958</u>	11,755,159	<u>7,390,745</u>	8,100,000	<u>5,092,660</u>
<b>Total Capital PW</b>			18,628,958			29,600,904	19,942,660
<b>20 yr O&amp;M PW</b>			<u>26,262,656</u>			<u>25,277,806</u>	<u>76,051,914</u>
<b>Total Alternative PW</b>			<b>\$44,891,613</b>			<b>\$54,878,710</b>	<b>\$95,994,575</b>

### 5.2.2 Alternative Analysis Summary and Recommendations

Common to each alternative is the requirement to construct a \$6,500,000 interceptor system to serve the area and bring wastewater to the confluence of Carter Creek and the Yadkin River below the Winston Salem (CCUC) potable water intake.

Speculative limits for the Treatment and Discharge Option were issued and are included in **Appendix F**.

The Land Application option is non-feasible by virtue of Phase 2 land availability however, if it were feasible, its present value of cost is approximately 22% greater than that of the treatment and discharge option.

The option of connecting to an existing system and continuing to pump to CCUC is more than twice as expensive as the treatment and discharge option owing to the fees charged for treatment services by CCUC and cost of constructing approximately 4.9 miles of large diameter forcemain for each phase.

Viable alternatives examined with associated 20 year present worth of costs (rounded) are:

**Treatment and Discharge:      \$45,000,000**

**Land Application:                \$55,000,000**

**Connection to to CCUC         \$96,000,000**

**Conclusion:** The least expensive option over a 20-year horizon is to construct a tertiary wastewater treatment plant near the confluence of Carter Creek and the Yadkin River with a discharge into the Yadkin.

### 5.2.3 Description of the Recommended Project

This analysis indicates that the most economical alternative includes constructing new collection and treatment system components with an outfall to the Yadkin River below Idols Dam.

Collection system requirements include:

1. Constructing 22,000 lf of new gravity interceptor along Carter Creek from the Smith Creek PS to the Treatment plant site near the confluence of Carter Creek and the Yadkin River below Idols Dam. Preliminary plan and profile drawings of the proposed Interceptor based on preliminary field surveys are contained in **Appendix E**;
2. Replacing existing Bermuda Run influent pump station components and constructing approximately 7,000 lf of new forcemain to discharge into the new gravity interceptor. Preliminary plan drawings of the proposed Bermuda Run Forcemain are shown in **Appendix E**;
3. Replacing existing Yadkin River pump station components and constructing approximately 5,000 lf of new forcemain along Hwy 158 to discharge into the new interceptor along Smith Creek above its confluence with Carter Creek. Preliminary plan drawings of the proposed Yadkin Forcemain are shown in **Appendix E**.

Treatment Plant requirements include:

1. Constructing a new tertiary wastewater treatment facility to speculative nutrient removal standards of 4 mg/l effluent total Nitrogen and 0.5 mg/l effluent Phosphorus. Preliminary site layout, system configuration and vicinity exhibits are shown in **Appendix H**. The biological treatment process used for this evaluation is the Aero-Mod process. Additional background information and specific preliminary design information on that process and the effluent filtration process are contained in **Appendix G**.
2. A three step biological treatment process followed by clarification, membrane filtration and UV disinfection is represented. The biological process is described in **Appendix G**. It involves an influent selector step followed by two aerobic/anoxic stages to result in denitrification (see **Appendix G-6**). It is anticipated Aluminum Sulfate may be added if needed to assure compliance the phosphorus limit of 0.5 mg/l. It is likely that Sodium Permanganate (liquid permanganate) will be available on site for odor control and process management. There will be no gaseous chlorine on site.
3. Sludge will be stored in the aerobic digesters and removed to land application as needed.

Outfall requirements include:

Constructing an 18" outfall forcemain as shown in the WWTP vicinity map in **Appendix H**. It is expected that the outfall will be bored under the portage trail, the railroad bridge and the river to emerge near the raceway of Idols Dam.

## **6.0 Environmental Information Document**

### **6.1 Existing Environmental Characteristics**

#### **6.1.1 Topography**

General topography (steep and semi steep slopes from soils information) and flood plains for the EDSA are shown on **Figure 8**. Detailed USGS topography is shown on **Figure 21**.

#### **6.1.2 Soils**

**Figure 9** shows generalized soils and development (parcel lines). Soils for that figure are aggregated by septic limitation from the Davie County Soils Survey. **Figure 20** represents the detailed Davie County Soils map.

#### **6.1.3 Land Use**

**Figure 10** represents areas covered by Phase 2 Stormwater regulations and WS IV watershed restrictions. The Phase 2 area is also the Winston Salem MSA that triggered Phase 2 compliance requirements.

**Figure 11** shows Bermuda Run and Davie County zoning.

**Figure 12** shows the Bermuda Run Master Plan ratified by the community after an extensive public participation effort.

**Figure 13** shows the Bermuda Run Town Center in greater detail and further represents the extent to which the community is active in planning for its orderly growth.

#### **6.1.4 Wetlands**

**Figure 14** is a wetlands overview taken from the National Wetlands Database. Preliminary corridor surveys were performed by S&ME and are shown in **Appendix I**.

#### **6.1.5 Prime or Unique Agricultural Lands**

The area is heavily subdivided. There are no Prime or Unique Agricultural lands present in the EDSA.

#### **6.1.6 Public Lands and Scenic, Recreational and State Natural Areas**

**Figure 15** indicates that the Smith Grove Park and the Yadkin River Trail, Idols Dam Portage #2585 are the only areas in this classification.

#### **6.1.7 Areas of Archaeological or Historic Value**

**Figure 16** was developed from the National Register of Historic Places. It indicates that the Win Mock Farm Dairy is the only registered historic place in the area.

#### **6.1.8 Air Quality**

Mr. Ray Stewart of the NCDENR WSRO reported in a telephone conversation that Davie County is an Attainment and Non-Transitional area with respect to Air Quality. There are no air quality concerns of record in the EDSA.

It should be noted that there are sporadic odor complaints arising from the Yadkin River Pump Station located on Hwy 158 near the entrance to Bermuda Run, the Soccer Association Fields and the Win-Moc Barn (Registered Historic Site). Odors at this location result from sewage that has passed through multiple pump stations on its way to the CCUC system.

### **6.1.9 Noise Levels**

The prospective plant site is a quiet field close to Underpass Road. Ambient noise levels are low.

### **6.1.10 Water Resources**

**Figure 19** shows surface waters in the area with HUC code, Stream Class Use Rating and DWQ Identifier. It can be seen that a reach of the Yadkin River between Bermuda Run and Forsyth County is classified as Impaired in the State's 303d program.

Sherri Knight, PE of the NCDENR WSRO Groundwater Quality Section indicates that there are no generalized groundwater issues in the area. The bedrock aquifer is Early Mesozoic. The State maintains a 400' deep monitoring well #H61U1 in the area and has recorded water levels between elevation 701 and 706 ftmsl since 1970.

It should also be noted here that the area is largely served by Davie County public water. Two water treatment plants, Sparks Road and Cooleemee, serve Davie County. The Sparks Road plant is rated at 3.0 MGD and the Cooleemee Plant is rated at 2.6 MGD. In 2013, the combined water output averaged approximately 2.3 MGD with a peak delivery day of approximately 3.7 MGD. Further, Davie has budgeted for a 5 year Capital Improvement Plan that includes an emergency connection to Davidson Water.

### **6.1.11 Forest Resources**

**Figure 17** indicates that the area contains both Conserved Working Forests and a Natural Heritage Forest. The Natural Heritage forest was delineated in 1992 and 1993 as part of an Inventory of Yadkin River Natural Areas sponsored by the North Carolina Natural Heritage Foundation. The area indicated was designated as Carter's Creek Bottomland Forest (D01). It is a Palustrine Community established on mixed alluvial sediments in the flood plain of the Yadkin. Among the varieties of important trees are: Tulip-Poplar, Winged Elm and Red Maple, along with the lesser important species: River Birch, Box Elder and Sycamore. The **Table 15** represents observed Flora and Fauna from the 1992 report.

Since the area is not under public jurisdiction, its northern portion has been subdivided into multiple small residential lots. The area as mapped in 1993 covers approximately 24 acres, of which the pipeline corridor is expected to impact approximately 5 acres.

### **6.1.12 Shellfish or Fish and Their Habitats**

A review of the North Carolina Natural Heritage Database reveals no endangered aquatic species. There are a variety of gamefish present below Idols Dam as determined by the NC Wildlife Resources Commission utilizing electrocution methods in 2001 and 2005. Kin Hodges, District 7 Fisheries Biologist provided the following information table. The section downstream of Idols Dam in **Table 14** is the Concord Church area.

**Table 14: Game Fish Below Idols Dam (Concord Church)**

TABLE 1.—Catch rates (fish/hr) of gamefish and ictalurids collected using the 120 pps electrofishing setting from the Yadkin River, 2001 and 2005.

Species	Yadkin River									
	W. K. Scott Tailrace	Wilkesboro	Ronda		Elkin		Shallowford	Donnoha	Concord Church	
	2005	2001	2005	2001	2005	2001	2001	2005	2005	2001
Smallmouth Bass	1.9	4.8	8.7	11.7	12.1	0.0	2.2	1.8	0.0	0.0
<b>Spotted Bass</b>	<b>57.2</b>	<b>52.8</b>	<b>5.2</b>	<b>18.8</b>	<b>19.7</b>	<b>33.2</b>	<b>42.3</b>	<b>7.0</b>	<b>18.0</b>	<b>32.1</b>
Largemouth Bass	18.8	4.8	0.0	2.3	3.0	0.0	6.7	0.0	5.4	0.0
<b>Redear Sunfish</b>	<b>0.9</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>4.5</b>	<b>0.0</b>
Bluegill	11.3	2.4	0.0	0.0	1.5	0.0	6.7	0.0	35.9	22.3
<b>Pumpkinseed</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.9</b>	<b>0.0</b>
Redbreast Sunfish	6.6	21.6	22.7	24.7	51.4	66.5	53.4	5.8	0.0	2.9
<b>Warmouth</b>	<b>0.9</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>1.9</b>
Rock Bass	0.9	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
<b>White Perch</b>	<b>1.9</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>1.8</b>	<b>8.7</b>
White Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
<b>Black Crappie</b>	<b>3.8</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>1.0</b>
Chain Pickerel	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<b>Channel Catfish</b>	<b>2.8</b>	<b>0.0</b>	<b>0.0</b>	<b>1.2</b>	<b>0.0</b>	<b>0.0</b>	<b>2.2</b>	<b>0.0</b>	<b>35.9</b>	<b>11.7</b>
Flathead Catfish	0.0	0.0	0.0	0.0	1.5	0.0	0.0	2.9	13.5	10.7
<b>White Catfish</b>	<b>10.3</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
Bullheads <sup>a</sup>	6.5	2.4	0.0	1.2	16.6	28.1	20.0	25.7	0.0	0.0
Time Sampled (s)	3840	1500	2066	3065	2381	1408	1618	6164	4011	3705

<sup>a</sup> includes flat and snail bullheads

### 6.1.13 Wildlife and Natural Vegetation

The only endangered species referenced in the National Heritage Database for Davie County is Michaux's Sumac, which is discussed below.

#### **Michaux's sumac (*Rhus michauxii*)**

Family: Anacardiaceae

Federal Status: Endangered

Date Listed: September 28, 1989

Michaux's sumac, a densely hairy shrub with erect stems 1 to 3 feet (0.3 to 0.9 meters) in height, grows in sandy or rocky open woods in association with basic soils. Michaux's sumac has compound leaves which are narrowly winged at the base, dull on the top, and veiny and slightly hairy on the bottom. Each leaf is finely toothed on its edges. Most plants are unisexual; however, more recent observations have revealed plants with both male and female flowers on one plant. The flowers are small, borne in a terminal, erect, dense cluster, and colored greenish yellow to white. Flowering usually occurs from June to July; while the fruit, a red drupe, is produced through the months of August to October.

Michaux's sumac survives best in areas that are open due to some form of disturbance such as roadside rights-of way, artificially maintained clearings, or in areas with periodic fires. It was

once found in Georgia, South Carolina, and North Carolina but now only has viable populations North Carolina. Just four plants still survive in one county (down from five counties) in Georgia. In South Carolina, two populations of the plant were historically known; now, the plant is considered extirpated from that State. Currently, the plant survives in the following North Carolina Counties: Richmond, Hoke, Scotland, Franklin, Davie, Robeson, and Wake. It has been eliminated from Durham, Moore, Orange, Randolph, Wilson, Lincoln, and Mecklenburg counties. Of the 15 existing populations in North Carolina, nine have less than 100 plants each, and three of these have less than a dozen plants each (USFWS 1993).

**BIOLOGICAL CONCLUSION: Unresolved**

Michaux's sumac is known from Davie County. It could occur within the power line easement and along pasture and road edges of the site. Based on NCNHP data no records of Michaux's sumac were found within of project site. Surveys will need to be conducted during the flowering season (June through July) to determine its presence or absence.

This plant was not discovered during the route surveys. See the S&ME environmental reports in **Appendix I**.

The Table below indicates wildlife and vegetation species of significance noted during the 1992 and 1993 study of the Carter's Creek Bottomland.

**Table 15: Significant Species in the Carter's Creek Bottomland Forest**

<p><b>Significant Species Present</b></p>	<p><b>Subcanopy and Shrubs</b></p>	<p><i>Commelina virginica</i>  <i>Cuscuta compacta</i>  <i>Geum canadense</i>  <i>Goodyera pubescens</i>  <i>Ligusticum canadense</i>  <i>Ludwigia palustris</i>  <i>Lycopus virginicus</i>  <i>Lysimachia nummularia</i>  <i>Penthorum sedoides</i>  <i>Sanicula canadensis</i>  <i>Tipularia discolor</i>  <i>Tovara virgin</i></p>
<p><i>Acer floridanum</i>  <i>Amsonia taberneamontanum</i>  <i>Quercus shumardii</i> and  <i>Q. shumardii</i>*<i>rubra</i>  <i>Viburnum dentatum</i></p>	<p><i>Asimina triloba</i>  <i>Carpinus caroliniana</i>  <i>Cornus florida</i>  <i>Hex verticillata</i>  <i>I. decidua</i>  <i>Viburnum dentatum</i>  <i>V. prunifolium</i></p>	<p><b>Animal Species</b>  Great Blue Heron  Louisiana Waterthrush  Green Backed Heron  (nesting)  Blue-gray Gnatcatcher</p>
<p><b>Plant Species</b></p>	<p><b>Vines</b></p>	
<p><b>Canopy</b></p>	<p><i>Anisostichus capreolata</i>  <i>Lonicera japonica</i>  <i>Rhus radicans</i>  <i>Smilax rotundifolia</i>  <i>Vitis rotundifolia</i></p>	
<p><i>Acer rubrum</i>  <i>Acer floridanum</i>  <i>Betula nigra</i>  <i>Carya ovata</i>  <i>Fraxinus pennsylvanica</i>  <i>Juglans nigra</i>  <i>Liquidambar styraciflua</i>  <i>Platanus occidentalis</i>  <i>Quercus alba</i>  <i>Q. lyrata</i>  <i>Q. falcata</i>  <i>Q. michauxii</i>  <i>Q. phellos</i>  <i>Q. rubra</i>  <i>Q. shumardii</i>  <i>Q. shumardii</i>*<i>rubra</i></p>	<p><b>Herbs</b></p>	
	<p><i>Alisma subcordata</i>  <i>Amphicarpa bracteata</i>  <i>Amsonia taberneamontanum</i>  <i>Arisaema draconitum</i>  <i>A. triphyllum</i>  <i>Arundinaria gigantea</i>  <i>Carex crinita</i>  <i>C. lupuliformis</i>  <i>Cicuta maculata</i>  <i>Cinna arundinacea</i></p>	

## **6.2 Predicted Environmental Effects**

Note that the population of the EDSA is expected to grow by approximately 1,500 persons over the next 20 years. This is not a dramatic population increase for an area of this size and would likely occur with additional stress on the environment from on-site systems in marginal soils. Moving into the future, the benefits of removing a discharge from an impaired section of the Yadkin and moving it away from a potable water intake combined with relief from the problems of failing residential on-site systems in marginal soils is likely to represent an overall net positive environmental impact for the area assuming that Phase 2 Stormwater rules continue to be implemented and their reach is extended throughout the urbanizing area.

### **6.2.1 Topography**

Direct: The new WWTP site will be graded to increase elevation. Discussions with the Davie County Flood Plain Administrator, in consultation with State Regulatory authorities support the strategy of increasing the elevation in the treatment facility area. The existing Bermuda Run WWTP will be demolished and its berm removed.

Secondary: None

Cumulative: None

### **6.2.2 Soils**

Direct: Construction sediment control activities.

Secondary: Relief of failed septic disposal areas.

Cumulative: Continued relief for moderately to severely limited soils.

### **6.2.3 Land Use**

Direct: None

Secondary: Bermuda Run Land use plans will be feasible because wastewater disposal facilities will be available and relatively more affordable.

Cumulative: Planned urbanization will be supported.

### **6.2.4 Wetlands**

Direct: Approximately 3 acres of wetlands will be temporarily disturbed.

Secondary: Wetland areas will be restored to grade without permanent damage.

Cumulative: None

### **6.2.5 Prime or Unique Agricultural Lands (N/A)**

### **6.2.6 Public Lands, Scenic and Recreational Areas (N/A)**

### **6.2.7 Areas of Archaeological or Historic Value (N/A)**

### **6.2.8 Air Quality**

Direct: The Bermuda Run WWTP will be removed and a downstream WWTP added. The design of plant will mitigate odor issues.

Secondary: Odor from the Yadkin River Pump Station will be reduced as flow and sewage age is reduced and flow is redirected to the interceptor.

Cumulative: Net positive

### **6.2.9 Noise Levels**

Direct: There will be a period of construction noise.

Secondary: Blower and machine noise will need to be mitigated.

Cumulative: Minimal if operational noise is mitigated by design.

#### **6.2.10 Water Resources**

Direct: Construction activities must be controlled to minimize sedimentation. This direct impact will be minimized during the construction phase.

Secondary: Removal of the Bermuda Run WWTP discharge from the impaired section of the Yadkin River just upstream of the Winston Salem water intake and construction of a facility treating to the highest standards in the basin will provide a net positive secondary impact.

Cumulative: Treating to high standards and relieving septic runoff from failed residential systems will yield a net positive outcome.

#### **6.2.11 Forest Resources**

Direct: Approximately 5 acres out of 24 acres of the Carter's Creek bottomland forest will be cleared and the area maintained as a pipeline corridor. Direct impacts will be minimized during design to avoid significant specimens and construct using minimal impact construction practices (such as precise and minimal clearing).

Secondary: An open corridor will exist through the forested areas that will be a protected wildlife corridor.

Cumulative: These forest area located in bottomlands that are not suitable for development and are likely to remain relatively undisturbed.

#### **6.2.12 Shell Fish or Fish and their Habitats**

Direct: Construction activities involving boring the outfall in rock under the river will minimize riverbed disturbance but some will take place.

Secondary: increased water quality should have a net positive effect on habitats and aquatic wildlife.

Cumulative: Net positive effect on river ecology.

#### **6.2.13 Wildlife and Natural Vegetation**

Direct: The proposed plant site is currently farmed. The only trees removed should be for constructing a portion of the outfall leading to the bore site. Wildlife would be disturbed during construction.

Secondary: As the construction impacts heal there should be no significant loss of habitat for wildlife and low growing vegetation will return. There will be a perpetual corridor over the pipelines.

Cumulative: Remembering that the expected population growth in the area is only 1,500 persons over 20 years and considering that the area is already profusely subdivided it is doubtful that significant cumulative impacts to wildlife and natural vegetation would be expected.

#### **6.2.14 Introduction of Toxic Substances**

Direct: The only toxic substances expected to be located at the WWTP are Aluminum Sulfate for Phosphorus control and Sodium Permanganate for process control. Both are routinely used in water treatment. There will be no chlorine gas at the site.

Secondary: None

Cumulative: None

### **6.3 Mitigative Measures**

#### **6.3.1 Moving the Bermuda Run Discharge**

Relocating the Bermuda Run discharge from a 303d section of the Yadkin and away from the CCUC potable water intake provides a substantial environmental advantage.

### **6.3.2 Treating Wastewater to Higher Standards of Purity**

It is well known that High Rock Lake is eutrophic and reducing its nutrient load will support water quality in the lake. The proposed facility will treat to higher standards than any other dischargers in the river.

### **6.3.3 Phase 2 Stormwater Regulation**

Davie County currently administers the Watershed protection program in the Eastern Davie Area but not the Phase 2 Stormwater program. A large portion of the area is already covered under Phase 2 regulations administered by the State. This area will continue to grow as the EDSA urbanizes and the Winston Salem MSA is extended.

### **6.3.4 Designing for Noise and odor control**

The new treatment facility will be specifically designed to be reasonably quiet and odor free.

### **6.3.5 Low Impact Design and Construction Practices**

The design process will proceed interactively with environmental reviews to minimize construction impacts and avoid significant elements.

## **6.4 Permits Required for Construction**

At least the following permits will be required for construction:

1. NCDENR NPDES
2. NCDENR Authorization To Construct
3. NCDENR Biosolids Land Application
4. NCDENR Erosion and Sediment Control
5. USACE Wetlands Permits for Utility Pipelines
6. NCDENR 401 Water Quality
7. NCDENR Stormwater
8. NC Department of Administration Permission to Encroach on Navigable Waters
9. NCDOT Encroachment Agreements
10. NCDENR Solid Waste Permission to Demolish the Bermuda Run WWTP
11. NCDENR DWQ Permission to Decommission the Bermuda Run WWTP
12. Norfolk Southern Railroad Utility Encroachment Agreement

## **7.0 References**

**Bermuda Run Planning** – Lee Rollins, Town Manager: Overall and Town Center Master Plans

**Davie County GIS** – John Gallimore, Director: Soils, Parcels, Zoning, Roads

**Davie County Planning** - Andrew Meadwell, Director: Flood Plain Regulations

**Davie County Utilities** – Johnny Lambert, Director: Historic Financial Information

**EPA Databases:** National Wetlands Inventory; Conserved Working Forests Inventory

**Grey Engineering:** Existing Utilities for Bermuda Run and Davie County

**NCWATER.ORG:** Ground Water Monitoring Wells

**NCDENR WSRO:** Ground Water - Sherri Knight and Air Quality – Ray Stewart

**NC Office of Budget and Management:** Demographics

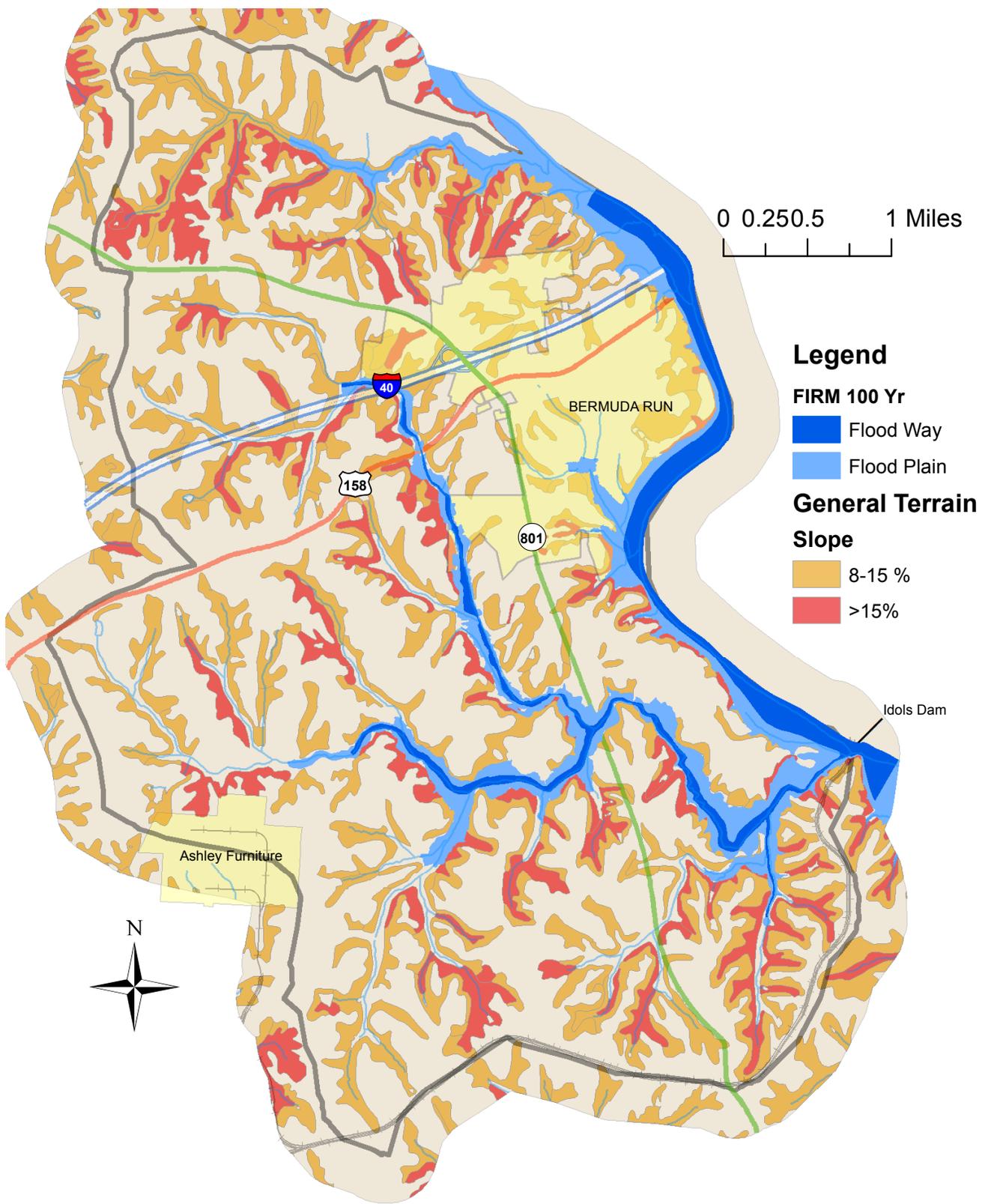
**NC OneMap:** Natural Heritage Database; Surface Water Hydrography and Classifications; NC 303d Rivers and Streams; Federal and State Public Lands; National Register of Historic Places

**NC Wildlife Resources Commission-** Kinnon Hodges, District 7 Biologist: Gamefish

**North Carolina Natural Heritage Foundation:** Yadkin River Natural Areas Inventory (1992,3)

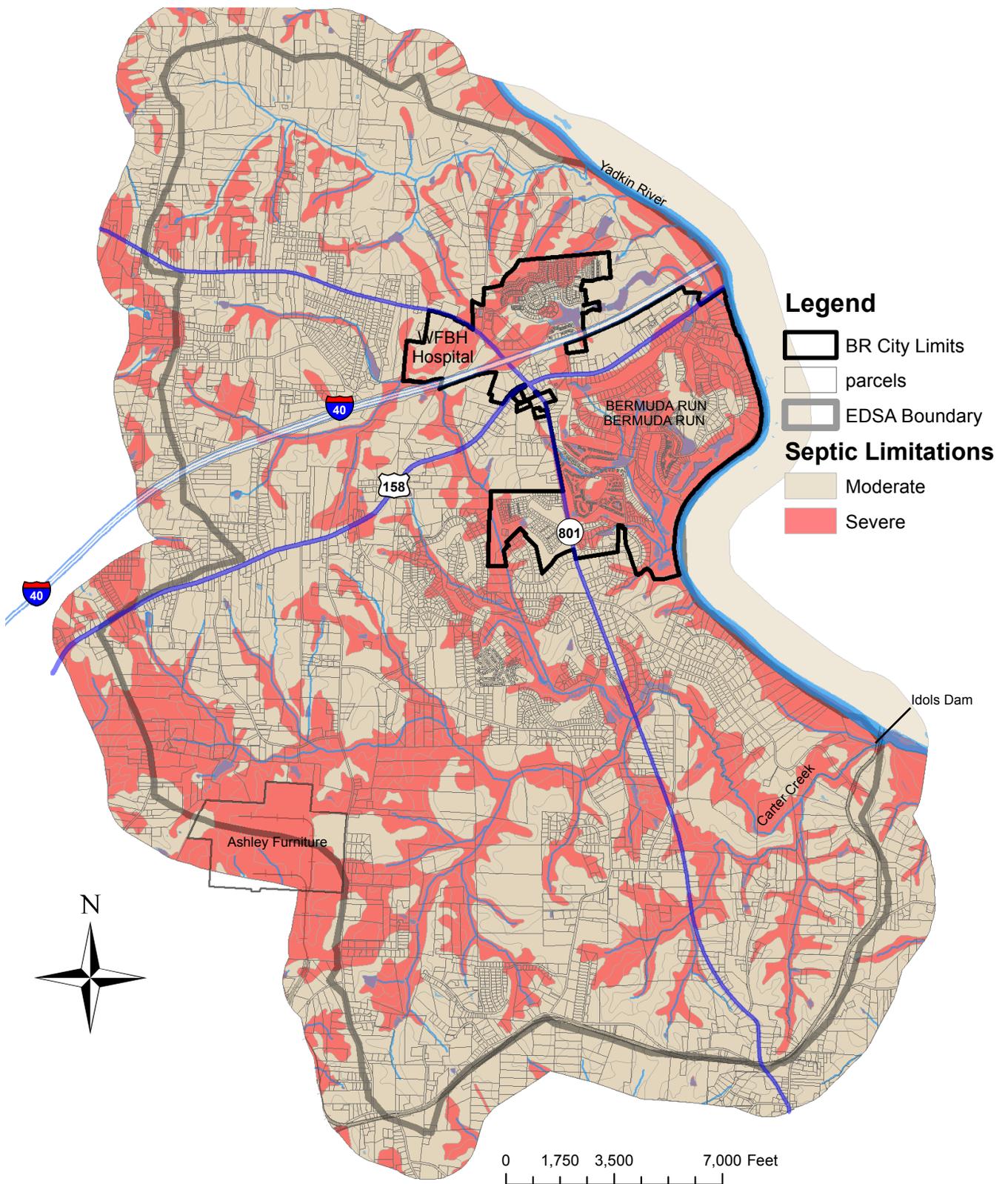
**S&ME-** Environmental Surveys: Darrin Peine, Ed Henriques

**US Census Bureau:** 2010 census mapping and data



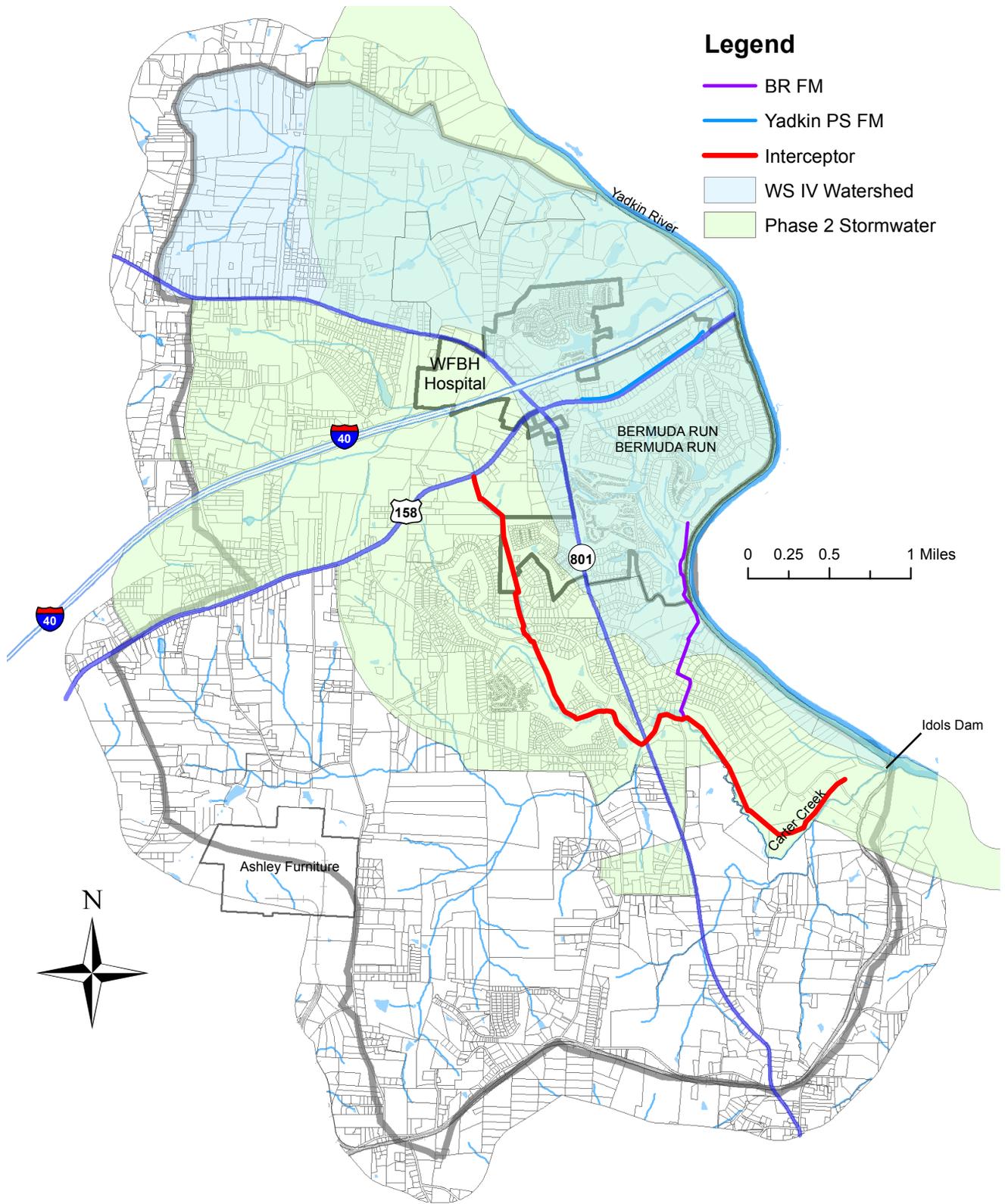
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**Figure 8: General Topography**



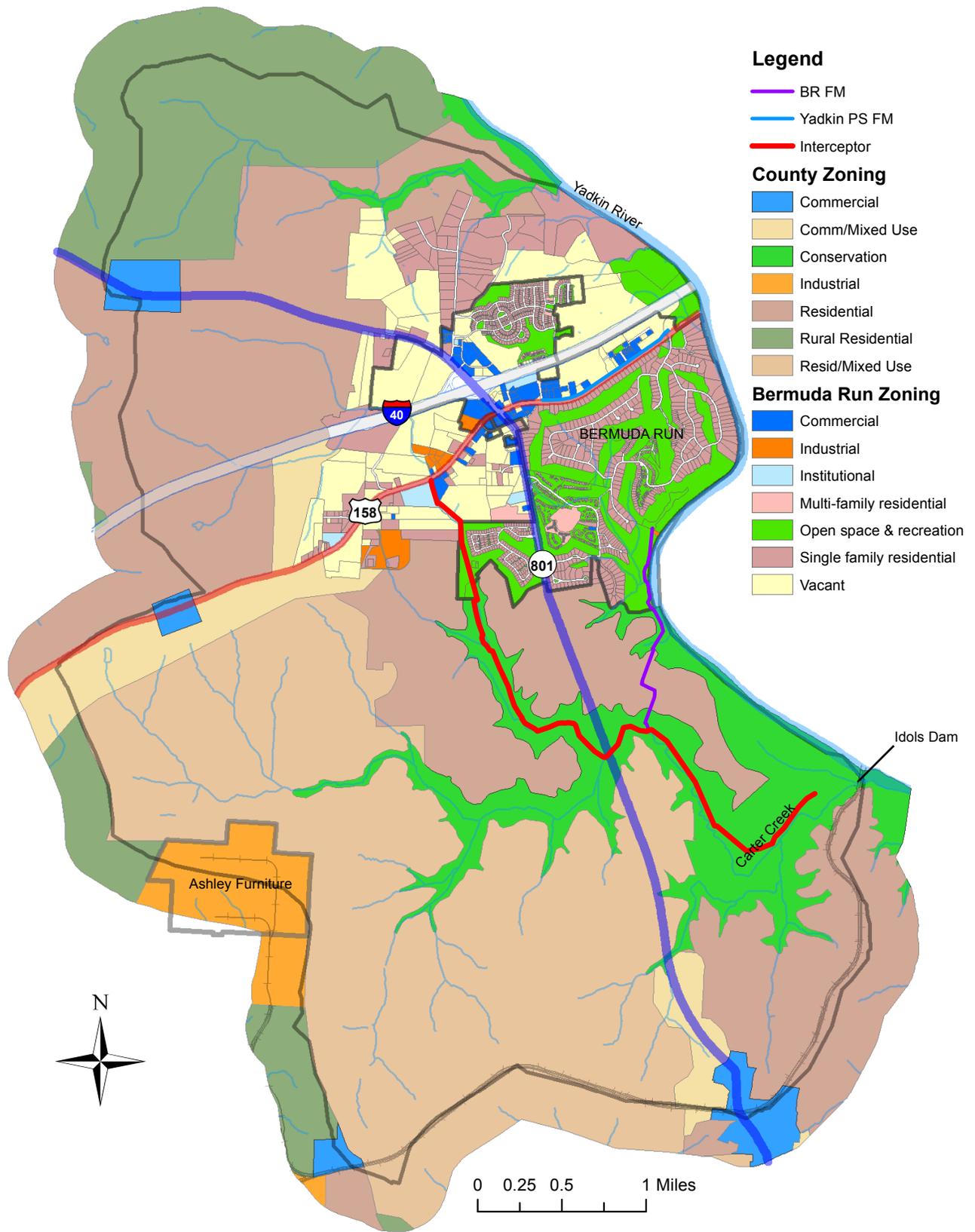
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**Figure 9: Generalized Soils and Development**



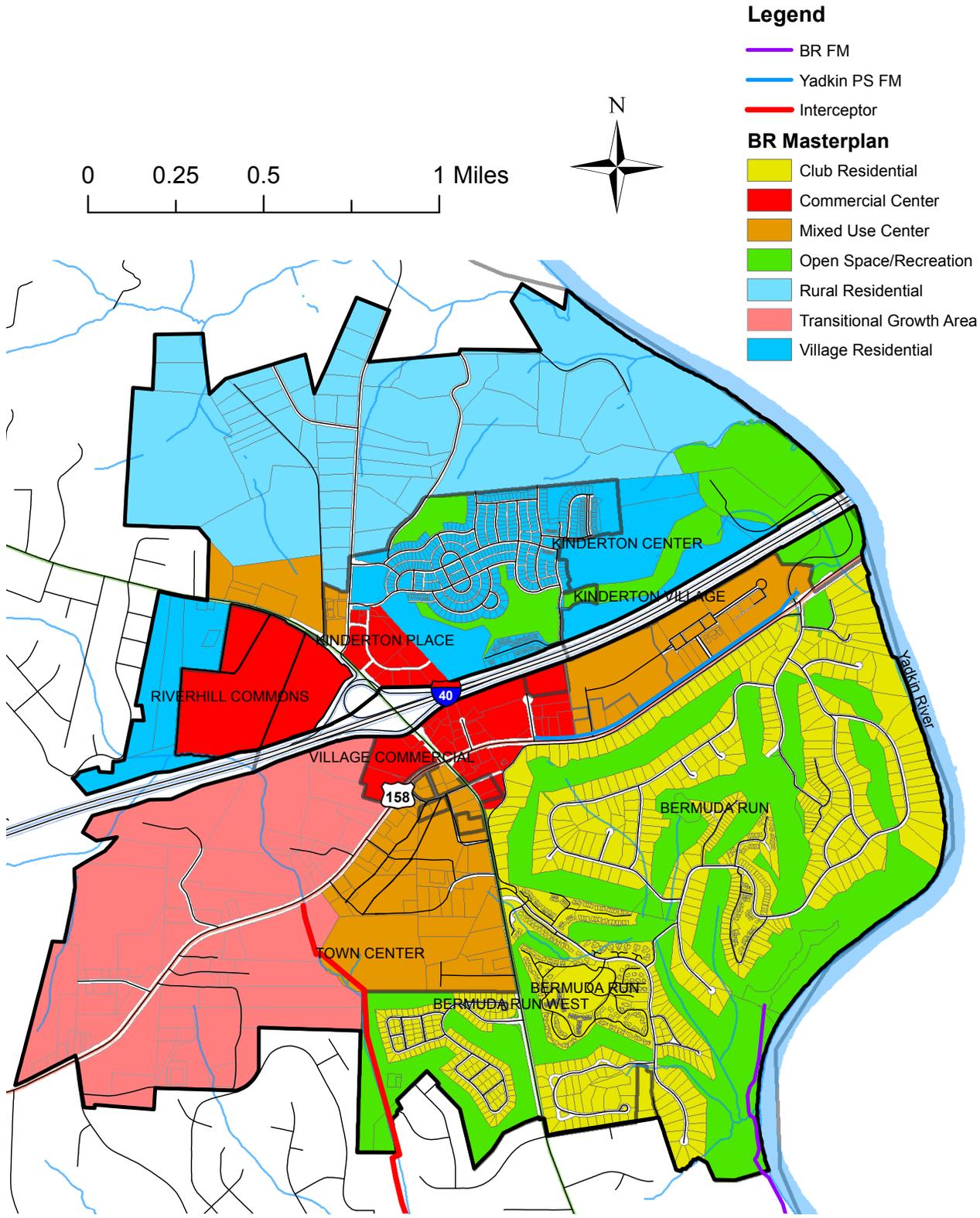
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**Figure 10: Phase 2 Stormwater and WS IV Areas**



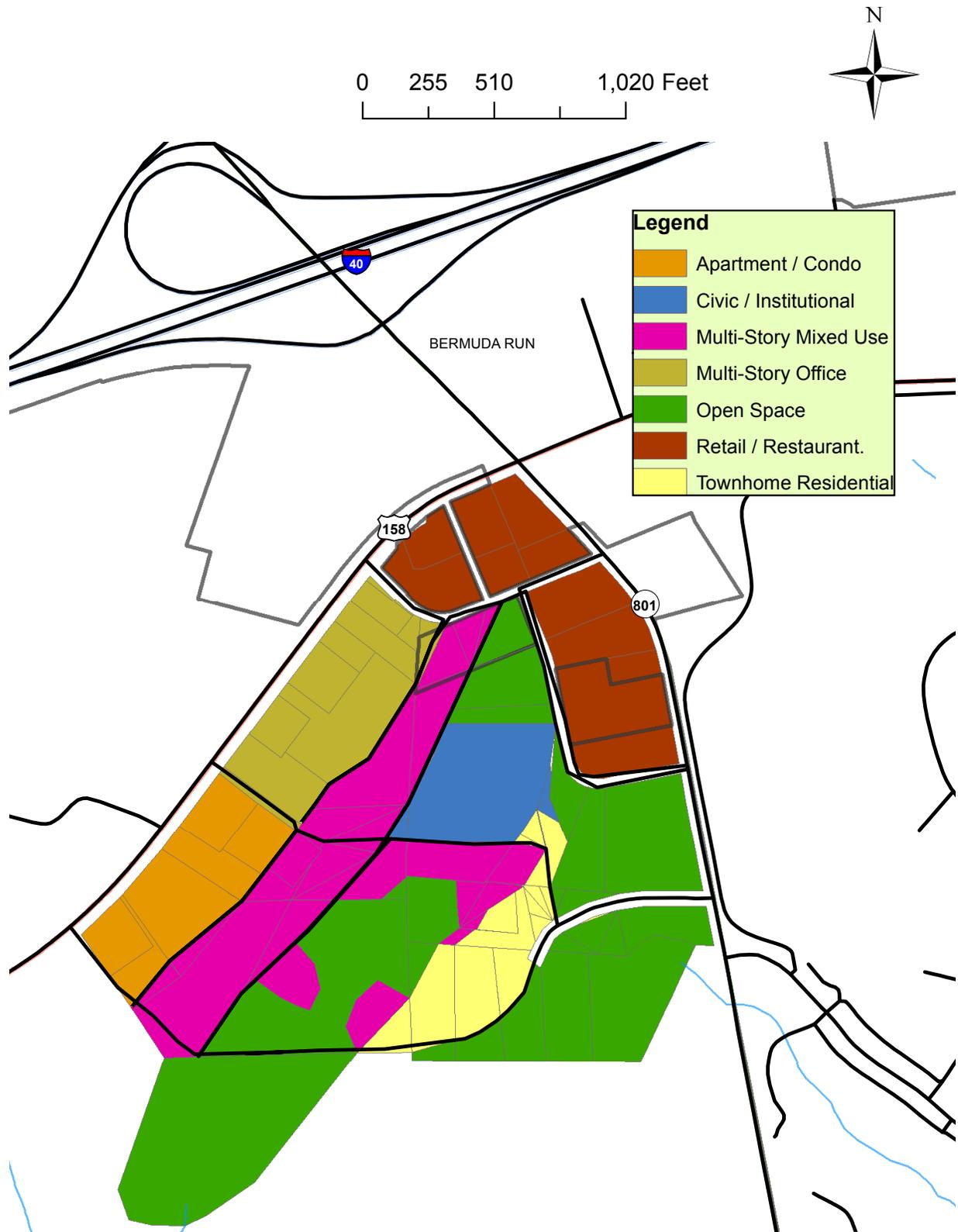
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**Figure 11: Area Zoning**



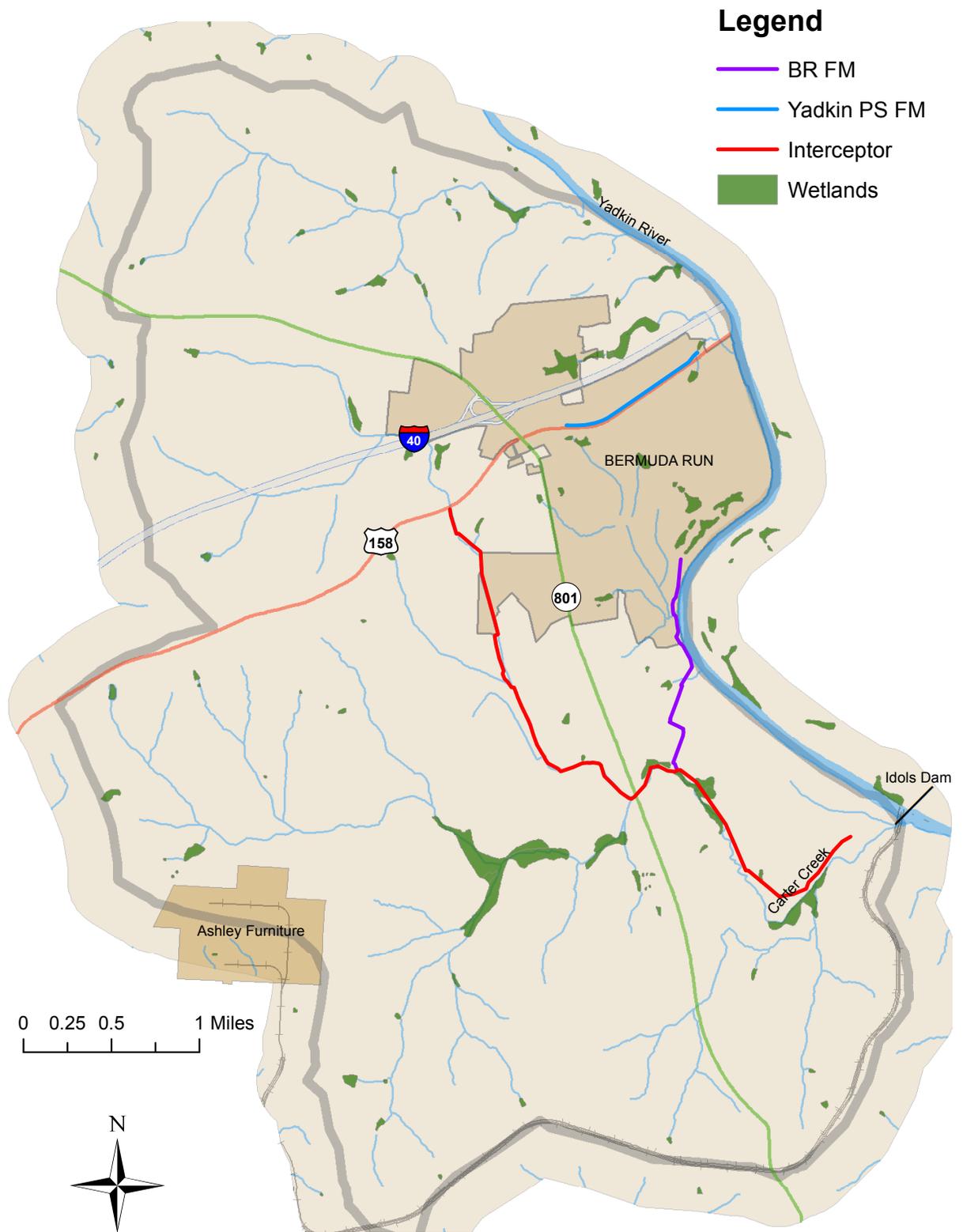
Eastern Davie Sewer ER/EID  
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**Figure 12: Bermuda Run Master Plan**



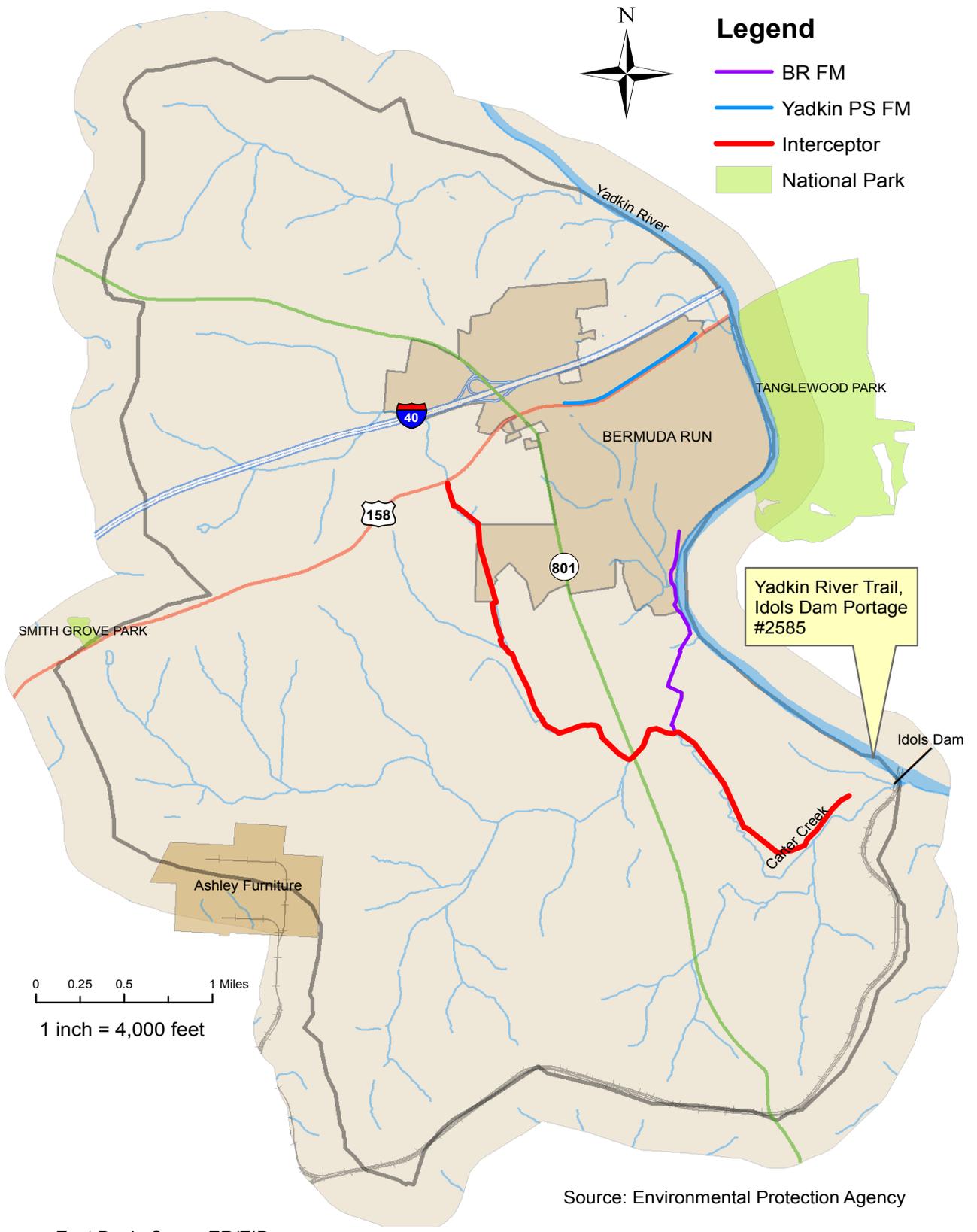
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**Figure 13: Bermuda Run Town Center Concept**



Source: National Wetlands Inventory  
 Eastern Davie Sewer ER/EID  
 Grey Engineering, Inc  
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**Figure 14: Wetlands Overview**

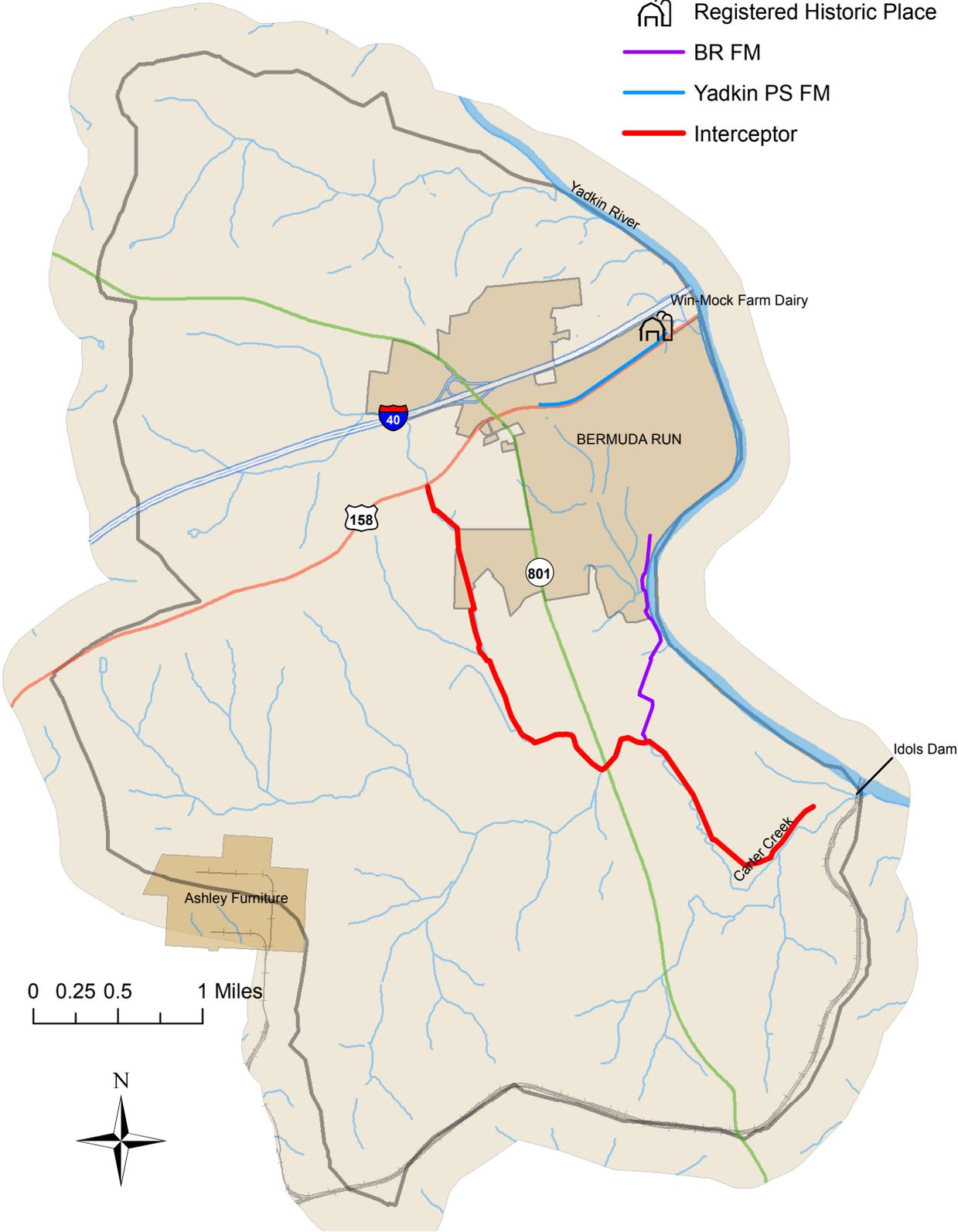


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**Figure 15: Federal and State Public Lands**

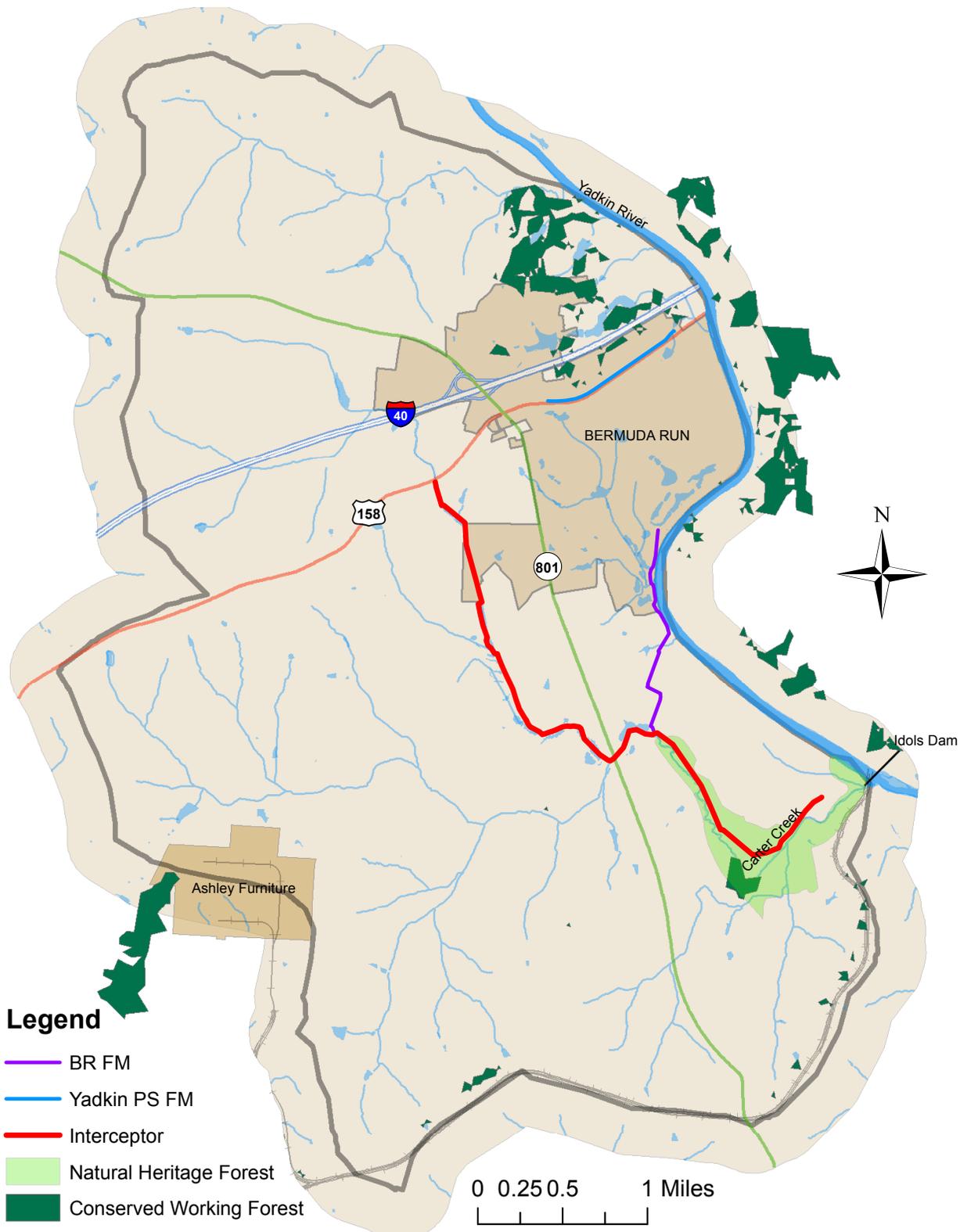
**Legend**

-  Registered Historic Place
-  BR FM
-  Yadkin PS FM
-  Interceptor



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**Figure 16: Historic Places**



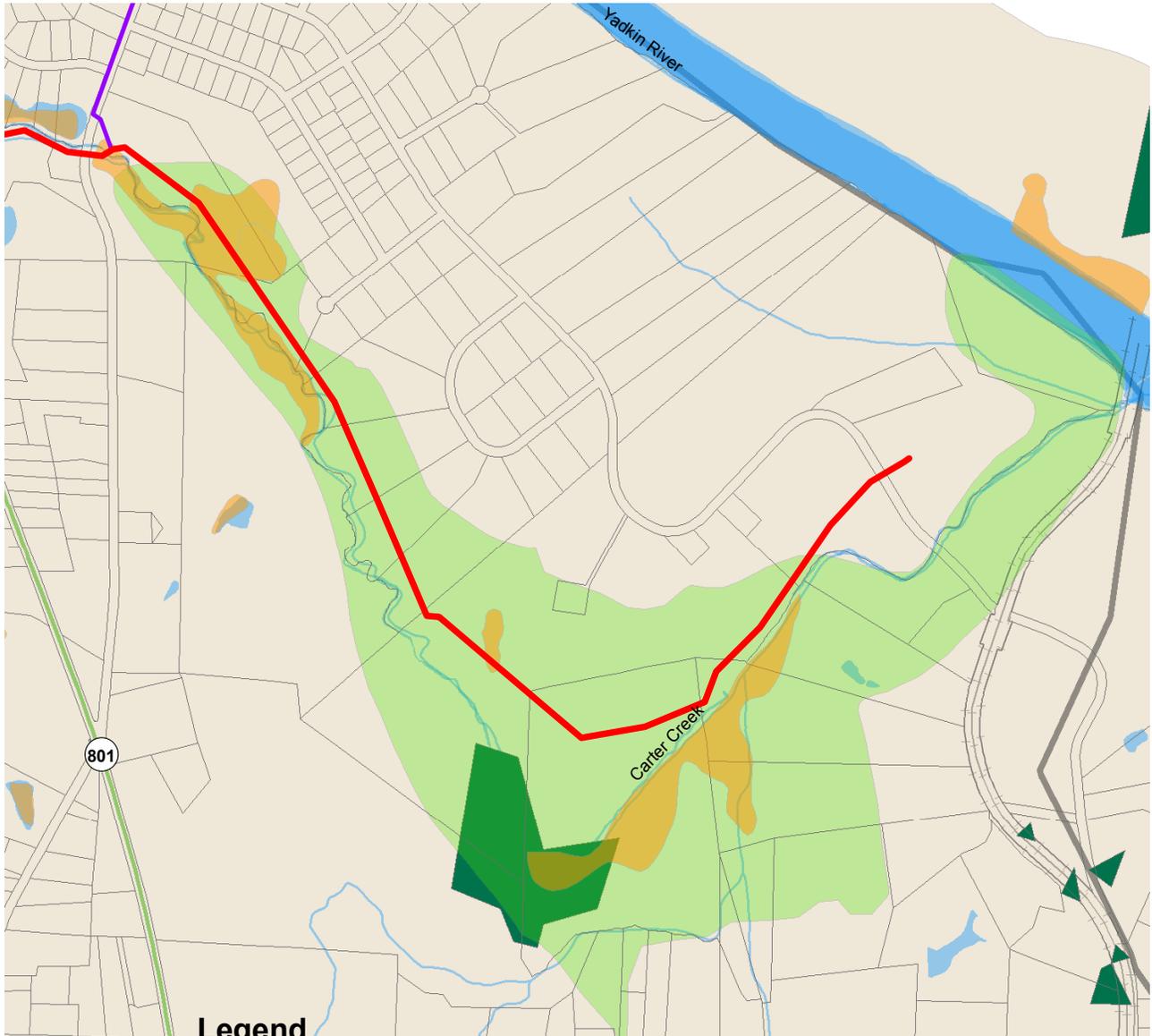
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Source: Environmental Protection Agency Conserved Working Forests

**Figure 17: Forest Resources**



0 550 1,100 2,200 Feet



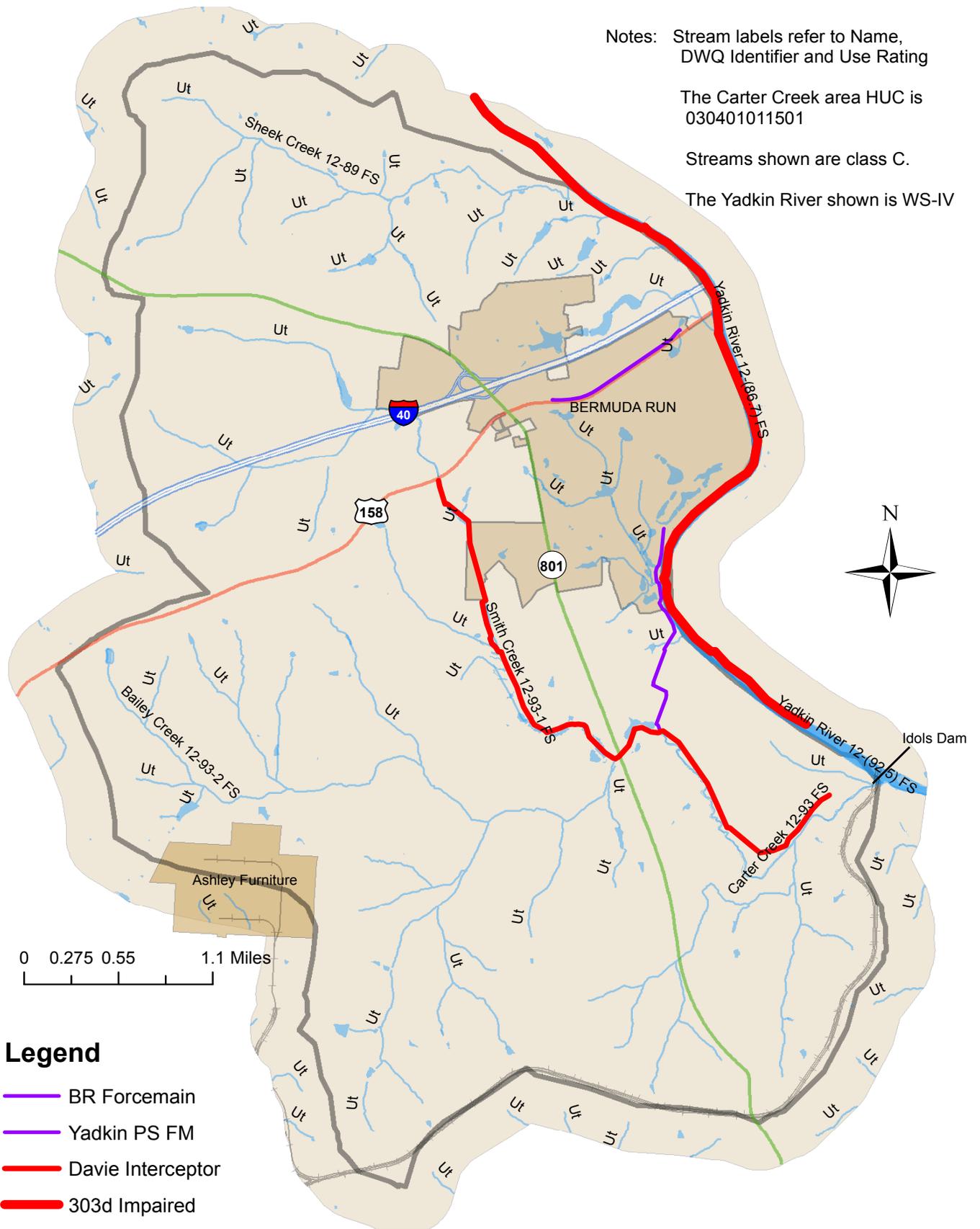
**Legend**

-  BR FM
-  Yadkin PS FM
-  Interceptor
-  Wetlands
-  Parcels
-  NHD Forest (1993)
-  Conserved Working Forest

Sources: EPA Conserved Working Forests  
National Wetlands Database  
NCDENR Natural Heritage Database

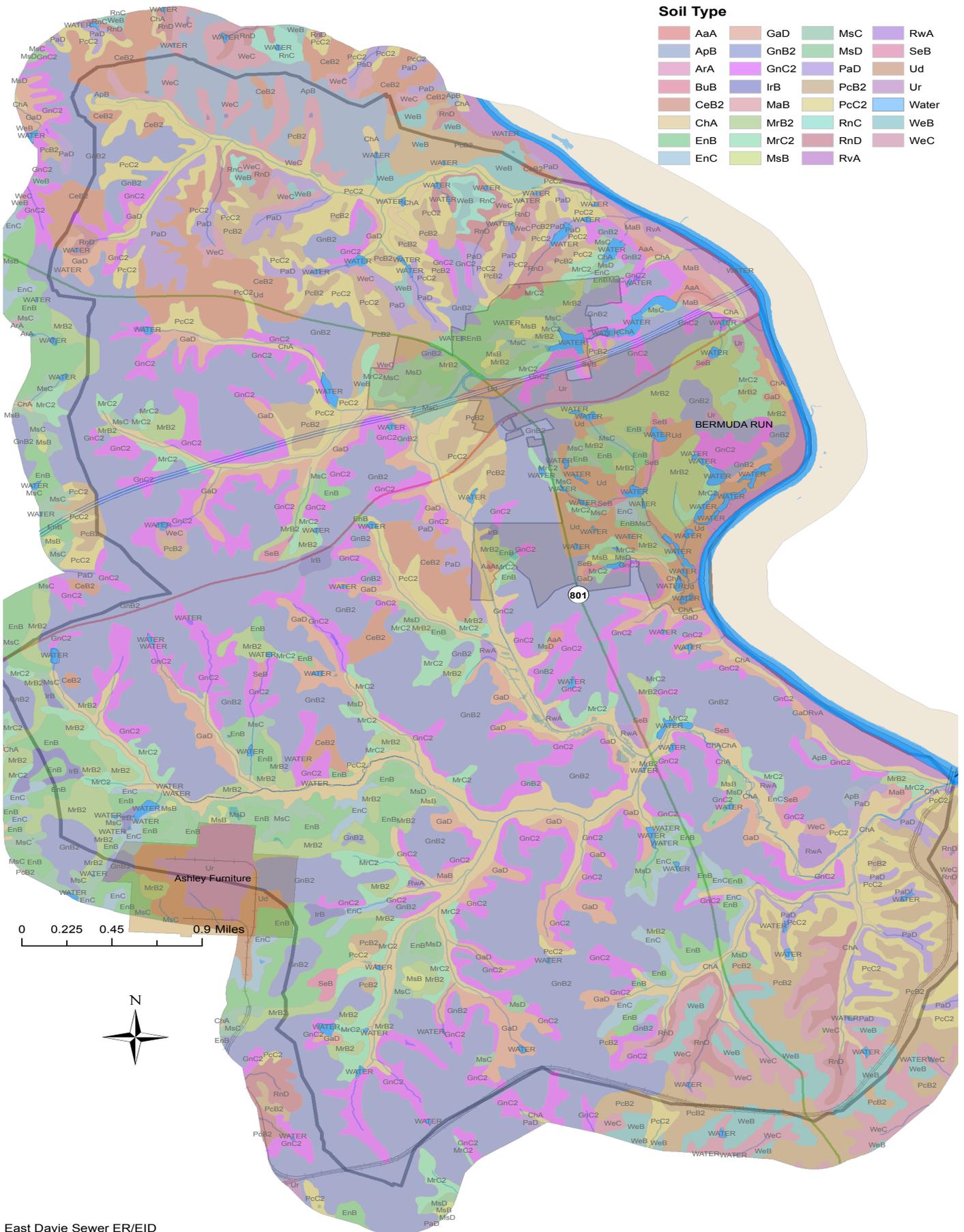
Note: NHD Forest Area = 23.8 ac (1993)  
Pipeline Corridor 30' wide = 4.5 ac

**Figure 18: Natural Heritage Forest Detail**



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**Figure 19: Surface Water Resources**



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**Figure 20: Detailed Soils Map**

USGS QUADS =  
\*ADVANCE, NC (LOWER PORTION)  
\*CLEMMONS, NC (UPPER PORTION)

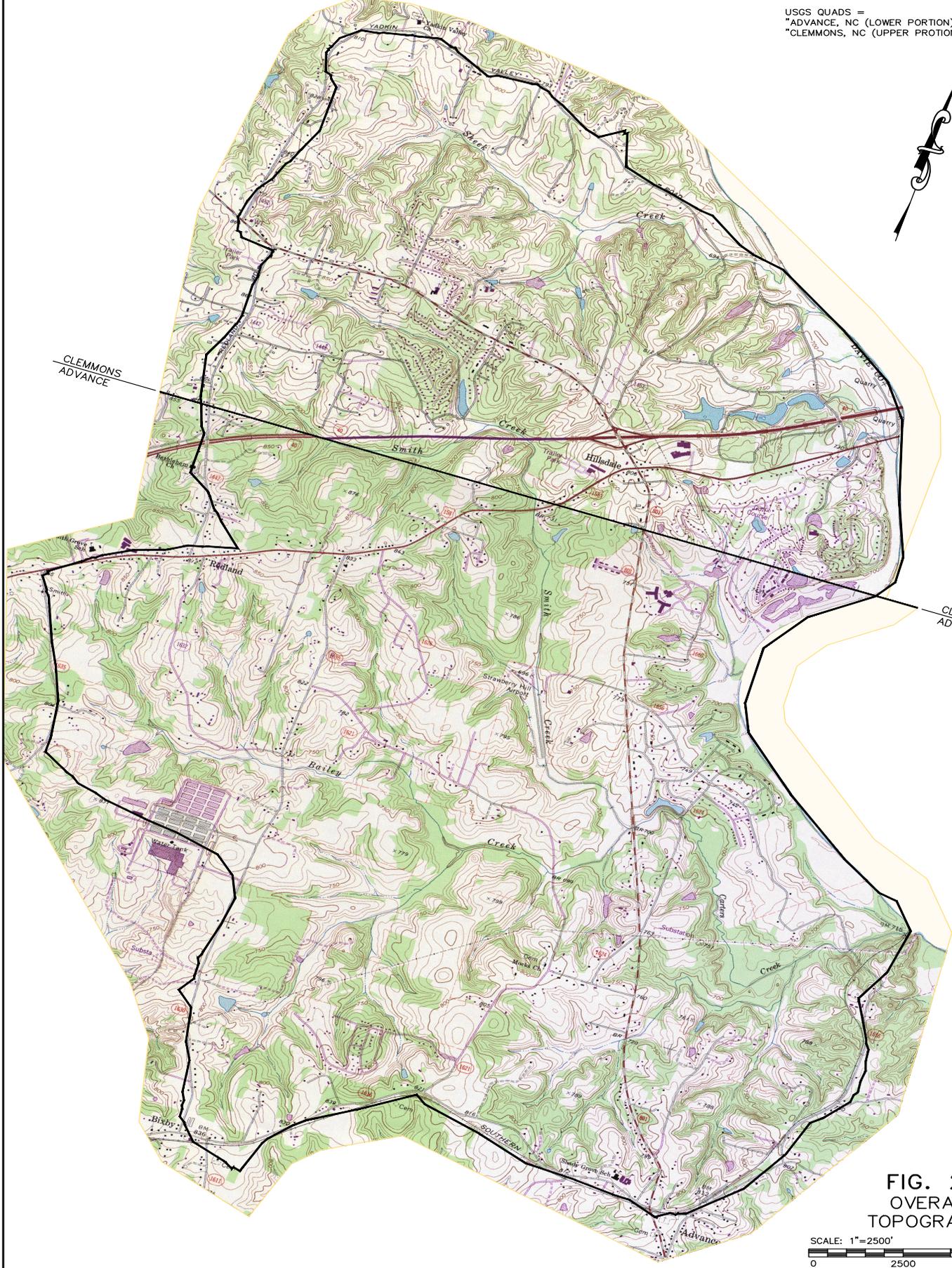


FIG. 21  
OVERALL  
TOPOGRAPHY

