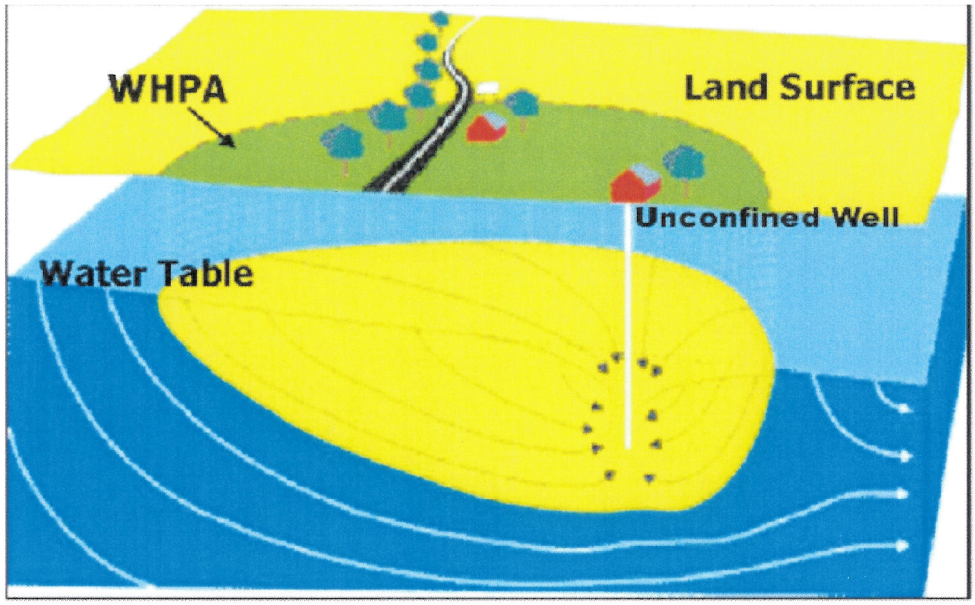
Source Water Assessment

For Transient Water Systems
Caroline County, Maryland



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Summary

The Maryland Department of the Environment's Water Supply Program (WSP) has conducted a Source Water Assessment for 58 Transient noncommunity water systems in Caroline County. The required components of this report as described in Maryland's Source Water Assessment Program (SWAP) are: 1) delineation of an area that contributes water to the source; 2) identification of potential sources of contamination; and 3) determination of the susceptibility of the water supply to contamination. Recommendations for protecting the drinking water supply conclude this report.

Confined aquifers protect water supplies from contaminants originating on the land surface. Transient water supply systems in Caroline County use both confined and unconfined aquifers. 60 wells supply Caroline County's 58 transient systems. 46 of these are completed in confined aquifers and 14 are completed in unconfined aquifers. The Source Water Assessment Areas for all unconfined wells were delineated by the WSP using EPA approved methods specifically designed for each source.

Potential point sources of contamination within the assessment areas were identified from field inspections and contaminant inventory databases. Common potential sources of contamination can be on-site septic systems and underground storage tanks. The Maryland Office of Planning's 2000 land use map for Caroline County was used to determine which land use was present in each assessment area. Cropland and forest uses were most commonly identified within the assessment areas. Figures showing well locations, assessment areas and potential contaminant sources overlain on aerial photographs were produced for all of the unconfined sources.

For each system, the WSP reviewed water quality results, along with the presence of potential sources of contamination in the individual assessment areas, the integrity of the system's well, and the inherent vulnerability of the aquifer. It was determined that some of the transient systems are susceptible to contamination by nitrates, volatile organic compounds, and microbiological contaminants. Sources using confined aquifers were determined not to be susceptible to these contaminants. Table 2 highlights those systems with nearby sources of volatile organic compounds, and Table 8 summarizes the susceptibility analysis for nitrates and microbiological contaminants. Most of the supply sources were not found to be susceptible to these contaminates.

INTRODUCTION

The Water Supply Program (WSP) has conducted a Source Water Assessment for 58 transient noncommunity water systems in Caroline County (Figure 1). As defined in Maryland's Source Water Assessment Plan (SWAP), a transient noncommunity water system is any noncommunity water system that does not regularly serve at least 25 of the same individuals over 6 months per year. Some good examples of transient water systems include hotels, restaurants, parks, fire departments, and churches. The transient systems must sample for two contaminants. The first is coliform, which is an indicator that other microbiological contaminants could be in the water supply. Systems are required to test for coliform regularly. Additional sampling is required following positive coliform results. The second contaminant is nitrogen in the form of nitrate or nitrite. This SWAP report will focus on these two contaminants, but will address other obvious potential sources of contamination.

Caroline County is located on the middle Eastern Shore portion of the State and is part of the Coastal Plain physiographic province. The Coastal Plain, geologically the youngest province in Maryland, covers nearly half of the State and consists entirely of unconsolidated sediments. All of the transient water supplies obtain their water from wells of various size and depth. Some of these wells are completed in confined aquifers, while others are using unconfined aquifers. For the purpose of this report, depth of well, lithology, and nitrate data were used to determine whether the wells are in confined or unconfined aquifers. An accurate determination of the aquifer type is very important because systems using confined aquifers are generally not vulnerable to contaminants present on the land surface or the shallow aquifer system.

WELL INFORMATION

Well information for each system was obtained from the WSP's database, site visits, well completion reports, sanitary survey inspection reports, and published reports. A total of 60 wells are used by the 58 transient systems assessed in this report. The well tag number, which provides vital well information, was found for 49 of the 60 wells. Table 1 contains a summary of the well information for each system. From the well tag information, ground water appropriation data, and with the nitrate sampling data it was concluded that 46 wells are completed in confined aquifers (Aquifer code "C"). The remaining 14 wells are completed in unconfined aquifers (Aquifer code "U").

Good well location information in the state's database for the Caroline Co. transient systems was marginal at best at the start of this project. It was decided that more accurate well locational information would have to be obtained to determine well contribution areas for systems using unconfined aquifers. Locations of all the unconfined wells were taken with a GPS and differentially corrected to increase the precision of each location.

An important aspect of the susceptibility of a ground water supply is the integrity of the well. The age, construction details and maintenance of the well affect its integrity, and protection against microbiological contamination. Information was found that at least 58

of the 60 wells were completed after 1973, which is when the state adopted the well completion standards for wells. The well completion standards set construction guidelines for well construction including requiring that all wells be grouted.

Site visits to evaluate the condition of the wellheads for the confined system wells were made by the Caroline County Health Department. MDE reviewed the results of the sanitary surveys to determine if the wellhead could be a source of contamination to water supplies using confined aquifers. A review of these sanitary surveys showed that a significant number of confined wellheads needed some type of improvement. Improvements for some systems are as simple as replacing an old one-piece style cap with a new insect-proof two-piece type. Previous testing has shown that insects nesting under well caps fall into wells thereby contaminating the water with coliform organisms. Wellhead improvements should be made at these locations to reduce the risk of positive bacteriological samples.

HYDROGEOLOGY

Caroline County is located in the middle Eastern Shore of Maryland. The entire county is located in the Coastal Plain physiographic province. All of the wells in Caroline County draw water from unconsolidated sediments. Ground water flows through pores between gravel, sand, and silt grains in unconsolidated sedimentary aquifers. Confined aquifers are those formations that are overlain by a confining layer consisting of clay or fine silt (Figure 2). This confining layer allows very little water to travel vertically through it. Unconfined aquifers are those formations that do not have a continuous confining layer above them. Unconfined aquifers are also known as water table aquifers. Precipitation that falls on the ground surface infiltrates directly into the unconfined aquifer in a short time. The unconsolidated sediment formations possess a large quantity of ground water. Transient water systems in Caroline County pump water from one of five aquifers. The first, and the shallowest in Caroline County, is the Quaternary Aquifer. The Quaternary Aquifer is always considered unconfined in Caroline County. The second aquifer is the Frederica Aquifer. This aquifer can be confined or unconfined depending on where in Caroline County the well is drilled. The third aquifer is the Federalsburg Aquifer. All the transient systems drawing from this aquifer are in southern Caroline County where it is confined. The next aquifer is the Cheswold. This aquifer is for the most part is confined across Caroline County the exception is in the northern part of the county. The deepest aquifer that Caroline County transient systems draw from is the Piney Point. The Piney Point Aquifer is always confined in Caroline County.

Quaternary Aquifer (110C)

The Quaternary Formation contains the youngest deposits on the Eastern Shore. Most of this formation is sand and gravel with some layers of silty clay and clay. These clay layers are broken and thin enough that true confining layers are not present. These clay layers do however slow down the percolating water somewhat. The thickness of the Quaternary deposits range from 0 to over 100 feet across Caroline County. This aquifer sand thickness varies somewhat, but

not exclusively on the land topography. The quantity of water available from this aquifer is very high. The water quality of the Quaternary Formation can vary depending on the local soil types and land use. Water quality impacts from farming and high-density development with on site septic systems can lead to elevated nitrate levels and pesticide contamination. Low pH along with high iron could be a concern in some areas where there is more clay and silt. In these areas the percolation rate is slower allowing iron to dissolve in the water (DNR, 1987).

Frederica Aquifer (122F)

The Frederica Aquifer is sandwiched between the shallow Quaternary Aquifer and the Federalsburg Aquifer. The Frederica Aquifer thickness ranges from 0 to over 150 feet thick in southern Caroline County. The Frederica Aquifer never outcrops to the land surface. This aquifer is recharged entirely through water percolating through shallow deposits. This updip area occurs in northern Caroline County. Where the Frederica is confined there is a clay layer above it to retard the downward movement of the local water from entering the aquifer. In areas where the Frederica is unconfined the clay layer is absent and permits water to enter the aquifer through the Quaternary Aquifer. In these unconfined areas the water quality can be affected by local surface activities. The water can be slightly acidic near the updip area in northern Caroline County. As the water travels downdip it has time to dissolve minerals and may need to be treated to use (DNR, 1987).

Federalsburg Aquifer (122E)

The Federalsburg Aquifer lies underneath the Frederica Aquifer. This aquifer is noted for its coarse gray sands. The average thickness of this aquifer is 50 feet. It is believed that in some areas, where the clay layers are thin enough, the Federalsburg, Frederica, and Cheswold Aquifers act as one unit. Overall the water quality of the Federalsburg Aquifer is very good, but dissolved minerals may need to be treated for in the southern part of the county (DNR, 1987).

Cheswold Aquifer (122C)

The Cheswold Aquifer lies underneath the Federalsburg Aquifer. The Cheswold Aquifer can be up to 150 feet thick in some areas. The Cheswold Aquifer, along with the Frederica, Federalsburg, and Piney Point Aquifers, gets deeper as you go to the southeast. The water in this aquifer usually has to be treated before it can be used (DNR, 1987).

Piney Point Aquifer (124E)

The Piney Point Aquifer is the deepest aquifer that the Caroline County transient systems withdraw water from. The Piney Point Aquifer is confined everywhere in Caroline County. The thickness of the aquifer increases as you travel to the southeast. Overall the water is a good source of drinking water, but as with most confined aquifers the chemical characteristics can be undesirable in most locations (DNR, 1987).

SOURCE WATER ASSESSMENT AREA DELINEATION

When Maryland's SWAP was written the method for delineating an assessment area for the unconfined transient systems using <10,000 gpd was not yet determined. An ongoing study between the United States Geologic Survey and MDE assisted MDE in selecting an appropriate method. One of the objectives of this study was to determine ground water flow paths for systems pumping <10000 gpd in unconfined Coastal Plain aquifers. The study concluded that small users, pumping <10,000 gpd, have very little effect on the ambient ground water flow in unconfined aquifers. Using this information MDE created a wedge shape delineation area that will be used for all the transient systems using <10,000 gpd from unconfined aquifers, where the general direction of ground water flow is known. The wedge is based on an annual recharge of 1 ft and ground water flow direction. The wedge shape has an angle of 60 degrees that extends against the ground water flow direction for a length of 1000-ft (Figure 3). The wedge was created to compensate for uncertainties in ground water flow direction and to provide sufficient recharge area to balance a withdraw of 10,000 gpd. A circle with a radius of 1000 ft will be used for all systems that pump from unconfined aquifers where the ground water flow direction is not known. As defined in Maryland's SWAP, no delineation area will be created for the transient systems drawing from confined sources. This is because the monitoring of these wells for their regulated contaminants and geologic protection has established that they are not vulnerable to contamination. The assessment focuses on the integrity of their water supply well(s), see well information section.

POTENTIAL SOURCES OF CONTAMINATION

As stated in the introduction, the focus of this SWAP is on the sources of contamination that would cause a coliform or nitrite/nitrate problem in the unconfined aquifers. Potential sources of contamination can be broken into two types. The first type is point source contamination. Some examples of potential point source contaminants would be feed lots, ground water discharge permits, and underground storage tanks. The second type of potential sources of contaminants is non-point sources. Some types of non-point sources can include general row-crop farming; land application of waste, pesticide and herbicide application, and various land uses. On-site septic systems are often referred to as non-point pollution as they are very common in non-sewered residential areas. Over 300,000 households in Maryland rely on on-site sewerage disposal for domestic wastes. In this project the location of specific septic systems were identified. Therefore they have been included with point sources.

Point Sources

Only 10 potential point sources of contamination have been identified within the 12 source water assessment areas. The WSP has located and mapped 12 on-site septic systems for the 14 unconfined transient systems in Caroline Co. Of the 12 mapped septic systems 8 are located inside the zone of contribution for the system's well. If extensive research and fieldwork were done we would find more systems with on-site septic systems within the zone of contribution for their well. Surprisingly there are no CERCLA sites or ground water discharges within

the SWAP areas. Using the WSP's current underground storage tanks (USTs) geographic information there were 2 SWAP areas with active tanks (Table 2 and 3). Although the Volatile Organic Compounds (VOC), which are the main contaminants of concern with UST's, are not sampled for under the current Transient System Regulations, UST sites were mapped. All of the potential point sources of contaminants in source water assessment areas for unconfined wells are identified in figures 4a-4k. Figure 1 shows where each individual system is located within the county.

Non-Point Sources

The Maryland Office of Planning's (MOP) 1997 Land Use map for Caroline County was used to identify predominant types of land use within the SWAP areas (Figure 5). The two largest proportions of land use for the SWAP areas are cropland and forest at 31.16 and 25.69% respectively. The next land use is low density residential at 22.34%. These three land uses make up 79.19% of the total land area. The next 3 land uses; commercial, wetlands, medium density residential, and water contribute the remaining 20.81% (Figure 6). These types of land use would be expected since most of the systems are located in small population centers in a rural county. Ground water contamination of unconfined aquifers is possible from a high density of multiple on-site systems, or from over fertilization of lawns and cropland.

The Maryland Office of Planning 1996 Caroline County Sewer map shows that only 1.3 percent of the county currently has sewer service (Figure 7). Another 0.5 percent is expected to have sewer service in 3 to 5 years. An additional 0.5 percent is scheduled to receive service in 6 to 10 years. At this time there are no plans to provide any new sewer service to the other 97.7 percent of Caroline County.

WATER QUALITY DATA

Water quality data was reviewed from the Water Supply Program's database for Safe Drinking Water Act (SDWA) contaminants. All data reported is from the water supplied to consumers. 10 out of the 58 Caroline County Transient Systems are known to have some type of water treatment. Table 3 summarizes the treatment methods and the reason for that treatment. Only 5 of the systems use disinfection. If coliforms in the finished water for the other 53 systems are not present, this data can be used to evaluate ground water or source water quality. A review of the monitoring data, Table 5 and Table 6, indicates that the finished water supplied by the transient systems is also meeting health standards.

Nitrogen compounds

Water quality data indicates that the nitrate levels for almost all of these 58 systems are <50% of the SDWA maximum contaminate level (MCL) standard of 10 ppm (Table 6). Table 7 shows all of the nitrate samples that were above 50%

of the MCL for the transient systems in Caroline County. If the result exceeded 10 ppm, which is the MCL for nitrate, it is shown in bold.

None of the systems had nitrite results that exceeded even 50% of the MCL of 1 PPM.

Microbiological Contaminants

All of the transient water suppliers are routinely sampled at least quarterly for microbiological contamination. If this routine sample is positive the system must then resample within 24 hours or as soon as possible. This bacteriological sampling is required by the SDWA (Table 5). 33 of the systems have never had a positive bacteriological sample. 17 systems have had more than 25 percent of their bacteriological samples come back positive since 1996. Surprisingly 16 of the 17 systems are drawing water from confined aquifers. These confined aquifers are free of any living coliform bacteria. This is evidence on how easy it is to contaminate a water supply with total coliform from a fouled ion-exchange unit or during distribution repairs. None of the systems has ever had a positive fecal coliform sample. This is proof that the unconsolidated sediments are very efficient at filtering the percolating water.

SUSCEPTIBILITY ANALYSIS

Wells serving the Caroline County Transient Water Systems all draw their water from wells in unconsolidated sedimentary aquifers. Some of these wells are in confined aquifers and others are in unconfined aquifers. The wells drawing from confined aquifers are protected, if the well is constructed correctly, and are not susceptible to contamination from surface activity. The unconfined aquifer wells are more susceptible to contamination from surface activities. Caroline County's unconsolidated sediments, and soil, provide protection from microbiological contamination as water percolates through the overlying soil and aquifer sediments. The lack of positive fecal samples proves this efficiency. However, nitrate and other water-soluble contaminates can percolate through the soil and contaminate unconfined wells. This is evident in the elevated nitrate levels in a few unconfined wells (see Table 6).

Inorganic Compounds

Nitrate was found to be above 5 ppm or greater in 5 of the 58 systems. The high nitrate levels for Marys Country Store is most likely coming from the large number of on-site septic systems around the well. J & R Country Store had to drill a deeper well because of the extremely high nitrate levels. This system is a good example of how land use affected the shallow aquifer but did not affect the confined aquifer where the nitrate levels are very low. The rest of the systems with elevated nitrate level seem to have a mix of agriculture, residential and commercial land use within their SWAP areas. One or all of the following: farming, multiple on-site septic systems, or some other commercial activity may be the source of the elevated nitrate in these areas. Some of these systems may want to drill deeper wells to alleviate their nitrate problem.

and the former Chicken processing plant.

Microbiological Contaminants

As stated earlier in this report, if there are no well construction problems with a well drawing from a confined aquifer the supply should be safe from microbiological contamination. A review of table 5 indicates that 21 of the 46 confined systems have had at least one positive total coliform sample in the past five years. These 21 systems most likely have or have had at one time a fouled ion-exchange unit. Storage or a distribution problem or repair can also introduce the coliform into the system. Correctly disinfecting the water system is very important after pulling a well pump or completing improvements to the distribution system. Wells may also be physically damaged from a vehicle hitting the well and providing a route for microbial contaminants to enter a well.

The wells drawing from unconfined aquifers could be contaminated from various sources. However, a source of microbiologic contamination would have to be very close to a well because of the high filtration effectiveness of the unconsolidated soils. Maryland regulations require at least 100 feet between on-site septic systems and unconfined wells. This distance is adequate to prevent microbial (bacteriological) contamination from on-site septic systems unless there is a major construction problem in either the well or on-site septic system. If a well was not grouted or if the casing was damaged, a well would be susceptible to surficial sources of pathogens. Surface water can carry contaminants down a well if these conditions are present. Wells that are subject to flooding or wells finished just above grade may need to be sampled following rain events to ensure their integrity. As with the confined systems positive bacteriological samples are most likely from the storage and/or distribution problems.

SUMMARY AND RECOMMENDATIONS FOR PROTECTING WATER SUPPLIES

Key Findings:

This report identified transient water supplies in Caroline County as being more likely to be contaminated by microbial contaminants than nitrate or nitrite nitrogen. Sources of microbial contamination, however, are not believed to be related to ground water contamination, but rather the maintenance of the integrity of the individual water supply system. The report also identified specific areas (SWAP areas) immediately surrounding the transient water supply sources as those that have the greatest potential to influence the quality of the water supply. On-site septic systems were the most commonly identified point source threat in these areas. Agricultural land use was the most common type of land use within the SWAP areas. The recommendations that immediately follow are a result of these key findings.

Recommendations for Individual Water System Owners

- The sanitary integrity of the water supply system must be maintained. Sanitary defects noted in county sanitary surveys should be corrected. All work on the

water system should be performed in a sanitary manner and followed with a one-time disinfection.

- Coliform testing results are a good indication if the sanitary integrity of the system has been affected. All positive results should be investigated to determine the cause of the positive tests. Corrective action should be taken to eliminate the source of the problem. Any sources with confirmed fecal contamination must be rehabilitated or abandoned.
- Installing new two-piece well caps is a good way to reduce potential contamination from insects. Caulking of the electrical conduit is needed to ensure a sanitary seal.
- Any wells in areas subject to flooding or just above grade should be sampled following significant rain events to demonstrate if they are sensitive to flooding impacts.
- Water systems for seasonal facilities should be disinfected and flushed prior to the opening of a new season.
- Wells identified to be at risk to contamination from underground storage tanks (USTs) should be sampled for Volatile Organic Compounds (VOCs). While not a regulatory requirement, it will help protect the health of regular consumers.
- Wells should be protected from damage by vehicles or other machinery. If a well is or was damaged, it should be repaired. All work on wells should be followed by disinfection to avoid contamination of the water supply.
- Owners should keep track of potential changes in land use that might impact their water supply. Letting neighboring property owners and local officials know their concerns can prevent problems from occurring. The individual maps of Figure 4 should be a useful starting point as these identify the specific areas that have the greatest potential to impact the water quality of each water supply.

<u>Recommendations for County Officials</u>

- Continue regular inspection, oversight and testing of transient noncommunity water systems. Ensure that systems correct the cause of positive bacteriological test results.
- Test results show that some systems have a high percentage of positive results. Priority should be placed on those systems that have not corrected the root causes of past positive results.
- Encourage planting of cover crops for fields upgradient of water supplies, particularly if systems are experiencing nitrate levels greater than 50% of the MCL.
- Consider working with systems to collect VOC samples for systems in the Quaternary Aquifer in proximity to USTs (see Tables 3 and 4). Positive results for petroleum compounds should be alerted to MDE's Oil Control Program and Water Supply Program.

Reference

Maryland Department of the Environment. Water Supply Program, 1999, Maryland's Source Water Assessment Plan.

Maryland Department of Natural Resources (DNR), 1987, The Quantity and Natural Quality of Ground Water in Maryland: DNR Water Resources Administration.

Other Sources of Data

Water Appropriation and Use Permits
Caroline County Sanitary Survey Inspection Reports
MDE Water Supply Program (PDWIS) Database
MDE Waste Management Sites Database
Department of Natural Resources Digital Orthophoto Quarter Quadrangles
USGS Topographic 7.5 Minute Quadrangles
Maryland Office of Planning 2000 Caroline County Land Use Map
Maryland Office of Planning 1996 Caroline County Sewer Map

PWSID	System Name	Source #	Plant #	Use Code	Ground Water Appropriation	Aquifer Code	Aquifer Type	Well Tag #	Casing Depth	Well Depth
1051002	WAYNE QUIDAS MIGRANT CAMP # 1	1	1	P	CO1999G020	122E	C	CO880214	148	160
1051003	AMERICAN LEGION POST #29	1	1	P	CO1975G002	124E	C	CO941571	200	400
1051006	CAROLINE COUNTRY CLUB	1	1	P	CO1963G002	124E	C	CO812006	380	400
1051006	CAROLINE COUNTRY CLUB	2	1	S	CO1963G102	122C	C			
1051007	CHANCES COUNTRY STORE	1	1	P	CO2002G013	124E	C			
1051008	CINDYS COUNTRY STORE	1	1	P	CO1999G026	110C	U			
1051010	ED QUIDAS MLC	1	1	P	CO1993G050	124E	C	CO880772	380	380
1051011	HOLIDAY PARK POOL	1	1	P	CO1972G104	122C	C	CO731155	146	166
1051013	LAKE BONNIE MAIN	1	1	P	CO1968G005	122C	U	CO690067	68	180
1051014	WORM MIGRANT LABOR	2	1	P	CO1985G005	122E	C	CO810664	215	230
1051014	WORM MIGRANT LABOR	1	1	P	CO2002G012	124E	C	CO940876	180	400
1051015	MARTINAK STATE PARK	1	1	P	CO1963G003	124E	C	CO710067	339	380
1051018	PHYTO ECOLOGY	1	1	P	CO1985G011	124E	C	CO810780	318	338
1051023	VFW POST 5246	1	1	P	CO1983G006	122E	C	CO810312	248	278
1051024	VFW POST 7937	1	1	P	CO1960G001	124E	C	CO731576	140	386
1051025	WALKERS MARKET	1	1	P	CO1975G001	122C	C	CO730373	142	142
1051027	WAYNE QUIDAS MIGRANT CAMP	1	1	P	CO1986G007	122E	C	CO811068	140	140
1051028	WORM BROTHERS MLC SITE #1	1	1	P	CO1985G004	122E	C	CO810662	212	232
1051029	WORM BROTHERS MLC SITE #2	1	1	P		122E	C	CO810158	171	191
1051030	4-H PARK MAIN WELL	1	1	P	CO1993G068	124E	C	CO880828	180	420
1051031	NINETEENTH HOLE	1	1	P	CO1980G006	124E	C	CO731679	360	360
1051032	CHOPTANK COMMUNITY HEALTH	1	1	P	CO1980G001	122C	C	CO810155	180	195
1051034	COHEES 404 RESTAURANT & LOUNGE	1	1	P	CO2001G012	110C	U			
1051035	ADKINS ARBORETUM	1	1	P		124E	C	CO810240	242	252
1051036	TUCKAHOE ST PARK (LAKE)	1	1	P	CO1982G003	122C	C	CO810211	213	223
1051037	TUCKAHOE STATE PARK (MAINT)	1	1	P	CO1982G003	124E	C	CO730424	251	332
1051039	GOLDSBORO GROCERY	1	1	P	CO1987G017	124E	C			
1051040	GOLDSBORO FIRE COMPANY	1	1	P	CO1985G012	122C	C	CO810781	155	175
1051041	CHOPTANK RIVER YACHT CLUB	1	1	P	CO1980G003	122E	C	CO731665	80	100
1051042	U5 FOODS	1	1	P	CO1985G007	122F	C	CO810718	135	147
1051044	D & B TAVERN	1	1	P	CO2002G010	122F	U			
1051046	MICKEYS TAVERN	1	1	P	CO1986G008	122C	C	CO811074	95	120
1051047	STATE LINE GAS	1	1	P	CO1990G053	122C	C	CO880171	120	145

Table 1, Well information for Caroline County Transient Systems

Type	Within Assessment for	PWSID	Potential Contaminate	Figure Shown
UST*	Marys Country Store	1051058	VOC	Figure 4i
On Site Septic	Marys Country Store	1051058	Bacteria, Viruses, Nitrogen	Figure 4i
On Site Septic	Camp Mardela	1051054	Bacteria, Viruses, Nitrogen	Figure 4g
On Site Septic	Sonny Macs Tavern	1051049	Bacteria, Viruses, Nitrogen	Figure 4e
On Site Septic	D & B Tavern	1051044	Bacteria, Viruses, Nitrogen	Figure 4d
On Site Septic	Cohees 404 Rest. and Lounge	1051034	Bacteria, Viruses, Nitrogen	Figure 4k
On Site Septic	Holiday Park	1051068	Bacteria, Viruses, Nitrogen	Figure 4j
On Site Septic	Holiday Park	1051069	Bacteria, Viruses, Nitrogen	Figure 4j
On Site Septic	Holiday Park	1051070	Bacteria, Viruses, Nitrogen	Figure 4j
UST*	Cindys Country Store	1051008	VOC	Figure 4a

Table 2, Known Potential Contaminant Point Sources Within the Source Water Assessment Areas

*Field visit concluded that USTs were present on site within SWAP area, but current UST locational data showed tank location outside of SWAP.

Location Name	Address	City	Tank Status	Substance	Method Closed
Cindys Country Store	10518 Greensboro Road	Denton	Currently In Use	Gasoline	
Cindys Country Store	10518 Greensboro Road	Denton	Currently In Use	Gasoline	
Cindys Country Store	10518 Greensboro Road	Denton	Currently In Use	Gasoline	

Table 3, Known underground storage tanks within the source water assessment areas.

PWSID	System Name	Plant ID	Known Treatment Methods	Reason for Treatment
1051002	WAYNE QUIDAS MIGRANT CAMP # 1	1	No Treatment	None
1051003	AMERICAN LEGION POST #29	1	Ion Exchange	Inorganics Removal
1051006	CAROLINE COUNTRY CLUB	1	No Treatment	None
1051007	CHANCES COUNTRY STORE	1	No Treatment	None
1051008	CINDYS COUNTRY STORE	1	No Treatment	None
1051010	ED QUIDAS MLC	1	No Treatment	None
1051011	HOLIDAY PARK POOL	1	No Treatment	None
1051013	LAKE BONNIE MAIN	1	No Treatment	None
1051014	WORM MIGRANT LABOR	1	No Treatment	None
1051015	MARTINAK STATE PARK	1	Gas Chlorination, Post	Disinfection
1051018	PHYTO ECOLOGY	1	No Treatment	None
1051023	VFW POST 5246	1	No Treatment	None
1051024	VFW POST 7937	1	No Treatment	None
1051025	WALKERS MARKET	1	No Treatment	None
1051027	WAYNE QUIDAS MIGRANT CAMP	1	No Treatment	None
1051028	WORM BROTHERS MLC SITE #1	1	No Treatment	None
1051029	WORM BROTHERS MLC SITE #2	1	No Treatment	None
1051030	4-H PARK MAIN WELL	1	No Treatment	None
1051031	STUDIO 404	1	No Treatment	None
1051032	CHOPTANK COMMUNITY HEALTH	1	No Treatment	None
1051034	COHEES 404 RESTAURANT & LOUNGE	1	No Treatment	None
1051035	ADKINS ARBORETUM	1	Hypochlorination, Post	Disinfection
1051036	TUCKAHOE ST PARK (LAKE)	1	Hypochlorination, Post	Disinfection
1051037	TUCKAHOE STATE PARK (MAINT)	1	No Treatment	None
1051039	GOLDSBORO GROCERY	1	No Treatment	None
1051040	GOLDSBORO FIRE COMPANY	1	Ion Exchange	Iron Removal
1051041	CHOPTANK RIVER YACHT CLUB	1	No Treatment	None
1051042	U5 FOODS	1	Ion Exchange	Iron Removal
1051044	D & B TAVERN	1	No Treatment	None
1051046	MICKEYS TAVERN	1	No Treatment	None
1051047	STATE LINE GAS	1	Filter, Cartridge	Iron Removal
1051049	SONNY MACS TAVERN	1	No Treatment	None
1051050	MAIN STREET MARKET	1	No Treatment	None
1051051	J & R COUNTRY STORE	1	No Treatment	None
1051054	CAMP MARDELA	1	No Treatment	None
1051055	CAMP TODD GIRL SCOUTS	1	Hypochlorination, Post	Disinfection
1051055	CAMP TODD GIRL SCOUTS	1	Ion Exchange	Iron Removal
1051056	CHOPTANK MARINA	1	No Treatment	None
1051058	MARYS COUNTRY STORE	1	Ultraviolet Radiation	Disinfection
1051059	BETHLEHEM TRADERS	1	No Treatment	None
1051060	BURRSVILLE RURITAN CLUB	1	No Treatment	None
1051061	CAMP MARDELA PAVILLION	1	No Treatment	None
1051062	CAMP TODD CHOPTANK LODGE	1	No Treatment	None
1051063	CAMP TODD MAIN CAMP LAKEVIEW LODGE	1	No Treatment	None
1051064	CAMP TODD WHISPERING PINES	1	No Treatment	None
1051065	CAROLINE COUNTY MOOSE LODGE #2332	1	No Treatment	None
1051066	ELLINGSWORTH MIGRANT CAMP	1	No Treatment	None
1051067	HEALTHY SMILES	1	No Treatment	None
1051068	HOLIDAY PARK SITE 101	1	No Treatment	None
1051069	HOLIDAY PARK SITE 203	1	No Treatment	None

Table 4, Known treatment methods for Caroline County Transient Systems.

PWSID	System Name	Plant ID	Known Treatment Methods	Reason for Treatment
1051070	HOLIDAY PARK SITE 317	1	No Treatment	None
1051071	LAKE BONNIE CAMPSITES EASTSIDE	1	No Treatment	None
1051073	WAYNE QUIDAS MIGRANT WELL # 2 MAIN CAMP	1	No Treatment	None
1051074	BROWN MLC, DANNY	1	No Treatment	None
1051075	COHEE MLC, JOHN JR	1	No Treatment	None
1051076	GREENSBORO QUICK SHOP	1	No Treatment	None
1051077	JOE KRAUS MIGRANT CAMP	1	No Treatment	None
1051078	UPLAND GOLF CLUB - CLUB HOUSE	1	No Treatment	None
1051079	UPLAND GOLF CLUB - COMFORT STATION	1	No Treatment	None

Table 4 (Continued), Known treatment methods for Caroline County Transient Systems.

PWSID	System Name	Total Number of Samples Taken	Number of Positive Bacti. Samples	Percentage of Total Samples Positive	Number of Postive Fecal Samples
1051030	4-H PARK MAIN WELL	25	7	**28**	0
1051035	ADKINS ARBORETUM	7	1	14	0
1051003	AMERICAN LEGION POST #29	9	0	0	0
1051059	BETHLEHEM TRADERS	12	6	**50**	**1**
1051074	BROWN MLC, DANNY	9	5	**56**	0
1051060	BURRSVILLE RURITAN CLUB	5	0	0	0
1051054	CAMP MARDELA	11	0	0	0
1051061	CAMP MARDELA PAVILLION	2	0	0	0
1051062	CAMP TODD CHOPTANK LODGE	11	2	18	0
1051055	CAMP TODD GIRL SCOUTS	28	5	18	0
1051063	CAMP TODD MAIN CAMP LAKEVIEW LODGE	3	0	0	0
1051064	CAMP TODD WHISPERING PINES	3	0	0	0
1051006	CAROLINE COUNTRY CLUB	57	31	**54**	0
1051065	CAROLINE COUNTY MOOSE LODGE #2332	7	1	14	0
1051007	CHANCES COUNTRY STORE	12	0	0	0
1051032	CHOPTANK COMMUNITY HEALTH	20	10	**50**	0
1051056	CHOPTANK MARINA	9	2	22	0
1051041	CHOPTANK RIVER YACHT CLUB	4	0	0	0
1051008	CINDYS COUNTRY STORE	13	0	0	0
1051075	COHEE MLC, JOHN JR	1	0	0	0
1051034	COHEES 404 RESTAURANT & LOUNGE	12	0	0	0
1051044	D & B TAVERN	12	0	0	0
1051010	ED QUIDAS MLC	4	1	**25**	0
1051066	ELLINGSWORTH MIGRANT CAMP	15	6	**40**	0
1051040	GOLDSBORO FIRE COMPANY	6	0	0	0
1051039	GOLDSBORO GROCERY	34	13	**38**	0
1051076	GREENSBORO QUICK SHOP	1	0	0	0
1051067	HEALTHY SMILES	3	0	0	0
1051011	HOLIDAY PARK POOL	18	0	0	0
1051068	HOLIDAY PARK SITE 101	3	0	0	0
1051069	HOLIDAY PARK SITE 203	3	0	0	0
1051070	HOLIDAY PARK SITE 317	3	0	0	0
1051051	J & R COUNTRY STORE	29	17	**59**	0
1051077	JOE KRAUS MIGRANT CAMP	1	0	0	0
1051071	LAKE BONNIE CAMPSITES EASTSIDE	8	2	**25**	0

Table 5, Routine and repeat bacteriological samples for each system since 1996.

PWSID	System Name	Total Number of Samples Taken	Number of Positive Bacti. Samples	Percentage of Total Samples Positive	Number of Postive Fecal Samples
1051013	LAKE BONNIE MAIN	8	0	0	0
1051050	MAIN STREET MARKET	11	1	9	0
1051015	MARTINAK STATE PARK	7	0	0	0
1051058	MARYS COUNTRY STORE	15	1	7	0
1051046	MICKEYS TAVERN	4	0	0	0
1051018	PHYTO ECOLOGY	5	0	0	0
1051049	SONNY MACS TAVERN	15	6	**40**	0
1051047	STATE LINE GAS	10	3	**30**	0
1051031	STUDIO 404	9	1	11	0
1051036	TUCKAHOE ST PARK (LAKE)	7	0	0	0
1051037	TUCKAHOE STATE PARK (MAINT)	12	3	**25**	0
1051042	U5 FOODS	18	7	**39**	0
1051078	UPLAND GOLF CLUB - CLUB HOUSE	9	5	**56**	0
1051079	UPLAND GOLF CLUB - COMFORT STATION	1	0	0	0
1051023	VFW POST 5246	4	0	0	0
1051024	VFW POST 7937	3	0	0	0
1051025	WALKERS MARKET	3	0	0	0
1051027	WAYNE QUIDAS MIGRANT CAMP	34	20	**59**	0
1051002	WAYNE QUIDAS MIGRANT CAMP # 1	7	0	0	0
1051073	WAYNE QUIDAS MIGRANT WELL # 2 MAIN CAMP	3	0	0	0
1051028	WORM BROTHERS MLC SITE #1	4	1	**25**	0
1051029	WORM BROTHERS MLC SITE #2	2	0	0	0
1051014	WORM MIGRANT LABOR	5	0	0	0

Table 5 (Continued), Routine and repeat bacteriological samples for each system since 1996.

PWSID	System Name	Total # of Nitrate Samples	Number of Nitrate Samples		Total # of Nitrite Samples	Number of Nitrite Samples > 50%
			> 1 ppm	> 50% MCL		
1051071	LAKE BONNIE CAMPSITES EASTSIDE	3	0	0	2	0
1051013	LAKE BONNIE MAIN	6	3	**3**	4	0
1051050	MAIN STREET MARKET	3	3	0	2	0
1051015	MARTINAK STATE PARK	3	0	0	3	0
1051058	MARYS COUNTRY STORE	3	2	**2**	3	0
1051046	MICKEYS TAVERN	4	0	0	4	0
1051018	PHYTO ECOLOGY	5	0	0	4	0
1051049	SONNY MACS TAVERN	4	2	0	2	0
1051047	STATE LINE GAS	3	0	0	2	0
1051031	STUDIO 404	3	0	0	2	0
1051036	TUCKAHOE ST PARK (LAKE)	6	0	0	5	0
1051037	TUCKAHOE STATE PARK (MAINT)	6	0	0	4	0
1051042	U5 FOODS	3	0	0	3	0
1051078	UPLAND GOLF CLUB - CLUB HOUSE	1	0	0	1	0
1051079	UPLAND GOLF CLUB - COMFORT STATION	1	0	0	0	0
1051023	VFW POST 5246	4	0	0	4	0
1051024	VFW POST 7937	5	0	0	5	0
1051025	WALKERS MARKET	3	0	0	3	0
1051027	WAYNE QUIDAS MIGRANT CAMP	10	0	0	5	0
1051002	WAYNE QUIDAS MIGRANT CAMP # 1	2	0	0	2	0
1051073	WAYNE QUIDAS MIGRANT WELL # 2 MAIN CAMP	2	0	0	1	0
1051028	WORM BROTHERS MLC SITE #1	5	0	0	2	0
1051029	WORM BROTHERS MLC SITE #2	3	0	0	1	0
1051014	WORM MIGRANT LABOR	2	0	0	2	0

Table 6 (Continued), Total IOC water quality samples collected for transient systems.

PWSID	System Name	Plant ID	Contaminant Name	MCL (PPM)	Sample Date	Result (PPM)
1051034	COHEES 404 RESTAURANT & LOUNGE	1	1040	10	6-Sep-01	8.2
1051034	COHEES 404 RESTAURANT & LOUNGE	1	1040	10	6-Jul-00	7.8
1051034	COHEES 404 RESTAURANT & LOUNGE	1	1040	10	15-Nov-99	7.5
1051044	D & B TAVERN	1	1040	10	21-Aug-01	6.64
1051044	D & B TAVERN	1	1040	10	12-Dec-00	6.7
1051051	J & R COUNTRY STORE	1	1040	10	5-Sep-01	**23.7**
1051051	J & R COUNTRY STORE	1	1040	10	12-Dec-00	**15.3**
1051051	J & R COUNTRY STORE	1	1040	10	12-Dec-00	**15.3**
1051013	LAKE BONNIE MAIN	1	1040	10	25-Apr-01	7.5
1051013	LAKE BONNIE MAIN	1	1040	10	12-Jun-00	8.7
1051013	LAKE BONNIE MAIN	1	1040	10	1-Apr-02	7.4
1051058	MARYS COUNTRY STORE	1	1040	10	30-Aug-01	**15.6**
1051058	MARYS COUNTRY STORE	1	1040	10	19-Sep-00	**17.3**

Table 7, Nitrate results greater than 50% of the MCL of 10 PPM.

PWSID	System Name	Source #	Aquifer Type	Nitrate Susceptibility			Microbiological Susceptibility			
				Detected in Signif. Amounts*	Source Present in SWAP	Suscep-tible	Detected in Signif. Amounts**	Source Present in SWAP	Is Well Integrity a Factor	Suscep-tible
1051008	CINDYS COUNTRY STORE	1	U	NO	NO	NO	NO	NO	NO	NO
1051013	LAKE BONNIE MAIN	1	U	YES	NO	**YES**	NO	NO	NO	NO
1051034	COHEES 404 RESTAURANT & LOUNGE	1	U	YES	YES	**YES**	NO	YES	NO	NO
1051044	D & B TAVERN	1	U	YES	YES	**YES**	NO	YES	NO	NO
1051049	SONNY MACS TAVERN	1	U	NO	YES	NO	YES	YES	NO	**YES**
1051050	MAIN STREET MARKET	1	U	NO	NO	NO	NO	NO	NO	NO
1051054	CAMP MARDELA	1	U	NO	YES	NO	NO	YES	NO	NO
1051055	CAMP TODD GIRL SCOUTS	1	U	NO	NO	NO	NO	NO	NO	NO
1051058	MARYS COUNTRY STORE	1	U	YES	YES	**YES**	NO	YES	NO	NO
1051064	CAMP TODD WHISPERING PINES	1	U	NO	NO	NO	NO	NO	NO	NO
1051068	HOLIDAY PARK SITE 101	1	U	NO	YES	NO	NO	YES	NO	NO
1051069	HOLIDAY PARK SITE 203	1	U	NO	YES	NO	NO	YES	NO	NO
1051070	HOLIDAY PARK SITE 317	1	U	NO	YES	NO	NO	YES	NO	NO
1051075	COHEE MLC, JOHN JR	1	U	NO	NO	NO	NO	NO	NO	NO

Table 8, Summary of Susceptibility of Transient Water Supplies to Nitrate, and Microbiological Organisms.

* Nitrate detected in significant amounts: Any system that had a sample >50% of the MCL, of 10 ppm, in the last 5 years.

** Microbiological organisms detected in significant amounts: Any system whose monitoring results were positive >25% of the time in the last 5 years.

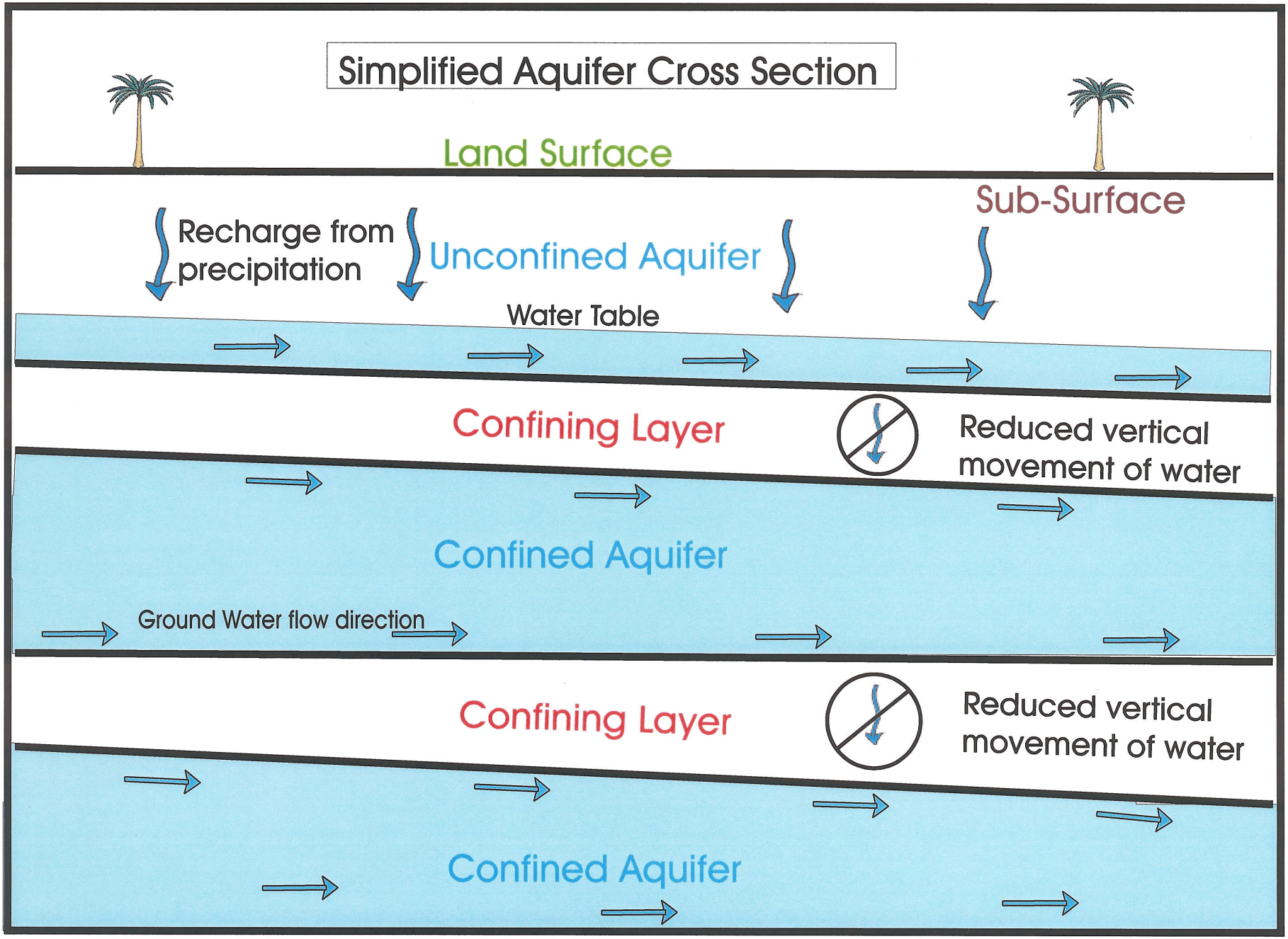
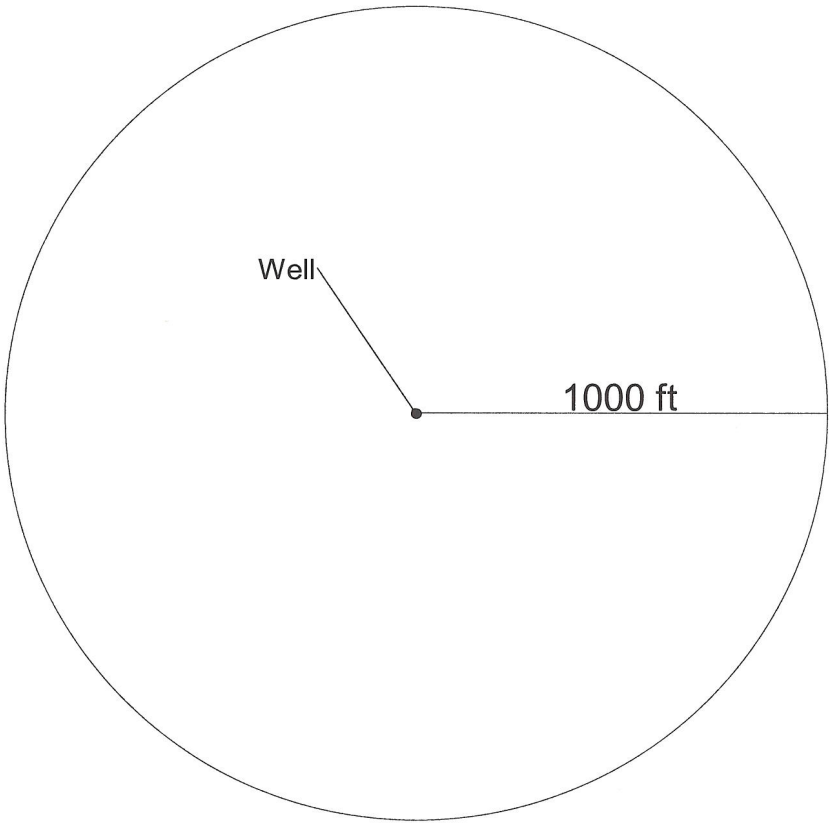

Simplified Aquifer Cross Section
Land Surface
Sub-Surface
Recharge from precipitation
Unconfined Aquifer
Water Table
Confining Layer
Reduced vertical movement of water
Confined Aquifer
Ground Water flow direction
Confining Layer
Reduced vertical movement of water
Confined Aquifer

Figure 2

Circle and Wedge Delineation Areas



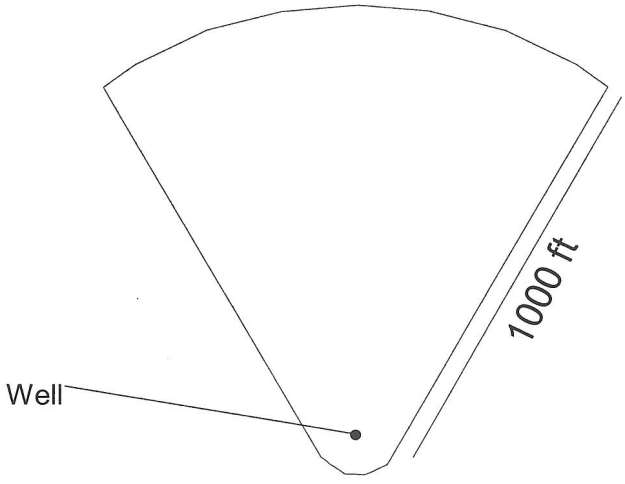


Figure 3

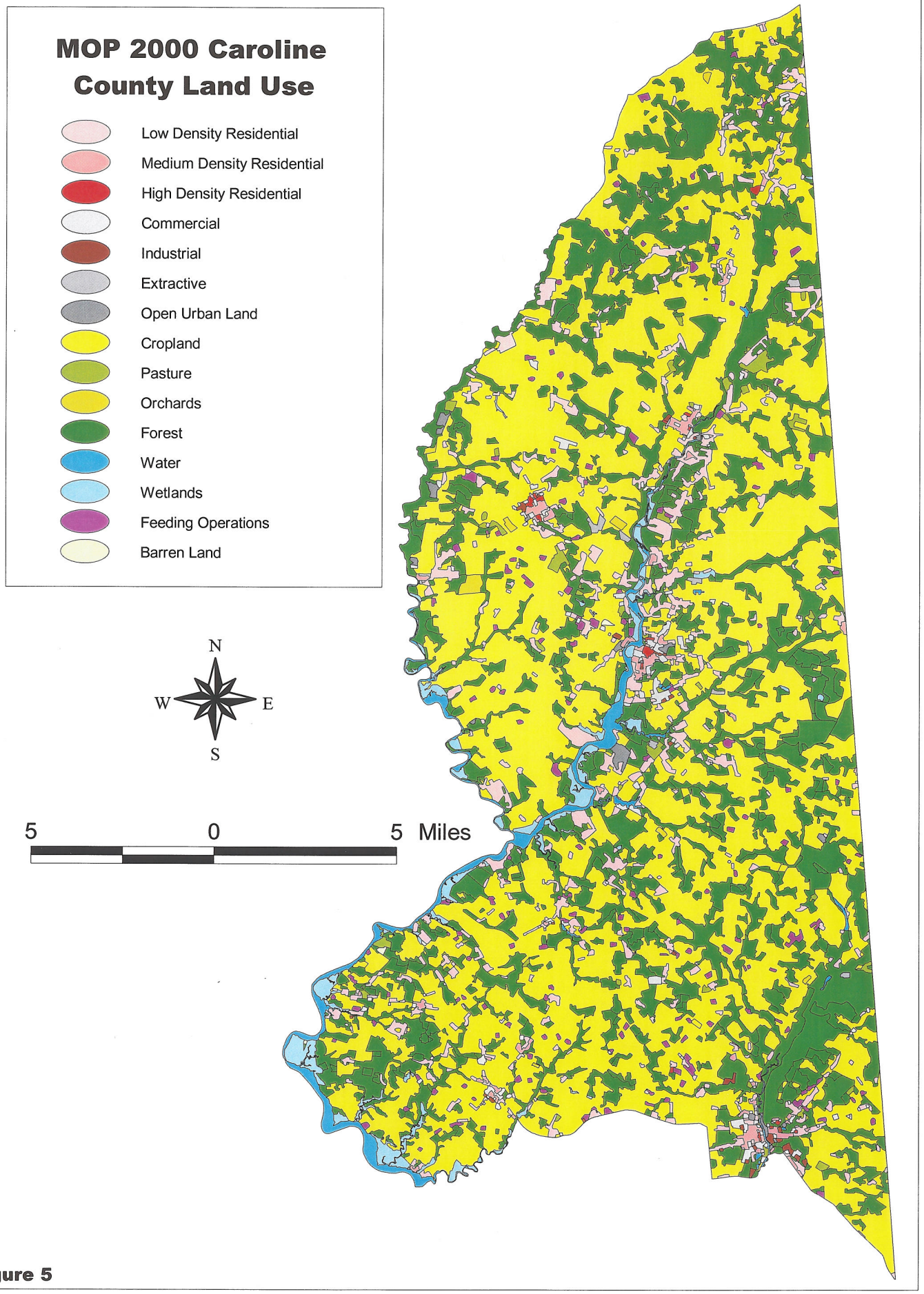

MOP 2000 Caroline County Land Use
Low Density Residential
Medium Density Residential
High Density Residential
Commercial
Industrial
Extractive
Open Urban Land
Cropland
Pasture
Orchards
Forest
Water
Wetlands
Feeding Operations
Barren Land
N
W
E
S
5
0
5 Miles

Figure 5

Land Use Type	Land Use Code	Counts in SWAP	Acres in SWAP	% of Total Area
Cropland	21	10	75.46	31.16
Forest	41, 43	6	62.21	25.69
Low Density Residential	11	7	54.10	22.34
Commercial	14, 16	5	26.16	10.80
Wetlands	60	1	15.93	6.58
Medium Density Residential	12	2	7.44	3.07
Water	50	1	0.89	0.37
	Totals	32	242.19	100

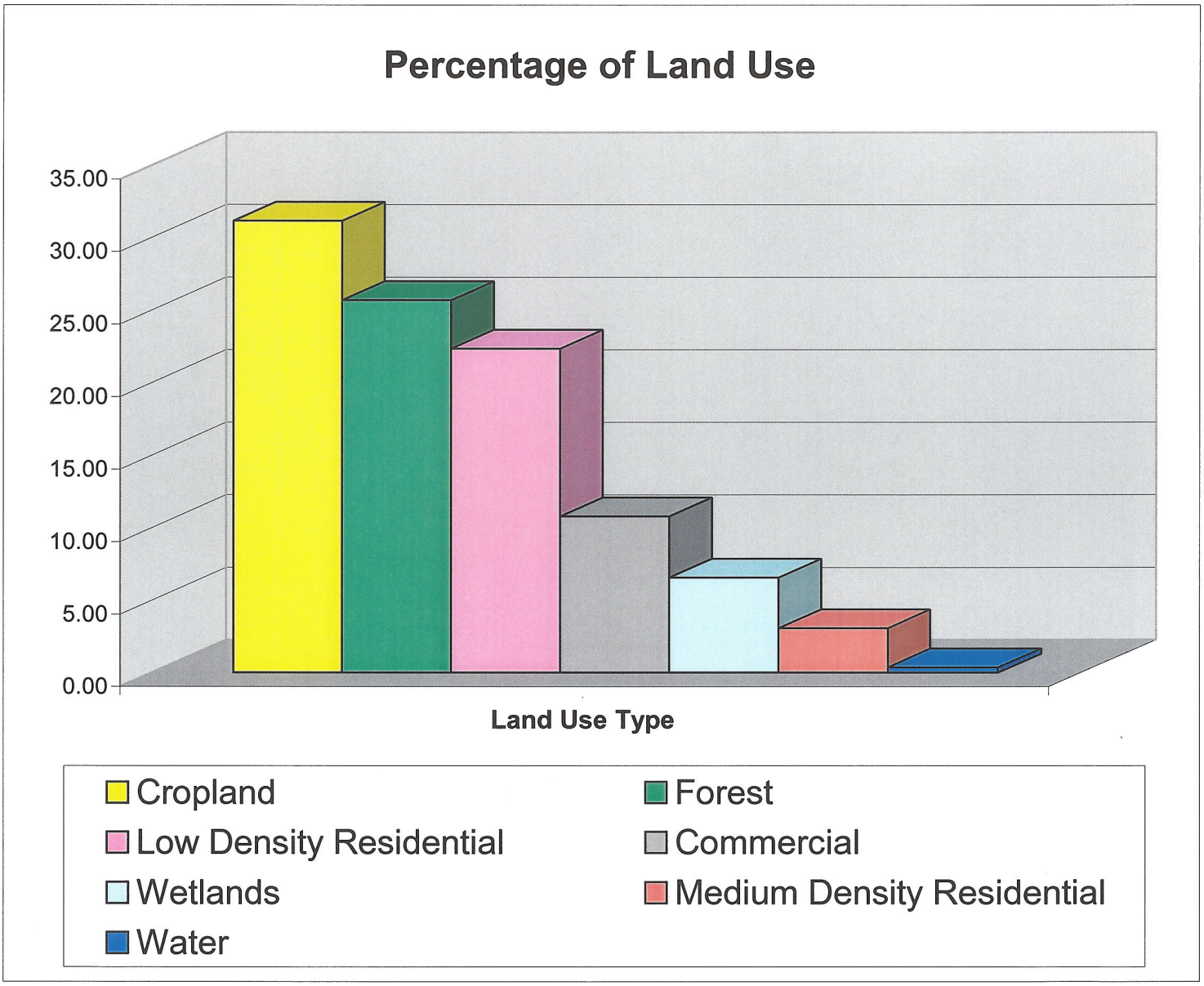


Figure 6

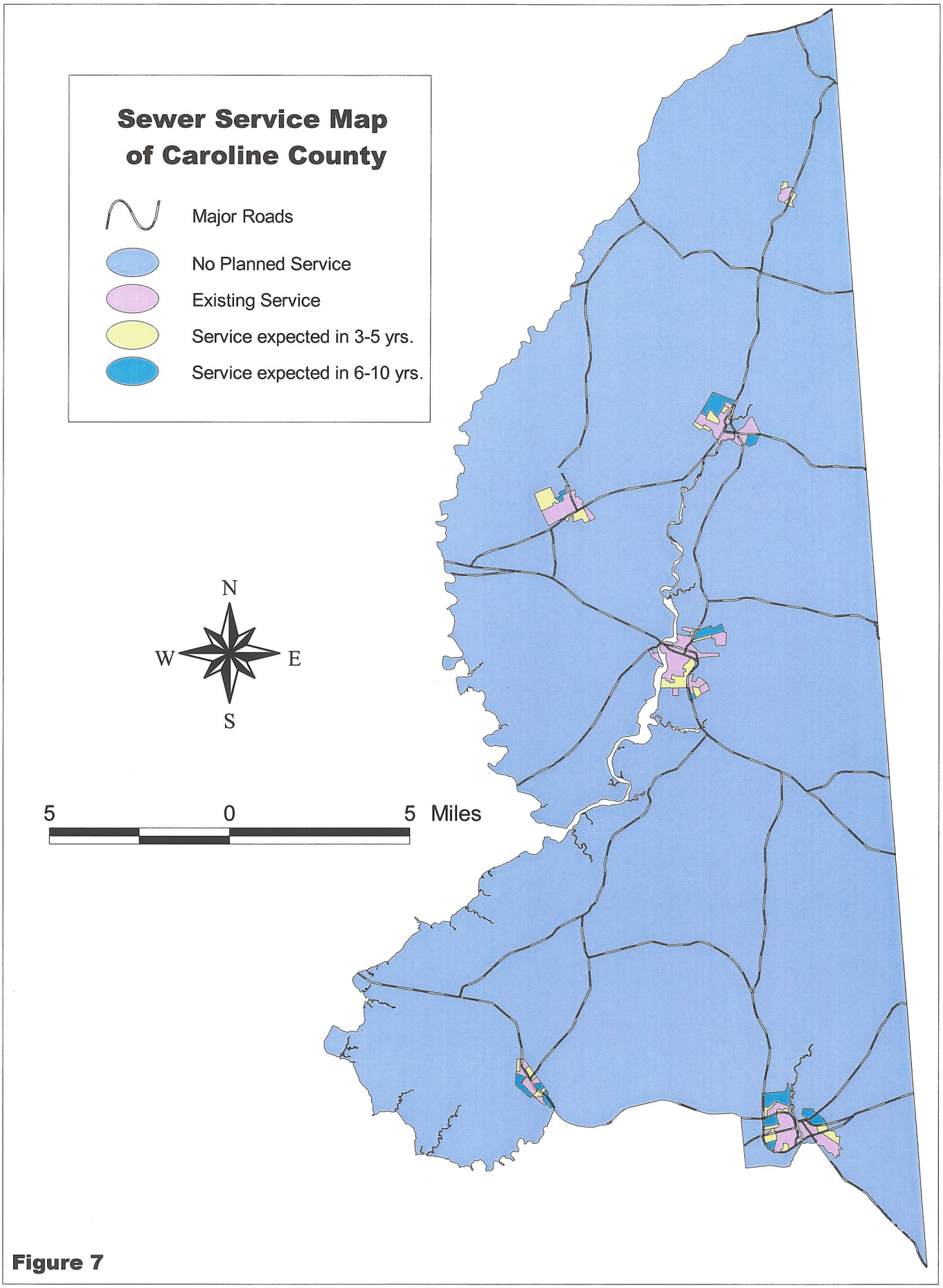

Sewer Service Map
of Caroline County
Major Roads
No Planned Service
Existing Service
Service expected in 3-5 yrs.
Service expected in 6-10 yrs.
N
W
E
S
5
0
5 Miles

Figure 7