Orange County, Virginia

Orange County Water Supply Plan

Report
Draft Copy

Wiley|Wilson Comm. No. 206060.00

July 6, 2007
Revised April 29, 2009

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Appendices

As a direct result of the drought of 1998 to 2002, the Commonwealth of Virginia adopted 9 VAC 25-780, "Local and Regional Water Supply Planning Regulations." These Regulations became effective November 2, 2005. The Regulations require that each jurisdiction in the State prepare and submit to the State a local water supply plan to be included in the State Water Supply Plan, upon approval. In addition, the State is currently in the process of revising the permit regulations for future water supply projects 9 VAC 25-210, "Virginia Water Protection Permit Programs." These two Regulations will be the first two steps in having a water supply project approved at the State level prior to obtaining a federal permit from the Corps of Engineers under the 401 and 404 combined permitting process.

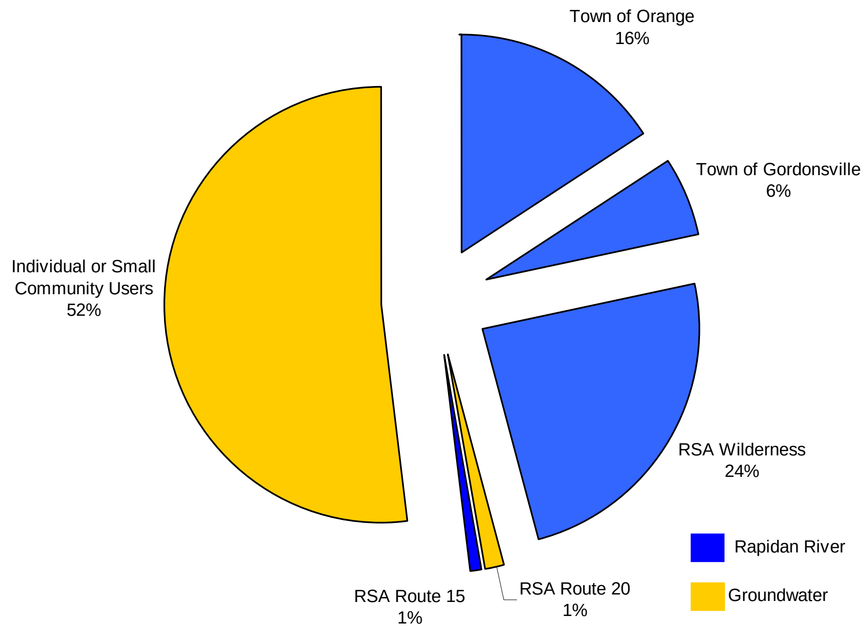
In order to comply with the water supply planning regulation and to begin the process of developing water supply solutions, Orange County initiated a regional water supply plan for the County; the Towns of Orange and Gordonsville; and the Rapidan Service Authority (RSA). To meet the regulation, the Orange County Water Supply Plan was assembled in two technical memorandums and affiliated appendices. Technical Memorandum No. 1 and Technical Memorandum No. 2, along with the Appendices to Technical Memorandum No. 2, serve as Orange County's Water Supply Plan in accordance with 9 VAC 25-780, "Local and Regional Water Supply Planning Regulations."

Orange County was greatly impacted by the drought of 1998 to 2002. During this most recent drought, flows in the Rapidan River reached their lowest recorded flows since 1930. This was critical because approximately half of the County relies on public water supply. Ninety-nine percent of this public water supply is obtained from the Rapidan River. The Town of Orange and the Rapidan Service Authority (RSA) both have raw water intakes on the Rapidan River. The Town of Orange intake and water treatment plant provides public water to the Town of Orange, the Town of Gordonsville, and the US 15 Corridor between the two towns. The RSA Wilderness intake and water treatment plant provides public water to the citizens in the Wilderness area of Orange County. The only public water supply not utilizing the Rapidan River is the RSA Route 20 system groundwater system, which accounts for the remaining 1 percent of public supply.

Groundwater from private wells provides the other half of the Orange County residents with water supply. Based on the highly variable nature of the fractured bedrock aquifers in the area, the accumulated existing well data shows a wide range of yields and well depths.

Figure E-1 shows a population breakdown of where Orange County residents currently get their water.

Figure E-1
Orange County Water Use in 2000



The drought of 1998 to 2002 peaked in the summer of 2002, resulting in record low stream flows and thousands of individual private well failures. During September of 2002, the Town of Orange was on the brink of a water shortage emergency and was developing emergency plans to pipe water from about 20 miles, near Culpeper, using a surface-laid pipeline.

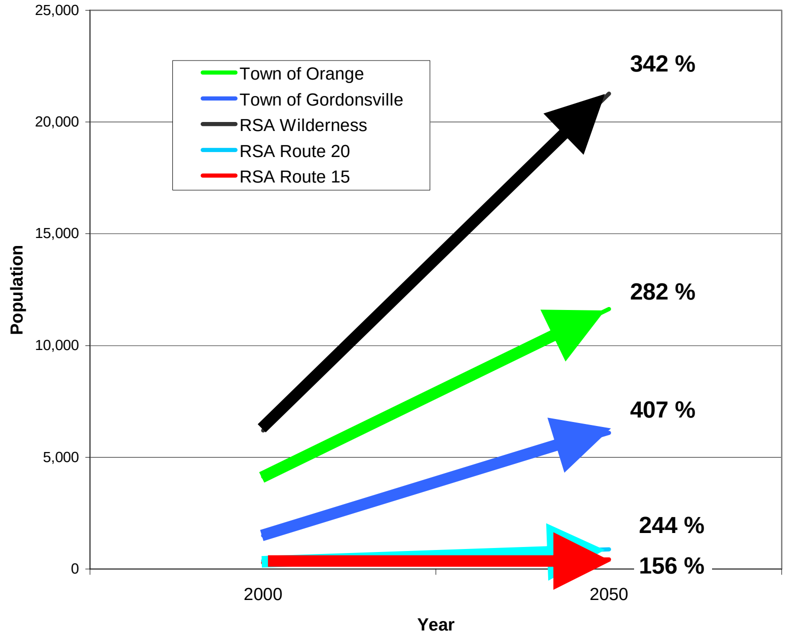
This was a dramatic reminder that water supply in Orange County is not unlimited, and that careful management is needed to ensure water availability for future generations. This is especially true considering the reoccurring nature of droughts in Virginia. The recent historical record shows that droughts occur approximately once every 20 to 30 years.

The quantity of water in the Rapidan River and the quantity of groundwater in Orange County are relatively constant, but the number of people relying on these sources of supply will continue to grow.

STATEMENT OF NEED

As the population increases in Orange County, droughts will only exacerbate the competition for water resources. Population projections to the year 2050, with the percent increase for each of the water system's service areas, are summarized in Figure E-2. Detailed population projections for each demand center are found in Technical Memorandum No. 2

Figure E-2
2050 Population Projection with Percent Increase



Based upon the current contractual agreements between the Towns and the RSA, some of the public water systems in Orange County could experience periods of water shortage as early as 2010. Although the duration and frequency of these water shortages cannot be accurately predicted, they will most likely first occur during the late summer and early fall, when stream flows and groundwater levels are typically at their lowest. All residents could be impacted, even though roughly half of the residents depend on the Rapidan River as a supply and the other half depend on groundwater. Dry wells could force some residents to purchase and transport containers of water for basic domestic use, while residents on public water systems in the County could likely face mandatory restrictions that will limit water use.

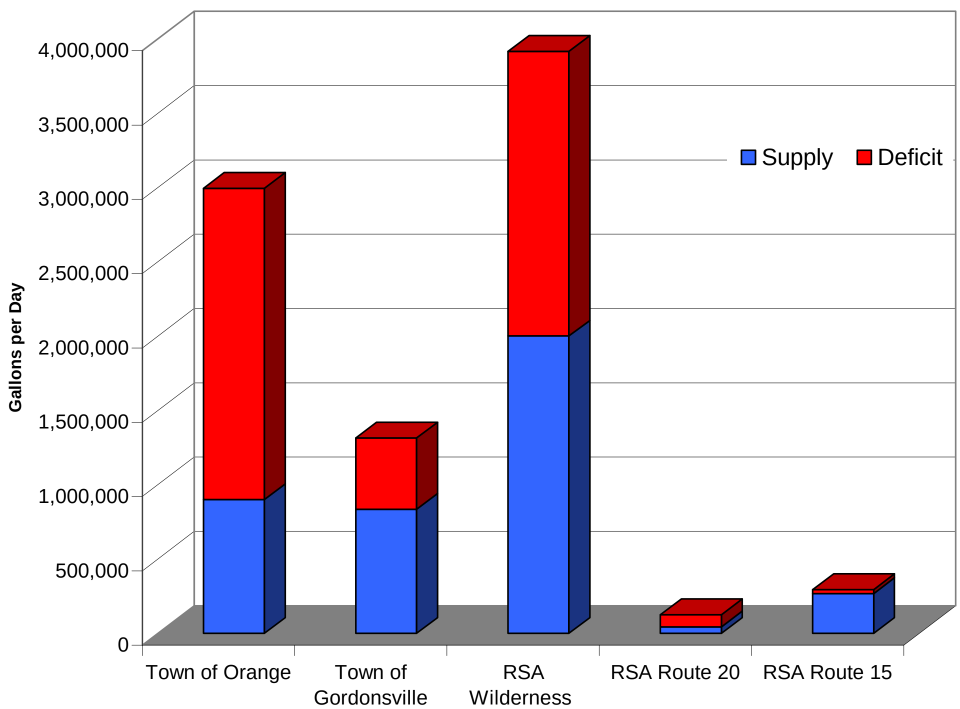
The potential for water shortages in Orange County is caused by the following two primary conditions:

- **Increased Growth**
  All of the large water demand centers in Orange County that have established public utilities will experience, on average, a 300 percent population growth from 2000 to 2050. This population surge will lead to a proportional increase in water demand.

- **No Growth in Water Supply**
  There are no planned increases in available water supply rates for Orange County.

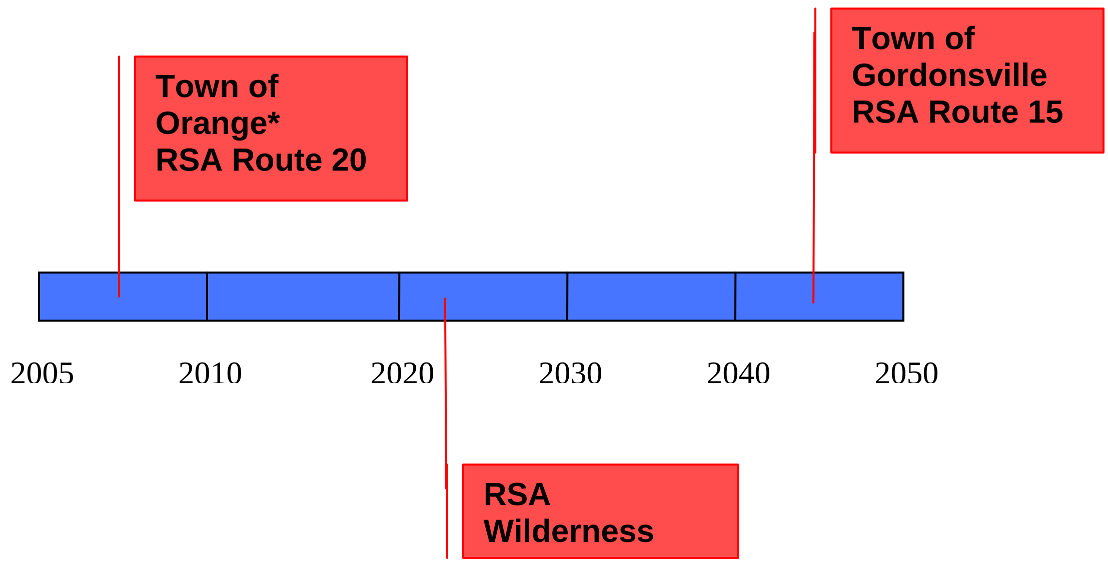
Based on the present water supply and the projected maximum day demands in 2050, Figure E-3 shows the amount of water deficits for all of the developed water systems. For example, the Figure shows that the Town of Orange has an overall demand in 2050 of 2.9 MGD with a supply of 0.9 MGD, which means there is a deficit of 2.0 MGD. The total maximum day demand deficit for the County's public water supply will be 4.61 MGD by the year 2050.

Figure E-3
2050 Projected Water Demand with Available Supply and Deficit



The existing water supply sources will not be able to sustain the anticipated water demands starting in the years shown in Figure E-4. For example, the RSA Wilderness system could expect a shortfall, or deficit, between 2020 and 2025, provided the source remains the Rapidan River intake. The Figure shows that the Town of Orange and RSA Route 20 will experience water shortages before other areas, provided the sources remain the Town of Orange intake and the Route 20 groundwater well.

Figure E-4
Water Supply Shortage Timeline



* Town of Orange realizes shortfall if RSA RT 15 system uses their contracted allotment.

Both Figures E-3 and E-4 show a clear statement of need for additional water supply alternatives for Orange County. Without the identification and development of new sources, water shortages will occur in Orange County.

WHAT ARE THE ALTERNATIVES?

This water supply plan attempted to identify and evaluate all feasible water supply alternatives to address the future water shortage in Orange County:

- Development of new surface water sources.
- Development of new groundwater sources.
- Construction of new raw water storage.
- Regional water supply approaches.
- Interconnections within and outside the County.
- Water demand management alternatives.

These alternatives were evaluated qualitatively and quantitatively, using a two-level screening process. The most favorable water supply alternatives remaining after the screening process are listed in the Recommendations found at the end of this Executive Summary.

PLANNING

Because the planning, permitting, and design of water supply projects is often a time-consuming process, Orange County should proceed immediately with the next steps in the process. The County should consider a three-pronged approach to address the future water deficits consisting of the simultaneous initiation of:

- Increasing the permitted withdrawal of the Wilderness Intake.
- Additional groundwater investigations.
- A reservoir site study to further investigate the following reservoir sites:
    - Unnamed Tributary above Wilderness Run.
    - Mountain Run.
    - Mine Run.
    - Poplar Run.
    - Poplar - Laurel Run.
    - Shotgun Hill Run.

The process of increasing the permitted withdrawal at the Wilderness Intake has already begun. Should additional groundwater investigations prove groundwater to be a viable alternative, those sources could optimistically be developed in three years, depending on permitting. While the Wilderness Intake withdrawal increase is being permitted and groundwater is being further explored, the County should proceed with further evaluation and permitting of the potential reservoir sites. This is because reservoir projects have traditionally taken a long time to develop. A reservoir site in Orange County could optimistically be developed in 12 years.

More detailed planning scenarios and planning schedules are presented in Technical Memorandum No. 2 and its Appendices.

RECOMMENDATIONS

Orange County and its plan participants should consider the following recommendations:

- **Groundwater Development**
  The Town of Orange, Town of Gordonsville, and RSA should continue to investigate new groundwater sources for the water demand centers to confirm quantity and quality

available. Further investigation will allow the cost of transport and treatment to be further refined. The next step in this process is Phase II – Geophysical Surveys.

- **New Raw Water Reservoir**
  Since permitting of a water supply reservoir will be more challenging and will likely require more time and resources to complete, Orange County and interested stakeholders should begin developing a new water source. Permitting requirements for new raw water reservoirs are significant, with much uncertainty as to the time and resources needed to complete the process successfully. Recent experiences of other Virginia communities attempting to permit new reservoir supplies have taken 15 to 20 years. The next step in this process is a reservoir site study to shorten the list of reservoir sites from six to one.

- **Increase RSA Wilderness Intake Permit**
  RSA should pursue a permit modification for its Wilderness permit to allow 3.0 MGD withdrawal based on this study's analysis of the Rapidan River. RSA has already submitted an application to the Virginia Department of Environmental Quality requesting a permitted withdrawal of 3.0 MGD. A plant expansion study will be needed, outlining options for increasing the plant capacity to 3.0 MGD.

- **Drought Contingency Plans**
  The Town of Orange and Town of Gordonsville have Drought Ordinances, and the Rapidan Service Authority has a Drought Water Conservation Plan for its Wilderness Water System. The Town of Orange-RSA Route 15-Gordonsville combined water systems should have one drought contingency plan, since the raw water source for the combined system is the Rapidan River. The RSA Route 20 and RSA Wilderness systems can have independent drought contingency plans, as they use different sources. The water supply plan participants should consider a stakeholder-led committee (Orange County Drought Committee), as proposed in the Drought chapter. It is recommended that the Drought Committee coordinate an effective countywide public education approach to water conservation and drought management.

- **Water Conservation and Demand Management**
  Water conservation and demand management programs are needed to sustain the existing water supplies in time of drought, as well as to reduce the quantity of additional supply needed. Initial implementation of these programs results in significant benefits in some systems; however, the magnitude of expected benefits is unique to each water system.

- **Unaccounted for Water Losses**
  Each water system in the planning area should compare water production and water sold on an annual basis to account for system losses.

- **Future Alternatives**
  The County, Towns, and Service Authority should remain open to consideration of the following alternatives:

  - **Interconnections with Neighboring Utilities.** As a parallel activity to the preliminary steps of the groundwater and surface water development, the following should be conducted:

    - Discussions with Louisa County and Fluvanna County regarding purchase of finished water to augment the Town of Orange and Town of Gordonsville.
    - Discussions with Spotsylvania County regarding purchase of finished water to augment the Wilderness supply or the development of a joint raw water source.

  - **Water Reuse.** This is an excellent option for reducing non-potable agricultural and industrial water demands. However, to be an economically viable option, the use of the reclaimed water needs to be located near a wastewater treatment plant that produces highly treated water. Once the state regulation is finalized and use of reclaimed water becomes an accepted practice in Virginia, the costs and benefits of the Water Reuse alternative can be better quantified.

With increasing needs and limited existing supplies, the potential for future water shortages exists. Orange County has already experienced a very real water shortage caused by the recent drought that peaked in the summer of 2002. While the water shortage potential is very real, that does not need to be Orange County's destiny. The evaluations conducted in this water supply plan will serve to assist the community in securing additional reliable sources of water supply to ensure that adequate and safe drinking water is available to all citizens of the County while serving to encourage, promote, and protect all other beneficial uses of Orange County's and the Commonwealth's water resources.

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TECHNICAL MEMORANDUM NUMBER 1

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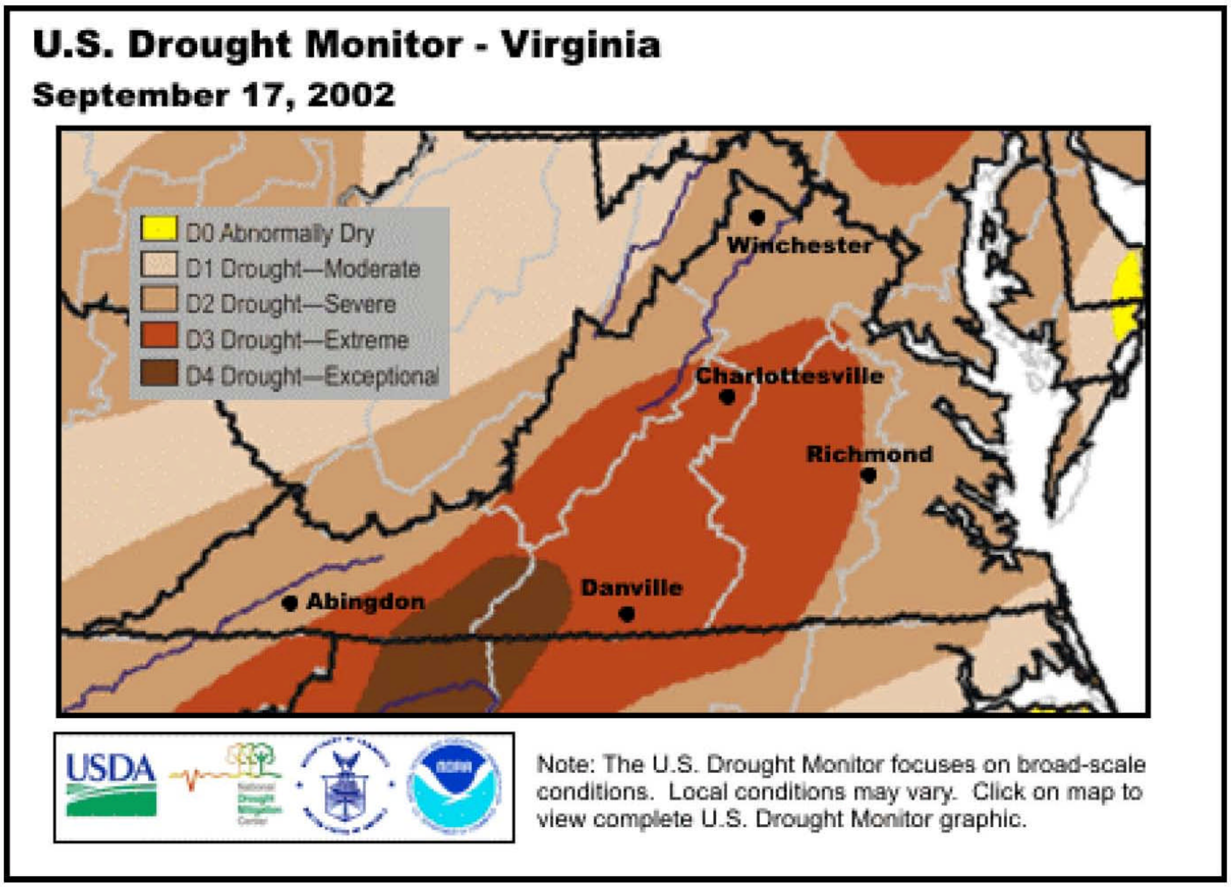
A. INTRODUCTION AND PURPOSE

In the summer of 2002, streamflow in the Rapidan River near the Town of Orange was very low due to an extended drought in the area. This is important because the Rapidan River is the raw water source for the Town of Orange, the Town of Gordonsville, and portions of Orange County around and between the two towns. The Rapidan River is also the raw water source for another public water system located in the eastern end of Orange County: the Rapidan Service Authority Wilderness System. Orange County and the two towns were not the only victims of the drought; most of Virginia was experiencing a drought of some magnitude, as shown in Figure A-1, and many communities had to modify their water use practices until the drought ended.

Figure A-1
2002 U.S. Drought Monitor - Virginia



A result of so many of Virginia's communities experiencing difficulties during the drought was the formation of the Water Policy Technical Advisory Committee (TAC). The goal of the TAC was to develop a water supply planning initiative to improve the Commonwealth's water resources planning activities to meet future water demands in an environmentally sound manner. The TAC was comprised of people representing conservation interests, agricultural, trade organizations, water suppliers, power generation, regional interests, local and regional managers, State and Federal agencies, academic interests, and recreation. The goals of the TAC were: 1) Develop a preliminary state water supply plan and, 2) Draft state regulatory criteria for local and regional plans. These goals were met and resulted in water supply planning regulations being adopted in autumn 2005.

The State Water Control Board adopted 9 VAC 25-780 "Local and Regional Water Supply Planning Regulations," effective November 2, 2005. These regulations require that each jurisdiction in the state prepare and submit to the State a local water supply plan to be included in the State Water Supply Plan, upon approval. In addition, the State is currently in the process of revising the permit regulations for future water supply projects 9 VAC 25-210 "Virginia Water Protection Permit Programs," which will be the second step in having a water supply project approved at the State level prior to obtaining a federal permit from the Corps of Engineers under the 401 and 404 combined permitting process.

In anticipation of the final regulation, Orange County began the process of procuring a consultant to prepare a regional water supply plan for the County, the Towns of Orange and Gordonsville, and the Rapidan Service Authority. The results of the procurement process was that Orange County entered into a contract with the Wiley & Wilson/Black & Veatch team to develop a water supply plan for the County that would not only meet the regulation, but provide the vehicle towards which to begin development of a water supply project. Other members of the consultant team include Emery & Garrett Groundwater, Inc., for groundwater issues, and McguireWoods, LLP for legal review.

The contract for development of the Orange County Water Supply Plan is structured around four main task series that correspond with elements of the water supply regulation, as shown in Table A-1. This Technical Memorandum No. 1 will present findings of the Task Series1, 2 and 3. Technical Memorandum No. 2 will be prepared upon completion of Task Series 4.

Table A-1
Water Supply Plan Tasks

Task Series	Description	Complies with Regulation Sections
1	Data Collection and Review	9 VAC 25-780-70, 80, and 90
2	Evaluation of Existing Water Supply Conditions	9 VAC 25-780-70, 80, and 90
3	Evaluation of Population and Land Use	9 VAC 25-780-100
4	Analysis of Water Supply Needs	9 VAC 25-780-110, 120, and 130

The findings of the first three task series will be presented in the following sections of this Technical Memorandum No. 1.

B. AVAILABLE ENVIRONMENTAL RESOURCE INFORMATION

In accordance with 9 VAC 25-780-90 of the Local and Regional Water Supply Planning Regulation, the regional water supply plan shall include a description of existing natural resource and environmental resource information that may affect existing water resources or may impact the development of new water resources. The available environmental resource information gathered for the Orange County Water Supply Plan is as follows:

B.1 GEOLOGIC

The geology of Orange County is shown in Figure B-1 with the map legend shown in Figure B-2[i.] The underlying rocks of Orange County affect the potential for development of groundwater and can affect the development of surface water impoundments in certain areas. Groundwater potential will be addressed in Technical Memorandum No. 2.

Surface water reservoirs, whether in-stream or off-stream, may be more difficult to develop in areas where the geology or soils are not capable of retaining stored water. For instance, development of reservoirs in Karst geology would be difficult due to the potential for migration of the stored water into the cracks and fissures in the rock. Luckily, Orange County has no known areas of Karst geology, though limestone is present in very small areas along the Mountain Run Fault. Shallow bedrock depths would also limit the potential of an area for development as an off-stream reservoir due to the inability to excavate the basin or obtain adequate material to construct a dam. A review of the geology of Orange County does not preclude the development of surface water impoundments in any area of the County. More detailed evaluation will be required for any individual reservoir site.

Figure B-1
Geologic Information

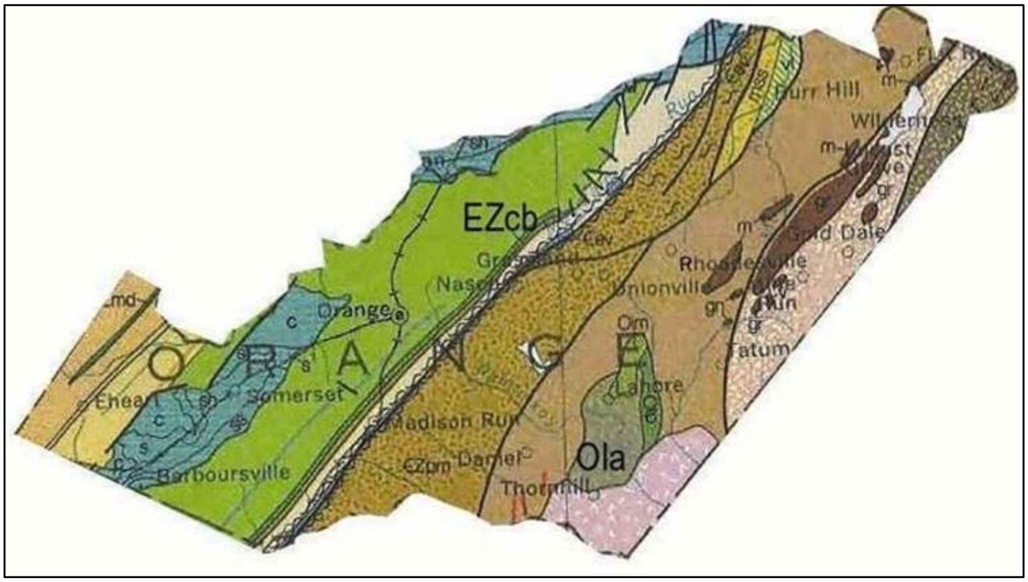
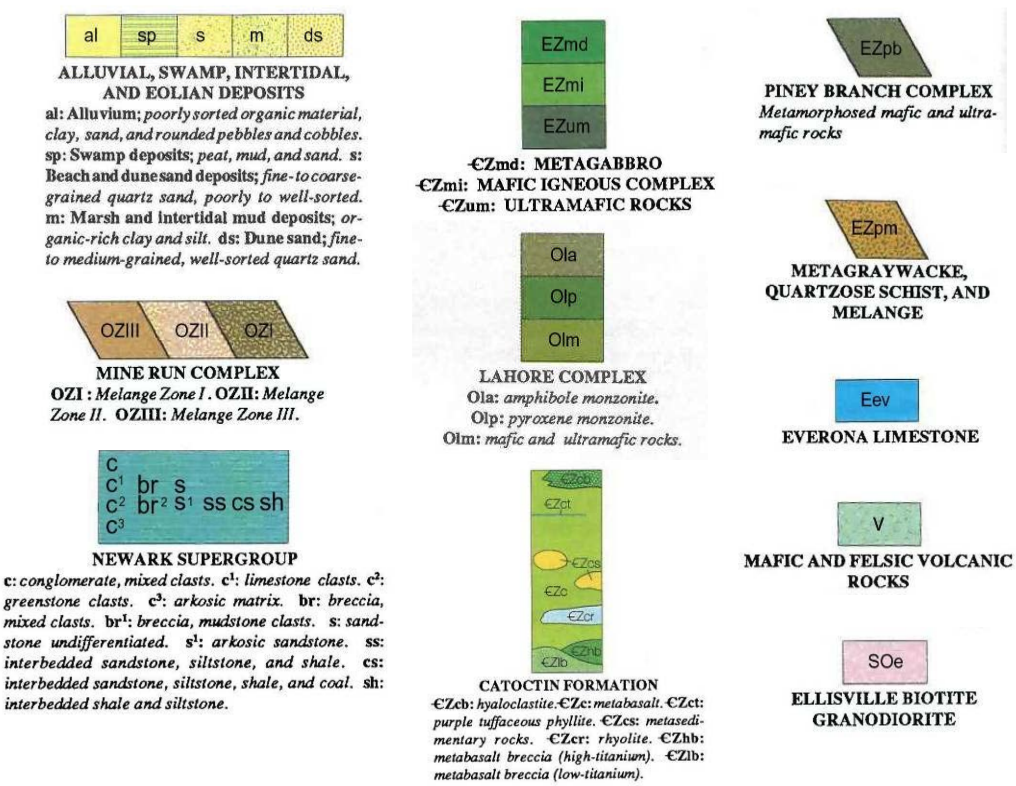
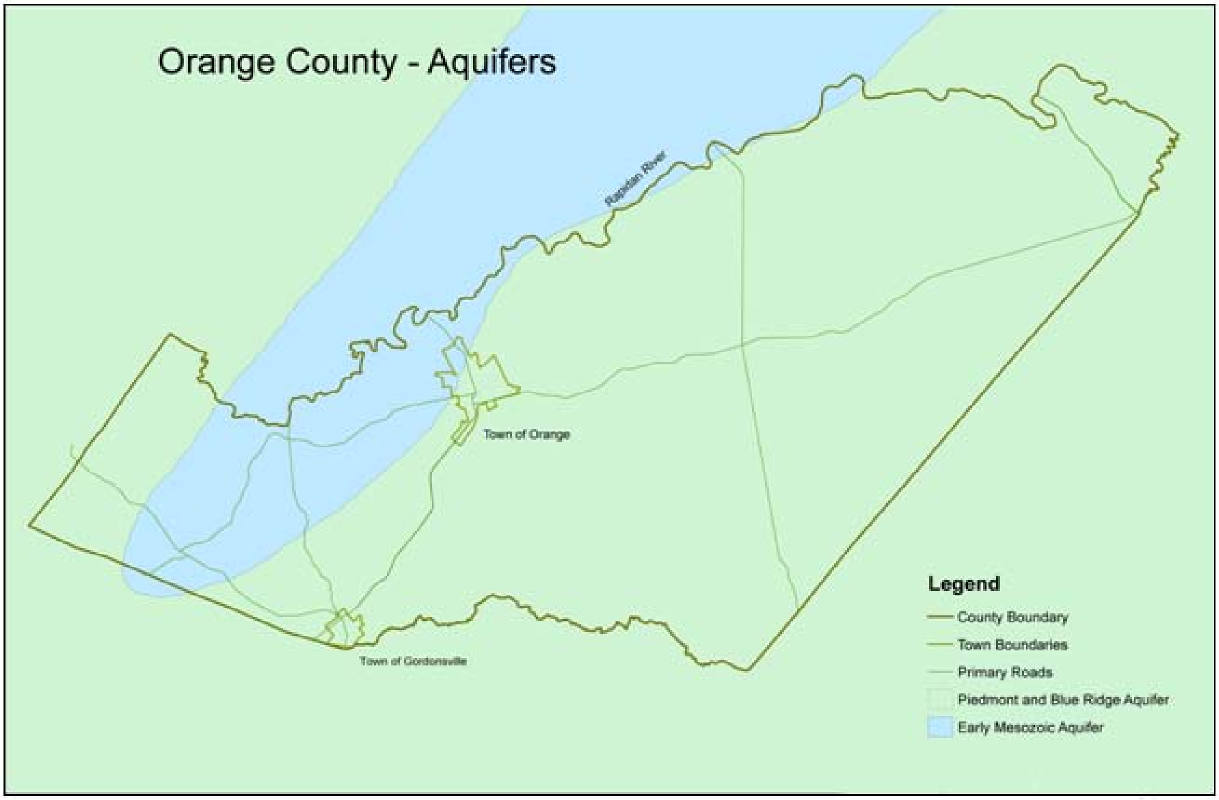


Figure B-2
Geology of Orange County, Virginia



B.2.a GROUNDWATER HYDROLOGY

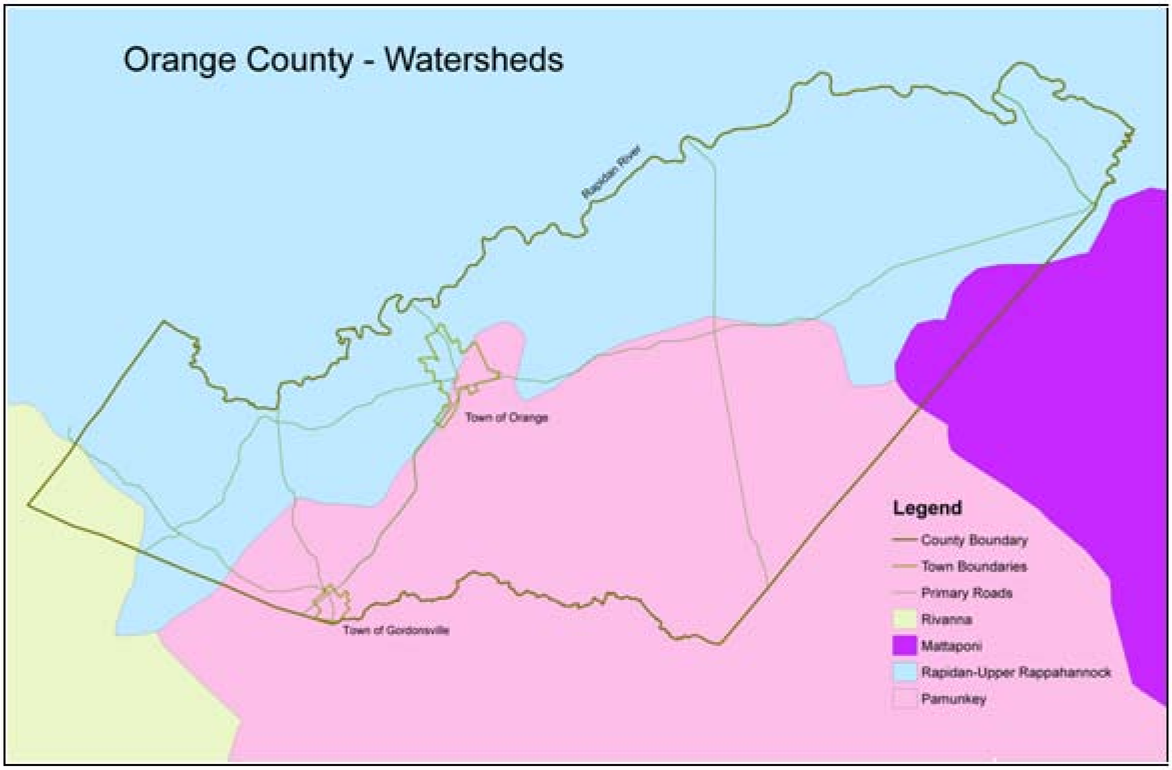
Figure B-3
Groundwater Hydrology - Aquifers



Orange County sits atop two major aquifers. The largest is the Piedmont and Blue Ridge Aquifer shown in green in Figure B-3. The Early Mesozoic Aquifer is shown in blue in Figure B-3[ii]. Both aquifers have layers of dense, almost impermeable bedrock, which means that most water come from fractures in the bedrock. A phase I ground water exploration program was conducted by Emery & Garrett Groundwater, Inc. as part of the Water Supply Plan. It included detailed investigation of the local bedrock, delineation of bedrock aquifers, bedrock fracture characterization, and identification of areas of groundwater recharge potential. The results of that study may be found in Appendix C of Technical Memorandum No. 2.

B.2.b WATERSHEDS/SURFACE WATER HYDROLOGY

Figure B-4
Orange County Watersheds



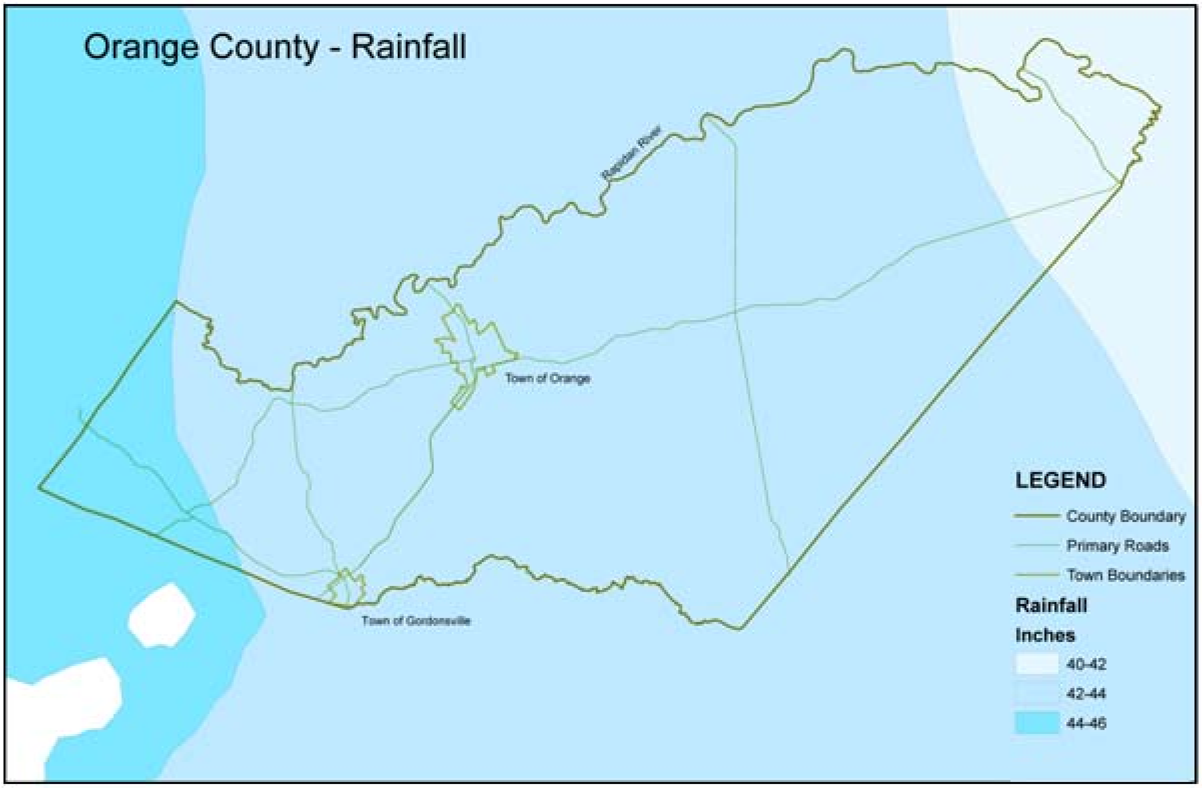
Orange County is located at the boundary of four major watersheds. Most of the County is divided between the Rapidan-Upper Rappahannock watershed on the north (55.8%) and the Pamunkey watershed on the south (40.6%). A very small section (2.1%) of the western part of the County is in the Rivanna watershed and a very small section (1.5%) of the eastern part of the County is in the Mattaponi watershed[iii].

The County's location at the boundary of four watersheds results in most of the surface waters in the County being small, headwater streams. This limits the amount of inflow into any potential in-stream reservoir, with the exception of the Rapidan River, however the probability of developing a traditional in-stream reservoir on the Rapidan River is very low.

The Rapidan River is the largest stream in or adjacent to Orange County and is currently used as the water source for the Town of Orange and RSA Wilderness Systems. The two existing surface water intakes are discussed in greater detail in Section C of this Technical Memorandum.

B.3 METEOROLOGICAL

Figure B-5
Average Annual Rainfall



The average annual rainfall for Orange County is shown in Figure B-5[iv]. The annual rainfall varies slightly across the county, with the greatest annual average near the western border of the county and the lowest annual average near the eastern end of the county. The headwaters of the Rapidan River, located at the crest of the Blue Ridge Mountains approximately 20 miles to the northwest of the County line, receives up to 52 inches of rainfall annually. The month with the highest average monthly rainfall is July, with an average of 4.44 inches, while February is normally the driest, with an average monthly total of 2.71 inches. Even though February is the driest month, it does have the highest average monthly snowfall amount of 6.2 inches[v]. The average annual snowfall for Orange County is approximately 20.5 inches.

Potential evapotranspiration for Orange County is approximately 29.89 inches per year. This varies over the course of a year, with a low of 0.04 inches in January and a high of 5.94 inches in July. When subtracted from the annual precipitation of 42.29 inches, only 12.40 inches of precipitation is left for surface runoff and infiltration into the groundwater table.

The temperatures vary from a mean of 34.2 degrees F in January to a mean of 76.2 in July. The highest recorded temperature was 106 degrees F and the lowest recorded temperature was –11 degrees F.

Orange County does suffer through droughts that reoccur approximately every 30 years, the most recent of which lasted from 1998 until 2002. This drought is discussed in more detail in Section C of this Technical Memorandum.

B.4 THREATENED AND ENDANGERED SPECIES

Table B-1
Threatened or Endangered Species and Migratory Fish or Trout

Status*	Common Name	Scientific Name
FT ST	Eagle, bald	*Haliaeetus leucocephalus*
FS	Warbler, cerulean	*Dendroica cerulea*
FS ST	Shrike, migrant loggerhead	*Lanius ludovicianus migrans*
FS SS	Lance, yellow	*Elliptio lanceolata*
FS	Fritillary, regal	*Speyeria idalia idalia*
ST	Shrike, loggerhead	*Lanius ludovicianus*
ST	Sandpiper, upland	*Bartramia longicauda*
SS	Harrier, northern	*Circus cyaneus*
SS	Egret, great	*Ardea alba egretta*
SS	Owl, barn	*Tyto alba pratincola*
SS	Shiner, bridle	*Notropis bifrenatus*
SS	Warbler, magnolia	*Dendroica magnolia*
SS	Kinglet, golden-crowned	*Regulus satrapa*
SS	Dickcissel	*Spiza americana*
SS	Otter, northern river	*Lontra canadensis lataxina*
SS	Moorhen, common	*Gallinula chloropus cachinnans*
SS	Tern, Caspian	*Sterna caspia*
SS	Wren, winter	*Troglodytes troglodytes*
SS	Nuthatch, red-breasted	*Sitta canadensis*
SS	Creeper, brown	*Certhia americana*
SS	Thrush, hermit	*Catharus guttatus*
SS	Finch, purple	*Carpodacus purpureus*

*FE=Federal Endangered; FT=Federal Threatened; FC=Federal Candidate; FS=Federal Species of Concern (not a legal status; list maintained by USFWS Virginia Field Office); SE=State Endangered; ST=State Threatened; SS=State Special Concern (not a legal status).

The threatened and endangered species in Orange County are listed in Table B-1[vi]. The Natural Heritage Resource Database of Virginia Department of Conservation and Recreation also provides the list of species in Table B-2 below.

Table B-2
VDCR Threatened or Endangered Species

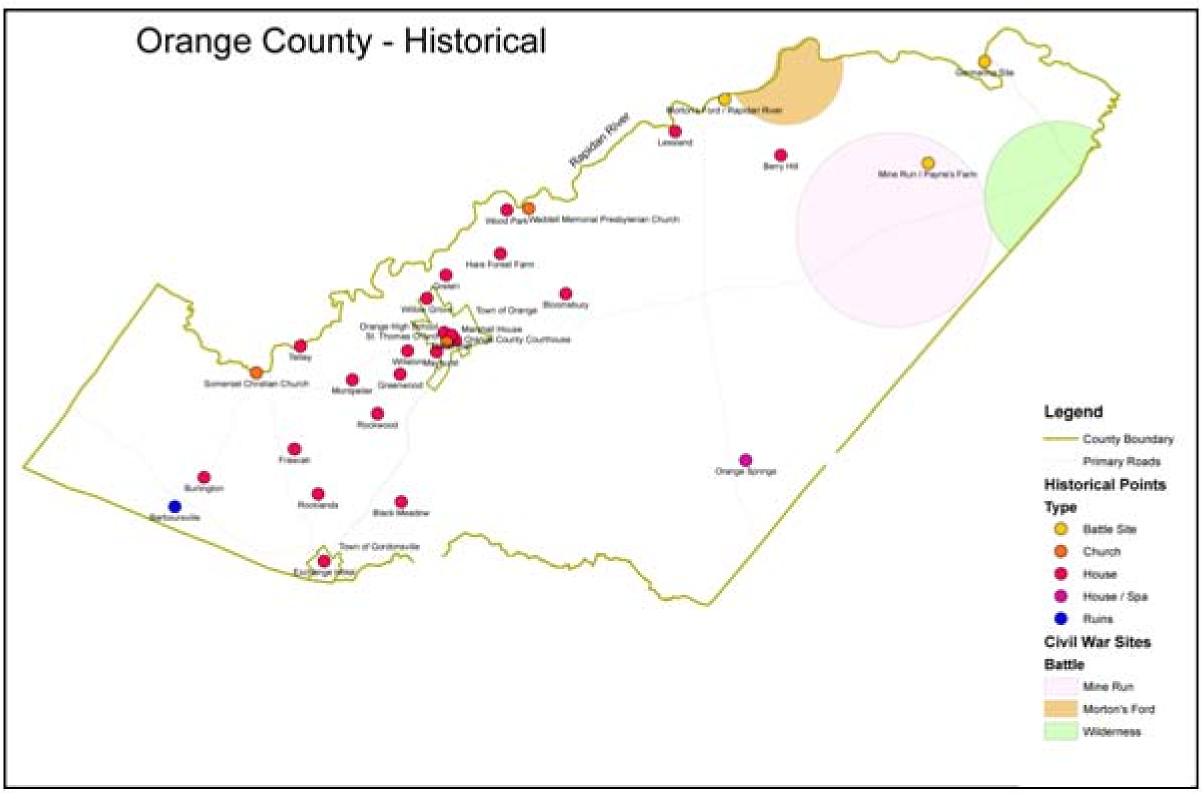
Scientific Name	Common Name	Federal Status	State Status	Last Year Observed
BIVALVIA (MUSSELS)				
Alasmidonta heterodon	Dwarf Wedgemussel	LE	LE	ND
Elliptio lanceolata	Yellow Lance	SOC	SC	ND
Lasmigona subviridis	Green Floater		LT	ND
Federal Status	**LE** - Listed Endangered		**SOC** - Species of Concern species that merit special concern **(not a regulatory category)**	
State Status	**LE** - Listed Endangered	**LT** - Listed Threatened	**SC** - Special Concern - animals that merit special concern according to VDGIF (**not a regulatory category**)	

Many bird species are listed in the threatened or endangered species list. Their nesting areas could be impacted by a surface water impoundment if in the area. In addition, several species of freshwater mussels may be located in the area. Also, any known trout or migratory fish species have been included in the list above. As part of the Wild Trout Program, the Department of Game and Inland Fisheries has a requirement that any trout caught from the Rapidan or its tributaries be released. In summary, any of the species listed above may be impacted by the development of new water resources or the expansion of existing water resources. If a potential water resource project is identified in areas believed to support one or more of these species, additional studies may be required to determine if the species does in fact inhabit the project area.

B.5 HISTORICAL OR SCENIC RIVERS OR STREAMS AND HISTORIC OR ARCHEOLOGICAL SITES

The Virginia Department of Conservation and Recreation[vii] has given the Rapidan River, along the northern border of Orange County, a status of “worthy of preservation”, which means that the river has not been studied in enough detail to become designated as a scenic river, but may have the potential for such a designation in the future. The river offers recreational opportunities including fishing, wading, and canoeing. The Department of Game and Inland Fisheries does not list the Rapidan as a public fishing location or area of public boating. A public boat landing at Germanna Bridge was closed in 1997. However, small local recreational activities could include the stretch of the Rapidan River located in Orange County. There is an outfitter canoeing put-in just downstream of Route 522. Camping and fishing are also associated with the canoe trips. The Town of Orange and Wilderness intakes have withdrawal permits located on this river with an average streamflow of over 300 MGD. For additional information related to streamflow and water withdrawal see section ‘C.2 Surface Water’.

Figure B-6
Orange County’s Historical Points



Historical places in Orange County are shown in Figure B-6[viii]. Historical Civil War battle sites in Orange County are also shown in Figure B-6[ix]. The development of water resources in known historic sites would be limited due to the possibility of damaging the cultural and historical resources and should be considered only after other sites have been excluded from consideration.

B.6 UNUSUAL GEOLOGY OR SOIL CONDITIONS

Figure B-7
Unusual Geology or Soil Conditions

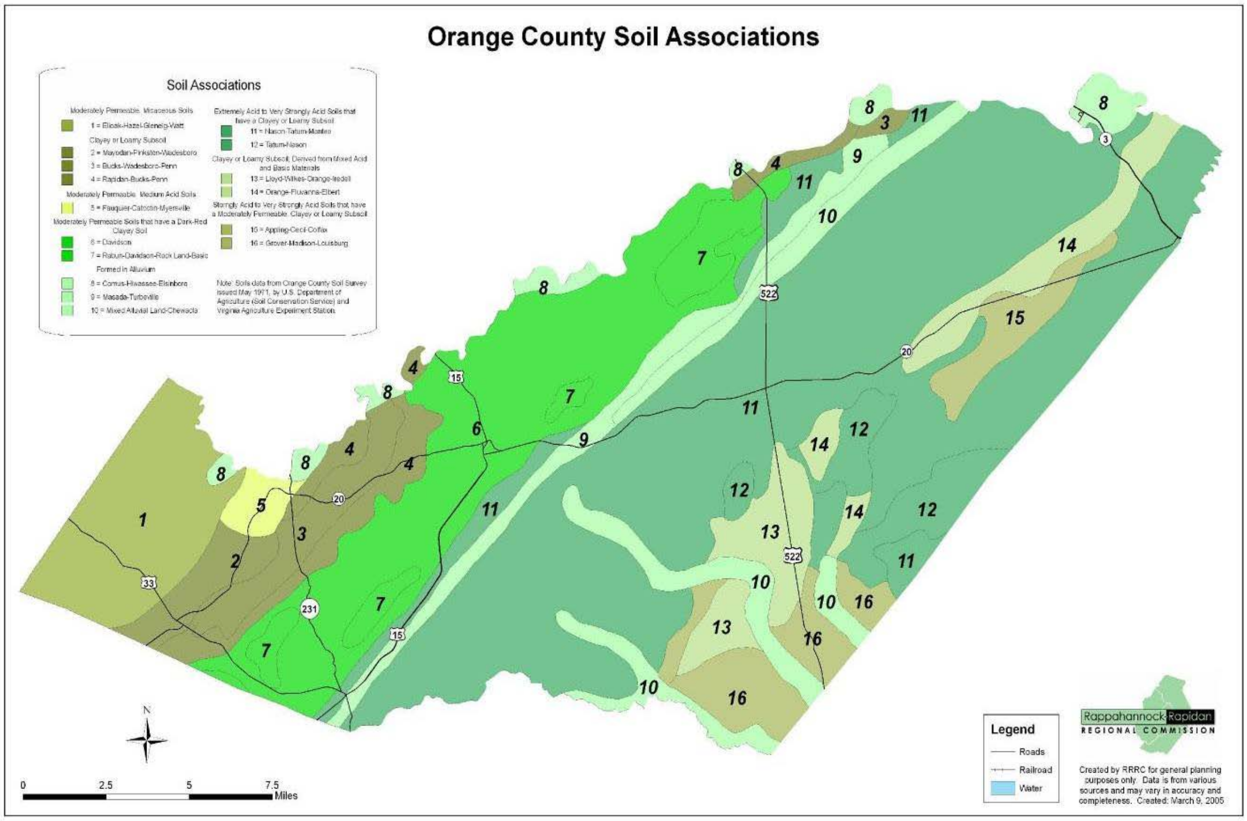


Figure B-8

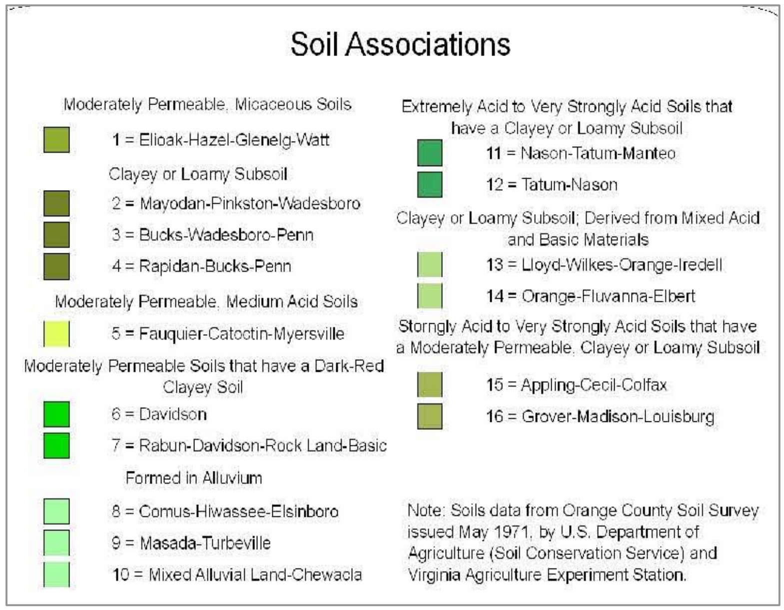


Figure B-8 shows the general soil associations in Orange County[x]. The limitations of each general soil association, in terms of surface water resource development, as derived from the Soil Survey of Orange County, Virginia, are as follows:

1 = Elioak-Hazel-Glenelg-Watt

The Elioak soils do not compact well due to a highly micaceous substratum and suffer from high seepage losses. The Hazel soils have a moderately high permeability and shallow bedrock (1-1/2 to 4 feet). The Glenelg soils are also micaceous, subject to piping, and have a permeable substratum. The Watt soils are erodible, have poor stability, high seepage losses and shallow bedrock.

2 = Mayodan-Pinkston-Wadesboro

The Mayodan soils are fairly stable, when compacted, but suffer from some seepage losses due to underlying pervious bedrock. The Pinkston soils can be stable, when compacted, but are pervious and have high seepage losses and shallow bedrock (3-1/2 to 6 feet.) The Wadesboro soils are very similar to the Mayodan soils in that they are stable when compacted but have high seepage losses due to the underlying pervious bedrock.

3 = Bucks-Wadesboro-Penn

The Wadesboro soils limitations are described above. The Bucks soils are fairly stable, but erodible in sloping areas, overlie pervious bedrock, and have moderate seepage losses. The Penn soils are fairly stable, but have a high silt content and shallow bedrock (2 to 3-1/2 feet) and suffer from high seepage losses in the underlying material.

4 = Rapidan-Bucks-Penn

The limitations of the Bucks and Penn soils are described above. The Rapidan soils have fair to poor stability, even when compacted, have moderate permeability and moderate seepage losses, and rock at a depth of 4 to 12 feet.

5 = Faquier-Catoctin-Myersville

The Faquier soils are fairly stable, when compacted, but suffer from high seepage losses. The Catoctin soils are very shallow to bedrock (2 feet), have stone and rock outcrops, and seepage losses. The Myersville soils are also fairly stable, when compacted, but suffer from high seepage losses through faults in the underlying bedrock, which is only 3 to 8 feet below ground.

6 = Davidson

The Davidson soils have moderate to slow permeability when compacted as an embankment, but have high seepage losses in their in-situ state.

7 = Rabun-Davidson-Rock Land, Basic Association

This soil association is located in the rough, mountainous areas that run southwest to northeast through the County. Development of surface water resources in these areas is impractical.

8 = Comus-Hiwassee-Elsinboro

This soil association is located along the nearly level to sloping soils and stream terraces along the Rapidan River. Development of surface water impoundments in these areas would have to take into consideration the infrequent flooding of some of the soils in this association. The Comus soils are infrequently flooded and have a moderately high permeability and high seepage losses, though they have fair to good stability when compacted for embankments. The Hiwassee soils have moderate permeability with some seepage losses and have fair to poor stability when compacted, except for the Hiwassee clay loam that has a fair stability when compacted. The Elsinboro soils have a fair to good stability when compacted, moderate permeability, some seepage losses, and the substratum is porous in places.

9 = Masada-Turbeville

This soil association is located along the gently sloping to sloping soils on stream terraces in a southwest to northeast strip running from Gordonsville through Madison Run and northwest of and parallel to Mountain Run. The Masada soils have a moderate permeability with some seepage losses, though they have fair stability when compacted for embankments. The Turbeville soils have moderate permeability with moderate seepage losses and have fair to poor stability when compacted.

10 = Mixed Alluvial Land-Chewacla

This soil association is located along Mountain Run and the tributaries of Lake Anna. Development of surface water impoundments in this soil association would most likely be in-stream impoundments. The Chewacla soils are frequently flooded and have occasional sand and gravel deposits in the substratum, a seasonal high water table 1 to 1-1/2 feet below surface, and have fair to poor stability when compacted.

11 = Nason-Tatum-Manteo

This soil association covers a large potion of the eastern part of Orange County. The Nason soils have a moderate permeability with seepage losses in the substratum and have a fair stability for embankments, but high silt content and are elastic. The Tatum soils have a moderate permeability with high seepage losses through rock fractures and have a fair stability for embankments when compacted. The Manteo soils have a rapid permeability and rock at less than 2 feet below the surface, have low stability, and are poor sources of borrow for embankments. Manteo soils, though only 8 percent of the association, should be avoided for surface water impoundments.

12 = Tatum-Nason

This soil association is also located in the eastern part of Orange County, always adjacent to the Nason-Tatum-Manteo association. The limitations of the Tatum and Nason soils are described above.

13 = Lloyd-Wilkes-Orange-Iredell

This soil association is located in the southeastern part of Orange County in the Lahore and Monrovia areas. Most of the association is nearly level, but steeper areas are present along the streams. The Lloyd soils have a moderate permeability with some seepage losses and have a fair to poor stability for embankments, though the clay loam varieties of Lloyd are slightly better. The Wilkes soils have a moderate permeability with high seepage losses through pervious rock at a depth of 2-1/2 to 4 feet, but they have a fair stability when compacted. The Orange soils have a slow permeability and rock at a depth of 3 to 6 feet below the surface and have low stability with a high silt content and high elasticity. The Iredell soils have a slow permeability and rock at a depth of 3 to 6 feet below the surface and have low stability with a plastic clay material

14 = Orange-Fluvanna-Elbert

This soil association is located in the eastern part of Orange County along Route 20 and Flat Run, with a small pocket near Ridge Run. Most of the association is nearly flat. The limitations of the Orange soils are described above. The Fluvanna soils have a moderate permeability with some seepage losses through pervious bedrock, but they have a fair stability when compacted. The Elbert soils have generally favorable features for surface water impoundments, but have low stability with a high shrink swell potential when used for embankments. Development of reservoirs in areas of Elbert soils could possibly require the import of embankment material.

15 = Appling-Cecil-Colfax

This soil association is located in the eastern part of Orange County along Route 20, with a small pocket near Monrovia. The Appling soils have a moderate permeability with some seepage losses, but they have a fair stability and slow permeability when compacted. The Cecil soils are very similar to the Appling soils. The Colfax soils are generally favorable for impoundment sites, even though they contain fragipan (a dense, brittle and low permeability layer), but have fair to poor stability for embankments and a seasonal high water table of 1 to 1-1/2 feet.

<u>16 = Grover-Madison-Louisburg</u>

This soil association is located in the southeastern part of Orange County on the upland areas upstream of Lake Anna. The Grover soils have a permeable substratum with high seepage losses and a low stability for embankment due to their high mica content. The Madison soils have moderate permeability and seepage loss, can be underlain by pervious bedrock, and have a fair stability; even with high mica content. The Louisburg soils have rapid permeability and pervious rock at a depth of 2 to 4 feet, but have a fair stability and can function as a limited source of borrow.

It should be noted that the limitations of the various soils were derived from the USDA Soil Survey of Orange County, Virginia[xi]. Soil surveys are published primarily for the agricultural community, though they do list some soils properties than affect other uses. This means that, even though the soil survey lists the limitations of soils for development of impoundments, the limitations were developed for agricultural impoundments. Impoundments to be used for public water supply will require more thorough evaluations to determine if the soils are suitable.

B.7 WETLANDS, RIPARIAN BUFFERS, AND CONSERVATION EASEMENTS

Figure B-9
Conservation and National Park Land

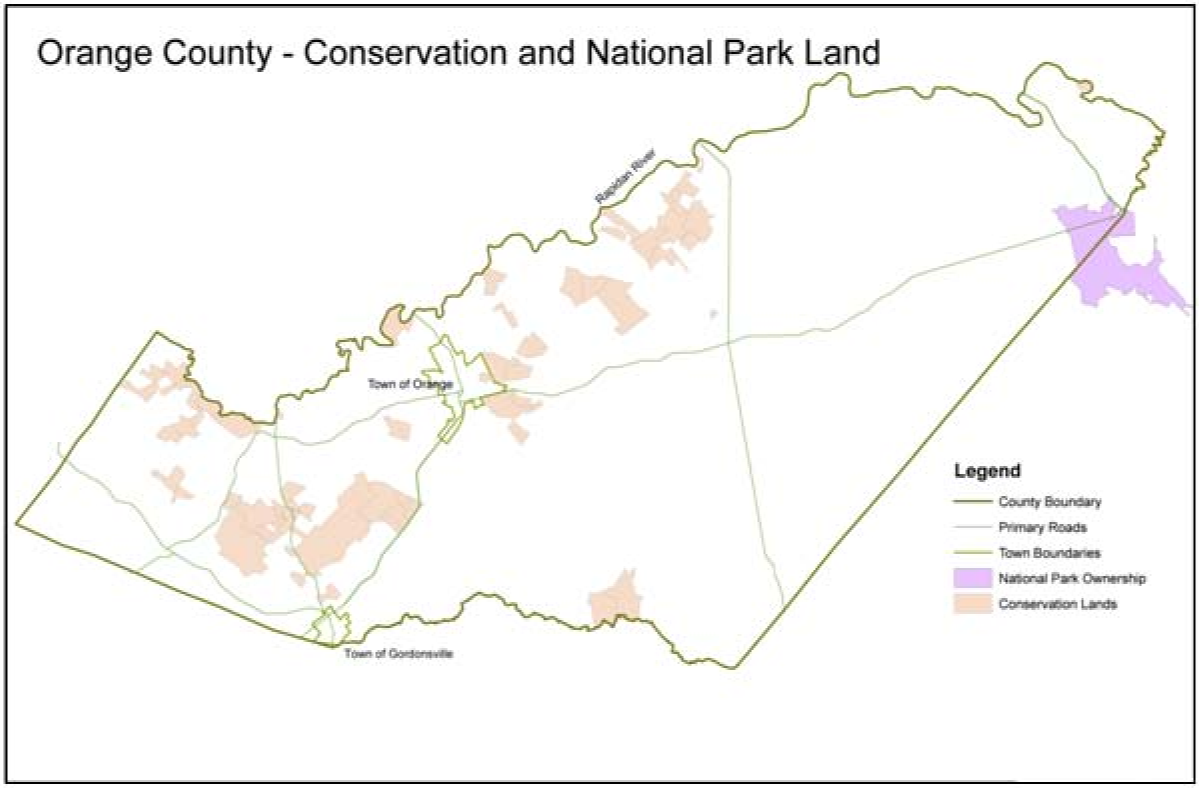


Figure B-9 shows National Park Service Land and areas for which conservation easements have been recorded[xii]. Development of water resources on National Park Service Land should not be considered. Development of water resources on areas for which conservation easements have been recorded may be possible, depending on the wording of the conservation easements. There are no recorded riparian buffers in Orange County known by the Virginia or U.S. Department of Forestry. Primary consideration for water resource development should be given to areas of the County not tied up by National Park Service Land or in conservation easements.

B.8 FLOOD PLAINS

Figure B-10
Orange County 100-Year Flood Plains

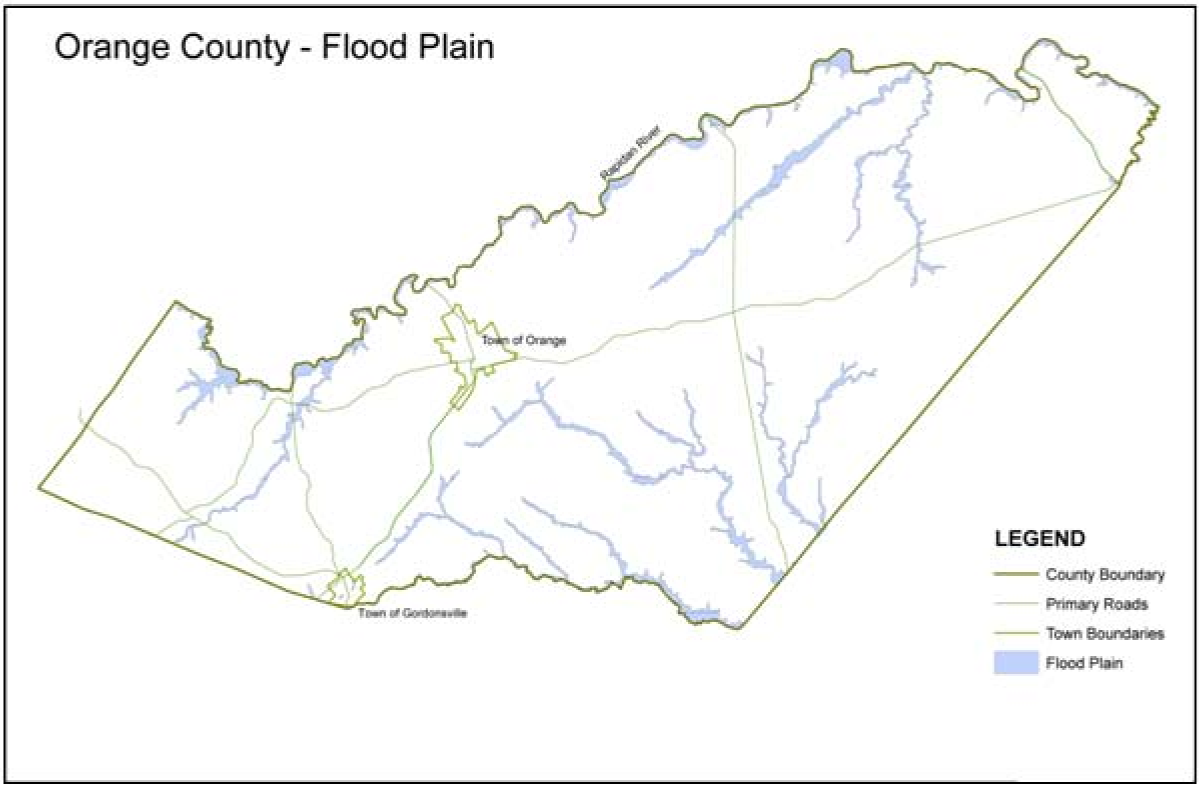


Figure B-10 shows the 100-year flood plain in Orange County[xiii]. Development of water resources in the 100-year flood plain would most likely be in-stream reservoirs. As previously stated, an in-stream reservoir in the Rapidan River would be extremely difficult to permit. Development of an in-stream reservoir in other areas is possible, though in-stream reservoirs take far longer to permit than off-stream reservoirs.

Even with development of an off-stream reservoir, the 100-year flood plain should be avoided to prevent erosion and scouring of embankments located in the flood plain. Also, construction of an embankment in the 100-year flood plain could raise the level of the 100-year flood and negatively impact the upstream properties.

B.9 WETLANDS

Figure B-11
Orange County Wetlands

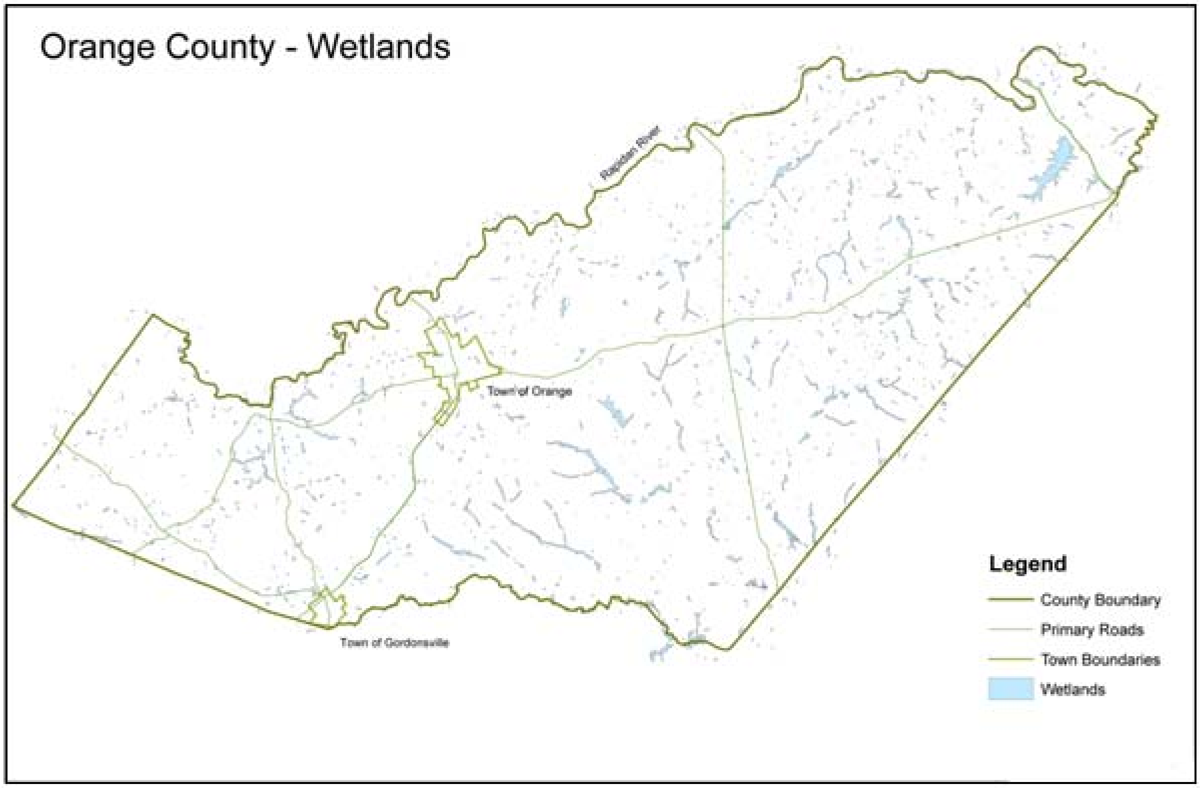


Figure B-11 shows the location of wetlands in Orange County[xiv]. Wetlands are to be considered in the development of water resources because construction of almost any type of water project could impact wetlands, either through the loss of wetlands or the change in wetland habitat. Loss of a stream and adjacent wetland areas is not offset by the creation of a reservoir because the habitat is different.

The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers defines a jurisdictional wetland as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." The U. S. Department of Agriculture Natural Resources Conservation Service (NRCS) and the U. S. Fish and Wildlife Service (FWS) define wetlands somewhat differently. However, all four agencies include three basic elements--hydrology, soils and vegetation--for identifying wetlands. On-site determinations of wetlands would be required during a detailed alternative analysis in the development of any water resources following the three-parameter method described in the *Corps of Engineers Wetlands Delineation Manual* (Environmental

Laboratory 1987), which is the legally accepted system for identifying wetlands. The method requires positive evidence of three criteria: hydrophytic vegetation, hydric soils and wetland hydrology--before an area can be termed a wetland. Areas generally must have all three criteria to be designated wetlands

The strategy of "Avoid, Minimize, and Mitigate" should always be used when planning a project that may impact wetlands. This means that the first step is to avoid any jurisdictional wetlands, if at all possible. The second step is to minimize the impacts to jurisdictional wetlands that cannot be avoided. The third, and last step, is to mitigate the jurisdictional losses that cannot be avoided or minimized.

Development of water resources usually involves going through all three steps due to the amount of jurisdictional wetlands in Orange County. Even though Orange County is located in the Piedmont and does not have extensive wetland areas, the County does have many small streams and adjacent wetland areas. There are also many agricultural ponds and adjacent wetlands in the County, which means that the development of any water resource project will have to be evaluated with regard to its impact on jurisdictional wetlands.

B.10 IMPAIRED WATERWAYS, POINT SOURCE DISCHARGES, AND POTENTIAL IMPACTS TO WATER QUALITY

Figure B-12 shows point source discharges in and around Orange County. The primary dischargers are noted by name[xv]; the unnamed points are typically schools or small businesses served by central sewer systems.

The location of point source discharges is of importance in that the development of a new or expansion of an existing surface water intake must be far enough downstream of the discharge to not be adversely affected by the discharge. Any new water resource planned downstream of a point source discharge must make a thorough evaluation of the records of the point source to determine the possibility of contamination from the point source.

Figure B-12
Point Source Discharges

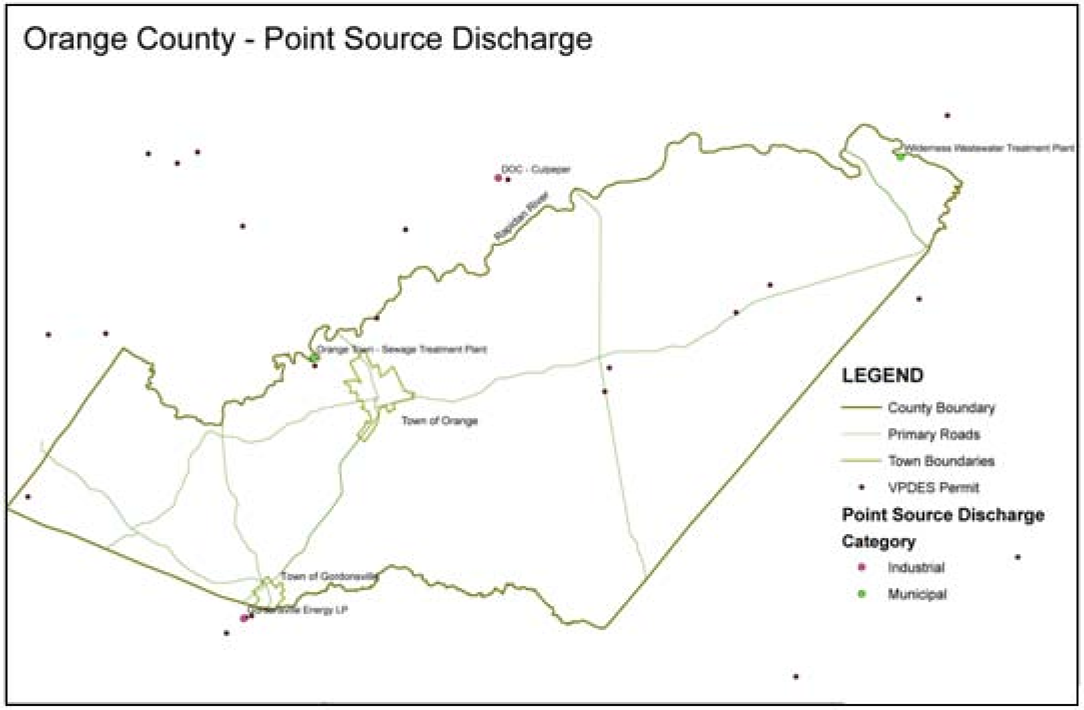
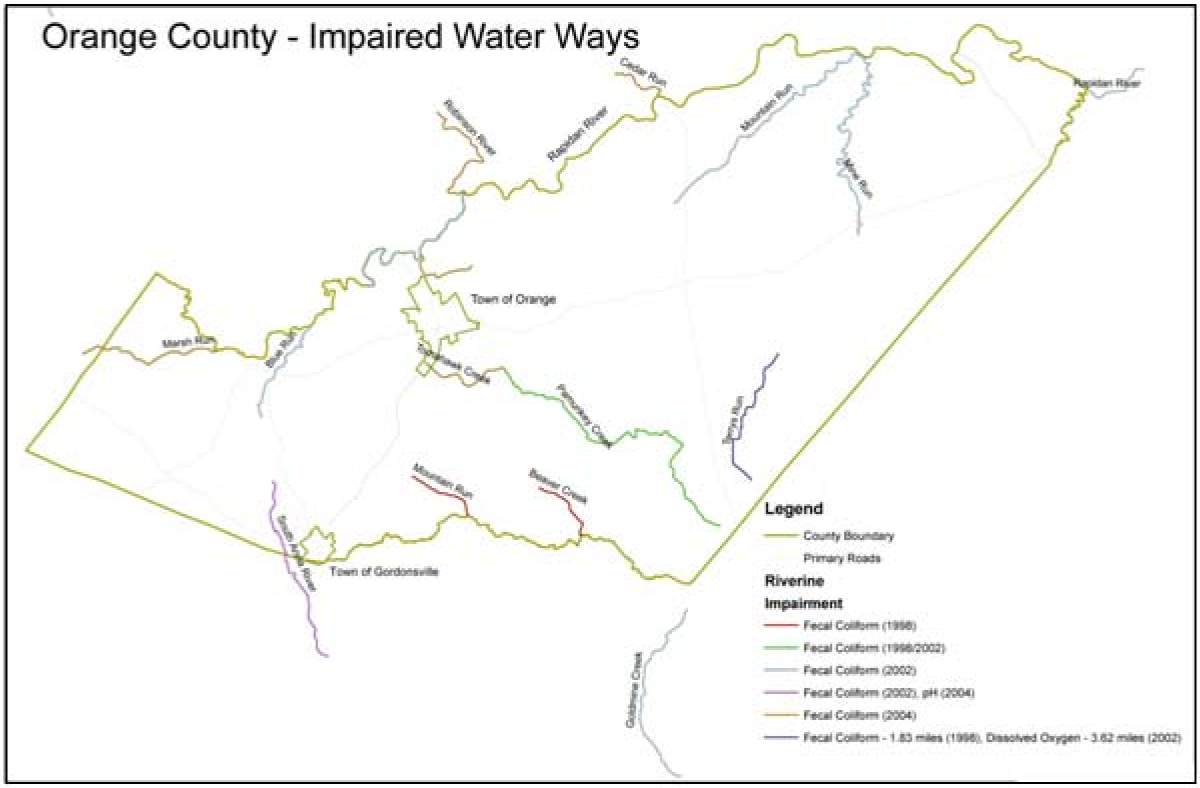


Figure B-13 shows impaired waterways in Orange County. The reason for the impairment is primarily fecal coliform, though the source of impairment is unknown[xvi]. Most of the waterways impaired for fecal coliform are not located below public wastewater treatment plants, but do flow through primarily agricultural land, which leads one to believe the source of impairment to be livestock or wildlife, though failing septic tanks is a possibility.

According to the EPA[xvii], Orange County has no sites listed on the National Priority List. According to the EPA Toxic Release Inventory[xviii] there are no toxicants released into surface or ground water in Orange County. The Virginia Department of Environmental Quality has records of petroleum releases, most of which have occurred in and around the Town of Orange and the Town of Gordonsville, though they have been recorded throughout the County, but mainly along the main roads. The County has one sanitary landfill, operated by Orange County, located 0.5 mile S of Route 635 and Route 20 intersection.

Figure B-13
Impaired Water Ways



B.11 OTHER POTENTIAL THREATS TO WATER QUALITY

Other threats to water quality that may affect the expansion of existing water sources or the development of new water resources are primarily non-point source. The non-point source threats include, but are not limited to, sediment, fertilizers, pesticides, herbicides, and toxic substance spills. Threats to the water quantity include over-irrigation of lawns or crops and withdrawal of water by other users without proper permits.

Sediment comes from improper sediment and erosion control on construction sites and from the improper implementation of Best Management Practices by the agricultural community. Sediment can clog river intakes, shorten the life of raw water pumps, and increase the operating and maintenance costs of water treatment plants. Sediment can also reduce the storage capacity of surface water impoundments.

The overuse of fertilizers can result in increased nitrogen and phosphorous loadings in the source waters, which can result in algal blooms that create taste and odor problems. The algae also affect downstream water quality by blocking sunlight from the submerged aquatic vegetation. The submerged aquatic vegetation then dies resulting in the loss of habit for fish, the loss of oxygen into the water from the vegetation, and the loss of the plants ability to take up nutrients.

The overuse of pesticides and herbicides can result in their migration to the source water, primarily through surface runoff. Once in the source water, the cost to remove the pesticides and herbicides at the water treatment plants increases.

Toxic substance spills, depending on the nature of the spill, have the potential to force a water treatment plant to cease withdrawing from its source until the spill has bypassed the intake. If there is not adequate storage volume in the distribution system, the water system may not be able to supply enough water to the customers while waiting for the spill to bypass the intake.

Many of the factors listed above are related to land use. Expansion of farm and crop lands would increase the potential for water quality impacts due to fertilizers and pesticides. More urbanized developments would increase the potential for toxic or hazardous waste spills, soil deposition due to construction activities, and increased pollutants due to impervious area runoff. The existing and future land uses are shown in the following sections. The overall affect of future land use changes can not be quantified due to the variability and uncertainty of potential improvements.

C. EXISTING SOURCES

C.1 PREVIOUS STUDIES

Prior to preparation of this report, available water supply data was collected and reviewed. Previous studies and reports have been generated that discuss the supply and distribution of water resources within Orange County. The reports and a summary of each are as follows:

Town of Orange

<u>Previous Studies:</u>

Engineer's Comprehensive Plan - Water and Sewerage Facilities - Greene, Madison, and Orange Counties (October 1967) by Martin, Clifford and Associates

> This report focused on a Tri-County approach to resource planning. However, County specific data is available. The water resource data may be useful for a general estimate of future water supply sources. The ground water source information included in the report has been summarized in the table below.

Table C-1
Ground Water Source Information

Formation	Location	Well depth (feet)	Yield (GPM)
Limestone	Gordonsville through Madison Run and Everona (east of Clarke Mountain)	Insufficient data	1 at 70 GPM
Metamorphic/igneous	East of the limestone formation	< 200 feet	5 to 40 GPM
Igneous	Northwest of the limestone formation	48 to 350 feet	0.3 to 20 GPM
Course grained sedimentary	East of Rapidan River, Liberty Mill to 3 miles NE of Racoon Ford	Insufficient data	Large amounts speculated
Fine grained sedimentary	Barboursville to Montpelier	50 to 700 feet	1 to 22 GPM 2 at 80 GPM
Igneous/metamorphic	Southwestern tip of the county	88 feet (only 1)	15 GPM
	Eastern 2/3 of County	Insufficient data	Some over 30 GPM

A surface water summary is included also. However, information included in the 'Existing Sources' section of this current report supersedes the older data. Many potential water supply projects are listed including water line and water treatment plants. The report also suggests several locations for water supply reservoirs. These sites are summarized in the Table C-2.

Table C-2 Water Supply Reservoir Sites									
Stream Name	Drainage Area (Sq. Mi.)	Max. draft (MGD)	Recom. draft (MGD)	Sediment Vol. (acre ft)	Water Supply Vol. (acre ft)	Flood Storage (acre ft)	Total Storage (acre ft)	Dam Height (feet)	Lake Area (acres)
Marsh Run	6.5	1.07	0.69	174	873	1,395	3,532	66	160
Blue Run	11.7	1.93	---	---	---	---	---	---	---
Blue Run	20.1	3.32	1.10	363	1,345	2,902	4,610	40	160
Barbour Run	3.0	0.50	0.32	80	398	637	1,613	57	71
Cooks Creek	7.0	1.15	0.73	186	934	1,491	3,775	62	140
Pamunkey Creek	21.9	3.61	2.31	583	2,922	4,666	11,817	65	380
Pamunkey Creek	26.5	4.38	2.80	706	3,546	5,652	9,904	53	390
Ridge Run	10.6	1.75	1.11	282	1,409	2,253	5,706	59	210
Ridge Run	7.0	1.15	0.73	186	934	1,491	3,776	56	165
Mine Run	11.5	1.90	0.54	306	374	2,450	3,130	40	110
Mine Run	20.0	3.30	2.10	534	2,670	4,268	7,472	61	250
Mountain Run	30.1	2.29	1.44	802	1,127	6,417	8,346	46	280

The cost estimates and comparisons provided for each reservoir alternative are well outdated and therefore, not of any value. A further investigation of water supply alternatives will be discussed in Technical Memorandum No. 2, a follow up to this current report. The report did suggest a water main be installed to the Town of Gordonsville. That water line was installed in 1976. No further recommendations in the report were developed.

Orange County Water Supply Study – Project 8514 – Final Report (April 1, 1986) by R. Stuart Royer and Associates, Inc.:

The report included the evaluation of present and future water use, existing water facilities, and potential future water supply projects. It focused exclusively on the Town of Orange and the surrounding area's water supply. Three potential reservoir sites were reviewed as potential water impoundments. They include Laurel Run, Poplar Run, and a branch of Beautiful Run near Burnt Tree. Of the three sites, the Poplar Run alternative was determined to be the most cost efficient, with 53 million gallons of usable water volume. The construction of an impoundment was recommended to prepare for future water supply difficulties associated with the Rapidan River. This recommendation was never implemented.

Feasibility Study Myers *Property Dam Sites* (January 10, 1989) by Gloeckner & Osborne, Inc.:

The report discussed the possibility of locating a surface water reservoir on Mountain Run, 1 mile east of US Route 15. The independent report was prepared for a group of developers interested in creating a recreational lake. According to the report, the 104-acre, 40-feet deep impoundment could produce up to 3.0 MGD for domestic water use. No action has been taken to pursue this site as a surface water impoundment.

Town of Orange Twenty-*Year Water Plan* (January 30, 1992) by Water Solutions Committee:

The report briefly discussed previous reports including the *Engineer's Comprehensive Plan - Water and Sewerage Facilities - Greene, Madison, and Orange Counties* - previously discussed; *Availability of Rapidan River Water* – outdated; *Orange County Water Supply Study – Project 8514 – Final Report* – previously discussed; and the *State Water Control Board, Planning Water Supply Plan* – no immediate action was recommended by the Board and the County took a neutral position. Recommendations were made for repairs to the Town of Orange intake weirs and further investigation into development of ground water wells for a backup supply.

Bryant Well letter report (March 1, 1993) by Page & McLawhorn Engineering, P.C.:

The letter report discussed the costs associated with development of a backup water supply source adjacent to the Town plant on the Bryant property. The well yield was estimated at 15 to 25 gallons per minute (GPM).

Technical Memorandum *for the Safe Yield of the Rapidan River* (November 1997) by Black & Veatch:

The report determined the safe yield of the Rapidan River based of low flows of record. Due to the recent drought the data is no longer relevant. A new analysis can be found in the 'Existing Sources' section of this current report. The B&V report also reviewed additional sources of backup water supply for drought conditions. A surface water impoundment near Gordonsville was recommended on the basis of adequate supply with further investigation of this and other sites. It was recommended that the Town of Orange seek to have their withdrawal permit increased based on the safe yield analysis in this report. Water conservation and reuse were also recommended to alleviate overall water demand.

Rapidan Service Authority – Project 2000 – Comprehensive Water Supply Plan (August 2000) by Gilbert W. Clifford & Associates, Inc. and Schnabel Engineering:

The report discusses existing facilities, future demands, and water source alternatives for each county served by the RSA. Groundwater wells were eliminated as a viable source of future water supply due to low yield and infrastructure costs. The report recognized surface water impoundments as the only means by which the future demand could be met. Proposed water improvements discussed included a parallel water main along US Route 15 and an interconnection between the Greene County water system and the Gordonsville/Orange system. No action has been taken on the recommendations.

Water Distribution Hydraulic *Model (October, 2000) by* Gilbert W. Clifford & Associates, Inc.:

The report was prepared to provide as an addendum to the August 2000 RSA Comprehensive Water Supply Plan. The addendum included simulation of the existing distribution system and planned improvements. Maps of all systems were included excluding Wilderness.

The previous studies and reports address continuing concerns over water supply options related to the Town of Orange water system. Equally important are the water service agreements between adjacent water suppliers or purchasers.

<u>Water service agreements:</u>

Under contract, the RSA can draw from the Orange system a maximum of 33 million gallons of water per month; additional if prior authorization is obtained. A water sales contract was first developed on May 14, 1971. The contract will expire September 30, 2023. At that time, a new water supply agreement will need to be negotiated.

Additionally, the Town or Orange has an agreement with the Town of Culpeper to obtain water from the Culpeper water treatment facility under emergency situations. In the event water withdrawal is necessary, the Town of Orange agrees to pay the transportation fees. The agreement is effective through September 23, 2007 and can be extended prior to its expiration. No piped connection is suggested under this agreement. The contract anticipates the trucking of water between the water supply entities.

Town of Gordonsville

<u>Previous Studies:</u>

Technical Memorandum on the Gordonsville Quarry Pumping Test – Gordonsville, Virginia (October, 1991) by CH2M Hill, Inc.

This report focused on the use of the Gordonville Quarry as a water supply source. The quarry is approximately 70 feet deep and has a 12-acre surface area. It was determined that groundwater was the principal source of water to the quarry. Through a pumped drawdown and recovery of the quarry it was determined that a maximum withdrawal of 96 GPM could be sustained. Any withdrawal beyond that rate may require long recovery times for groundwater recharge in the area and would adversely affect the adjacent stream. Any withdrawal dropping the water level beyond 3.1 feet has an adverse effect on the adjacent stream, the South Anna River. When the quarry was drawn down 6 feet, the river went dry for a 600 foot stretch adjacent to the quarry. A drawdown of 3.1 feet in the quarry drops the stream level 0.5 feet, which corresponds to approximately 25% of the water column in the river.

Gordonsville's Water System Evaluation (G.E.L.P.) (not dated: est. 1992-1993) by Page & McLawhorn Engineering, P.C.:

The report's focus was to determine if the current system could supply a requested 350 gallons per minute (GPM) with a 40 psig residual to G.E.L.P. The report concluded that the system could not supply this required flow given the allowed purchase of 25 millionsgallons per month (578 gallons per minute) from the Rapidan Service Authority (RSA). The Town, along with Liberty Fabrics, had a peak use of 573 gallons per minute. Recommendations were to form an agreement with RSA for an additional 1,700 GPM, plus some for growth and fire demand. The Town should increase the permit to include the above flow. The RSA's 10-inch line is now at capacity and a new line must be installed for additional demand. The current water usage only allows for 176 GPM for fire flow. The sum of the peak flows depletes the RSA supply and fire flow would then be supplied from the Gordonsville water storage tank. The minimum recommended fire flow is 500 GPM. The Town had a 300,000 gallon tank only at the time. Liberty Fabrics took over the 300,000 gallon storage tank for their use. The Town installed a new 500,000 gallon water storage tank in 1994 to provide peak demand flows.

Town of Gordonsville, Virginia Gordonsville, Water Study RSR&A Project Number 9960 (August, 2000) by R. Stuart Royer & Associates, Inc.

This report reviewed existing water use data, projected future demand, and investigated 4 options for alternative water sources including: building new infrastructure to increase the availability of the RSA supply, build a new water line to Louisa and connect to the LCSA system, build a treatment plant at Lake Gordonsville (Bowlers Mill Lake) with water lines to the Town, and build a treatment plant at the quarry and an intake on Lake Gordonsville supplying raw water to the quarry plant. The report recognized the adequacy of the RSA supply but made a recommendation to pursue the building of a conventional water treatment facility at Lake Gordonsville with a backup supply from the quarry. The safe yield of Lake Gordonsville was listed at 0.71 MGD in a safe yield analysis conducted by the Department of Environmental Quality dated October 16, 1995. It should be noted that Gordonsville only owns rights to 10% of the water; Louisa County has rights to the remaining 90%. The safe yield of Lake Gordonsville is based on the 1977 drought. The safe yield would need to be re-evaluated based on 2002 drought if used for an alternative water source. The report also recommended that a safe yield determination be conducted at the quarry and to pursue a water loss prevention program due to a 12.34 percent water loss estimate.

Gordonsville Water Study, Project 0435 (November, 2005) by R. Stuart Royer & Associates, Inc.

> This report recognized that the existing 10-inch line from the RSA is at capacity and cannot provide future demand. The report reiterated the water source alternatives given in the August, 2000 water supply report. The recommendation was to build a membrane filtration water treatment facility at the quarry and pump a backup supply from Lake Gordonsville (Bowlers Mill Lake). The conclusions state that if the entire volume of the quarry were used as an emergency supply, that it would supply 500,000 GPD for up to 390 days.

The previous studies and reports address continuing concerns over water supply options related to the Town of Gordonsville water system. Equally important are the water service agreements between adjacent water suppliers or purchasers.

Water Service Agreements:

The RSA has a contract with the Town of Gordonsville dated May 14, 1971 to supply up to 25 million gallons of water per month. The contract expires after 40 years, but may be extended prior to its termination date if agreed to by both parties.

The Town has a contract with Gordonsville Energy, Limited Partnership (GELP) dated January 28, 1993 to provide up to 3 million gallons of water per month. The contract expires after a 30-year period, but will automatically be extended two consecutive 5-year terms unless terminated by GELP.

The Town has an agreement with GELP dated July 18, 1994 to reserve a supply of up to 5 million gallons per month of water from the Gordonsville Quarry (see CH2M Hill report above). The contract expires after a 30-year period, but will automatically be extended two consecutive 5-year terms unless terminated by GELP. According to the 1995 Gordonsville Comprehensive Plan, both GELP and Klockner Pentaplast use raw water from the quarry.

Orange County

Previous Studies:

Orange County Comprehensive Plan concerned with hydrogelogical considerations (July, 12 1991) by John Stanley: - Applies to the Entire County-

> The report presents a broad overview of the County's soils, ground and surface water, geology and mineral deposits. It was recommended that a professional evaluation of the County's hydrogeology be taken so that they may safeguard the resources and evaluate the County's capacity to accommodate population growth.

Rapidan Service Authority – Wilderness System

<u>Previous Studies:</u>

Letter from Orange County Planning & Zoning (January 26, 1996) by Benjamin W. Blankenship:

> The letter shows the projections for water demand in the Germanna Highway Corridor for the years 2000, 2005, 2010.

Orange County Wilderness Run Reservoir Water Supply and Growth Management Project (March 19. 1996) by Orange County Economic Development Office and Industrial Development Authority:

> The report outlines the development of water supply from the Wilderness Run Reservoir to support an R. Lindsay Gordon Employment Center. The project is justified by Orange County attracting new jobs and investments to offset the public service costs associated with residential development, prime industrial and commercial sites.

Letter from Department of the Army (September 5, 1997) by Bruce F. Williams:

> The letter to Mr. Gary Burton is asking for more clarification on the Wilderness Run project. Mr. Williams would like to know who the proponent on the project is, if the project would be a growth inducer or a solution to long-term water needs, and the project's engineering feasibility. Attached to the letter is a format for an Environmental Impact Report.

Rapidan Service Authority: Preliminary Engineering *Report*:

> The purpose of the report was to identify any impoundment sites and determine their feasibility as water supply reservoirs on the 1,400 acres of land owned by Mr. Charles King. Three locations where found and it was recommended the best site was #2, Shotgun Hill Branch. It offered the cleanest site with few previously-developed drainage problems and a good lake depth. Attached to the report is a comparison of each dam.

Rapidan Service Authority: Project 2000 Source of Supply Alternative Analysis (September 2000) by Schnabel Engineering Associates, Inc.:

> The report provides information on a study of groundwater and surface water to be used in the future to supply water to meet anticipated future needs in the Tri-County areas of Greene, Orange, and Madison Counties. It was concluded that given the limited availability of groundwater relative to the projected demand, further consideration of groundwater as a major source of supply in not merited. However carefully sited wells with higher yields could serve as a sole source or interim supply to smaller isolated communities located near the contact of major geological formations. The assessment of new reservoir sites resulted in a short list of three alternatives. The results of this evaluation identified White Run Tributary, which is located in Greene County, as being the site best suited for development, given the projected demand of 4 MGD within the

planning period.

Map – Rapidan Service Authority, Comprehensive Water Supply Plan, Somerset, Wilderness, and Lake of the Woods, Preliminary Water Distribution-Hydraulic Model (April 2002) by Gilbert W. Clifford & Associates, Inc.:

The map illustrates the existing distribution system in the RSA Wilderness system.

All agreements between the Town of Orange, Town of Gordonsville, and the Rapidan Service Authority have been discussed in their appropriate sub-section above.

C.2 SURFACE WATER

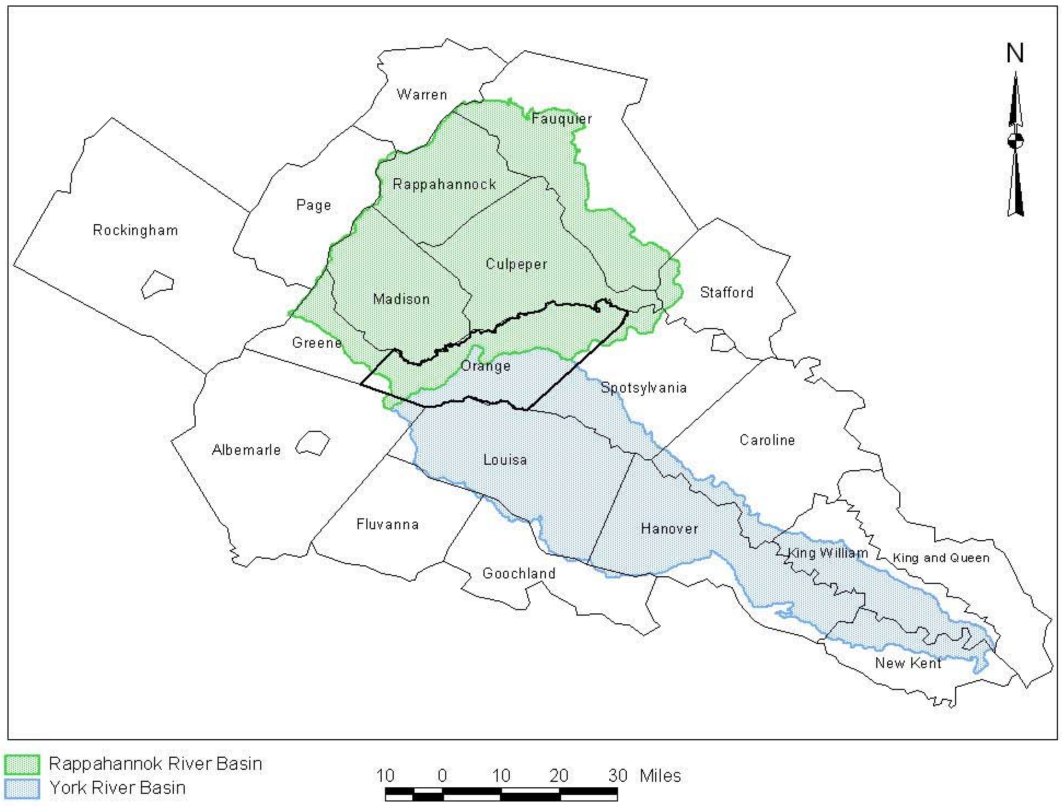
Introduction and Purpose

As a part of the development of the Orange County Water Supply Plan, Black & Veatch performed a streamflow analysis of the Rapidan River at the Town of Orange's Water Treatment Plant (WTP) intake and at the Rapidan Service Authority's Wilderness WTP intake. The purpose of this analysis was to determine and confirm the total available water for each intake in accordance with regulatory requirements.

While it is believed that the name for the Rapidan River is a combination of the word rapids with the name of Queen Anne of England, there is no question that this river is the largest tributary of the Rappahannock River in the central part of Virginia. The two rivers converge just west of the city of Fredericksburg and eventually drain into the Chesapeake Bay. The Rapidan River has its headwaters near Big Meadows in the Blue Ridge Mountains' Shenandoah National Park. The basin covers two distinct physiographic provinces: the Blue Ridge and the Piedmont.

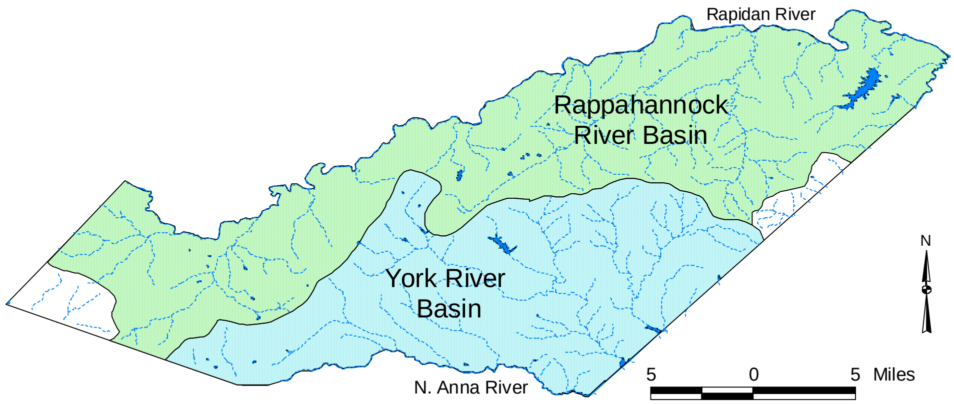
Orange County is located in what is known as the upper part of the Piedmont Plateau within the Piedmont physiographic province. Orange County is essentially divided into two primary watersheds as shown in Figures C-1 and C-2.

Figure C-1
Watershed Map



The northern half of Orange County drains to the Rapidan River, which is part of the Rappahannock River watershed, while the southern half of the county drains to the North Anna River and is located in the York River watershed. Approximately 23 percent of the watershed for Lake Anna is located in Orange County.

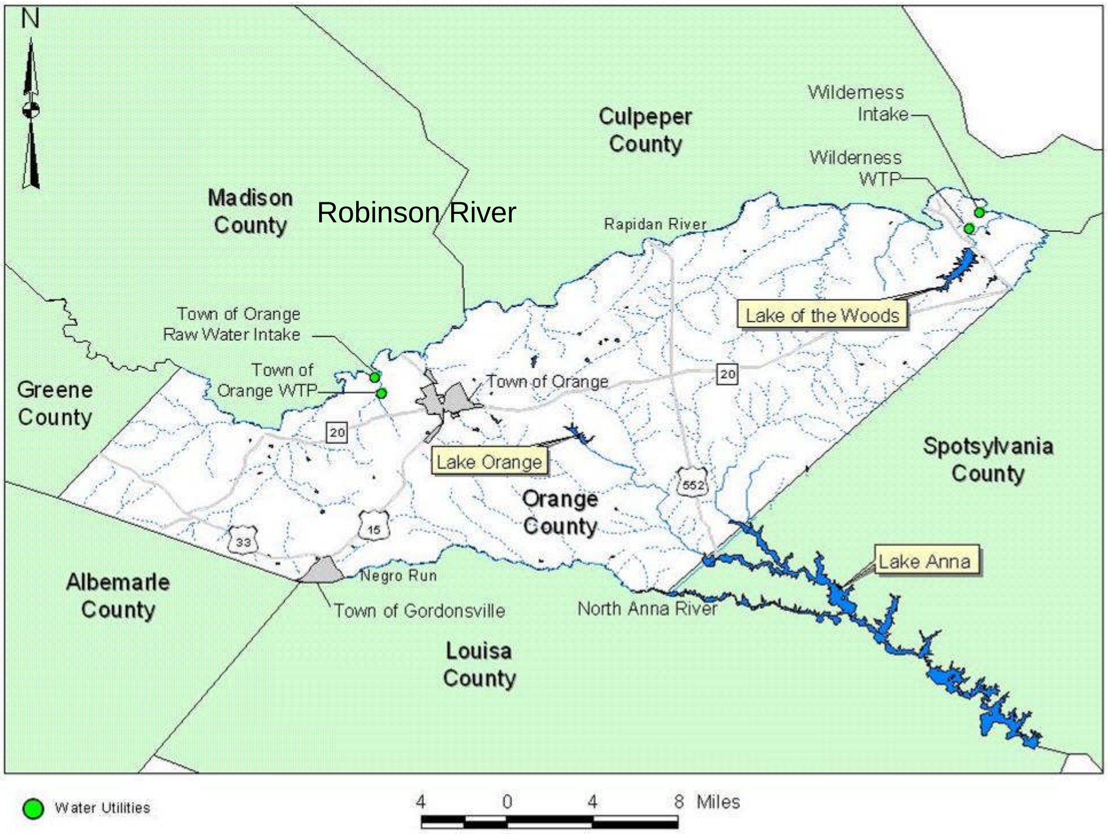
Figure C-2
Orange County Watershed Map



The scope of this work for Technical Memorandum No. 1 includes only a streamflow analysis of the Rapidan River at the Town of Orange's Water Treatment Plant (WTP) intake and at the Rapidan Service Authority's Wilderness WTP Intake. Technical Memorandum No. 2 will discuss the adequacy of these sources by comparing the water demands for each service area with the capacities of existing water sources. If needed, additional sources of supply and storage will also be identified.

Virginia Regulations do not define a required minimum flow; however, the Virginia Department of Health (VDH) uses the safe yield as one parameter in certifying the operating capacity of a waterworks. According to the VDH[xix], the safe yield of the source for a simple intake is defined as "the minimum withdrawal rate available during a day and recurring every 30 years (30 year – one day low flow)." This statistic is also referred to as the 1Q30. VDH regulations require that the worst drought of record since 1930 be used in determining the 1Q30. If actual gage records are not available for this, gages are to be correlated from similar watersheds and the records are to be synthesized.

Figure C-3
Overall Map



Town of Orange WTP

The Town of Orange's intake is located on the Rapidan River northwest of the town on Route 633 as shown on Figure C-3. The drainage area at the intake is estimated as 230 square miles.

The WTP has a design capacity of 2.0 MGD. A new 45 million gallon raw water reservoir was completed in 2005, and was designed to provide a 30-day minimum water supply. The raw water pump station has two primary pumps capable of pumping 1,600 GPM (2.3 MGD) each and one pump capable of pumping 1,800 GPM (2.6 MGD). The primary pumps are 60 HP and only capable of pumping to the water treatment plant. The third pump is 125 HP and capable of pumping to either the raw water storage reservoir or the water treatment plant. The 1Q30, as previously calculated by Black & Veatch in 1997, was 3.07 MGD. The duration of the USGS gage records used for B&V's 1997 study was between 1944 and 1995.

A special condition in the plant's VWP Permit limits the maximum daily withdrawal not to exceed 2.6 million gallons and limits the maximum instantaneous withdrawal not to exceed 1,800 GPM. Also, there is another condition that no more than 1.3 million gallons per day may be sold to out-of-basin customers. The Town of Orange is located on the drainage divide between the

Rappahannock basin and the York Basin, but its raw water intake is located in the Rappahannock basin. The Town of Orange sells water to the RSA Route 15 System and the Town of Gordonsville, both of which are located in the York basin.

If the previous year's total water withdrawal was less than or equal to 511 million gallons, then mandatory drought water conservation plans are required whenever the 14-day rolling average of the streamflow at the Rapidan River falls below 44 CFS (28 MGD). If the previous year's total water withdrawal was greater than 511 million gallons, then mandatory drought water conservation plans are required whenever the 14-day rolling average of the streamflow at the Rapidan River falls below 63 CFS (41 MGD).

RSA's Wilderness WTP

RSA's intake is located in the Rappahannock River Basin on the Rapidan River as shown in Figure C-3. The drainage area at the intake is estimated as 558 square miles.

The intake structure consists of a stainless steel intake screen that is rated 1,200 GPM and an intake located near the riverbank that has a capacity of 1,200 GPM. Two pumps, each rated at 650 GPM, combine for a total capacity of 1,100 GPM or 1.584 MGD to pump the raw water to the two presedimentation basins. The WTP has a design capacity of 1.584 MGD.

A special condition in the plant's VWP Permit limits the maximum daily withdrawal not to exceed 2 million gallons and limits the maximum instantaneous withdrawal not to exceed 2,083 GPM. Therefore, the source capacity is effectively 2.0 MGD.

Voluntary and mandatory drought water conservation plans are required whenever the 14-day rolling average of the streamflow at the Rapidan River at Culpeper falls below 53 CFS (34 MGD) and 28 CFS (18 MGD), respectively. While the Town of Orange and the Wilderness WTPs use the same USGS gage to evaluate the need for conservation, it should be noted that the minimum streamflow requirements are significantly lower for the Wilderness plant.

Low-flow Frequency Analysis Development

A low-flow frequency analysis was conducted using the USGS river flow data to calculate the frequency distributions of the data. Frequency distributions show the probability of certain flow rates as a function of recurrence interval. A recurrence interval (or return period) is a statistically derived estimate of the probability of the occurrence of a given event. It represents the probability that a particular event will be equaled or exceeded in a given year.

In terms of low-flow or drought analysis, the recurrence interval represents the probability that the streamflow will be equal to or lower than a particular event. For example, if a streamflow value of Q has a recurrence interval of 50 years, there is a 1 in 50 chance that the flow in the river will be equal to or lower than Q for any given year. Therefore, the 1Q30 requirement used for safe yield is the average flow rate in which, for any given year, there is a 1 in 30 (or 3.33 percent) chance that the streamflow is equal to or less than it.

The Log-Pearson Type III distribution (LP3) is the statistical method used to normalize the frequency distributions to predict low flows. This method is commonly used for streamflow analysis and generally provides a close fit for skewed distributions. Through the LP3 method, historical streamflow data is analyzed and used to produce low-flow frequency curves. These curves are then used to determine the flow rates for particular recurrence intervals used for low flow frequency analysis.

The general equation used in LP3 calculations is

$$\log(Q') = \overline{\log(Q)} + K\sigma_{\log(Q)} \qquad \text{(Equation 1)}$$

where Q' is the log-Pearson distributed streamflow, Q is the minimum daily streamflow for each year on record, $\overline{\log(Q)}$ is the average of $\log(Q)$, K is a frequency factor, and $\sigma_{\log(Q)}$ is the standard deviation of $\log(Q)$. The average of $\log(Q)$ is found by

$$\overline{\log(Q)} = \frac{\sum[\log(Q_i)]}{n} \qquad \text{(Equation 2)}$$

where n is the number of years during the period of record. The standard deviation of $\log(Q)$ is found by

$$\sigma_{\log(Q)} = \sqrt{\frac{\sum\left[\log(Q) - \overline{\log(Q)}\right]^2}{n-1}} \qquad \text{(Equation 3)}$$

The frequency factor, K, is a function of the skewness coefficient, Gi, and probability of exceedance (equal to or less than), P. The skewness coefficient, Gi, which used to determine the frequency factor is found by

$$Gi = \frac{n\sum\left[\log(Q) - \overline{\log(Q)}\right]^3}{(n-1)(n-2)\left(\sigma_{\log(Q)}\right)^3} \qquad \text{(Equation 4)}$$

For the low flow frequency analysis, the frequency factors are found using the USDA's standard frequency factor tables[xx]. These tables provide frequency factor values for specified skewness coefficients and probabilities of exceedance. The recurrence intervals, T_r, associated with each frequency factor are simply the reciprocal of the probability of exceedance (1/P).

Once the frequency factor for each recurrence interval is determined, Equation 1 can be applied to calculate the streamflow values. The recurrence intervals and streamflows are then plotted to create a low-flow frequency distribution graph.

Town of Orange Intake 1Q30 Results

Streamflow

Since river flow is not recorded directly at the intake, nearby USGS gages were researched for use as the simulated historical streamflow at the intake. Several factors such as hydrology, geology, and proximity were considered when determining acceptable gages to use.

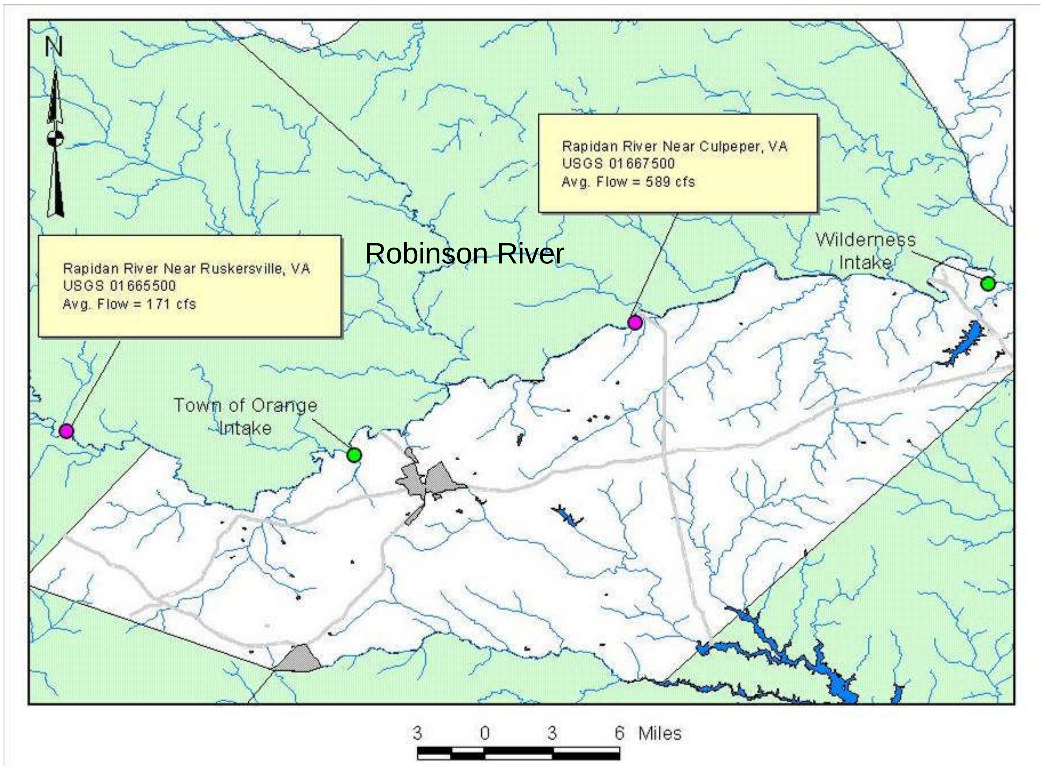
Two gages closest to the intake, the USGS gage near Ruckersville, VA (01665500) and the USGS gage near Culpeper, VA (01667500), were both considered. Their locations are shown on Figure C-4. Table C-3 shows the gage characteristics used in determining the appropriate gage to select.

Table C-3
USGS Gage Information

Location	USGS ID	Drainage Area (mi^2)	River	River-Basin	Gage Datum (ft)	Period of Record
Near Ruckersville *(18 miles Upstream of Town of Orange's intake)*	01665500	114	Rapidan	Rappahannock	439.44	10/01/1942 to 09/30/2004
Near Culpeper *(20 miles Upstream of Wilderness intake)*	01667500	472	Rapidan	Rappahannock	241.36	10/01/1930 to 09/30/2004

Drainage area plays a major role in determining the appropriate gages to use. The ratio of drainage area of the Town of Orange's intake and the Ruckersville gage (230 mi^2 / 114mi^2) is 2.02, while the drainage area ratio for the Culpeper gage (230 mi^2 / 472 mi^2) is 0.49. Since the drainage areas of both gages are reasonably comparable to that of the intake, both are considered acceptable on the basis of drainage area. Similarly, since both USGS gages are located on the same river, same river basin, and in relatively close proximity to the Town of Orange's intake, both may be presumed to be appropriate.

Figure C-4
Orange County USGS Locations



The USGS gage near Ruckersville and the Town of Orange's intake both lie upstream of the confluence of the Robinson and Rapidan Rivers, while the USGS gage near Culpeper lies downstream of the confluence. Additionally, the Culpeper gage is affected by and would include discharged flows (0.72 MGD average) from the Town of Orange wastewater treatment plant. For this reason, the gage near Ruckersville may provide a more accurate approximation of streamflow conditions at the intake. Therefore, the USGS gage near Ruckersville was used to estimate streamflow at the Town or Orange's intake.

Historical streamflow data at the USGS Ruckersville gage for the period from October 1, 1942 to September 30, 2004 was used. The streamflow at the Town of Orange's intake was approximated by using the ratio of the Town of Orange's drainage area to the Ruckersville gage drainage area, 2.02. The following equation was used:

$$Q_{\text{intake}} = Q_{\text{gage}} \frac{A_{\text{intake}}}{A_{\text{gage}}} \qquad \text{(Equation 5)}$$

Where Q_{intake} is the average daily streamflow at the intake, Q_{gage} is the average daily streamflow at the USGS gage, A_{intake} is the drainage area at the intake (230 square miles) and A_{gage} is the drainage area at USGS gage (114 square miles).

It should be noted that while the VDH requires flow data dating back to the worst drought on record in Virginia since 1930, the streamflow data for the gage at Ruckersville only dates back to 1942. For this reason, flow data from the gage at Culpeper from October 1, 1930 to September 30, 1942 was used to approximate streamflow at the Ruckersville gage for that time period. The drainage area approach, as described above, was used for this approximation by using the ratio of the Ruckersville gage drainage area to the Culpeper gage drainage area, 0.24.

The lowest mean daily streamflows during the period of record at the Town of Orange's intake are shown on Figure C-5. Several major droughts can be clearly identified. The worst drought since 1930 occurred in September of 2002 with a low flow of 0.59 MGD. The mean daily streamflows for the drought of 2002 are shown on Figure C-6.

Figure C-5
Average, Maximum, and Minimum Daily Streamflows Plotted by Year: Town of Orange's Intake

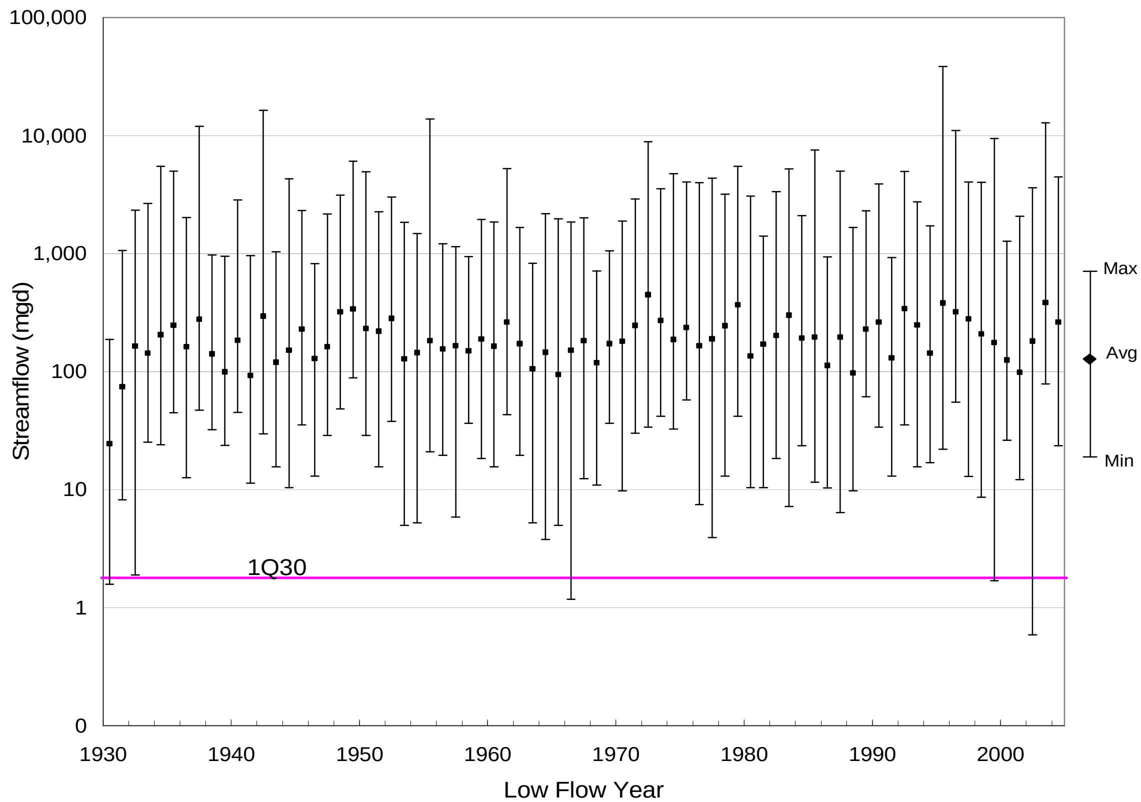
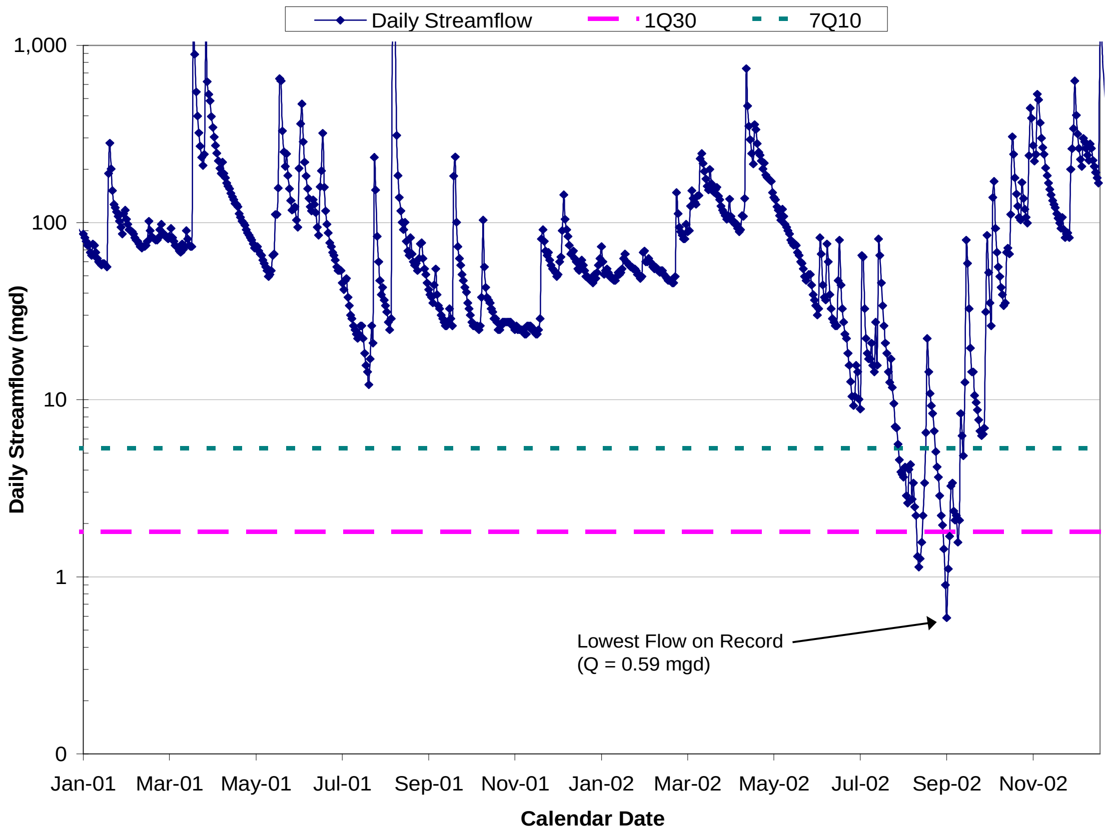


Figure C-6
Drought of 2002 – Town of Orange's Intake

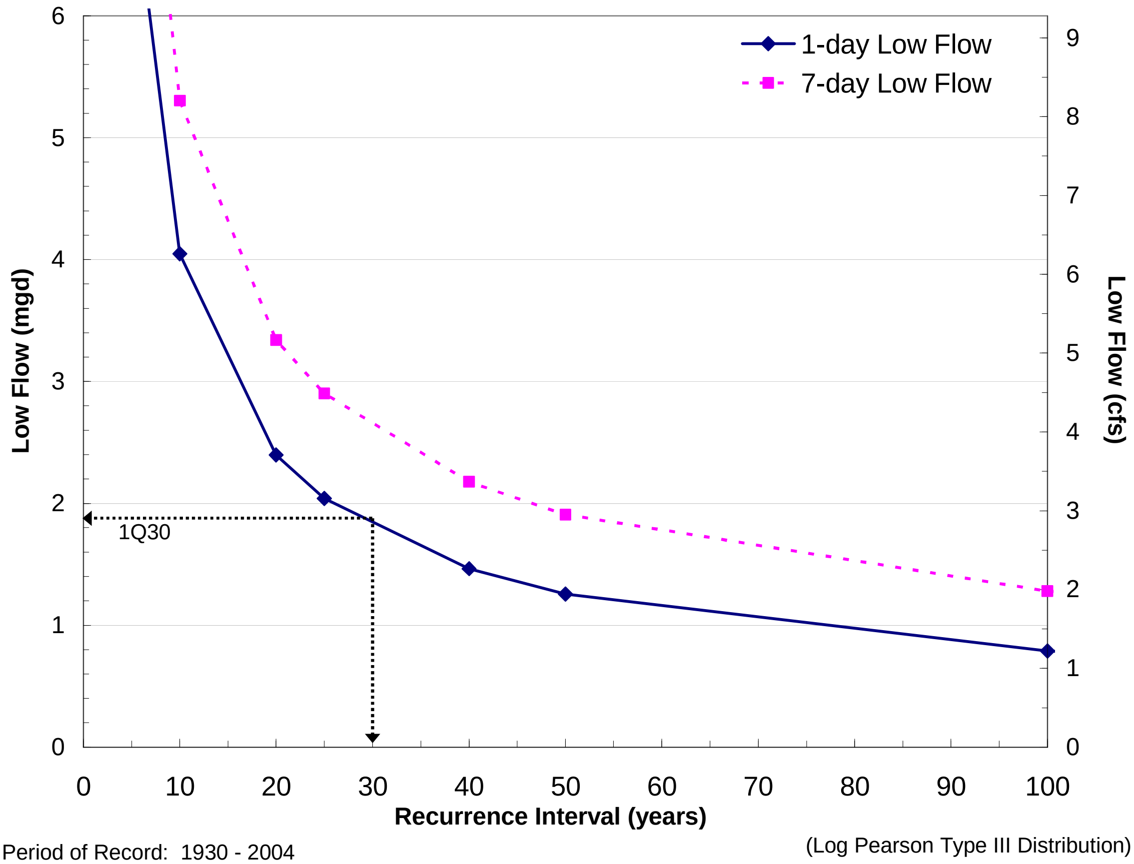


Analysis

Low-flow recurrence intervals were determined using the Log-Pearson Type III distribution. Figure 6 shows the 1-day low-flow and 7-day average low-flow values at the Town of Orange's intake. The higher 7-day average flows shown in the figure have roughly the same trend as the 1-day low flows but are slightly higher. As shown in Figure C-7, for a 10-year recurrence interval, the one-day low flow (1Q10) is roughly 4.1 MGD (6.3 CFS). Similarly, the 1Q30 and 1Q50 are approximately 1.8 MGD (2.8 CFS) and 1.3 MGD (1.9 CFS).

The 7Q10 is defined as the 7-day average low flow with a predicted recurrence interval of 10 years. Figure C-7 shows that for a 10-year recurrence interval, the 7-day average low flow is roughly 5.3 MGD (8.2 CFS).

Figure C-7
Low Flow Frequency Distribution: Town of Orange's Intake



1Q30 Result.

The Virginia Department of Health recognizes the 1Q30 as the safe yield for simple river intakes. Table C-4 summarizes the yield results of previous studies and this current study.

Table C-4
1Q30 Results for Town of Orange's Intake

Study	1Q30 (MGD)	1Q30 (CFS)	Period of Record
B&V 1997 Study	3.07	4.75	1942 to 1995
B&V Current Study	1.79	2.78	1930 to 2004

Table C-4 shows that the estimated 1Q30 is significantly lower in the current study. As shown in Table C-5, the first and third lowest streamflows during the period of record of the current study occurred in 2002 and 1930, respectively. Since both of these droughts were included in the current study, and not included in the 1997 study, the 1Q30 value was reduced.

Table C-5
Lowest Mean Daily Streamflows for Town of Orange's Intake

Year	Minimum Yearly Mean Daily Streamflow (MGD)	(CFS)
2002	0.59	0.91
1966	1.17	1.82
1930	1.57	2.44
1999	1.70	2.62

As mentioned previously, the Town has recently constructed a 45 million gallon (MG) water storage reservoir. This reservoir will affect the overall water supply reliability and therefore a more detailed safe yield analysis must be performed.

Town of Orange Safe Yield Analysis Development

Since the Town of Orange has a 45 MG raw water storage reservoir, the safe yield for the Town must be modeled using a reservoir mass balance. The Town of Orange yield model was developed to determine the maximum amount of water that could be physically withdrawn from the storage reservoir without violating allowable constraints. To determine the safe yield, the reservoir was simulated with a constant withdrawal rate over a 76-year period, and an established minimum storage volume was reached during the most severe drought period on record. The safe yield is defined as the withdrawal rate above which the water volume would fall below the critical volume during the most severe drought on record.

To simulate the reservoir, a yield model was developed to perform a hydrologic budget on the reservoir using a mass balance approach. An iterative Excel spreadsheet was used to calculate the volume of the reservoir in daily time steps using input that includes inflows, precipitation, evaporation, reservoir characteristics, and operational constraints. The mass balance calculation for the reservoir volume was performed using Equation 1.

$$DS = I + P - E - W \quad (1)$$

Where,

DS = Change in storage volume in the Town of Orange's storage reservoir
I = Inflow pumped from the Rapidan River
P = Precipitation falling directly to the storage reservoir surface
E = Evaporation from the storage reservoir surface
W = Water withdrawn (yield)

Where available, data were collected for each component of the mass balance. The source and description of the data collected for each component are as follows:

Inflow, I

Streamflow in the Rapidan River at the Town of Orange's intake was calculated using data from USGS gage number 01665500 near Ruckersville, VA and USGS gage number 01667500 near Culpeper, VA. The process used to calculate the streamflow for the period of record is described in this Technical Memorandum.

In the yield model, the inflow pumped into the storage reservoir from the Rapidan River is calculated based on a number of factors. The first factor is the minimum downstream flow requirement. This represents the minimum amount of flow left in the Rapidan River after pumping from the Town of Orange intake. Two scenarios for minimum downstream flow requirement were used in the yield model. The first scenario used the calculated 1Q30 value (1.79 MGD) for the Rapidan River at the Town of Orange's intake as the requirement. The second scenario used the 7Q10 value (5.30 MGD) for the Rapidan River as the requirement. In the yield model, it was assumed that the pumping rate could not exceed a value that would make the river streamflow less than the downstream flow requirement.

Another factor affecting the inflow pumped from the Rapidan River is the maximum pumping rate available at the pump station. For this yield analysis, a maximum pumping rate of 2.0 MGD was assumed.

In the yield model, the pumped inflow was calculated as the minimum of the following:

- maximum allowable pumping rate based on the downstream flow requirement,
- maximum available pumping rate at the intake pump station, and
- amount of pumping required to fill the reservoir to the normal pool elevation.

Precipitation, P

Daily precipitation data were obtained from the National Oceanic & Atmospheric Administration's (NOAA) National Weather Service (NWS) database. Rainfall data from three different gages were used as listed below:

Table C-6

Precipitation Gages for Town of Orange Intake			
Precipitation Station		Period of Record	Latitude/ Longitude (decimal degrees)
Number	Name		
44 6712	PIEDMONT RESEARCH ST	Nov. 1946 – Nov. 2007	38.23 / 78.12
44 7033	RAPIDAN	Nov. 1944 – Dec. 1981	38.3 / 78.07
44 7904	SOMERSET	Jan. 1945 – Nov. 2007	38.25 / 78.27

The Virginia gage station number 44 6712 (Piedmont Research Station) was considered ideal due to its close proximity to the Town of Orange's intake and its extended period of record. If data for a particular day was missing from the Piedmont Research Station gage, then data from the Rapidan gage was used. If data was also missing for the Rapidan gage, then the Somerset gage was used. If data were missing from all three gages for a particular day, then the monthly average for the available period of record for the Piedmont Research Station gage was used.

Additionally, to extend the period of record back to 1930, the calculated monthly averages for the available period of record for the Piedmont Research Station gage were used.

The precipitation data values from the gages were used without adjustment because no data were available to determine actual precipitation at the reservoir. The compiled precipitation data was multiplied by the normal-pool reservoir surface area to calculate the volume gained per each time step of the model.

Evaporation, E

Daily pan-evaporation data from two NOAA gages were obtained from the NOAA's NWS online database.

Table C-7 Pan Evaporation Gages for Town of Orange Intake			
Pan Evaporation Station		Period of Record	Latitude/ Longitude (decimal degrees)
Number	Name		
44 1598	CHARLOTTESVILLE 1 W	Aug. 1951 – Aug. 1970	38.03 / 78.52
44 6712	PIEDMONT RESEARCH ST	June 1971 – Nov. 2007	38.23 / 78.12

The daily evaporation estimates used in the yield model between 1951 and 1970 came solely from the Charlottesville gage. If a day of data was missing for this gage, then the 30-day rolling average evaporation was used. If 30-days in a row or more of daily data were missing, then the monthly averages for the calculated period of record for the Charlottesville gage were used. The calculated monthly averages were also used to extend the period of record back to 1930.

The evaporation estimates used in the yield model between 1971 and 2006 came solely from the Piedmont Research Station gage. If a day of data was missing, then the 30-day rolling average was used. If 30-days in a row or more of daily data were missing, then the monthly averages for the calculated period of record for the Piedmont Research Station gage were used. It should be noted that no pan evaporation data for the months of January and February were available for the Piedmont Research Station gage for the entire period of record. Therefore, the monthly averages calculated from the Charlottesville gage were used for days of missing data within these two months.

Withdrawals, W

A constant reservoir withdrawal rate was assumed for the entire period of record. The withdrawal rate that would cause the reservoir to drop to a set minimum allowable surface elevation only once during the entire period of record was considered the safe yield.

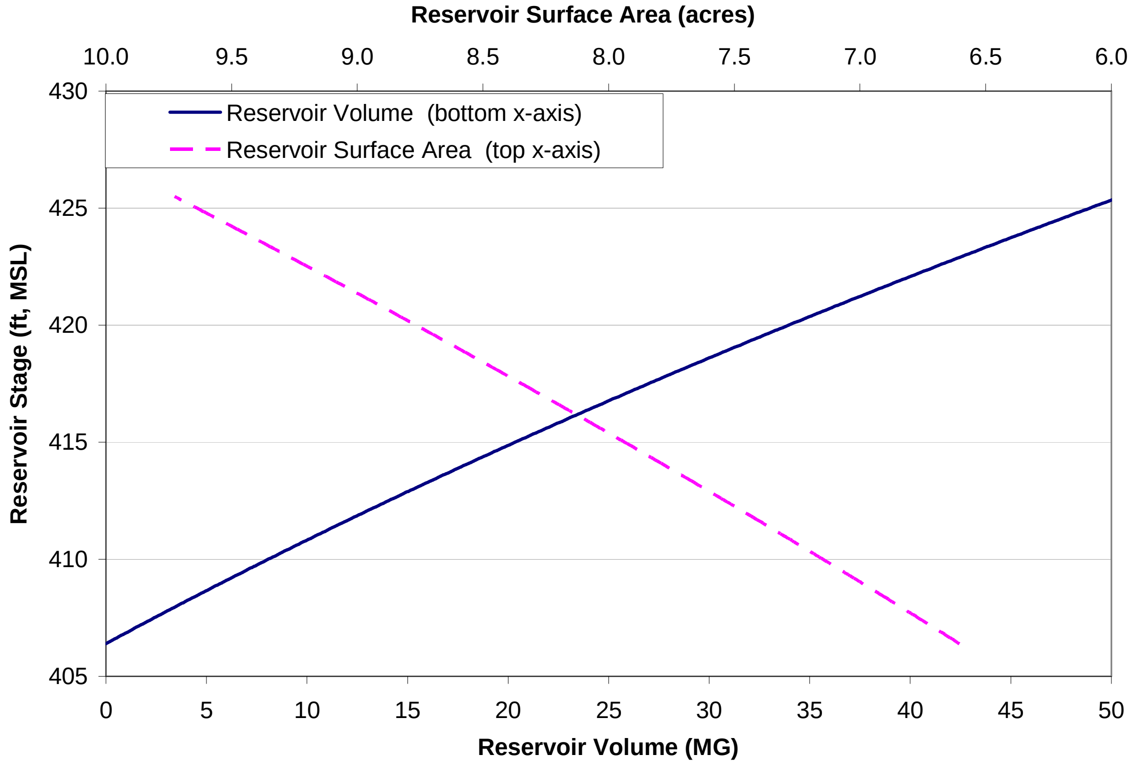
Storage, S

A stage-storage relation was developed using the design dimensions of the Town of Orange's storage reservoir. The following dimensions were used to develop the relationship:

- Bottom Elevation – 406.4 feet, msl.
- Normal Pool Elevation – 425.5 feet, msl.
- Storage Volume at Normal Pool – 155 acre-feet.
- Side Slopes – 3:1.

The stage-storage curve developed is shown in Figure X. The relationship between stage and storage is used in yield model calculations to estimate the drawdown of the storage reservoir resulting from inputs and outputs to the storage volume.

Figure C-8 Town of Orange Storage Reservoir Stage-Storage Curve



Safe Yield Model Results

The simulation model used for the yield analyses determined the maximum average daily withdrawal rate that can be maintained throughout the period of record while drawing the reservoir volume down to a pre-set minimum value only once (one day) during the period of record.

The following assumptions were made in the yield model:

- Initial Conditions: The reservoir was assumed to be full on day one (October 1, 1930) of the model simulation.
- Pumps Start Conditions: It was assumed that the raw water pumps would start anytime the reservoir drops below normal pool elevation of 425.5 feet, msl.
- Maximum Available Pumping Rate: A maximum pumping rate of 2 MGD was assumed.
- Minimum Allowable Reservoir Volume: It was assumed that the reservoir could be completely drained, thereby having a minimum allowable reservoir volume of 0 MG
- Minimum Downstream Streamflow Requirement: Two scenarios were analyzed for the minimum streamflow allowable on the Rapidan River downstream of the Orange

Intake; the 1Q30 flow (1.79 MGD) and the 7Q10 flow (5.30 MGD).

The results from the Town of Orange safe yield model are as follows:

- For a minimum release requirement of 1Q30 (1.79 MGD), the calculated safe yield is 1.98 MGD.
- For a minimum release requirement of 7Q10 (5.30 MGD), the calculated safe yield is 1.25 MGD.

Wilderness Intake 1Q30 Results

The Wilderness intake is located in the Rappahannock River Basin on the Rapidan River near the Lake of the Woods. The drainage area at the intake is estimated as 558 square miles.

USGS Gage Information

Since river flow is not recorded at the Wilderness WTP intake, flow records for similarly gaged watersheds are used to simulate historical streamflows for the low flow frequency evaluation. The USGS gage near Culpeper, VA (01667500) was chosen to estimate streamflow at the Wilderness WTP intake due to is close proximity to the intake and similar hydrologic and geologic conditions.

Historical streamflow data at the USGS Culpeper gage for the period from October 1, 1930 to September 30, 2004 was used. Equation 5 was used to calculate the streamflow at the Wilderness intake. The ratio of the Wilderness intake drainage area (558 square miles) to the Culpeper gage drainage area (472 square miles) was calculated as 1.18.

Figure C-8 shows the lowest mean daily streamflows over the period of record for the Wilderness intake. The worst drought on record since 1930 occurred in 2002 with a low flow of 1.15 MGD (1.77 CFS). The mean daily streamflow values during the 2002 drought are shown on Figure C-9.

Figure C-9
Average, Maximum, and Minimum Daily Streamflows:
Wilderness Intake

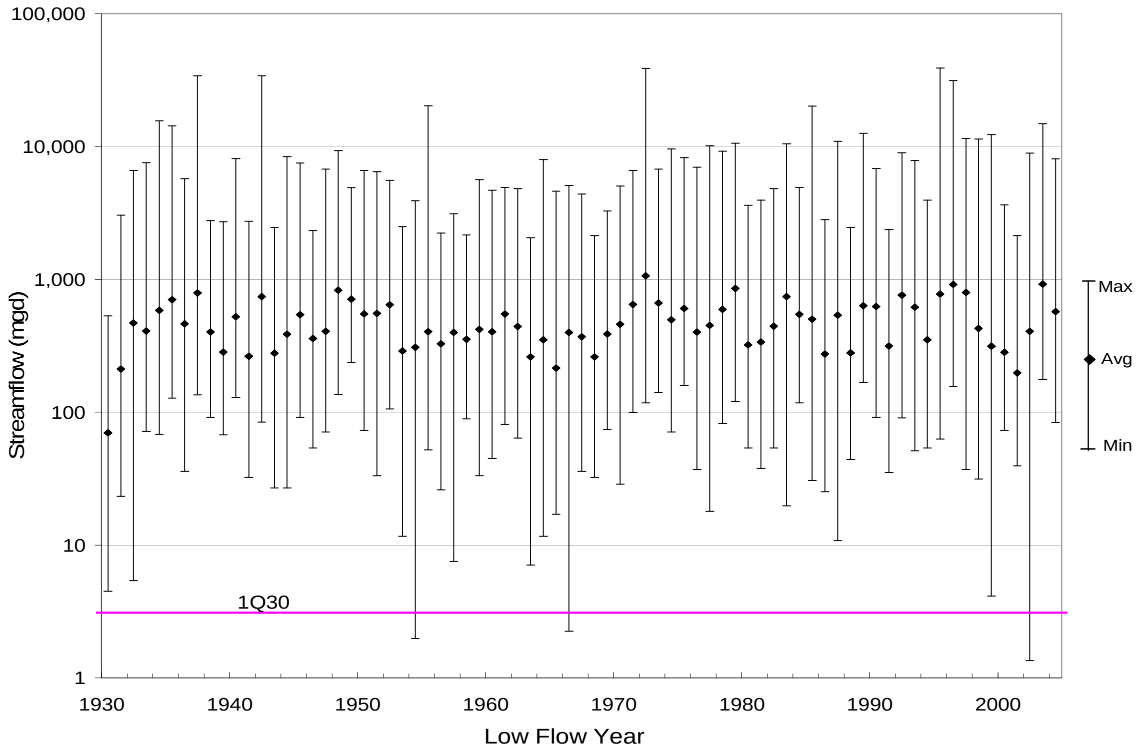
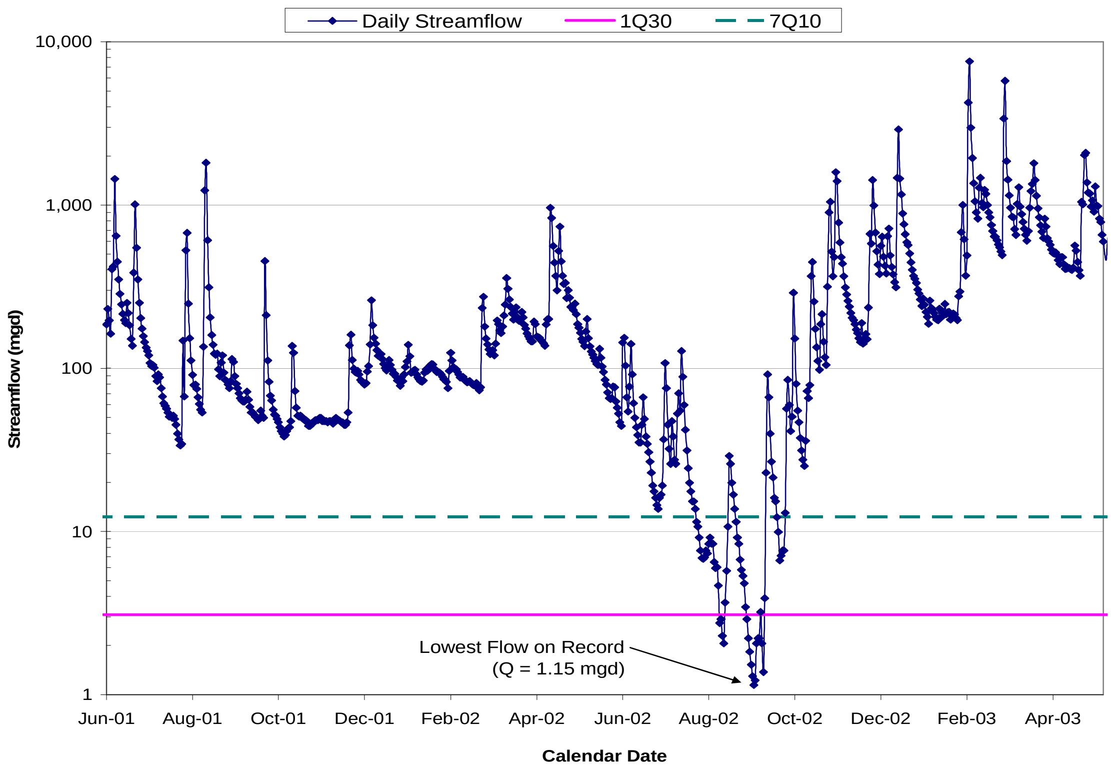


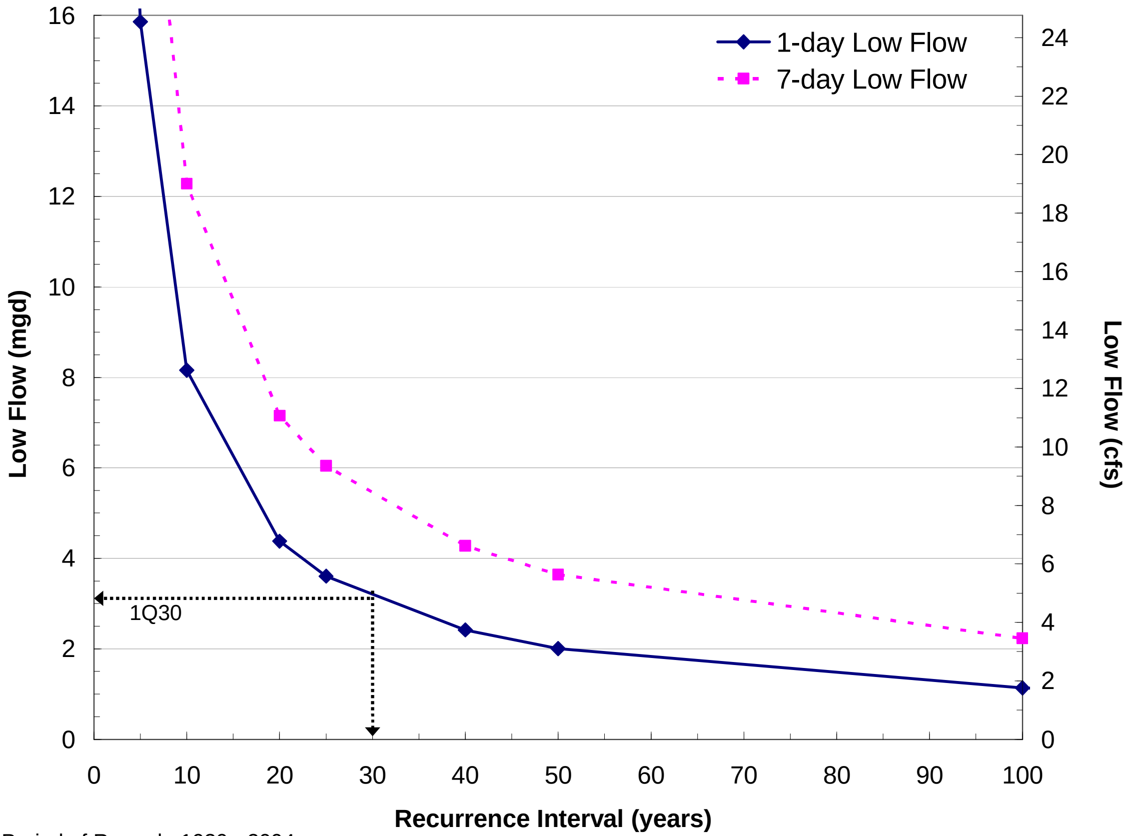
Figure C-10
Drought of 2002 – Wilderness Intake



Analysis

Low-flow recurrence intervals were determined using the Log-Pearson Type III distribution which was previously discussed. Figure C-10 shows the 1-day low-flow and 7-day average low-flow values at the Wilderness intake. As shown in the figure, the 1Q10, 1Q30, and 1Q50 are roughly 8.2 MGD (12.6 CFS), 3.1 MGD (4.8 CFS), and 2.0 MGD (3.1 CFS), respectively. The 7Q10 is approximately 12.3 MGD (19.0 CFS).

Figure C-11
Low Flow Frequency Distribution: Wilderness Intake



Period of Record: 1930 - 2004

(Log Pearson Type III Distribution)

1Q30 Result

As previously discussed, the Virginia Department of Health recognizes the 1Q30 as the safe yield. Therefore, the 1Q30 for the Wilderness intake is estimated as 3.09 MGD (4.78 CFS). The lowest mean daily streamflows per year at the Wilderness intake are shown in Table C-6.

Table C-8
Lowest Mean Daily Streamflows for Wilderness Intake

Year	Minimum Yearly Mean Daily Streamflow (MGD)	Minimum Yearly Mean Daily Streamflow (CFS)
2002	1.15	1.77
1954	1.68	2.60
1966	1.91	2.96
1999	3.51	5.44

C.3 GROUNDWATER

Rapidan Service Authority (RSA) Route 20 Well

The RSA currently operates a groundwater well located along State Route 625 (Porter Road) near the Orange County Sheriff's Office just south of State Route 20. The report entitled "*Rapidan Service Authority – Project 2000 – Comprehensive Water Supply Plan* (August 2000) by Gilbert W. Clifford & Associates, Inc. and Schnabel Engineering" lists the well yield at 25 gallons per minute (source of information unknown). However, the Orange County Comprehensive Plan lists the well yield at 30 gallons per minute (source of information unknown). A well production rate of 25-30 gallons per minute translates to 0.036 – 0.043 million gallons per day or 1.08 – 1.30 million gallons per month. Assuming an average usage of 70 gallons per day per person, this well yield is enough to serve an equivalent residential population of 617 persons. Actual water usage and future demands on this water source will be discussed in further detail in the section of this report entitled 'Existing Service Areas and Water Use'.

Additional Public System Wells and Schools

Several small businesses throughout the County are served by public water systems. Each public system is supplied by a common well. There are 13 such public system wells in Orange County. A list of their safe yields has not been obtained. However, the Virginia Department of Health has approved their use as a public water system source. Therefore, it is assumed that the yield is adequate for the planned development. No further expansion of the systems beyond their existing limits is expected including the community water system of Wolftrap Woods. Future isolated public systems would need to develop their own water source. A list of each existing development and its water usage is available in the section of this report entitled 'Existing Service Areas and Water Use.'

Four of the County's twelve schools use on site wells as their water source. The wells are approved by the Virginia Department of Health as a public water source. Unionville Elementary School and Lightfoot Elementary School are served by individual wells. Locust Grove Elementary and Locust Grove Middle School are both supplied by a single well source. The safe yield of each well has not been obtained. A discussion of the water use at each facility can be found in the 'Existing Service Areas and Water Use' section of this report.

Individual Wells (Out of Service Area)

Residential and isolated commercial establishments throughout Orange County generally receive their potable water through groundwater wells. To determine the number of residences and other establishments outside of the existing service areas, the County's GIS information was utilized. The addresses were compared to the existing service areas created as part of this report to determine which were located both inside and outside of the service area boundaries. It was determined that approximately 7,340 addresses lie outside publicly served areas. It is assumed that each of these addresses would have a groundwater well associated with it.

Well data associated with the two wells classified as ‘community’ water systems is included below for reference. The information in included with the ‘Water Well Completion Reports’ obtained from the Virginia Department of Health, Office of Drinking Water.

Table C-9
Community Systems – Water Well Data

Well name	Route 20	Wolftrap Woods
Well ID number	PWSIS 6137120	PWSID 6137900
Well depth	505 feet	205 feet
Casing depth	132 feet	118 feet
Screen depth	N/A	None
Casing diameter	6 inch	6.25 inches
Static water level	15 feet from surface	75 feet from surface
System capacity	40 GPM	30 GPM

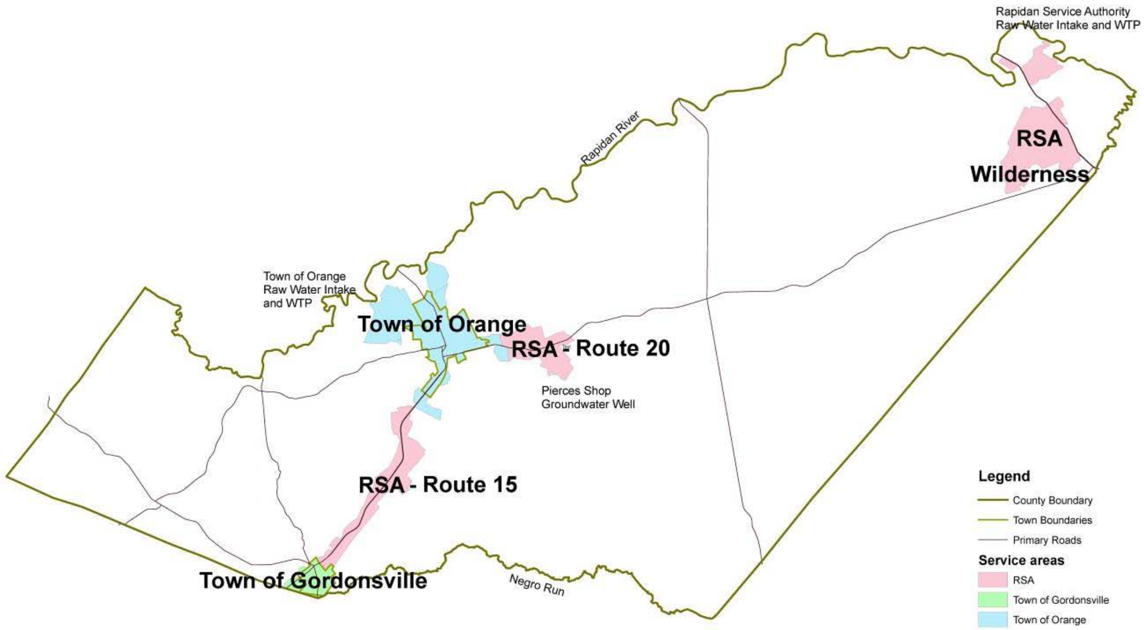
D. EXISTING SERVICE AREAS AND WATER USE

D.1 TOWN OF ORANGE

Data Collection and Review

The Town of Orange is located at the intersection of US Route 15 and State Route 20 and serves as the County government seat. The service area for Town of Orange extends beyond the Town limits along Route 20 to the east, along State Route 633 to the west, and along Route 15 to the north and south. The approximate service area boundary is shown in Figure D-1.

Figure D-1
Service Area Boundary



As previously discussed in the 'Existing Sources' section of this report, the Town currently holds a withdrawal permit on the Rapidan River and has an intake approximately 2.3 miles west of Town where State Route 633 nears the Rapidan. The water treatment facility has a rated capacity of 2.0 million gallons per day (MGD). This capacity currently serves the Towns of Orange and Gordonsville, as well as the intermediate area along US Route 15.

Many data sources were consulted during the compilation of this report. Previous studies and reports were obtained from the Town of Orange in addition to the water service agreements held with adjacent entities. The previous studies discuss past views regarding the supply and distribution of water resources within this portion of the County. The reports and water service agreements are summarized in the 'Existing Sources' section of this report.

Water usage data was obtained from the Town to develop a historic pattern of water use by which to project future demand and to ultimately determine the adequacy of the existing water supply source, both currently and into the future. The data, when obtained, was already disaggregated according to use, including residential, commercial, industrial, and institutional. In addition, the total number of connections per use was included. Summary sheets were developed for years 2002 through 2005. Because of data gaps in the years prior to 2002, an accurate account of water use could not be established. The data was received in monthly totals and is shown in Table D-1 as Average Daily Flow. Max day and max month flows for each year are also shown in Table D-2.

Geographic Information System (GIS) mapping was obtained from Orange County and the Town of Orange. The mapping included typical map features including roads, buildings, etc. It also included water lines, fire hydrants, parcels, zoning, and other layers used to develop service area boundaries. A complete list of GIS mapping layers received, and a brief description of each, is available in the Appendix of this report.

Another key component in water supply planning is the adherence to the Town's Comprehensive Plan. A draft of the most recent plan, having just been adopted, has been received and reviewed to determine the focus of Town planning. Additional relevance to the water supply plan can be found in the 'Evaluation of Population and Land Use' section below.

Water Use

The Town of Orange supplies domestic water service to customers in and around the Town including residential, commercial, institutional, and industrial users. As mentioned previously, they also sell a large quantity of water to the Rapidan Service Authority (RSA). The yearly water usage fluctuates between 350 to 400 million gallons, with the Town using approximately 200 million gallons and approximately 150 to 200 million gallons going to the RSA. Water sales records have been obtained from the Utilities Department to give a more accurate account of specific uses. A complete set of data was not available for each year. Where a month of data was missing, an estimate of usage was made based on the previous year's monthly total. The usage is recorded in monthly intervals by the Town by disaggregated use. Tables D-1 and D-2 present the data as flow in million gallons per day (MGD).

Table D-1
Town of Orange Water Billings

Year	Average Daily Flow (MGD)				
	Residential	Commercial	Industrial	Institutional	Total
2000	Ins. Data	Ins. Data	Ins. Data	Ins. Data	Ins. Data
2001	Ins. Data	Ins. Data	Ins. Data	Ins. Data	Ins. Data
2002	0.213	0.103	0.029	0.082	0.427
2003	0.200	0.101	0.022	0.070	0.392
2004	0.208	0.095	0.021	0.070	0.394
2005	0.247	0.112	0.034	0.085	0.478

Table D-2 Town of Orange Peak Usage						
Year	Maximum Month			Max Day		
	Month	Flow (mgd)	Peaking Factor	Date	Flow (mgd)	Peaking Factor
2000	Ins. Data	Ins. Data	Ins. Data	XX	XX	XX
2001	Ins. Data	Ins. Data	Ins. Data	XX	XX	XX
2002	Jun.	0.554	1.30	XX	n/a	XX
2003	Oct.	0.417	1.07	6-May	0.767	1.96
2004	Aug.	0.411	1.05	5-Jul	1.037	2.63
2005	Sept.	0.594	1.25	1-Aug	1.123	2.36

The year 2005 totals are different from previous years. An error in metering, recording, or processing may have occurred in one or more months to create the difference. However, the increase seems to be spread across all classifications with residential developments accounting for almost half of the increase. The Town has experienced several residential development projects within the past year. This could account for a large portion of the increase. With many more development projects due to occur in the next few years this significant upward trend in water usage is of great significance.

In addition to billing data, water production data was also obtained for the Town of Orange water treatment plant. This information was used to identify actual water withdrawal and unaccounted water losses in the systems. Average and maximum day tables are given for reference.

Table D-2A Town of Orange WTP production - to Town (MGD)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2001	0.532	0.483	0.494	0.497	0.600	0.557	0.610	0.600	0.640	0.671	0.640	0.474
2002	0.613	0.493	0.494	0.563	0.587	0.640	0.558	0.597	0.420	0.439	0.477	0.513
2003	0.516	0.514	0.506	0.520	0.542	0.520	0.558	0.539	0.557	0.561	0.507	0.468
2004	0.555	0.538	0.539	0.503	0.519	0.567	0.494	0.555	0.543	0.542	0.537	0.526
2005	0.452	0.566	0.539	0.537	0.542	0.693	0.590	0.603	0.627	0.610	0.573	0.603

Table D-2B Max Day Finished Water Production (MGD) to Town of Orange												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
2003	0.697	0.732	0.698	0.704	0.767	0.693	0.686	0.727	N/A	0.743	N/A	N/A
2004	0.765	0.682	0.674	0.705	0.818	0.797	1.037	0.892	0.773	N/A	N/A	N/A
2005	N/A	0.757	0.786	0.869	0.855	1.047	1.094	1.123	0.940	0.750	0.879	1.050

The difference between water production (Tables D-2A and D-2B) and water billed (Tables D-1 and D-2) represents the unaccounted for water (UFW) or potential water loss in a system. A discussion and summary of water losses can be found in Technical Memorandum No. 2, Section 6 – Demand Management, including Table 6-2.

Evaluation of Population and Land Use

The population of the Town has been gradually increasing over the past several decades with a 2% - 3% annual growth rate. However, there is a recent trend for population increases primarily associated with Northern Virginia commuters. In the Town Comprehensive Plan the growth rate goal is defined as 2% per year. Paraphrased from the Comprehensive Plan, “the Department of Public Works can not maintain service at a growth rate of more that 2% per year without an increase in staff”. Table D-3 lists housing and population data obtained from the 2000 U.S. Census and the percentage of each in relation to all of Orange County.

Table D-3 Town of Orange Housing and Population Data			
Housing Units Within the Town of Orange		**Population in the Town of Orange**	
Number	% County	Number	% County
1,712	15.1	4,123	15.9

The Town Comprehensive plan lists a target overall population goal of 8,000 to 10,000 persons. With a growth rate of 2% per year and a total goal of 10,000 persons, the Town would reach its maximum in the year 2045. However, this growth is not anticipated to be linear over time; the growth rate for the near term is expected to be higher and then drop off as the Town reaches buildout. Table D-4 lists the Town population in 10-year intervals given a 3% medium annual growth rate, with a low estimate of 2% annual and a high estimate of 4% annual from 2005 until 2020. From 2020 until 2050 the annual growth rate estimates drop to 1% for the low estimate, 1.5% for the medium estimate, and 2 % for the high estimate.

Table D-4 Town of Orange Population Projections						
	Year					
Population Estimate	2005	2010	2020	2030	2040	2050
Low	4123	5026	6127	6768	7476	8258
Medium	4123	5541	7447	8642	10029	11640
High	4123	6103	9034	11012	13424	16364

The population increases will be spread across different areas of the Town. Land uses will be modified where necessary to comply with the Comprehensive Plan future land use projections. Figures D-2 and D-3 show both the current land use within the Town and the future land use projected under the most recent Town Comprehensive Plan.

Figure D-2
Town of Orange – Current Land Use

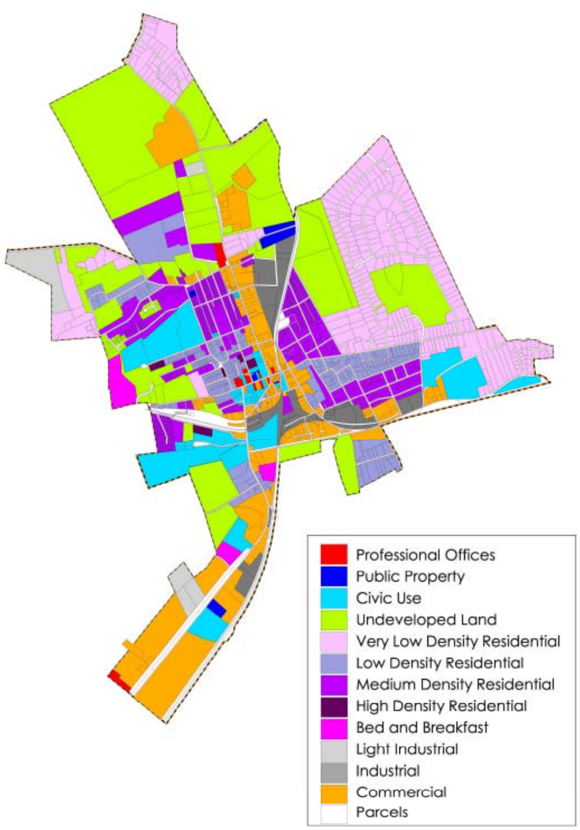


Figure D-3
Town of Orange – Future Land Use

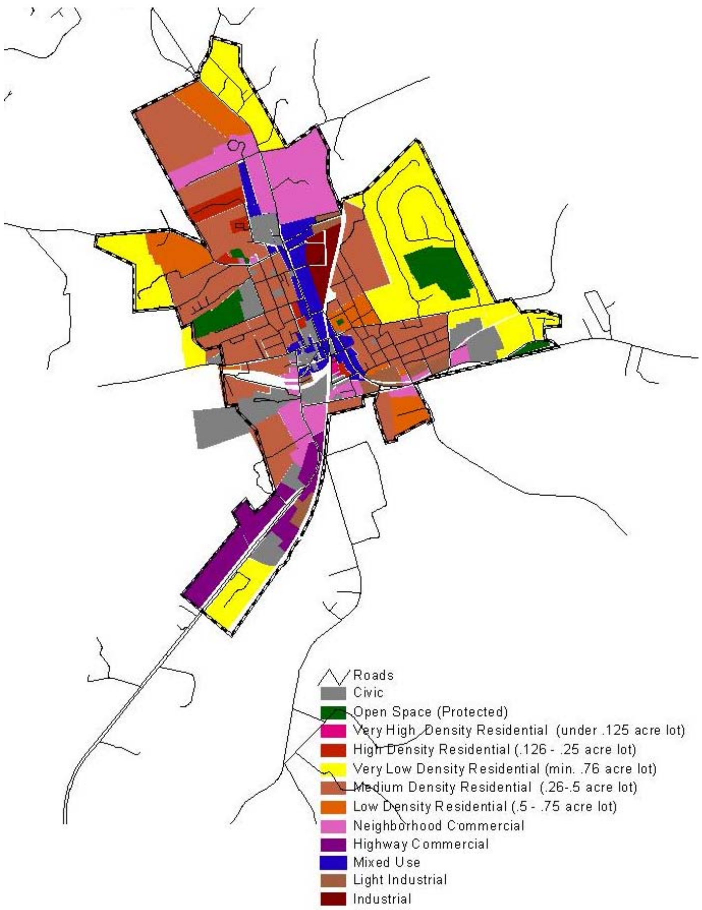


Table D-5
Planned Development Summary *

Residential Development	Residential Units	Use	Year	Location/Description
Poplar Forest	50	single family	2005-2007	Off Harper Drive toward Porterfield Drive
Orange Estates	74	single family	2005-2007	Off Oakbrook Drive
Porterfield II	30	townhouses	2006-2007	Off Porterfield Drive
Parkview	64	townhouses	2005-2006	Porterfield Drive at Montevista Avenue
Orange Estates II	30	single family	2006-2007	Off Kean Road
Round Hill Meadows	127	single family	2006-2008	Off Radney Road
Round Hill	600	single family	2007-?	Off Radney Road
Kimpe	100	single family	2009-?	Off Landon Lane
Montebello	50	single family	2010-?	Off North Madison Road
Un-named	50	Single family /townhouses	Beyond 2010	Off Constitution Highway
Rezone vacant & exist. developed prop,	1000	mixed	Beyond 2010	Various locations within Town Limits
Andrewsia (County)	326	single family	2006	In County, off Spicers Mill Road
Un-named (County)	??	??	Beyond 2010	In County, west of Route 15, south of Route 20
Joint Planning Area (County)	1000	mixed	Beyond 2010	In County, adjacent to Town
Commercial Development	**Size**	**Use**	**Year**	**Location/Description**
Airport Area (County)	??	??	Beyond 2010?	In County at airport east of Town
Nursing Home Expansion	100 rooms		2006	Off Oakbrook Drive
Round Hill - Commercial	210,000 sq.ft.	commercial	2007	Off Radney Road
Un-named commercial	100,000 sq.ft.	commercial	2007	Off North Madison Road
Un-named commercial	100,000 sq.ft.	commercial	??	South of Montebello Road
Un-named business park	8,000 sq.ft.	commercial	??	Off Lafayette Street
Un-named industrial (County)	??	industrial	??	In County off Route 15, south of Town

* Listing of known planned developments based on information provided by Town personnel, February 2005 and meeting with Orange County

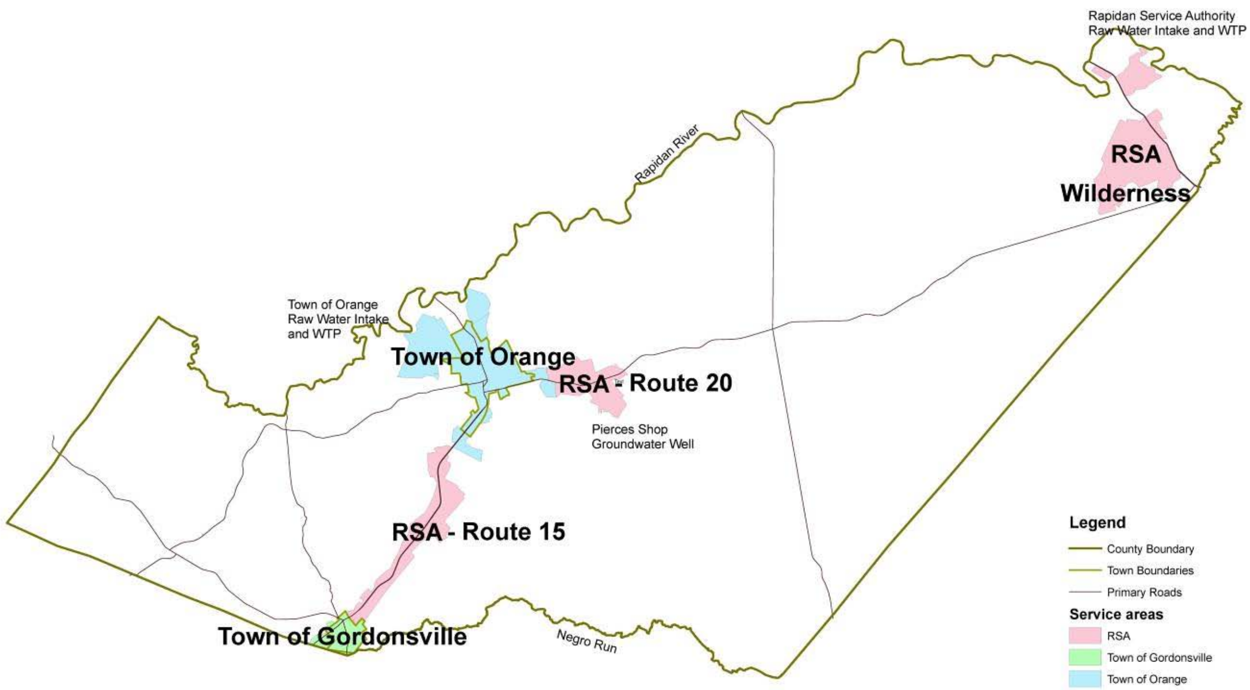
There are many development projects already planned that will be located in and around the Town or Orange and will become reliant on the Town water supply. Table D-5 lists several projects that are either underway or likely to occur in the next 5 to 10 years.

D.2 TOWN OF GORDONSVILLE

Data Collection and Review

The Town of Gordonsville is located at the intersection of US Route 15, State Route 231, and US Route 33. The service area for the Town of Gordonsville extends beyond the town limits along Routes 15 and 33 to the southeast and into Louisa County. The approximate service area boundary is shown Figure D-4.

Figure D-4
Gordonsville Service Area Boundary



As mentioned in the previous section, the Town of Gordonsville receives its complete water supply from a transmission main owned and operated by Rapidan Service Authority along Route 15. The RSA receives the water supply from the Town of Orange water treatment facility located on Spicers Mill Road.

Many data sources were consulted during the compilation of this report. Previous studies and reports were obtained from the Town of Gordonsville in addition to the water service agreements held with adjacent entities. Additionally because of their interconnected systems, any water studies related to the Town of Orange directly impact Gordonsville. The previous studies discuss past views regarding the supply and distribution of water resources within this portion of the County. The reports and water service agreements are summarized in the 'Existing Sources' section of this report.

Water usage data was obtained from the Town to develop a historic pattern of water use by which to project future demand and to ultimately determine the adequacy of the existing water supply source, both currently and into the future. The data, when obtained, was already disaggregated according to use, including residential, commercial, industrial, and Gordonsville Energy L.P. (GELP), a local energy producer. In addition, the total number of connections per use was included. Summary sheets were developed for years 2002 through 2005. Limited data was obtained for the period prior to 2002 and, therefore, an accurate account of water use could not be expressed. The data received was in monthly totals. Therefore, the peak month was shown for each year. Peak daily flows were not available at the time of this report.

Geographic Information System (GIS) mapping was obtained from Orange County. The mapping included typical map features including roads, buildings, etc. It also included a fire hydrant layer and parcel information that were used in conjunction with a paper water system map included in the report "*Gordonsville Water Study, Project 0435* (November, 2005) by R. Stuart Royer & Associates, Inc." to develop the service area boundary for Gordonsville. A current zoning map was also received from the Town.

Another key component in water supply planning is the adherence to the Town's Comprehensive Plan. The most recent plan, adopted in 1995, has been received and reviewed to determine the focus of Town planning. Additional relevance to the water supply plan can be found in the 'Evaluation of Population and Land Use' section below.

Water Use

The Town of Gordonsville supplies domestic water service to customers in and around the Town including residential, commercial, institutional, and industrial users. The Town's entire water supply comes from the Rapidan Service Authority (RSA). The yearly water usage fluctuates between 100 and 110 million gallons. Water sales records have been obtained from the Town to give a more accurate account of specific uses. A complete set of data was not available for every year. Where a month of data was missing, an estimate of usage was made based on the previous year's monthly total. The Town has recorded the usage in monthly intervals by its disaggregated use and Table D-7 reports the data as a flow in million gallons per day (MGD).

Table D-7 Town of Gordonsville Water Billings								
Year	**Average Daily Flow (MGD)**					**Maximum Month**		
	Residential	Commercial	Industrial	GELP	Total	Month	Flow (MGD)	Peaking Factor
2000	XX	XX	XX	XX	XX	N/A	no info	XX
2001	XX	XX	XX	XX	XX	Nov.	0.464	only 2 mon.
2002	0.109	0.005	0.080	0.037	0.231	Jan.	0.329	1.43
2003	0.109	0.003	0.098	0.036	0.246	Sept.	0.339	1.38
2004	0.111	0.003	0.122	0.033	0.270	May	0.345	1.28
2005	0.122	0.002	0.041	0.022	0.187	Aug.	0.411	2.20

In addition to billing data, water sales data was also obtained from the Rapidan Service Authority. This information was used to identify actual water purchased and unaccounted water losses in the systems. Average monthly flow tables are given for reference. Max day data was not available for the Gordonsville system due to monthly meter reading. However, the water production data for Town of Orange can be used to estimate an approximate peak day. Peak volume can not be known because data for production to RSA includes both the Route 15 system and Town of Gordonsville. Peak day information including water to both Route 15 and Gordonsville is included for reference.

Table D-7A Average Day Finished Water Sales (MGD) to Town of Gordonsville												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
2002	0.333	0.274	0.216	0.216	0.225	0.288	0.299	0.382	0.311	0.207	0.216	0.256
2003	0.235	0.462	0.273	0.272	0.227	0.258	0.241	0.299	0.318	0.267	0.352	0.241
2004	0.281	0.443	0.238	0.300	0.315	0.331	0.323	0.385	0.362	0.357	0.321	0.293
2005	0.348	0.313	0.233	0.243	0.215	0.233	0.256	0.245	0.245	0.207	0.200	0.183

Table D-7B Max Day Finished Water Production (MGD) to RSA												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
2003	0.870	0.779	0.727	0.743	0.779	0.482	0.721	0.731	N/A	0.594	N/A	N/A
2004	0.789	0.726	0.603	0.766	0.729	0.937	0.851	0.684	0.686	0.650	N/A	N/A
2005	N/A	0.540	0.639	0.593	0.545	0.350	0.644	0.574	0.546	0.747	0.550	0.642

The difference between water production (Table D-7A and D-7B) and water billed (Table D-7) represents the unaccounted for water (UFW) or potential water loss in a system. A discussion and summary of water losses can be found in Technical Memorandum No. 2, Section 6 – Demand Management, including Table 6-2.

The yearly water use has been consistent over the past several years. However, a 290-unit Planned Unit Development recently received County approval and will be located just outside the Town limits. Another major item affecting the water use totals is the closing of the Liberty Fabrics textile facility in 2004. A commercial user has recently purchased the Liberty Fabrics facility, but its projected water use should be much lower than a textile facility. It should be noted that Orange County and the Town of Gordonsville are discussing a boundary adjustment to the Town. This will increase the amount of available land in the Town of Gordonsville. This additional land would be served by the Gordonsville water system

Evaluation of Population and Land Use

The population of the Town has been gradually increasing over the past several decades with an approximate 2% annual growth rate, except during the 80s, when a slight decrease was experienced. However, within the past decade, the rate has slowed somewhat to approximately 1.6% per year, according to the Rappahannock-Rapidan Regional Commission. There are currently no plans for rapid growth within the Town. However, developments are under construction and additional developments are proposed near the Town that will probably be served by the Town's system. Table D-8 lists housing and population data obtained from the 2000 U.S. Census and the percentage of each in relation to all of Orange County.

Table D-8
Gordonsville Housing and Population Data

Housing Units Within the Town of Gordonsville		Population In the Town of Gordonsville	
Number	% County	Number	% County
688	6.1	1,498	5.8

The Town of Gordonsville does not state a growth rate projection in their Comprehensive Plan, however the Town has been experiencing a recent growth increase. This growth is not anticipated to be linear over time; the growth rate for the near term is expected to be higher and then drop off as the Town reaches buildout. Table D-9 lists the Town population in 10-year intervals given a 3.75% medium annual growth rate, with a low estimate of 2.5% annual and a high estimate of 5% from 2005 until 2020. From 2020 until 2050 the annual growth rate estimates drop to 1.5% for the low estimate, 2.25% for the medium estimate, and 3 % for the high estimate.

Table D-9 Town of Gordonsville Population Projections						
	Year					
Population Estimate	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Low	1498	1918	2455	2849	3306	3837
Medium	1498	2165	3128	3908	4881	6098
High	1498	2440	3975	5342	7179	9647

The population increases will be spread across different areas of the Town. Land use will change very little. The changes defined within the Town of Gordonsville's 1995 Comprehensive Plan will now be discussed. The Town will promote the expansion of a centralized business zone. In order to decrease the tax burden on Town citizens, the Town also plans to expand the commercial and industrial tax base in a centralized method. In addition, the Town will promote the development of a shopping center along State Route 231. Existing open spaces will be protected and enhanced. Of other significance is the intent to make Town boundary adjustments to incorporate those areas contiguous to the Town that are affected by Gordonsville's infrastructure and economy. Maps of the existing and future land use were not available. The existing land use as defined in the 1995 Comprehensive Plan is shown in Table D-10.

Table D-10 Town of Gordonsville Land Areas Used - 1995		
Land Use Category	**Total Acres in Category**	**% of Total Town Acres**
Residential	280	47
Single Family		
Multi Family		
Commercial	35	6
General		
Retail		
Office/Service		
Public/Semi-Public	69	11
Public		
Semi-Public		
Industrial	24	4
Total Developed Land	**317**	
Transportation R.O.W.	83	14
Vacant, Forest, Farm/Agricultural	109	18
Total Land Area	**600**	**100**

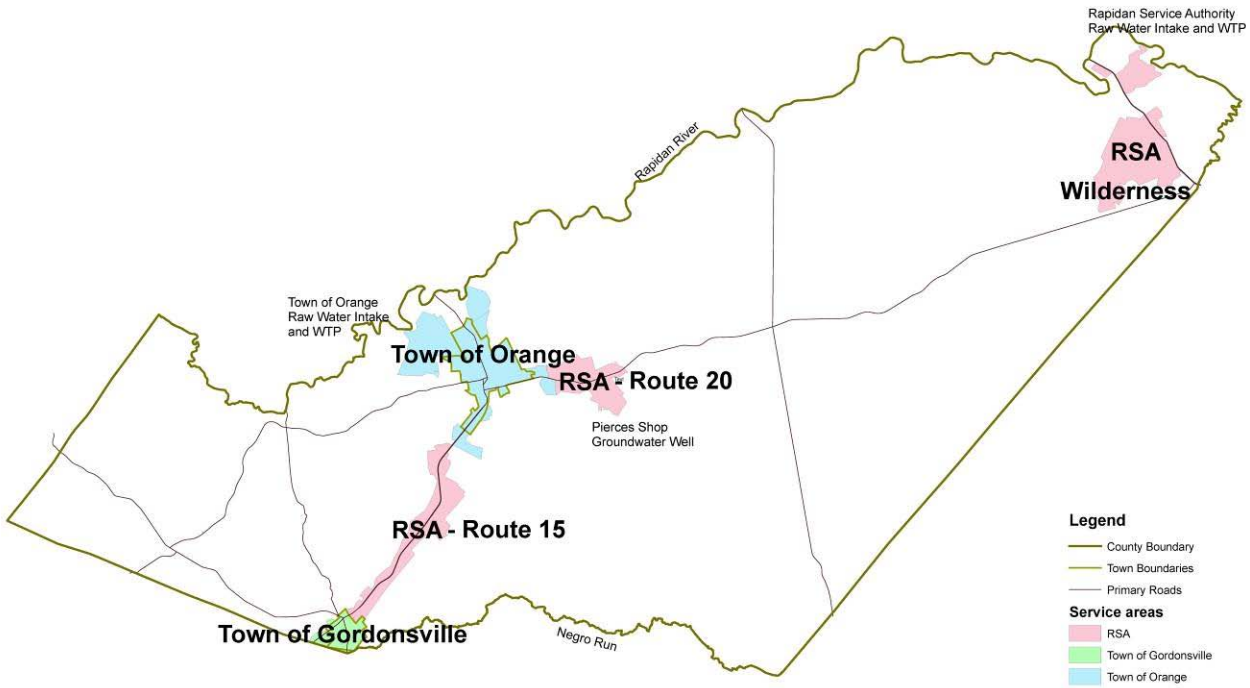
D.3 ORANGE COUNTY

Rapidan Service Authority – Wilderness System

Data Collection and Review

The Rapidan Service Authority (RSA) operates water and wastewater systems in the counties of Madison, Greene, and Orange. Within Orange County the RSA operates three individual and separate water systems. The Wilderness system is the largest, with approximately 3,920 connections. The system is located along State Route 3 at the very eastern end of the County from Route 20 to the northern border of Orange County. The approximate service area boundary is shown in Figure D-5.

Figure D-5
Orange County Approximate Service Areas



As previously discussed in the 'Existing Sources' section of this report, the RSA currently holds a withdrawal permit on the Rapidan River and has an intake approximately 1.3 miles east of State Route 3. The water treatment facility has a rated capacity of 1.584 million gallons per day (MGD). This capacity serves the Lake of the Woods community in addition to commercial developments along Route 3.

Many data sources were consulted during the compilation of this report. Previous studies and reports were obtained from the Rapidan Service Authority (RSA). The previous studies discuss past views regarding the supply and distribution of water resources within this portion of the

County. The reports and water are summarized in the 'Existing Sources' section of this report. There are no water service agreements related to this system.

Water usage data was obtained from the RSA to develop a historic pattern of water use by which to project future demand and to ultimately determine the adequacy of the existing water supply source, both currently and into the future. The data, when obtained, was not disaggregated according to use. An estimation of disaggregated uses was made. Further explanation of the method can be found below in the 'Water Use' section. The total number of connections was included with the data. Summary sheets were developed for years 2000 through 2005. Usage data was complete through this period. Therefore, an accurate account of water use for each year could be expressed. The data received was in monthly totals. Therefore, the peak month was shown for each year. Peak daily flows for this system were also available at the time of this report.

Geographic Information System (GIS) mapping was obtained from Orange County. The mapping included typical map features including roads, buildings, etc. It also included a fire hydrant layer and parcel information that were used in conjunction with a paper water system map included in a hydraulic model entitled "*Rapidan Service Authority, Comprehensive Water Supply Plan, Somerset, Wilderness, and Lake of the Woods, Preliminary Water Distribution-Hydraulic Model (April 2002) by* Gilbert W. Clifford & Associates, Inc." to develop the service area boundary for the RSA Wilderness system.

Another key component in water supply planning is the adherence to the County's Comprehensive Plan. The most recent plan, adopted in May, 2006, has been received and reviewed to determine the focus of County planning within the service area. Additional relevance to the water supply plan can be found in the 'Evaluation of Population and Land Use' section below.

Water Use

The RSA supplies domestic water service to customers within the service area including residential, commercial, and institutional users. The yearly water usage for the Wilderness area has been steadily increasing with approximately 127 million gallons being used in 2000 and almost 175 million gallons being used in 2005. The RSA has provided monthly usage totals for the service area. Data was not available to disaggregate the data into specific uses. Therefore, an estimate of total flow to institutional users was made based on the current student enrollment and faculty. This amount was subtracted from the total and the remainder was divided based on the percentage of existing land use categories compared to the total land area with 93% being residential and 3% being commercial. Tables D-11 and D-12 give the data as a flow in million gallons per day (MGD).

Table D-11

RSA Wilderness System Water Billings								
Year	Average Daily Flow (MGD)					Maximum Month		
	Residential	Commercial	Industrial	Institutional	Total	Month	Flow (MGD)	Peaking Factor
2000	0.324	0.024	N/A	0.002	0.350	Jun.	0.420	1.21
2001	0.341	0.025	N/A	0.002	0.368	Aug.	0.449	1.22
2002	0.342	0.026	N/A	0.002	0.370	Jul.	0.494	1.34
2003	0.353	0.026	N/A	0.002	0.381	Aug.	0.461	1.22
2004	0.385	0.029	N/A	0.002	0.416	Jul.	0.472	1.14
2005	0.444	0.033	N/A	0.002	0.479	Jul.	0.622	1.30

Table D-12 RSA Wilderness System Peak Usage						
Year	Maximum Month			Max Day		
	Month	Flow (mgd)	Peaking Factor	Date	Flow (mgd)	Peaking Factor
2000	Jun.	0.420	1.21	6-Apr	0.642	1.84
2001	Aug.	0.449	1.22	21-Jul	0.775	2.11
2002	Jul.	0.440	1.34	7-Jul	0.927	2.51
2003	Aug.	0.461	1.22	31-Oct	0.921	2.42
2004	Jul.	0.472	1.14	1-Aug	0.942	2.27
2005	Jul.	0.622	1.30	25-Jun	1.064	2.23

In addition to billing data, water production data was obtained for the Wilderness water treatment plant. The average day table has been given for reference. Maximum day data was not readily available at the time of this report.

Table D-12A
Average Day (MGD) Production for RSA Wilderness System

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2000	0.390	0.380	0.376	0.420	0.464	0.465	0.467	0.446	0.410	0.426	0.447	0.417
2001	0.391	0.364	0.391	0.420	0.501	0.474	0.550	0.495	0.462	0.470	0.476	0.436
2002	0.429	0.406	0.428	0.460	0.495	0.538	0.569	0.519	0.443	0.422	0.431	0.432
2003	0.417	0.383	0.394	0.430	0.431	0.456	0.519	0.486	0.465	0.404	0.449	0.437
2004	0.439	0.511	0.510	0.552	0.583	0.581	0.559	0.592	0.549	0.547	0.543	0.543
2005	0.551	0.487	0.518	0.594	0.630	0.769	0.728	0.673	0.684	0.619	0.617	0.625

The difference between water production (Table D-12A) and water billed (Tables D-11 and D-12) represents the unaccounted for water (UFW) or potential water loss in a system. A discussion and summary of water losses can be found in Technical Memorandum No. 2, Section 6 – Demand Management, including Table 6-2.

Evaluation of Population and Land Use

The population of the Wilderness service area has increased significantly over the past several decades. Table D-13 lists housing and population data obtained from the 2000 U.S. Census and the percentage of each in relation to all of Orange County.

Table D-13
RSA Wilderness System Housing and Population Data

Housing Unit Within RSA Wilderness Systems		Population In RSA Wilderness System	
Number	% County	Number	% County
2,744	24.2	6,209	24.0

The Orange County Comprehensive plan does not list a growth rate projection for this area of the County. However, Table D-14 lists the number of new water connections over the past 5 years. Using this information, an average annual current growth rate of 6% can be estimated for this area.

Table D-14 RSA Wilderness System New Water Connections					
Year	**2001**	**2002**	**2003**	**2004**	**2005**
New Connections	132	188	197	205	332
% Change	4.6	6.3	6.2	6.0	9.2

6% annual growth is difficult to sustain, especially as an area is built out. Table D-15 lists the population of the area served by the Wilderness System in 10-year intervals given a 4% medium annual growth rate, with a low estimate of 2% annual and a high estimate of 6% from 2005 until 2020. From 2020 until 2050 the annual growth rate estimates drop to 1% for the low estimate, 1.5% for the medium estimate, and 3 % for the high estimate. The growth rate is assumed to slow as usable area becomes limited. The beginning population is known from the 2000 U.S. Census.

Table D-15 RSA Wilderness System Population Projections						
	Year					
Population Estimate	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Low	6209	7569	9226	10192	11258	12436
Medium	6209	9191	13605	15789	18324	21265
High	6209	11119	19913	26762	35965	48334

Because the exact nature of development is not known, an ultimate build-out cannot be accurately determined. If more multi-family dwellings are allowed within the growth area, the ultimate build-out will be much higher than if only single family dwellings are allowed. There will almost certainly be some level of multi-family dwellings. The extent of which can only be estimated. There are approximately 3,600 acres of land that could potentially be developed under the future land use plan. A more detailed estimate is provided in the 'Future Demand' section of Technical Memorandum No. 2. The population increases will be confined to areas immediately adjacent to Route 3 as shown on the future land use plan. Zoning modifications to certain parcels will be necessary if development occurs as allowed by the Comprehensive Plan's future land use projections. Figures D-6 and D-7 show both the current land use in this area of the County and the future land use projected under the most recent Orange County Comprehensive Plan.

Figure D-6
Existing Land Use

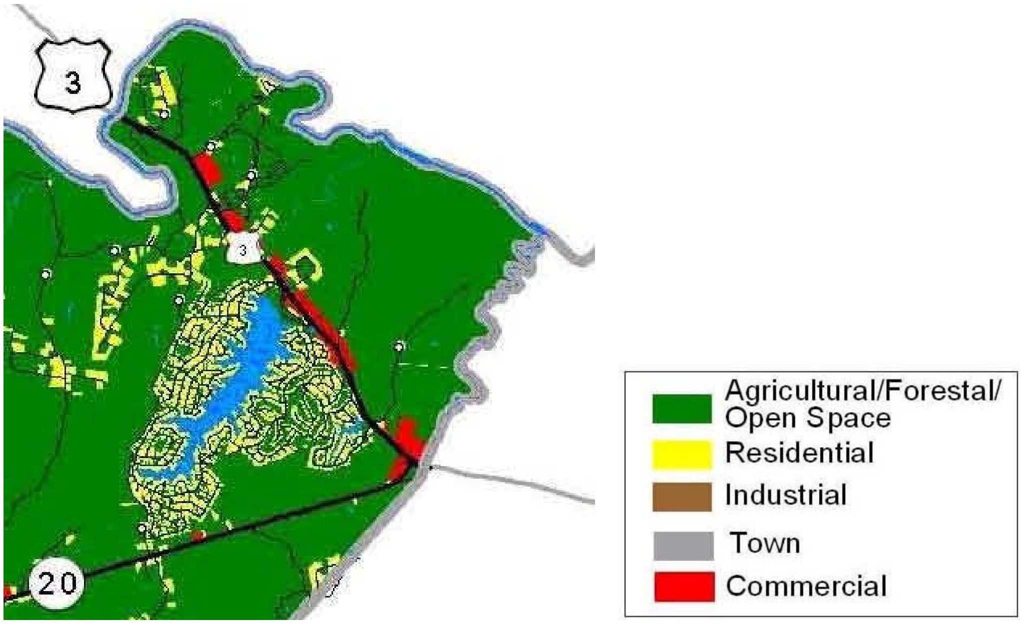
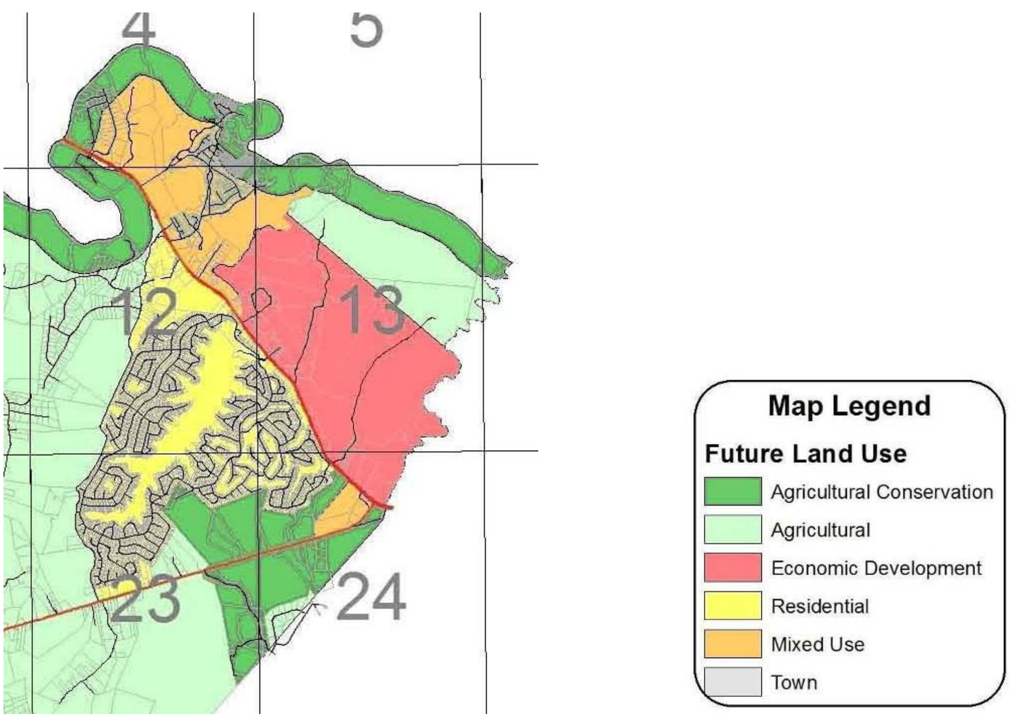


Figure D-7
Future Land Use

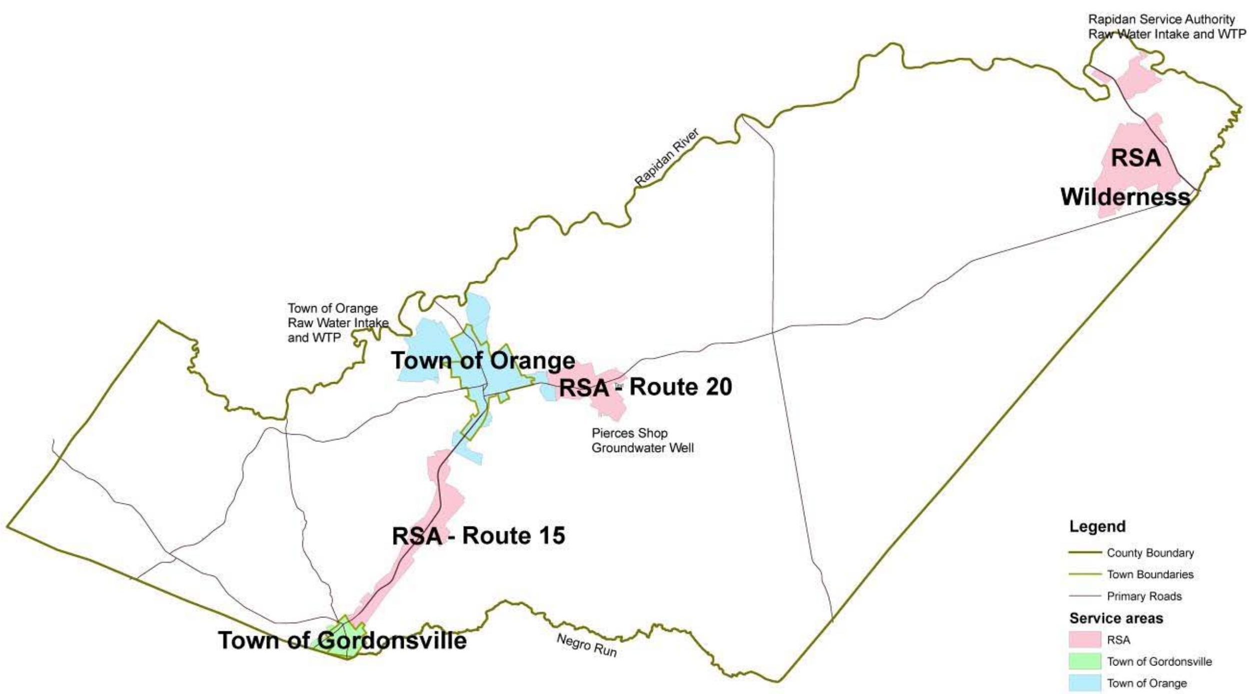


Rapidan Service Authority – Route 20

Data Collection and Review

The RSA owns and maintains a small water distribution system just east of the Town of Orange along State Route 20. The system serves approximately 141 connections and is supplied entirely by a ground water well on Porter Road. The approximate service area boundary is shown in Figure D-8.

Figure D-8
RSA Route 20 Approximate Service Boundary



The well at Pierces Shop is discussed further in the 'Existing Sources' section of this report. The system serves residential, industrial, and commercial establishments directly adjacent to State Route 20.

Many data sources were consulted during the compilation of this report. Previous studies and reports were obtained from the County. None of the previous studies address the supply and distribution of water resources within this service area as it is currently configured. However there is one report that discusses the extension of a water line from the Town of Orange or the placement of a surface water impoundment in that area of the County. The report is entitled "*Engineer's Comprehensive Plan - Water and Sewerage Facilities - Greene, Madison, and*

Orange Counties (October 1967) by Martin, Clifford and Associates". A summary of this report can be found in the 'Existing Sources' section of this report. There are currently no water purchase agreements or water supply agreements related to this service area.

Water usage data was obtained from the RSA to develop a historic pattern of water use by which to project future demand and to ultimately determine the adequacy of the existing water supply source, both currently and into the future. The data, when obtained, was not disaggregated according to use. An estimation of disaggregated uses was made. Further explanation of the method can be found below in the 'Water Use' section. The total number of connections was included with the data. Summary sheets were developed for years 2000 through 2005. Usage data was complete through this period. Therefore, an accurate account of water use for each year could be expressed. The data received was in monthly totals. Therefore, the peak month was shown for each year. Peak daily flows for this system were not available at the time of this report.

Geographic Information System (GIS) mapping was obtained from Orange County. The mapping included typical map features including roads, buildings, etc. It also included a fire hydrant layer and parcel information that were used in conjunction with a paper water system map included in a hydraulic model report entitled "*Water Distribution Hydraulic Model (October, 2000) by* Gilbert W. Clifford & Associates, Inc." to develop the service area boundary for the RSA Route 20 system.

Another key component in water supply planning is the adherence to the County's Comprehensive Plan. The most recent plan, adopted in May 2006, has been received and reviewed to determine the focus of the County planning within the service area. Additional relevance to the water supply plan can be found in the 'Evaluation of Population and Land Use' section below.

Water Use

The RSA supplies domestic water service to customers within the service area including residential, industrial, and commercial users. The yearly water usage for the Route 20 service area has fluctuated over the past several years between 7.5 million and 8.5 millions gallons. The RSA has provided monthly usage totals for the service area. Data was not available to disaggregate the data into specific uses. Therefore, the monthly water total was divided based on the percentage of each existing land use category compared to the total land area with 84% being residential, 12% being industrial, and 4% being commercial. Table D-16 gives the data as a flow in million gallons per day (MGD).

Table D-16 RSA Route 20 System Water Billings								
Year	**Average Daily Flow (MGD)**					**Maximum Month**		
	Residential	**Commercial**	**Industrial**	**Institutional**	**Total**	**Month**	**Flow (MGD)**	**Peaking Factor**
2000	0.018	0.001	0.003	N/A	0.021	Nov.	0.024	1.16
2001	0.019	0.001	0.003	N/A	0.022	Aug.	0.027	1.22
2002	0.019	0.001	0.003	N/A	0.022	Jun.	0.028	1.28
2003	0.017	0.001	0.002	N/A	0.020	Jul.	0.025	1.25
2004	0.018	0.001	0.003	N/A	0.021	Sept.	0.027	1.27
2005	0.019	0.001	0.003	N/A	0.023	Jul.	0.030	1.31

In addition to billing data, water production data was obtained for the Route 20 system. The average day table has been given for reference. Maximum day data was not readily available at the time of this report.

Table D-16A Average Day (MGD) Production for RSA Route 20 System												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
2000	0.008	0.017	0.013	0.022	0.023	0.022	0.030	0.024	0.023	0.030	0.027	0.020
2001	0.021	0.023	0.028	0.025	0.026	0.030	0.027	0.026	0.023	0.026	0.024	0.025
2002	0.024	0.021	0.025	0.014	0.016	0.017	0.028	0.013	0.019	0.018	0.021	0.018
2003	0.023	0.011	0.023	0.020	0.020	0.023	0.025	0.024	0.024	0.017	0.026	0.020
2004	0.026	0.026	0.023	0.024	0.022	0.024	0.024	0.024	0.028	0.024	0.021	0.025
2005	0.025	0.019	0.020	0.026	0.027	0.029	0.029	0.022	0.026	0.026	0.024	0.028

The difference between water production (Table D-16A) and water billed (Table D-16) represents the unaccounted for water (UFW) or potential water loss in a system.

A discussion and summary of water losses can be found in Technical Memorandum No. 2, Section 6 – Demand Management, including Table 6-2.

Evaluation of Population and Land Use

There are no population estimates of the Route 20 service area. However, the Virginia Department of Health, Office of Drinking Water lists the public water system as having an equivalent population of 365 persons in their May 2006 listing of Waterworks and Owners. The Orange County Comprehensive plan does not list a growth rate projection for this area of the County. However, Table D-17 lists the number of new water connections over the past 5 years.

Table D-17 RSA Route 20 System New Water Connections					
Year	**2001**	**2002**	**2003**	**2004**	**2005**
New Connections	1	2	2	2	2
% Change	0.8	1.5	1.5	1.5	1.4

The area is adjacent to the Town of Orange and the growth patterns may be similar to the Town, therefore the growth rates in the Route 20 service area will match those of the Town. Table D-18 lists the population of the area served by the Route 20 System in 10-year intervals given a 3% medium annual growth rate, with a low estimate of 2% annual and a high estimate of 4% from 2005 until 2020. From 2020 until 2050 the annual growth rate estimates drop to 1% for the low estimate, 1.5% for the medium estimate, and 2 % for the high estimate. The growth rate is assumed to slow as usable area becomes limited. The beginning population is taken as 365 in year 2005 using the VDH listing of Waterworks and Owners.

Table D-18 RSA Route 20 System Population Projections						
	Year					
Population Estimate	**2005**	**2010**	**2020**	**2030**	**2040**	**2050**
Low	365	403	491	543	599	662
Medium	365	423	569	660	766	889
High	365	444	657	801	977	1191

Because the exact nature of development is not known, an ultimate build-out cannot be accurately determined. The future land use plan allows for only limited development in the Route 20 service area. Any population increases will be confined to areas immediately adjacent to Route 20 and along Routes 625, 629, and 631 as shown on the future land use plan. Zoning modifications to certain parcels may be necessary if development occurs as allowed by the Comprehensive Plan's future land use projections. Figures D-9 and D-10 show both the current land use in this area of the County and the future land use projected under the most recent Orange County Comprehensive Plan.

Figure D-9
RSA Route 20 System Existing Land Use

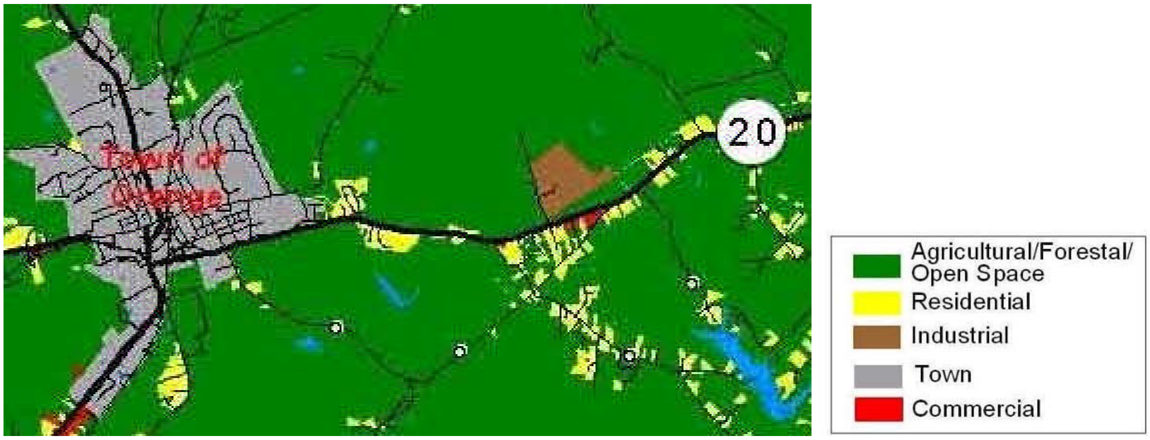


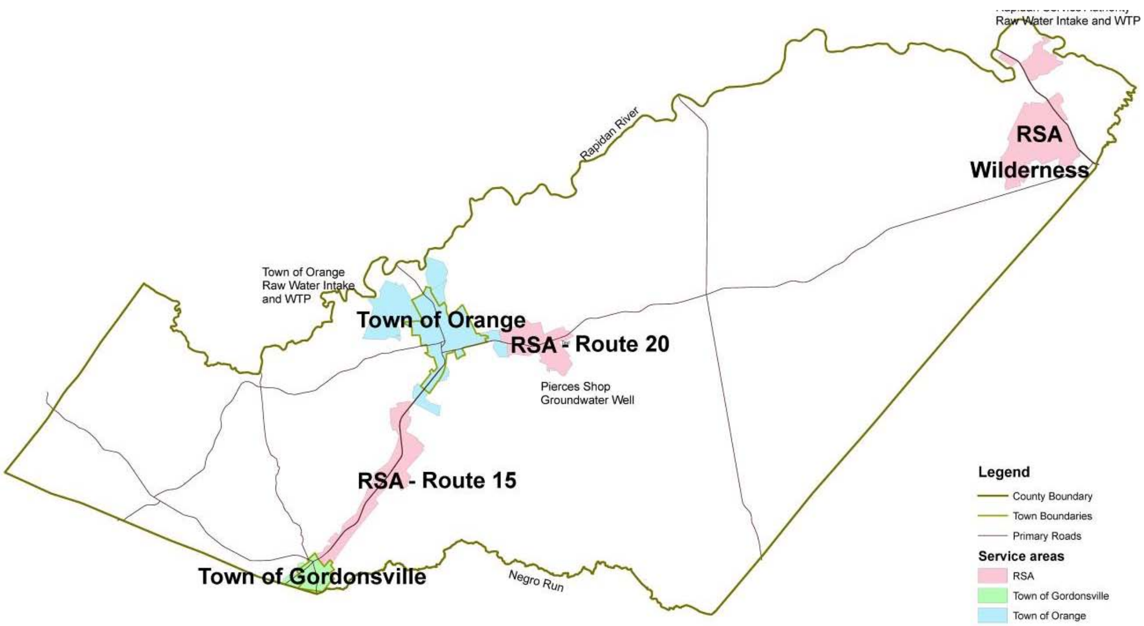
Figure D-10
RSA Route 20 System Future Land Use

Rapidan Service Authority – Route 15 System

Data Collection and Review

The RSA owns and maintains the water distribution system along U.S. Route 15 between the Town of Orange and the Town of Gordonsville. The system serves approximately 110 connections and is supplied entirely by a transmission main from the Town of Orange water system. The approximate service area boundary is shown in Figure D-11.

Figure D-11
RSA Route 15 System Service Area Boundary



A discussion of the Town of Orange water source can be found in the 'Existing Sources' section of this report. In addition to serving residential, industrial, and commercial establishments directly adjacent to U.S Route 15, the transmission main is also the sole source of water supply for the Town of Gordonsville.

Many data sources were consulted during the compilation of this report. Previous studies and reports were obtained from the Rapidan Service Authority in addition to the water service agreements held with adjacent entities. Additionally because of the interconnection, any water studies related to the Town of Orange directly impact this system. The previous studies discuss past views regarding the supply and distribution of water resources within this portion of the County. The reports and water service agreements are summarized in the 'Existing Sources' section of this report.

Water usage data was obtained from the RSA to develop a historic pattern of water use by which to project future demand and to ultimately determine the adequacy of the existing water supply source, both currently and into the future. The data, when obtained, was not disaggregated according to use. An estimation of disaggregated uses was made. Further explanation of the method can be found below in the 'Water Use' section. The total number of connections was included with the data. Summary sheets were developed for years 2000 through 2005. Usage data was complete through this period. Therefore, an accurate account of water use for each year could be expressed. The data received was in monthly totals. However, due to reporting differences between RSA and Gordonsville, the amount allocated to

Gordonsville can not be accurately removed from the total. Therefore, peak month flow will not be shown for each year. Peak daily flows for this system were not available at the time of this report.

Geographic Information System (GIS) mapping was obtained from Orange County. The mapping included typical map features including roads, buildings, etc. It also included a fire hydrant layer and parcel information that were used in conjunction with a paper water system map included in a hydraulic model report entitled "*Water Distribution Hydraulic Model (October, 2000) by* Gilbert W. Clifford & Associates, Inc." to develop the service area boundary for the RSA Route 15 system.

Another key component in water supply planning is the adherence to the County's Comprehensive Plan. The most recent plan, adopted in May, 2006, has been received and reviewed to determine the focus of County planning within the service area. Additional relevance to the water supply plan can be found in the 'Evaluation of Population and Land Use' section below.

Water Use

The RSA supplies domestic water service to customers within the service area including residential, industrial, and commercial users. The yearly water usage for the Route 15 service area has fluctuated over the past several years between 115 million and 170 millions gallons. However, a large portion of this usage does go to the Town of Gordonsville. The actual area uses only an average of 3 million to 8 million after subtracting Gordonsville's reported water use. The RSA has provided monthly usage totals for the service area. Data was not available to disaggregate the data into specific uses. Therefore the monthly water total was divided based on the percentage of each existing land use category compared to the total land area with 43% being residential, 40% being industrial, and 17% being commercial. Table D-19 gives the data as a flow in million gallons per day (MGD).

Table D-19 RSA Route 15 System Water Billings								
Year	Average Daily Flow (MGD)					Maximum Month		
	Residential	Commercial	Industrial	Institutional	Total	Month	Flow (MGD)	Peaking Factor
2000	N/A	N/A	N/A	N/A	N/A	Feb.	N/A	---
2001	N/A	N/A	N/A	N/A	N/A	Sept.	N/A	---
2002	0.019	0.008	0.017	N/A	0.044	Jun.	0.070	1.61
2003	0.013	0.006	0.012	N/A	0.030	Sept.	0.044	1.43
2004	0.014	0.006	0.013	N/A	0.032	Mar.	0.045	1.39
2005	0.015	0.006	0.013	N/A	0.034	Sept.	0.052	1.55

In addition to billing data, water production data was also obtained from the Town of Orange water treatment plant. This information was used to identify actual water withdrawal and unaccounted water losses in the systems. Average and maximum day tables are given for reference. These tables represent water used by Town of Gordonsville and the Route 15 system but are included for reference.

Table D-19A Town of Orange WTP production - to RSA (MGD)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2001	0.574	0.490	0.513	0.497	0.516	0.530	0.535	0.658	0.550	0.590	0.517	0.539
2002	0.458	0.290	0.300	0.277	0.352	0.403	0.623	0.532	0.313	0.326	0.300	0.355
2003	0.468	0.414	0.365	0.403	0.506	0.347	0.371	0.439	0.397	0.419	0.367	0.516
2004	0.494	0.410	0.377	0.407	0.403	0.467	0.448	0.471	0.457	0.458	0.460	0.455
2005	0.455	0.293	0.281	0.280	0.271	0.280	0.271	0.348	0.307	0.242	0.277	0.274

Table D-19B Max Day Finished Water Production - to RSA (MGD)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2003	0.870	0.779	0.727	0.743	0.779	0.482	0.721	0.731	N/A	0.594	N/A	N/A
2004	0.789	0.726	0.603	0.766	0.729	0.937	0.851	0.684	0.686	0.650	N/A	N/A
2005	N/A	0.540	0.639	0.593	0.545	0.350	0.644	0.574	0.546	0.747	0.550	0.642

The difference between water production and water billed represents the unaccounted for water (UFW) or potential water loss in a system. A discussion and summary of water losses can be found in Technical Memorandum No. 2, Section 6 – Demand Management, including Table 6-2.

Evaluation of Population and Land Use

There are no population estimates of the Route 15 service area. However, the Virginia Department of Health, Office of Drinking Water lists the public water system as having an equivalent population of 273 persons in their May 2006 listing of Waterworks and Owners. The Orange County Comprehensive plan does not list a growth rate projection for this area of the County. However, Table D-20 below lists the number of new water connections over the past 5 years. Using this information an average annual growth rate of 2.0% can be estimated for this area.

Table D-20
RSA Route 15 System New Water Connections

Year	2001	2002	2003	2004	2005
New Connections	2	2	4	2	0
% Change	2.0	2.0	3.8	1.9	0

Table D-21 lists the population of the area served by the Route 15 System in 10-year intervals given a 1% medium annual residential growth rate, with a low estimate of 0.5% annual and a high estimate of 1.5% from 2005 until 2050. The beginning population is taken as 365 in year 2005 using the VDH listing of Waterworks and Owners.

Table D-21
RSA Route 15 System Population Projections

	Year					
Population Estimate	2005	2010	2020	2030	2040	2050
Low	273	280	294	309	325	342
Medium	273	287	317	350	387	427
High	273	294	341	396	460	534

Because the exact nature of development is not known, an ultimate build-out cannot be accurately determined. The future land use plan allows for economic development opportunities in the Route 15 service area along with some continued residential expansion. Any population increases will be confined to areas immediately adjacent to Route 15 as shown on the future land use plan. Zoning modifications to certain parcels may be necessary if development occurs as allowed by the Comprehensive Plan's future land use projections. Figures D-12 and D-13 show both the current land use in this area of the County and the future land use projected under the most recent Orange County Comprehensive Plan.

Figure D-12
RSA Route 15 System Existing Land Use

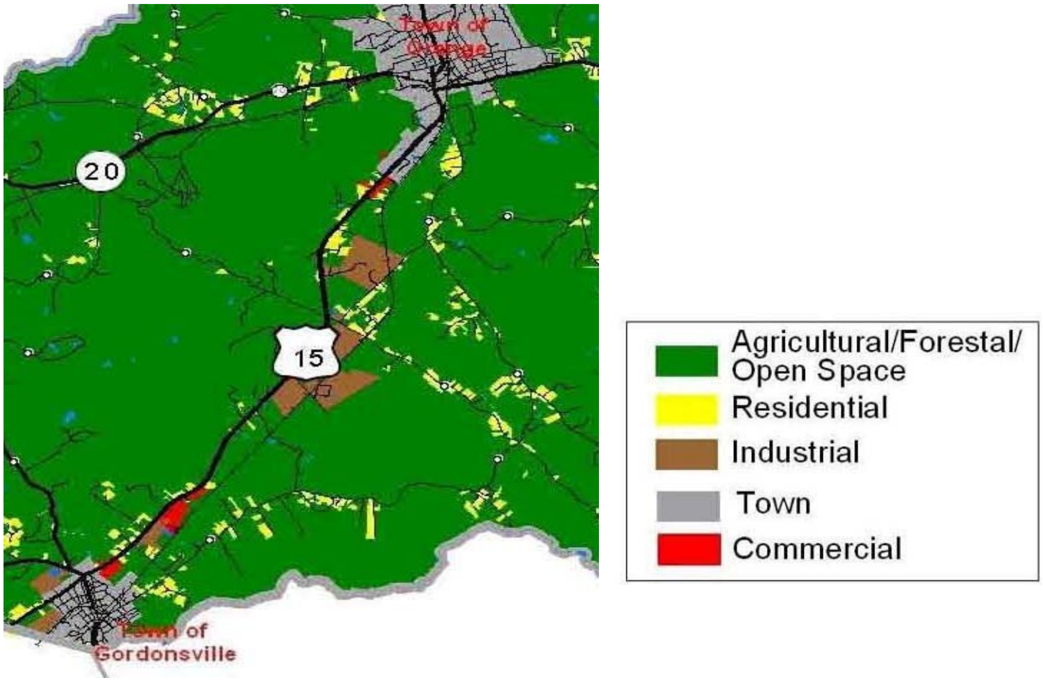
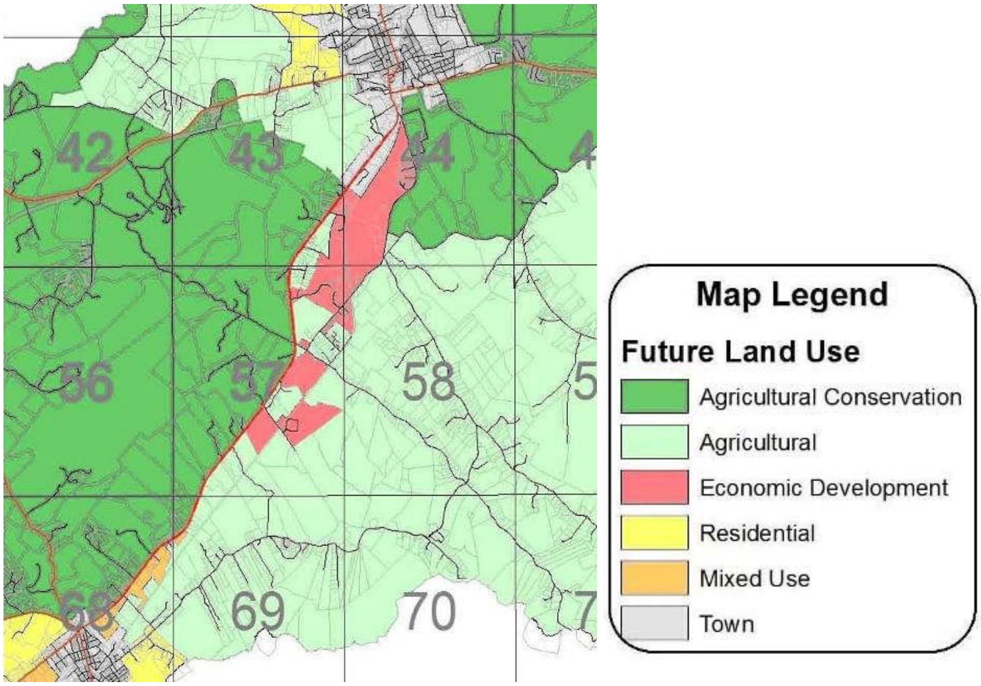


Figure D-13
RSA Route 15 System Future Land Use

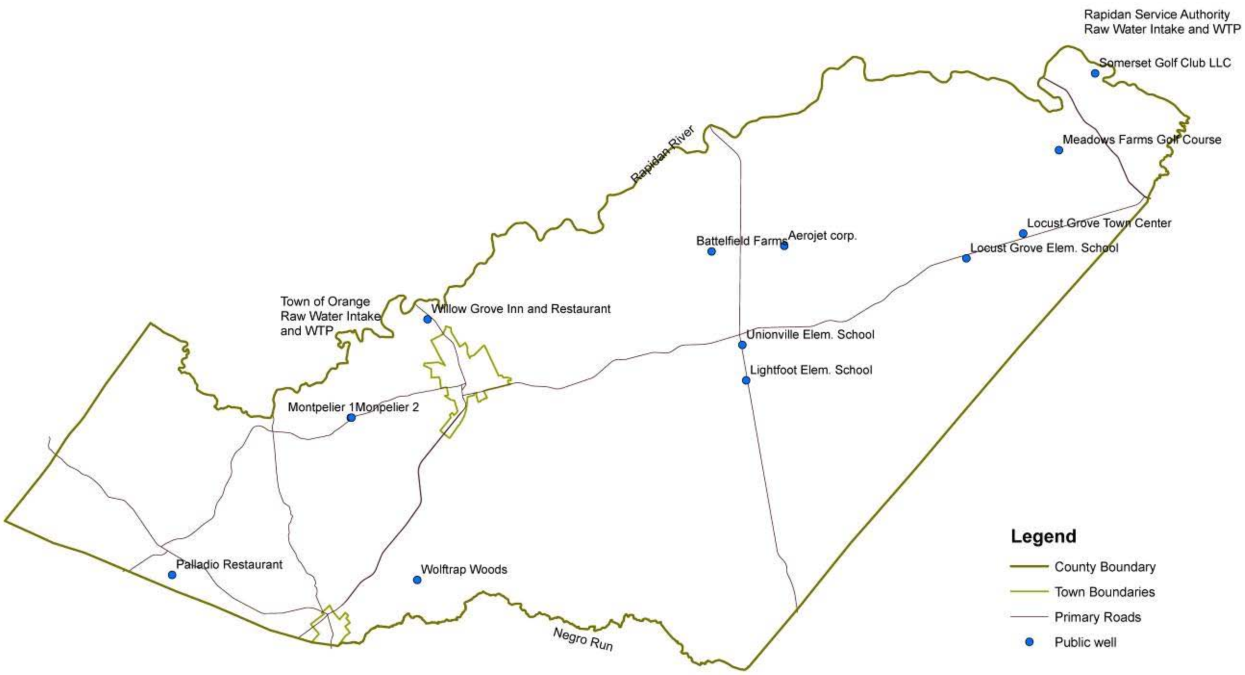


Additional Public Water Systems and Uses

Data Collection and Review

According to the Virginia Department of Health (VDH), Office of Drinking Water, there are 13 isolated public water systems in Orange County classified as non-community or non-transient, non-community. One system, Wolftrap Woods, is classified as a community water system. These public systems are served by groundwater wells. They primarily serve businesses located outside of the previously discussed public water system service areas. The businesses range from golf courses to tourist centers such as Montpelier. The Wolftrap Woods water system serves a residential subdivision located in the southern portion of the County. The VDH lists a combined equivalent population of 895 for these public water supplies excluding school use. Four County schools with an equivalent population of 2081 are served by 3 groundwater wells. The location of each system is shown in Figure D-14.

Figure D-14
Additional Public Water Systems



A discussion of the public system water sources can be found in the ‘Existing Sources’ section of this report. In addition to serving businesses, the town center at Locust Grove is served by a public groundwater well system.

Many data sources were consulted during the compilation of this report. There were no previous studies regarding the isolated public systems. Additionally, there are no service agreements related to the public water supplies.

Water usage was estimated for each system based on the equivalent population given by the VDH. A usage category has been assigned to each system to disaggregate the data according to use. The summary can be found in the ‘Water Use’ section below.

Geographic Information System (GIS) mapping was obtained from Orange County. The mapping included typical map features including roads, buildings, etc. The public systems are located on Figure D-14.

Another key component in water supply planning is the adherence to the County’s Comprehensive Plan. The most recent plan, adopted in May, 2006, has been received and reviewed to determine the focus of County planning. Additional relevance to the water supply plan can be found in the ‘Evaluation of Population and Land Use’ section below.

Water Use

The groundwater wells associated with the additional public water systems supply an estimated combined total of 34.7 million gallons per year to the various systems across the County. Where water use data was available, the average data was given. Where specific water use data was not available, the population of each system as supplied by the VDH was multiplied by 70 gallons per day per person to obtain an estimated daily water use. For school use, the number of students and faculty was multiplied by 15 GPD per person. Only average day data is given. Peak data is not available. A disaggregated category was assigned to each system. The following table gives the data as a flow in million gallons per day (MGD).

Table D-22
Water Use – Additional Public Water Systems and Uses

Public Water System Name	Service Connection	Equivalent Pop.	Water Use (MGD)	Water Use Category
Industrial				
AEROJET CORPORATION	36	25	0.002	Industrial
GENERAL SHALE BRICK	N/A	N/A	.003	Industrial
Subtotal	**36**	**25**	**0.002**	
Commercial				
LOCUST GROVE TOWN CENTER	1	182	0.013	Commercial
BATTLEFIELD FARMS	2	70	0.005	Commercial
MEADOWS FARMS GOLF COURSE	2	151	0.011	Commercial
MONTPELIER MANSION (KITCHEN)	8	111	0.008	Commercial
MONTPELIER VISITOR'S CENTER	1	50	0.004	Commercial
SOMERSET GOLF CLUB LLC	2	100	0.007	Commercial
PALLADIO RESTAURANT	1	50	0.004	Commercial
WILLOW GROVE INN AND RESTAURANT	2	106	0.007	Commercial
LAKE OF THE WOODS GOLF COURSE – IRR.	N/A	N/A	0.026	Commercial
SOMERSET GOLF COURSE – IRR.	N/A	N/A	0.230	Commercial
Subtotal	**19**	**820**	**0.059**	
Residential				
WOLFTRAP WOODS	15	50	0.004	Residential
Subtotal	**15**	**50**	**0.004**	
Public Schools				
LIGHTFOOT ELEM SCHOOL	1	318	0.005	Institutional
UNIONVILLE ELEMENTARY SCHOOL	1	342	0.005	Institutional
LOCUST GROVE ELEMENTARY/MIDDLE SCHOOLS	2	1421	0.022	Institutional
Subtotal	**4**	**2081**	**0.032**	
TOTAL:	**74**	**2976**	**0.097**	

N/A = Data not available

Evaluation of Population and Land Use

The Virginia Employment Commission (VEC) provides population projections for the County as a whole. These projections can be used in conjunction with the future land use plan to estimate the future demand for water resources. It should be noted, however, that according to the Orange County Comprehensive Plan, the VEC estimates are already inaccurate. The Plan lists the Orange County estimated population in January 2006 as 32,000. However, the VEC's estimated population for year 2010 is 30,000 persons. Because of the discrepancies, the Comprehensive Plan lists differing growth rates and their affect on the population. The Virginia Employment Commission estimates are shown in Table D-23.

Table D-23
Virginia Employment Commission Population Estimates

	1990	2000	2010	2020	2030
Age in years	Total Population	Total Population	Total Projections	Total Projections	Total Projections
< 5	1,388	1,552	1,637	2,111	2,420
5 - 9	1,524	1,621	1,608	1,991	2,430
10 - 14	1,470	1,756	1,766	1,911	2,410
15 - 19	1,337	1,570	1,943	1,931	2,330
20 - 24	1,240	1,134	1,953	2,011	2,130
25 - 29	1,573	1,346	1,657	2,111	2,100
30 - 34	1,730	1,669	1,263	2,141	2,220
35 - 39	1,650	2,113	1,499	1,831	2,310
40 - 44	1,508	2,056	1,894	1,431	2,360
45 - 49	1,262	1,845	2,476	1,751	2,080
50 - 54	1,121	1,714	2,436	2,241	1,660
55 - 59	1,088	1,555	2,190	2,871	2,000
60 - 64	1,139	1,506	1,933	2,661	2,370
65 - 69	1,173	1,385	1,558	2,181	2,730
70 - 74	906	1,179	1,401	1,791	2,400
75 - 79	636	885	1,079	1,477	2,007
80 - 84	367	576	838	937	1,392
85 +	309	419	868	1,021	1,255
Total	21,421	25,881	30,000	34,400	38,600

Table D-24 from the 2006 Orange County Comprehensive Plan is shown below.

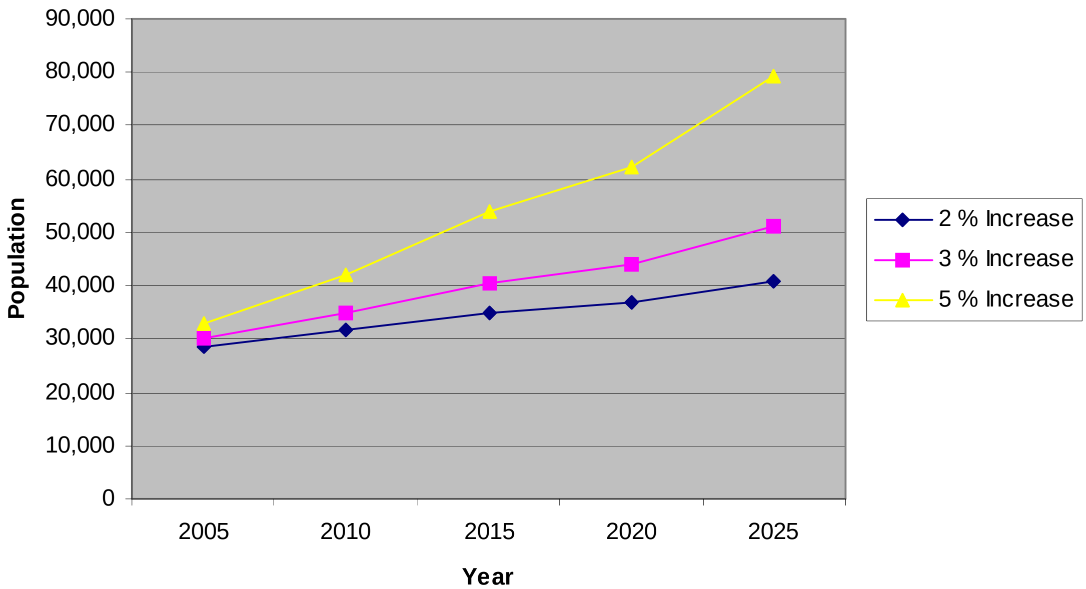
Table D-24
County-Wide Population Projections from Comprehensive Plan

Year	2 % Increase	3 % Increase	5 % Increase
2005	28,572	30,000	33,028
2010	31,543	34,776	42,150
2015	34,823	40,312	53,792
2020	36,953	44,048	62,270
2025	40,796	51,061	79,472

Source: Orange County Department of Planning and Zoning

This information is also summarized in Figure D-15.

Figure D-15
County-Wide Population Projections from Comprehensive Plan



Source: Orange County Department of Planning and Zoning

The exact nature of development is not known. However, the future land use plan serves as a guide for growth throughout the County. Population increases will be confined primarily to the growth areas defined in the growth plan. Although there will be some growth in all areas. Figures D-16 and D-17 show both the current land use in the County and the future land use projected under the most recent Orange County Comprehensive Plan.

Figure D-16
County-Wide Existing Land Use

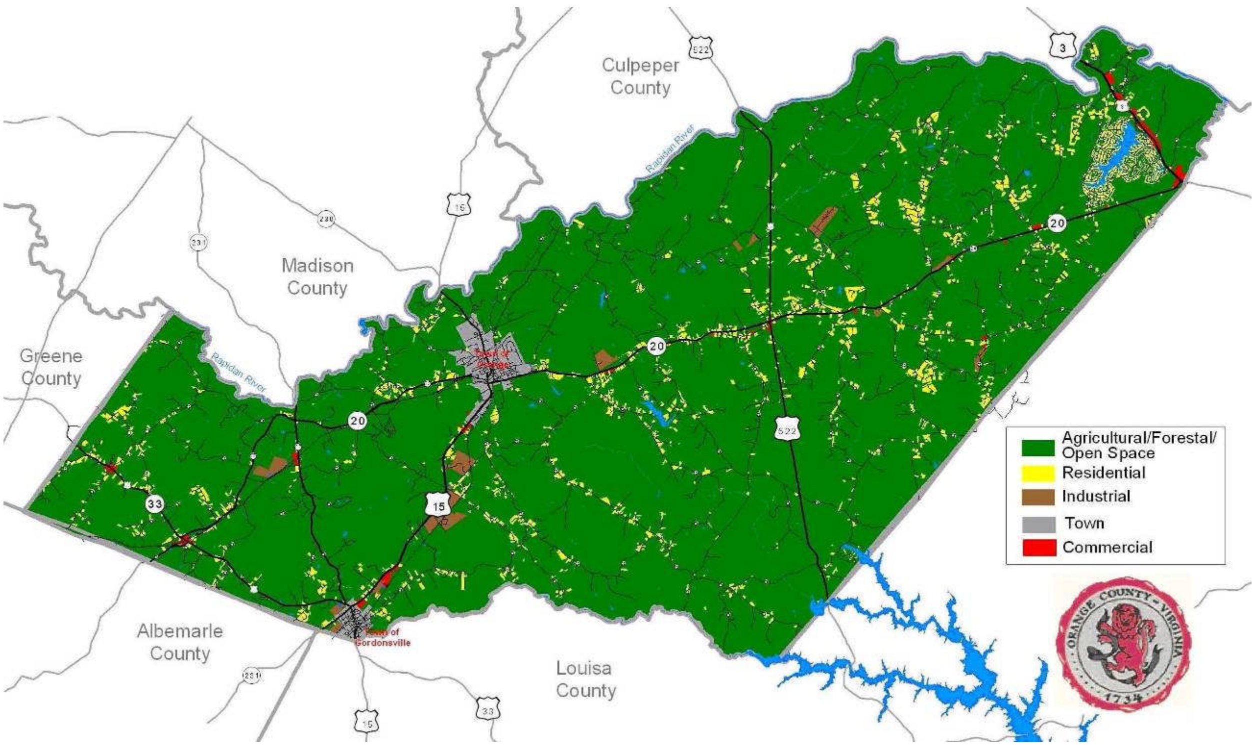
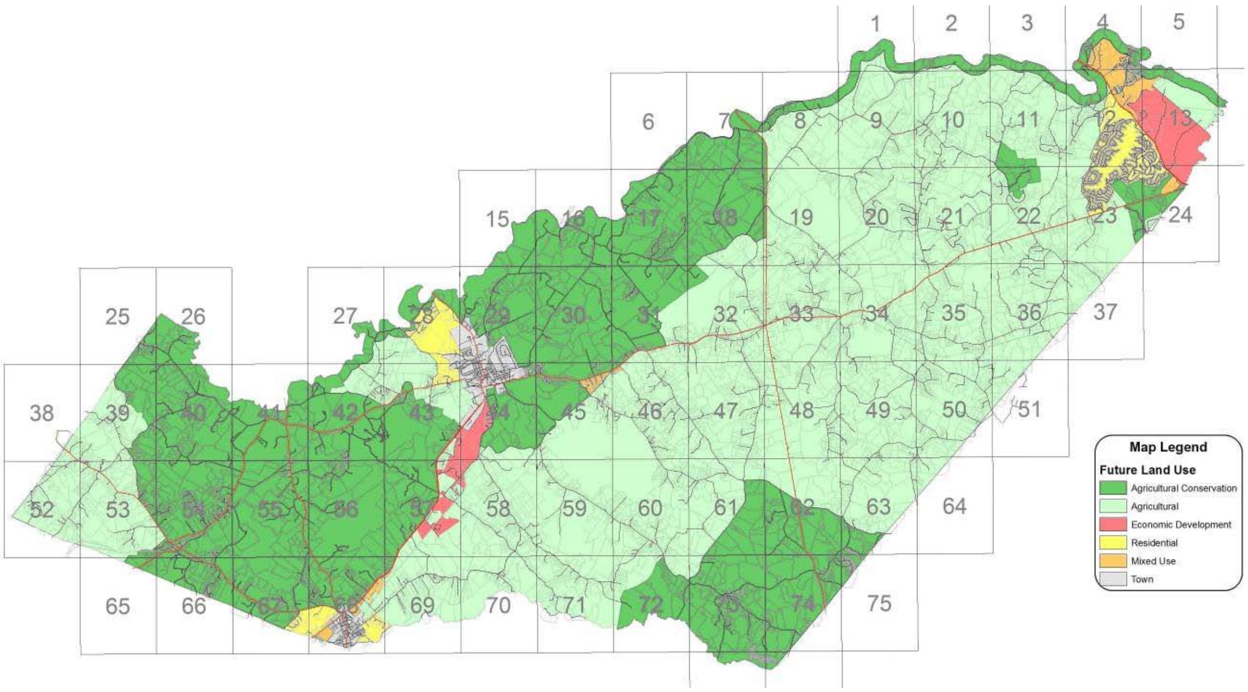


Figure D-17
County-Wide Future Land Use



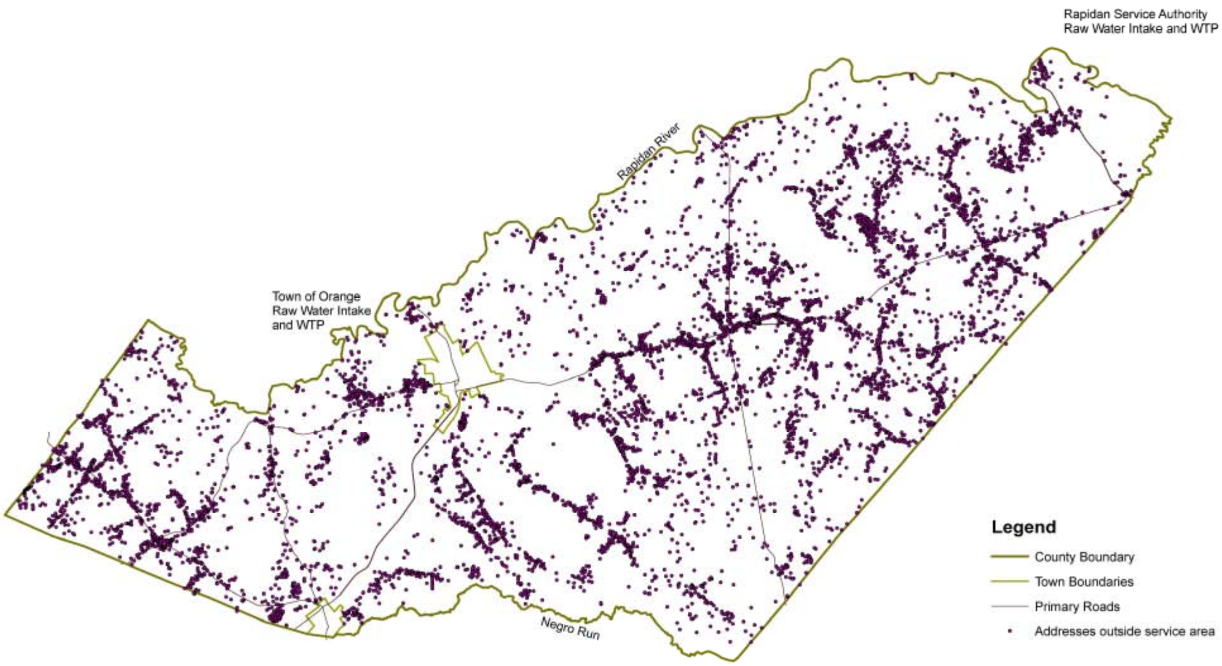
D.4 OUTSIDE SERVICE AREAS

Residential Usage

Data Collection and Review

As discussed in the 'Existing Sources' section of this report there are approximately 7,339 addresses located outside of the defined service areas. Of these, 14 are related to the public wells listed above. It is assumed that each of the remaining 7,325 addresses also have a groundwater well associated with it. Confirming the existence of each well was impractical and unnecessary. A general estimate of groundwater use from these will be sufficient for the purpose of this report. Figure D-18 depicts the distribution of addresses throughout the County.

Figure D-18
Address Distribution Map



An in depth review of the geology and groundwater yield potential for Orange County will be performed by Emery & Garrett Groundwater, Inc. and included in the Technical Memorandum No. 2. However, from a prior report discussed in the 'Existing Sources' section of this report, groundwater availability varies throughout the County.

Geographic Information System (GIS) mapping was obtained from Orange County. The mapping included typical map features including roads, buildings, etc. Service areas were defined from paper system maps of each water provider. The GIS mapping was queried to determine the number of addresses lying outside of the current service areas.

The Orange County Comprehensive Plan, adopted in May, 2006, has been received and reviewed to determine the focus of County planning. Additional relevance to the water supply plan can be found in the 'Evaluation of Population and Land Use' section below.

Water Use

The groundwater wells associated with the individual residences supply an estimated combined total of 438 million gallons per year. Water usage was estimated for each address based on an average occupancy rate of 2.3 persons per household[xix] and an average use of 70 gallons per day (GPD) per person. Although the Virginia Waterworks Regulation defines the water consumption rate as 100 GPD per person, a review of the historic residential water use provided by the RSA, Town of Orange and Town of Gordonsville indicates an average use of 130 – 165 gallons per day per connection. Dividing this average by the average number of persons per household (2.3) yields an average residential use of 56 – 71 gallons per day per person. Therefore, 70 GPD per person was used as the average rate. Using these figures, the county-wide groundwater use for residential connections outside of publicly served areas is approximately 1,200,000 gallons per day. While a few small commercial establishments are likely included in this residential volume, it is assumed that the water consumption for these would generally be less than 160 GPD (70 GPD x 2.3). It is also assumed that any users over the 160 GPD would be offset by the unoccupied dwellings included in the overall count. It would be impractical and unnecessary to include all variables associated with addresses outside of the service areas. The approximation of water use shown above is sufficient for this report.

Evaluation of Population and Land Use

The population and land use for locations outside of the defined service areas are discussed in the 'Public System Wells' section above. The population increases will be primarily confined to the growth areas allowed under the future land use plan. However, land divisions and development will occur in some form throughout the County. The growth rate outside defined service areas will likely match the lower projections presented above, while the growth rates inside the defined service areas will likely match the higher projections.

Agricultural Users

There are several large agricultural water users throughout Orange County as well. The largest agricultural users include turkey farms, dairy farms, poultry operations, green houses, and vineyards. Most of the farms, although large, do not use a substantial amount of water. Data regarding the farms in Orange County was obtained from the Virginia Cooperative Extension Agricultural Extension Agent. Additionally, from the USDA National Agricultural Statistics Service, it was determined that the above uses include approximately 1,556 acres of irrigated land. Only the greenhouse and poultry operation use a significant amount of water. The remaining users consume less than 10,000 gallons per day on average. The water use for major users is summarized in the section below. It is assumed that there will be no significant growth in the agricultural sector.

Other users

All significant water users within the County have been discussed in the preceding text. However, there may be other users scattered across the County. Any additional users not already considered would be of little impact to the existing and future water supply. For quick referencing, a summary of all significant water use in the County has been included in Table D-25.

Table D-25
Significant Water Users in Orange County and Water Use (MGD)

Service Area	Population (2005)	Connections (2005)	Water Use (Avg. Daily 2005)
Town of Orange	4,500	2,220	0.478
Town of Gordonsville	1,800	743	0.187
RSA -Wilderness	9,609	3,623	0.479
RSA - Route 15	237	102	0.034
RSA - Route 20	365	137	0.023
Additional Public Water Systems and Uses*			
Aerojet Corporation	25	36	0.002
General Shale Brick, Inc.	n/a	n/a	0.003
Locust Grove Town Center	182	1	0.013
Battlefield Farms	70	2	0.005
Meadows Farms Golf Course	151	2	0.011
Montpelier Mansion (Kitchen)	111	8	0.008
Montpelier Visitor’s Center	50	1	0.004
Somerset Golf Club LLC	100	2	0.007
Palladio Restaurant	50	1	0.004
Willow Grove Inn And Restaurant	106	2	0.007
Wolftrap Woods	50	15	0.004
Lake Of The Woods Golf Course – Irrigation	n/a	n/a	0.026
Somerset Golf Course – Irrigation	n/a	n/a	0.230
School Use-Wells*			
Lightfoot Elem School	318	1	0.003
Locust Grove Elementary/Middle Schools	1,421	1	0.014
Unionville Elementary School	342	1	0.003
County Residential	16,848	7,325	1.179
AG Use			
Feedlot & Poultry Operation			0.020
Greenhouse 1			0.100
Greenhouse 2			0.015
Total:			2.858

* Equivalent population for additional public water systems and schools.

E. PUBLIC INVOLVEMENT

Orange County, the Town of Orange, the Town of Gordonsville, and the Rapidan Service Authority all understand the importance of public involvement, especially with something as important as a regional water supply plan. Therefore, public meetings were incorporated into the consultant contract so that public-interest groups and the general public can stay informed of, and provide their input to, the Orange County Water Supply Plan. This also allows the participants to meet the public notice, public comment, and public meeting requirements of Sections 9 VAC 25-780-150 and 160 of the Water Supply Planning Regulation.

A strong public involvement process during this planning phase of water resource development also reduces negative comments that may arise during the permitting phase and reduces the amount of rework that must be done. This is particularly important for population and land use projections that are used for water demand projections. Having public acceptance of population projections is critical, because projections can vary and the public has to be willing to agree to certain growth rates over time. The public has to agree to future land uses also, because, with population growth, more land is converted from agricultural to residential, commercial, and industrial, or either existing residential land becomes more densely developed. The public needs to accept where these land use changes and density increases will occur. Once the public has accepted the population and land use projections, the water demand forecasting becomes easier, though public input and acceptance of future water use rates is desired. This is because of certain elements of water demand management such as water reuse, water conservation, water saving fixtures, etc., will affect the public and they must be aware of the impacts such measures will have to their daily lives.

To date, two public meetings have been held. The first meeting was held on 7:00 pm, April 4, 2006 at VHPS, which is an industry located just off of Route 15 between the Town of Orange and the Town of Gordonsville. The primary audience was the Orange County Water Solutions Committee, which is comprised of County citizens, business and industry leaders, environmental groups and elected officials from the County and the two towns. Representatives of the Virginia Department of Environmental Quality were also in attendance. The consultant team of Wiley & Wilson and Black & Veatch presented a PowerPoint presentation to introduce the project to the group. The presentation included a discussion of how the water supply regulation came into existence, what it entails, and how the County will use the regulation as a vehicle to begin the process of developing a water supply project. The presentation also informed the group of the scope of work tasked to the consultants and a review of the project schedule with emphasis on future public meetings. A question and answer period followed in which quite a few questions were asked about groundwater, to which the group was informed that groundwater would be discussed in greater detail in the next public meeting.

The second public meeting was held on 7:00 pm, May 25, 2006 in the Orange County Board of Supervisors Board Room at the Gordon Building in the Town of Orange. The general public was invited via newspaper advertisements and members of the general public were in attendance, in addition to members of the same groups that were in attendance at the first public meeting. The second public meeting was a two-part meeting, wherein the first part was an introduction of the project to the new attendees, status report with emphasis on population projections, and a discussion of the yield of the Rapidan River; the second part of the meeting was a presentation of the Groundwater Potential Study by Emery & Garrett Groundwater, Inc. A question and answer period followed each part, and once again, most questions were directed towards the groundwater portion of the project, though some questions arose regarding the population projections and the cumulative impact of surface water withdrawals on the Rapidan River.

Future meetings are scheduled for September 5, 2006, in October 2006, and in February 2007. The September 5, 2006 meeting is planned as an "Open House" style meeting, wherein information pertaining to various elements of the Orange County Water Supply Plan will be set up in manned booths. The public will have the opportunity to ask questions and make comments at the various booths and fill out comment cards. The October meeting is planned as a policy meeting to present the findings of Technical Memorandum No. 1 and Technical Memorandum No. 2 to the elected boards of the County and the two Towns before submittal of the documents to the DEQ Technical Evaluation Committee. The February 2007 meeting is a public meeting at which the DEQ Technical Evaluation Committee comments and the County's responses to the comments will be presented.

References:

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[v] Southeast Regional Climate Center, Data for Station 446712 Piedmont Research Station, April 11, 2005

[vi] Virginia Fish and Wildlife Information Services, Species Information, http://vafwis.org/WIS/visitor/species.asp?ln=V&sID=91668&nav=species, June 2006

[vii] Virginia's Conservation Lands Database, http://www.dcr.state.va.us/dnh/conslandindex.htm, June 2006

[viii] Piedmont Environmental Council, http://www.pecva.org/index.php, June 2006

[ix] Virginia's Conservation Lands Database, http://www.dcr.state.va.us/dnh/conslandindex.htm, June 2006

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Soil Survey Orange County, Virginia, USDA-SCS and Virginia Agricultural Experiment Station, May 1971.

[xii] Virginia's Conservation Lands Database, http://www.dcr.state.va.us/dnh/conslandindex.htm, June 2006

[xiii] Flood Plain Map, Town of Orange, VA, June 2006

[xiv] US Fish and Wildlife Services, National Wetland Inventory, http://wetlandsfws.er.usgs.gov/NWI/download.html, June 2006

[xv] Virginia DEQ, Geographic Environmental Mapping System, http://gisweb.deq.state.va.us/, June 2006

[xvi] Virginia DEQ, Geographic Environmental Mapping System, http://gisweb.deq.state.va.us/, June 2006

[xvii] Environmental Protection Agency, National Priorities List http://www.epa.gov/superfund/sites/npl/va.htm, June 2006

[xviii] Environmental Protection Agency, Toxic Release Inventory Program http://www.epa.gov/tri/, June 2006

[xix] Virginia Department of Health. *Waterworks Regulations*: *12VAC5-590-830*. Office of Drinking Water, March 20, 2006. Virginia General Assembly – Legislative Information System Website: http://leg1.state.va.us/000/reg/TOC09025.HTM#C0010. Accessed May 2006.

[xx] USDA. Technical Release 38: Tables of Percentage Points of the Pearson Type III Distribution. Natural Resources Conservation Service – Conservation Engineering Division, December 1998

[xxi] U.S. Census Bureau – 2000 Census

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APPENDICES

1.0 INTRODUCTION

Technical Memorandum No. 2 serves as a continuation of the work initiated in Technical Memorandum No. 1 dated July 31, 2006. Technical Memorandum No. 1 and Technical Memorandum No. 2 combined shall serve as Orange County's Water Supply Plan in accordance with 9 VAC 25-780 "Local and Regional Water Supply Planning Regulations". In addition to meeting the regulation, the Orange County Water Supply Plan provides the vehicle to initiate development of water supply projects to meet the County's anticipated water demands.

To meet the regulation, the work was divided into four task groups, as shown in Table 1-1. Technical Memorandum No. 1 presented findings of the Task Series 1, 2, and 3; and Technical Memorandum No. 2 presents the findings of Task Series 4.

Table 1-1 Work Division

Task Series	Description	Complies with Regulation Sections
1	Data Collection and Review	9 VAC 25-780-70, 80, and 90
2	Evaluation of Existing Water Supply Conditions	9 VAC 25-780-70, 80, and 90
3	Evaluation of Population and Land Use	9 VAC 25-780-100
4	Analysis of Water Supply Needs	9 VAC 25-780-110, 120, and 130

As reported in Technical Memorandum No. 1, Orange County is located on the boundary of four major watersheds, with the two largest watersheds being the Upper Rappahannock watershed in the north (56%) and the Pamunkey watershed in the south (41%). The Rapidan River is the largest stream in or adjacent to Orange County and, as a result, supplies water to nearly half of the Orange County residents through the Town of Orange's Water Treatment Plant (WTP) and RSA Wilderness' WTP.

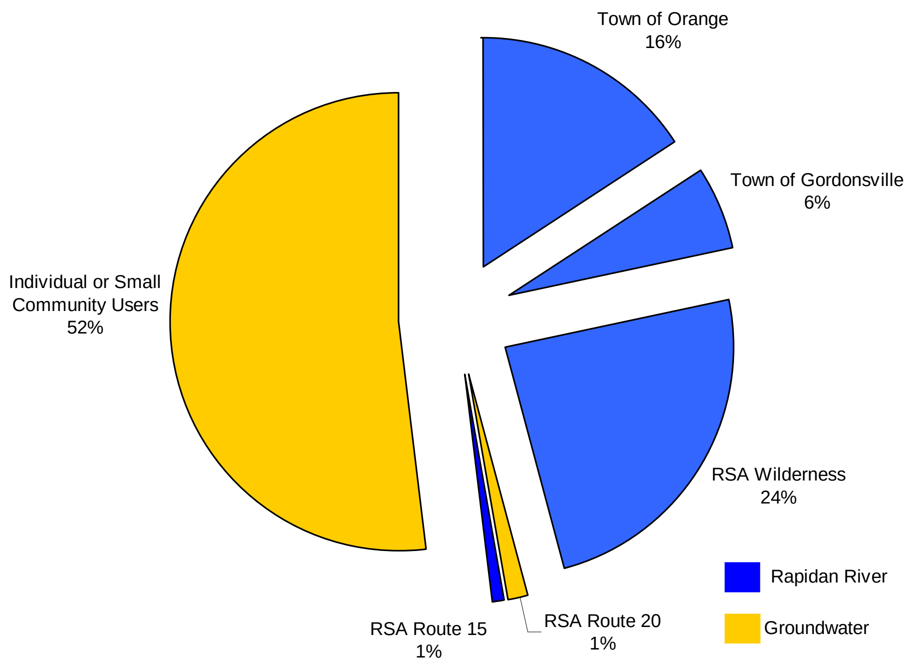
Groundwater provides the other half of the Orange County residents with water supply. Orange County has three distinct geologic provinces: the Blue Ridge Province, the Piedmont Province, and the Mesozoic Culpeper and Barboursville Basins. Based on these different provinces and the highly variable nature of the fractured bedrock aquifers in the area, the accumulated existing well data show a wide range of yields and well depths.

On most days of the year, the use of the Rapidan River and groundwater is more than sufficient for Orange County; however, the amount of water available is not static. Like any river, the Rapidan River is most abundant during the spring months when stream flows and groundwater levels are at their highest. Less water is available during the late summer and early fall, when stream flows and groundwater levels are typically at their lowest.

The recent drought in the Commonwealth of Virginia that peaked in the summer of 2002 resulted in stream flows reaching record lows and thousands of individual private wells failing. During September of 2002, the Town of Orange was on the brink of a water shortage emergency and was developing emergency plans to pipe water about 20 miles from a location near Culpeper using a surface laid pipeline.

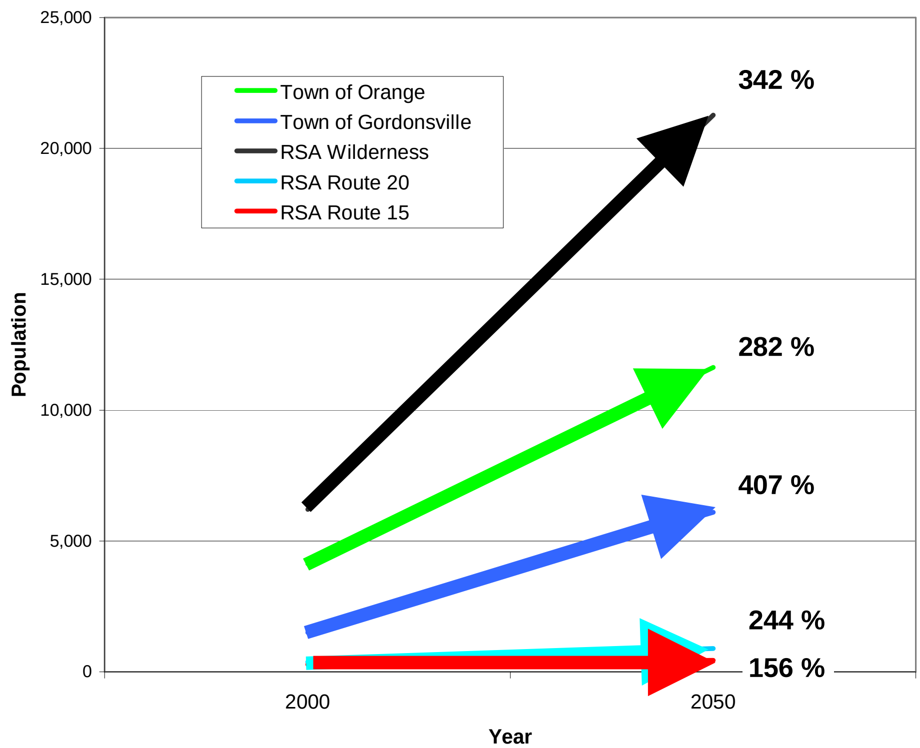
This was a dramatic reminder that water supply in Orange County is not unlimited, and that careful management is needed to ensure water availability for future generations. Figure 1-1 shows a population breakdown of where Orange County population gets their water.

Figure 1-1 Orange County Water Use in 2000



As the population increases in Orange County, droughts will only exacerbate the competition for water resources. Population projections, to the year 2050 with the percent increase for each of the water system's service areas, are summarized in Figure 1-2. These are based on population projections provided in Technical Memorandum No. 1.

Figure 1-2 2050 Population Projection with Percent Increase



There is no doubt that this increase in population will result in a subsequent increase in water demand. These dual increases generate the following questions:

- How will Orange County prepare for this growth?
- Will there be enough water for the Orange County residents in the future?
- Can Orange County and its water providers develop more groundwater wells?
- Is development of a water surface reservoir a necessity?

How Orange County will ensure that there is adequate and safe drinking water available in the future to all of its citizens is the subject of this Technical Memorandum No 2. Specifically, Technical Memorandum No. 2 tasks include the following:

- Water demand projections were developed for each of the major service areas within Orange County and areas outside of central service systems.
- The adequacy of existing water sources was determined.
- Water demand management options were evaluated such as water efficiency programs and other conservation measures, water system maintenance, and water loss identification strategies. Potential new demand management strategies were identified.
- Additional sources of supply were identified and evaluated, including traditional surface water and groundwater options.
- The most promising alternatives were further evaluated with regard to planning-level project cost, environmental and community impacts, reliability, and feasibility of implementation (including permitting).

- A groundwater investigation was performed which produced a map that identified favorable groundwater development areas.
- Non-traditional Water Demand Management alternatives such as water reuse were considered with regard to their applicability in Orange County.
- Water treatment and distribution improvements were identified and planning-level program costs were developed to assess the feasibility of treatment and transmission projects that would be required to develop new and expanded water sources.
- Existing drought response and contingency plans were described and evaluated with regard to their consistency with DEQ regulations. Recommended plan amendments or new plans were developed.
- The potential for interconnections with water systems inside and outside the county were considered.
- A planning schedule was developed which identifies existing water resource capacities, anticipated water demands, and the implementation of projects required to meet incremental demand.

The items are addressed in the following sections of Technical Memorandum No. 2.

2.0 WATER DEMAND PROJECTIONS

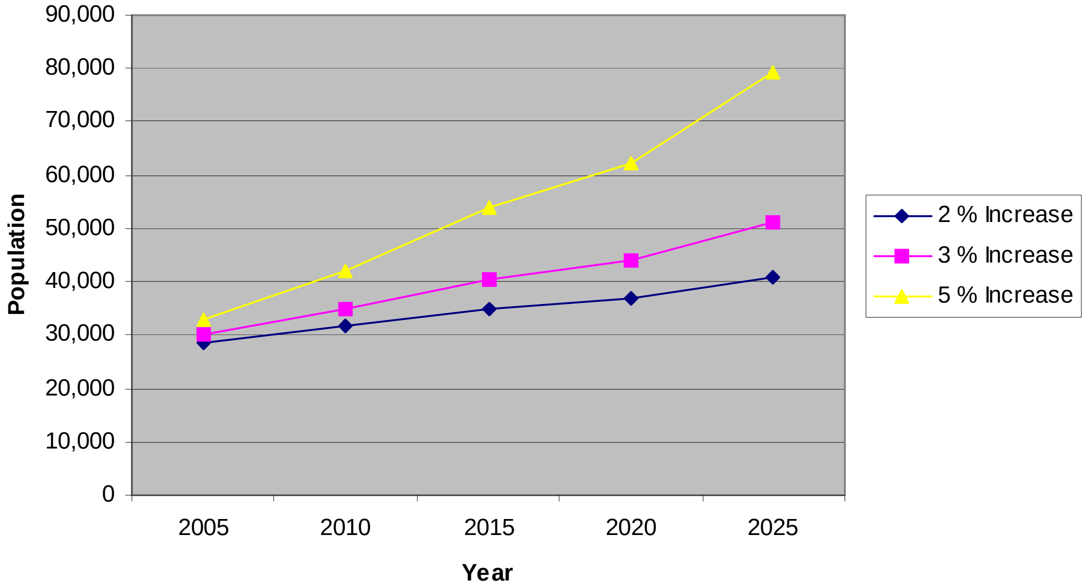
In Technical Memorandum No. 1, population projections were made for all areas of Orange County. These included areas served by public water systems such as the Town of Orange, the Town of Gordonsville, and the Rapidan Service Authority (RSA) Route 15, Route 20, and Wilderness systems. Population projections were also made for areas served by small community water systems and individual groundwater wells.

The population growth rates for various demand centers and decentralized areas of the County were discussed at a meeting on June 29, 2006, that was attended by the Orange County Administrator, Town of Orange Manager, Town of Gordonsville Manager, Rapidan Service Authority Director, and representatives of the Piedmont Environmental Council and Orange County Planning Commission. The overall consensus of the meeting participants was that the Virginia Employment Commission (VEC) projections for Orange County will underestimate the future population based on the VEC projection of 30,000 people for the year 2010. The Orange County Comprehensive Plan estimated the population of the County as 32,000 in January 2006. This was based on the number of new building permits issued since 2000 and the average number of residents per new dwelling. Because of the discrepancy between the VEC projection and the building permit data from the County, the Comprehensive Plan included low, medium, and high projections so that the County could plan for varying growth rates. These countywide population projections are shown in Table 2-1 and Figure 2-1, County-Wide Population Projections from Comprehensive Plan.

Table 2-1 County-Wide Population Projections from Comprehensive Plan

Year	2 % Increase	3 % Increase	5 % Increase
2005	28,572	30,000	33,028
2010	31,543	34,776	42,150
2015	34,823	40,312	53,792
2020	36,953	44,048	62,270
2025	40,796	51,061	79,472

Figure 2-1 County-Wide Population Projections from Comprehensive Plan



The Orange County Comprehensive Plan examined population projections for the County as a whole and did not evaluate different growth rates for different areas within the County. Since growth rates in the demand centers will normally be higher than in the decentralized areas, it is important for water supply planning to determine the population growth in the demand centers. The demand centers in Orange County are where public utilities already exist, namely the Town of Orange and its environs, the Town of Gordonsville and its environs, the Wilderness area, along Route 15 between the Town of Orange and the Town of Gordonsville, and the Route 20 area just east of the Town of Orange.

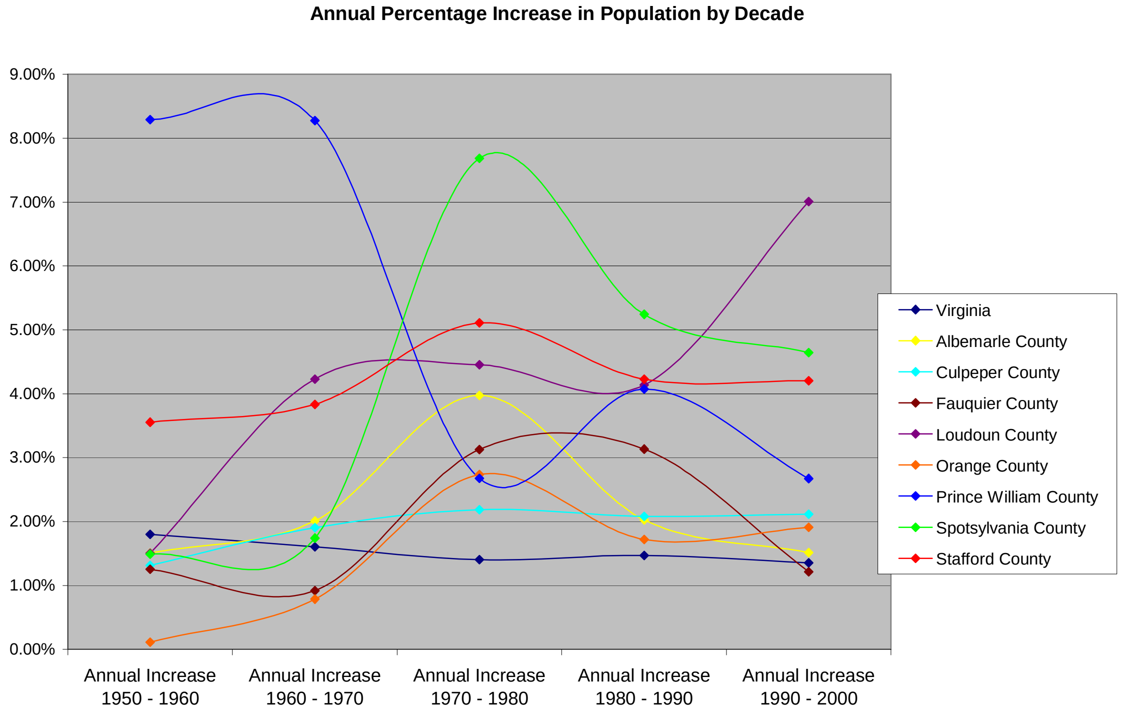
The growth rates in the demand centers vary depending on the location of the demand center and the County and Towns' respective policies for growth as set by their comprehensive plans. Growth is expected to be higher in the Wilderness area of the County due to its proximity to Fredericksburg and I-95. This is supported by the number of new water connections seen in the RSA Wilderness system since 2000. Because of its proximity to Albemarle County and Charlottesville, the Town of Gordonsville's growth rate is expected to be slightly higher than the Town of Orange's, though both are expected to be somewhat lower than Wilderness.' The growth rate in the area served by the RSA Route 20 system will be similar to that of the Town of Orange, while the growth rate along the Route 15 corridor will be lower than the other demand centers due to the future land use set out in the Orange County Comprehensive Plan. As discussed in Technical Memorandum No. 1, Wolftrap Woods is a small single family residential subdivision. It is not expected to grow throughout the study period.

The projected growth rates outside of the demand centers will be similar to those of the two towns except for the small community systems; the growth rates of the small community systems are not very high due to the limited amount of available parcels left in the areas served by the small community systems.

Population growth rates are higher initially as development rapidly fills up the land that is properly zoned for residential development and tapers off as the available residential parcels are filled. The consensus of the group in attendance at the meeting on June 29, 2006, was that the growth rates in all of the demand centers, except the RSA Route 15 system, would decrease around the year 2020. The growth rate in the RSA Route 15 system would remain constant from 2000 to 2050. The projected growth rate in the areas served by individual groundwater wells will also decrease after 2020, while the growth rate in the small community systems remains constant over the entire period.

Examples of initially high growth rates tapering off to slower growth rates are apparent in the counties to the north and east of Orange County, especially Stafford and Spotsylvania County. Figure 2-2 shows the rates of growth for these counties. As seen in the figure, nearly all of the counties between Orange County and Washington, DC have experienced a period of rapid growth followed by a period of slower growth. The only exception appears to be Culpeper County. Culpeper County's growth rate has increased from approximately 1.3% to a plateau of approximately 2.0%. It is interesting to note that the growth rate for both Stafford and Spotsylvania Counties have both been above 4% since at least 1970. Due to the growth patterns of these nearby counties, Orange County's projected medium growth rate of approximately 3.25% until 2020, followed by approximately 1.5% is realistic.

Figure 2-2 Growth Rates of Nearby Counties

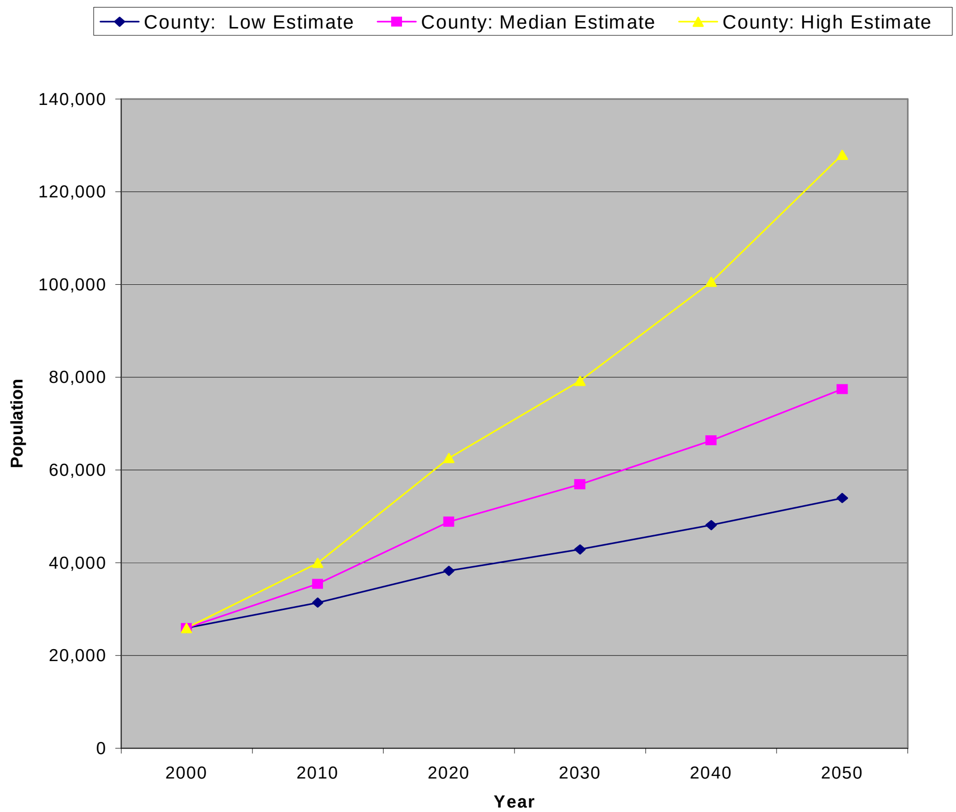


The results of this population projection analysis are shown in Table 2-2 and Figure 2-3. The analysis compares well with the low and medium growth rates forecast by the Orange County Comprehensive Plan. The projected high growth rate of 4% is lower than the high rate of 5% projected by the Comprehensive Plan. This is appropriate because the Comprehensive Plan only projects to 2025 while the Water Supply Plan projects until 2050. Five percent annual growth over a 50-year period is considered unrealistic.

Table 2-2 Orange County Population Projections

Service Area		2000 Pop	Annual Incr. 2000-2020	Annual Incr. 2020-2050	Projected Population					
					2000	2010	2020	2030	2040	2050
Town of Orange		4,123								
	Low Estimate		2.00%	1.00%	4,123	5,026	6,127	6,768	7,476	8,258
	Medium Estimate		3.00%	1.50%	4,123	5,541	7,447	8,642	10,029	11,640
	High Estimate		4.00%	2.00%	4,123	6,103	9,034	11,012	13,424	16,364
Town of Gordonsville		1,498								
	Low Estimate		2.50%	1.50%	1,498	1,918	2,455	2,849	3,306	3,837
	Medium Estimate		3.75%	2.25%	1,498	2,165	3,128	3,908	4,881	6,098
	High Estimate		5.00%	3.00%	1,498	2,440	3,975	5,342	7,179	9,647
RSA-Route 15		273								
	Low Estimate		0.50%	0.50%	273	280	294	309	325	342
	Medium Estimate		1.00%	1.00%	273	287	317	350	387	427
	High Estimate		1.50%	1.50%	273	294	341	396	460	534
Orange WTP:										
	Low Estimate				**5,894**	**7,223**	**8,875**	**9,926**	**11,107**	**12,436**
	Medium Estimate				**5,894**	**7,993**	**10,892**	**12,900**	**15,298**	**18,165**
	High Estimate				**5,894**	**8,837**	**13,350**	**16,750**	**21,062**	**26,545**
RSA-Wilderness		6,209								
	Low Estimate		2.00%	1.00%	6,209	7,569	9,226	10,192	11,258	12,436
	Medium Estimate		4.00%	1.50%	6,209	9,191	13,605	15,789	18,324	21,265
	High Estimate		6.00%	3.00%	6,209	11,119	19,913	26,762	35,965	48,334
RSA-Route 20		365								
	Low Estimate		2.00%	1.00%	365	403	491	543	599	662
	Medium Estimate		3.00%	1.50%	365	423	569	660	766	889
	High Estimate		4.00%	2.00%	365	444	657	801	977	1,191
Public Systems (Community):										
	Low Estimate				**12,468**	**15,195**	**18,593**	**20,660**	**22,964**	**25,534**
	Medium Estimate				**12,468**	**17,607**	**25,065**	**29,348**	**34,387**	**40,319**
	High Estimate				**12,468**	**20,401**	**33,920**	**44,313**	**58,004**	**76,070**
Add. Public Systems + Wolftrap		895								
	Low Estimate		1.00%	1.00%	895	941	1,039	1,148	1,268	1,401
	Medium Estimate		1.50%	1.50%	895	964	1,119	1,299	1,507	1,749
	High Estimate		2.00%	2.00%	895	988	1,205	1,468	1,790	2,182
Individual/Residential		12,518								
	Low Estimate		2.00%	1.25%	12,518	15,259	18,601	21,061	23,847	27,002
	Medium Estimate		3.00%	1.50%	12,518	16,823	22,609	26,239	30,451	35,340
	High Estimate		4.00%	2.00%	12,518	18,530	27,428	33,435	40,757	49,683
TOTALS:		25,881								
	Low Estimate				**25,881**	**31,395**	**38,233**	**42,869**	**48,079**	**53,936**
	Medium Estimate				**25,881**	**35,394**	**48,793**	**56,886**	**66,345**	**77,407**
	High Estimate				**25,881**	**39,919**	**62,553**	**79,216**	**100,552**	**127,935**
Aggregate Annual Rate (10-Year Increments)	Low Estimate					1.95%	1.99%	1.15%	1.15%	1.16%
	Medium Estimate					3.18%	3.26%	1.55%	1.55%	1.55%
	High Estimate					4.43%	4.59%	2.39%	2.41%	2.44%
Aggregate Annual Rate (30-Year and 50-Year)	Low Estimate							1.70%		1.48%
	Medium Estimate							2.66%		2.22%
	High Estimate							3.80%		3.25%

Figure 2-3 Orange County Population Projections



Population projections can be used to determine future water demands; however, there are many variables that affect the outcome of such calculations, such as water losses; variability of the customer base; the percentage of the year a residence is occupied; and variability of the residential use rate. Therefore, one cannot simply take the projected population and multiply it by the typical rate of 75 gallons per person per day seen in Virginia.[1] In fact, the water use per connection in the various public systems varies from a low of 115 GPD per residential connection for the RSA Wilderness system to a high of 166 GPD/residential connection for the Town of Gordonsville. Using the 2000 US Census data of 2.35 persons per household in the Town of Gordonsville produces a demand rate of 71 GPD/person, which shows their rate to be close to normal. Using the 2000 Census data of 2.50 persons per household for Orange County produces a rate of 46 GPD/person for the RSA Wilderness system, which can be attributed to the fact that Lake of the Woods still functions as a summer home area for some residents.

Because of the variability between different systems, it was decided to start with the 2005 water use data and apply the same growth rates to the water usage as were applied to the population, but with the caveat that the water use per residential connection would increase to 190

[1] Mays, L.W. (2000) Water Distribution Systems Handbook, McGraw-Hill, New York.

GPD/connection by the year 2020 and remain at that usage rate until 2050. The only exception would be the Wilderness system, where a jump from 115 GPD/ residential connection to 190 GPD/connection would be too abrupt; in this case, the water use would increase to 150 GPD/residential connection by 2020 and then to 190 GPD/ residential connection by 2030. The 190 GPD/residential connection is based on a rate of 70 GPD/person times 2.71 persons per dwelling. 2.71 persons per dwelling is the number of occupants per dwelling forecast in the Orange County Comprehensive Plan. The number of occupants per dwelling is expected to increase from the current 2.50 to 2.71 because Orange County is experiencing growth similar to that of neighboring Spotsylvania County, wherein the new occupants are typically young families with children.

Furthermore, the water projections were not developed on a disaggregated basis due to unknown factors affecting commercial, industrial, and institutional uses. It would be impractical to project each category individually. The alternate method used for this report assumed each category to grow proportionally along with residential growth whereas more residential development would create a need for additional commercial and institutional support services and increased industrial would spur increased residential growth. While this method is not precise, the interlink of the water use categories is real. Additionally, trying to predict a more detail disaggregated growth would be unfruitful.

Based on these factors, the projected water demands in Orange County are as shown in Table 2-3 and Figure 2-3. Note that the demands are for an annual average day. Water systems relying on surface water intakes or on groundwater wells must plan for the maximum day demand[2]. This is especially important because the maximum day demand quite often occurs at the same time as the low flow in the surface water source: late summer.

Because of this co-occurrence, the needs of the environment must be balanced with the needs of public water supply. At a time when stream flows are at their lowest, it is critical to the aquatic eco-systems that minimum in stream flows be maintained. Generally, this issue would be addressed with any withdrawal permit filed with the Virginia DEQ. For current withdrawal permits a streamflow analysis was performed and is included in Technical Memorandum No. 1, Section C. Therefore the maximum day demand over the last few years for the public systems in Orange County were averaged for each system to determine a maximum day demand multiplier to apply to the annual average day demand. For the public systems of the Town of Orange, RSA Route 15, RSA Route 20, and the Town of Gordonsville, this multiplier was determined to be 1.8. For the RSA Wilderness system the multiplier was determined to be 2.1. A multiplier of 1.8 was applied to all non-public systems. The maximum day demand projections are shown in Table 2-4.

[2] 12 VAC 5-590-690, Commonwealth of Virginia Waterworks Regulations

Table 2-3 Orange County Water Demand Projections

(Annual Average Day Demand)
Includes Unaccounted for Water

Service Area		Water Demand (gallons per day)								
		Existing	Annual Incr.		2010	2020	2030	2040	2050
Town of Gordonsville		221,500			<--exist 166 gpcd (res)-->		<--------190 gpcd (residential)-------->		
	Low Estimate		2.50%	1.50%	245,940	304,635	379,030	435,063	500,093
	Median Estimate		3.75%	2.25%	259,067	357,905	478,745	590,574	730,271
	High Estimate		5.00%	3.00%	272,828	420,748	605,507	803,433	1,069,430
RSA-Route 15		70,640			<--exist 161 gpcd (res)-->		<--------190 gpcd (residential)-------->		
	Low Estimate	0.5%(res)	2.00%	1.00%	76,849	91,183	102,833	112,555	123,242
	Median Estimate	1.0%(res)	3.00%	1.50%	80,321	104,298	123,435	142,026	163,472
	High Estimate	1.5%(res)	4.00%	3.00%	83,924	119,233	148,058	179,031	216,555
Town of Orange		579,200	till 2020	2020-2050	<--exist 134 gpcd (res)-->		<--------190 gpcd (residential)-------->		
	Low Estimate		2.00%	1.00%	639,484	779,527	1,015,875	1,122,158	1,239,561
	Median Estimate		3.00%	1.50%	671,452	902,375	1,235,500	1,433,849	1,664,040
	High Estimate		4.00%	3.00%	704,685	1,043,106	1,500,120	1,828,638	2,229,099
Subtotal - Orange WTP:		**871,340**							
	Low Estimate				**962,273**	**1,175,345**	**1,497,738**	**1,669,777**	**1,862,896**
	Median Estimate				**1,010,840**	**1,364,579**	**1,837,681**	**2,166,449**	**2,557,783**
	High Estimate				**1,061,437**	**1,583,088**	**2,253,684**	**2,811,102**	**3,515,083**
RSA-Wilderness		525,420			exist 115 gpcd	150gpcd	<--------190 gpcd (residential)-------->		
	Low Estimate		2.00%	1.00%	580,437	707,550	984,953	1,088,000	1,201,829
	Median Estimate		4.00%	1.50%	639,619	946,792	1,384,712	1,607,015	1,865,007
	High Estimate		6.00%	3.00%	703,532	1,259,919	2,133,827	2,867,685	3,853,929
RSA-Route 20		25,120			<--exist 160 gpcd (res)-->		<--------190 gpcd (residential)-------->		
	Low Estimate		2.00%	1.00%	27,735	33,808	42,682	47,148	52,081
	Median Estimate		3.00%	1.50%	29,121	39,136	51,910	60,244	69,915
	High Estimate		4.00%	2.00%	30,562	45,240	63,028	76,831	93,657
Sub-public systems (comm.):		**1,421,880**							
	Low Estimate				**1,570,445**	**1,916,703**	**2,525,373**	**2,804,926**	**3,116,806**
	Median Estimate				**1,679,580**	**2,350,507**	**3,274,304**	**3,833,707**	**4,492,705**
	High Estimate				**1,795,531**	**2,888,246**	**4,450,540**	**5,755,618**	**7,462,669**
Add. Public Systems + Wolfrap		22,950							
	Low Estimate		1.00%	1.00%	23,860	26,861	29,672	32,776	36,205
	Median Estimate		1.50%	1.50%	24,567	29,361	34,075	39,545	45,894
	High Estimate		2.00%	2.00%	25,292	32,102	39,133	47,702	58,149
Schools		20,800							
	Low Estimate		2.00%	1.00%	22,965	27,994	31,697	35,889	40,637
	Median Estimate		3.00%	1.50%	24,113	32,406	37,608	43,646	50,653
	High Estimate		4.00%	2.00%	25,306	37,460	45,663	55,663	67,853
Individual/Residential		935,410							
	Low Estimate		2.00%	1.25%	1,032,768	1,258,939	2,062,963	2,335,832	2,644,795
	Median Estimate		3.00%	1.50%	1,084,397	1,457,338	2,447,695	2,840,650	3,296,690
	High Estimate		4.00%	2.00%	1,138,069	1,684,621	2,971,942	3,622,780	4,416,149
Agricultural		135,000							
	Low Estimate		0.50%	0.50%	138,409	145,487	152,927	160,748	168,969
	Median Estimate		1.00%	1.00%	141,886	156,731	173,128	191,241	211,249
	High Estimate		2.00%	2.00%	149,051	181,692	221,482	269,985	329,110
TOTALS:									
	Low Estimate	**2,536,040**			**2,788,447**	**3,375,985**	**4,802,632**	**5,370,172**	**6,007,411**
	Median Estimate	**2,536,040**			**2,954,542**	**4,026,343**	**5,966,810**	**6,948,790**	**8,097,191**
	High Estimate	**2,536,040**			**3,133,250**	**4,824,121**	**7,728,759**	**9,751,749**	**12,333,930**

Totals include all major existing uses plus existing water loss percentage
The calculations do not include fire demand
Losses for community systems, schools, agriculture, and individual residences are considered negligible

In comparing the projected water demands to the population projections, the annual average day demand for all water demands, county wide, including losses, is 98 GPD/person in 2005 and varies from 105 GPD/person in 2050 for the medium water demand projection. Both of these demand numbers compare well with the US average of 105 GPD/person for all uses.[3] Note that these water demand numbers are without any demand management or water conservation measures in place.

[3] Mays, L.W. (2000) Water Distribution Systems Handbook, McGraw-Hill, New York.

Table 2-4 Orange County Water Demand Projections

(Max Day Demand)
Includes Unaccounted for Water

Service Area			2005	2010	2020	2030	2040	2050
			Gallons per day					
Town of Gordonsville			<--exist 166 gpcd (res)-->			<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	398,700	442,693	548,342	682,254	783,114	900,167
		Median Estimate	398,700	466,321	644,230	861,742	1,063,034	1,314,488
		High Estimate	398,700	491,090	757,347	1,089,913	1,446,180	1,924,973
RSA-Route 15			<--exist 161 gpcd (res)-->			<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	127,152	138,329	164,130	185,099	202,600	221,836
		Median Estimate	127,152	144,578	187,737	222,184	255,646	294,250
		High Estimate	127,152	151,062	214,620	266,504	322,256	389,798
Town of Orange			<--exist 134 gpcd (res)-->			<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	1,042,560	1,151,070	1,403,148	1,828,576	2,019,885	2,231,210
		Median Estimate	1,042,560	1,208,613	1,624,275	2,223,901	2,580,928	2,995,272
		High Estimate	1,042,560	1,268,434	1,877,592	2,700,216	3,291,548	4,012,378
Subtotal - Orange WTP:								
	Demand	**Low Estimate**	**1,568,412**	**1,732,092**	**2,115,621**	**2,695,928**	**3,005,599**	**3,353,212**
		Median Estimate	**1,568,412**	**1,819,512**	**2,456,241**	**3,307,826**	**3,899,607**	**4,604,010**
		High Estimate	**1,568,412**	**1,910,586**	**2,849,558**	**4,056,632**	**5,059,983**	**6,327,150**
RSA-Route 20			<--exist 160 gpcd (res)-->			<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	45,216	49,922	60,855	76,828	84,866	93,745
		Median Estimate	45,216	52,418	70,445	93,438	108,439	125,848
		High Estimate	45,216	55,012	81,431	113,451	138,296	168,582
Subtotal - Orange WTP + RSA Route 20								
	Demand	**Low Estimate**	**1,613,628**	**1,782,014**	**2,176,476**	**2,772,757**	**3,090,465**	**3,446,958**
		Median Estimate	**1,613,628**	**1,871,930**	**2,526,686**	**3,401,265**	**4,008,046**	**4,729,857**
		High Estimate	**1,613,628**	**1,965,598**	**2,930,990**	**4,170,083**	**5,198,279**	**6,495,732**
RSA-Wilderness			<--exist 115 gpcd (res)-->		150 gpcd	<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	1,103,382	1,218,918	1,485,855	2,068,400	2,284,801	2,523,842
		Median Estimate	1,103,382	1,343,199	1,988,263	2,907,896	3,374,731	3,916,514
		High Estimate	1,103,382	1,477,417	2,645,829	4,481,037	6,022,139	8,093,251
Subtotal - public systems (community):								
	Demand	**Low Estimate**	**2,717,010**	**3,000,933**	**3,662,331**	**4,841,157**	**5,375,266**	**5,970,799**
		Median Estimate	**2,717,010**	**3,215,129**	**4,514,950**	**6,309,160**	**7,382,778**	**8,646,371**
		High Estimate	**2,717,010**	**3,443,015**	**5,576,819**	**8,651,119**	**11,220,418**	**14,588,983**
	Community Systems							
		Low Estimate	41,310	42,948	48,351	53,409	58,997	65,169
		Median Estimate	41,310	44,220	52,850	61,335	71,181	82,609
		High Estimate	41,310	45,526	57,784	70,439	85,864	104,668
	Schools							
		Low Estimate	37,440	41,337	50,389	57,054	64,601	73,146
		Median Estimate	37,440	43,403	58,330	67,695	78,562	91,175
		High Estimate	37,440	45,551	67,427	82,194	100,193	122,135
	Individual/Residential							
		Low Estimate	1,683,738	1,858,983	2,266,090	3,713,333	4,204,498	4,760,631
		Median Estimate	1,683,738	1,951,914	2,623,209	4,405,851	5,113,170	5,934,042
		High Estimate	1,683,738	2,048,525	3,032,317	5,349,495	6,521,004	7,949,068
	Agricultural							
		Low Estimate	243,000	249,136	261,877	275,269	289,347	304,144
		Median Estimate	243,000	255,395	282,115	311,631	344,234	380,249
		High Estimate	243,000	268,292	327,046	398,667	485,973	592,399
	TOTALS:							
		Low Estimate	**4,722,498**	**5,193,336**	**6,289,037**	**8,940,223**	**9,992,709**	**11,173,889**
		Median Estimate	**4,722,498**	**5,510,062**	**7,531,455**	**11,155,671**	**12,989,926**	**15,134,446**
		High Estimate	**4,722,498**	**5,850,909**	**9,061,393**	**14,551,914**	**18,413,454**	**23,357,253**

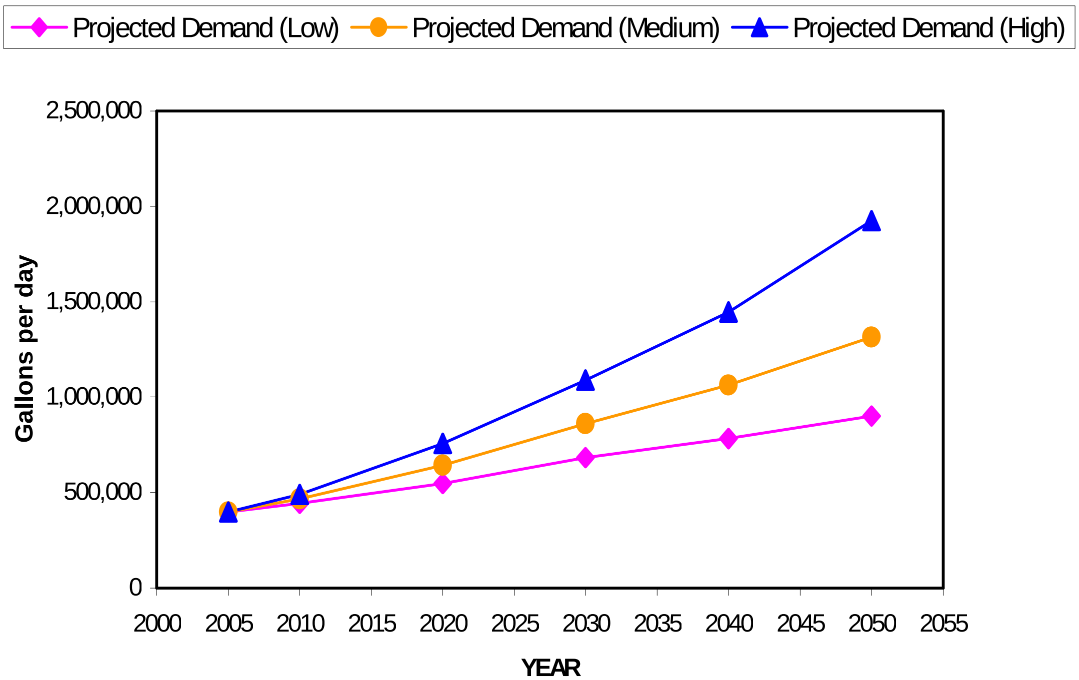
Totals include all major existing uses plus existing water loss percentage
The calculations do not include fire demand.
Losses for community systems, schools, agriculture, and individual residences are considered negligible

A breakdown of the projected maximum day demands for each of the demand centers is as follows:

2.1 Town of Gordonsville

The growth rates for water demand in the Town of Gordonsville, as shown in Tables 2-3 and 2-4, closely parallel the population growth rates shown in Table 2-2. The projected maximum day water demand for the Town of Gordonsville is shown in Figure 2-4. If the medium water demand growth rate is considered, the maximum day demand will be approximately 1.3 MGD by the year 2050. This could vary as the population growth rate varies.

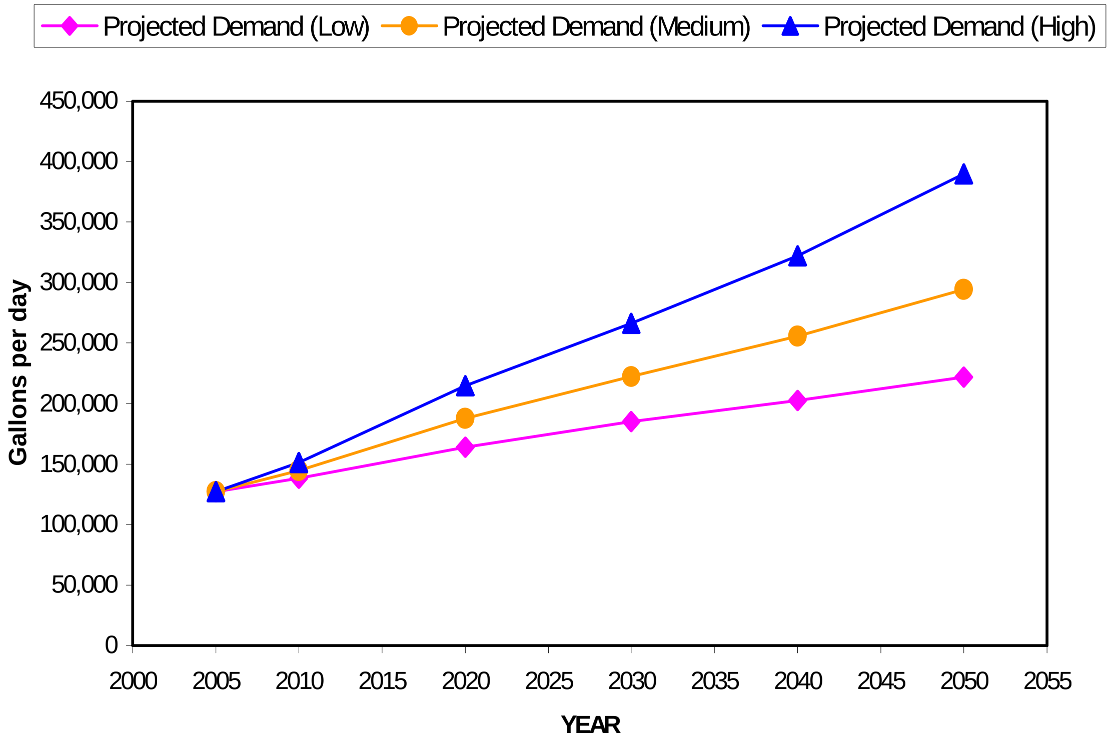
Figure 2-4 Projected Water Demands Town of Gordonsville - Maximum Day



2.2 RSA Route 15 System

The growth rates for water demand in the RSA Route 15 system as shown in Tables 2-3 and 2-4 closely parallel the population growth rates shown in Table 2-2. The projected maximum day water demand for the RSA Route 15 system is shown in Figure 2-5. If the medium water demand growth rate is considered, the maximum day demand will be approximately 0.3 MGD by the year 2050. This could vary as the population growth rate varies.

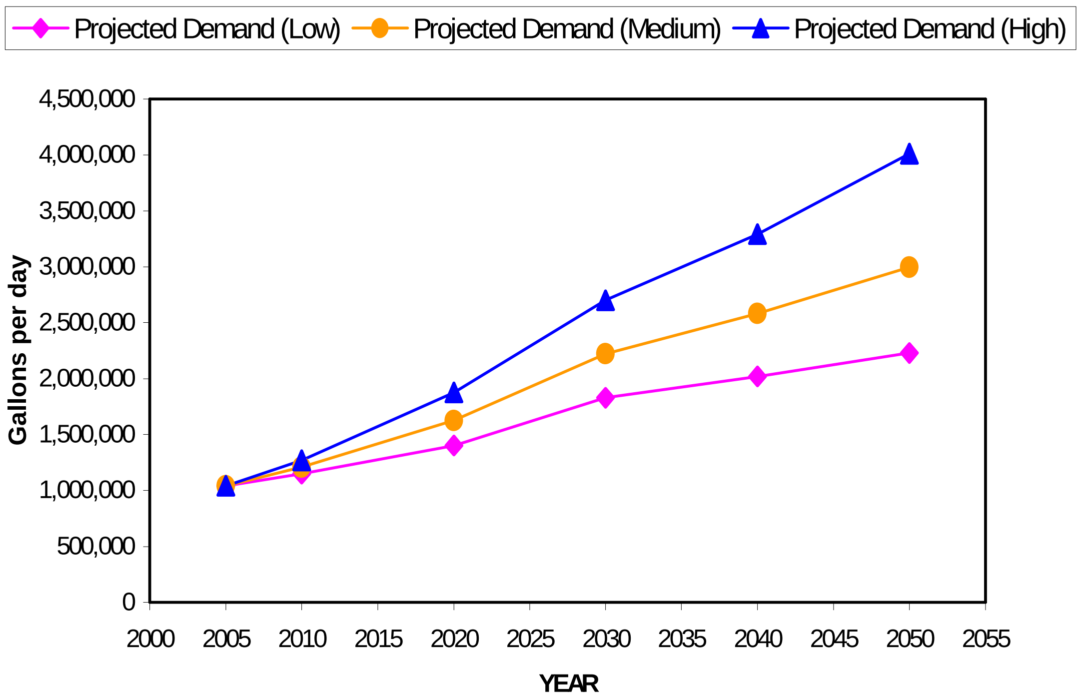
Figure 2-5 Projected Water Demands RSA Route 15 System – Maximum Day



2.3 Town of Orange System

The growth rates for water demand in the Town of Orange system as shown in Tables 2-3 and 2-4 closely parallel the population growth rates shown in Table 2-2. The projected maximum day water demand for the Town of Orange system is shown in Figure 2-6. If the medium water demand growth rate is considered, the maximum day demand will be approximately 3.0 MGD by the year 2050. This could vary as the population growth rate varies.

Figure 2-6 Projected Water Demands Town of Orange System - Maximum Day

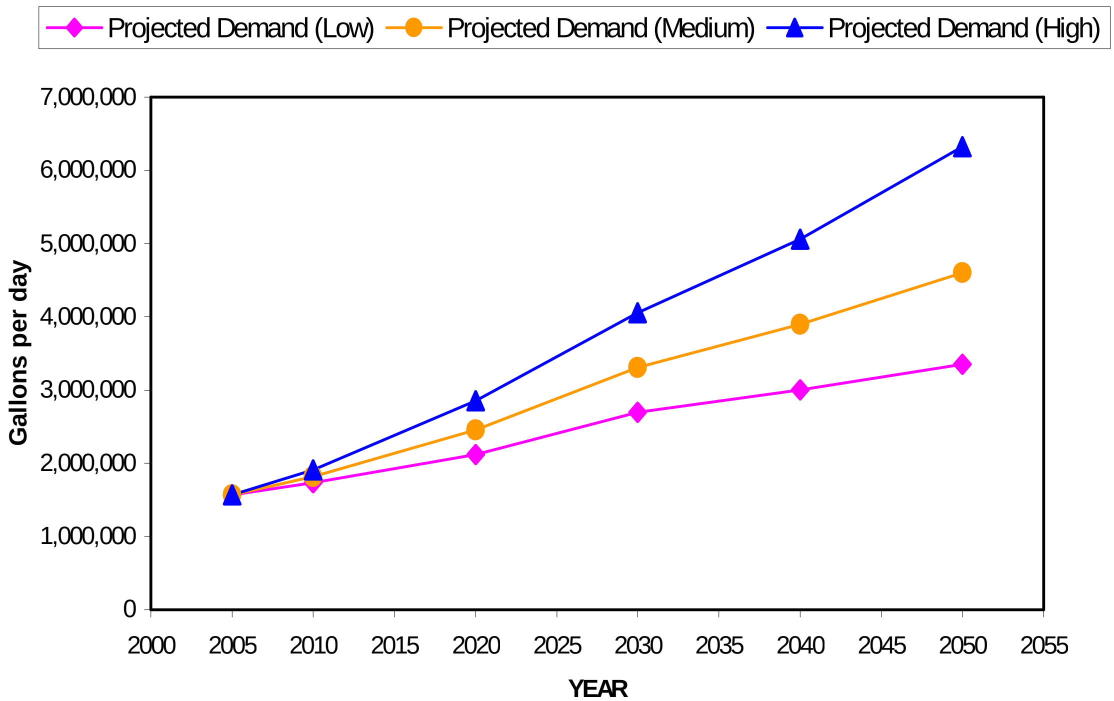


2.4 Area Served by the Town of Orange WTP

The Town of Orange water treatment plant currently serves as the source of supply for the Town of Orange system, the RSA Route 15 system, and the Town of Gordonsville System. All of the systems are currently interconnected, as the RSA Route 15 system purchases water from the Town of Orange and resells water to the Town of Gordonsville. These three systems will most likely remain interconnected even if new sources are developed. Because of this, it is important to view the projected water demands of the three systems in aggregate.

The growth rates for water demand in the Town of Orange, RSA Route 15, and the Town of Gordonsville combined system, as shown in Tables 2-3 and 2-4, closely parallel the population growth rates shown in Table 2-2. The projected maximum day water demand for the combined system is shown in Figure 2-7. If the medium water demand growth rate is considered, the maximum day demand for the combined system will be approximately 4.6 MGD by the year 2050. This could vary as the population growth rate varies.

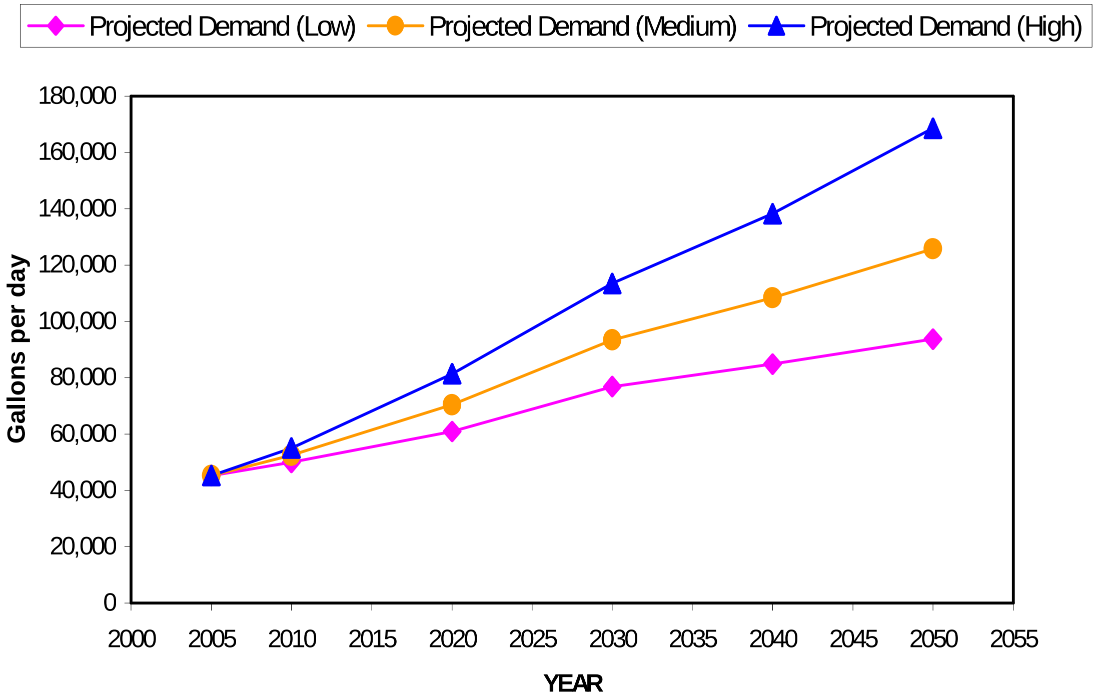
Figure 2-7 Projected Water Demands Orange WTP System (All Service Areas) – Maximum Day



2.4.1 RSA Route 20 System

The growth rates for water demand in the RSA Route 20 system, as shown in Tables 2-3 and 2-4, closely parallel the population growth rates shown in Table 2-2. The projected maximum day water demand for the RSA Route 20 system is shown in Figure 2-8. If the medium water demand growth rate is considered, the maximum day demand will be approximately 0.13 MGD by the year 2050. This could vary as the population growth rate varies.

Figure 2-8 Projected Water Demands RSA Route 20 System – Maximum Day



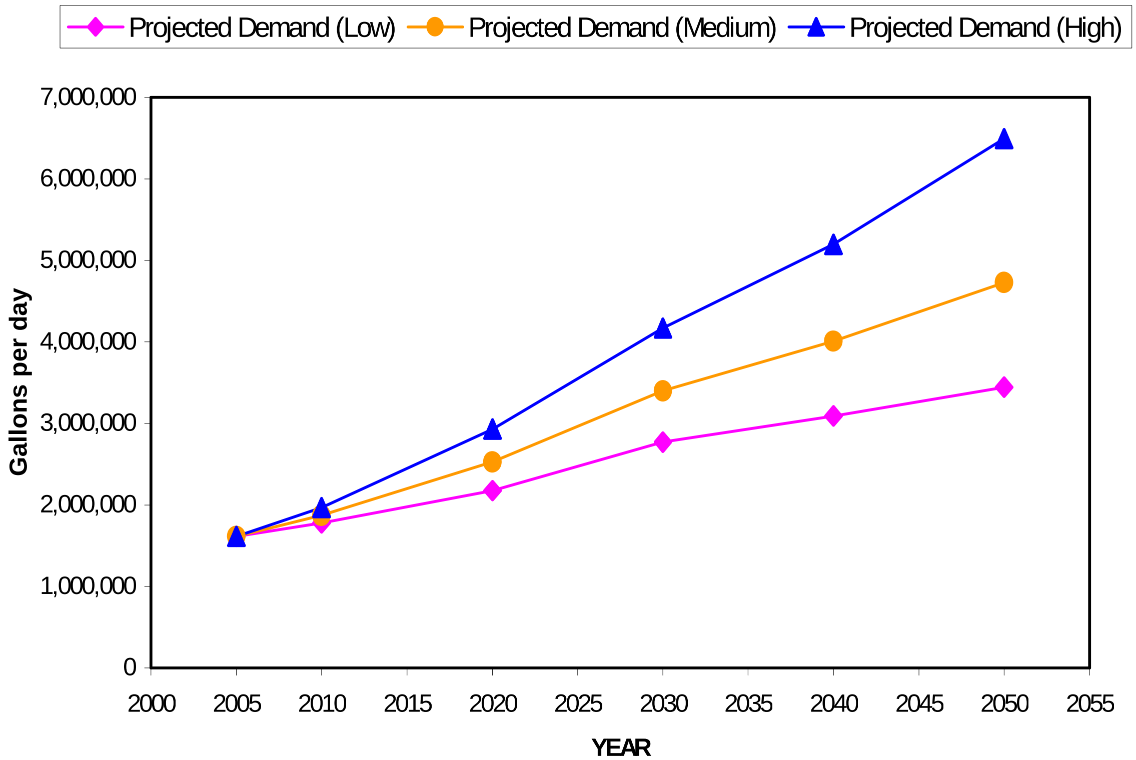
2.5 Area served by the Town of Orange WTP and the RSA Route 20 System

The Town of Orange, RSA Route 15, and the Town of Gordonsville combined system are connected to the RSA Route 20 system by a closed line valve. The valve currently functions as an emergency interconnection in case the groundwater well supply for the Route 20 system fails. The possibility exists that the valve could be opened in the future so that all four systems are truly interconnected. Because of this, it is important to view the projected water demands of the four systems in aggregate.

The growth rates for water demand in the Town of Orange, RSA Route 15, the Town of Gordonsville, and RSA Route 20 combined system, as shown in Tables 2-3 and 2-4, closely parallel the population growth rates shown in Table 2-2. The projected maximum day water demand for the combined system is shown in

Figure 2-9. If the medium water demand growth rate is considered, the maximum day demand for the combined system will be approximately 4.7 MGD by the year 2050. This could vary as the population growth rate varies.

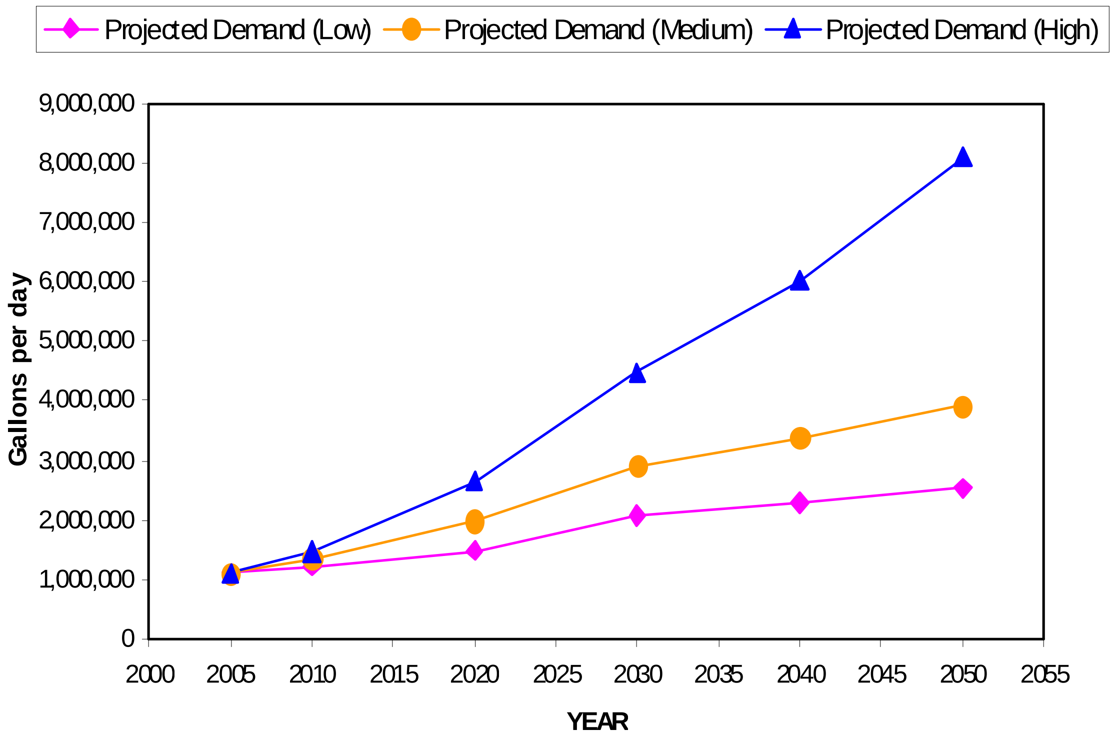
Figure 2-9 Projected Water Demands Orange WTP + RSA Route 20 Systems – Maximum Day



2.5.1 RSA Wilderness System

The growth rates for water demand in the RSA Wilderness system, as shown in Tables 2-3 and 2-4, closely parallel the population growth rates shown in Table 2-2. The projected maximum day water demand for the RSA Wilderness system is shown in Figure 2-10. If the medium water demand growth rate is considered, the maximum day demand will be approximately 3.9 MGD by the year 2050. This could vary as the population growth rate varies.

Figure 2-10 Projected Water Demands RSA Wilderness System – Maximum Day

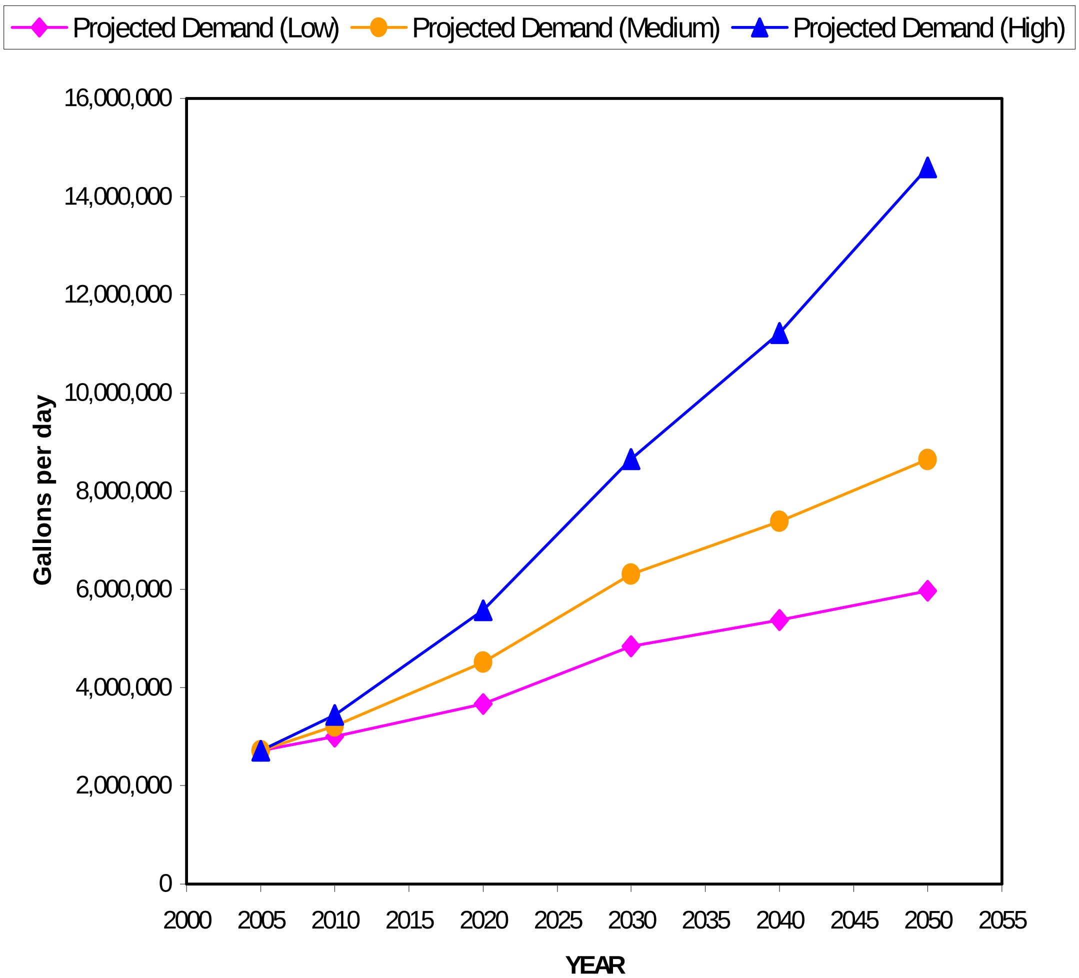


2.6 Public Systems

As with any long-term water demand projection, the possibility exists to interconnect all existing public systems. This enhances the reliability of all of the interconnected systems and provides some level of backup if one of the sources experiences water quality issues. Due to this possibility, the future water demands of all public systems have been determined.

The projected maximum day water demand for all public water systems is shown in Figure 2-11. If the medium water demand growth rate is considered, the maximum day demand will be approximately 8.6 MGD by the year 2050. This could vary as the population growth rate varies.

Figure 2-11 Projected Water Demands All Public Systems – Maximum Day



2.7 Non-Public Systems

Because of the existing land use and the projected future land use shown in the Orange County Comprehensive Plan, it is apparent that the county wishes to preserve a large amount of its rural and agricultural areas. The Orange County Comprehensive Plan states, "Goal: Shield the rural character of the county from the undesirable effects of uncontrolled growth, thereby preserving the unique and distinguishing characteristics of Orange County." The County plans on reaching this goal by keeping a large portion of the land in the county as Agricultural Conservation or Agricultural, as shown in Table 2-5.[4]

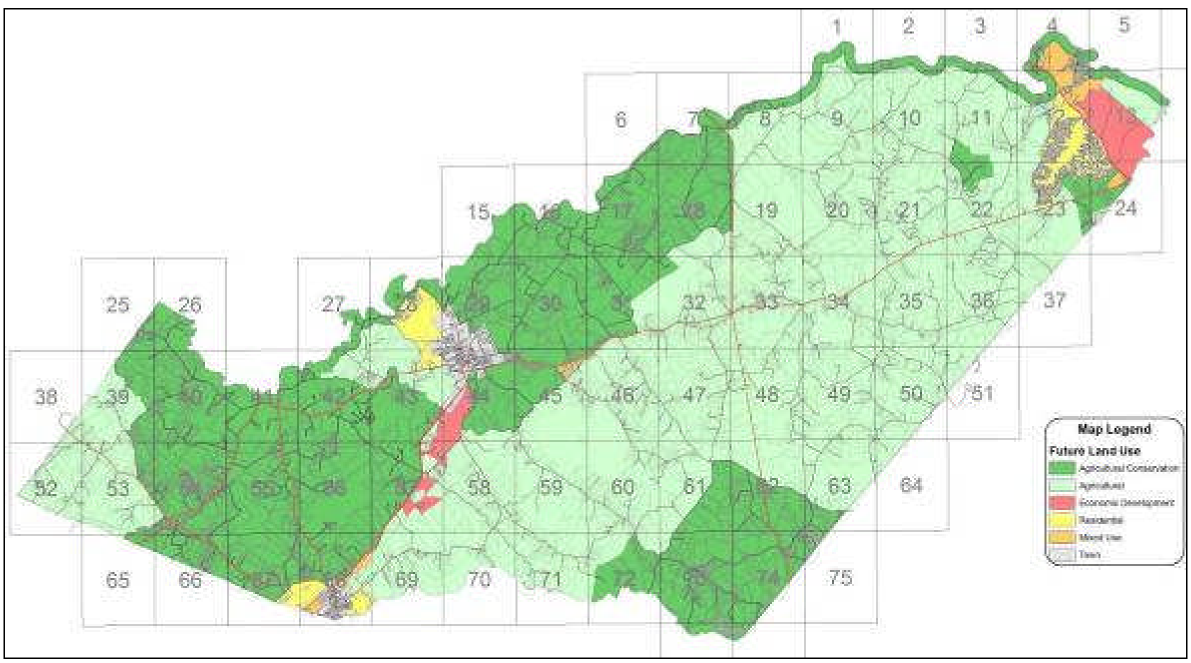
[4] Orange County Comprehensive Plan, As adopted by the Orange County Board of Supervisors on May 9, 2006

Table 2-5 Orange County Future Land Use Categories

Percentage of Land	*Future Land Use Category*
39%	Agricultural Conservation
56%	Agricultural
2%	Residential
1%	Mixed Use
2%	Economic Development

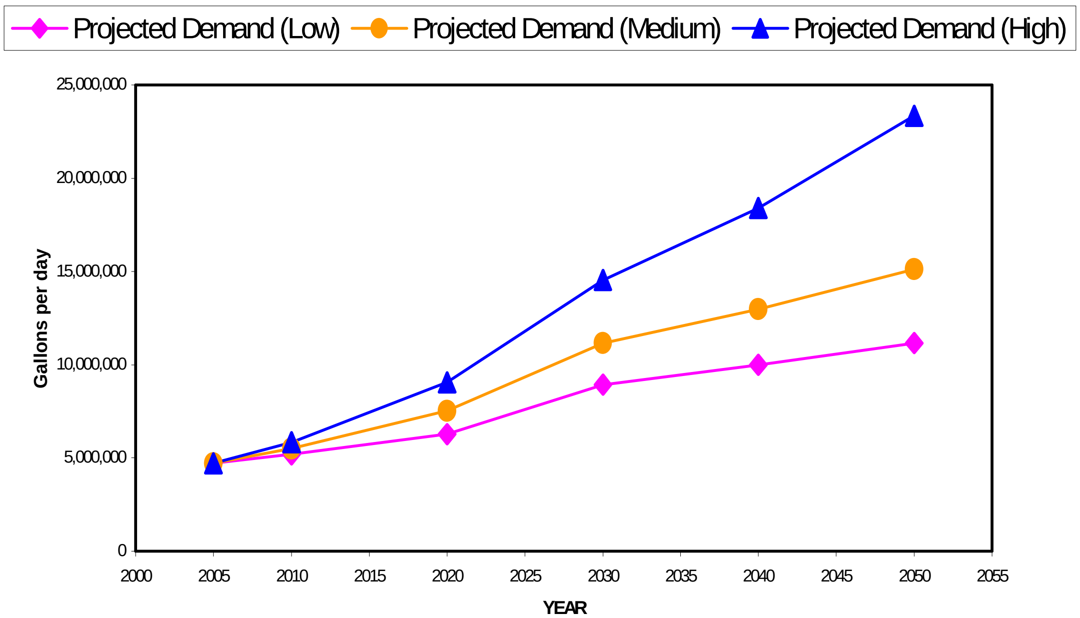
The remaining categories of Residential, Mixed Use, and Economic Development are located near the existing and future public water supply areas, as shown in Figure 2-12. Properties located in the Agricultural Conservation and Agricultural Areas will be served by individual wells. The small community systems and some of the county schools are located in these areas and use groundwater wells as their sources of water. The agricultural users use both groundwater and surface water, normally from small streams or farm ponds. When the decentralized water demands are added to the water demands of the public systems, the medium total projected maximum water demand for the County is 15.1 MGD, as shown in Figure 2-13.

Figure 2-12 Orange County Future Land Use[5]



[5] Orange County Comprehensive Plan, As adopted by the Orange County Board of Supervisors on May 9, 2006

Figure 2-13 Projected Water Demands Maximum Day – All Water Demands



2.8 Water Conservation

The Local and Regional Water Supply Planning (9 VAC 25-780-10 through 9 VAC 25-780-190) regulations state, "Current conservation practices, techniques, and technologies shall be considered in projecting water demand."

As described in more detail in the Water Demand Management Section 6 of this memorandum, the current conservation practices are minimal in the study area and cannot be quantified to determine their impacts on future demand. However, with the implementation of more efficient water technologies and increasing regulations, it can be assumed that future water demand will be reduced due to overall water conservation. Predicting the 50-year reduction in water demand due to conservation requires a number of assumptions such as savings due to individual conservation efforts and public participation.

In the American Water Works Association's 2006 publication, *Water Conservation Programs – A Planning Manual (M52)*, various water-efficient devices are listed, along with their end-use reduction and device-life. Five of these devices are listed as "Required for New Installation," as shown in Table 2-6. The combined end-use reduction for these devices is 15 gallons/capita/day. These requirements are based on the Federal Energy Policy Act of 1992, which require all faucet and shower fixtures to have a flow rate of no more than 2.2 GPM at 60 psi, and requires 1.6 gallons per flush (gpf) toilets for all new construction.

Table 2-6 Water-Saving Devices Required for New Installations[6]

Device Description	Device Life (yrs)	End-Use Reduction (gal/cap/day)
New Showerhead	5-10	2.4
Bathroom Faucet Actuator	5	1.6
1.6 gallon Toilets	20-30	10.4
Kitchen Faucet Actuator	5	0.3
Laundry Faucet Actuator	5	0.3
		TOTAL = 15 gal/cap/day

The following assumptions are made in calculating the potential water conservation savings:

- The introduction of these newly required water-saving devices will occur through either the replacement of existing devices or the installation of new facilities.
- The “existing” population begins in 2000 with non-efficient devices.
- The conservation due to the “existing” population replacing their existing water devices will occur evenly for 25 years beginning in 2000. Therefore, by the year 2025, it was assumed that the “existing” population would have replaced their old water devices with the more water-efficient devices.
- Due to the number of assumptions, the total reduction due to conservation was applied to the high projection demand.

2.8.1 Water Conservation Analysis

2.8.1.1 Town of Orange

Table 2-7 summarizes the potential conservation for the Town of Orange based on the high projected water demand. This table shows that by the year 2050, water conservation could reduce demand by 0.25 MGD due to more water-efficient devices.

[6] Device Life and End-Use Reduction according to Water Conservation Programs – A Planning Manual (Manual M52), Pages 53-54, Table 3-5, published in 2006 by American Water Works Association.

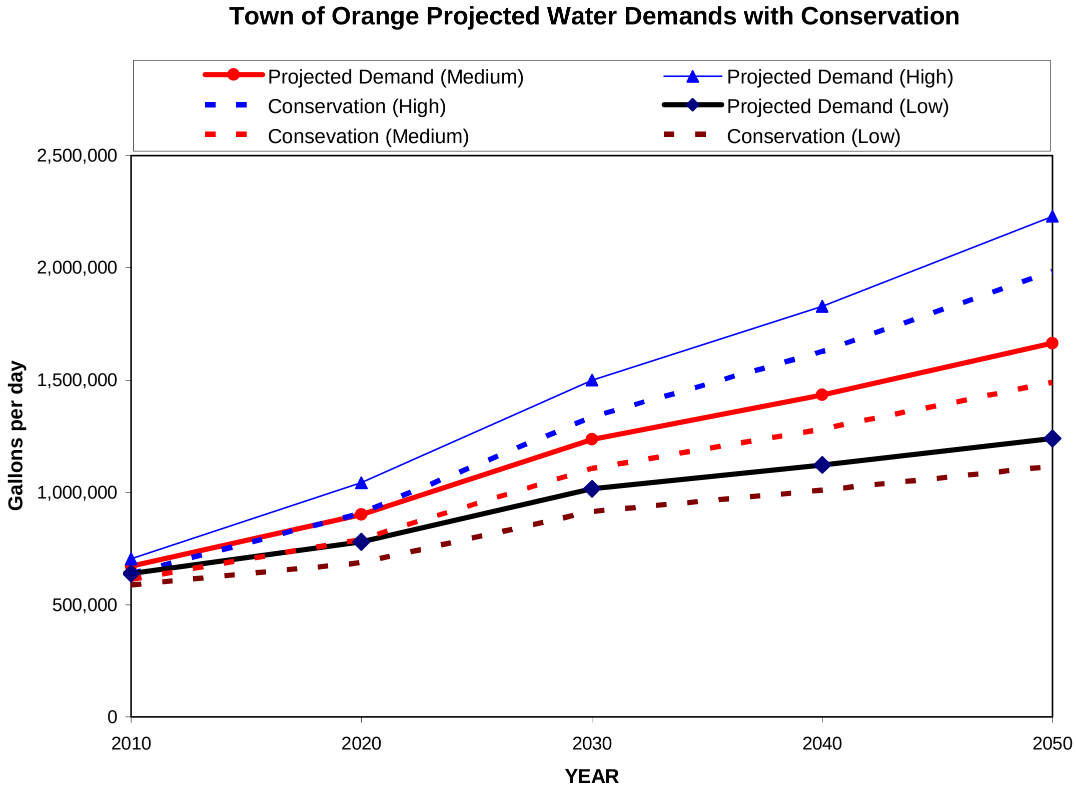
Table 2-7 Town of Orange Conservation Reduction Summary

Year	"Existing" Population Conservation Savings			"New" Population Conservation Savings			Overall Conservation[ii] (MGD)
	Capita	Savings per Capita	Savings[i] (MGD)	Capita	Savings per Capita	Savings[i] (MGD)	
2000	4,123	3	.01	-	-	-	.01
2010	4,123	9	.04	1,980	15	.03	.07
2020	4,123	15	.06	4,911	15	.07	.14
2030	4,123	15	.06	6,889	15	.10	.17
2040	4,123	15	.06	9,301	15	.14	.20
2050	4,123	15	.06	12,241	15	.18	.25

[i] Savings = [Savings per capita] x [Capita].
[ii] Existing Population Conservation Savings + "New" Population Conservation Savings

Figure 2-14 shows conservation reduction for the low, medium and high water demand projections. For example, for the high demand the peak day demand is reduced from 2.2 to 2.0 MGD in the year 2050. This is an 11% reduction in the demand.

Figure 2-14 Conservation Reduction Applied to Projected Peak Day Demand



2.8.1.2 Town of Gordonsville

Table 2-8 summarizes the potential conservation for the Town of Gordonsville based on the high projected water demand. This table shows that by the year 2050, water conservation could reduce demand by 0.14 MGD due to more water-efficient devices.

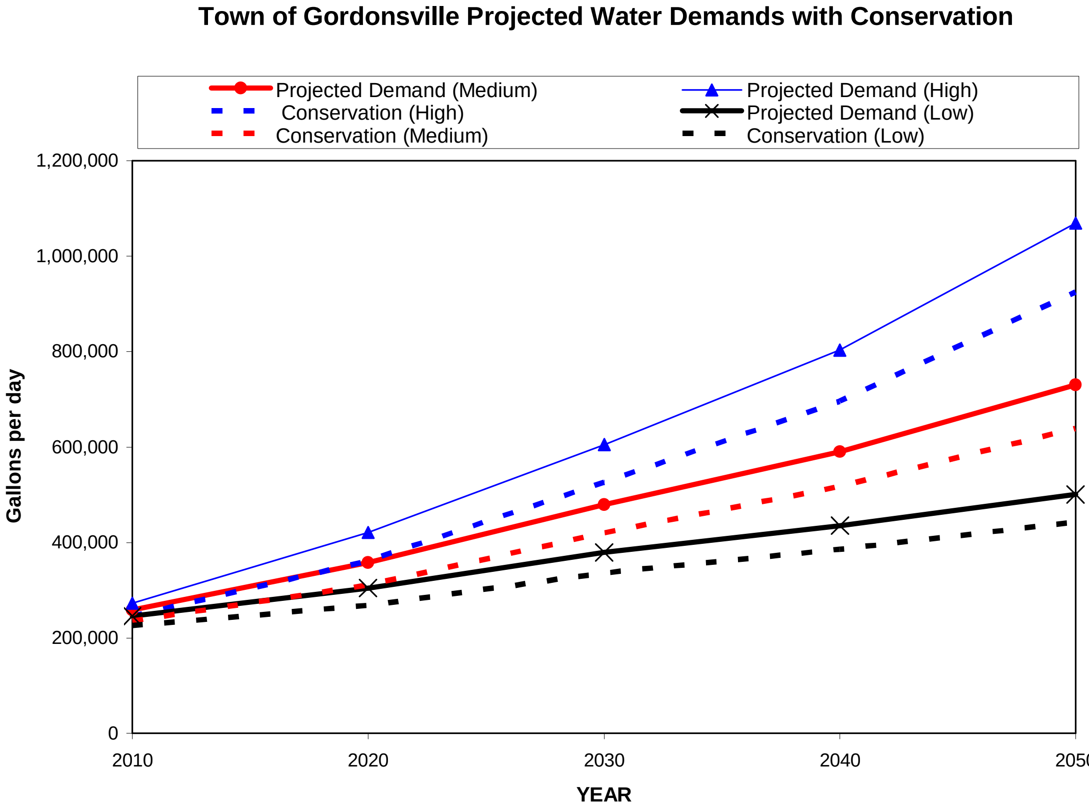
Table 2-8 Town of Gordonsville Conservation Reduction Summary

Year	"Existing" Population Conservation Savings			"New" Population Conservation Savings			Overall Conservation[ii] (MGD)
	Capita	Savings per Capita	Savings[i] (MGD)	Capita	Savings per Capita	Savings[i] (MGD)	
2000	4,198	3	.00	-	-	-	
2010	4,198	9	.01	942	15	.01	.03
2020	4,198	15	.02	2,477	15	.04	.06
2030	4,198	15	.02	3,844	15	.06	.08
2040	4,198	15	.02	5,681	15	.09	.11
2050	4,198	15	.02	8,149	15	.12	.14

[i] Savings = [Savings per capita] x [Capita].
[ii] Existing Population Conservation Savings + "New" Population Conservation Savings

Figure 2-15 shows that with conservation reduction for the low, medium and high water demand projections. For example, for the high demand the peak day demand is reduced from 1.1 to 0.9 MGD in the year 2050. This is 14% reduction in the demand.

Figure 2-15 Conservation Reduction Applied to Projected Peak Day Demand



2.8.1.3 RSA Route 15

Table 2-9 summarizes the potential conservation for the RSA Route 15 system based on the high projected water demand. This table shows that by the year 2050, water conservation could reduce demand by .008 million gallons per day due to more water-efficient devices.

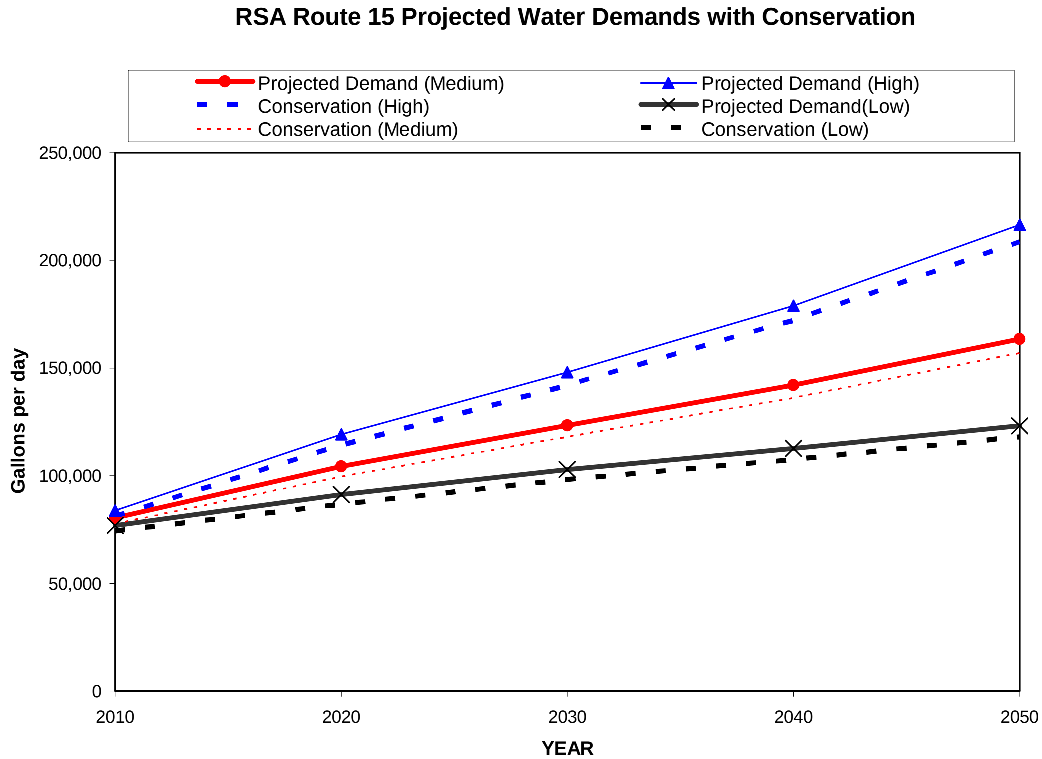
Table 2-9 RSA Route 15 Conservation Reduction Summary

	"Existing" Population Conservation Savings			"New" Population Conservation Savings			
Year	Capita	Savings per Capita	Savings[i] (MGD)	Capita	Savings per Capita	Savings[i] (MGD)	Overall Conservation[ii] (MGD)
2000	273	3	.001	-	-	-	.001
2010	273	9	.002	21	15	0	.003
2020	273	15	.004	68	15	.001	.005
2030	273	15	.004	123	15	.002	.006
2040	273	15	.004	187	15	.003	.007
2050	273	15	.004	261	15	.004	.008

i Savings = [Savings per capita] x [Capita].
ii Existing Population Conservation Savings + "New" Population Conservation Savings

Figure 2-16 shows that with conservation reduction for the low, medium and high water demand projections. For example, for the high demand the peak day demand is reduced from 0.22 to 0.21 MGD in the year 2050. This is 4% reduction in the demand.

Figure 2-16 Conservation Reduction Applied to Projected Peak Day Demand



2.8.1.4 RSA Route 20

Table 2-10 summarizes the potential conservation for RSA's Route 20 system on the high projected water demand. This table shows that by the year 2050, water conservation could reduce demand by .02 MGD due to water-efficient devices.

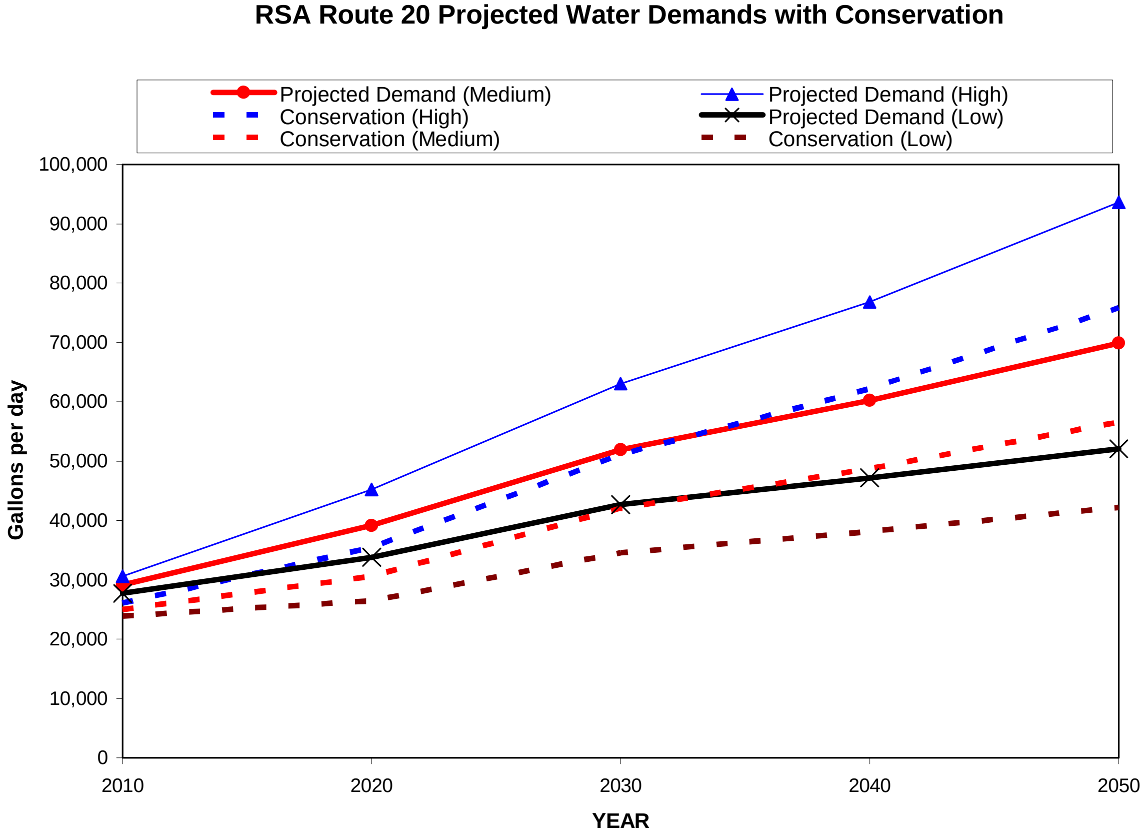
Table 2-10 RSA Route 20 Conservation Reduction Summary

Year	"Existing" Population Conservation Savings			"New" Population Conservation Savings			Overall Conservation[ii] (MGD)
	Capita	Savings per Capita	Savings[1] (MGD)	Capita	Savings per Capita	Savings[i] (MGD)	
2000	365	3	0	-	-	-	0
2010	365	9	0	79	15	0	0
2020	365	15	.01	292	15	0	.01
2030	365	15	.01	436	15	.01	.01
2040	365	15	.01	612	15	.01	.01
2050	365	15	.01	826	15	.01	.02

[i] Savings = [Savings per capita] x [Capita].
[ii] Existing Population Conservation Savings + "New" Population Conservation Savings

Figure 2-17 shows that with conservation reduction for the low, medium and high water demand projections. For example, for the high demand the peak day demand is reduced from 94,000 to 76,000 gallons per day in the year 2050. This is 19% reduction in the demand.

Figure 2-17 Conservation Reduction Applied to Projected Peak Day Demand



2.8.1.5 RSA Wilderness

Table 2-11 summarizes the potential conservation for the RSA Wilderness system based on the high projected water demand. This table shows that by the year 2050, water conservation could reduce demand by 0.73 MGD due to water-efficient devices.

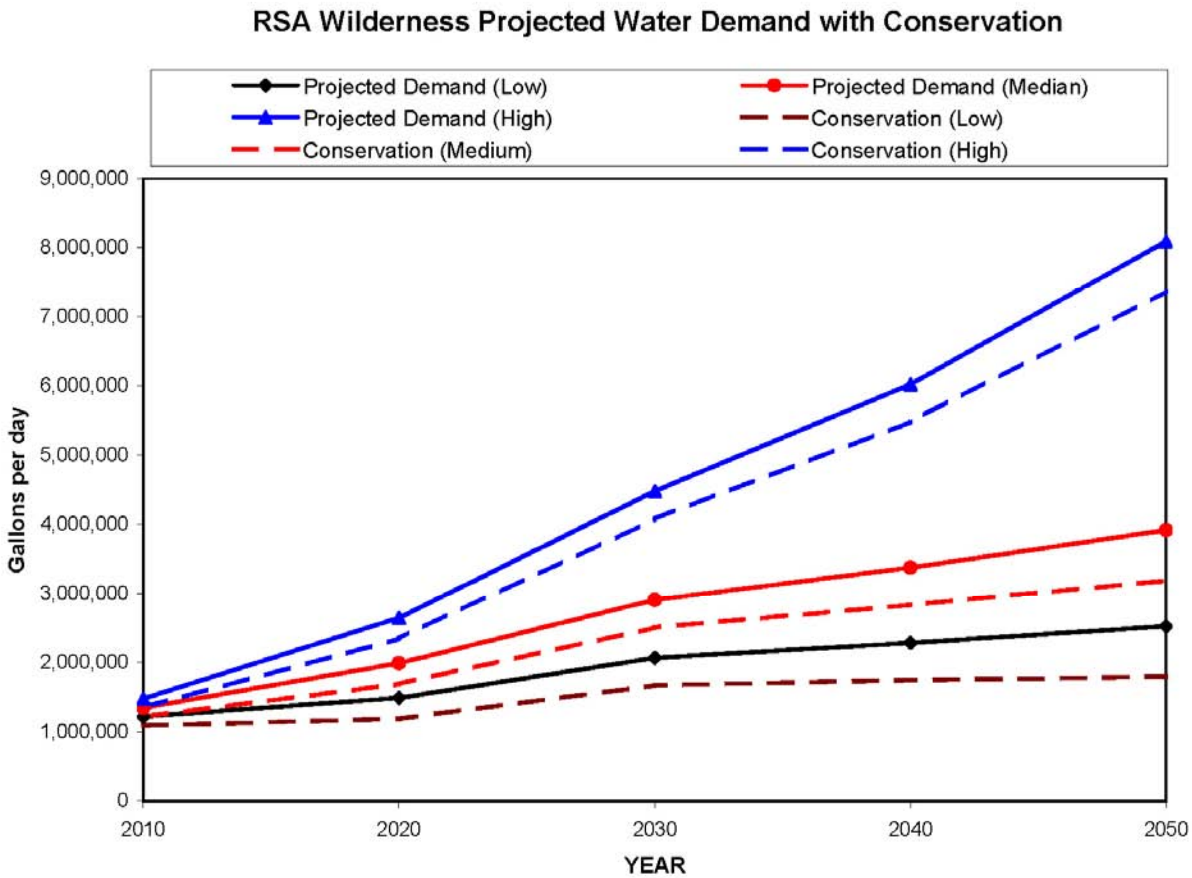
Table 2-11 RSA Wilderness Conservation Reduction Summary

Year	"Existing" Population Conservation Savings			"New" Population Conservation Savings			Overall Conservation[ii] (MGD)
	Capita	Savings per Capita	Savings[i] (MGD)	Capita	Savings per Capita	Savings[i] (MGD)	
2000	6,209	3	.02	-	-	-	.02
2010	6,209	9	.06	4,910	15	.07	.13
2020	6,209	15	.09	13,704	15	.21	.30
2030	6,209	15	.09	20,553	15	.31	.40
2040	6,209	15	.09	29,756	15	.45	.54
2050	6,209	15	.09	42,125	15	.62	.73

i Savings = [Savings per capita] x [Capita].
ii Existing Population Conservation Savings + "New" Population Conservation Savings

Figure 2-18 shows that with conservation reduction for the low, medium and high water demand projections. For example, for the high demand the peak day demand is reduced from 4.7 to 4.0 MGD in the year 2050. This is 15% reduction in the demand.

Figure 2-18 Conservation Reduction Applied to Projected Peak Day Demand



Even with conservation measures applied to the high projected maximum day demand, the high maximum day demand still exceeds the medium projected maximum day demand; therefore, the medium maximum day demand projections for the various public and non-public systems will be used to perform the adequacy analysis of the existing and new water sources. Refer to Section 4.3.9, Section 6, and Section 8 for more information regarding current programs and future conservation plan recommendations.

3.0 ADEQUACY ANALYSIS

3.1 Introduction

The Local and Regional Water Supply Planning (9 VAC 25-780-10 through 9 VAC 25-780-190) regulations state that a water plan shall include information describing the "the adequacy of existing water sources to meet current and projected demand by preparing a clear statement of need that is derived from an evaluation of the information required by 9 VAC 25-780-70 through 9 VAC 25-780-110. The statement of need shall contain, at a minimum, a determination of whether the existing source(s) is adequate to meet current and projected demands."

A deficit or excess was calculated for each water system in Orange County as the difference between the available water supply and the projected future demand as determined in Section 2, Water Demand Projections. The available water supply was based on the permitted intake capacity at the river intakes and/or the committed supplies as defined in existing inter-governmental agreements. All agreements between the Town of Orange, Town of Gordonsville, and the Rapidan Service Authority were discussed in Technical Memorandum No. 1.

The medium water demand projection without a reduction in conservation was used for the adequacy analysis for each Orange County system suppliers. While conservation is an important tool in future water supply planning and should be promoted by each of the system suppliers, due to the number variables and unknowns, for planning purposes a medium water demand projection without incorporating conservation was determined to be a more prudent approach. However, since the water supply plan is required to be updated every five years, it would good for the County and the system suppliers to reevaluate conservation based on their actual water demand.

3.2 Adequacy Analysis

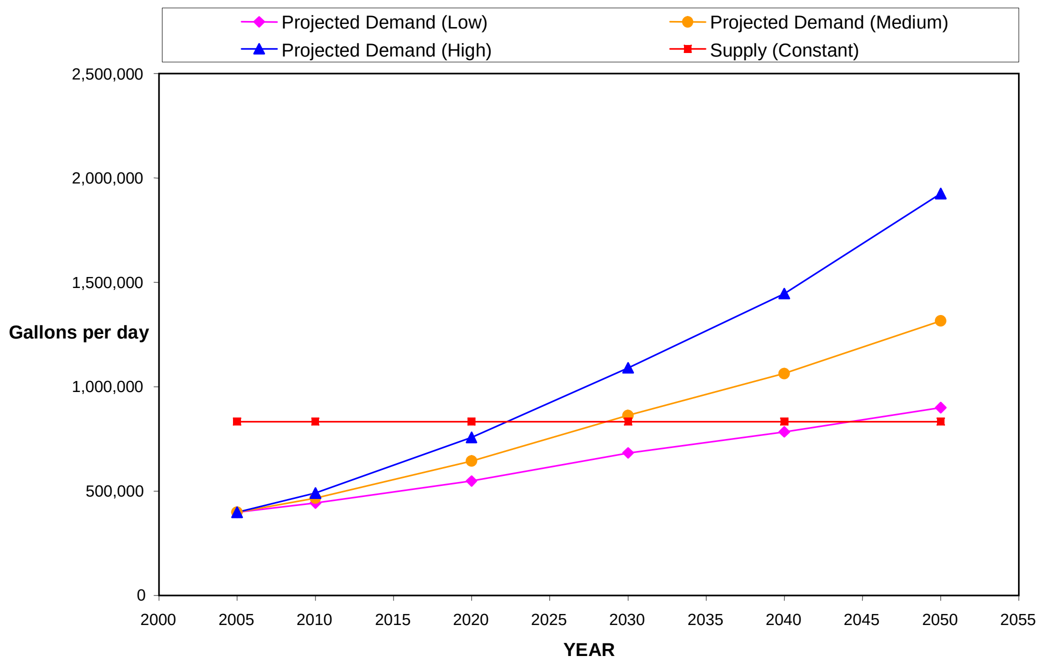
The comprehensive adequacy analysis calculations for the Orange County Water Supply Study are found in Appendix A.

3.2.1 Town of Gordonsville

The RSA Route 15 system supplies water to the Town of Gordonsville under an agreement that enables the Town of Gordonsville to receive 25 million gallons (MG) of water every month. The agreement is effective through May 2011. For the analysis, it was assumed that the present agreement could be extended through to the year 2050; and the present supply of 25 MG per month, or 833,333 gallons per day, would be available.

If the medium population growth rate is considered, the supply shall become insufficient to meet the maximum day demand by the year 2028 as shown in Figure 3-1. If the population grows at a higher rate than the medium growth rate, then the present supply could become insufficient sometime between the years 2020 and 2025 based on the maximum day demand.

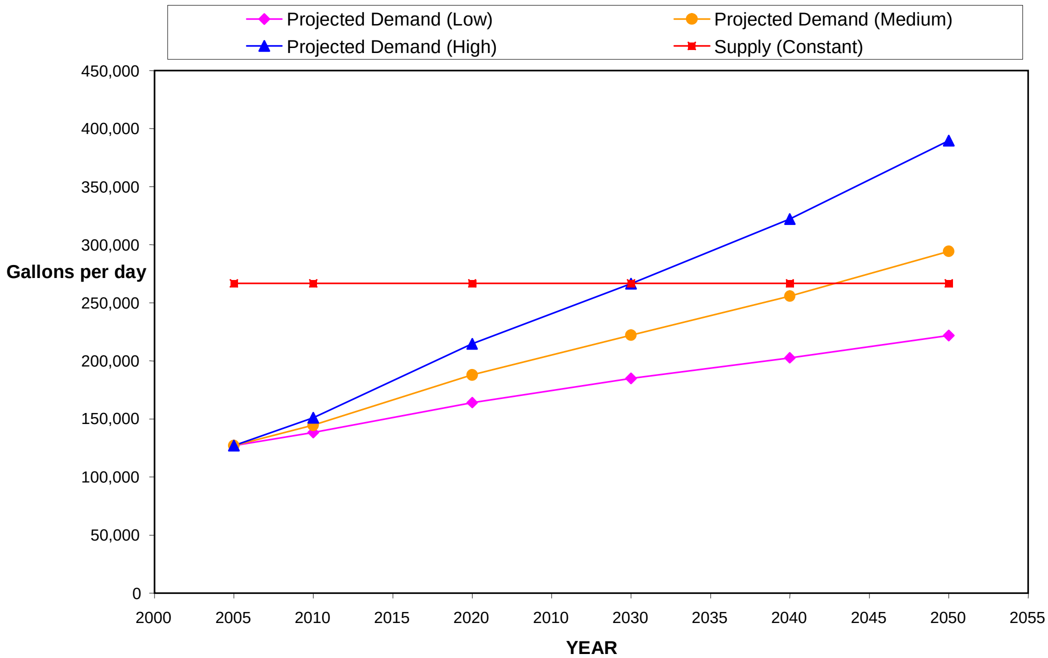
Figure 3-1 Water Supply Adequacy Analysis for Town of Gordonsville Based on Maximum Day



3.2.2 RSA Route 15 System

The Town of Orange supplies water to the RSA Route 15 water system with an agreement which allows the RSA Route 15 system to receive up to 33 MG of water each month. This agreement is effective through September 2023. The RSA Route 15 system also has an agreement with the Town of Gordonsville to supply 25 MG of water each month which is effective through May 2011. As a result of the two agreements, the RSA Route 15 system effectively has 8 MG of water per month to meet its own demands. For the analysis it is assumed that both these agreements could be extended through to the year 2050 and the present supply of 8 MG per month would be available. Considering a 30-day month, the supply of 8 MG per month corresponds to an average supply of 266,667 GPD. If the medium population growth rate is considered, the supply shall become insufficient to meet the maximum day demand by the year 2043 as shown in Figure 3-2. However, if the population grows at a higher rate than the medium growth rate, then the present supply could become insufficient sometime by the year 2030 based on the maximum day demand.

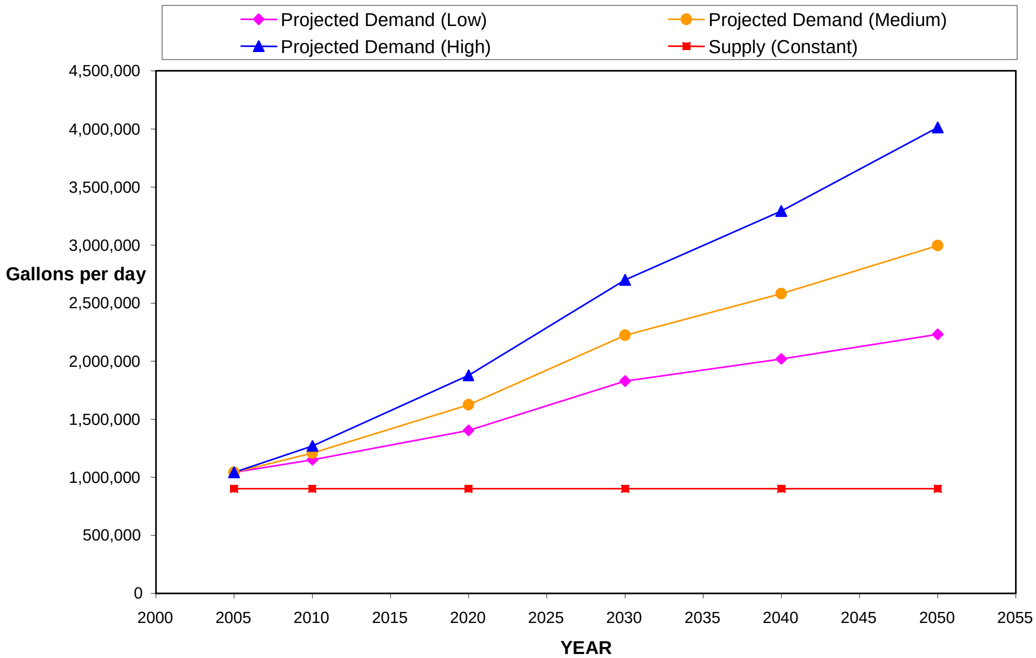
Figure 3-2 Water Supply Adequacy Analysis for the RSA Route 15 System Based on Maximum Day



3.2.3 Town of Orange System

The Town of Orange water treatment plant supplies water to the Town of Orange system. The water treatment plant's intake is located to the north of the Town of Orange at the Rapidan River. The permitted operating capacity of the plant is 2.0 MGD. As stated previously, the Town of Orange system supplies water to the RSA Route 15 system under a contract that ensures a supply of 33 MG per month to the RSA Route 15 system. The agreement is effective through September, 2023. Hence, the net available capacity for the Town of Orange system (after supplying 33 MG per month to the RSA Route 15 system) is 0.9 MGD. For the analysis, it is assumed that the agreement shall be extended through to the year 2050, and the operating permit for the Town of Orange water treatment plant remains at 2.0 MGD. As calculated in Technical Memorandum No. 1, the 1Q30 for the Town of Orange intake on the Rapidan River is 1.79 MGD; thus, there may be a period when the water treatment plant at the Town of Orange may not get 2.0 MGD from the river intake. However, the 45 MG reservoir enables the plant to utilize the permitted withdrawal. If the Town of Orange supplies 33 MG to the RSA Route 15 system, it would not be able to meet its maximum day demand. (Figure 3-3) This conclusion was based on the assumption that the RSA Route 15 and the Town of Gordonsville systems immediately utilize their full contractual allocations, which are well above the present demands in these systems. An analysis using their present demands and the demand projections was presented earlier for both of these systems.

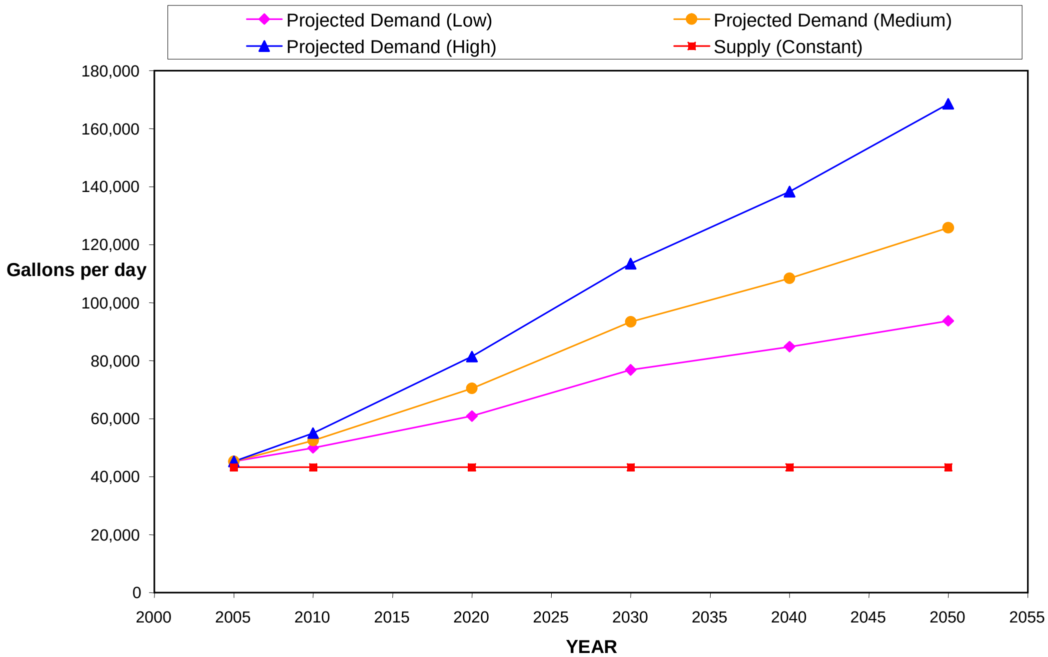
Figure 3-3 Water Supply Adequacy Analysis for the Town of Orange System on Maximum Day



3.2.4 RSA Route 20 System

The supply in the RSA Route 20 water system is produced by a well with a safe yield of 30 gallons per minute (GPM). The RSA Route 20 water system is connected to the Town of Orange water system by a 10 inch PVC transmission main. The present analysis assumes that no water enters the system through this interconnection; a separate analysis for the Town of Orange and all interconnected system (together) is presented later in the section. A supply of 30 GPM, or 43,200 GPD, is available for the RSA Route 20 system. The instantaneous withdrawal rate may be higher and may help in meeting the maximum day demands to some extent. The present supplies may not meet the maximum day demand without assistance from the Town of Orange System, as shown in Figure 3-4.

Figure 3-4 Water Supply Adequacy Analysis for the RSA Route 20 System Based on Maximum Day

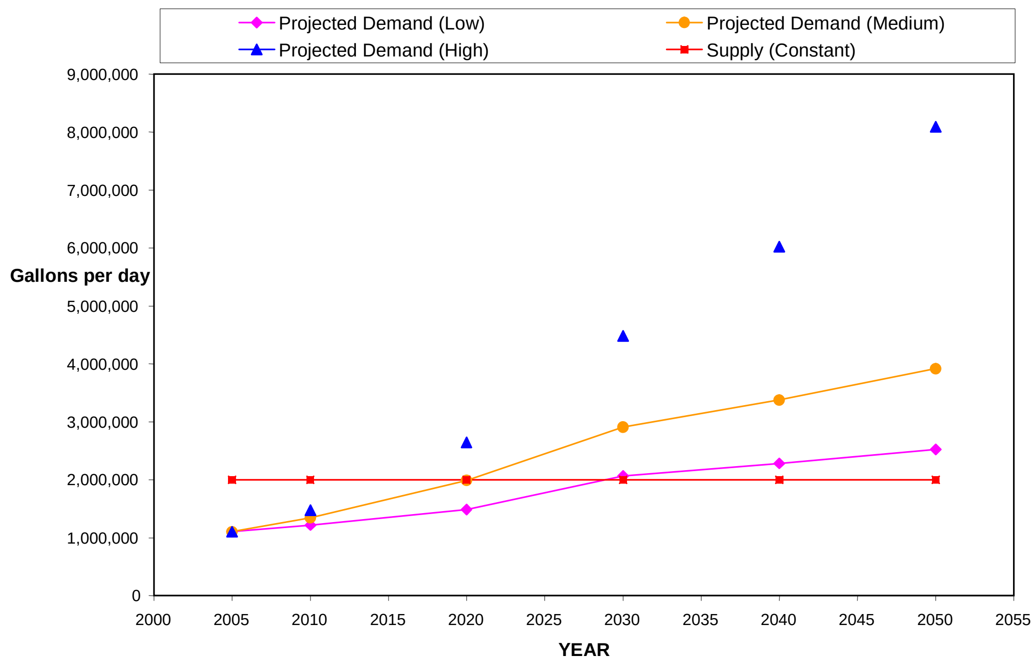


3.2.5 RSA Wilderness System

The RSA Wilderness water treatment plant supplies water to the RSA Wilderness water system. The water treatment plant's intake is located in the Wilderness area on the Rapidan River. The permitted operating capacity of the plant is 1.584 MGD. The operating permit imposes an additional restriction of 2.0 MGD on the maximum capacity of the water treatment plant. The restriction is based on the 1Q30 of 2.30 MGD for the Wilderness intake (calculated by VDH). As calculated in Technical Memorandum No.1, the 1Q30 for the Wilderness river intake is 3.09 MGD. For this analysis, the available water supply is assumed to remain constant through to the year 2050. The present available supply for the system is assumed to be equal to the permitted intake of 2.0 MGD. The feasibility of increase in permit of the river intake will be considered in the alternative analysis (Section 4.4).

If the medium population growth rate is considered, the supply shall become insufficient to meet the maximum day demand by the year 2020 as shown in Figure 3-5. However, if the population grows at a higher rate than the medium growth rate, then the present supply could become insufficient sometime between the years 2010 and 2020 based on the maximum day demand.

Figure 3-5 Water Supply Adequacy Analysis for the RSA Wilderness System Based on Maximum Day

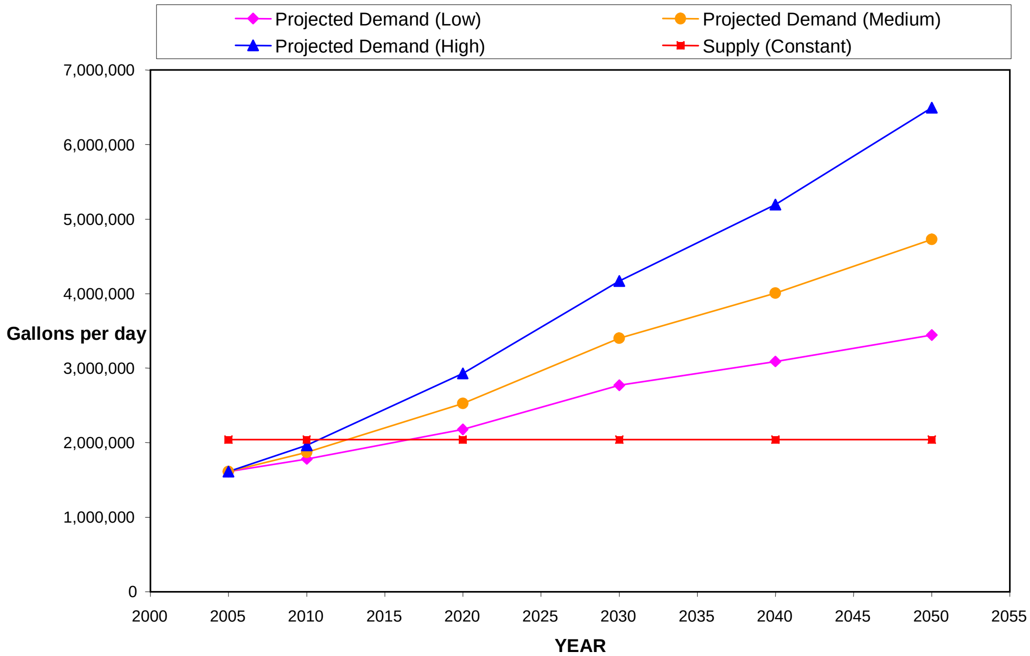


3.2.6 Combined Town of Orange WTP and RSA Route 20 Systems

Since the Town of Orange - RSA Route 15 - Town of Gordonsville combined system is connected to RSA Route 20 by a currently closed line valve, a combined analysis of both these systems is presented. It is assumed that the excess water could be shared within the subsystems, although the agreements may require modification if such a situation occurs. However, the analysis is worth considering due to the expected shortfall in the water supplies in the Town of Orange - RSA Route 15 - Town of Gordonsville system. The analysis presents an integrated view of all the subsystems, considering all the demands and supplies are lumped together. The total supplies for the combined system would be the supply from the Town of Orange treatment plant (2.0 MGD) and the supply from the well (43,200 GPD) which is located in the RSA Route 20 water system.

If the medium population growth rate is considered, then the supply in the combined system shall become insufficient to meet the maximum day demand by the year 2013 as shown in Figure 3-6. However, if the population grows at a higher rate than the medium growth rate, then the present supply could become insufficient several years earlier, based on the maximum day demand.

Figure 3-6 Water Supply Adequacy Analysis for the Combined System Based on Maximum Day



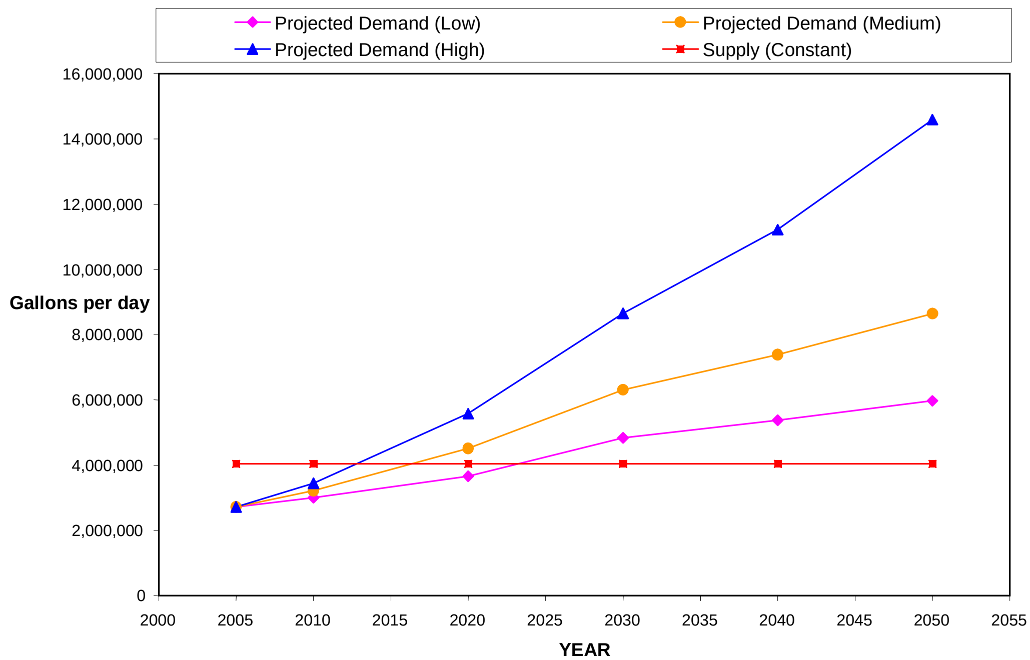
3.2.7 Public Systems

The purpose of the analysis is to evaluate the lumped demand and supply for the entire county and assess the total deficit. In order to evaluate the resources for the entire Orange County, all the public systems are considered together.

The total supplies for all public systems in Orange County would be the supplies from the Town of Orange WTP (2.0 MGD), supplies from RSA Route 20 (0.043 MGD) and supplies from RSA Wilderness WTP (2.0 MGD). Hence, the total supplies are about 4.043 MGD, assuming all the supplies remain constant at the present level.

If the medium population growth rate is considered, then the supply in the combined public systems will become insufficient to meet the maximum day demand by the year 2017 (Figure 3-7). However, if the population grows at a higher rate than the medium growth rate, then the present supply could become insufficient sometime between the years 2010 and 2017 based on the maximum day demand.

Figure 3-7 Water Supply Adequacy Analysis for the Public Systems Based on Maximum Day



3.2.8 Statement of Need

The Local and Regional Water Supply Planning (9 VAC 25-780-10 through 9 VAC 25-780-190 – Appendix B) regulations state that a "clear statement of need shall contain, at a minimum, a determination of whether the existing source(s) is adequate to meet current and projected demands."

Based on the present supply levels and the projected maximum day demands for year 2050, the shortfall in supply for each subsystem is summarized below. For example, Table 3-1 shows that the Town of Gordonsville will have approximately 0.5 MGD deficit or shortfall in water supply in the year 2050. As stated in the previous chapter the medium population growth is considered for projecting this deficit.

Table 3-1 Summary of Additional Maximum DayWater Needs in the Year 2050

Source/ WTP	Service Area	Shortfall in Supply in the year 2050 (MGD)
Rapidan River/Orange WTP	Town of Gordonsville	0.48
	RSA Route 15	0.028
	Town of Orange	2.10
	Sub total Orange WTP	**2.61**
Wells / RSA Route 20	RSA Route 20	0.083
Rapidan River/ RSA Wilderness WTP	RSA Wilderness	**1.92**
	Public Systems Combined	**4.61**

Based on this analysis, the existing sources for each of the service areas will not be adequate to meet the projected demands. The existing sources will not be able to sustain the anticipated water demands starting in the years summarized in Table 3-2. For example, the RSA Wilderness system could expect a shortfall or deficit between 2020 and 2025.

Table 3-2 Summary of Additional Water Needs in the Year 2050

Source / WTP	Service Area	Range of Years Water Supply Deficit Begins[1]
Rapidan River/Orange WTP	Town of Gordonsville	2040-2045
	RSA Route 15	2040-2045
	Town of Orange	2005-2010
Wells/ RSA Route 20	RSA Route 20	2005-2010
Rapidan River/RSA Wilderness WTP	RSA Wilderness	2020-2025
	Public Systems Combined	2015-2020
[1] Based on existing water purchase agreements.		

For a more detailed listing of annual average demand projections and max day demand projections Tables 3-3 and 3-4 have been included.

Table 3-3 Summary of Annual Average Water Demands (GPD)

	2005	2010	2020	2030	2040	2050	Supply	Shortfall
Town of Gordonsville	221,500	259,067	357,905	478,745	590,574	730,271	833,333	0
RSA-Route 15	70,640	80,321	104,298	123,435	142,026	163,472	266,667	0
Town of Orange	579,200	671,452	902,375	1,235,500	1,433,849	1,664,040	900,000	-764,040
Subtotal - Orange WTP:	871,340	1,010,840	1,364,579	1,837,681	2,166,449	2,557,783	2,000,000	-557,783
RSA-Route 20	25,120	29,121	39,136	51,910	60,244	69,915	43,200	-26,715
RSA-Wilderness	525,420	639,619	946,792	1,384,712	1,607,015	1,865,007	2,000,000	0
Public systems (combined):	1,421,880	1,679,580	2,350,507	3,274,304	3,833,707	4,492,705	4,043,200	-449,505

Table 3-4 Summary of Max Day Water Demands (GPD)

	2005	2010	2020	2030	2040	2050	Supply	Shortfall
Town of Gordonsville	398,700	466,321	644,230	861,742	1,063,034	1,314,488	833,333	-481,155
RSA-Route 15	127,152	144,578	187,737	222,184	255,646	294,250	266,667	-27,583
Town of Orange	1,042,560	1,208,613	1,624,275	2,223,901	2,580,928	2,995,272	900,000	2,095,272
Subtotal - Orange WTP	1,568,412	1,819,512	2,456,241	3,307,826	3,899,607	4,604,010	2,000,000	2,604,010
RSA-Route 20	45,216	52,418	70,445	93,438	108,439	125,848	43,200	-82,648
RSA-Wilderness	1,103,382	1,343,199	1,988,263	2,907,896	3,374,731	3,916,514	2,000,000	1,916,514
Public systems (combined):	2,717,010	3,215,129	4,514,950	6,309,160	7,382,778	8,646,371	4,043,200	4,603,171

4.0 ALTERNATIVE ANALYSIS

4.1 Introduction and Background

The Local and Regional Water Supply Planning (9 VAC 25-780-10 through 9 VAC 25-780-190) regulations state that an alternative analysis of potential sources must include the following information:

- A description of potential water savings from water demand management actions, including an estimated volume for each action;
- A description of potential sources for new supplies, including an estimated volume from each source; and
- A description of potential resource issues or impacts identified in accordance with 9 VAC 25-780-140 G, known for each potential new source that any future water project will need to consider in its development.

The regulations also state “potential alternatives considered shall include water demand management alternatives as well as more traditional means of increasing supply, i.e., wells, reservoirs, impoundments, and stream intakes. Where appropriate, the program shall consider nontraditional means of increasing supplies such as interconnection, desalination, recycling and reuse. The analysis of potential alternatives may include a combination of short-term and long-term alternatives.”

Since the process for expanding a water supply and developing new sources of raw water can be difficult and require a substantial amount of time, this alternative analysis will also serve as a basis for planning-level decisions regarding short-term and long-term water supply alternatives for Orange County.

4.2 Purpose

The purpose of this analysis was to present and evaluate alternatives that provide a reliable source of quality water supply capable of satisfying the projected deficit of water supply at the right time for the individual water systems through the year 2050. In general terms, this means providing the right amount of water, of the right quality, to the right places, and at the right time. The deficit in the water supply for the individual service areas was summarized in Table 3-1, in Section 3.

This deficit of 4.61 MGD represents the total projected unmet water supply need for Orange County.

4.3 Scope of Analysis

The alternatives analyzed in this study are based on a comprehensive literature search that identified previous studies describing potential water sources for Orange County in addition to nontraditional means of increasing supplies. This study considered the following general alternatives to meet the purpose:

4.3.1 Water Supply Augmentation

- Development of new surface water sources.
- Development of new groundwater sources.
- Construction of new raw water storage.
- Regional water supply approaches.
- Interconnections within and outside of the county.

4.3.2 Water Demand Reduction

- Water Reuse
- Conservation

4.3.3 Development of New Surface Water Sources

These alternatives involved developing new surface water sources that could potentially provide additional raw water with minimal cost and environmental impacts as compared, for example, with the development of a new water surface reservoir.

4.3.3.1 South Anna River, Lake Gordonsville, and/or Quarry

This alternative assumes that a water treatment plant could be built near the quarry southwest of the Town of Gordonsville. There are three possible sources of raw water supply that could be utilized:

- Quarry: The quarry is approximately 70 feet deep, has a 12-acre surface area, and is located adjacent to the South Anna River. The quarry was estimated in the R. Stuart Royer & Associates, Inc. 2000 report[1] to provide approximately 140,000 gallons per day. Based on a quarry volume of 195 million gallons, this could supply 500,000 gallons per day for 390 days.
- Lake Gordonsville: Lake Gordonsville was developed by the Town of Gordonsville in the late 1960's and was later sold by the Town to Louisa County. The Town did retain the rights to 10 percent of the water from the Lake. A study[1] of Lake Gordonsville by the Department of Environmental Quality (DEQ) found that the maximum allowable withdrawal from Lake Gordonsville would be 710,000 gallons per day.
- South Anna River: There are no reported yield estimates for this portion of the South Anna River.

4.3.3.2 Lake Anna

This alternative was based on pumping raw water from Lake Anna and constructing a water treatment plant near the lake.

[1] Town of Gordonsville, Virginia Gordonsville Water Study RSR&A Project Number 9960 (August, 2000) by R. Stuart Royer & Associates, Inc.

Lake Anna was formed by a dam on the North Anna River in 1968 when Virginia Electric and Power Company (now Dominion Virginia Power) purchased 18,000 acres in three counties along the North Anna and Pamunkey Rivers. The lake's primary purpose was to provide water to cool the nuclear power generating plants at the North Anna Nuclear Generating Station adjacent to the lake. Lake Anna is the second largest lake located entirely in Virginia, with over 200 miles of shoreline and a surface area of 13,000 acres. Approximately 23 percent of Lake Anna's watershed for Lake Anna is located in Orange County.

The North Anna nuclear power plant has two pressurized water reactors. Unit 1 began commercial operation on June 6, 1978 (currently licensed to operate until April 1, 2018), and Unit 2 on December 14, 1980 (licensed to operate until August 21, 2020). Dominion has filed for an Early Site Permit from the Nuclear Regulatory Commission to build two new nuclear reactor units. If issued, NRC's Early Site Permit would allow the applicant to "reserve" the site for as long as 20 years while considering the new reactors and doing site preparation activities.

4.3.3.3 Increase the withdrawal permit at Wilderness intake

This alternative would involve revising RSA's Wilderness system permit to allow for an increased intake capacity of 3.09 MGD. The maximum day demand at the RSA Wilderness water system is expected to exceed the present permitted withdrawal rate of 2.0 MGD sometime between 2025 and 2030. The 1Q30 for the Rapidan River at the Wilderness intake (as calculated in Technical Memorandum No. 1) is 3.09 MGD. If the permit was revised and the water treatment plant upgraded, this would enable the Wilderness system to meet or exceed the projected maximum day demands through approximately the year 2035.

4.3.4 Development of New Groundwater Sources

Groundwater has historically been a significant resource for municipalities in the region. It is likely that groundwater sources will continue to be an important component of public and private water systems in the region.

Unfortunately, predicting the extent and yield of groundwater sources not currently developed is not an easy task. The hydraulics of surface water systems are well understood, and potential future surface water sources can be modeled using historic stream gauge and rainfall data. Therefore, the supply capabilities of existing rivers, lakes, and proposed impoundments can be predicted with a relatively high level of certainty. In addition, the location of surface resources is fixed.

Groundwater sources do not lend themselves to the same level of prediction or certainty. Detailed groundwater investigations are necessary in successfully locating local groundwater resources that are of high yield and remain sustainable during drought periods. Advantages to using groundwater resources, if they are available in sufficient quantity to meet public water supply needs, include the following: 1) there are minimal land purchase requirements for developing wells; 2) less treatment may be required; 3) groundwater resources are typically more drought resistant than surface water sources; 4) groundwater resources can be permitted by the pertinent regulatory agencies within six months after the supply has been developed and tested for yield and quality; 5) groundwater resources can be phased-in on an as-needed basis, thereby reducing the debt service of other capital-intensive water supply options.

4.3.4.1 Development of New Groundwater Sources

As a part of this study, Emery & Garrett have identified ten (10) Primary Groundwater Development Zones as potential sites for groundwater development. In addition, six (6) Secondary and thirteen (13) Tertiary Groundwater Development zones were identified. (Emery & Garrett Groundwater, Inc., October 2006). The Phase 1 Groundwater Exploration and Development report is included in this report as Appendix C. The groundwater report concluded that a reasonable yield from the selected Primary Groundwater Development Zones would be between 1 MGD and 2 MGD. Furthermore, 1 to 1.6 MGD could potentially be developed from the Secondary and Tertiary Groundwater Development Zones identified in this groundwater study.

4.3.4.2 Aquifer Storage Recovery

Aquifer Storage and Recovery (ASR) involves injecting water into an aquifer through wells or by surface spreading and infiltration and then pumping it out when needed. The aquifer essentially functions as a water bank. Deposits are made in times of surplus, typically during periods of excess supply, and withdrawals occur during periods of demand or short supply.

4.3.4.3 Rainwater Harvesting

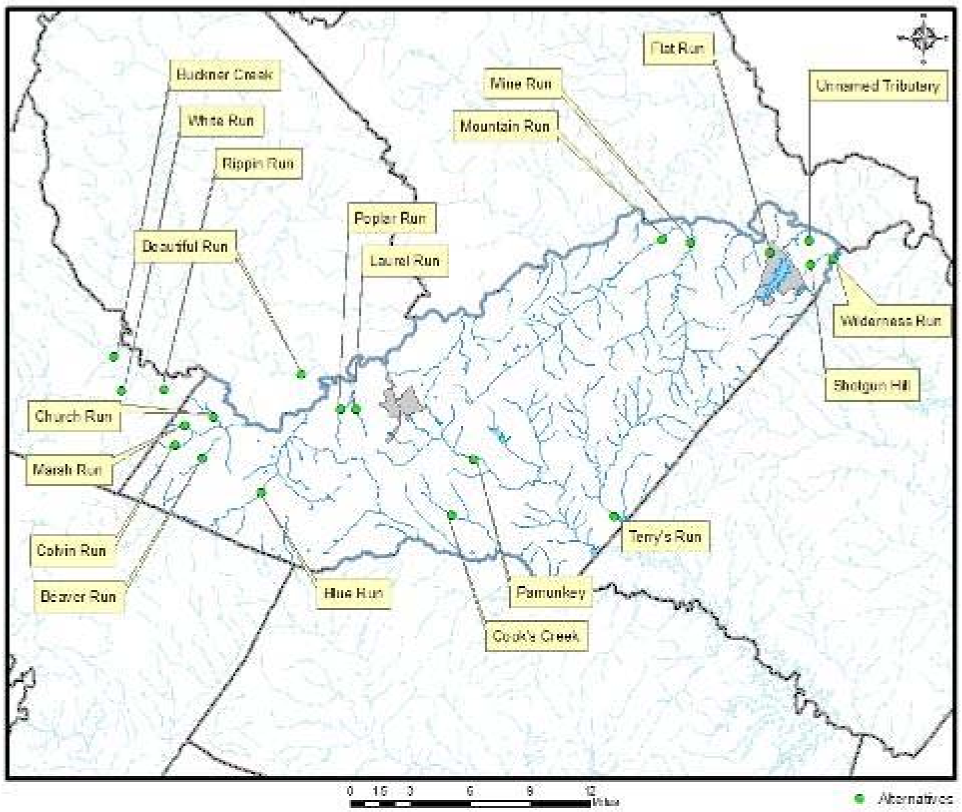
Rainwater harvesting is the practice of collecting rainfall usually from roof surfaces in cisterns for domestic use; however, it may also include surface water collection in small tanks or impoundments for livestock watering and landscape irrigation. In the early part of the 20th century, rainwater harvesting was practiced in many areas of Virginia; but with the development of municipal water systems, the practice became obsolete. Other rainwater harvesting practices include shallow recharge of groundwater by increasing the infiltration through a system of soak trenches, filter beds, and pervious surface traps. This increases the base flow in streams and tributaries in the near vicinity. With the growing limitations of finding new water resources and increasing demands for water, this option needed to be included as an alternative.

4.3.5 Construction of a New Surface Water Reservoir

This alternative involves the development and construction of a dam and reservoir. Most of the reservoir locations were developed from existing reports, as summarized in Technical Memorandum No. 1. All the reservoir locations were located off of a main-stem river such as the Rapidan River, and most could be categorized as a pumped storage reservoir. While an on stream reservoir relies on usable reservoir storage capacity and natural basin runoff for meeting water supply needs, a pumped storage reservoir has some amount of pumped diversion as a component for meeting water supply needs.

These sites are summarized in Figure 4-1.

Figure 4-1 New Surface Water Reservoir Alternative Locations



4.3.6 Regional Water Supply Approaches

This alternative would develop a new regional water supply not located within Orange County.

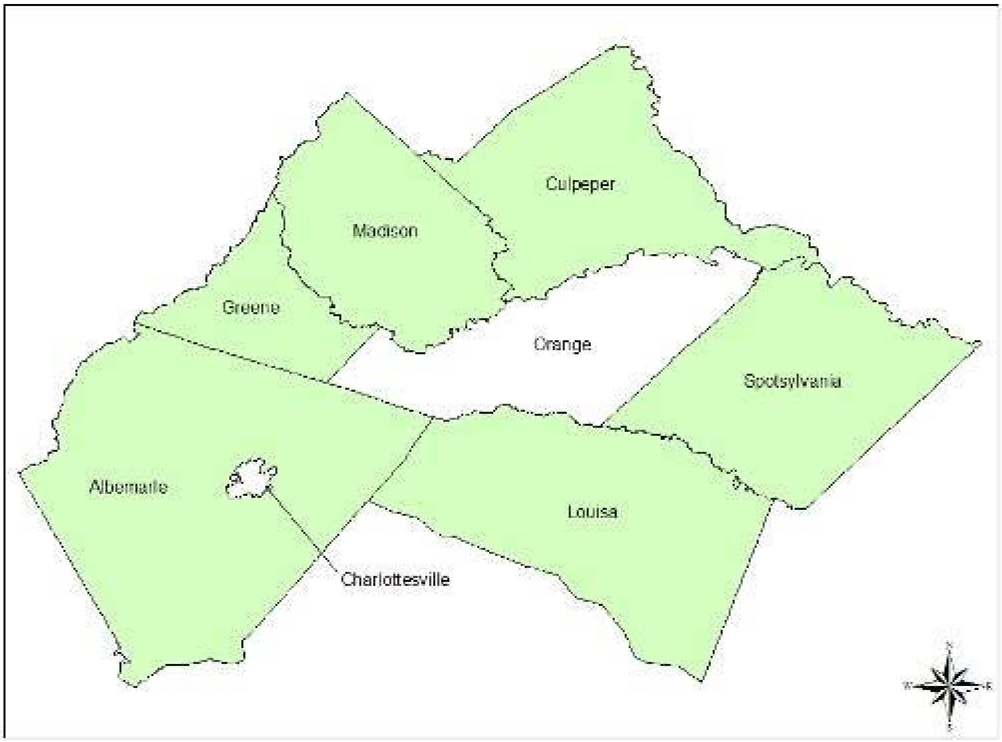
4.3.6.1 Regional Water Treatment Plant at Louisa County using Lake Gordonsville (Bowler's Mill Lake)

This alternative would assume building a Regional Water Treatment at Lake Gordonsville and providing water to both Louisa County and Orange County. The Town of Gordonsville developed the lake in the late 1960s and later sold it to Louisa County. The Town did retain the rights to 10 percent of the water from the lake. According to a Department of Environmental Quality (DEQ) study of Lake Gordonville, it found the maximum allowable withdrawal from Lake Gordonsville to be 710,000 gallons per day.

4.3.7 Interconnections Within and Outside the County

These alternatives were based on purchasing water from outside the county and would eliminate the construction of any new facilities for water supply. As shown on Figure 4-2, Orange County shares its county boundary with six counties.

Figure 4-2 Regional Map



4.3.7.1 Louisa County

The Louisa County Water Authority treats and distributes drinking water to the town of Louisa and Mineral and certain unincorporated portions of central Louisa County. Louisa County is exploring the development of groundwater resources to meet their public water supply needs.

R. Stuart Royer & Associates, Inc. 2000 report[2] for the Town of Gordonsville outlined a plan to construct 68,000 feet of 12-inch transmission line to connect the Louisa County Water Authority (LCWA) water system at the Town of Louisa with the Gordonsville water system. This alternative assumes that an agreement with LCWA could be negotiated. Louisa County is working in conjunction with Fluvanna County to develop water resources for the Zion Crossroads area of Louisa County. The source would be from an intake on the James River at Bremo Bluff. There is a possibility that Louisa County may extend waterlines from Zion Crossroads to the Town of Gordonsville in order to increase the utilization of this resource.

4.3.7.2 Greene County

Greene County is growing rapidly and is presently investigating the possibilities of developing additional water resources. However, largely due to topographic and geologic features, Greene County has limited surface water from the pattern of small headwaters. Greene County is exploring the development of groundwater for public water supply. Approximately 66 percent of commercial and residential water users utilize private groundwater wells; the remainder is

[2] Town of Gordonsville, Virginia Gordonsville Water Study RSR&A Project Number 9960 (August, 2000) by R. Stuart Royer & Associates, Inc.

served by RSA, treating water pumped under a restricted DEQ permit from the Rapidan River. Given its own need for water, Greene County may be reluctant to guarantee water for Orange County's use.

4.3.7.3 Madison County

The public water and sewer systems in the County mainly service the Town of Madison and have less than 300 users. The systems are owned and maintained by the Rapidan Service Authority (RSA). The water source for Madison's water system is White Oak Lake. Madison County has historically not been supportive of development of additional water resources that might encourage development.

4.3.7.4 Culpeper County

Culpeper County, exclusive of the incorporated Town of Culpeper, is currently almost entirely dependent upon groundwater to meet its water needs, with the vast majority of residents and businesses relying on individual wells for their water supply. Currently, the Town of Culpeper is the major water supplier in the County of Culpeper, however, the County is developing groundwater resources to provide current and future water supply needs. The Town's water source is provided by Lake Pelham and Mountain Run Lake. Raw water is withdrawn from Lake Pelham through an 18-inch gravity line to the Culpeper water treatment plant located within the Town's corporate limits. The safe yield from both lakes combined is 4.0 million gallons per day (MGD).

4.3.7.5 Spotsylvania County

Spotsylvania County's water system services about 28,000 customers with drinking water in both Spotsylvania County and the City of Fredericksburg. Spotsylvania County currently manages water production and distribution at both the Ni and Motts Run water treatment facilities. The Spotsylvania County water system consists of the following principal features:

- Ni Reservoir: The Ni Reservoir, the raw water supply to the adjacent Ni Water Treatment Plant, was constructed in 1974 and has a surface area of 417 acres. The safe yield, as defined by the Virginia Water Control Board, is 4.0 MGD annual average withdrawal.
- Ni Water Treatment Plant: The Ni WTP was initially constructed in 1974 with a 1.0 MGD capacity; expanded in 1977 to 2.0 MGD; expanded again in 1981 to 4.0 MGD, and in 1993 underwent final expansion to its current capacity of 6.0 MGD.
- Motts Run Reservoir: The Motts Run Reservoir was built in 1971, with a safe yield estimated to be between 3.5 and 4.0 MGD.
- Motts Run Water Treatment Plant and Intake on the Rappahannock River: The Motts Run water treatment facility and Rappahannock River raw water pumping station were completed in the spring of 2000. The current water treatment plant capacity is 12 MGD and is expandable to 24 MGD.
- Hunting Run Side-Stream Storage Reservoir and Intake on the Rapidan River: The Hunting Run water supply dam and side-stream reservoir was completed in 2002 and has a safe yield estimated at 8 MGD.

4.3.7.6 Albemarle County

Two public authorities are responsible for providing water and treatment services in the County: Rivanna Water and Sewer Authority (RWSA) and Albemarle County Service Authority (ACSA). All existing water supply facilities are operated by the RWSA. Three reservoirs and a direct river withdrawal (Sugar Hollow/Ragged Mountain Reservoir System, the South Rivanna Reservoir and the North Rivanna River) have a combined existing safe yield of approximately 18.0 million gallons per day (MGD).

4.3.8 Water Reuse

Use of reclaimed water serves to reduce demand on the potable water system, if some of the treated wastewater can satisfy non-potable uses. The required level of treatment is linked to the potential for public contact, depending on its intended use. For example, most non-potable urban uses of reclaimed water have potential for contact with the public. That water will be required to meet a higher standard of treatment and disinfection.

In Virginia, the development of regulations to cover uses other than indirect potable reuse should serve to encourage the use of reclaimed water for a variety of other uses. As the use of reclaimed water becomes a more widely accepted practice and as the health effects are better defined, it is expected that the use of highly treated wastewater for augmenting raw water sources will become an acceptable practice.

4.3.9 Water Conservation

This alternative would involve the implementation of water conservation measures to reduce the amount of future water demand in an attempt to eliminate the need for an additional water supply source. Section 2 has examples of potential demand reduction due to water conservation measures. Further discussion of water conservation or demand management options is included in Section 6 of this Technical Memorandum. While these measures are critical to controlling overall water demand, they were not included in final projections due to uncertainty of their implementation. Many of the measures include some aspect of public involvement. When defining the public water supply needs of the County it would be unwise to rely upon the conservation of users to fall within projected limits of water use without a record of actual program success. To do so could produce a premature deficiency in the public water supply. As discussed in Section 6 and Section 8, all water purveyors are encouraged to implement water conservation measures, perform water audits, and determine the overall effect of these programs on the unaccounted for water. Once a track record has been established, the timing of water supply projects can be adjusted to reflect the conservation program results.

4.4 Evaluation Process

Evaluation and screening of the identified water supply alternatives was conducted in several steps. A preliminary screening of alternatives was conducted to identify those that were unable to satisfy threshold criteria related to capacity, technical and logistical feasibility, and environmental impacts. The remaining alternatives were considered with respect to the factors described below.

The list of potential water supply alternatives was evaluated considering reliability, schedule, cost, feasibility, and environmental factors. Reliability considerations are defined as factors that could affect the quantity or quality of the available water source, such as potential pollution sources and land uses that could affect water quality negatively. Factors positively affecting reliability would be multiple supplies of different source type (groundwater and surface water) or from different drainage sources.

Schedule is a consideration of the timing of needs that will develop in each of the demand centers relative to the time required to develop each alternative. Capital and operating costs of the various options are used to differentiate the life cycle costs of the alternative concepts in a preliminary manner. Feasibility considerations include technical factors that determine whether the alternative has the needed capacity, as well as logistical factors that could complicate the implementation of the option. Factors that may make an alternative less feasible include institutional obstacles such as the need to coordinate with parties outside the control of the County, Towns, and RSA.

Environmental considerations include many of the factors that were inventoried in Technical Memorandum No. 1, especially those that have been considered significant on other similar types of projects. Environmental factors could include impacts to wetland and sensitive habitats, cultural or community impacts, historical sites requiring protection, impacts to fishery or recreational uses of waterways and other factors that can be identified in a preliminary evaluation.

Several alternatives were considered to address the shortfall in water supply; these alternatives were evaluated qualitatively and quantitatively using a two-level screening process; preliminary screening and primary screening. A combination of the short-listed alternatives was developed to identify sustainable sources of water supply for the future.

The alternatives evaluated in the present study include new surface water sources, new groundwater sources, new raw water storage, regional water supply approaches, and interconnections within and outside the county.

4.5 Preliminary Screening

The initial list of alternatives was examined, and a number of feasibility issues were identified that limit the implementation potential for some of the alternatives. The feasibility factors of most concern include project location, local approvals, and potential conflicts with existing uses of the water source. Further discussion of these concerns are detailed below:

Logistical feasibility factors. Some of the water supply alternatives identified in previous studies are located outside the municipal boundaries of Orange County and the Towns. In many cases, these projects do not already exist, and their development would require approval, acceptance, and collaboration with the municipality in which they are located. The complexity of potential project development was considered in the initial screening step. Water sources that already exist were evaluated differently. If the use of the source for water supply would affect the existing uses negatively, the alternative was recommended for elimination from further consideration.

- Insufficient capacity or yield. The projected water supply shortfall for the combined service areas of the Town of Orange, Town of Gordonsville, and the publicly-served areas of the County outside of the Towns is 4.61 MGD. Preference was given to regional projects with higher yields. Generally, projects with reliable yields less than 0.5 MGD were recommended for elimination from further consideration.

Based on the initial review, a number of alternatives are recommended for elimination from further consideration. These are summarized in Table 4-1.

Table 4-1 Eliminated Results from Preliminary Screening

Category	Alternative Description	Comments
New Surface Water Sources	South Anna River-Gordonsville quarry with a new water treatment plant.	Limited yield. Anticipated yield is 0.96 gpm or 0.138 MGD [a]
	Lake Gordonsville with a new water treatment plant.	Outside of Orange County. Limited yield of 0.07 MGD.
	Intake at South Anna River-Lake Gordonsville (Bowler's Mill Lake) and new water treatment plant at Quarry.	Limited yield. Anticipated yield is 96 gpm or 0.138 MGD[a] (less than 0.5 MGD)[a, b].
	Lake Anna with a new water treatment plant.	There would be substantial permitting obstacles. One of the main obstacles would be the fact that the lake is used by Dominion Virginia Power for cooling nuclear power reactor units (with a likelihood of capacity expansion, which will increase the use of the lake).
Increase Raw Water Storage	White Run Tributary, Branch of Beautiful Run, Buckner Run and, Rippin Run.	These impoundment sites are located outside of Orange County.
Groundwater	Aquifer Storage Recovery. (ASR)	Based on Emery & Garrett's groundwater experience, Orange County's geology is not suitable for this type of technology.
	Rainwater Harvesting (artificial recharge of groundwater) to increase base flow in the streams.	The increase in yield is difficult to quantify for this level of planning.
Regional Approaches	A new Regional water treatment plant in at Louisa County using Lake Gordonsville (Bowler's Mill Lake).	Does not provide sufficient yield. The Town of Gordonsville has rights to 10% of the water of Lake Gordonsville (Bowler's Mill Lake). Yield =0.07 MGD[a] (i.e., 10% of 0.7 MGD)
	Interconnections with neighboring water systems	Deferred further evaluation pending discussions with neighboring locations
Non-traditional approaches	Water Reuse	Deferred further Evaluation

[a] Town of Gordonsville, Virginia Gordonsville Water Study RSR&A Project Number 9960 - August, 2000
[b] Gordonsville Quarry Pumping Test-1991

Some of the alternatives eliminated in this stage of the evaluation could become favorable options as conditions change over time: and the County, the Towns, and the Service Authority should remain open to consideration of those opportunities. Specifically, interconnections with other counties and development of regional options outside Orange County would be viewed favorably, if location and timing are consistent with Orange County's developing needs. Water reuse is an excellent option for reducing non-potable water demands. However, to be an economically viable option, the use of the reclaimed water needs to be located very near the wastewater treatment plant that produces the highly treated water. Once the state regulation is finalized, and use of reclaimed water becomes an accepted practice in Virginia, the costs and benefits of the Water Reuse alternative can be better quantified.

4.6 Secondary Screening

The process of initial screening reduced the water supply alternatives under consideration to the following categories:

- Increase the Rapidan River supply at Wilderness.
- Develop new raw water storage impoundments (15 options).
- Develop new groundwater supply (29 options).
- Water conservation measures.

The large number of potential sites for construction of raw water storage impoundments and groundwater development required a process of prioritization based on qualitative and quantitative factors. The evaluation and prioritization process is described for each in the following sections of this chapter.

4.6.1 Raw Water Storage Alternatives

These alternatives included the fifteen (15) previously identified raw water storage alternatives in Orange County.

4.6.1.1 Qualitative Screening – Analytical Hierarchy Process

A total of 15 potential reservoir sites in Orange County were evaluated. Eight different criteria were used to differentiate between the individual alternatives sites. Many of these criteria were selected based on the American Water Works Association Manual of Water Supply Practices titled, Water Resources Planning (AWWA, 2001). The following criteria were used in the evaluation:

- Proximity to wetlands.
- Proximity to protected lands (including Conservation Areas).
- Proximity to gas pipelines (natural gas pipelines through the central portion of the County and a petroleum pipeline through the eastern portion of the County).
- Extent of upstream and nearby development.
- Proximity to known pollution sources (WWTP or any other).
- Proximity to known archeological or historical sites.
- Proximity to the existing infrastructure.
- Drainage area.

The assessment used a well-documented algorithm to solve the multi-criteria decision problem. The algorithm is known as the Analytical Hierarchy Process or AHP, (http://thequalityportal.com/q_ahp.htm). The AHP algorithm is useful in comparing options when quantitative measures are not available. Scores were assigned to the alternatives based on priorities and relative comparisons. These scores were later used to rank the alternatives and, in this case, to identify the most promising options for further evaluation. A more detailed explanation of the analysis and the supporting documentation is provided in Appendix D, and the results are presented in Table 4-2.

Table 4-2 Results of Reservoir Location Scoring

Alternatives	Score	Rank
Unnamed tributary above Wilderness Run	0.08695	First
Mountain Run	0.08567	Second
Mine Run	0.08362	Third
Poplar Run	0.08107	Fourth
Pamunkey Creek	0.07993	Fifth
Marsh Run	0.07865	Sixth
Wilderness Run	0.07764	Seven
Colvin Run	0.07731	Eight
Laurel Run	0.07713	Nine
Shotgun Hill Branch	0.07708	Ten
Cooks Creek	0.04946	Eleven
Beaver Run	0.04928	Twelve
Church Run	0.04854	Thirteen
Blue Run	0.02516	Fourteen
Barbour Run	0.02349	Fifteen

Based on the ranking of the alternatives resulting from the decision support analysis using the Analytical Hierarchy Process, the first four alternatives from Table 4-2 were chosen for additional quantitative analysis.

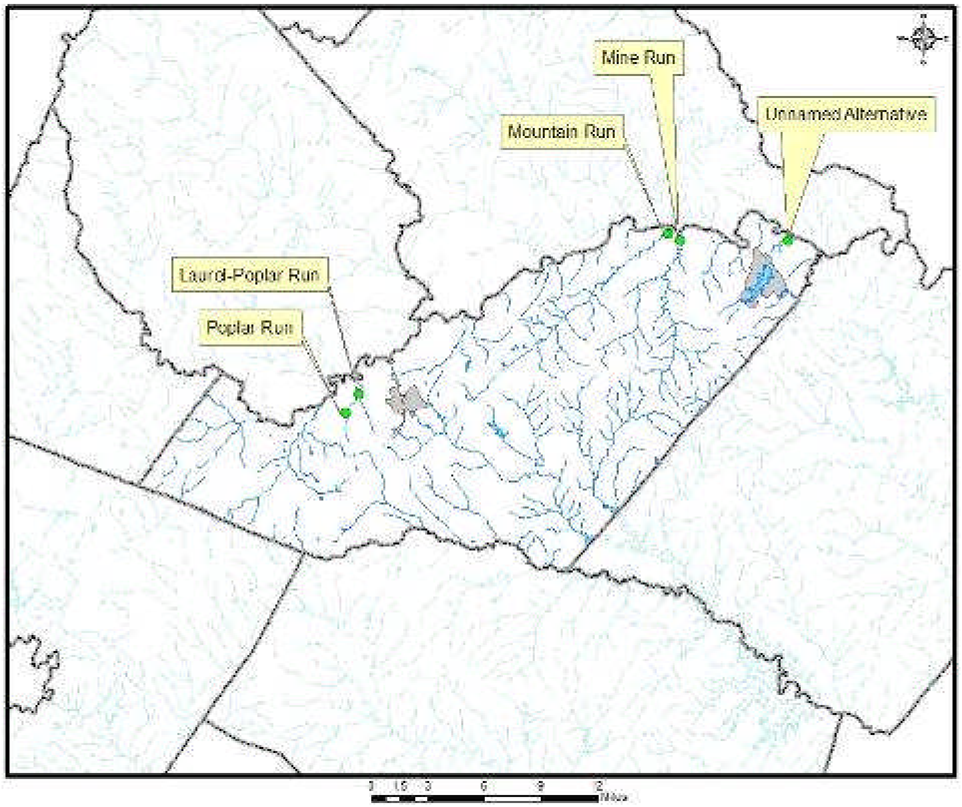
4.6.1.2 Quantitative Assessment – Safe Yield Analysis

An estimated safe yield was calculated for each of the reservoir options:

- Unnamed tributary above Wilderness Run.
- Mountain Run.
- Mine Run.
- Poplar Run.

The locations of the four alternatives are shown in Figure 4-3. Laurel Run was included as well as a reservoir built on Poplar Run for yield comparison purposes.

Figure 4-3 Potential Reservoir Locations- Orange County, Virginia



For general determination of the storage potential at these locations, a 30-foot high impoundment was assumed for each potential reservoir location. Using a Digital Elevation Model from the USGS, the storage and the surface area of the potential reservoirs was determined. The summary of the total storage volume and surface area for the five alternatives is presented in Table 4-3 – Potential Storage and Surface Area Considering a 30-ft High Impoundment.

Table 4-3 Potential Storage and Surface Area Considering a 30-ft High Impoundment

Site Name	Bottom Elevation (ft)	Normal Pool Elevation (ft)	Surface Area (Acres)	Storage (MG)
Unnamed Tributary above Wilderness	200	230	23	110
Mountain Run	240	270	234	1720
Mine Run	230	260	273	1450
Poplar Run	380	410	95	430
Poplar - Laurel Run	370	400	199	830

Each reservoir alternative was analyzed as an in-stream and pumped storage for different pump station capacities. The flows in the tributaries were estimated based on the flow records of the nearest USGS stream gauge, using a drainage area adjustment. The flows were adjusted in ratio of the drainage areas. Flow data for the 75-year period (1930-2004) was routed through a preliminary mass balance model for estimating the safe yield. The following assumptions were made in the yield analysis:

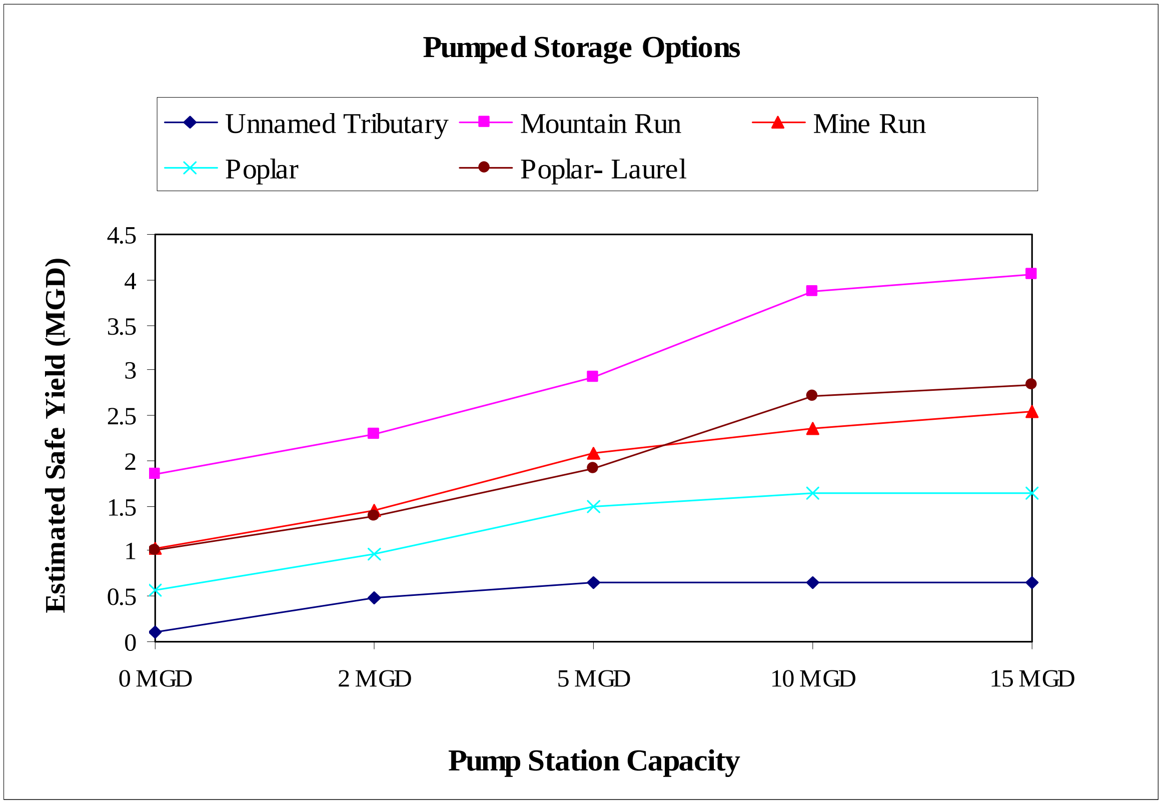
- The stage-storage curve was derived by scaling the stage-storage of a similar reservoir which is located in a representative geographical region.
- The Mean Annual Flow (MAF) for the tributaries was estimated using the MAF of the nearest USGS stream gauge, and adjusted based on the size of the drainage area.
- The minimum in-stream flow (MIF) required to be released downstream was assumed to be uniform, equal to 30 percent of the MAF for all months of the year.
- Dead storage and sedimentation volume in the reservoir was assumed to be equal to 10 percent of total reservoir storage.
- The pumped volume for any period was assumed to be constrained by the minimum of three values: the pumping capacity, the available reservoir capacity and its committed outflow, or the flows in the Rapidan River greater than 30 percent of MAF.
- The rainfall and the evaporation data was taken from a representative geographical region.

The estimated safe yields from the primary analysis are presented in Table 4-4. These values are preliminary and are intended for relative comparisons between options and for preliminary planning decisions.

Table 4-4 Estimated Safe Yield (in MGD) Yield Based on Preliminary Mass Balance

Site Name	Pump Station Capacity				
	(In- Stream) **0 MGD**	**2 MGD**	**5 MGD**	**10 MGD**	**15 MGD**
Unnamed Tributary above Wilderness	0.10	0.45	0.60	0.60	0.60
Mountain Run	1.80	2.30	2.90	3.80	4.0
Mine Run	1.0	1.40	2.0	2.30	2.50
Poplar Run	0.50	0.95	1.50	1.60	1.60
Poplar - Laurel Run	1.0	1.35	1.90	2.70	2.80

Figure 4-4 Preliminary Estimated Reservoir Yield vs. Pumping Capacity



As shown in Figure 4-4, the yield of each the potential reservoir increases as the pumping capacity increases, until some limiting factor results in a diminishing increment of yield relative to the increase in pumping. One of the limiting factors is the volume of available reservoir storage, which varies from 110 to 1,720 million gallons, depending on the alternative. The other limiting factor is the availability of Rapidan River flow for withdrawal by pumping. If the safe yield is controlled by storage volume, increasing the volume may result in increased yield. However, if the yield is limited by low available flows in the Rapidan River, then an increase in the size of reservoir may not increase the safe yield. Site-specific analyses are recommended to better define the optimal dam and reservoir configuration and yield. The location and configuration of the five reservoir alternatives are shown on Figure 4-5 through Figure 4-10.

Figure 4-5 General Location Map of the Five Reservoir Alternatives

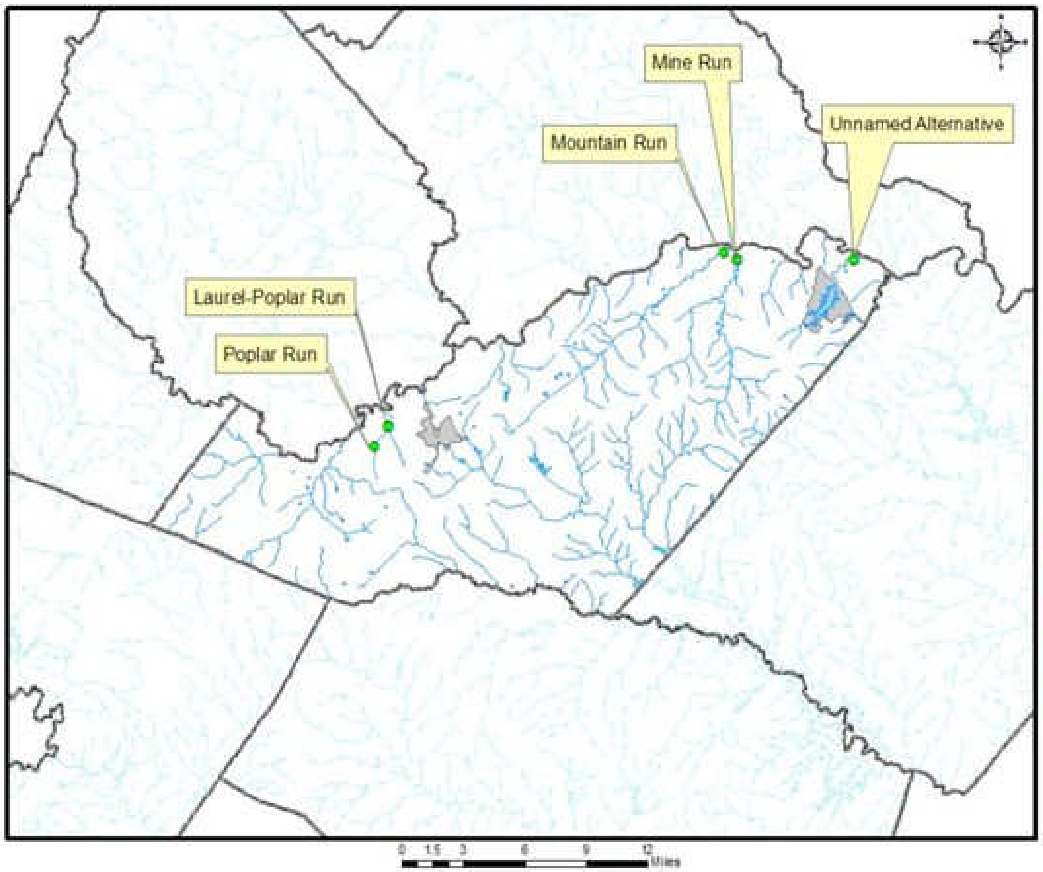


Figure 4-6 Potential Reservoir at Unnamed Tributary Above Wilderness Alternative

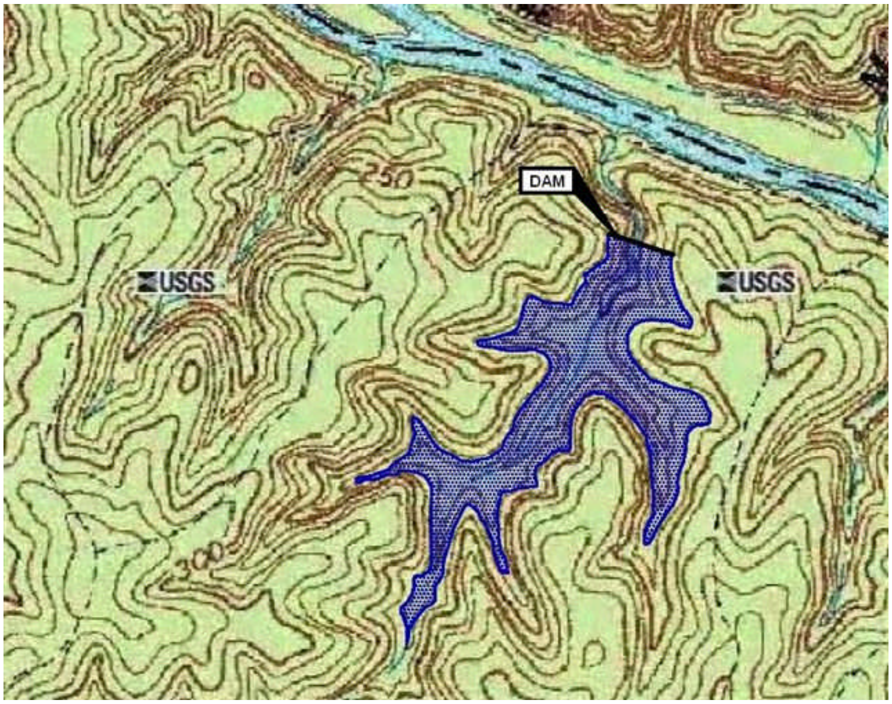


Figure 4-7 Potential Reservoir at Mountain Run Alternative

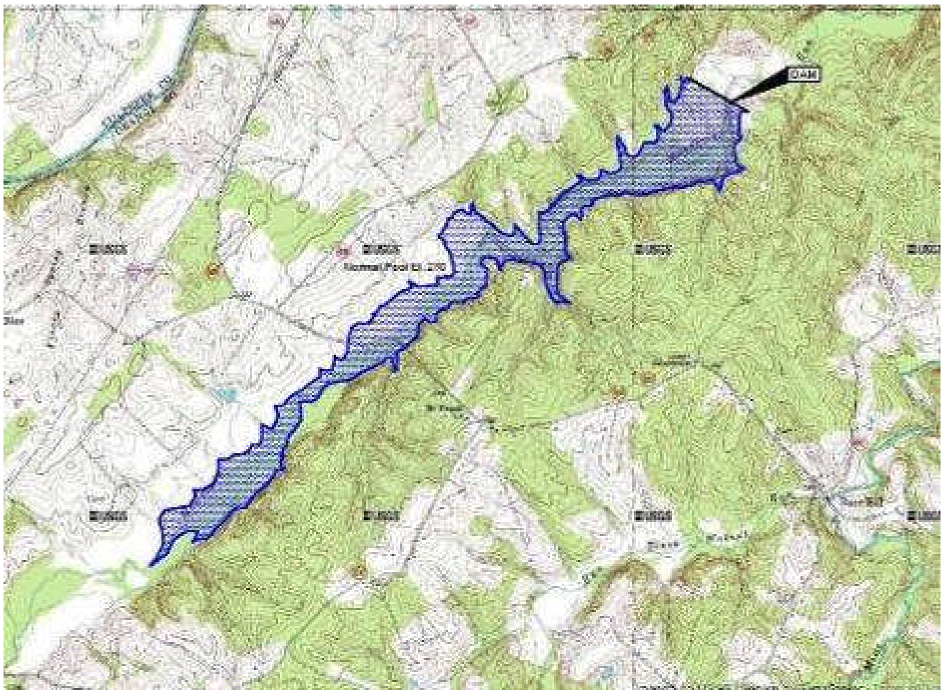


Figure 4-8 Potential Reservoir at Mine Run Alternative

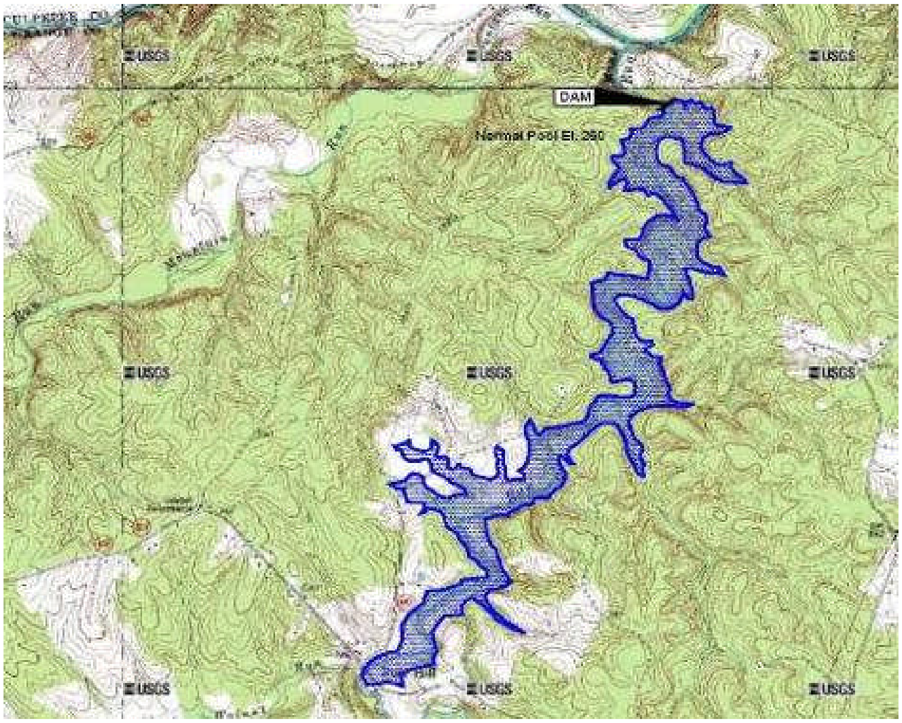


Figure 4-9 Potential Reservoir at Poplar Run Alternative

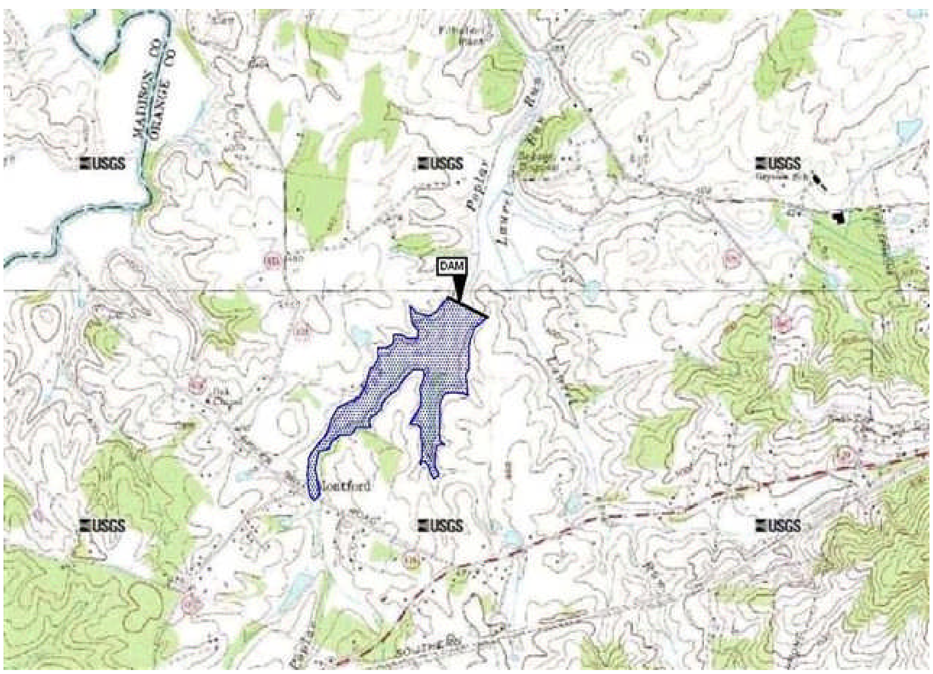
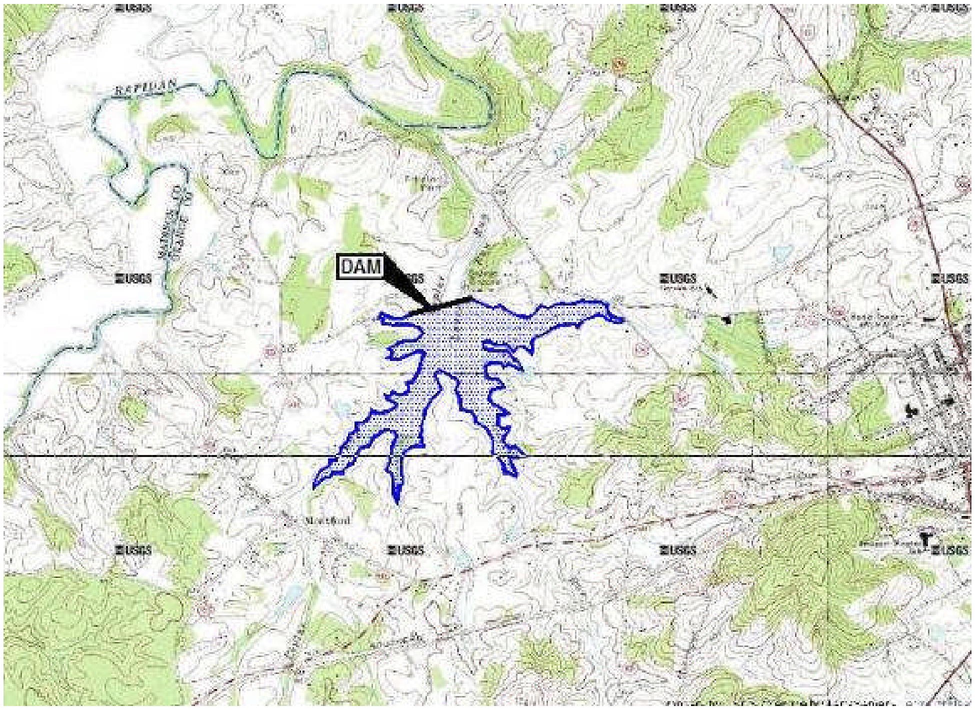


Figure 4-10 Potential Reservoir at Laurel and -Poplar Run Alternative



In addition to the five pumped storage reservoir sites identified as viable alternatives, other potential reservoir sites identified in the Orange County Water Supply Plan, or that may come to light in the future, may be considered if the property owners are willing to convey the property to a public or semi-public entity for development of a public water supply reservoir. One such site currently fits this criterion – Shotgun Hill Branch. This potential reservoir site should also be investigated in further detail.

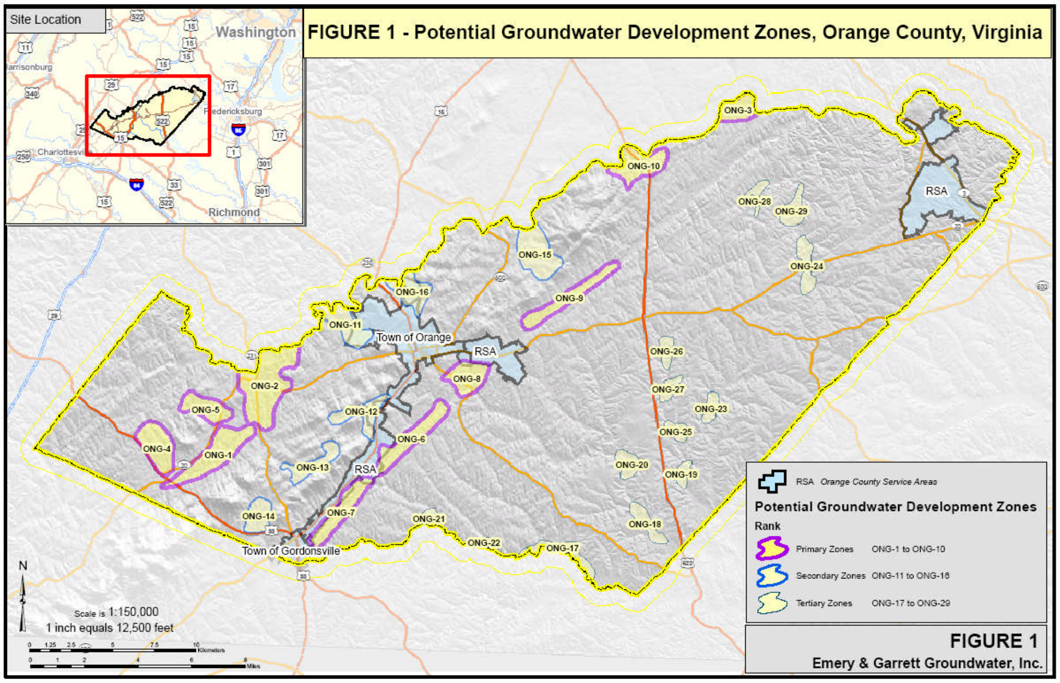
4.6.2 Groundwater Alternatives

Emery & Garrett's Phase I assessment of the groundwater potential in Orange County identified 29 zones that may be hydrogeologically favorable for potential development of groundwater supplies. The investigations were based on the following evaluation parameters:

- Bedrock geology and geologic mapping data.
- Bedrock fracture fabric and local bedrock structures (faults, fractures, and other bedrock discontinuity).
- Potential for groundwater recharge.
- Potential for groundwater resources to be adversely impaired by past and existing land uses.

The details of the assessment are available in the groundwater study report for Orange County in Appendix C. The zones for potential groundwater sites are shown in Figure 4-11.

Figure 4-11 Zones for Potential Groundwater in Orange County



Based on the Phase I investigations, the twenty-nine identified potential Groundwater Development Zones were classified into Primary, Secondary, and Tertiary zones, with the primary zones (10 options) considered most favorable and the secondary (6 options) and tertiary zones (13 options) less favorable for development of groundwater supplies. The classification was based on the estimated (combined) yield from these zones. The estimated combined yield for the Primary, Secondary, and Tertiary Groundwater Development Zones is 2.0 to 3.6 MGD (1.0 to 2.0 MGD in Primary Zones, 0.4 to 0.6 MGD in Secondary Zones, and 0.6 to 1.0 MGD in Tertiary Zones). Establishing actual yields for a particular location or choosing the location of best yield and water quality requires further investigations. New wells are evaluated based on the Phase I zone maps, as shown in Figure 4-11.

Most of the primary and secondary zones are located in the Blue Ridge Geologic province in the western part of the county, which is near to the Town of Orange, RSA Route 15, and the Town of Gordonsville combined water systems. The only primary location near the RSA Wilderness water system is “ONG-3,” which is west of the potential Mountain Run reservoir location. Also, almost all of the tertiary zones are found in the Piedmont Geologic Province, toward the east end of the county, which is closer to the RSA Wilderness system (although in a different watershed). Based on the location of these zones, it may be concluded that the RSA Wilderness system has limited potential for developing new potential groundwater supplies. The development of new groundwater has a higher potential in the western side of the county (i.e., near the Town of Orange, the Town of Gordonsville, RSA Route 15, and RSA Route 20 water systems).

4.6.3 Safe Yield Estimate

Only preliminary estimates for safe yield were determined during this initial investigation. It is estimated that the total potential for groundwater development in the combined Primary Groundwater Development Zones is somewhere between 1.0 MGD and 2.0 MGD. It is further estimated that up to 5 wells would be needed for every 1.0 MGD of yield; therefore, a total of 5 to 10 wells would be needed to develop the full yield of the Primary Zones. The Secondary and Tertiary Groundwater Development Zones are estimated to have a combined safe yield of 1 to 1.6 MGD. Many of the Tertiary Groundwater Development Zones are located in the southeastern portions of the County, which the County wishes to maintain as Agricultural or Agricultural Conservation, therefore the development of groundwater resources for public supply in this area is not recommended at this time. The Secondary Groundwater Development Zones are located closer to the projected growth areas of the County, but the total estimated combined safe yield for the Secondary Groundwater Development Zones is 0.4 to 0.6 MGD, therefore these zones should be held in reserve in case the Primary Groundwater Development Zones do not provide the anticipated safe yield.

4.7 Results of Secondary Screening

The preliminary screening reduced the water supply alternatives under consideration to four categories. Through the secondary screening, the raw water storage and groundwater options with less favorable yield potential were eliminated. The following alternatives remain as the most favorable for further consideration.

- Increase the Rapidan River supply at Wilderness by 1 MGD (to 3 MGD).
- Develop new raw water storage impoundments; 3 options remaining with individual yields from 2.5 to 4.0 MGD.
- Develop new groundwater supply near the Town of Orange side of the County; 5 to 10 wells with a total yield between 1 to 2 MGD.
- Water conservation measures with a total demand reduction of 1.1 MGD.

The following discussion summarizes McGuire Wood's letters found in Appendix E that discusses potential legal and permitting issues with developing raw storage impoundments and new groundwater supply. A discussion of project timing and a proposed schedule are discussed in the conclusion chapter.

4.7.1 Legal and Permitting issues with New Raw Water Storage Impoundments

The raw water storage alternative locations are all on tributaries that are both State waters and waters of the United States. This is because "State waters" is broadly defined to include all waters in the State, and "Waters of the United States" is broadly defined to include tributaries to interstate waters. Therefore, the reservoir and associated structures such as intakes and piping will require permits from the U. S. Army Corps of Engineers ("Corps"), the Virginia State Water Control board ("SWCB"), and possibly the Virginia Marine Resources Commission ("VMRC").

A Corps permit is required pursuant to Section 404 of the Clean Water Act for any dredge or fill activity in waters of the United States, which also includes wetlands. In addition to the water quality impacts, the Corps is required to consider all of the potential impacts of the project under the National Environmental Policy Act (NEPA), including impacts on the environment, endangered species, and historic and cultural resources. The Corps cannot issue its permit for the project until the SWCB has issued a certification pursuant to Section 401 of the Clean Water Act certifying that the project will not cause or contribute to a violation of water quality standards ("401 Certification"). The SWCB must also issue a Virginia Water Protection ("VWP") permit for the project pursuant to Va. Code § 62.1-44.15:5. The VWP serves as the SWCB's 401 Certification and is required for projects involving water withdrawals and impacts to wetlands. Although VMRC likely will issue a permit for the water withdrawal, its review is very limited and should not be a significant factor in the approval process.

4.7.2 Legal and Permitting Issues with New Groundwater Development

The General Assembly has authorized the Virginia Health Department (VDH) to regulate the quality and quantity of groundwater withdrawals intended for public drinking water supplies. The statute requires permits for waterworks, which by definition serve at least 15 connections or an average of at least 25 individuals, and for private wells.

VDH's waterworks regulations require a locality intending to utilize groundwater for drinking water purposes to apply for and obtain permission from VDH. The application must include, among other things, information relating to: 1) the needs of the community to be served; 2) current water consumption and trends; and 3) projected yield of the source. If VDH engineers determine that the proposed location is suitable as a well site, the applicant is given tentative approval to drill a well. Prior to obtaining a final operation permit, the applicant must also demonstrate that the water to be delivered from the well will not exceed certain bacteriological, physical, chemical, and radiological levels.

In addition to the VDH permit program, the County should also be aware of possible legal challenges by nearby property owners who may feel that their groundwater rights are threatened. As mentioned above, water rights between landowners may be defined, in part, by the common law. Virginia courts have divided water into two general categories – surface water and groundwater. The courts have established further distinctions between groundwater flowing through subterranean channels and water "percolating" through underlying soil and rock strata. Courts apply different legal standards depending on which of these classifications the groundwater at issue is located. Groundwater in Orange County is typically found in fractured bedrock and in overlying saprolite, which would likely be viewed by a Virginia Court as "percolating" groundwater.

While groundwater is preferred by many localities due, in part, to the greater expense of developing, constructing, and permitting surface water facilities, in this case, the County should review the potential for common law challenges and develop a technical strategy for minimizing them.

5.0 FACILITY IMPROVEMENTS AND COST ANALYSIS

Additional water treatment and distribution systems will be required in conjunction with the development of future supply sources. Treatment will be primarily dependant on the quality of the source water and governing state regulations at the time of design. A general level of treatment will be assumed based on current design standards. Distribution systems will be required to transfer untreated water to a central treatment location and to transfer finished water to the existing water distribution network.

As described briefly in the Alternatives Analysis section of this report, the two basic sources of water are ground water and surface water. Public ground water supply sources are very similar to an average household well. The primary difference is the means by which the drilling location and well yield are determined. Prior to drilling, an initial geologic investigation is performed to identify potential high yield groundwater zones. After the wells are drilled, a series of pumping tests will be performed to determine a rate of groundwater withdrawal that will not affect the overall groundwater table and nearby wells. A detailed description of this procedure is included in Appendix C Groundwater Exploration and Development Program by Emery & Garrett Groundwater, Inc. A water source developed from high yield wells can have treatment located directly adjacent to the wellhead or several wells could be pumped to a single treatment location. The groundwater exploration, development, and testing program is focused (in part) in developing groundwater sources that do not require significant levels of treatment, however, depending on the quality of the groundwater discovered, treatment may be required.

Treatment of groundwater may consist of some of the following components:

- Aeration for removal of radon.
- Disinfection and oxidation with chlorine or potassium permanganate.
- Filtration.
- Radium removal by chemical addition or filtration.
- Arsenic removal by ion exchange.
- pH adjustment.
- Fluoridation.
- Phosphate addition to inhibit corrosion in the distribution system.
- Raw water holding tank.
- Finished water clearwell.

Certain treatment components listed above may not be required depending on the quality of the groundwater. Additional components could be added to the above list, also depending on the quality of the groundwater. Alternatively, there is a possibility that treatment could be limited to chlorine and corrosion inhibitor injection with nothing additional required. Samples taken at each well will determine the required treatment components and the level of treatment for each. The pump house for each well would include a flow meter, shut-off valves, and level indicators.

Surface water sources often contain a differing list of potential contaminants and generally require a more extensive level of treatment. Some of the potential treatment components include the following:

- Oxidation.
- Flash mix.
- Polymer addition for flocculation.
- Coagulant addition.
- Sedimentation basins.
- Filtration.
- Disinfection with chlorine or chloramines.
- pH adjustment.
- Fluoridation.
- Phosphate addition to inhibit corrosion in the distribution system.
- Finished water clearwell.

Again, the exact treatment components and level of treatment will vary depending on the source water samples. A plant location directly adjacent to the surface water impoundment would reduce construction and operations costs and is, therefore, desirable. Reservoir permitting, design, and construction would begin long in advance of the need for a new water source, whereas, the actual treatment facility could be permitted, designed, and constructed a few years prior to the need. At that time, finished water storage and distribution system improvements could also be made. The sections below will describe which treatment and distribution improvements are best suited for the selected source water alternatives. It will be assumed that treatment plants will be located adjacent to the reservoir site for surface water impoundments and that wells will be pumped to a single treatment location.

The potential exists in Orange County to mix water from different sources, especially if groundwater is developed in the western portion of the County or if water is purchased from a provider outside of the County. Mixing water from various sources can produce water quality issues in the distribution system, especially if a new source is added. Distribution systems become acclimated to treated water from one or more sources, over a period of time, and the introduction of treated water from a new source may disrupt the state of equilibrium that has been obtained in the system. Even though water from different sources are treated to drinking water standards, different chemistries of the finished water from different sources may result in water quality issues such as an increase in apparent color, turbidity, and total iron, especially if the distribution system has unlined iron pipes.

Care has to be used in the type of disinfection used when blending waters from different sources. While some utilities have successfully blended waters that contain free chlorine with waters that contain combined chlorine, this type of blending can be difficult. Specifically, the free chlorine (Cl^2) to ammonia (measured as N) weight ratio, a key consideration in chloramines systems, can be difficult to control. When chlorinated and chloraminated waters are combined, the Cl^2:N ratio can exceed 5:1, which leads to the conversion of monochloramine to dichloramine, which is susceptible to breakdown and creates undesired tastes. Higher Cl^2:N ratios can lead to breakpoint chlorination, which can lead to the presences of no disinfectant residual which is not an acceptable practice.

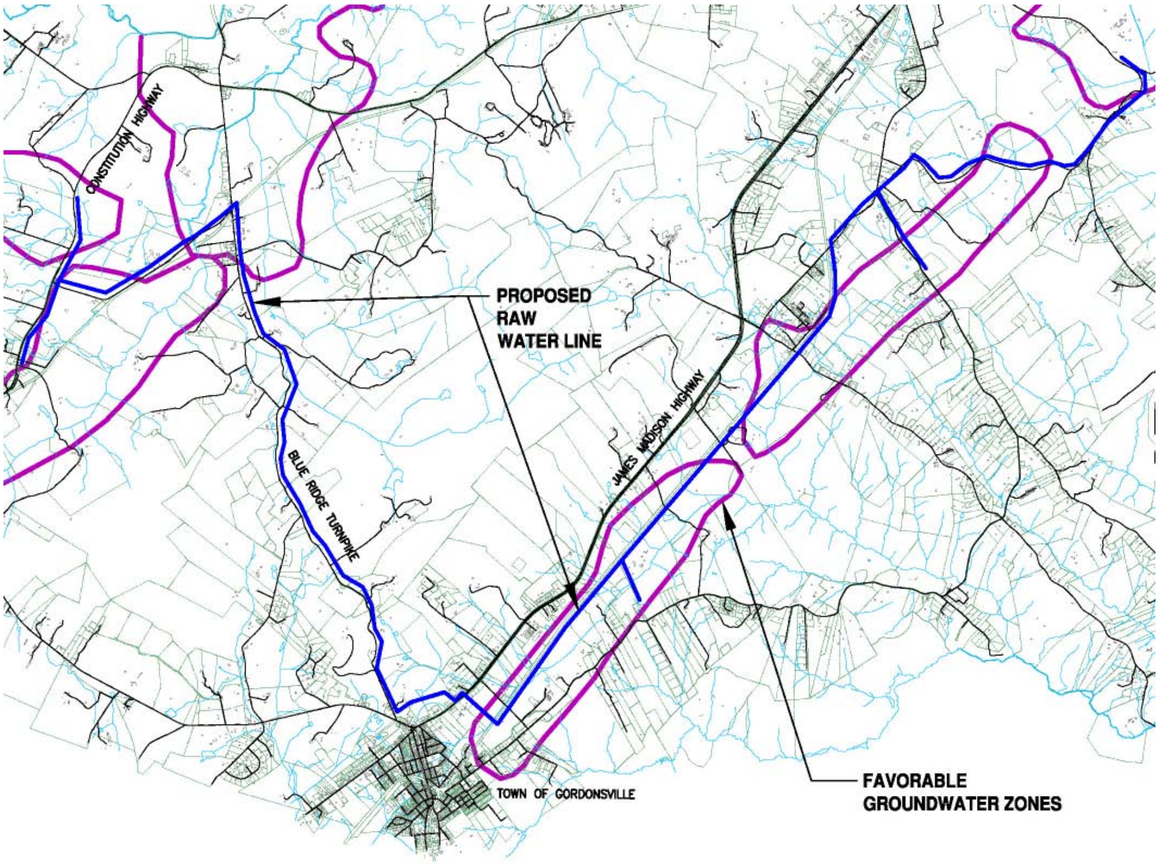
Also, while all materials in contact with the water in the distribution system and household plumbing systems are subject to corrosion in various degrees, several utilities have reported incidents of increased corrosion of elastomers in systems when switching from free chlorine to chloramines. Water quality issues resulting from the blending of water using different disinfection methods can be mitigated by trying to use the same type of disinfection processes at all treatment facilities supplying the distribution system.

5.1 Groundwater

Groundwater is a potential source water alternative for the western portion of Orange County where development will be allowed to occur per the County's current zoning and per the Orange County Comprehensive Plan. This area is comprised primarily of the Town of Orange, the Town of Gordonsville, the RSA Route 15, and RSA Route 20 water systems. Currently these water systems are all interconnected, though the RSA Route 20 system is separated from the other three by a closed line valve. A single water source is the most economical solution to serving the growing water demand of the area. The groundwater exploration identified several primary zones of potentially high yielding groundwater wells in this geographic region. The primary zones that could be developed are located east and west of Route 15. Each well would require a one-acre lot, pump house, power service, and access. If the groundwater is found to be of very high quality, chlorine and corrosion inhibitor can be injected at each wellhead without further treatment. The wells could then be connected to the existing system.

If a low quality water is discovered, the wells should be pumped to a central location for treatment. The raw water collection system would be more expensive and time consuming to install. A concept of potential collection lines is shown on Figure 5-1 – Raw Water Transmission Lines (Groundwater) for this region and includes nearly 92,000 feet of line. This configuration is capable of reaching 6 of the 7 primary groundwater zones identified in the western portion of the County. The final route of the raw water lines will likely change after an exact location of the groundwater test wells has been determined.

Figure 5-1 Raw Water Transmission Lines (Groundwater)



It is recommended that the treatment facility be located near Gordonsville. Placing the treatment plant away from the population center would encourage growth along the finished water line leading to Gordonsville or the Town of Orange. Having raw water lines only along the transmission routes would deter that growth and lessen public concerns as well. The estimated costs for the transmission lines and treatment facility are included in the opinion of probable costs section of this report.

Additional finished water line improvement will be required within each system but are not included as part of this report. A separate water model of each system would be required to determine deficiencies.

Groundwater was not identified as a viable alternative for source water supply in the eastern portion of the County because the Groundwater Potential Zones in the eastern potion of Orange County are located a significant distance from the projected growth areas. Orange County wishes to maintain the Agricultural and Agricultural Conservation land uses in the eastern part of the County. Development of groundwater resources for public water supply in this part of the County could encourage growth in an area in which the County does not desire growth.

5.2 Surface Water

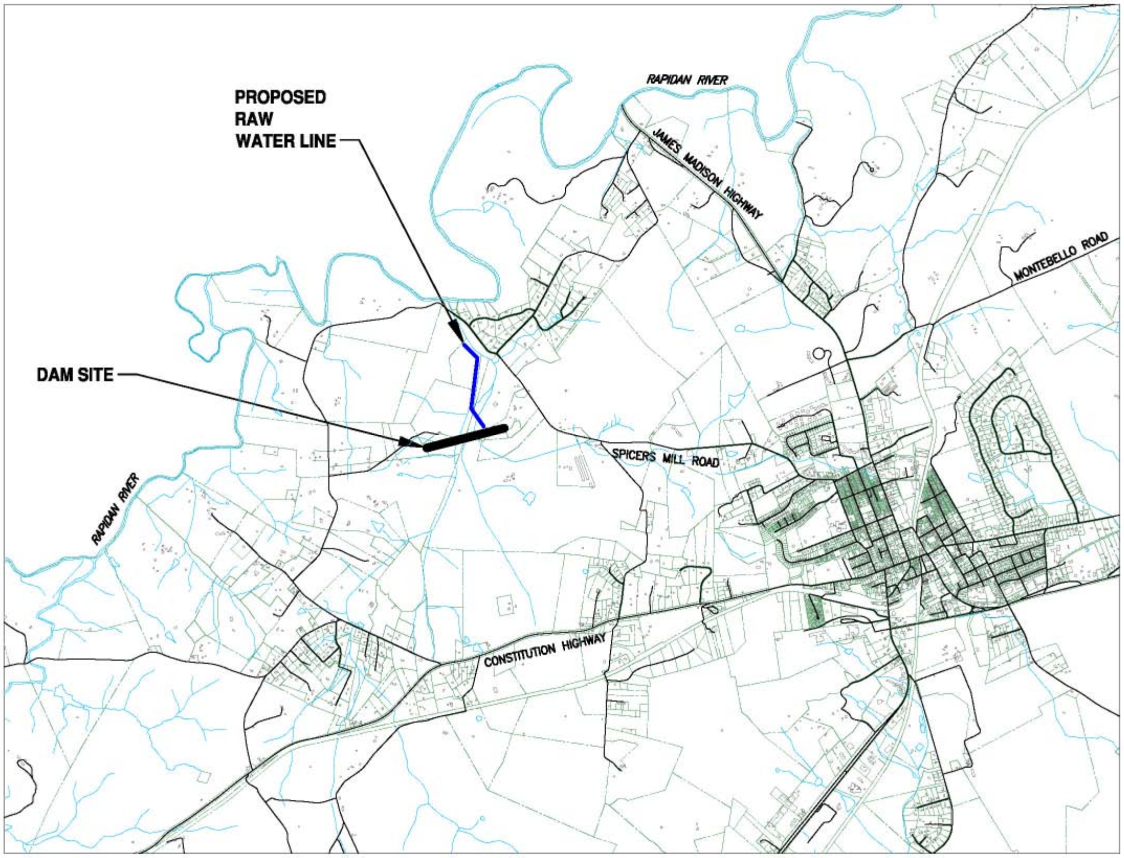
Groundwater can only supply a portion of the projected water demand in the western portion of the County and the County as a whole. As discussed in the 'Alternative Analysis' section, a surface water impoundment located near the convergence of Poplar Run and Laurel Run has the potential to provide for additional future demand. In this scenario, there would be no need for construction of a new water treatment facility directly adjacent to the reservoir. The Town of Orange water treatment plant is located approximately 3,000 feet downstream of the proposed impoundment site. Therefore, a raw water pump station and force main would be the most economical solution for development of this water source. The current water treatment facility would need both substantial upgrades and a major expansion to treat the additional volume of water. Distribution improvements would include approximately 3,000 feet of raw water force main, raw water pump station, and an estimated 20,000 feet of finished water line upgrades to move the increased water volume to the Town of Orange water system.

This reservoir could also provide additional supply to the eastern portion of the County. However, to do so, a finished water transmission main would be required. The most economical location for this transmission main would be along Route 20. Approximately 113,000 feet of water main would be required to convey the finished water to the RSA Wilderness water system on the eastern end of the County. An estimate of cost for the treatment and distribution improvements is included in the 'Preliminary Opinions of Probable Construction Cost' section of this chapter.

In addition to be these improvements, several finished water distribution improvements will be required in the Town of Orange, the Town of Gordonsville, and the RSA Route 15, Route 20, and Wilderness water systems. A full scope of the required upgrades cannot be completed without creating a water model of the combined service area and identifying system deficiencies. Therefore, no specific improvements have been suggested as part of this report beyond the Route 20 water main.

The location of raw water improvements at the Poplar/Laurel Run site are shown in Figure 5-2 – Potential Surface Water Impoundment Site Laurel Run & Poplar Run below.

Figure 5-2 Potential Surface Water Impoundment Site Laurel Run & Poplar Run

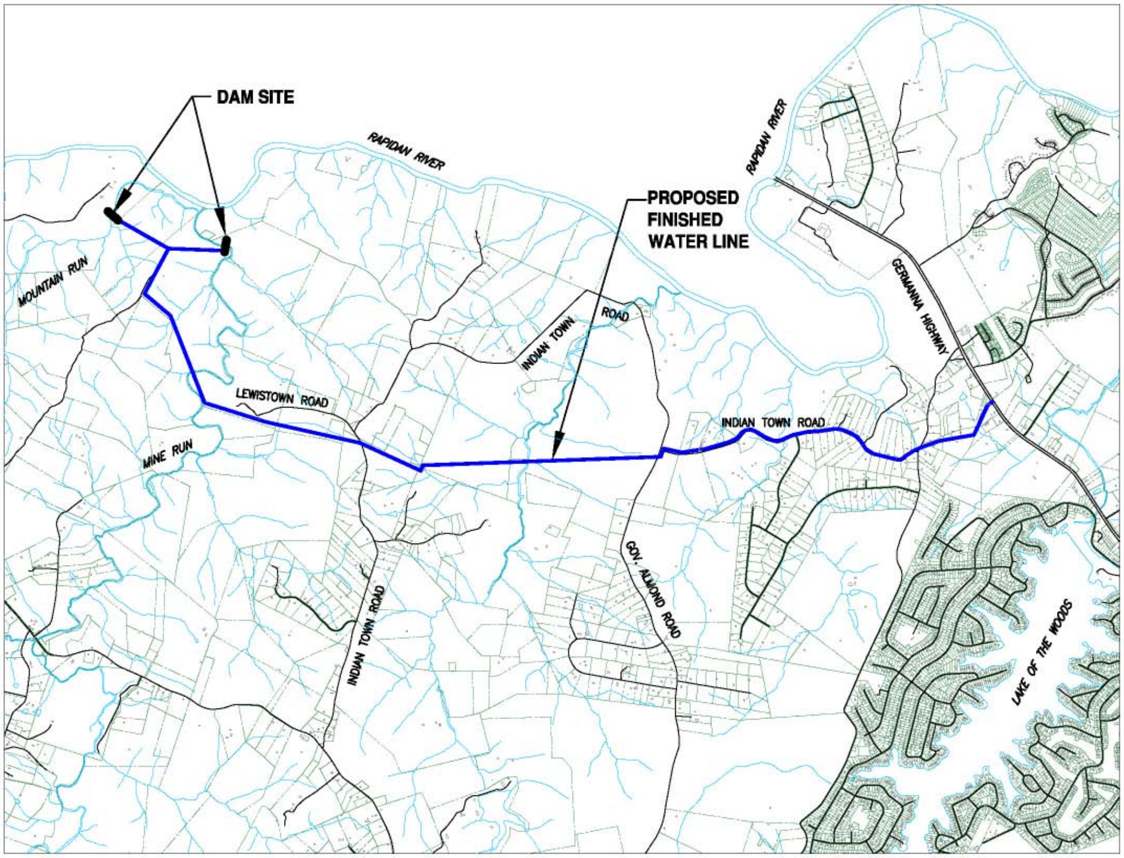


The Route 20 connector line is not shown. However, it would basically follow the right of way from Town of Orange to Route 3.

In addition to the Poplar/Laurel Run site, two potential reservoir sites have been identified in the eastern portion of the county. The Mountain Run and Mine Run sites are described in more detail in the 'Alternatives Analysis' section of this report. Either site, in conjunction with groundwater development in the western end of the County and a permit increase for the Wilderness intake will provide an adequate water supply through the year 2050, according to predictions provided in this report. A more detailed study will be required prior to selecting the most suitable reservoir site for the County water supply.

As previously mentioned, a water treatment plant located directly adjacent to the impoundment is most desirable. For either eastern reservoir site, the water treatment plant will be constructed beside the reservoir. There will be minor raw water improvements and a finished water pump station directly at the impound site. Distribution improvements will include approximately 31,000 feet of finished water line to carry treated or finished water to the existing Wilderness system. A concept of the finished water main alignment is shown in Figure 5-3 below.

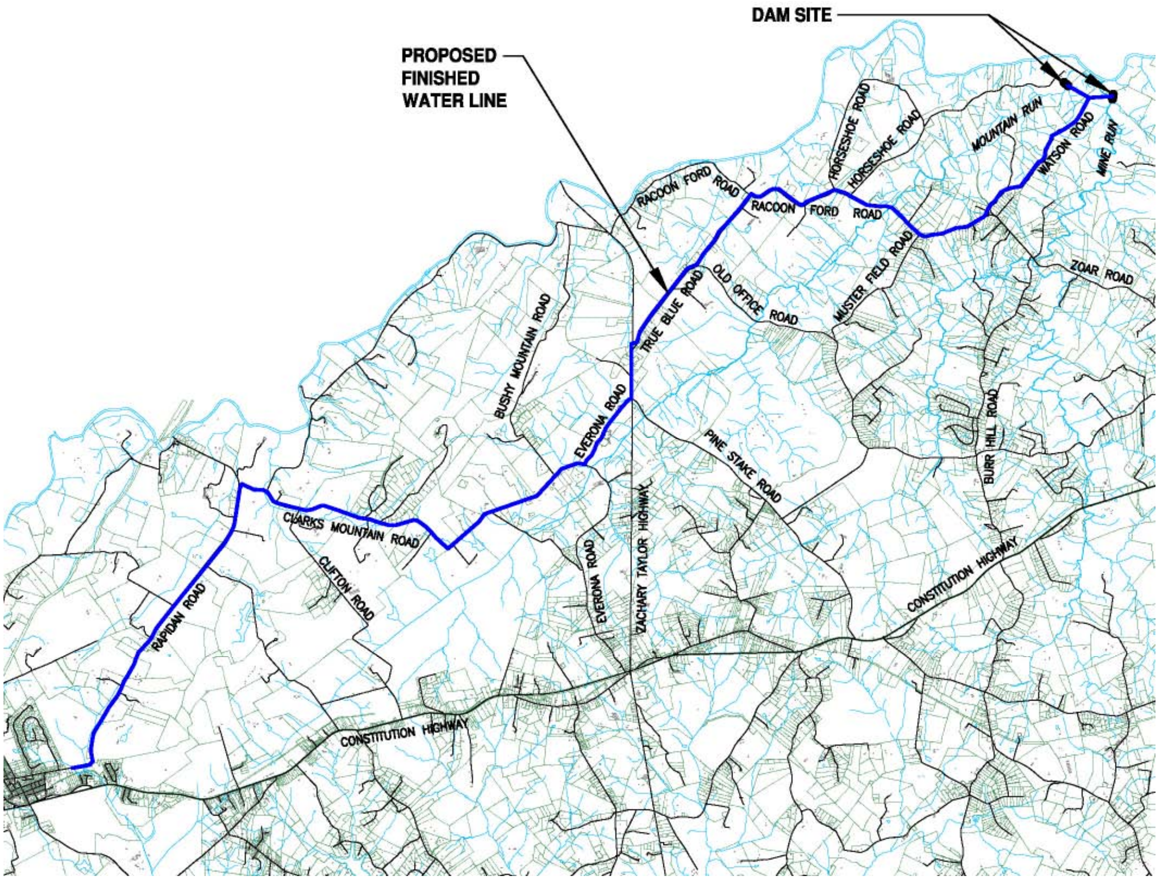
Figure 5-3 Potential Surface Water Impoundment Site - Mountain Run or Mine Run – Wilderness Supply Line



This alignment allows for service to existing subdivisions along the route. The additional subdivision service lines have not been included in this concept. An estimate of potential improvements has been prepared for this system and is included in the ‘Preliminary Opinions of Probable Construction Cost’ section of this chapter.

In addition to serving the water demand needs of the western portion of Orange County, the reservoir on Mine Run or Mountain Run would be used to serve the eastern service areas. The finished water supply system would include two pumps stations and approximately 106,000 feet of water main. A concept of the potential alignment is shown below in Figure 5-4. An estimate of potential improvements has been prepared and is included in the ‘Preliminary Opinions of Probable Construction Cost’ section of this chapter.

Figure 5-4 Potential Surface Water Impoundment Site - Mountain Run or Mine Run – Town of Orange Supply Line



The listed treatment and distribution improvements will provide treated water for the projected 50-year water demands. Improvements should be phased to meet demands. The section entitled ‘Alternative Analysis’ gives an estimate of when each area can expect a water supply shortfall. Generally, the treatment plant, raw water, and finished water improvements should be constructed during the final stages of source water development. Because variations in the growth patterns and development trends can greatly impact the timing of source water development and additional improvements, it is important to monitor County and service area growth rates and adjust the improvement implementation schedule accordingly.

5.3 Preliminary Opinions of Probable Construction Cost

An opinion of probable construction cost was determined for the preferred alternatives to serve as a planning level tool for future water supply decisions especially alternatives that were eliminated in the initial screening which could become favorable options as conditions change over time such as interconnections with other Counties and development of regional options outside Orange County.

5.3.1 Increase Raw Water Storage

The following alternatives (reservoir locations) are considered for the cost assessment:

- Mountain Run
- Mine Run
- Poplar and- Laurel Run (combination)
- Unnamed Tributary to Wilderness Run
- Poplar Run

The following assumptions were used to develop the cost estimates:

- The present capacities of the water treatment plant are equal to the permitted intake capacities, i.e. the present capacity of the Town of Orange WTP is 2.0 MGD and that of at the RSA Wilderness WTP is 2.0 MGD. (RSA Wilderness WTP intake is permitted for 2.0 MGD, though the WTP has a current design capacity of 1.584 MGD)
- The planning period for the new facilities is 50 years, and the interest rate 3 percent (real) and is constant over this period. (since inflation is not accounted in the future costs, the real interest rates are used instead of nominal rates)
- Engineering contingency is kept at 30 percent on the capital cost.
- The cost of a water treatment plant is $1,750,000 per MGD.
- The cost of a raw water pump Station is $ 2,000,000.
- The cost of a finish water pump station is $700,000.
- The operation and maintenance cost per 1000 gallons is $ 0.50.
- The water treatment plant closest to the reservoir site needs an upgrade of additional 2 MGD in the year 2020.
- The cost of upgrading the water treatment plant is $ 2,000,000 per MGD
- The cost of land for a water treatment plant is $ 25,000 per acre
- The additional land needed for water treatment plant is 40 acres
- The cost of wetland mitigation (land cost) is $ 100,000 per acre
- The cost of pumping is $ 0.06 per kwh, and the efficiency of the pump is 70 percent
- The pumping capacity at the raw water pump station is 10 MGD.
- The cost of the dam is calculated based on the lump sum break down for land acquisition, land clearing, earth work, earth filling, stream diversion, drainage, rip rap and other components whose quantities are assumed or suitable adopted for preliminary costing.

Based on the assumptions, the estimates for three reservoir locations are obtained. The summary of the cost estimates are presented in Table 5-1. The detailed calculations for the cost estimates are placed in Appendix-F. A comparison of the storage and yield per unit price of present worth is presented in Table 5-1.

Table 5-1 Preliminary Comparative Cost Estimate for New Surface Water Reservoir

	Mountain Run	Mine Run	Laurel-Poplar	Unnamed Tributary to Wilderness Run	Poplar Run
Total Capital Cost [a]	$17,000,000	$18,130,000	$21,800,000	$12,300,000	$14,000,000
Engineering Contingency [b]	$4,300,000	$4,480,000	$5,800,000	$2,800,000	$4,000,000
Annual O&M Cost	$74,000	$63,000	$150,000	$280,000	$170,000
Present Worth [c]	$27,300,000	$28,100,000	$34,000,000	$27,900,000	$26,700,000
Safe Yield (MGD)	3.8	2.3	2.7	0.6	1.6
Yield (gallon per dollar)	**0.14**	**0.08**	**0.08**	**0.02**	**0.06**

[a] Excluding Engineering contingencies.
[b] Excluding Cost of wetland mitigation .
[c] For 50-year life cycle. Based on assumption that WTP expansion will take place in the year 2020.

Finished water piping and pump station costs from each reservoir are provided in the Table 5-2 below:

Table 5-2 Opinion of Probable Costs for Finished Water Distribution Improvements

		To Orange	To Wilderness	Total
Mt. Run or Mine Run	Linework	$16,800,000	$3,255,000	$20,055,000
	PS	$1,000,000	$500,000	$1,500,000
	Total:	$17,800,000	$3,755,000	$21,555,000
Poplar/Laurel or Poplar	Linework	$2,100,000	$11,865,000	$13,965,000
	PS	$500,000	$1,000,000	$1,500,000
	Total:	$2,600,000	$12,865,000	$15,465,000

Budgetary costs in 2006 dollars, Engineering and construction contingencies included
Finished water would not be conveyed from Wilderness to Orange for the Unnamed Tributary Reservoir because of the low safe yield.

5.3.2 Groundwater

A preliminary cost estimate for constructing the new groundwater wells and treatment plant is shown in Table 5-3. The rates are assumed based on similar works in the nearby areas. A detailed cost estimate can be prepared once detailed subsurface investigations are complete and the location and yield of the wells is determined.

Table 5-3 Preliminary Cost Estimate for Developing Well Supply

Item Description	Quantity	Unit	Rate	Amount
Development cost	2,000,000	Gallons	$0.75	$1,500,000
Pump house [a]	10	each	$100,000	$1,000,000
Treatment Plant	1	L.S.		$8,000,000
Piping for collection and distribution	1	L.S		$7,000,000
Cost of Land	10	Acre	$10,000	$100,000
Sub Total				$17,600,000
Engineering Contingency @ 30% on sub total				$5,280,000
Capital Costs				**$22,880,000**
Operating Cost				**$65,000**
Present Worth [b]				**$23,300,000**
Yield (gallons) per unit dollar = 0.08 gallon/ dollar				

[a] It is assumed that 5 wells would yield 1 MGD, hence for 2.0 MGD yield approximately 10 wells are needed.
[b] For 50-year life cycle.

It should be noted that if the wells produce high quality water, the treatment costs can be reduced significantly. Minor treatment could be accomplished at each individual well. This would result in a $6,500,000 reduction in overall capital costs. However, recent wells drilled in Culpeper County to the north have yielded water with contaminants requiring a higher level of treatment. The estimate has been prepared with that in mind. It is assumed a higher level of treatment will be required.

6.0 DEMAND MANAGEMENT

6.1 Introduction and Background

Water demand management encompasses a spectrum of water measures that improve the efficiency and timing of water use. This approach differs from traditional water supply management, which aims at increasing the supply whatever the demand. Water demand management differs from water supply management in that it targets the water user rather than the supply of water to achieve more desirable allocations and sustainable use of water. Apart from structural measures such as drip irrigation or low-flow plumbing fixtures, demand management strategies mainly consist of non-structural measures such as economic and legal incentives to change the behavior of water users. A general list of water demand management measures are shown in Table 6-1.

Table 6-1 Water Demand Management Example Measures

Strategies	Specific Examples
Legal	• Water policy • Water use permits • Landscaping ordinances • Water restrictions • Plumbing codes for new structures • Appliance standards • Regulations
Economic	• Rebates for more efficient technologies (e.g., toilets, showers, faucets, appliances, drip irrigation) • Tax credits for reduced use • High-consumption fines and penalties • Pricing structures - Seasonal rates - Increasing block rates - Marginal cost pricing - Daily peak-hour rates - Sewer and waste water charges
Structural	• Metering • Landscape efficiency • Soil moisture sensors • Watering timers • Micro and drip irrigation • Rain sensors • Efficient irrigation systems • Soaker hoses • Leak detection and repair • Water audits • Pressure reduction • System rehabilitation • Efficient technology - Dual flush toilets - Low-flow faucets - Efficient appliances (dishwashers/washing machines) • Recycling and Reuse – ranging from cooling and process water, to grey water for toilets or irrigation, to treating and reclaiming wastewater for reuse

Demand management is different from practices for drought management in that demand management refers to a permanent behavioral change or application of technology that changes the baseline level of water use. Drought management practices are often enacted in response to an emergency in either the raw water available or water utilities treatment and distribution capability.

The advantages of implementing the demand management practices can include a reduction in overall system demand, deferral of capital investments, and minimization of environmental impacts.

6.2 Practices for More Efficient Use of Water

The Local and Regional Water Supply Planning (9 VAC 25-780-10 through 9 VAC 25-780-190) regulations state that the water plan needs to describe practices for more efficient use of water that is used within the planning area. The type of measures to be described "may include, but are not limited to, the adoption and enforcement of the Virginia Uniform Statewide Building Code sections that limit maximum flow of water closets, urinals and appliances; use of low-water use landscaping; and increases in irrigation efficiency."

This section describes practices for more efficient use of water used within Orange County. Where certain practices have been implemented by the localities a statement has been made to that effect. If not mentioned, the plan participants are not currently implementing the particular conservation practice.

6.2.1 Building Codes

The Virginia Uniform Statewide Building Code (USBC) is a state regulation promulgated by the Virginia Board of Housing and Community Development, a Governor-appointed board, for the purpose of establishing minimum regulations to govern the construction and maintenance of buildings and structures.

The provisions of the USBC are based on nationally recognized model building and fire codes published by the International Code Council, Inc. The 2003 editions of the International Codes are incorporated by reference into this version of the USBC.

Enforcement of the USBC is the responsibility of the Orange County building inspections department. Enforcement of the USBC has been part of the Orange County ordinance since 1973. While the County does not have any additional requirements above those incorporated into the USBC, the National Energy Policy Act of 1992 which mandated the introduction of 1.6 gallon-per-flush toilets and reduced maximum allowable flow rates for showerheads in the United States has led to more efficient water use in the County.

6.2.2 Conservation Incentives and Rate Structure

Strategic pricing of water can be helpful in achieving water conservation. Some of the useful options for pricing are tiered rate structure, time of day pricing, water surcharges, and rebates for water conservation. A tiered rate structure provides direct incentives to cut down the demand and save on water bills. All three water providers in the past twenty years have modified their pricing structure from a declining block structure, where a user actually pays less per gallon if a user consumes more, to a flat rate structure, where all users pay the same cost per gallon of water no matter how much a user consumes.

Water surcharge is similar to the tiered rate structure, wherein the per unit price of water would increase if the usage exceeds a pre-defined limit. Rapidan Service Authority is the only provider of water in Orange County that has a water surcharge. RSA bills an additional $1.00 per 1,000 gallons for water usage over 6,000 gallons for the months of July through October.

6.2.3 Water Recycling/Reuse

The use of recycled or reclaimed water for non-potable purposes may be a good alternative to reduce the demand of potable water. In residential communities, the gray water (wastewater from kitchens, tubs, clothes washers and laundry tubs) can effectively be used for watering lawns, gardening, and landscaping. This will reduce the demand for potable water as well as reduce the cost of treatment for the wastewater. For industrial establishments, the recycled water can be used for various processes, cleaning, cooling systems, flushing toilets, air washers and other such places where the use of potable water is not deemed necessary. Another possible use of recycled water could be in irrigation of farms, golf courses and agricultural use (in the vicinity of wastewater treatment plants). The recycling of water may bring about overall significant reduction in demand.

The Virginia Department of Environmental Quality (DEQ) is currently developing regulations entitled, "Wastewater Reclamation and Reuse" that will provide standards for the use of wastewater treated to defined levels of quality. The use of wastewater for landscape irrigation and equipment washing has routinely been provided for in the discharge permits issued to treatment works. More frequently, reuse involves irrigation of golf courses and other areas open to controlled public access. The reuse of wastewater with more opportunity for public exposure will require the use of advanced wastewater treatment technologies, such as chemically enhanced pollutant removal, filtration, absorption with activated carbon and ion-exchange with specific media, to provide an acceptable level of health and environmental protection.

In the last meeting minutes for the TAC Meeting for the Water Reclamation and Reuse Regulations on August 3, 2006, several concerns were still being addressed, such as:

- Disinfection issues, including bacterial standards, turbidity and TSS, and TRC.
- Who will be issued the permit? DEQ makes the determination as to who must apply for a permit.
- Appropriate recordkeeping.

6.3 Water Conservation Measures

The Local and Regional Water Supply Planning (9 VAC 25-780-10 through 9 VAC 25-780-190) regulations state that a water plan shall include information describing the "water conservation measures used within the planning area to conserve water through the reduction of use. The types of measures to be described may include, but are not limited to, technical, educational and financial programs." This section describes practices for more efficient use of water in Orange County.

6.3.1 Public Education

Public education can be an important means for creating more efficient use of water. These can be done by conducting public meetings, advocating benefits of the conservation measures, answering queries and providing technical support for program implementation. The benefits from these measures include reduction in system demands due to reduction in water wastages, public understanding and effective implementation of the other conservation measures, suggestions and improvements in the conservation programs.

Besides answering customer queries, all three water providers in Orange County provide educational material as a part of their billing.

6.3.2 Emergency Restrictions

These restrictions are implemented during emergency (drought) situations. The intensity of these restrictions may vary depending on the gravity of the anticipated shortage in supplies. The Department of Environmental Quality in Virginia defines three different stages of drought; these are Drought Watch, Drought Warning, and Drought Emergency. These stages are defined based on four drought indicators: namely, precipitation, stream flows, groundwater levels, and reservoir storage.

These measures require lowering of system demand by a pre-defined percentage of the total demand. This is achieved by cutting down (with exceptions) the non-essential uses of water, such as watering lawns, watering golf courses, washing paved surfaces (roads, sidewalks, driveways etc.), washing automobiles, and all ornamental uses of water. These measures are discussed in detail in *Drought Response and Contingency Plans*.

6.4 Water Loss Measures

The Local and Regional Water Supply Planning (9 VAC 25-780-10 through 9 VAC 25-780-190) regulations state that a water plan shall include information that describes, within the planning area, the "practices to address water loss in the maintenance of water systems to reduce unaccounted-for water loss. The types of items to be described may include, but are not limited to, leak detection and repair, and old distribution line replacement."

In the past, utilities have typically used the term "unaccounted-for water" or "unmetered water" to describe water loss or water that is not billed. Water loss occurs in two ways:

1. Actual water lost from the distribution system through leaks, tank overflows, flushing of water lines, and fire suppression. These are called real losses.
2. Water that reaches a customer that is not properly measured or tabulated. These are referred to as apparent losses.

Real losses indirectly require water suppliers to supply, treat, and transport greater volumes of water than their customer demand requires. Leakage is the most common form of real losses for water suppliers. Apparent losses do not result in the physical losses as that of real losses, but exert a significant financial effect on water supplies. These losses represent service rendered without payment. Apparent loses of water occur as errors in water flow measurement, errors in water accounting, and/or unauthorized usage.

For the purposes of this study, unaccounted-for water (UFW) losses have been defined as the total volume of water metered and billed subtracted from the total volume of water entering the distribution system. Table 6-2 shows the unaccounted-for losses as a percentage of system input volume for each of the service areas. In the past, the American Water Works Association had broadly recommended a goal of 10 percent for unaccounted-for water[1]. Using this as a guide, RSA's Route 20 and Route 15, Gordonsville, and the Town of Orange would have exceeded this goal of 10 percent more than once in the past six years.

Table 6-2 Unaccounted for Losses (%) for each Service Area
(volume of non-revenue water as a percentage of input volume)

Year	Town of Orange	RSA Route 15	Gordonsville	RSA Route 20	RSA Wilderness
2000	-	11	10	8	0
2001	-	12	10	14	13
2002	20	17	15	10	1
2003	26	21	17	0	0
2004	26	18	17	13	6
2005	18	12	28	13	8

Notes:
Town of Orange. These unaccounted percentages were computed by comparing the Town of Orange water production records from the plant and monthly billing statements.
RSA Route 15. These unaccounted percentages were calculated from the Town of Orange's water production records and comparing it with bulk sales records to Gordonsville and monthly Rt. 15 customer sales.
Gordonsville. These unaccounted percentages were calculated by comparing annual production records from RSA with billed sales.
RSA Route 20. These unaccounted percentages were calculated by comparing annual production records with billed sales.
RSA Wilderness**.** These unaccounted percentages were calculated by comparing production records with billed sales.

A water audit is used to help determine the amount of water lost due to leakage, theft, or other unauthorized uses. Water audits can range in complexity from basic spreadsheets to more complicated water audit software. The time involved can also range from one day to a few weeks depending on the complexity of the audit and the quality and availability of the data. The AWWA is currently recommending the IWA/AWWA Water Audit Method as the best practice method. This method is found in Appendix M and will also be incorporated into the next version

[1] AWWA Leak Detection and Water Accountability Committee Report. XXX. AWWA Journal; Vol. 88, Issue 7, July 1996.

of the AWWA M36 publication, *Water Audits and Leak Detection.* This method may be too complicated for small water systems such as the ones located in Orange County. A simplified water audit method may be used.

6.4.1 Simplified Water Audit Method

A simplified water audit consists of the following elements[2]:

1. Record of the amount of water produced or purchased from a water producer.
2. Record of the amount delivered to metered users.
3. Record of the amount delivered to unmetered users.
4. Record of the amount of water loss (1-(2+3)).
5. Measures to address the water loss (leaks and other unaccounted water).

Items 1 through 3 can be input into a spreadsheet in order to calculate item 4. The volume of water loss calculated will determine the measures required to address the water losses. The records used for items 1 through 3 should be compiled for a one-year period. A shorter period would encounter problems with meter readings lagging behind the production numbers. A longer period would be difficult to manage.

Adjustments to the data will be required to account for known inaccurate production or master meters and the difference in storage volumes from the beginning to the end of the study period. Adjustments may be necessary for known inaccurate customer meters. All adjustments to the data must be documented.

Unbilled authorized water use must be estimated if not recorded by meters. These uses include water used for fire fighting, water main flushing, water distribution system blowoffs, street cleaning, storage tank draining and overflows, etc.

The difference between water produced or purchased and the amount of water sold to customers plus the unbilled authorized uses will normally be either theft or leakage. If this amount of unaccounted for water is greater than 10 percent the water system should initiate a program to identify and reduce the unaccounted for water use.

An example water audit worksheet is shown in Figure 6-3.

[2] Maryland Department of the Environment, Water Supply Program Water Audit Guidance, October 16, 2002.

Table 6-3 Water Audit Worksheet

Water Audit Worksheet for Treated Water*
All units are millions of gallons

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Water Delivered													
1. Total Water Supply to Distribution System													
2. Adjustments to Water Delivery													
3. Net Water Produced or Purchased													
Water Used													
4. Gallons of Metered Water Sold													
Residential													
Commercial													
Industrial													
Institutional													
Other													
Total													
5. Billed Unmetered Sales													
6. Unbilled Authorized Consumption													
Water Main Flushing													
Sewer/Storm Drain Flushing													
Parks/Playgrounds/Pools													
Cemeteries													
Street Washing													
Fire Fighting and Training													
Construction													
Storage Tank Draining													
Water Treatment Plant Uses													
Wastewater Treatment Plant Uses													
Other													
Total													
7. Apparent Water Losses													
Water Meter Malfunction													
Theft													
Other													
Total													
8. Real Water Losses													
Leaks													
Storage Overflow													
Other													
Total													
9. Net Lost or Unmeasured Water (3-(4+5+6))**													
10. Percentage of Lost or Unmeasured Water (9/3)													

* Worksheet dervived from Maryland Department of the Environment
** Line 9 should equal the sum of Lines 7 and 8

7.0 DROUGHT RESPONSE AND CONTINGENCY PLANS

7.1 Introduction and Background

Drought is a normal, recurrent "natural" hazard that occurs in virtually all parts of the world. However, a lack of one universal definition of a drought, combined with the difficulty in determining when a drought begins and ends, has resulted in the slow development of drought preparedness and policy development. As population increases in many parts of the world, droughts will only exacerbate the competition for water resources.

The recent drought in the Commonwealth of Virginia that peaked in the summer of 2002 resulted in stream flows reaching record lows and thousands of individual private wells failing. During September 2002, the Town of Orange was on the brink of a water shortage emergency and was drawing emergency plans to pipe water about 20 miles from a location near Culpeper using a surface laid pipeline. As a result of this drought, on December 13, 2002, the Governor of Virginia issued Executive Order #39, which required the Commonwealth's Drought Coordinator to develop a formal drought assessment and response plan. A drought response Technical Advisory Committee chaired by the Virginia Department of Environmental Quality was formed to develop this plan.

Thirteen drought evaluation regions were established based on a consideration of river basins, climatic divisions, and other features. Orange County is in the Northern Piedmont Drought Evaluation Region. The plan uses the following four indicators to evaluate the drought severity:

- Precipitation deficits
- Stream flows
- Groundwater levels
- Reservoir storage

The plan acknowledges that there exists a substantial amount of variability and, as such, one plan cannot be expected to represent the entire Commonwealth of Virginia, nor can one plan be expected to represent all water systems in a certain geographic region if they rely on separate sources of water supply. For example, water supply systems that rely on smaller streams and do not have storage may experience large impacts from a small drought, whereas a water system that relies on a larger reservoir may experience limited impacts from the same drought.

Due to the variability of drought conditions across the Commonwealth, local governments have the power to declare drought emergencies and implement conservation activities prior to the declaration of a drought emergency by the Governor of the Commonwealth of Virginia. Local governments also have the power not to declare drought emergencies or implement conservation activities if local conditions indicate that such a condition does not exist.

7.2 Goal and Objectives

A drought contingency plan is required as part of the Local and Regional Water Supply Planning Regulation, 9 VAC 25-780-120. The requirements state that the drought plan must do the following:

1. Address the unique characteristics of the water source that is being utilized and the nature of the beneficial use of water.
2. Contain, at a minimum, three graduated stages of response to the onset of drought conditions.
3. Include references to local ordinances, if adopted, and procedures for the implementation and enforcement of drought response and contingency plans.

7.3 Orange County Drought Committee

While both the Town of Gordonsville (Appendix K) and Town of Orange (Appendix H) have enacted Drought Ordinances and the Rapidan Service Authority has established a Water Conservation Plan, in order to meet the above objectives, Orange County will establish a countywide drought response committee. During drought conditions, this drought response committee could ensure a successful response by facilitating communications between the stakeholders. It is envisioned that this committee will provide support for making and implementing decisions during a water shortage, and their participation will help ensure an appropriate and effective community response.

The membership committee should include the County Administrator, the Town Managers of Orange and Gordonsville, and the General Manager of the Rapidan service Authority. The committee chairman shall be the County Administrator or a person appointed by the County Administrator. The Committee Chairman will lead communication efforts among the local governments, utilities, and the public.

7.3.1 Meetings and Responsibilities

The committee will have the responsibility for updating and ensuring that assessment and suggested response measures reflect current conditions as they pertain to each water source. The drought plan should be reviewed for adequacy at a regular meeting of the committee, and an update should be prepared on a 5-year cycle in concert with Water Supply Planning updates to this document. Items that may require change include, but are not limited to, changes in the Virginia Water Protection Permits for surface water supply and Virginia Department of Health Permits for groundwater supply, reference to customer demands, available conservation measures, and target demand reductions. The committee will not have the authority to direct the operations of the water systems; only the operators of the water systems shall have authority over their operations.

To accomplish the objectives of the Plan, the drought committee will meet at least once a year for preparatory purposes. It is anticipated that this meeting will occur in May each year prior to the peak demand season. During a drought, additional meetings will be required.

7.3.2 Committee Activities

An important responsibility of the committee is to assist the utilities with implementing drought restrictions that may include the following activities:

1. Recommend incentives to meeting conservation requirements.
2. Recommend measures for monitoring water use prohibitions during a drought.
3. Review and recommend fines and penalties associated with excessive use or nonessential water use during a drought.
4. Review and recommend residential use allotments during water rationing stages of a drought.

7.4 Initial Drought Indicators

The Orange County Drought Response Committee could assist individual water providers in the County with the development of a countywide drought plan based on precipitation, stream flow, groundwater gages, and local water supply conditions as the initial indicators when considering a recommendation of a drought stage. The Town of Orange, Town of Gordonsville, and the Rapidan Service Authority Route 15 System will also utilize the available storage in the Town of Orange 45 MG reservoir as an indicator when considering a recommendation of a drought stage.

7.4.1 Precipitation

Precipitation will be monitored by comparing current precipitation amounts with historical precipitation values as a percent of normal long-term average values. These normal long-term average values are the accumulated daily precipitation values for each water year. The precipitation gage that could be used is number 446712, which is maintained by the Piedmont Research Station. Drought stages will be identified as a percentage of normal rainfall for a 12-month rolling average.

Table 7-1 Precipitation Table

Months	Normal (% of Normal Precipitation)	Watch (% of Normal Precipitation)	Warning (% of Normal Precipitation)	Emergency (% of Normal Precipitation)
October– September	>85.0	<85.0	<75.0	<65.0

All of the water systems in the region are, to various degrees, impacted by antecedent precipitation. The surface water systems are impacted more by recent precipitation events than are the groundwater systems, whereas the groundwater systems can possibly be impacted by long-term precipitation deficits. Therefore, the Town of Orange, Town of Gordonsville, Rapidan Service Authority Route 15 System, and the Rapidan Service Authority Wilderness System will utilize precipitation indicators more so than the Rapidan Service Authority Route 20 System and the Wolftrap Woods System. The two groundwater systems will utilize precipitation indicators, but only long-term precipitation data rather than short term.

7.4.2 Streamflow

The stream flow gage on the Rapidan River near Culpeper (USGS #01667500) will be used to monitor the stream flow responses to drought conditions. This is the same gage that is utilized by the Virginia Task Force to evaluate this region for drought conditions.

Stream flow above 93 CFS at USGS #01667500 will be considered normal conditions for the Town of Orange intake. Stream flow above 70 CFS at USGS #01667500 will be considered normal conditions for the RSA Wilderness intake.

The Town of Orange, Town of Gordonsville, Rapidan Service Authority Route 15 System, and the Rapidan Service Authority Wilderness System will utilize stream flow indicators in accordance with the respective VWP Permits for the two water intakes utilized by the four systems. The two groundwater systems will not utilize the stream flow indicators as they are a significant distance from the Rapidan River.

7.4.3 Groundwater

The Gordonsville Observation Well (USGS local Number 45P 1 SOW 030) could be used to monitor groundwater responses to drought conditions. This is the same well that is used in the Commonwealth of Virginia's Drought Assessment and Response Plan.

The two groundwater systems may utilize the Gordonsville Observation Well as an indicator of drought conditions possibly impacting the groundwater resources. However, as groundwater conditions can vary significantly over relatively short distances, the two groundwater systems will also utilize the water levels in their individual wells.

7.4.4 Town of Orange 45 MG Reservoir

The Town of Orange 45 MG Reservoir was constructed not long after the water emergency of 2002. The purpose of the reservoir was to provide an emergency supply for times when the stream flow in the Rapidan River is extremely low and the Town of Orange water supply intake cannot adequately withdraw the necessary volume of water for the demand.

This indicator will be utilized for the Town of Orange, Town of Gordonsville, and the Rapidan Service Authority Route 15 System. This indicator will not be used for the Rapidan Service Authority Route 20 System or the Wolftrap Woods System.

7.4.5 Drought Stages

Because the water systems in the region rely on different sources of water, the drought indicators used for each system will vary. However all of the water systems in the County will have four stages:

1. Normal Conditions
2. Drought Watch

3. Drought Warning
4. Drought Emergency

The water systems will be grouped as follows in accordance with their respective water sources:

1. Town of Orange – Town of Gordonsville – RSA Route 15 System
2. RSA Wilderness System
3. RSA Route 20 System
4. Wolftrap Woods System
5. Non-Public and Non-Community Systems

7.4.6 Drought Stages for Town of Orange – Town of Gordonsville – RSA Route 15 System

7.4.6.1 Normal Conditions (No more than one indicator outside of the normal range)

- Precipitation exceeds 85 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge is above 93 CFS.
- Town of Orange 45 MG Reservoir is within 2 feet of full pond.

7.4.6.2 Stage 1. Drought Watch (At least two indicators meet the following conditions)

- Precipitation levels are at or below 85 percent of normal and greater than 75 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge falls between 93 CFS and 71 CFS.
- Town of Orange 45 MG Reservoir is between 2 feet and 5 feet below full pond.

7.4.6.3 Stage 2. Drought Warning (At least two indicators meet the following conditions)

- Precipitation levels are at or below 75 percent of normal and greater than 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge falls between 71 CFS and 44 CFS.
- Town of Orange 45 MG Reservoir is between 5 feet and 10 feet below full pond.

7.4.6.4 Stage 3. Drought Emergency (At least two indicators meet the following conditions)

- Precipitation levels are at or below 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge falls below 44 CFS.
- Stream flows are below the levels established in VWP 02-1835
- Town of Orange 45 MG Reservoir is more than 10 feet below full pond.

7.4.7 Drought Stages for RSA Wilderness System

7.4.7.1 Normal Conditions (No more than one indicator outside of the normal range)

- Precipitation exceeds 85 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge is above 70 CFS.

7.4.7.2 Stage 1. Drought Watch (Indicators meet the following conditions)

- Precipitation levels are at or below 85 percent of normal and greater than 75 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge falls below 70 CFS.

7.4.7.3 Stage 2. Drought Warning (Indicators meet the following conditions)

- Precipitation levels are at or below 75 percent of normal and greater than 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge falls below 53 CFS.

7.4.7.4 Stage 3. Drought Emergency (Indicators meet the following conditions)

- Precipitation levels are at or below 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average stream flow at the Culpeper gauge falls below 33 CFS.

7.4.8 Drought Stages for RSA Route 20 System

It must be stressed that, even though the RSA Route 20 System is a small groundwater system serving approximately 127 connections, it is interconnected to the Town of Orange water system by a normally closed valve. Should the well fail for some reason, the General Manager of the system can contact the Town of Orange to coordinate the opening of the valve. Because the system is a groundwater system, and not necessarily located in the same geology as the Gordonsville Observation well, Orange County can only notify the owner of the system of the various drought stages and encourage conservation if any of the three drought stages listed below occur. This notification will be in the form of a letter from the County to the owner of the system when the Town of Orange – RSA RT 15 – Town of Gordonsville water system goes on Drought Watch, Drought Warning, or Drought Emergency.

7.4.8.1 Normal Conditions (No more than one indicator outside of the normal range)

- Precipitation exceeds 85 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge is above its historical 25th percentile level.
- The groundwater depth of the RSA Route 20 well is above its historical 25th percentile level.

7.4.8.2 Stage 1. Drought Watch (Indicators meet the following conditions)

- Precipitation levels are at or below 85 percent of normal and greater than 75 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge falls between the 10th and 25th percentiles of its historical levels.
- The groundwater depth of the RSA Route 20 well falls between the 10th and 25th percentiles of its historical levels.

7.4.8.3 Stage 2. Drought Warning (Indicators meet the following conditions)

- Precipitation levels are at or below 75 percent of normal and greater than 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge falls between the 5th and 10th percentiles of its historical levels.
- The groundwater depth of the RSA Route 20 well falls between the 5th and 10th percentiles of its historical levels.

7.4.8.4 Stage 3. Drought Emergency (Indicators meet the following conditions)

- Precipitation levels are at or below 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge falls below the 5th percentile of its historical level.
- The groundwater depth of the RSA Route 20 well falls below the 5th percentile of its historical level.

7.4.9 Drought Stages for Wolftrap Woods System

It must be stressed that, even though Wolftrap Woods is a community water system by the Virginia Department of Health definition, it is a privately-owned and operated system. The system is a small groundwater system serving a subdivision of 15 residential properties. The owner of the system, Mr. Dave Travers, has stated that he has a spare well lot that can be developed if the existing well cannot meet the demand in the system. Because the system is privately owned and operated, Orange County can only notify the owner of the system of the various drought stages and encourage conservation if any of the three drought stages listed below occur. This notification will be in the form of a letter from the County to the owner of the system when the public water systems go on Drought Watch, Drought Warning, or Drought Emergency.

7.4.9.1 Normal Conditions (No more than one indicator outside of the normal range)

- Precipitation exceeds 85 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge is above its historical 25th percentile level.

7.4.9.2 Stage 1. Drought Watch (Indicators meet the following conditions)

- Precipitation levels are at or below 85 percent of normal and greater than 75 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge falls between the 10th and 25th percentiles of its historical levels.

7.4.9.3 Stage 2. Drought Warning (Indicators meet the following conditions)

- Precipitation levels are at or below 75 percent of normal and greater than 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge falls between the 5th and 10th percentiles of its historical levels.

7.4.9.4 Stage 3. Drought Emergency (Indicators meet the following conditions)

- Precipitation levels are at or below 65 percent of normal for a 12-month rolling average.
- The 14-day rolling average groundwater depth of the Gordonsville Groundwater Observation Well gauge falls below the 5th percentile of its historical level.

7.4.10 Drought Stages for Non-Public and Non-Community Systems

It must be stressed that Orange County has no direct control over individual-owned water systems, nearly all of which are groundwater systems, and can only advise the owners of such systems that the public and community water systems are either entering or exiting one of the three drought stages. The County, with the assistance of the Drought Committee, will initiate a multi-faceted public information campaign involving press releases, newsletter inserts, public broadcasting of drought status, and involvement of other public agencies to aid in reducing water use in the County.

7.4.11 Permit Special Conditions

7.4.11.1 Town of Orange Water Treatment Plant Intake

In addition to the three Drought Stages listed above, the Town of Orange must also take into consideration the special permit conditions for the water treatment plant. The following is taken from the Virginia Water Protection Individual Permit No 02-1835, Part I – Section D (Appendix G):

> "When the previous year's total water withdrawal was *less than or equal to* 511 million gallons: The permittee shall enact mandatory conservation whenever the 14-day rolling average stream flow of the Rapidan River at the USGS Culpeper gage is, or falls below, 44 cubic feet per second (CFS). Mandatory conservation may be lifted once the 14-day rolling average at the Culpeper gage exceeds 44 cfs.
>
> When the previous year's total water withdrawal was *greater than* 511 million gallons: The permittee shall enact mandatory conservation whenever the 14-day rolling average stream flow of the Rapidan River at the USGS Culpeper gage is, or falls below, 63 cubic feet per second (cfs). Mandatory conservation may be lifted once the 14-day rolling average at the Culpeper gage exceeds 63 cfs.
>
> A 14-day rolling average shall be calculated by recording the stream flow rate at the Culpeper gage once per day, then adding 14 consecutive days of stream flow rates and dividing that sum by 14.
>
> Mandatory conservation measures shall consist of those outlined in Condition 2 in the Town of Orange Ordinance Number 02-08, Section 74-57(b) [Appendix H]. Conservation measures shall apply to all users of water withdrawn under the permit."

The special conditions of the Town of Orange VWP align with Stage 3 – Drought Emergency as defined for the Town of Orange, Town of Gordonsville, and the RSA Route 15 System. The conditions of the VWP permit should override any conservation measures associated with the three Drought Stages. Regardless of the Drought Stage, if the 14-day rolling average stream flow falls below the target value, the mandatory conservation efforts must be implemented.

7.4.11.2 Wilderness Water Treatment Plant Intake

The Wilderness Water Treatment Plant is limited by permit special conditions similar to those of the Town of Orange. Virginia Water Protection Permit No. 96-0271, Part I – *Special Conditions* (Appendix I) states the following:

> "A 14-day rolling average of stream flow shall be calculated using the Rapidan River at Culpeper gage. If the 14-day rolling average flow falls to 33 cubic feet per second (cfs) or less, mandatory conservation measures are required, as detailed in Attachment A of this permit. At such time that the County of Orange, Virginia adopts a final drought response ordinance, the permittee may request a minor modification of this permit 96-0271 to specify the mandatory conservation measures adopted in that ordinance rather than those in Attachment A."

The special conditions of the RSA Wilderness VWP align with Stage 3 – Drought Emergency as defined for the RSA Wilderness System. Again, the permit conditions shall override any conservation measures associated with the three Drought Stages. If the stream flow on the Rapidan River at Culpeper falls below the target values, as a minimum, the voluntary and mandatory conservation measures outlined in the *RSA East Drought Water Conservation Plan* shall be followed (Appendix J).

7.5 Demand Management Stages

The demand reduction measures will follow a logical progression from voluntary water use restrictions, to a mandatory ban of nonessential uses. The demand reduction measures could correspond to Drought Stages 1 through 3. Recommendations are designed to reduce water usage within residential dwellings, commercial and industrial establishments, and institutions in addition to the continued reduction of nonessential water uses.

Ongoing efforts to educate water customers about water conservation practices could be increased during early drought conditions. Water utilities, with the assistance of the Drought Committee, could then alert customers to drought conditions and inform them of actions required to respond to water shortages. This may be accomplished through local newspaper articles and news broadcasts, and through presentations on water conservation and drought response activities to local organizations. Water conservation literature will be distributed to residential customers to discourage wasteful habits and to encourage the installation of water-saving plumbing fixtures in homes that are not already so equipped. Household leak detection programs should also be instituted during early drought conditions, and meter readers should inform customers with unusually high readings.

An important aspect of implementing a drought contingency plan is the early notification to appropriate municipal officials and employees of the plan provisions that they could be called upon to implement and enforce.

The following section describes the steps associated with the drought contingency plan. The drought plan consists of three stages, with each stage having an indication trigger and targeted water-use reduction.

7.5.1 Stage 1 – Drought Watch

The individual water systems will determine, after consultation with the Chairman of the Drought Committee, that declaration of Drought Watch (Stage 1) is appropriate for their respective systems. In Stage 1 of a water shortage, all customers in the system are encouraged to employ voluntary conservation measures to especially limit non-essential water uses.

The goal of the voluntary conservation efforts is to achieve a 5 percent reduction in total system demands, compared to use in the same month of the previous non-drought year. The focus of this stage is on education and preparation for more stringent water use restrictions that may follow. The County (municipality, utility, or water system owner), with the assistance of the Drought Committee, will initiate a multi-faceted public information campaign involving press releases, newsletter inserts, public broadcasting of drought status, and involvement of other public agencies to aid in reducing water use in the system.

7.5.1.1 Voluntary Restrictions for Residential Customers

Residential customers are asked to employ water-conserving measures on a voluntary basis. The objective is to reduce water use by 5 percent. The following actions are requested:

- Repair leaks, faulty faucets, and toilets.
- Reduce lawn and landscape watering.
- Reduce vehicle washing.
- Reduce outdoor water use, such as sidewalk, paths, and exterior surface washing.
- Turn off water when brushing teeth, shaving, or shampooing.
- Take shorter showers.
- Use laundry washing machines and dishwashers only when loads are full.
- Install water-saver devices in the home, such as low-flow toilets and showerheads.
- Turn off ornamental fountains.

7.5.1.2 Voluntary Restrictions for Non-residential Customers

Non-residential customers are asked to develop or review individual customer specific drought contingency plans, explore installation of permanent water-recycling equipment and other water conserving measures, and set minimum indoor temperatures to 75 degrees F for evaporative cooling systems unless equipment re-circulates water. Implementation of water-conserving measures is voluntary at this stage, with an objective of reducing water use by 5 percent. The following actions are requested:

- Repair all faulty faucets and toilets.

- Limit lawn and landscape watering.
- Limit vehicle washing.
- Limit outdoor water use, such as sidewalk, paths, and exterior surface washing.
- Use laundry washing machines and dishwashers only when loads are full.
- Install water-saver devices, such as low-flow toilets.
- Turn off ornamental fountains.
- Review or update customer-specific drought contingency plan.

7.5.2 Stage 2 – Drought Warning

The individual utilities or water system owners will determine, after consultation with the Chairman of the Drought Committee, that declaration of Drought Warning (Stage 2) is appropriate for their respective system. In Stage 2 of a water shortage, certain actions are specifically prohibited, and all customers are encouraged to voluntarily conserve water through additional means. A 10 percent reduction in total system demand, compared to the same month in a non-drought year, is targeted. The focus of this stage is on eliminating non-essential uses of water and on continued preparation for more stringent water use restrictions that may follow.

7.5.2.1 Restrictions for Residential Customers

The goal is to reduce water use by 5 to 10 percent. For residential customers of the public water systems, the following actions are prohibited:

- Operating any outdoor ornamental fountain or other structure making a similar use of water. Indoor fountains may be operated as long as no water is added. Fountains and other means of aeration necessary to support aquatic life are permitted.
- Using automatic fill valves in swimming and wading pools. Pools that show no signs of leakage may be manually filled.
- Washing automobiles, trucks, trailers, or any other type of mobile equipment, except from a bucket or other container not exceeding 5 gallons in capacity.
- Washing of sidewalks, streets, driveways, parking lots, exteriors of homes or apartments, commercial or industrial buildings or any other outdoor surface, except where required to ensure public safety and health or where mandated by federal, state, or local law.
  - ➢ Driveways and roadways may be pre-washed in preparation for recoating and sealing.
  - ➢ Tennis courts composed of clay or similar materials may be wetted by means of a hand-held hose equipped with an automatic shutoff device at the minimum rate necessary for maintenance. Automatic wetting systems may be used between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary.
- Unrestricted irrigation of lawns is prohibited.
  - ➢ Newly sodded and seeded areas may be irrigated to establish cover on bare ground at the minimum rate necessary for no more than a period of 60 days. Irrigation rates may not exceed 1 inch of applied water in any 7-day period.

- Gardens, bedding plants, trees, shrubs and other landscape materials may be watered with hand-held containers, hand-held hoses equipped with an automatic shutoff device, sprinklers or other automated watering devices at the minimum rate necessary, but in no case more frequently than twice per week. Irrigation should not occur during the heat of the day.
- All allowed lawn irrigation must be applied in a manner to assure that no runoff, puddling, or excessive watering occurs.
- Irrigation systems may be tested after installation, routine maintenance, or repair for no more than ten minutes per zone.
- All allowed lawn irrigation must be done between the hours of 8:00 p.m. and 10:00 a.m.

7.5.2.2 Restrictions for Non-residential Customers

Non-residential customers' goals will be to reduce water use by 10 percent, or implement approved individual customer specific drought contingency plans for Stage 2. In addition, for non-residential customers of the public water systems, the following actions are prohibited:

- Operating any outdoor ornamental fountain or other structure making a similar use of water. Indoor fountains may be operated as long as no water is added. Fountains and other means of aeration necessary to support aquatic life are permitted.
- Using automatic fill valves in swimming and wading pools. Pools that show no signs of leakage may be manually filled.
- Using fire hydrants for any purpose other than necessary governmental operations.
- Serving water in restaurants, cafeterias, or any other establishment, unless specifically requested by the individual being served.
- Washing automobiles, trucks, trailers, or any other type of mobile equipment, except from a bucket or other container not exceeding 5 gallons.
    - Mobile equipment may be washed using hand-held containers or hand-held hoses equipped with automatic shutoff devices, provided that no mobile equipment is washed more than once per calendar month and the minimum amount of water is utilized.
    - Construction, emergency, or public transportation vehicles may be washed as necessary to preserve the proper functioning and safe operation of the vehicle.
    - Mobile equipment may be washed at licensed commercial vehicle washing facilities that utilize reclaimed water as part of the wash process or reduce water consumption by at least 10 percent when compared to a similar period when water use restrictions were not in effect.
    - Automobile dealers may wash cars that are in inventory no more than once per week utilizing hand-held containers and hoses equipped with automatic shutoff devices, automated equipment that utilizes reclaimed water as part of the wash process, or automated equipment where water consumption is reduced by at least 10 percent when compared to a similar period when water use restrictions were not in effect.

  - ➢ Automobile rental agencies may wash cars no more than once per week utilizing hand-held containers and hoses equipped with automatic shutoff devices, automated equipment that utilizes reclaimed water as part of the wash process, or automated equipment where water consumption is reduced by at least 10 percent when compared to a similar period when water use restricts were not in effect.
  - ➢ Marine engines may be flushed with water for a period that does not exceed 5 minutes after each use.
- Washing of sidewalks, streets, driveways, parking lots, service station aprons, exteriors of homes or apartments, commercial or industrial buildings or any other outdoor surface, except where required to ensure public safety and health or where mandated by federal, state, or local law.
  - ➢ Driveways and roadways may be pre-washed in preparation for recoating and sealing.
  - ➢ Tennis courts composed of clay or similar materials may be wetted by means of a hand held hose equipped with an automatic shutoff device at the minimum rate necessary for maintenance. Automatic wetting systems may be used between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary.
  - ➢ Public eating and drinking areas may be washed using the minimum amount of water required to assure sanitation and public health.
  - ➢ Water may be used at the minimum rate necessary to maintain effective dust control during the construction of highways and roads.
- Unrestricted irrigation of lawns is prohibited.
  - ➢ Newly sodded and seeded areas may be irrigated to establish cover on bare ground at the minimum rate necessary for no more than a period of 60 days. Irrigation rates may not exceed 1 inch of applied water in any 7-day period.
  - ➢ Gardens, bedding plants, trees, shrubs and other landscape materials may be watered with hand-held containers; hand-held hoses equipped with an automatic shutoff device; sprinklers; or other automated watering devices at the minimum rate necessary, but in no case more frequently than twice per week. Irrigation should not occur during the heat of the day.
  - ➢ All allowed lawn irrigation must be applied in a manner to assure that no runoff, puddling, or excessive watering occurs.
  - ➢ Irrigation systems may be tested after installation, routine maintenance, or repair for no more than 10 minutes per zone.
  - ➢ All allowed lawn irrigation must be done between the hours of 8:00 p.m. and 10:00 a.m.
- Watering of golf courses should be limited.

7.5.3 Stage 3 – Drought Emergency

The individual utilities or water system owners will determine, after consultation with the Chairman of the Drought Committee, that declaration of Drought Emergency (Stage 3) is appropriate for their respective systems. In Stage 3 of a water shortage, allocations for residential and non-residential customers are established, and customers exceeding those allotments are notified. The focus of this stage is educating the community and preparing for possible water rationing. A 10 to 15 percent reduction in total system demand, compared to the same month in a non-drought year, is targeted.

7.5.3.1 Restrictions for Residential Customers

The goal is to reduce water use by 10 to 15 percent. During a Drought Emergency, the following actions are prohibited for residential customers of the public water systems:

- Use of water for the operation of ornamental fountains, artificial waterfalls, misting machines, reflecting pools, or any other structure making a similar use of water is prohibited.
- The filling of swimming or wading pools requiring more than 5 gallons of water, or the refilling of swimming or wading pools which were drained after the effective date of the declaration of emergency, except that pools may be filled to a level of 2 feet below normal, or water may be added to bring the level to 2 feet below normal as necessary to protect the structure from hydrostatic damage. Residential swimming pools may be filled only to protect its structural integrity.
- Using fire hydrants for any purpose other than necessary governmental operations.
- The operation of any water-cooled comfort air-conditioning that does not have water-conserving equipment in operation.
- Use of water for washing or cleaning of mobile equipment including automobiles, trucks, trailers, and boats is prohibited.
    - Mobile equipment may be washed at car washes that utilize reclaimed water as part of the wash process or reduce water consumption by at least 10 percent when compared to a similar period when water use restrictions were not in effect.
- Washing of sidewalks, streets, driveways, parking lots, service station aprons, exteriors of homes or apartments, commercial or industrial buildings, or any other outdoor surface, except where mandated by federal, state, or local law.
- Watering of outside shrubbery, trees, lawns, grass, plants, home vegetable gardens, or any other vegetation except from a watering can or other container not exceeding 5 gallons in capacity.
    - Newly sodded and seeded areas may be irrigated to establish cover on bare ground at the minimum rate necessary for no more than a period of 60 days. Irrigation rates may not exceed 1 inch of applied water in any 7-day period.
    - Gardens, bedding plants, trees, shrubs, and other landscape materials may be watered with hand-held containers; hand-held hoses equipped with an automatic shutoff device; sprinklers; or other automated watering devices at the minimum rate necessary, but in no case more frequently than twice per week. Irrigation should not occur during the heat of the day.

- All allowed lawn irrigation must be applied in a manner to assure that no runoff, puddling, or excessive watering occurs.
- Irrigation systems may be tested after installation, routine maintenance, or repair for no more than 10 minutes per zone.
- All allowed lawn irrigation must be done between the hours of 8:00 p.m. and 10:00 a.m.

7.5.3.2 Restrictions for Non-Residential Customers

Non-residential customers reduce water use by 15 percent, or implement approved individual customer specific drought contingency plans for Stage 3. Also, the following actions are prohibited in the public water systems:

- Use of water for the operation of ornamental fountains, artificial waterfalls, misting machines, reflecting pools, or any other structure making a similar use of water is prohibited.
- The filling of swimming or wading pools requiring more than 5 gallons of water, or the refilling of swimming or wading pools which were drained after the effective date of the declaration of emergency, except that pools may be filled to a level of 2 feet below normal, or water may be added to bring the level to 2 feet below normal as necessary to protect the structure from hydrostatic damage. Swimming pools operated by health care facilities used in relation to patient care and rehabilitation may be filled or topped off.
- Using fire hydrants for any purpose other than necessary governmental operations.
- Serving water in restaurants, cafeterias, or any other establishment, unless specifically requested by the individual being served.
- The operation of any water-cooled comfort air-conditioning that does not have water-conserving equipment in operation.
- Use of water for washing or cleaning of mobile equipment, including automobiles, trucks, trailers, and boats are prohibited.
    - Mobile equipment may be washed at car washes that utilize reclaimed water as part of the wash process or reduce water consumption by at least 10 percent when compared to a similar period when water use restrictions were not in effect.
- Washing of sidewalks, streets, driveways, parking lots, service station aprons, exteriors of homes or apartments, commercial or industrial buildings, or any other outdoor surface, except where mandated by federal, state, or local law.
- Watering of outside shrubbery, trees, lawns, grass, plants, home vegetable gardens, or any other vegetation except from a watering can or other container not exceeding 5 gallons in capacity. This limitation shall not apply to commercial greenhouses or nursery stocks, which may be watered in the minimum amount required to preserve plant life before 7:00 a.m. or after 8:00 p.m.
    - Newly sodded and seeded areas may be irrigated to establish cover on bare ground at the minimum rate necessary for no more than a period of 60 days. Irrigation rates may not exceed 1 inch of applied water in any 7-day period.

- Gardens, bedding plants, trees, shrubs and other landscape materials may be watered with hand-held containers; hand-held hoses equipped with an automatic shutoff device; sprinklers; or other automated watering devices at the minimum rate necessary, but in no case more frequently than twice per week. Irrigation should not occur during the heat of the day.
- All allowed lawn irrigation must be applied in a manner to assure that no runoff, puddling, or excessive watering occurs.
- Irrigation systems may be tested after installation, routine maintenance, or repair for no more than 10 minutes per zone.
- All allowed lawn irrigation must be done between the hours of 8:00 p.m. and 10:00 a.m.

- Unrestricted irrigation of golf courses is prohibited.
  - Tees and greens may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary.
  - Localized dry areas may be irrigated with a hand-held container or hand- held-hose equipped with an automatic shutoff device at the minimum rate necessary.
  - Greens may be cooled by syringing or by the application of water with a hand held hose equipped with an automatic shutoff device at the minimum rate necessary.
  - Fairways may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary not to exceed 1 inch of applied water in any 10-day period.
  - Fairways, tees, and greens may be irrigated during necessary overseeding or resodding operations in September and October at the minimum rate necessary. Irrigation rates during this restoration period may not exceed 1 inch of applied water in any 7-day period.
  - Newly constructed fairways, tees, greens, and areas that are re-established by sprigging or sodding may be irrigated at the minimum rate necessary not to exceed 1 inch of applied water in any 7-day period for a total period that does not exceed 60 days.
- Fairways, tees, and greens may be irrigated without regard to the restrictions listed above so long as:
  - The only water sources utilized are water features whose primary purpose is stormwater management.
  - Any water features utilized do not impound permanent streams.
  - During declared Drought Emergencies, these water features receive no recharge from other water sources such as groundwater wells, surface water intakes, or sources of public water supply.
  - All irrigation occurs between 9:00 p.m. and 10:00 a.m.
  - All allowed golf course irrigation must be applied in a manner to assure that no runoff, puddling, or excessive watering occurs.
  - Rough areas may not be irrigated.

- Unrestricted irrigation of athletic fields is prohibited.
  - Athletic fields may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. at a rate not to exceed 1 inch per application or more than a total of 1 inch in multiple applications during any 10-day period. All irrigation water must fall on playing surfaces with no outlying areas receiving irrigation water directly from irrigation heads.
  - Localized dry areas that show signs of drought stress and wilt (curled leaves, foot-printing, purpling) may be syringed by the application of water for a cumulative time not to exceed 15 minutes during any 24-hour period. Syringing may be accomplished with an automated irrigation system or with a hand-held hose equipped with an automatic shutoff device at the minimum rate necessary.
  - Athletic fields may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. during necessary overseeding, sprigging, or resodding operations at the minimum rate necessary for a period that does not exceed 60 days. Irrigation rates during this restoration period may not exceed 1 inch of applied water in any 7-day period. Syringing is permitted during signs of drought stress and wilt (curled leaves, foot-printing, or purpling).
  - All allowed athletic field irrigation must be applied in a manner to assure that no runoff, puddling, or excessive watering occurs.
  - Irrigation is prohibited on athletic fields that are not scheduled for use within the next 120-day period.
  - Water may be used for the daily maintenance of pitching mounds, home plate areas, and base areas with the use of hand-held containers or hand-held hoses equipped with an automatic shutoff device at the minimum rate necessary.
  - Skinned infield areas may utilize water to control dust and improve playing surface conditions utilizing hand-held containers or hand-held hoses equipped with an automatic shutoff device at the minimum rate necessary no earlier than 2 hours prior to official game time.

7.6 Implementation and Enforcement

The responsibility of implementing and enforcing conservation measures and water use restrictions will be the individual water providers. For example, in the Town of Orange, Ordinance Number 02-08, Sections 74-56 through 74-59 (Appendix H) gives the Town Manager, with the approval of the Town Council, the authorization to declare water emergencies and implement certain water use restrictions. A similar authorization is given to the Town Manager of Gordonsville through the Town of Gordonsville Ordinance Number 23.19-02 through 23.19-05 (Appendix K). The Rapidan Service Authority (RSA) is charged with overseeing conservation and water use restrictions for customers receiving water from the Wilderness Water Treatment Plant (Appendix J).

Since there is no countywide measure for enforcing water use restrictions, the Drought Committee should act as a facilitator, providing common ground and communications among the stakeholders. The committee may make recommendations, based on the Drought Contingency Plan, to the appropriate officials, thereby helping to reinforce or strengthen certain Town and County ordinances already in place.

During each drought stage, certain measures should be taken to ensure appropriate response to water shortages for each respective water system. The Drought Committee is charged with coordinating the appropriate actions to be taken.

7.6.1 Stage 1 – Drought Watch

7.6.1.1 Drought Stage Declaration

Public notice of the declaration of a Stage 1 water shortage in specific water systems is required by publication in the newspaper, or broadcast by radio or television. Voluntary water conservation becomes effective by publishing in the newspaper or broadcast by radio or television.

7.6.1.2 Public Education

Initiate a public education program, including explanation of drought conditions and reason for implementing Stage 1. Explain future stages of the drought contingency plan. Distribute simple technical information on reducing water use. Identify appropriate City/County contacts and phone numbers to forward customer calls.

7.6.1.3 Conservation Strategies

- Provide technical specifications and information on where low-flow showerheads and water-saving toilet devices may be obtained.
- Update water use data and information for residential and non-residential customer classes for later use in setting mandatory reductions and allotments. Focus on determining feasible reductions based on per capita and household demand.
- Request submission or update of non-residential customer specific drought contingency plans.
- Each utility should attempt to locate and correct any leaks.

7.6.2 Stage 2 – Drought Warning

7.6.2.1 Drought Stage Declaration

Public notice of the declaration for specific water systems is required by publication in the newspaper, or broadcast by radio or television. Specific restrictions become effective by publishing in the newspaper or by broadcast on radio or television.

7.6.2.2 Public Education

Continue public education program, including explanation of new drought conditions and reason for implementing Stage 2. Explain future stages of the drought contingency plan. Distribute additional conservation information.

7.6.2.3 Conservation Strategies

- Provide technical specifications and information on where low-flow showerheads and water-saving toilet devices may be obtained.

7.6.2.4 Excess Use Charges

Discuss billing schedule changes and other preparations needed for possible future implementation of drought surcharges. Through customer education, explain how the excess use surcharge will apply, if implemented in later stages of the drought.

7.6.3 Stage 3 – Drought Emergency

7.6.3.1 Drought Stage Declaration

Public notice of the declaration for specific water systems is required by publication in the newspaper, or broadcast by radio or television. Specific restrictions become effective by publishing in the newspaper or by broadcast on radio or television.

7.6.3.2 Public Education

Continue public education program, including explanation of new drought conditions and reason for implementing Stage 3.

7.6.3.3 Excess Use Charges

Discuss billing schedule changes and other preparations needed for possible implementation of drought surcharges. Through customer education, explain how the excess use surcharge will apply, if implemented.

7.6.3.4 Drought Surcharge Rates

Such rates may include, but not be limited to the following:

- Higher charges per unit for increasing water usage (peak charges).
- Higher rates to recover increased costs of water purchased from other jurisdictions.
- Discounts for conserving water beyond specific levels.

In some cases, the mandatory non-essential water use restrictions may not be sufficient to protect the supplies of an individual public waterworks. When an individual waterworks' sources are so depleted as to threaten public health and safety, it may become necessary to ration water within that system in order to assure that water is available to support essential uses. Rationing water is a more severe measure than merely banning non-essential uses of water. Under rationing, each customer is allotted a given amount of water, based on a method of allotment developed by the waterworks or local government. Generally, it will be based on a percentage of previous usage or on a specific daily quantity per household. Rationing is more likely to have more of an effect on welfare than mandatory non-essential use restrictions, because industrial and commercial water uses may be curtailed or eliminated to assure that an adequate supply is available for human consumptive uses.

The decision to ration water will be made by the local government or waterworks operator. The Virginia Drought Coordinator will work closely with any entity where water rationing is required to assure that all available state resources are effectively used to support these highly stressed water supply systems. The Virginia Department of Emergency Management (VDEM) is the first point of contact for waterworks or local governments who decide to ration water. VDEM will coordinate the Commonwealth's response and assistance to such entities.

This drought contingency plan recognizes three graduated drought stages: Stage 1 – Drought Watch, Stage 2 – Drought Warning, and Stage 3 – Drought Emergency. Drought stage is a function of indicators specific to the water source utilized by the water system as listed in Table 7-2:

Table 7-2 Drought Indicators

Water System	Drought indictors Utilized
Town of Orange	Precipitation Streamflow 45 MG Reservoir Level VWP Permit
Town of Gordonsville	Precipitation Streamflow 45 MG Reservoir Level VWP Permit
RSA Route 15	Precipitation Streamflow 45 MG Reservoir Level VWP Permit
RSA Wilderness	Precipitation Streamflow VWP Permit
RSA Route 20	Long Term Precipitation Gordonsville Observation Well Level Route 20 Well Levels
Wolftrap Woods	Long Term Precipitation Gordonsville Observation Well Level

At the onset of a drought, certain conservation measures are recommended. These recommended measures start with voluntary conservation for a drought warning and progress to stringent mandatory water use restrictions during drought emergencies. The goals of the recommended conservation measures are to reduce water usage by 5 percent during a drought watch, by 5 to 10 percent during a drought warning, and by 10 to 15 percent during a drought emergency.

A key factor in achieving conservation goals is public education. Water utilities and private water system owners, with the assistance of the Drought Committee, should alert customers to the drought status and inform them of actions required to respond to water shortages. Public notification and education can be accomplished through several outlets, including local media. While both the Town of Orange and Gordonsville have drought ordinances, it is recommended that the drought committee coordinate an effective countywide public education approach to water conservation.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Water Supply Need is Real

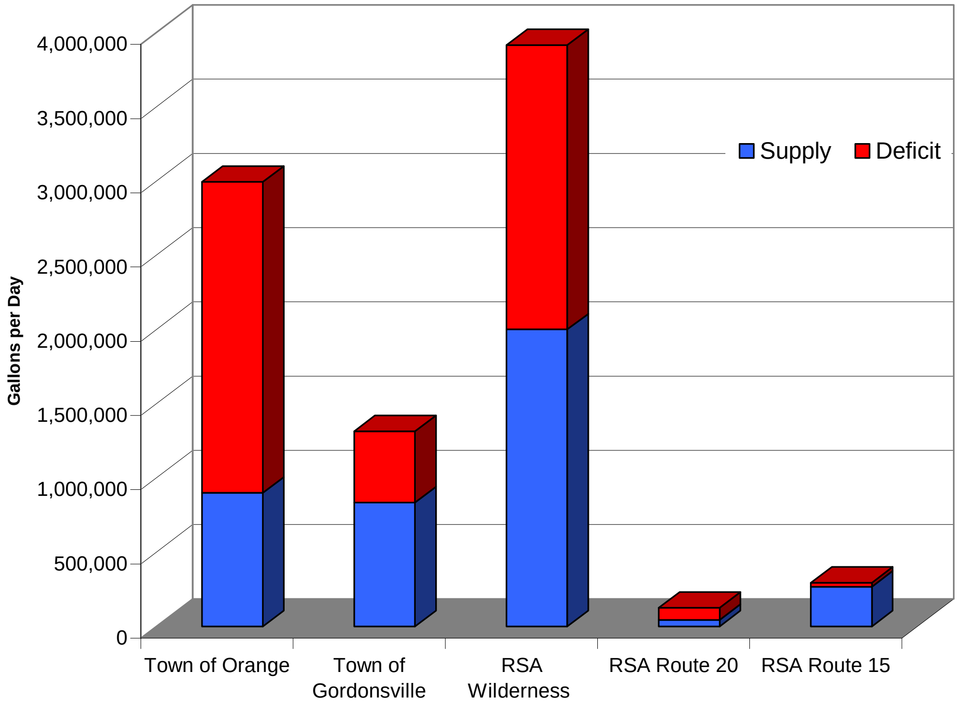
Based upon the current contractual agreements, some of the public water systems in Orange County could experience periods of water shortages as early as 2010. Despite the fact that the duration and frequency of these water shortages cannot be predicted, they will most likely first occur during the late summer and early fall, when stream flows and groundwater levels are typically at their lowest. Even though roughly half of the residents depend on the Rapidan River and the other half depend on groundwater, all residents could possibly be impacted. Dry wells could force some residents to purchase and transport containers of water for basic domestic use, while residents on public water systems in the county could likely face mandatory restrictions that will limit water use.

The potential for water shortages in Orange County is caused by the following two primary conditions:

- Increased Growth - All of the large water demand centers in Orange County where established public utilities exist will experience, on average, a 300 percent population growth from 2000 to 2050, which will lead to an increase in water demand.
- No Growth in Water Supply - There are no planned increases in available water for Orange County.

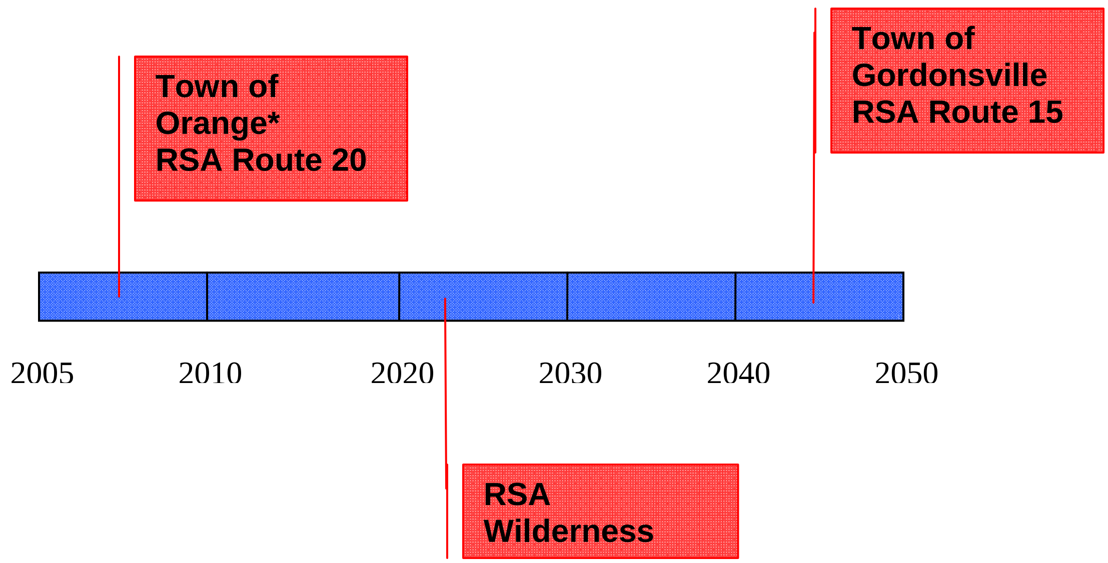
Based on the present water supply and the projected maximum day demands in 2050, Figure 8-1 shows the amount of water deficits for all of the developed water systems. For example, the figure shows that the Town of Orange has an overall demand in 2050 of 2.9 MGD with a supply of 0.9 MGD, which means there is a deficit of 2.0 MGD.

Figure 8-1 2050 Projected Water Demand with Available Supply and Deficit



The existing water supply sources will not be able to sustain the anticipated water demands starting in the years shown in Figure 8-2. For example, the RSA Wilderness system could expect a shortfall, or deficit, between 2020 and 2025. The figure shows that the Town of Orange and RSA Route 20 will experience some water shortage conditions first.

Figure 8-2 Water Supply Shortage Timeline



* Town of Orange realizes shortfall if RSA RT 15 system uses their contracted allotment.

Both Figures 8-1 and 8-2 show a clear statement of need for additional water supply alternatives for Orange County. Without the identification and development of new sources, water shortages will occur in Orange County.

8.2 What are the Alternatives?

This study attempted to identify and evaluate all possible water supply alternatives to address the future water shortage in Orange County:

- Development of new surface water sources.
- Development of new groundwater sources.
- Construction of new raw water storage.
- Regional water supply approaches.
- Interconnections within and outside of the county.
- Water demand management alternatives.

These alternatives were evaluated qualitatively and quantitatively, using the following two-level screening process.

Some of the alternatives eliminated during the screening process could become favorable options as conditions change over time; and the County, the Towns, and the Service Authority should remain open to consideration of those opportunities. These alternatives include:

- **Interconnections with Other Counties and Development of Regional Options Outside Orange County.** This option would be viewed favorably if location and timing are consistent with Orange County's developing needs.
- **Water Reuse.** This is an excellent option for reducing non-potable water demands. However, to be an economically viable option, the use of the reclaimed water needs to be located near a wastewater treatment plant that produces the highly treated water. Once the state regulation is finalized, and use of reclaimed water becomes an accepted practice in Virginia, the costs and benefits of the Water Reuse alternative can be better quantified.

This process identified the five new pumped storage reservoirs as viable alternatives. These reservoirs were located on the following streams:

- Unnamed Tributary above Wilderness Run
- Mountain Run
- Mine Run
- Poplar Run
- Poplar - Laurel Run

In addition to the five pumped storage reservoir sites identified as viable alternatives, other potential reservoir sites identified in the Orange County Water Supply Plan, or that may come to light in the future, may be considered if the property owners are willing to convey the property to a public or semi-public entity for development of a public water supply reservoir. One such site currently fits this criterion – Shotgun Hill Branch. This potential reservoir site should also be investigated in further detail.

The groundwater exploration process also identified some Primary Groundwater Development Zones as viable alternatives (Emery & Garrett Groundwater, Inc, October 2006). The Phase 1 Groundwater Exploration and Development report is included in this report as Appendix C. This report concluded a reasonable yield from the Primary Groundwater Development Zones to be between 1.0 MGD and 2.0 MGD (total from all wells in the primary zones). While this alternative may not meet the expected overall deficit, the use of groundwater could complement the development of water supply reservoirs. For most parts of the country, groundwater is considered the most reliable and safest source of drinking water supply. Groundwater has historically been a significant resource for municipalities in the region. It is likely that groundwater sources will continue to be an important component of water systems in the region.

Water conservation programs are needed to sustain the existing water supplies in time of drought, as well as to defer the need for additional supplies. Initial implementation of these programs has been shown to result in significant benefits in some systems; however, the magnitude of expected benefits is unique to each water system. It was determined that water conservation measures could produce a total demand reduction of 1.1 MGD; however, this involved a number of assumptions that have not been implemented.

8.3 Proposed Planning Scenario

Since the development of water supply reservoirs and groundwater have different regulatory and schedule requirements, as well as financial impacts, a planning scenario was proposed to ensure that adequate future water supply is brought on-line in a timely manner that fits Orange County's needs.

Orange County has a combined deficit water supply of 4.61 MGD for the year 2050. As shown in Figure 8-2, the Town of Orange and RSA Route 20 water system's available water supply is already limited and is anticipated to be the first to experience water shortages; therefore, immediate development of groundwater is recommended for these systems.

Assuming the primary groundwater zone is found to be productive and that 2.0 MGD of groundwater could be developed by the year 2010, then the water supply could sustain the future water demand for another 20 years (approximately through the year 2030), after which additional sources of supply would be needed. This is not to say that the development of surface water resources should be deferred until 2030. The permitting process for the surface water resources is often time consuming and thus it should begin immediately.

The maximum day demand at the RSA Wilderness water system is expected to exceed the present level of supply of 2.0 MGD sometime between 2025 and 2030. The 1Q30 for Rapidan at the Wilderness intake (as calculated in Technical Memorandum No. 1) is 3.09 MGD. This study recommends that RSA begin to revise its permit to allow for an increased intake capacity of 3.09 MGD. Prior to initiating the permitting process, a plant rating study would need to be conducted to determine the options of increasing the water treatment plant. This would enable the supply to meet or exceed the projected maximum day demands for another 10 years (through approximately the year 2035).

Based on the development of groundwater and the revision of the RSA Wilderness Permit, these alternatives would ensure a sufficient water supply until approximately 2035. This study recommends development of a suitable reservoir location from the three selected pumped storage reservoir alternatives for meeting the water demands after the year 2035.

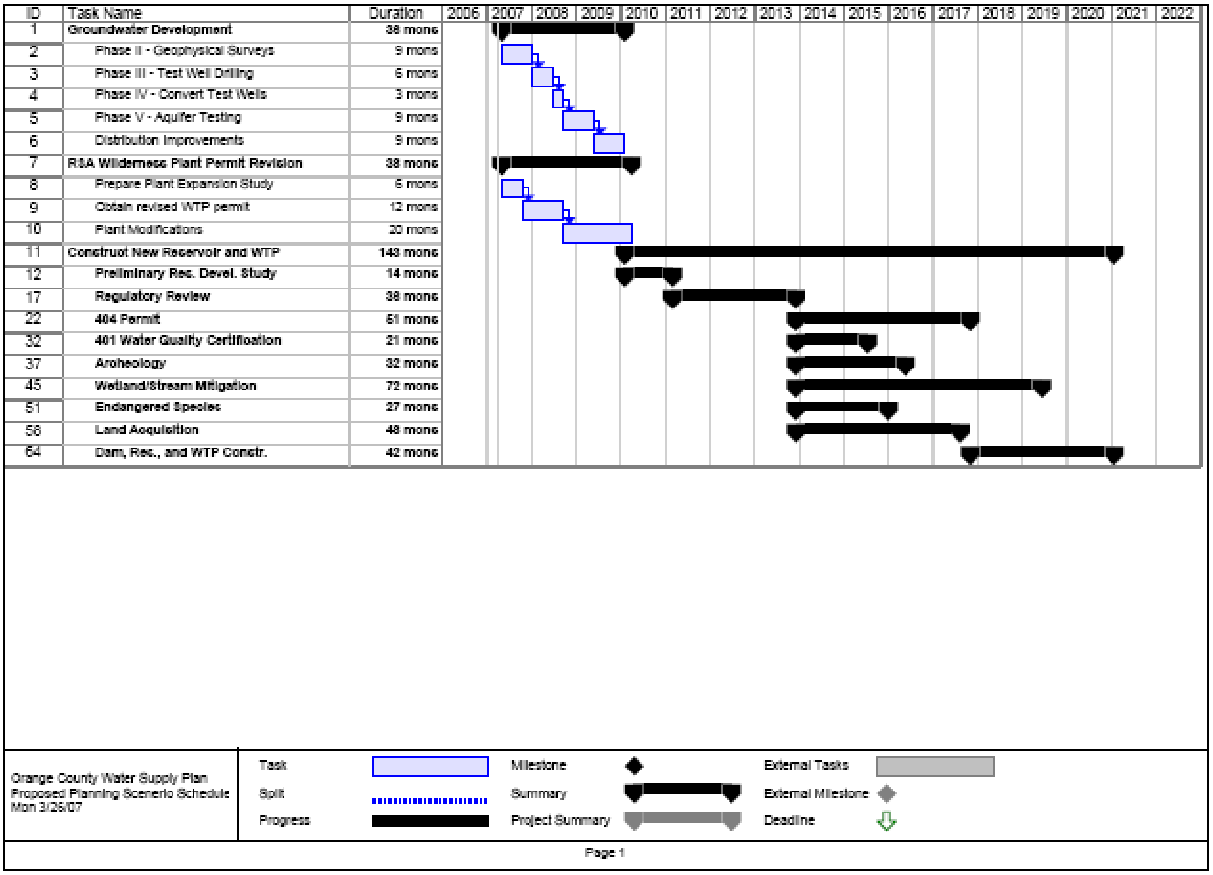
8.3.1 Planning Schedule

A planning schedule was created for these alternatives as shown in Figure 8-3. A more detailed breakdown of this schedule is included in this report as Appendix L. This schedule shows that groundwater development would begin as soon as possible, with production of water anticipated by mid-2009. The process to revise the Wilderness WTP's permit was also shown to begin immediately, with the earliest increase in capacity occurring by mid-2009.

This study recommends proceeding with the development of a new reservoir and water treatment plants as soon as groundwater development and Wilderness WTP permit revision is completed. The process of constructing a new reservoir was anticipated to take 12 years with completion of the reservoir and WTP as early as 2020. While this additional water may not be needed until 2030, it may be in the County's and interested stakeholders' best interest to begin the process of developing a reservoir earlier rather than later since this study was based on many assumptions. These assumptions could affect the exact timing of when water may be needed from the reservoir. Potential issues that could affect the timing include the following:

- Unexpected changes in water demands.
- Source water quality degradation.
- Wilderness WTP permit revision implementation.
- Groundwater development implementation.

Figure 8-3 Planning Level Schedule



8.4 Recommendations

Orange County and its plan participants should consider the following recommendations:

- **Groundwater Development** - The Town of Orange, Town of Gordonsville, and RSA should consider developing new groundwater sources immediately for the water demand centers.
- **New Raw Water Reservoir** - Since permitting of a water supply reservoir will be more challenging and will likely require more time and resources to complete, Orange County and interested stakeholders should begin developing a new water source. Permitting requirements for new raw water reservoir are significant, with much uncertainty as to the time and resources needed to complete the process successfully. Recent experiences of other Virginia communities attempting to permit new reservoir supplies have taken 15 to 20 years.

- **Increase RSA Wilderness Intake Permit** - RSA should pursue a permit modification for its Wilderness permit to allow 3.09 MGD withdrawal based on this study's 1Q30 analysis. RSA has already submitted an application to the Virginia Department of Environmental Quality requesting a permitted withdrawal of 3.0 MGD. A plant expansion study will be needed that would outline options for increasing the plant capacity.
- **Drought Contingency Plans** - The Town of Orange and Town of Gordonsville have drought ordinances and the Rapidan Service Authority has a Drought Water Conservation Plan for its Wilderness Water System. The Town of Orange-RSA Route 15-Gordonsville combined water systems should have one drought contingency plan since the raw water source for the combined systems is the intake on the Rapidan River at Orange. The RSA Route 20 and RSA Wilderness systems can have independent drought contingency plans as they utilize different sources. The water supply plan participants should consider a stakeholder-led committee (Orange County Drought Committee), as proposed in the Drought chapter. It is recommended that the drought committee coordinate an effective countywide public education approach to water conservation and drought management.
- **Water Conservation and Drought Management** - Water Conservation and demand management programs are needed to sustain the existing water supplies in time of drought, as well as to defer the need for additional supplies. Initial implementation of these programs has been shown to result in significant benefits in some systems; however, the magnitude of expected benefits is unique to each water system.
- **Water Audits** - Each water purveyor should initiate a water audit.
- **Other** - The County, the Towns, and the Service Authority should remain open to consideration of the following alternatives:
  - **Interconnections with neighboring utilities.** As a parallel activity to the preliminary steps of the groundwater and surface water development, the following should be conducted:
    - Discussions with Louisa County regarding purchase of finished water to augment the Town of Orange and Town of Gordonsville.
    - Discussions with Spotsylvania County regarding purchase of finished water to augment the Wilderness supply.
  - **Water reuse.** This is an excellent option for reducing non-potable water demands. However, to be an economically viable option, the use of the reclaimed

water needs to be located near a wastewater treatment plant that produces highly treated water. Once the state regulation is finalized, and use of reclaimed water becomes an accepted practice in Virginia, the costs and benefits of the Water Reuse alternative can be better quantified.

With increasing needs and limited existing supplies, the potential for future water shortage exists. Orange County has already experienced a very real water shortage caused by the recent drought in the Commonwealth of Virginia that peaked in the summer of 2002. While the water shortage potential is very real, that is not Orange County’s destiny. The evaluations conducted in this study will serve to assist the community in securing additional reliable sources of water supply to ensure that adequate and safe drinking water is available to all citizens of the County while serving to encourage, promote, and protect all other beneficial uses of Orange County’s and the Commonwealth's water resources.

Appendices

APPENDIX-A

Adequacy Analysis for Orange County Water Supply Study Calculations

Table A 1 2005 - 2050 Water Supply Adequacy Analysis- Based on Population Projections and River Intake Permits

(Max Day Demand)

Includes Unaccounted for Water

Service Area			**Gallons per day**					
			2005	2010	2020	2030	2040	2050
Town of Gordonsville			**<--exist gpcd (res)-->**			**<--------190 gpcd (residential)-------->**		
	Demand	Low Estimate	398,700	442,693	548,342	682,254	783,114	900,167
		Median Estimate	398,700	466,321	644,230	861,742	1,063,034	1,314,488
		High Estimate	398,700	491,090	757,347	1,089,913	1,446,180	1,924,973
	Supply[1]	(assumed constant)	833,333	833,333	833,333	833,333	833,333	833,333
	Shortfall / Excess[2]	Low Estimate	434,633	390,640	284,991	151,080	50,219	-66,833
		Median Estimate	434,633	367,012	189,103	-28,408	-229,700	-481,155
		High Estimate	434,633	342,243	75,987	-256,579	-612,846	-1,091,640
RSA Route 15			**<--exist gpcd (res)-->**			**<--------190 gpcd (residential)-------->**		
	Demand	Low Estimate	127,152	138,329	164,130	185,099	202,600	221,836
		Median Estimate	127,152	144,578	187,737	222,184	255,646	294,250
		High Estimate	127,152	151,062	214,620	266,504	322,256	389,798
	Supply[3]	(assumed constant)	266,667	266,667	266,667	266,667	266,667	266,667
	Shortfall / Excess[2]	Low Estimate	139,515	128,338	102,536	81,568	64,067	44,831
		Median Estimate	139,515	122,088	78,930	44,483	11,021	-27,583
		High Estimate	139,515	115,604	52,047	163	-55,589	-123,132
Town of Orange			**<--exist gpcd (res)-->**			**<--------190 gpcd (residential)-------->**		
	Demand	Low Estimate	1,042,560	1,151,070	1,403,148	1,828,576	2,019,885	2,231,210
		Median Estimate	1,042,560	1,208,613	1,624,275	2,223,901	2,580,928	2,995,272
		High Estimate	1,042,560	1,268,434	1,877,592	2,700,216	3,291,548	4,012,378
	Supply[4]	(assumed constant)	900,000	900,000	900,000	900,000	900,000	900,000
	Shortfall / Excess[2]	Low Estimate	-142,560	-251,070	-503,148	-928,576	-1,119,885	-1,331,210
		Median Estimate	-142,560	-308,613	-724,275	-1,323,901	-1,680,928	-2,095,272
Subtotal Orange WTP:		High Estimate	-142,560	-368,434	-977,592	-1,800,216	-2,391,548	-3,112,378

(Max Day Demand)

Includes Unaccounted for Water

Service Area			Gallons per day					
			2005	2010	2020	2030	2040	2050
	Demand	Low Estimate	1,568,412	1,732,092	2,115,621	2,695,928	3,005,599	3,353,212
		Median Estimate	1,568,412	1,819,512	2,456,241	3,307,826	3,899,607	4,604,010
		High Estimate	1,568,412	1,910,586	2,849,558	4,056,632	5,059,983	6,327,150
	Supply[5]	(assumed constant)	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
	Shortfall / Excess[6]	Low Estimate	431,588	267,908	-115,621	-695,928	-1,005,599	-1,353,212
		Median Estimate	431,588	180,488	-456,241	-1,307,826	-1,899,607	-2,604,010
		High Estimate	431,588	89,414	-849,558	-2,056,632	-3,059,983	-4,327,150
RSA Route 20			<--exist gpcd (res)-->			<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	45,216	49,922	60,855	76,828	84,866	93,745
		Median Estimate	45,216	52,418	70,445	93,438	108,439	125,848
		High Estimate	45,216	55,012	81,431	113,451	138,296	168,582
	Supply[7]	(assumed constant)	43,200	43,200	43,200	43,200	43,200	43,200
	Shortfall / Excess	Low Estimate	-2,016	-6,722	-17,655	-33,628	-41,666	-50,545
		Median Estimate	-2,016	-9,218	-27,245	-50,238	-65,239	-82,648
		High Estimate	-2,016	-11,812	-38,231	-70,251	-95,096	-125,382
Subtotal Orange WTP + RSA Route 20								
	Demand	Low Estimate	1,613,628	1,782,014	2,176,476	2,772,757	3,090,465	3,446,958
		Median Estimate	1,613,628	1,871,930	2,526,686	3,401,265	4,008,046	4,729,857
		High Estimate	1,613,628	1,965,598	2,930,990	4,170,083	5,198,279	6,495,732
	Supply	(assumed constant)	2,043,200	2,043,200	2,043,200	2,043,200	2,043,200	2,043,200
	Shortfall / Excess	Low Estimate	429,572	261,186	-133,276	-729,557	-1,047,265	-1,403,758
		Median Estimate	429,572	171,270	-483,486	-1,358,065	-1,964,846	-2,686,657
		High Estimate	429,572	77,602	-887,790	-2,126,883	-3,155,079	-4,452,532

(Max Day Demand)

Includes Unaccounted for Water

Service Area			Gallons per day					
			2005	2010	2020	2030	2040	2050
RSA Wilderness								
			<--exist gpcd (res)-->		**150 gpcd**	**<--------190 gpcd (residential)-------->**		
	Demand	Low Estimate	1,103,382	1,218,918	1,485,855	2,068,400	2,284,801	2,523,842
		Median Estimate	1,103,382	1,343,199	1,988,263	2,907,896	3,374,731	3,916,514
		High Estimate	1,103,382	1,477,417	2,645,829	4,481,037	6,022,139	8,093,251
	Supply[8]	(assumed constant)	**2,000,000**	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
	Shortfall / Excess	Low Estimate	896,618	781,082	514,145	-68,400	-284,801	-523,842
		Median Estimate	896,618	656,801	11,737	-907,896	-1,374,731	-1,916,514
Subtotal public systems:		High Estimate	896,618	522,583	-645,829	-2,481,037	-4,022,139	-6,093,251
	Demand	**Low Estimate**	**2,717,010**	**3,000,933**	**3,662,331**	**4,841,157**	**5,375,266**	**5,970,799**
		Median Estimate	**2,717,010**	**3,215,129**	**4,514,950**	**6,309,160**	**7,382,778**	**8,646,371**
		High Estimate	**2,717,010**	**3,443,015**	**5,576,819**	**8,651,119**	**11,220,418**	**14,588,983**
	Supply[9]	**(assumed constant)**	**4,043,200**	**4,043,200**	**4,043,200**	**4,043,200**	**4,043,200**	**4,043,200**
	Shortfall / Excess[6]	**Low Estimate**	**1,326,190**	**1,042,267**	**380,869**	**-797,957**	**-1,332,066**	**-1,927,599**
		Median Estimate	**1,326,190**	**828,071**	**-471,750**	**-2,265,960**	**-3,339,578**	**-4,603,171**
		High Estimate	**1,326,190**	**600,185**	**-1,533,619**	**-4,607,919**	**-7,177,218**	**-10,545,783**

[1] Assumed that water will be supplied to full capacity as per the agreement between the Town of Gordonsville and RSA Route 15. As per the agreement the Town of Gordonsville shall get 25 MG of water every month from RSA. The agreement is effective through May 2011. For the calculations each month is assumed to be of 30 days. A constant supply through 2050 is assumed.

[2] The shortfall/ excess is defined as the difference between the supply and the demand. A negative value indicates a shortfall, while a positive value indicates excess for that particular part of system.

[3] Assumed that water will be supplied to full capacity as per the agreement between the Town of Orange and RSA. As per the agreement the RSA shall get 33 MG of water every month from the Town of Orange. The agreement is effective through September 2023. For the calculations each month is assumed to be of 30 days. A constant supply through 2050 is assumed.

[4] Supply values are taken based on WTP capacity at the Town of Orange (2.0 MGD) minus the water that is supplied to RSA Route 15 (i.e. 33 MG per month). A constant supply through 2050 is assumed. The safe yield of the river intake is not considered.

(Max Day Demand)

Includes Unaccounted for Water

Service Area		Gallons per day					
		2005	2010	2020	2030	2040	2050

[5] Supply values are taken based the permitted capacity of WTP (2.0 MGD). A constant supply through 2050 is assumed. The safe yield of the river intake is not considered.

[6] A negative value indicates a shortfall. The values are representative of the system as a whole and may not reflect the excess or shortfall in sub-systems

[7] The supply values are based on safe yield of 30 gallons per minute of the well on Route 20 as reported in the Orange County Comprehensive Plan. A constant supply through 2050 is assumed.

[8] Supply values are taken based the permitted river intake capacity at Wilderness (2.0 MGD). A constant supply through 2050 is assumed. The safe yield of the river intake is not considered.

[9] Supply values are added up for all the public systems (RSA-Route 15, Town of Gordonsville, Town of Orange, RSA Route 20 and RSA Wilderness). It is to check the adequacy of the system if all the supply sources and demands are combined.

Totals include all major existing uses plus existing water loss percentage

The calculations do not include fire demand.

Losses for community systems, schools, agriculture, and individual residences are considered negligible.

Table A-2 2005 - 2050 Water Supply Adequacy Analysis- Based on Population Projections and River Intake Permits

(Annual Average Daily Demand)

Includes Unaccounted for Water

Service Area			**Gallons per day**					
			2005	**2010**	**2020**	**2030**	**2040**	**2050**
Town of Gordonsville			**<--exist gpcd (residential)-->**			**<--------190 gpcd (residential)-------->**		
	Demand	Low Estimate	221,500	245,940	304,635	379,030	435,063	500,093
		Median Estimate	221,500	259,067	357,905	478,745	590,574	730,271
		High Estimate	221,500	272,828	420,748	605,507	803,433	1,069,430
	Supply[1]	(assumed constant)	833,333	833,333	833,333	833,333	833,333	833,333
	Shortfall / Excess[2]	Low Estimate	611,833	587,393	528,699	454,304	398,270	333,241
		Median Estimate	611,833	574,266	475,428	354,588	242,759	103,062
		High Estimate	611,833	560,506	412,585	227,826	29,900	-236,096
RSA Route 15			**<--exist gpcd (residential)-->**			**<--------190 gpcd (residential)-------->**		
	Demand	Low Estimate	70,640	76,849	91,183	102,833	112,555	123,242
		Median Estimate	70,640	80,321	104,298	123,435	142,026	163,472
		High Estimate	70,640	83,924	119,233	148,058	179,031	216,555
	Supply[3]	(assumed constant)	266,667	266,667	266,667	266,667	266,667	266,667
	Shortfall / Excess[2]	Low Estimate	196,027	189,817	175,483	163,834	154,111	143,424
		Median Estimate	196,027	186,345	162,368	143,231	124,641	103,195
		High Estimate	196,027	182,743	147,433	118,609	87,636	50,112
Town of Orange			**<--exist gpcd (res)-->**			**<--------190 gpcd (residential)-------->**		
	Demand	Low Estimate	579,200	639,484	779,527	1,015,875	1,122,158	1,239,561
		Median Estimate	579,200	671,452	902,375	1,235,500	1,433,849	1,664,040
		High Estimate	579,200	704,685	1,043,106	1,500,120	1,828,638	2,229,099
	Supply[4]	(assumed constant)	900,000	900,000	900,000	900,000	900,000	900,000
	Shortfall / Excess[2]	Low Estimate	320,800	260,516	120,473	-115,875	-222,158	-339,561
		Median Estimate	320,800	228,548	-2,375	-335,500	-533,849	-764,040
		High Estimate	320,800	195,315	-143,106	-600,120	-928,638	-1,329,099
:								

(Annual Average Daily Demand)

Includes Unaccounted for Water

Service Area			Gallons per day					
			2005	2010	2020	2030	2040	2050
Subtotal Orange WTP	**Demand**	**Low Estimate**	**871,340**	**962,273**	**1,175,345**	**1,497,738**	**1,669,777**	**1,862,896**
		Median Estimate	**871,340**	**1,010,840**	**1,364,579**	**1,837,681**	**2,166,449**	**2,557,783**
		High Estimate	**871,340**	**1,061,437**	**1,583,088**	**2,253,684**	**2,811,102**	**3,515,083**
	Supply[5]	**(assumed constant)**	**2,000,000**	**2,000,000**	**2,000,000**	**2,000,000**	**2,000,000**	**2,000,000**
	Shortfall / Excess[6]	**Low Estimate**	**1,128,660**	**1,037,727**	**824,655**	**502,262**	**330,223**	**137,104**
		Median Estimate	**1,128,660**	**989,160**	**635,421**	**162,319**	**-166,449**	**-557,783**
		High Estimate	**1,128,660**	**938,563**	**416,912**	**-253,684**	**-811,102**	**-1,515,083**
RSA Route 20			<--exist gpcd (res)-->			<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	25,120	27,735	33,808	42,682	47,148	52,081
		Median Estimate	25,120	29,121	39,136	51,910	60,244	69,915
		High Estimate	25,120	30,562	45,240	63,028	76,831	93,657
	Supply[7]	(assumed constant)	43,200	43,200	43,200	43,200	43,200	43,200
	Shortfall / Excess	Low Estimate	18,080	15,465	9,392	518	-3,948	-8,881
		Median Estimate	18,080	14,079	4,064	-8,710	-17,044	-26,715
		High Estimate	18,080	12,638	-2,040	-19,828	-33,631	-50,457
Subtotal Orange WTP + RSA Route 20								
	Demand	**Low Estimate**	**896,460**	**990,008**	**1,209,153**	**1,540,420**	**1,716,925**	**1,914,976**
		Median Estimate	**896,460**	**1,039,961**	**1,403,715**	**1,889,591**	**2,226,692**	**2,627,699**
		High Estimate	**896,460**	**1,091,999**	**1,628,328**	**2,316,713**	**2,887,933**	**3,608,740**
	Supply	**(assumed constant)**	**2,043,200**	**2,043,200**	**2,043,200**	**2,043,200**	**2,043,200**	**2,043,200**
	Shortfall / Excess	**Low Estimate**	**1,146,740**	**1,053,192**	**834,047**	**502,780**	**326,275**	**128,224**
		Median Estimate	**1,146,740**	**1,003,239**	**639,485**	**153,609**	**-183,492**	**-584,499**

(Annual Average Daily Demand)

Includes Unaccounted for Water

Service Area			**Gallons per day**					
			2005	**2010**	**2020**	**2030**	**2040**	**2050**
		High Estimate	**1,146,740**	**951,201**	**414,872**	**-273,513**	**-844,733**	**-1,565,540**
RSA-Wilderness			<--exist gpcd (res)-->		150 gpcd	<--------190 gpcd (residential)-------->		
	Demand	Low Estimate	525,420	580,437	707,550	984,953	1,088,000	1,201,829
		Median Estimate	525,420	639,619	946,792	1,384,712	1,607,015	1,865,007
		High Estimate	525,420	703,532	1,259,919	2,133,827	2,867,685	3,853,929
	Supply[8]	(assumed constant)	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
	Shortfall / Excess	Low Estimate	1,474,580	1,419,563	1,292,450	1,015,047	912,000	798,171
		Median Estimate	1,474,580	1,360,381	1,053,208	615,288	392,985	134,993
		High Estimate	1,474,580	1,296,468	740,081	-133,827	-867,685	-1,853,929
Subtotal public systems:								
	Demand	**Low Estimate**	**1,421,880**	**1,570,445**	**1,916,703**	**2,525,373**	**2,804,926**	**3,116,806**
		Median Estimate	**1,421,880**	**1,679,580**	**2,350,507**	**3,274,304**	**3,833,707**	**4,492,705**
		High Estimate	**1,421,880**	**1,795,531**	**2,888,246**	**4,450,540**	**5,755,618**	**7,462,669**
	Supply[9]	**(assumed constant)**	**4,043,200**	**4,043,200**	**4,043,200**	**4,043,200**	**4,043,200**	**4,043,200**
	Shortfall / Excess[6]	**Low Estimate**	**2,621,320**	**2,472,755**	**2,126,497**	**1,517,827**	**1,238,274**	**926,394**
		Median Estimate	**2,621,320**	**2,363,620**	**1,692,693**	**768,896**	**209,493**	**-449,505**
		High Estimate	**2,621,320**	**2,247,669**	**1,154,954**	**-407,340**	**-1,712,418**	**-3,419,469**

[1] Assumed that water will be supplied to full capacity as per the agreement between the Town of Gordonsville and RSA Route 15. As per the agreement the Town of Gordonsville shall get 25 MG of water every month from RSA. The agreement is effective through May 2011. For the calculations each month is assumed to be of 30 days. A constant supply through 2050 is assumed.

[2] The shortfall/ excess is defined as the difference between the supply and the demand. A negative value indicates a shortfall, while a positive value indicates excess for that particular part of system.

(Annual Average Daily Demand)

Includes Unaccounted for Water

Service Area		**Gallons per day**					
		2005	**2010**	**2020**	**2030**	**2040**	**2050**

[3] Assumed that water will be supplied to full capacity as per the agreement between the Town of Orange and RSA. As per the agreement the RSA shall get 33 MG of water every month from the Town of Orange. The agreement is effective through September 2023. For the calculations each month is assumed to be of 30 days. A constant supply through 2050 is assumed.

[4] Supply values are taken based on WTP capacity at the Town of Orange (2.0 MGD) minus the water that is supplied to RSA Route 15 (i.e. 33 MG per month). A constant supply through 2050 is assumed. The safe yield of the river intake is not considered.

[5] Supply values are taken based the permitted capacity of WTP (2.0 MGD). A constant supply through 2050 is assumed. The safe yield of the river intake is not considered.

[6] A negative value indicates a shortfall. The values are representative of the system as a whole and may not reflect the excess or shortfall in sub-systems

[7] The supply values are based on safe yield of 30 gallons per minute of the well on Route 20 as reported in the Orange County Comprehensive Plan. A constant supply through 2050 is assumed.

[8] Supply values are taken based the permitted intake capacity of WTP (2.0 MGD). A constant supply through 2050 is assumed. The safe yield of the river intake is not considered.

[9] Supply values are added up for all the public systems (RSA-Route 15, Town of Gordonsville, Town of Orange, RSA Route 20 and RSA Wilderness). It is to check the adequacy of the system if all the supply sources and demands are combined.

Totals include all major existing uses plus existing water loss percentage

The calculations do not include fire demand.

Losses for community systems, schools, agriculture, and individual residences are considered negligible

APPENDIX-B

State Water Control Board Regulation 9 VAC 25-780

State Water Control Board Regulation

9 VAC 25-780

TITLE 9. ENVIRONMENT

STATE WATER CONTROL BOARD

Title of Regulation: **9 VAC 25-780. Local and Regional Water Supply Planning (adding 9 VAC 25-780-10 through 9 VAC 25-780-190).**

Statutory Authority: §§ 62.1-44.15 and 62.1-44.38:1 of the Code of Virginia.

Effective Date: November 2, 2005.

Agency Contact: Scott Kudlas, Department of Environmental Quality, P.O. Box 10009, Richmond, VA 23240, telephone (804) 698-4456, FAX (804) 698-4347, or e-mail swkudlas@deq.virginia.gov.

Summary:

The regulation establishes a planning process and criteria that all local governments will use in the development of local or regional water plans. These plans will be reviewed by the Department of Environmental Quality and a determination will be made by the State Water Control Board on whether the plans comply with this regulation. Within five years of a compliance determination by the board, the plans will be reviewed to assess adequacy and significant changes will require the submission of an amended plan and review by the board. All local programs will be reviewed, revised and resubmitted to the Department of Environmental Quality every 10 years after the last approval.

Summary of Public Comments and Agency's Response: A summary of comments made by the public and the agency's response may be obtained from the promulgating agency or viewed at the office of the Registrar of Regulations.

CHAPTER 780.
LOCAL AND REGIONAL WATER SUPPLY PLANNING.

9 VAC 25-780-10. Application.

A. All counties, cities and towns (hereinafter "local governments") in the Commonwealth of Virginia shall submit a local water supply plan or shall participate in a regional planning unit in the submittal of a regional water supply plan to the board in accordance with this chapter.

B. The provisions of this regulation shall not affect any water supply project for which a permit application was submitted prior to January 1, 2003, to any state or federal agency. The provisions of this regulation shall not affect any water supply project for which an application for grant, loan or other funding has been made to a state or federal agency prior to January 1, 2003. All projects shall remain subject to applicable federal and state regulatory requirements.

C. Nothing in this chapter shall be construed as altering or authorizing any alteration of any existing surface, ground water or common law water rights of any property owner within the Commonwealth, except as required by federal or state law.

D. The review required by 9 VAC 25-780-140 shall not be a prerequisite for applying for a permit from the Commonwealth of Virginia for a water supply project.

9 VAC 25-780-20. Purpose of chapter.

The purpose of this chapter is to establish a comprehensive water supply planning process for the development of local, regional, and state water supply plans. This process shall be designed to (i) ensure that adequate and safe drinking water is available to all citizens of the Commonwealth; (ii) encourage, promote, and protect all other beneficial uses of the Commonwealth's water resources; and (iii) encourage, promote, and develop incentives for alternative water sources, including but not limited to desalinization.

This chapter establishes the required planning process and criteria that local governments shall use in the development of the local and regional plans.

9 VAC 25-780-30. Definitions.

Unless otherwise defined in this chapter or unless the context clearly indicates otherwise, the terms used in this regulation shall have the meanings ascribed to them by the State Water Control Law, Chapter 3.1 (§ 62.1-44.2 et seq.) of Title 62.1 of the Code of Virginia; the Ground Water Management Act of 1992, Chapter 2.5 (§ 62.1-254 et seq.) of Title 62.1 of the Code of Virginia; the Virginia Water Protection Permit Regulation, 9 VAC 25-210 (2004); and the Surface Water Management Area Regulation, 9 VAC 25-220 (2004), including any general permits issued thereunder.

"Beneficial use" means both in-stream and off-stream uses. In-stream beneficial uses include, but are not limited to, the protection of fish and wildlife habitat, maintenance of waste assimilation, recreation, navigation, and cultural and aesthetic values. Off-stream beneficial uses include, but are not limited to, domestic (including public water supply), agricultural, electric power generation, and commercial and industrial uses.

"Board" means the State Water Control Board.

"Community water system" means a waterworks that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents, and is regulated by the Virginia Department of Health Waterworks Regulation (12 VAC 5-590).

"Conservation" means practices, techniques, and technologies that improve the efficiency of water use.

"Department" means the Department of Environmental Quality.

"Local government" means a city, incorporated town or county.

"Local program" means the combined water plan, resource conditions, and drought response and contingency plan developed in compliance with this regulation. The term "local program" will be used in this regulation to mean either local or regional programs. The term "program" implies the institution of a continuous planning process for maintenance of these documents.

"Planning area" means the geographical area as defined by local government boundaries that is included in a local or regional water supply plan.

"Planning period" means the 30- to 50-year time frame used by the locality to project future water demand in accordance with 9 VAC 25-780-100 B.

"Regional planning unit" means a collection of local governments who have voluntarily elected to develop and submit a regional water plan. A regional planning unit may be composed of all local governments located within the bounds of a planning district, any subset of local governments within the bounds of a planning district, or any group of local governments within multiple planning districts.

"Regional water plan" means a water plan developed and submitted by two or more cities or counties or both. A town and an adjacent county may develop a regional water plan. Two or more towns may develop and submit a regional water plan where the plan results in the proposed development of future water supply projects that supply the water supply demands of the affected towns. Such plans developed by two or more towns may be included in regional water plans developed and submitted by counties or cities. Regional water plans shall be developed and submitted in conjunction with all public service authorities operating community water systems within the regional planning unit, if applicable.

"Self-supplied user" means any person making a withdrawal of surface water or ground water from an original source (e.g., a river, stream, lake, aquifer, or reservoir fed by any such water body) for their own use. Self-supplied users do not receive water from a community water system.

"Service area" means the geographical area served by a community water system.

"Technical evaluation committee" means a committee of state agencies, including but not limited to the Department of Health, the Department of Conservation and Recreation, the Marine Resources Commission, the Department of Historic Resources, and the Department of Game and Inland Fisheries, convened by the Department of Environmental Quality in accordance with subdivision 8 of 9 VAC 25-780-60 to provide comments on the impacts to or conflicts among in-stream and off-stream uses resulting from proposed alternatives for meeting projected water demands.

"Unaccounted for losses" means the difference between a community water system's billing records for volumes of water distributed and production records for volumes of water treated.

"Water demand management" means plans for water conservation, reuse, and reducing unaccounted for water losses contained in a local program.

"Water plan" means a document developed in compliance with this regulation. The term "water plan" will be used in this regulation to mean either local or regional water plans.

"Water sources" means wells, stream intakes, and reservoirs that serve as sources of water supplies.

9 VAC 25-780-40. Program development.

Local governments shall develop programs for local or regional water plans that are necessary to comply with this chapter. Local governments shall consult and coordinate with all community water systems in the planning area during the preparation of local or regional programs. Community water systems within the planning area shall cooperate and participate with the locality during preparation of the local program. Counties, cities, and towns are encouraged to develop regional programs. Local programs shall be designed to (i) ensure that adequate and safe drinking water is available, (ii) encourage and protect all beneficial uses, (iii) encourage and promote alternative water sources, and (iv) promote conservation.

9 VAC 25-780-50. Preparation and submission of a program.

A. Local governments must adopt a local program as defined in this section, including any revisions to comprehensive plans, water supply plans, water and sewer plans, and other local authorities necessary to implement this chapter. A local public hearing consistent with § 15.2-1427 of the Code of Virginia is required during the development of the local program. The public hearing may be combined with other public hearings that may be required.

B. All local governments shall submit a local program to the department in accordance with the following schedule:

1. Local governments with populations in excess of 35,000 persons based on the most recent U.S. Census shall do so no later than November 2, 2008.

2. Local governments with populations in excess of 15,000 persons but no more than 35,000 persons *based on the most recent U.S. Census shall do so no later than November 2, 2009.*

3. Local governments with populations less than or equal to 15,000 persons based on the most recent U.S. Census shall do so no later November 2, 2010.

4. Notwithstanding the above, local governments may elect to participate in the submittal of regional water supply plans By November 2, 2008, local governments participating in a regional plan shall provide notice to the department of the intent to participate in a regional plan and shall include the names of the other participating localities. Such regional plans shall be submitted no later November 2, 2011.

Nothing in this section shall be construed as limiting the submittal of local or regional water supply plans before the date when such plans are due.

C. Local programs shall contain the elements listed below. This information may be derived from existing, readily available information and additional detailed studies shall not be required.

1. A description of existing water sources in accordance with the requirements of 9 VAC 25-780-70;

2. A description of existing water use in accordance with the requirements of 9 VAC 25-780-80;

3. A description of existing water resource conditions in accordance with the requirements of 9 VAC 25-780-90;

4. An assessment of projected water demand in accordance with the requirements of 9 VAC 25-780-100;

5. A description of water management actions in accordance with the requirements of 9 VAC 25-780-110 and 9 VAC 25-780-120;

6. A statement of need in accordance with the requirements of 9 VAC 25-780-130;

7. An alternatives analysis that identifies potential alternatives to address projected deficits in water supplies in accordance with the requirements of 9 VAC 25-780-130;

8. A map or maps identifying important elements of the program that may include existing environmental resources, existing water sources, significant existing water uses, and proposed new sources;

9. A copy of the adopted program documents including any local plans or ordinances or amendments that incorporate the local program elements required by this chapter;

10. A resolution approving the plan from each local government that is party to the plan; and

11. A record of the local public hearing, a copy of all written comments and the submitter's response to all written comments received.

D. All local programs shall be reviewed no later than five years after a compliance determination by the board in accordance with 9 VAC 25-780-140 F. Revised plans shall be submitted when this review indicates that circumstances have changed or new information has been made available that will result in water demands that will not be met by alternatives contained in the water plan. These circumstances may be caused by changes in demands, the availability of the anticipated source, cumulative impacts, in-stream beneficial uses, or other factors. In the case where the review by the local government or regional planning unit indicates that the circumstances have not changed sufficiently to warrant a revision of the water plan after five years, the locality shall notify the department that the existing plan is still in effect.

E. Notwithstanding subsection D of this section, all local programs shall be reviewed, revised and resubmitted to the department every 10 years after the date of last approval.

9 VAC 25-780-60. State role in program preparation.

To assist local governments in the development of local programs, the board will:

1. Provide technical and financial assistance;

2. Provide guidance on compliance options;

3. Facilitate acquisition of existing resource conditions (the department shall prepare and post on its website a list of readily available sources for the items identified in 9 VAC 25-780-90 B);

4. Facilitate acquisition of existing use information that has been reported to the department;

5. Facilitate acquisition of water management information (the department shall prepare and post on its website a list of acceptable practices that are used with regard to the topics in 9 VAC 25-780-110);

6. Identify acceptable methods for the projection of future water demands as per 9 VAC 25-780-100;

7. Provide any information regarding known conflicts relating to the development of alternatives;

8. At the request of the applicant, convene a technical evaluation committee meeting; and

9. Provide notice of local public hearings on the local program upon notification by the locality.

9 VAC 25-780-70. Existing water source information.

A. A water plan shall include current information on existing water sources.

B. A water plan shall include, for community water systems using ground water, the name and identification number of the well or wells, the well depth, the casing depth, the screen depth (top and bottom) or water zones, the well diameter, the design capacity for the average daily withdrawal and maximum daily withdrawal, the system capacity permitted by Department of Health, and the annual and monthly permitted amounts contained in ground water withdrawal permits for all wells located within ground water management areas.

C. A water plan shall include, for community water systems using surface water reservoirs, the name of the reservoirs, the sub-basins in which the reservoirs are located, the drainage area, the amount of on-stream storage available for water supply, the design capacity for average daily and maximum daily withdrawals from the reservoirs, the safe yield of the reservoirs, the capacity of any associated water treatment plant, the Department of Health permitted capacity of the systems, and any limitations on withdrawal established by permits issued by the board. For a community water system that operates a system of interconnected reservoirs, the reporting of the design capacity for withdrawals, designed average daily withdrawal, the designed maximum daily withdrawal and the safe yield may be for the entire system or may be reported as subsets of the system. The plan shall designate which reservoirs and which intakes constitute a system for the purposes of this paragraph. The plan must report the drainage area and amount of storage available for water supply from each reservoir independently.

D. A water plan shall include, for community water systems using stream intakes, the name of the stream or river, the drainage area of the intake, the sub-basin in which the intake is located, the design capacity for average daily and designed maximum daily withdrawal from the stream, the safe yield, the lowest daily flow of record the design capacity of the pump station, the design capacity of the water treatment plant, the capacity of the system permitted by the Department of Health, and any limitation on withdrawals established by permits issued by the board.

E. To the extent that information is available, a water plan shall include a list of all self-supplied users of more than 300,000 gallons per month of surface water for nonagricultural uses, the name of the water body utilized, the design capacity for the average daily and maximum daily withdrawal, and any limitation on withdrawals established by permits issued by the board, the Department of Health or any other agency.

F. To the extent that information is available, a water plan shall include, for all self-supplied users of more than 300,000 gallons per month of ground water for nonagricultural uses, the name and identification number of the well or wells, the well depth, the casing depth, the screen depth (top and bottom) or water zones, the well diameter, the design capacity for the average daily and maximum daily withdrawal and any limitation on withdrawal established by permits issued by the board.

G. A water plan shall include the amount of ground or surface water to be purchased from water supply systems outside the geographic boundaries of the planning area on a maximum daily and average annual basis, any contractual limitations on the purchase of the water including but not limited to the term of any contract or agreement, the recipient(s) or areas served by the water purchased, and the name(s) of the supplier(s).

H. A plan shall include the amount of water available to be purchased outside the planning area from any source with the capacity to withdraw more than 300,000 gallons per month of surface and ground water, reported on a maximum daily and average annual basis and any contractual limitations on the purchase of the water including but not limited to the term of any contract or agreement, the geographic region(s) that receive the water purchased, and the name(s) of the supplier(s).

I. A water plan shall include, to the extent possible, a list of agricultural users who utilize more than 300,000 gallons per month, an estimate of total agricultural usage by source, whether the use is irrigation or nonirrigation, and whether the source is surface or ground water.

J. A water plan shall include an estimate of the number of residences and businesses that are self-supplied by individual wells withdrawing less than 300,000 gallons per month and an estimate of the population served by individual wells.

K. When available, a water plan shall include a summary of findings and recommendations from applicable source water assessment plans or wellhead protection programs.

9 VAC 25-780-80. Existing water use information.

A. A water plan shall include, at a minimum, current information documenting existing water use as listed below. Water use information shall be obtained from Department of Health waterworks permit compliance reports, the department ground water permit compliance reports or department water use reports. Information shall be reported for the most recent previous annual compilation of such data that is available on the date of submission of the water plan.

B. A water plan shall include the following information for community water systems:

1. The population within the planning area served by each community water system.

2. The number of connections within the planning area for each community water system.

3. The average and maximum daily withdrawal for each community water system within the planning area.

4. The amount of water used within the planning area on an annual average basis, and on an average monthly basis for each community water system expressed in terms of million gallons per day.

5. The peak day water use by month for each community water system within the planning area.

6. An estimate of the water used on an average annual basis by self-supplied nonagricultural users of more than 300,000 gallons per month of surface and ground water within the service area of each community water system.

7. An estimate of the amount of water used on an average annual basis by self-supplied agricultural users of more than 300,000 gallons per month of surface and ground water within the service area of each community water supply.

8. An estimate of the number of self-supplied users of less than 300,000 gallons per month of ground water and an estimate of the total amount of water used by them on an annual average basis within the service area of each community water supply.

9. For each community water system included in the water plan, the plan shall include an estimate of the disaggregated amounts of water used in categories of use appropriate for the system. Typical categories may include:

a. Residential use;

b. Commercial institutional and light industrial (CIL) use;

c. Heavy industrial use;

d. Military water use;

e. Water used in water production processes;

f. Unaccounted for losses;

g. Sales to other community water systems and the names of such systems; or

h. Subtotals of the above categories for all community water systems

10. To the extent that information is available pursuant to 9 VAC 25-780-60 and other sources, for each community water system included in the water plan using stream intakes, the plan shall include a qualitative description of existing in-stream beneficial uses within the planning area or outside the planning area that may be affected by the point of stream withdrawal.

C. A water plan shall include an estimate of the water used on an average annual basis by self-supplied nonagricultural user of more than 300,000 gallons per month of surface and ground water outside the service areas of community water systems.

D. A water plan shall include an estimate of the amount of water used on an average annual basis by self-supplied agricultural users of more than 300,000 gallons per month of surface and ground water outside the service areas of community water systems.

E. A water plan shall include an estimate of the number of self-supplied users of less than 300,000 gallons per month of ground water and an estimate of the total amount of water used by them on an annual average basis outside the service areas of community water systems.

9 VAC 25-780-90. Existing resource information.

A. A program shall include a description of existing geologic, hydrologic, and meteorological conditions within the planning area, and in proximity to the point of withdrawal if it is outside the planning area.

B. A program shall include a description of existing environmental conditions that pertain to, or may affect, in--stream flow, in-stream uses, and sources that provide the current supply. This description of conditions may be provided in a distinct section of the plan document or as a part of the existing water sources information required pursuant to 9 VAC 25-780-70. This information may be derived from existing, readily available information and additional detailed studies shall not be required. The description of conditions shall include the following items, as they are applicable:

1. State or federal listed threatened or endangered species or habitats of concern;

2. Anadromous, trout and other significant fisheries;

3. River segments that have recreational significance including state scenic river status;

4. Sites of historic or archaeological significance;

5. Unusual geologic formations or special soil types;

6. Wetlands;

7. Riparian buffers and conservation easements;

8. Land use and land coverage including items such as percentage of impervious cover within a watershed and areas where new development may impact water quality of the source;

9. The presence of impaired streams and the type of impairment;

10. The location of point source discharges; and

11. Potential threats to the existing water quantity and quality, other than those from above.

9 VAC 25-780-100. Projected water demand information.

A. A water plan shall include projections of future water demand as listed below. Population in aggregate and disaggregate formulations should be estimated according to information from the U.S. Census Bureau, Bureau of Economic Analysis, the Virginia Employment Commission, or other accepted source of population information, including but not limited to, local or regional sources. Demand projection methodologies should be consistent with those outlined in the American Water Works Association or American Society of Civil Engineers manuals. Sources of information and methodologies used in projecting future water demand shall be documented.

B. A water plan shall estimate water demand within the planning area for a minimum of 30 to a maximum of 50 years into the future. While not required, localities are encouraged to plan for the maximum planning period to ensure that the most appropriate and sustainable alternatives are identified.

C. A water plan shall include an estimated future water use projected at the beginning of each decade (2010, 2020, 2030, etc.) within the planning period.

D. A water plan shall include the following projections for community water systems:

1. An estimate of population within the planning area served by each community water system;

2. A map depicting the proposed service area of each existing or proposed community water system;

3. Estimated water demand for each existing or proposed community water system on both an annual average and peak monthly basis;

4. Estimated water demand for each existing or proposed community water system disaggregated into categories of use appropriate for the system. Typical categories may include:

a. Residential use;

b. Commercial institutional and light industrial (CIL) use;

c. Heavy industrial use;

d. Military water use;

e. Water used in water production processes;

f. Unaccounted for losses;

g. Sales to other community water systems and the names of such systems; or

h. Subtotals of the above categories for all community water systems; and

5. Total projected water demand for all existing or proposed community water systems disaggregated into the categories used in subdivision 4 of this subsection.

E. A water plan shall include a projection of water demand within the planning area on an annual average basis for each existing and any proposed self-supplied nonagricultural user of more than 300,000 gallons per month of surface and ground water located outside the service areas of community water systems.

F. A water plan shall include a projection of the amount of water use on an annual average basis for each existing and any projected self-supplied agricultural user of more than 300,000 gallons per month of surface and ground water located outside the service areas of community water systems.

G. A water plan shall include a projection of the number of self-supplied users of less than 300,000 gallons per month of ground water and a projection of the amount of water used on an annual average basis outside the service areas of community water systems.

H. A water plan shall include, if available, any cumulative demand, use conflict, or in-stream flow information developed pursuant to 9 VAC 25-780-140 G.

I. A water plan shall explain how the projected needs of domestic consumption, in-stream uses, and economic development have been accounted for in the demand projection for the planning period.

9 VAC 25-780-110. Water demand management information.

A. As part of a long-term strategy, a water plan shall address conservation as a part of overall water demand management in accordance with the following requirements:

1. A water plan shall include information that describes practices for more efficient use of water that are used within the planning area. The type of measures to be described may include, but are not limited to, the adoption and enforcement of the Virginia Uniform Statewide Building Code sections that limit maximum flow of water closets, urinals and appliances; use of low-water use landscaping; and increases in irrigation efficiency.

2. A water plan shall include information describing the water conservation measures used within the planning area to conserve water through the reduction of use. The types of measures to be described may include, but are not limited to, technical, educational and financial programs.

3. A water plan shall include information that describes, within the planning area, the practices to address water loss in the maintenance of water systems to reduce unaccounted for water loss. The types of items to be described may include, but are *not limited to: leak detection and repair and old distribution line replacement.*

B. Current conservation practices, techniques, and technologies shall be considered in projecting water demand pursuant to 9 VAC 25-780-100 D.

9 VAC 25-780-120. Drought response and contingency plans.

A program that includes community water systems and self-supplied users who withdraw more than an average of 300,000 gallons per month of surface water and ground water shall contain drought response and contingency plans in accordance with the following requirements:

1. Drought response and contingency plans shall be structured to address the unique characteristics of the water source that is being utilized and the nature of the beneficial use of water.

2. Drought response and contingency plans shall contain, at a minimum, the following three graduated stages of responses to the onset of drought conditions:

a. Drought watch stage responses are generally responses that are intended to increase awareness in the public and private sector to climatic conditions that are likely to precede the occurrence of a significant drought event. Public outreach activities shall be identified to inform the population served by a community water system of the potential for drought conditions to intensify and potential water conservation activities that may be utilized.

b. Drought warning stage responses are generally responses that are required when the onset of a significant drought event is imminent. Voluntary water conservation activities shall be identified with the goal of reducing water use by 5-10%.

c. Drought emergency stage responses are generally responses that are required during the height of a significant drought event. Mandatory water conservation activities shall be identified with the goal of reducing water use by 10-15%.

3. Drought response and contingency plans shall include references to local ordinances, if adopted, and procedures for the implementation and enforcement of drought response and contingency plans.

9 VAC 25-780-130. Statement of need and alternatives.

A. A water plan shall determine the adequacy of existing water sources to meet current and projected demand by preparing a clear statement of need that is derived from an evaluation of the information required by 9 VAC 25-780-70 through 9 VAC 25-780-110. The statement of need shall contain, at a minimum, a determination of whether the existing source(s) is adequate to meet current and projected demands.

B. If the determination is that the existing source is inadequate to meet projected demands during the planning period, the program shall include an alternative analysis of potential sources that includes the following information:

1. A description of potential water savings from water demand management actions including an estimated volume for each action;

2. A description of potential sources for new supplies including an estimated volume from each source; and

3. A description of potential resource issues or impacts, identified in accordance with 9 VAC 25-780-140 G, known for each potential new source that any future water project will need to consider in its development.

C. Potential alternatives considered shall include water demand management alternatives as well as more traditional means of increasing supply, i.e., wells, reservoirs, impoundments and stream intakes. Where appropriate, the program shall consider nontraditional means of increasing supplies such as interconnection, desalination, recycling and reuse. The analysis of potential alternatives may include a combination of short-term and long-term alternatives. The result of this analysis shall be provided as part of the submission required by 9 VAC 25-780-50 C 7.

9 VAC 25-780-140. Review of local programs.

A. The board shall review all programs to determine compliance with this regulation and consistency with the State Water Resources Plan. The board will review adopted elements of a local program according to review policies adopted by the board. Copies of the adopted local program documents and subsequent changes thereto shall be provided to the board.

B. To assist in the review of the program, the board shall provide the Department of Health and other agencies listed in 9 VAC 25-780-150 B along with any other agency the board deems appropriate, 90 days to evaluate the program. Comments must be received from the Department of Health or other agency by the deadline stipulated in the written notification from the board.

C. The board will assess the compliance of submitted programs with these regulations. The board shall prepare a tentative statement of findings on whether the program has demonstrated compliance with the following:

1. All elements of a local program identified in 9 VAC 25-780-50 have been submitted;

2. The program was developed through a planning process consistent with this chapter;

3. The results of any evaluation conducted pursuant to subsection G of this section have been appropriately accommodated;

4. The existing sources information complies with 9 VAC 25-780-70;

5. The existing water use information complies with 9 VAC 25-780-80;

6. The existing resources information complies with 9 VAC 25-780-90;

7. The projected water demand is based on an accepted methodology and complies with 9 VAC 25-780-100;

8. The water demand management information complies with 9 VAC 25-780-110;

9. The drought response and contingency plan complies with 9 VAC 25-780-120;

10. The statement of need complies with 9 VAC 25-78-130 A;

11. When required, the alternatives comply with 9 VAC 25-780-130;

12. The local program is consistent with 9 VAC 25-390-20, § 62.1-11 of the Code of Virginia and Chapter 3.2 (§ 62.1-44.36 et seq.) of Title 62.1 of the Code of Virginia.

D. If the board's tentative decision is to find the local program in compliance with subsection C of this section, the board shall provide public notice of its findings pursuant to 9 VAC 25-780-150.

E. If the tentative decision of the board is to find the local program in noncompliance with subsection C of this section, the board shall identify (i) the reason for the finding of noncompliance, (ii) what is required for compliance, and (iii) the right to an informational proceeding under Article 3 (§ 2.2-4018 et seq.) of Chapter 40 of the Virginia Administrative Process Act.

F. The board shall make a final decision on whether the local program is in compliance with this chapter after completing review of the submitted program, any agency comments received, and any public comment received from a public meeting held pursuant to 9 VAC 25-780-160.

G. In conjunction with the compliance determination made by the board, the state will develop additional information and conduct additional evaluation of local or regional alternatives in order to facilitate continuous planning. This additional information shall be included in the State Water Resources Plan and used by localities in their program planning. This information shall include:

1. A cumulative demand analysis, based upon information contained in the State Water Resources Plan and other sources;

2. The evaluation of alternatives prepared pursuant to 9 VAC 25-780-130 B and C;

3. The evaluation of potential use conflicts among projected water demand and estimates of requirements for in-stream flow; and

4. An evaluation of the relationship between the local plan and the State Water Resources Plan.

H. The board may facilitate information sharing and discussion among localities when potential conflicts arise with regard to demands upon a source.

I. A local program's information shall be included in the State Water Resource Plan when determined to be in compliance by the board.

9 VAC 25-780-150. Public notice and public comment period.

A. The board shall give public notice on the department website for every tentative and final decision to determine local program compliance.

B. The board shall give public notice to the Department of Health, the Department of Conservation and Recreation, the Marine Resources Commission, the Department of Historic Resources, and the Department of Game and Inland Fisheries for every tentative and final decision on program compliance. The agencies shall have 90 days to submit written comment. At the request of the applicant, the board will convene a technical evaluation committee meeting to facilitate receipt of these comments.

C. The board shall provide a comment period of at least 30 days following the date of the public notice for interested persons to submit written comments on the tentative or final decision. All written comments submitted during the comment period shall be retained by the board and considered during its final decision.

D. Commenters may request a public meeting when submitting comments. In order for the board to grant a public meeting, there must be a substantial public interest and a factual basis upon which the commenter believes that the proposed program might be contrary to the purposes stated in 9 VAC 25-780-20.

E. The contents of the public notice of a proposed program compliance determination shall include:

1. Name(s) and address(es) of the locality(ies) that submitted the local or regional water plan;

2. Brief synopsis of the proposed plan including any identified future alternatives;

3. The name(s) of the principal water supply sources;

4. A statement of the tentative determination to certify or deny consistency with the regulation;

5. A brief description of the final determination procedure;

6. The address, e-mail address and phone number of a specific person at the state office from whom further information may be obtained; and

7. A brief description on how to submit comments and request a public meeting.

9 VAC 25-780-160. Public meetings.

A. Public notice of any public meeting held pursuant to 9 VAC 25-780-150 shall be circulated as follows:

1. Notice shall be published on the department website;

2. Notice shall be published once in a newspaper of general circulation in the county, city, or town where the local or regional water plan is in effect; and

3. Notice of the public meeting shall be sent to all persons and government agencies that requested a public meeting or have commented in response to the public notice.

B. Notice shall be effected pursuant to subdivisions A 1 through 3 of this section at least 30 days in advance of the public meeting.

C. The content of the public notice of any public meeting held pursuant to this section shall include at least the following:

1. Name and address of the localities who prepared the program;

2. The planning area covered by the program;

3. A brief reference to the public notice issued for the comment period including the date of issuance unless the public notice includes the public meeting notice;

4. Information regarding the time and location for the public meeting;

5. The purpose of the public meeting;

6. A concise statement of the relevant water resources planning, water quality, or fish and wildlife resource issues raised by the persons requesting the public meeting;

7. Contact person and the address, e-mail address and phone number of the department office at which the interested persons may obtain further information or request a copy of the draft statement of findings prepared pursuant to 9 VAC 25 780-140 D; and

8. A brief reference to the rules and procedures to be followed at the public meeting.

9 VAC 25-780-170. Appeals.

All appeals taken from actions of the board or the director relative to the provisions of this chapter shall be governed by the Virginia Administrative Process Act (§ 2.2-4000 et seq. of the Code of Virginia).

9 VAC 25-780-180. Enforcement.

Enforcement of this chapter will be in accordance with §§ 62.1-44.15, 62.1-44.23, and 62.1-44.32 of the Code of Virginia.

9 VAC 25-780-190. Delegation of authority.

The executive director, or his designee, may perform any action of the board provided under this chapter, except as limited by § 62.1-44.14 of the Code of Virginia.

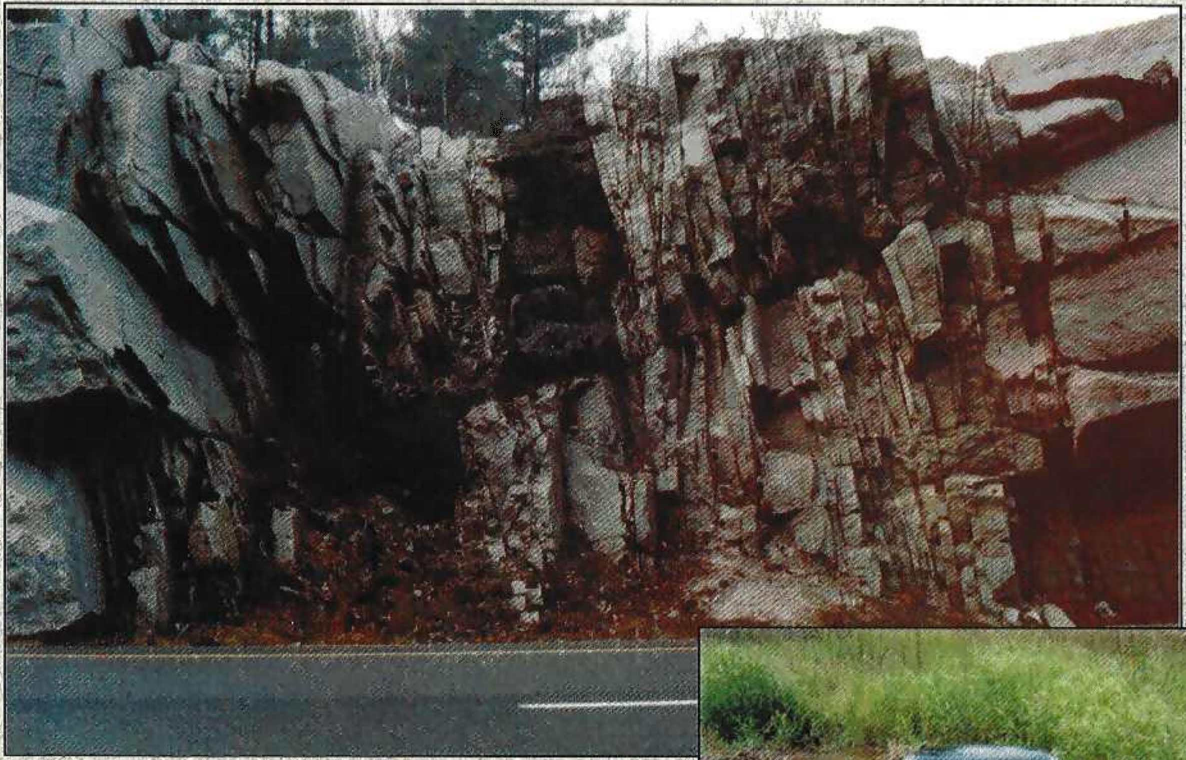
APPENDIX C –

Groundwater Exploration

GROUNDWATER EXPLORATION AND DEVELOPMENT PROGRAM

PHASE I

ORANGE COUNTY WATER SUPPLY PLAN
ORANGE COUNTY, VIRGINIA



October 2006

Presented to:
Mr. Tim Wagner
WILEY & WILSON, INC.

EMERY & GARRETT GROUNDWATER, INC.
56 Main Street • P.O. Box 1578
Meredith, New Hampshire 03253

New England **Mid-Atlantic** **South Atlantic**

Emery & Garrett Groundwater, Inc.
56 Main Street • P.O. Box 1578
Meredith, New Hampshire 03253
(603) 279-4425 ***Fax (603) 279-8717***

October 11, 2006

Mr. Tim Wagner, P.E.
Wiley & Wilson
2310 Langhorne Road
Lynchburg, VA 24501

Dear Mr. Wagner,

As you know, Emery & Garrett Groundwater, Inc. (EGGI) has been conducting a Phase I groundwater investigation of the entire Orange County to assess the overall potential to develop groundwater resources from local bedrock aquifers.

The results of this Phase I groundwater exploration program has served to delineate twenty-nine (29) zones throughout Orange County, which EGGI's groundwater investigation team has identified as being hydrogeologically favorable for groundwater development. These *potential* groundwater development zones are distributed throughout the County in a wide variety of hydrogeologic settings (Plate 1). The potential groundwater development zones are divided into three categories: 10 **"primary"** zones[1], 6 **"secondary"** zones, and 13 **"tertiary"** zones. Technical criteria used to select these zones included topography, bedrock geology, bedrock structural features, lineament data, fracture fabric data, existing wells, current and past land uses, potential sources of groundwater recharge, and the location and type of potential threats to groundwater quality.

It should be recognized that EGGI's exploration efforts have been restricted to evaluating only "above" surface (aerial platforms) and "ground" surface hydrogeologic information. Based upon the results of EGGI's Phase I investigation, we believe that the development of significant groundwater resources is achievable. The development of such volumes of groundwater should make a significant contribution to the overall total water supply capacity that can be used to meet present and anticipated future water demands of Orange County.

I hope you find this information responsive to your needs. If you have any questions, please do not hesitate to contact either one of us.

Best regards,

James M. Emery
President

Ken C. Hardcastle, Ph.D.
Senior Geologist

[1] Primary zones are considered more favorable for groundwater development than secondary zones and so forth. However, information obtained from Phase II investigations may serve to modify the relative priority ranking of these potential groundwater development areas.

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GROUNDWATER EXPLORATION AND DEVELOPMENT PROGRAM

PHASE I

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GROUNDWATER EXPLORATION AND DEVELOPMENT PROGRAM

PHASE I

ORANGE COUNTY WATER SUPPLY PLAN ORANGE COUNTY, VIRGINIA

Submitted to
Wiley & Wilson, Inc.
October 2006

I. INTRODUCTION

In accordance with Emery & Garrett Groundwater, Inc.'s (EGGI's) proposal dated April 6, 2006, this document serves as a summary of our Phase I groundwater investigation, which was conducted for Orange County (Figure 1). Orange County is currently researching its water-supply options. A draft report by Wiley & Wilson, Inc., dated June 20, 2006, entitled *"Orange County Water Supply Plan, Technical Memorandum No. 1"* discusses the existing water supplies and analyzes the future water supply needs of the County. According to the 2006 Wiley & Wilson report, water supplies currently used for public consumption in the Town of Orange, the Town of Gordonsville, and portions of Orange County are derived almost exclusively from surface water obtained from the Rapidan River[1]. However, projections for future water needs have caused concern regarding the ability of the surface water supplies to meet future anticipated water demands. In fact, according to projections by Black & Veatch 2006, maximum daily water demands will exceed River withdrawal limits as early as 2010.

In light of water supply concerns, Orange County felt it prudent to investigate the potential to develop groundwater resources with the intent of using this water to supplement existing surface water sources. With this goal in mind, EGGI was contracted to conduct the first phase of a Countywide groundwater exploration and development program with the primary objective of identifying zones (sub-areas) within the County considered favorable for developing potable groundwater resources.

The investigation reported herein is the first phase of a multi-phased groundwater exploration and development program. Subsequent phases of this groundwater investigation would include the identification of specific well targets (Phase II), drilling of selected exploratory test wells (Phase III), conversion of exploratory test wells to production wells (Phase IV), testing

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[1] The Rapidan Service Authority (RSA) maintains a small water distribution system located east of the Town of Orange along Route 20 that is supplied by a low-yielding groundwater well.

of the wells for sustainable yield and water quality (Phase V), and preparation of a detailed hydrogeologic report (Phase VI).

The work tasks undertaken in this initial phase of work included the following:

1. **Detailed investigation of the local bedrock geology:**
   Detailed geologic field mapping was carried out to characterize the local bedrock geology in terms of mineral composition and texture; the pervasiveness, orientation, and dip of layering and folds; the presence of bedrock discontinuities resulting from compositional differences within subsurface rock units; the presence of contact zones between bedrock units of contrasting character; and the presence of fault zones.

2. **Delineation of fractured bedrock aquifers with the help of the following methods:**
   a) *Remote sensing and lineament analysis*, which utilized aerial photography, topographic maps, and satellite imagery. This includes the measurement of lineament length and orientation and correlation of lineaments to observed bedrock fractures.
   b) *Bedrock fracture characterization.* This includes the documentation and evaluation of bedrock fracture morphology, length, termination, roughness, density, and orientation.

3. **Compilation and evaluation of construction data for existing wells within the study area.**

4. **Identification of areas where the potential availability of groundwater recharge is the greatest.**

5. **Location of contaminant threats/existing land uses proximal to potential groundwater development areas that could potentially degrade groundwater quality.**

The results of this Phase I groundwater exploration program has served to delineate twenty-nine (29) zones throughout Orange County, which EGGI's groundwater investigation team has identified as being hydrogeologically favorable for groundwater development. These *potential* groundwater development zones are distributed throughout the County in a wide variety of hydrogeologic settings (Plate 1). The potential groundwater development zones are divided into three categories: 10 **"primary"** zones[2], 6 **"secondary"** zones, and 13 **"tertiary"** zones. All 29 zones are shown on Plates 1 and 2. Technical criteria used to select these zones included topography, bedrock geology, bedrock structural features, lineament data, fracture fabric data, existing wells, current and

---

[2] Primary zones are considered more favorable for groundwater development than secondary zones and so forth. However, information obtained from Phase II investigations may serve to modify the relative priority ranking of these potential groundwater development areas.

past land uses, potential sources of groundwater recharge, and the location and type of potential threats to groundwater quality.

II. POSSIBLE ADVANTAGES OF USING GROUNDWATER RESOURCES

There are several possible advantages to developing groundwater resources for water utilities seeking to supplement their existing surface water sources. The advantages that are pertinent to Orange County are as follows:

- Groundwater resources can be phased-in on an as-needed basis.
- Groundwater sources are very drought-resistant, as they depend upon the earth's crust for water storage.
- The development of groundwater resources can act as an excellent means to provide peak water supply demands for public water systems nearing maximum supply capacity.
- The usage of groundwater resources significantly reduces the need to dedicate and, therefore, purchase land.
- The use of groundwater typically does not require the complex interaction of the Army Corps of Engineers and EPA for obtaining withdrawal permit approvals and thus there is a significant reduction in the time needed to obtain approvals for groundwater withdrawals. Typically, groundwater resource withdrawal can be permitted by the State of Virginia within 100 days of source development and testing.
- Groundwater resources are generally inexpensive to operate and maintain because of the minimal equipment, treatment, and labor required. (Data collected from active water superintendents indicate O&M costs for groundwater usage to be as low as 20-35% of that for other water sources.)

III. EXISTING WATER USE

The Town of Orange is permitted to withdraw 2.0 millions gallons per day (mgd) from the Rapidan River. The service area extends beyond the Town limits along Route 20 to the east, along Route 633 to the west, and along Route 15 to the south (Wiley & Wilson, 2006).

The Rapidan Service Authority (RSA) owns and operates three individual and separate water systems in Orange County. These water systems include: the Wilderness System, a small water system along Route 20 that is serviced by a low-yielding groundwater well on Porter Road, and a water distribution system along Route 15 between the Town of Orange and the Town of Gordonsville. The RSA has a permit to withdraw 2.0 mgd from the Rapidan River that serves the Wilderness System, which includes the Lake of the Woods community, and commercial developments along Route 3. The small RSA groundwater system on Route 20 has 141 connections. The RSA system along Route 15 has 110 connections and is supplied by a transmission main from the Town of Orange water system (Wiley & Wilson, 2006).

Lastly, the Town of Gordonsville has a water system that obtains its water from the transmission main along Route 15 that is owned and operated by the RSA.

IV. HYDROGEOLOGIC EVALUATION OF THE STUDY AREA

A. Evaluation of Bedrock Geology

The bedrock's chemical and physical characteristics directly influence the quality and quantity of groundwater that can be extracted from bedrock systems. The control of bedrock type on well yield has been well documented and it is important to determine and evaluate the nature of bedrock in any groundwater exploration program. Existing bedrock maps provided coverage for background information and comparison (Pavlides, 1990; Lee and Froelich, 1989; Geologic Map of Virginia). A total of 343 exposures of bedrock and/or soil were identified; over 205 of these were mapped in detail for the purposes of collecting bedrock fracture fabric, structure, and lithologic data. (Plate 1).

Three distinct geologic provinces underlie Orange County: the Blue Ridge Province, the Piedmont Province, and the Mesozoic Culpeper and Barboursville Basins (Figure 2). The Blue Ridge Province is located in the western portion of the County, and is comprised of metamorphosed volcanic rocks and metasedimentary rocks. The Piedmont Province occupies the eastern portion of the County and is also comprised of metasedimentary rocks and metamorphosed volcanic rocks. The Barboursville Basin is located in the western portion of the County, north of the Town of Barboursville. The southern tip of the Culpeper Basin intersects with the northern tip of the County. Both Basins are chiefly comprised of sedimentary rocks within the limits of Orange County.

1. Brief Geologic History

The Blue Ridge Province is a large geologic region that stretches from Alabama to northern Virginia. In the broadest sense, this province is an elongate arched package of rocks, called an anticlinorium. All of these Blue Ridge rocks were re-folded, faulted, and metamorphosed when the rocks of Piedmont Province were accreted onto the edge of the North American continent during a tectonic event that formed the Appalachian Mountains over 350 million years ago.

Following this mountain building event, approximately 200 million years ago, the breakup of the continent led to the development of subaerial basins, including the formation of the Barboursville and Culpeper Basins. As the basins formed, sediments, derived from adjacent highlands (Blue Ridge rocks), were deposited in rivers and shallow lakes. The early deposits were buried as deposition and basin subsidence continued, and sedimentary rocks, such as sandstones and siltstones, were formed. Subsequent to this period of basin development, weathering and erosion have given the landscape its present form.

2. Blue Ridge Geologic Province

Rocks of the Blue Ridge Province that are located within Orange County include (from west to east): the Lynchburg Group, the Catoctin Formation, the Candler Formation, and the Everona Limestone. The foliation[3] and compositional layering in these rocks all trend to the north-northeast and dip to the southeast at moderate to steep angles. In general, rocks of the Blue Ridge Geologic Province are considered more favorable for groundwater resource development than the rocks within the Piedmont Geologic Province.

The Lynchburg Group (Zlm, Zlg, Zch)[4] is a thick sequence of clastic sedimentary rocks. The most common rock types are fine- to medium-grained, thinly to thickly cross-bedded, feldspathic to quartz-rich, graywackes and siltstone/sandstones. A black graphite-bearing phyllite (Zlg) separates the greywacke (Zlm) and quartz-rich sandstone (Zch) units in Orange County.

The Catoctin Formation (Zc) is primarily comprised of greenschists and greenstones. These rocks are fine- to medium-grained, metamorphosed volcanic rocks comprised primarily of the green minerals chlorite and epidote, hence their name and color. The greenschists are moderately to well foliated while the greenstones are massive and poorly foliated.

The Candler Formation (ca, cas) is a sequence of fine-grained phyllites, schists, metasiltstones, and metasandstones. Lenses and discontinuous pods of quartzite have also been mapped within the Candler Formation.

The Everona Limestone (ev) is a thinly laminated bluish grey limestone interlayered with a calcareous graphitic phyllite. The Everona Limestone is poorly exposed in Orange County and underlies Mountain Run from Gordonsville to slightly north of Route 20 (Plate 1) (Pavlides, 1990 and the Geologic Map of Virginia).

3. Piedmont Geologic Province

The rocks of the Piedmont Geologic Province include quartz schist and metagraywacke units, the Mine Run Complex, the Lahore Complex, and the Ellisville Granodiorite. The foliation (when present) and compositional layering in these rocks all trend to the north-northeast and dip to the southeast at moderate to steep angles. In general, unless a specific bedrock fracture/fault system can be intercepted when drilling, the rocks of the Piedmont Geologic Province within Orange County are considered poor candidates for groundwater development.

The quartz schists and metagraywacke (Zpm) are an interlayered package of rocks that lie east of the Everona limestone (Plate 1). The rocks locally have a pinstriped appearance and are

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[3] Foliation is the parallel alignment of minerals developed during the metamorphism and deformation of the rocks.
[4] The distribution of rock types throughout Orange County is shown on Plate 1. Map symbols are provided for each rock type and are provided in the text after each rock unit is described. For example, the symbols Zlm, Zlg, and Zch are the map symbols shown on Plate 1 that represent the rocks of the Lynchburg Group.

comprised of greenish-grey, fine-to medium-grained quartz and/or biotite schists that are interlayered with dark greenish-grey medium-grained metasandstone or metagraywacke.

The Mine Run Complex in Orange County consists of a variety of metavolcanic and granitoid exotic blocks[5] contained within a matrix of fine-grained phyllites, schists and metasandstones. The rocks of the Mine Run Complex are shown on Plate 1 and are identified by the symbols OZI, OZII, and OZII. The Mine Complex is interpreted to consist of a series of imbricated thrust slices (tectonic packages of rock) each with its own distinctive exotic block content. Within Orange County, the Mine Run Complex is subdivided into three zones and from east to west the zones are referred to on Plate 1 as mélange zones I, II, and III.

The Lahore Complex (Olm, Ola, Olp) is a dark grey fine- to medium-grained volcanic package of rocks that is located in the southeastern portion of the County. The Lahore Complex is subdivided into three subunits based on distinctive mineral compositions.

The Ellisville granodiorite (Soe) is a felsic volcanic pluton located southeast of the Lahore Complex. The granodiorite is poorly exposed in Orange County but is described as a coarse- to medium-grained, massive to strongly foliated granodiorite (Pavlides, 1990).

4. Mesozoic Barboursville and Culpeper Basins

The rock types belonging to the Barboursville Basin shown on Plate 1 View A include the Balls Bluff Siltstone (Trb), Manassas Sandstone (Trm), Poolsville Member (Trmp) and the Rapidan Member of the Manassas Sandstone (Trmra), the Tibbstown Formation (Trt), and the Haudricks Member of the Catharpin Creek (Trth) (Lee and Froelich, 1989). Bedding surfaces typically strike northeast and have a shallow (10° - 20°) dip to the west. With the exception of the conglomerate-bearing rocks, the rocks contained within the Barboursville Basin are considered to be good to very good producers of groundwater.

The Balls Bluff Siltstone underlies the core or the central portion of the Barboursville Basin. The rocks are dusky-red to grayish-red, fine- to medium-grained, thinly layered siltstone interbedded with fine laminar, cross and wavy-bedded sandstone. The interbedded nature of these rocks is thought to explain their tendency to be good producers of groundwater. The gentle dips insure that wells penetrate numerous layers, further enhancing the yield potential of this rock type in specific areas of the study region.

The Manassas Sandstone lies on the eastern margin of the Barboursville Basin. It is comprised of dark red to grayish-red micaceous sandstone interbedded with dark red sandy siltstone.

The Tibbstown Formation underlies the west-central portion of the Basin. The rocks are comprised of reddish-brown, fine- to medium-grained, feldspathic, micaceous sandstone that is interbedded with siltstone, shale, and discontinuous layers of pebble conglomerate.

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[5] The metavolcanic and granitoid blocks are identified on Plate 1 by the symbols mf, gr, and vo.

The Poolsville Member of the Manassas Sandstone underlies the north-central portion of the Basin. The rocks are comprised of dusky red to grayish red, fine- to medium-grained feldspathic, micaceous sandstone.

The Haudricks Member of the Catharpin Creek Formation underlies the western margin of the Basin. The conglomerate is composed of pebbles, cobbles, and boulders of quartzite, metasiltstone, gneissic granite, and greenstone in a matrix of dark grayish-red sand and silt. These rocks are poorly exposed but forms resistant ledges near Hardwick Mountain.

The Rapidan Member of the Manassas Sandstone is located in the northern portion of the Basin. The conglomerate is comprised of greenish-grey greenstone cobbles, boulders and pebbles in a firmly cemented matrix of clayey sand and silt.

The southern edge of the Culpeper Basin intersects the northern tip of Orange County (Figure 2). The rock types belonging to the Culpeper Basin within Orange County include Rapidan Member of the Manassas Sandstone, the Poolsville Member of the Manassas Sandstone, and the Balls Bluff Siltstone. Bedding surfaces are similar to those found in the Barboursville Basin- typically strike northeast and have a shallow (10° - 20°) dip to the northwest. Although the sandstones and siltstones of the Balls Bluff Siltstone and the Poolsville Member of the Manassas Sandstone are considered good to excellent producers of groundwater, the lateral extent of these rocks within the Culpeper Basin are very limited in Orange County (Plate 1 View A).

5. Major Geologic Structures

Faults occur both on a regional and local scale in Orange County (Plate 1 View A). Although their precise locations could not be confirmed during our geologic mapping program, such regional faults (as presented on the Geologic Map of Virginia) could significantly influence groundwater flow. Many potential groundwater development zones were selected, in part, to further investigate the water-bearing potential of such faults. Phase II work efforts will determine the location of such structures, if present in the bedrock underlying these zones. Outcrop-scale faults were discovered and mapped in several places throughout the County, including primary groundwater development zone ONG-9 (Plate 1 View A). The fractured rock associated with such faults and fault systems often enhance the water-bearing capabilities of the bedrock.

B. Delineation of Fractured Bedrock Aquifers

1. Introduction

Besides being dependent on the physical and chemical composition of the bedrock units, the capacity of bedrock to be water bearing also depends on the occurrence of fractures, faults, or other bedrock discontinuities, which provide avenues for the transmission of groundwater. Therefore, in addition to evaluating the *primary* characteristics of rock types, EGGI also investigated the *secondary* permeability associated with bedrock discontinuities within the study area. EGGI used a two-fold approach in investigating these secondary characteristics: 1) remote sensing analysis of the site using multiple scales and types of aerial photography and imagery, and 2) measurement of bedrock fracture characteristics at bedrock exposures in all rock types present in the study area. It should be emphasized that this review is separate and distinct from the evaluation of the bedrock's inherent capability to store and yield groundwater as described in the previous section (i.e., rock composition, nature of layering, and dip of layering).

Analysis of remote sensing data provided 100% coverage of the study area. Data collected during EGGI's on-site investigations of bedrock exposures provided field evidence on the orientation and nature of the faults and fracture systems whose existence was indicated by the remote sensing results. Statistical definition of the trend of bedrock fracture families was correlated with remote sensing data (i.e., lineaments) to define areas considered sufficiently disrupted to be capable of yielding significant volumes of groundwater.

2. Remote Sensing Analysis of Local Hydrogeologic Environment

The ability of geologists to consistently and accurately delineate water-bearing bedrock fracture systems is the key to successful evaluation of the potential for development of groundwater supplies from bedrock sources. One tool that supports this ability is remote sensing. Remote-sensing analysis of different scales of imagery was conducted to help characterize the geologic structure and fracture fabric of the study area. This was accomplished by delineating lineaments[6], or "fracture traces," for two sets of images. **The images used for this study are presented on the lineament table shown on Plate 1; *a total of 8,977 lineaments were identified and evaluated.***

The rose diagrams graphically displayed on Plate 1, View C show the orientations of the most common lineament trends across the study area. Note, however, that lineaments with different trends do occur locally, as shown by the map of individual lineaments (Plate 1 View B). The rose diagrams shown on Plate 1, View C were generated based on lineaments collected within a seven-kilometer radius circle. Each circle overlapped each other 30% across the study area to help smooth the data by area averaging. The statistically significant trends shown by the cumulative rose diagram in decreasing order of prominence are: 51°, 89°, and 148°, with slightly smaller peaks found at 178° and 7°.

3. Geologic Field Mapping/Fracture Fabric Analysis

Structural mapping was focused on features known to control the directional permeability of the bedrock, such as the fractures (and their orientation, size, spacing, and interconnectedness), faults, deeply weathered zones, or other geological discontinuities. In

[6] Many water-bearing subsurface features, such as fracture zones, bedrock discontinuities, faults, and geologic contacts, have a ground surface expression that can be detected through a remote sensing analysis of photographic images and topographic maps. These surface expressions typically appear on the ground surface as topographic linear features, vegetation changes or tonal anomalies (i.e., contrast changes), and are known as lineaments. A lineament can be loosely defined as a mapable linear feature, as seen on the terrain surface, whose parts are aligned in a rectilinear or curvilinear manner.

addition, the structural data collected provided some "ground truth" that could be compared with the remote-sensing data.

Four hundred and ten (410) fractures (and fracture families) were recorded in this investigation (Plate 1). The strike and dip[7] of the statistically distinct bedrock fracture orientations were identified as follows: 154°(87°), 66°(86°), 108°(88°), 126°(89°), and 223°(90°). Locally, other orientations are found as shown by the fracture symbols on Plate 1.

The statistically significant fracture trends are loosely matched with the statistically significant lineament trends. However, the local fracture family roses match local lineament roses that were generated across the County. The correlation of local fracture and lineament family trends helps to validate the use of lineaments as indicators of fracture features where bedrock is not exposed in the many areas of the County.

C. Existing Wells

Information on existing wells was also compiled and evaluated to gain additional insights into the fractured bedrock aquifers present in the County (Plate 2, View B). Unfortunately, very few records were available, considering the large number of domestic wells that are used within the county[8]. Local well information was collected from several sources to help characterize the groundwater resources available in the area (Plate 2, View B). These sources include:

- The national STORET database, maintained by EPA, accounted for 337 wells in the study area, with varying amounts of subsurface information available.
- Information was gathered on 13 Public Wells at the Virginia Department of Environmental Quality.
- Information on 25 domestic wells was provided by a local well driller (Leazer Brothers Drilling & Pump Company, October 2006).

The accumulated well data show a wide range of yields and well depths, which is consistent with the highly variable nature of the fractured bedrock aquifers in the area.

Inspection of the well tables shown on Plate 2 View B shows that wells with yields over 50 gpm (both domestic wells and wells that serve community systems) have not been restricted to any single area of the study region. Comparison of Plate 2 View B with the geologic map of Plate 1, View A shows that nearly all of the rock types mapped in the area host at least one high-yielding well. Thus, the distribution of well yields demonstrates that it is possible to drill high-yielding wells in any portion of the study area, or in any of its geologic environments, if highly permeable bedrock structures are intercepted.

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[7] Dip refers to the angle at which a fracture, geologic bed, etc., is inclined from the horizontal plane (measured in degrees). Strike refers to the orientation of a horizontal line in the plane of an inclined planar feature such as a fracture or a geologic bed. It is measured in degrees east of north.

[8] The 2006 Wiley & Wilson report estimates that 7,325 addresses derive their water source from a residential well.

D. Groundwater Recharge Assessment

1. Water Budget

The amount of available groundwater recharge determines the long-term sustainable yield available to a well or well field. The ultimate source of all recharge to fractured-bedrock aquifers is precipitation, which infiltrates via some circuitous pathway to the transmissive fracture systems. Average annual precipitation in Orange County is about 42 inches (Wiley & Wilson, 2006). Precipitation is split into two primary categories, total runoff and evapotranspiration. Total runoff is measured and recorded at many watersheds throughout Virginia by the U. S. Geological Survey. A stream gage on Rapidan River near Ruckersville shows annual average total runoff of about 13 inches per year, or one-third of precipitation. The remaining two-thirds, or 29 inches of precipitation, is lost to evapotranspiration and is thus unavailable to pumping wells.

Total runoff can be subdivided into quickflow (which runs off quickly to streams) and groundwater recharge (which potentially becomes available to pumping wells). In the Piedmont of Virginia and nearby Maryland, estimates of groundwater recharge have ranged from 8.4 inches per year (Pavich, 1986), to 10.5 inches per year (Richardson, 1980), to 11.3 inches per year (Nutter and Otton, 1969). Therefore, a value of 10 inches per year is considered by EGGI to be appropriate for the Orange study area.

Based on the average annual groundwater recharge value of 10 inches and the size of Orange County (approximately 343.5 square miles), the County receives annual groundwater recharge totaling approximately 59 billion gallons per year, or 163 million gallons per day. This value represents the theoretical total volume of water available in the County for groundwater resource recovery.

Such volumes of recharge to the groundwater system will allow the development of numerous high-yielding wells within the County. However, the specific amount of recharge that can be captured by such wells can only be determined through the detailed hydrologic testing of wells drilled within any specific hydrogeologic setting.

2. Conceptual Model of Recharge to Bedrock Wells

The ability of a bedrock well to obtain recharge is a function of many factors. Most types of bedrock have relatively low porosity. Although transmissive bedrock fractures can allow rapid movement of water, only a small percentage of the rock volume consists of open space in which water can be stored. Therefore, it is very important that there is sufficient availability of recharge water to the underlying bedrock aquifer that is being investigated.

The unconsolidated porous medium above bedrock is referred to as regolith. Its presence and nature has a large impact on the sustainable yield of nearby bedrock wells, since it tends to be a highly porous material that can store large volumes of water. Regolith is predominantly composed of saprolite (rock which has weathered in place and has been partially converted to clay minerals), soil, or alluvial material (sediment deposited by streams). The total volume of regolith within the zone of contribution of a pumping well is important to consider when estimating the ability of a specific area to sustain recharge to a pumping well and/or wellfield.

In all three Geologic Provinces within Orange County, potential groundwater development zones were delineated in those areas where groundwater recharge characteristics are considered to be most favorable. Generally speaking, recharge is most favorable in areas where regolith is likely to be thickest.

E. Potential Contaminant Threats

1. Methods and Summary Results

An inventory of known and potential contaminant threats was completed for the entire study area. Contaminant threats include any land use or activity that has the potential to release substances into the environment, which would degrade groundwater quality. Contaminant threats can be limited to very specific point sources, such as gasoline stations, or they may be broad areas, such as intensive agricultural development or closely spaced septic systems. A survey of contaminant threats was integrated into the exploration program as a fundamental consideration for the selection of potential groundwater development zones. Such an inventory reduces the risk that wells will be drilled in an area that contains or is threatened by groundwater contamination.

All of the identified sources of known and potential contamination are identified on Plate 2. The inventory of potential threats to groundwater quality was generated from the following sources:

- Detailed inspection of County-wide 2002 high-resolution aerial photographs, which focused on identifying areas of land-use activities considered potentially incompatible with groundwater resource development (such as junkyards, commercial and industrial activities).

- Windshield surveys of the study area, with emphasis on those areas selected as most favorable for groundwater development. Potential contaminant threat sites identified during the aerial photograph inspection were also confirmed during windshield survey.

- Virginia Department of Environmental Quality (VDEQ) provided potential contaminant threat sites that were within a 1-mile radius of the 13 public supply wells that exist in the County.

- Collection of EPA files on sites listed as CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as Superfund), NPDES (National Pollution Discharge Elimination System), RCRA (Resource Conservation and Recovery Act), and TRI (Toxics Release Inventory).

- Compilation of Leaking Underground Storage Tank (LUST) sites listed at the Virginia Department of Environmental Quality (VDEQ).

An assessment of the relative risk of contaminant threats to groundwater quality was made using these datasets and then integrated with the other geologic factors associated with developing potable groundwater resources (i.e., bedrock type, availability of groundwater recharge, etc.). This information influenced the final selection of potential groundwater development zones.

V. SUMMARY OF RESULTS

The many criteria integrated to rank zones according to their favorability for developing groundwater supplies cannot be quantified by a rigid mathematical equation. Rather, the results of the exploration program is dependent upon an experienced team of earth scientists integrating all of the criteria and qualitatively assigning a "likelihood" of a particular zone to produce protected, sustainable groundwater supplies of good quality.

The results of this Phase I groundwater exploration program has served to delineate 29 zones, which the groundwater investigation team has selected as favorable for groundwater development. These potential groundwater development zones are distributed throughout the County in a wide variety of hydrogeologic settings (Figures 1 and 3; Plates 1 and 2). The potential groundwater development zones are divided into three categories: 10 "**primary**" zones[9], 6 "**secondary**" zones, and 13 "**tertiary**" zones. Technical criteria used to evaluate these areas include topography, bedrock geology, bedrock structural features, lineaments, fracture fabric, existing wells, current and past land uses, potential sources of groundwater recharge, and the location and type of potential contaminant threats.

It is very difficult, if not impossible, to predict the ultimate yields of wells targeted for drilling or even the total capacity of a selected groundwater development zone to produce water, prior to subsurface investigation (i.e., geophysical surveys, test well drilling, and/or long-term pumping yield tests). However, based upon our combined experiences and the hydrogeological data we have collected and evaluated during this Phase I study, we believe that the following water supply goals developed from groundwater sources are achievable:

Primary Favorable Zones (combined) –	**1,000,000-2,000,000+**	**gallons per day**
Secondary Favorable Zones (combined) –	**400,000-600,000+**	**gallons per day**
Tertiary Favorable Zones (combined) –	**600,000-1,000,000+**	**gallons per day**
Total	***2,000,000-3,600,000+***	***gallons per day***

[9] Primary zones are considered more favorable than secondary zones and so forth. However, information obtained from Phase II investigations may serve to modify the relative priority ranking of these groundwater development areas.

It should be recognized that EGGI's exploration efforts have been restricted to evaluating only "above" surface (aerial platforms) and "ground" surface hydrogeologic information. The results of subsurface investigations, such as geophysical surveys and test well drilling, may ultimately support increases/decreases in groundwater production capacity for the County. In addition, the results of Phase II investigations may serve to modify the ranking of some groundwater development zones and/or our estimate of groundwater production capacity for the County.

The results of EGGI's Phase I investigation indicates the development of significant groundwater resources within the County is achievable. The development of such volumes of groundwater should make a significant contribution to the overall total water supply capacity that can supplement present and anticipated future water use needs of Orange County.

VI. LIMITATIONS

EGGI has collected and evaluated the available technical data according to professionally accepted scientific standards. The recommendations provided herein represent EGGI's professional opinion based upon the hydrogeologic data collected and do not constitute a warranty written or implied.

VII. REFERENCES

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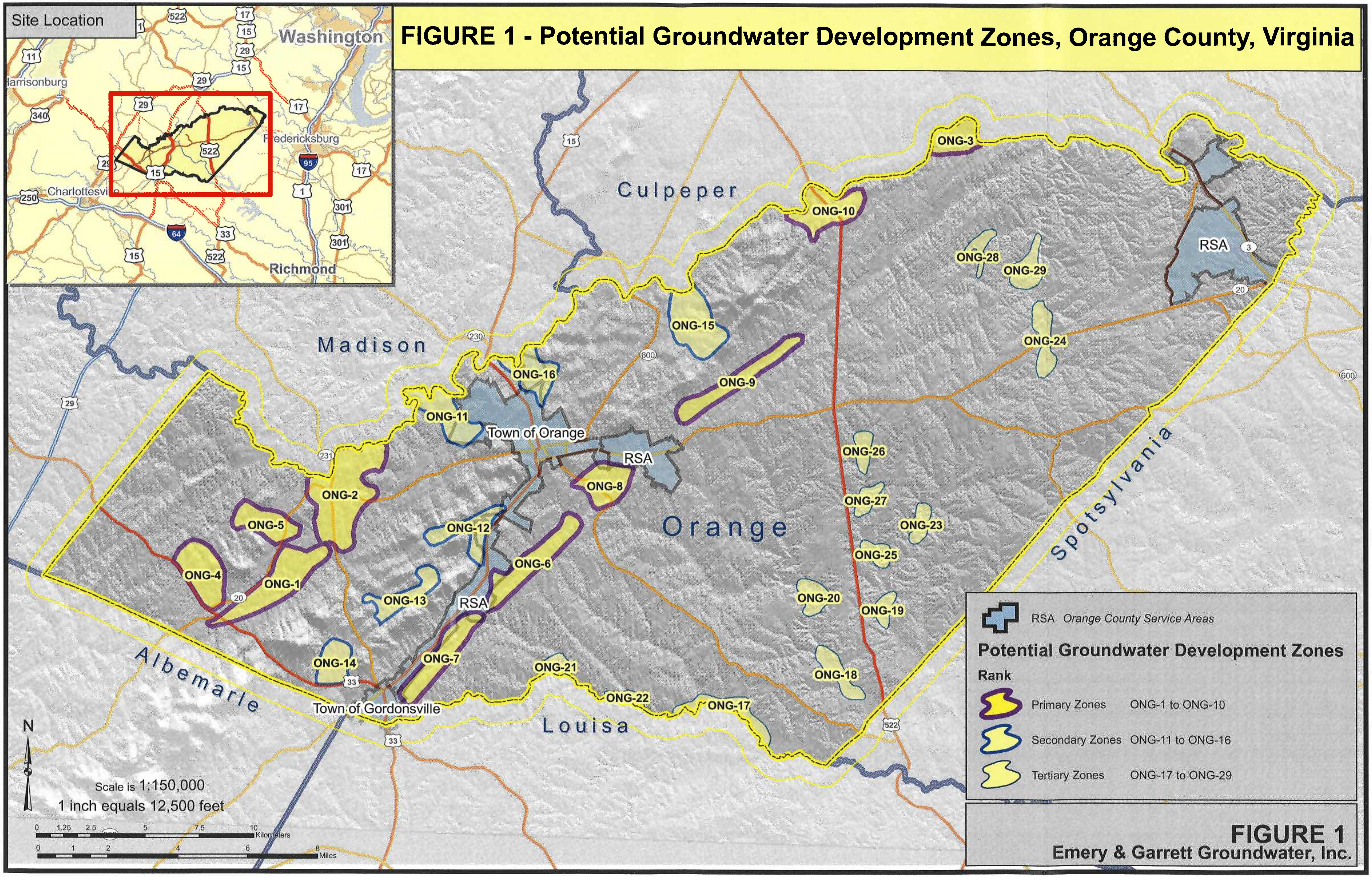

FIGURE 1 - Potential Groundwater Development Zones, Orange County, Virginia
Site Location
Washington
Harrisonburg
Fredericksburg
Charlottesville
Richmond
Culpeper
Madison
Orange
Spotsylvania
Albemarle
Louisa
Town of Orange
Town of Gordonsville
RSA
ONG-1
ONG-2
ONG-3
ONG-4
ONG-5
ONG-6
ONG-7
ONG-8
ONG-9
ONG-10
ONG-11
ONG-12
ONG-13
ONG-14
ONG-15
ONG-16
ONG-17
ONG-18
ONG-19
ONG-20
ONG-21
ONG-22
ONG-23
ONG-24
ONG-25
ONG-26
ONG-27
ONG-28
ONG-29
RSA Orange County Service Areas
Potential Groundwater Development Zones
Rank
Primary Zones ONG-1 to ONG-10
Secondary Zones ONG-11 to ONG-16
Tertiary Zones ONG-17 to ONG-29
N
Scale is 1:150,000
1 inch equals 12,500 feet
0 1.25 2.5 5 7.5 10 Kilometers
0 1 2 4 6 8 Miles
FIGURE 1
Emery & Garrett Groundwater, Inc.

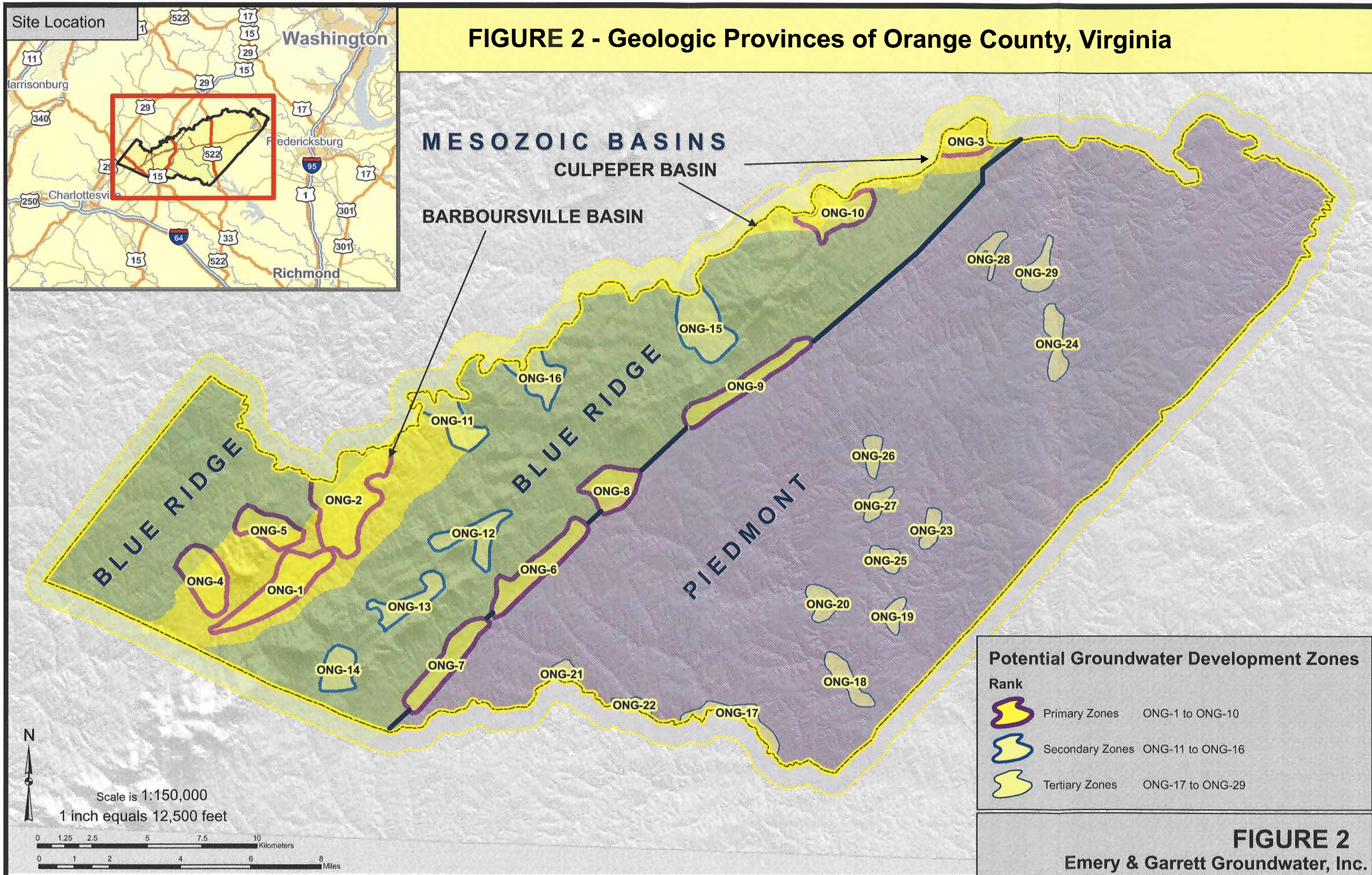

FIGURE 2 - Geologic Provinces of Orange County, Virginia
Site Location
Washington
Harrisonburg
Fredericksburg
Charlottesville
Richmond
MESOZOIC BASINS
CULPEPER BASIN
BARBOURSVILLE BASIN
BLUE RIDGE
BLUE RIDGE
PIEDMONT
ONG-1
ONG-2
ONG-3
ONG-4
ONG-5
ONG-6
ONG-7
ONG-8
ONG-9
ONG-10
ONG-11
ONG-12
ONG-13
ONG-14
ONG-15
ONG-16
ONG-17
ONG-18
ONG-19
ONG-20
ONG-21
ONG-22
ONG-23
ONG-24
ONG-25
ONG-26
ONG-27
ONG-28
ONG-29
Potential Groundwater Development Zones
Rank
Primary Zones ONG-1 to ONG-10
Secondary Zones ONG-11 to ONG-16
Tertiary Zones ONG-17 to ONG-29
N
Scale is 1:150,000
1 inch equals 12,500 feet
0 1.25 2.5 5 7.5 10 Kilometers
0 1 2 4 6 8 Miles
FIGURE 2
Emery & Garrett Groundwater, Inc.

Plates 1 and 2 of this report are not included. They are available for review at the following locations:

Orange County
Gordon Building
112 West Main Street
Orange, VA 22960

Town of Orange
119 Belleview Avenue
Orange, Virginia 22960-1499

Town of Gordonsville
112 South Main Street
Gordonsville, VA 22942

Rapidan Service Authority
11235 Spotswood Trail
Ruckersville, VA 22968

EMERY & GARRETT GROUNDWATER, INC.
56 Main Street • P.O. Box 1578
Meredith, New Hampshire 03253

APPENDIX-D

Alternative Analysis- Qualitative Assessment of Alternatives
Using Analytical Hierarchy Process

About the Analytical Hierarchy Process

The AHP algorithm works on the methodology of comparison of two entities. The comparison of two entities is used to determine relative preference. Based on the preference levels, numerical scores are assigned. The relative preferences are related to numerical scores by a predefined scale which was developed by T.L.Saaty, 1980. The value on numerical scale ranges from 1 through 9, with 9 being extremely preferred and 1 being equally preferred choice. The said scale is presented below for reference.

Preference Level	Numerical Score
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

The AHP algorithm is beneficial in determining the choices in a multi-criterion environment, where all the criterions are not equally preferable. To summarize, the algorithm works on the following methodology:

- First, the AHP compares the criterions that are used for evaluation. This is achieved by pair wise (two at a time) comparison of criterions and establishing relative preferences for each pair. This primarily establishes the relative ranking of the criterions in form of a matrix.
- Next, the alternatives are compared pair wise (two at a time) under each criterion independently. Hence, under each criterion, the relative ranking of the alternatives is established. The rankings under each of these criterions are used to get another matrix.

- Finally, the product of the two matrices provides the ranked preferences of alternatives. A detailed description of the methodology is available in *Analytical Hierarchy Process-Saaty T., McGraw Hill, 1980*.

Comment [W&W1]: Add to bibliography.

Qualitative Assessment of Alternatives Using AHP

First Step- Ranking of Criterions

The relative preference (based on the scale defined earlier) is used to assign weights to each pair. The criterions are assigned weights in form of a matrix (Table B-1.A). For instance the relative preference of protected land over wetland is considered “extremely preferred” and hence a weight of “9” is assigned. After all the weights are allocated, the weights are normalized by dividing each value with the sum of the respective column (Table B-1.B). The normalized matrix is then averaged across the rows to derive the average of the normalized weights (Last Column Table B-1.B). The averaged value of the normalized matrix is the relative ranking of the criterions on a normalized scale.

Second Step- Ranking of Alternatives

Similar to the first step, the alternatives are compared (pair wise) under each criterion, independently. This results in eight matrices (one for each criteria), and the average values of the normalized matrix under each criterion describes the rank of the alternatives under the respective criteria, independently. The weights assigned to alternatives under each criteria, the normalized matrices and the average of the normalized matrices are shown in Table D-1 through Table D-18)

Final Step- Ranked Preferences

The averaged normalized values for each criterion are a column matrix with 15 rows and 1 column. Each of these 8 column matrices (one for each criterion) is joined in original sequence to obtain 8 x 15 matrix (Matrix-A). This 8 x 15 matrix expresses the relative preference of attributes under each criterion (in each column). The matrix is multiplied to the averaged normalized preferences of the criteria (last column Table D-2) to obtain the final preferences of alternatives. The final preferences obtained from the multiplication of the matrices is shown in Table D-19.

Comparison of Criteria

Table D-1 A Assigned Weights based on Pair wise Comparison of Criteria

Criteria	a	b	c	d	e	f	g	h
a	1	0.111	3	0.250	0.333	0.111	0.333	0.333
b	9	1	9	9	9	1	9	9
c	0.333	0.111	1	0.333	0.250	0.111	0.250	0.200
d	4	0.111	3	1	2	0.111	0.500	3
e	3	0.111	4	0.5	1	0.111	2	2
f	9	1	9	9	9	1	9	9
g	3	0.111	4	2	0.500	0.111	1	2
h	3	0.111	5	0.333	0.500	0.111	0.500	1
Sum	*32.333*	*2.667*	*38*	*22.417*	*22.583*	*2.667*	*22.583*	*26.533*

Legends

a	Proximity to Wetlands
b	Proximity to Protected Lands
c	Proximity to Gas Pipelines
d	Extent of Development
e	Proximity to Pollution Source
f	Proximity to Archeological Site
g	Proximity to Existing Infrastructure
h	Drainage Area

Table D-2 B Normalized Weights Derived from Pair Wise Comparison of Criteria

	a	b	c	d	e	f	g	h	AVERAGE
a	0.031	0.042	0.079	0.011	0.015	0.042	0.015	0.013	0.031
b	0.278	0.375	0.237	0.401	0.399	0.375	0.399	0.339	0.350
c	0.010	0.042	0.026	0.015	0.011	0.042	0.011	0.008	0.021
d	0.124	0.042	0.079	0.045	0.089	0.042	0.022	0.113	0.069
e	0.093	0.042	0.105	0.022	0.044	0.042	0.089	0.075	0.064
f	0.278	0.375	0.237	0.401	0.399	0.375	0.399	0.339	0.350
g	0.093	0.042	0.105	0.089	0.022	0.042	0.044	0.075	0.064
h	0.093	0.042	0.132	0.015	0.022	0.042	0.022	0.038	0.051

Comparison of Alternatives

<u>Criteria</u>- Proximity to Wetlands

Table D-3 A Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	2	1	1	1	3	5	1	2	3	2	0.111	0.333	1	1
B	0.500	1	0.500	0.500	0.500	3	5	1	2	2	2	0.111	1	1	1
C	1	2	1	1	1	5	5	1	1	3	2	0.111	1	1	1
D	1	2	1	1	0.5	5	5	1	1	2	2	0.111	0.500	0.500	0.500
E	1	2	1	2	1	5	5	1	1	3	2	0.111	0.500	0.500	0.500
F	0.333	0.333	0.200	0.200	0.200	1	3	0.200	0.200	0.25	0.200	0.111	0.200	0.200	0.200
G	0.200	0.200	0.200	0.200	0.200	0.333	1	0.200	0.200	0.200	0.200	0.111	0.200	0.200	0.200
H	1	1	1	1	1	5	5	1	1	2	2	0.111	1	1	1
I	0.500	0.500	1	1	1	5	5	1	1	2	2	0.111	1	1	1
J	0.333	0.500	0.333	0.500	0.333	4	5	0.500	0.500	1	0.333	0.111	0.333	0.333	0.333
K	0.500	0.500	0.500	0.500	0.500	5	5	0.500	0.500	3	1	0.111	0.500	0.500	0.500
L	9	9	9	9	9	9	9	9	9	9	9	1	9	9	9
M	3	1	1	2	2	5	5	1	1	3	2	0.111	1	1	1
N	1	1	1	2	2	5	5	1	1	3	2	0.111	1	1	1
O	1	1	1	2	2	5	5	1	1	3	2	0.111	1	1	1
Sum	*21.4*	*24*	*19.7*	*23.9*	*22.2*	*65.3*	*73*	*20.4*	*22.4*	*39.5*	*30.7*	*2.56*	*18.6*	*19.2*	*19.2*

<u>Legends</u>

- **A** Laurel Run
- **B** Poplar Run
- **C** Marsh Run
- **D** Blue Run
- **E** Barbour Run
- **F** Cooks Creek
- **G** Pamunkey Creek
- **H** Mine Run
- **I** Mountain Run
- **J** Wilderness Run
- **K** Shotgun Hill Branch
- **L** Unnamed trib. above Wilderness
- **M** Beaver Run
- **N** Colvin Run
- **O** Church Run

Table D-4 B Normalized Weights Derived from Pair Wise Comparison of Alternatives

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
A	0.047	0.083	0.051	0.042	0.045	0.046	0.068	0.049	0.089	0.076	0.065	0.043	0.018	0.052	0.052	0.055
B	0.023	0.042	0.025	0.021	0.022	0.046	0.068	0.049	0.089	0.051	0.065	0.043	0.054	0.052	0.052	0.047
C	0.047	0.083	0.051	0.042	0.045	0.077	0.068	0.049	0.045	0.076	0.065	0.043	0.054	0.052	0.052	0.057
D	0.047	0.083	0.051	0.042	0.022	0.077	0.068	0.049	0.045	0.051	0.065	0.043	0.027	0.026	0.026	0.048
E	0.047	0.083	0.051	0.084	0.045	0.077	0.068	0.049	0.045	0.076	0.065	0.043	0.027	0.026	0.026	0.054
F	0.016	0.014	0.010	0.008	0.009	0.015	0.041	0.010	0.009	0.006	0.007	0.043	0.011	0.010	0.010	0.015
G	0.009	0.008	0.010	0.008	0.009	0.005	0.014	0.010	0.009	0.005	0.007	0.043	0.011	0.010	0.010	0.011
H	0.047	0.042	0.051	0.042	0.045	0.077	0.068	0.049	0.045	0.051	0.065	0.043	0.054	0.052	0.052	0.052
I	0.023	0.021	0.051	0.042	0.045	0.077	0.068	0.049	0.045	0.051	0.065	0.043	0.054	0.052	0.052	0.049
J	0.016	0.021	0.017	0.021	0.015	0.061	0.068	0.025	0.022	0.025	0.011	0.043	0.018	0.017	0.017	0.027
K	0.023	0.021	0.025	0.021	0.022	0.077	0.068	0.025	0.022	0.076	0.033	0.043	0.027	0.026	0.026	0.036
L	0.421	0.374	0.456	0.377	0.405	0.138	0.123	0.441	0.402	0.228	0.293	0.391	0.485	0.468	0.468	0.365
M	0.140	0.042	0.051	0.084	0.090	0.077	0.068	0.049	0.045	0.076	0.065	0.043	0.054	0.052	0.052	0.066
N	0.047	0.042	0.051	0.084	0.090	0.077	0.068	0.049	0.045	0.076	0.065	0.043	0.054	0.052	0.052	0.060
O	0.047	0.042	0.051	0.084	0.090	0.077	0.068	0.049	0.045	0.076	0.065	0.043	0.054	0.052	0.052	0.060

Legends

A Laurel Run
B Poplar Run
C Marsh Run
D Blue Run
E Barbour Run
F Cooks Creek
G Pamunkey Creek
H Mine Run
I Mountain Run
J Wilderness Run
K Shotgun Hill Branch
L Unnamed trib. above Wilderness
M Beaver Run
N Colvin Run
O Church Run

Criteria- Proximity to Protected Lands

Table D-5 A Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	1	1	9	9	3	1	1	1	1	1	1	7	1	9
B	1	1	1	9	9	3	1	1	1	1	1	1	7	1	9
C	1	1	1	9	9	3	1	1	1	1	1	1	7	1	9
D	0.111	0.111	0.111	1	1	0.200	0.111	0.111	0.111	0.111	0.111	0.111	0.500	0.111	1
E	0.111	0.111	0.111	1	1	0.333	0.111	0.111	0.111	0.111	0.111	0.111	0.500	0.111	1
F	0.333	0.333	0.333	5	3	1	0.143	0.143	0.143	0.143	0.143	0.143	5	0.143	1
G	1	1	1	9	9	7	1	1	1	1	1	1	7	1	9
H	1	1	1	9	9	7	1	1	1	1	1	1	7	1	9
I	1	1	1	9	9	7	1	1	1	1	1	1	7	1	9
J	1	1	1	9	9	7	1	1	1	1	1	1	7	1	9
K	1	1	1	9	9	7	1	1	1	1	1	1	7	1	9
L	1	1	1	9	9	7	1	1	1	1	1	1	7	1	9
M	0.143	0.143	0.143	2	2	0.200	0.143	0.143	0.143	0.143	0.143	0.143	1	0.111	2
N	1	1	1	9	9	7	1	1	1	1	1	1	9	1	9
O	0.111	0.111	0.111	1	1	1	0.111	0.111	0.111	0.111	0.111	0.111	0.500	0.111	1
Sum	*10.8*	*10.8*	*10.8*	*100*	*98*	*60.7*	*10.6*	*10.6*	*10.6*	*10.6*	*10.6*	*10.6*	*79.5*	*10.6*	*96*

Legends

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

Table D-6 B Normalized Weights Derived from Pair Wise Comparison of Alternatives

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**Average**
A	0.093	0.093	0.093	0.090	0.092	0.049	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.090
B	0.093	0.093	0.093	0.090	0.092	0.049	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.090
C	0.093	0.093	0.093	0.090	0.092	0.049	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.090
D	0.010	0.010	0.010	0.010	0.010	0.003	0.010	0.010	0.010	0.010	0.010	0.010	0.006	0.010	0.010	0.010
E	0.010	0.010	0.010	0.010	0.010	0.005	0.010	0.010	0.010	0.010	0.010	0.010	0.006	0.010	0.010	0.010
F	0.031	0.031	0.031	0.050	0.031	0.016	0.013	0.013	0.013	0.013	0.013	0.013	0.063	0.013	0.010	0.024
G	0.093	0.093	0.093	0.090	0.092	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.094
H	0.093	0.093	0.093	0.090	0.092	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.094
I	0.093	0.093	0.093	0.090	0.092	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.094
J	0.093	0.093	0.093	0.090	0.092	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.094
K	0.093	0.093	0.093	0.090	0.092	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.094
L	0.093	0.093	0.093	0.090	0.092	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.088	0.094	0.094	0.094
M	0.013	0.013	0.013	0.020	0.020	0.003	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.010	0.021	0.014
N	0.093	0.093	0.093	0.090	0.092	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.113	0.094	0.094	0.096
O	0.010	0.010	0.010	0.010	0.010	0.016	0.010	0.010	0.010	0.010	0.010	0.010	0.006	0.010	0.010	0.010

<u>Legends</u>

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

<u>Criteria</u>- Proximity to Gas Pipelines

Table D-7 A Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	1	1	1	3	9	9	1	1	1	1	1	1	1	1
B	1	1	1	1	3	9	9	1	1	1	1	1	1	1	1
C	1	1	1	1	3	9	9	1	1	1	1	1	1	1	1
D	1	1	1	1	3	9	9	1	1	1	1	1	1	1	1
E	0.333	0.333	0.333	0.333	1	7	7	1	1	1	1	1	1	1	1
F	0.111	0.111	0.111	0.111	0.143	1	1	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
G	0.111	0.111	0.111	0.111	0.143	1	1	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
H	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
I	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
J	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
K	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
L	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
M	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
N	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
O	1	1	1	1	1	9	9	1	1	1	1	1	1	1	1
Sum	*12.6*	*12.6*	*12.6*	*12.6*	*21.3*	*117*	*117*	*13.2*	*13.2*	*13.2*	*13.2*	*13.2*	*13.2*	*13.2*	*13.2*

<u>Legends</u>

A Laurel Run
B Poplar Run
C Marsh Run
D Blue Run
E Barbour Run
F Cooks Creek
G Pamunkey Creek
H Mine Run
I Mountain Run
J Wilderness Run
K Shotgun Hill Branch
L Unnamed trib. above Wilderness
M Beaver Run
N Colvin Run
O Church Run

Table D-8 B Normalized Weights Derived from Pair Wise Comparison of Alternatives

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
A	0.080	0.080	0.080	0.080	0.141	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.081
B	0.080	0.080	0.080	0.080	0.141	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.081
C	0.080	0.080	0.080	0.080	0.141	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.081
D	0.080	0.080	0.080	0.080	0.141	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.081
E	0.027	0.027	0.027	0.027	0.047	0.060	0.060	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.059
F	0.009	0.009	0.009	0.009	0.007	0.009	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
G	0.009	0.009	0.009	0.009	0.007	0.009	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
H	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075
I	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075
J	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075
K	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075
L	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075
M	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075
N	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075
O	0.080	0.080	0.080	0.080	0.047	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.075

Legends

A Laurel Run
B Poplar Run
C Marsh Run
D Blue Run
E Barbour Run
F Cooks Creek
G Pamunkey Creek
H Mine Run
I Mountain Run
J Wilderness Run
K Shotgun Hill Branch
L Unnamed trib. above Wilderness
M Beaver Run
N Colvin Run
O Church Run

Criteria- Extent of Development

Table D-9 A   Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	0.200	0.200	0.333	0.200	0.200	0.200	0.333	0.500	1	0.333	0.333	0.200	0.200	0.200
B	5	1	1	2	1	1	1	1	2	3	1	1	1	1	1
C	5	1	1	2	1	1	1	1	3	3	1	1	1	1	1
D	3	0.500	0.500	1	0.333	0.500	0.500	0.500	1	1	0.500	0.500	0.500	0.500	0.500
E	5	1	1	3	1	1	1	1	3	3	1	1	1	1	1
F	5	1	1	2	1	1	1	1	3	3	1	1	1	1	1
G	5	1	1	2	1	1	1	1	3	3	1	1	1	1	1
H	3	1	1	2	1	1	1	1	3	3	1	1	1	1	1
I	2	0.500	0.333	1	0.333	0.333	0.333	0.333	1	1	0.333	0.333	0.333	0.333	0.333
J	1	0.333	0.333	1	0.333	0.333	0.333	0.333	1	1	0.333	0.333	0.333	0.333	0.333
K	3	1	1	2	1	1	1	1	3	3	1	1	1	1	1
L	3	1	1	2	1	1	1	1	3	3	1	1	1	1	1
M	5	1	1	2	1	1	1	1	3	3	1	1	1	1	1
N	5	1	1	2	1	1	1	1	3	3	1	1	1	1	1
O	5	1	1	2	1	1	1	1	3	3	1	1	1	1	1
Sum	*56*	*12.5*	*12.4*	*26.3*	*12.2*	*12.4*	*12.4*	*12.5*	*35.5*	*37*	*12.5*	*12.5*	*12.4*	*12.4*	*12.4*

Legends

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

Table D-10 **B Normalized Weights Derived from Pair Wise Comparison of Alternatives**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
A	0.018	0.016	0.016	0.013	0.016	0.016	0.016	0.027	0.014	0.027	0.027	0.027	0.016	0.016	0.016	0.019
B	0.089	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.056	0.081	0.080	0.080	0.081	0.081	0.081	0.079
C	0.089	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.081
D	0.054	0.040	0.040	0.038	0.027	0.040	0.040	0.040	0.028	0.027	0.040	0.040	0.040	0.040	0.040	0.038
E	0.089	0.080	0.081	0.114	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.084
F	0.089	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.081
G	0.089	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.081
H	0.054	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.079
I	0.036	0.040	0.027	0.038	0.027	0.027	0.027	0.027	0.028	0.027	0.027	0.027	0.027	0.027	0.027	0.029
J	0.018	0.027	0.027	0.038	0.027	0.027	0.027	0.027	0.028	0.027	0.027	0.027	0.027	0.027	0.027	0.027
K	0.054	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.079
L	0.054	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.079
M	0.089	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.081
N	0.089	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.081
O	0.089	0.080	0.081	0.076	0.082	0.081	0.081	0.080	0.085	0.081	0.080	0.080	0.081	0.081	0.081	0.081

Legends

A Laurel Run
B Poplar Run
C Marsh Run
D Blue Run
E Barbour Run
F Cooks Creek
G Pamunkey Creek
H Mine Run
I Mountain Run
J Wilderness Run
K Shotgun Hill Branch
L Unnamed trib. above Wilderness
M Beaver Run
N Colvin Run
O Church Run

Criteria- Proximity to Pollution Source

Table D-11 A Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	1	0.111	0.111	0.111	0.111	0.111	1	0.111	0.111	0.111	0.111	0.111	0.111	0.111
B	1	1	0.111	0.111	0.111	0.111	0.111	1	0.111	0.111	0.111	0.111	0.111	0.111	0.111
C	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
D	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
E	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
F	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
G	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
H	1	1	0.111	0.111	0.111	0.111	0.111	1	0.111	0.111	0.111	0.111	0.111	0.111	0.111
I	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
J	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
K	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
L	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
M	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
N	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
O	9	9	1	1	1	1	1	9	1	1	1	1	1	1	1
Sum	*111*	*111*	*12.3*	*12.3*	*12.3*	*12.3*	*12.3*	*111*	*12.3*	*12.3*	*12.3*	*12.3*	*12.3*	*12.3*	*12.3*

Legends

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

Table D-12 B Normalized Weights Derived from Pair Wise Comparison of Alternatives

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
A	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
B	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
C	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
D	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
E	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
F	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
G	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
H	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
I	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
J	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
K	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
L	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
M	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
N	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
O	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081

Legends

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

<u>Criteria</u>- Proximity to Archeological Site

Table D-13 A Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
B	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
C	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
D	0.200	0.200	0.200	1	3	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
E	0.143	0.143	0.143	0.333	1	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.143
F	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
G	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
H	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
I	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
J	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
K	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
L	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
M	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
N	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
O	1	1	1	5	7	1	1	1	1	1	1	1	1	1	1
Sum	*13.3*	*13.3*	*13.3*	*66.3*	*95*	*13.3*	*13.3*	*13.3*	*13.3*	*13.3*	*13.3*	*13.3*	*13.3*	*13.3*	*13.3*

<u>Legends</u>

A Laurel Run
B Poplar Run
C Marsh Run
D Blue Run
E Barbour Run
F Cooks Creek
G Pamunkey Creek
H Mine Run
I Mountain Run
J Wilderness Run
K Shotgun Hill Branch
L Unnamed trib. above Wilderness
M Beaver Run
N Colvin Run
O Church Run

Table D-14 B Normalized Weights Derived from Pair Wise Comparison of Alternatives

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
A	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
B	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
C	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
D	0.015	0.015	0.015	0.015	0.032	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.016
E	0.011	0.011	0.011	0.005	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.010
F	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
G	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
H	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
I	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
J	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
K	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
L	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
M	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
N	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
O	0.075	0.075	0.075	0.075	0.074	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075

<u>Legends</u>

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

<u>Criteria</u>- Proximity to Existing Infrastructure

Table D-15 A Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	1	5	5	5	5	4	3	3	3	3	3	5	5	5
B	1	1	5	5	5	5	4	3	3	3	3	3	5	5	5
C	0.200	0.200	1	3	3	3	3	1	1	2	2	2	1	1	1
D	0.200	0.200	0.333	1	1	1	1	0.200	0.200	0.333	0.333	0.333	1	1	1
E	0.200	0.200	0.333	1	1	1	1	0.200	0.200	0.333	0.333	0.333	0.500	0.500	0.500
F	0.200	0.200	0.333	1	1	1	1	0.200	0.200	0.333	0.333	0.333	0.500	0.500	0.500
G	0.250	0.250	0.333	1	1	1	1	0.200	0.200	0.333	0.333	0.333	1	1	1
H	0.333	0.333	1	5	5	5	5	1	1	2	2	2	3	3	1
I	0.333	0.333	1	5	5	5	5	1	1	2	2	2	3	3	1
J	0.333	0.333	0.500	3	3	3	3	0.500	0.500	1	1	1	3	3	2
K	0.333	0.333	0.500	3	3	3	3	0.500	0.500	1	1	1	2	2	1
L	0.333	0.333	0.500	3	3	3	3	0.500	0.500	1	1	1	2	2	1
M	0.200	0.200	1	1	2	2	1	0.333	0.333	0.333	0.500	0.500	1	1	0.500
N	0.200	0.200	1	1	2	2	1	0.333	0.333	0.333	0.500	0.500	1	1	0.500
O	0.200	0.200	1	1	2	2	1	1	1	0.500	1	1	2	2	1
Sum	*5.32*	*5.32*	*18.8*	*39*	*42*	*42*	*37*	*13*	*13*	*17.5*	*18.3*	*18.3*	*31*	*31*	*22*

<u>Legends</u>

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

Table D-16 B Normalized Weights Derived from Pair Wise Comparison of Alternatives

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
A	0.188	0.188	0.265	0.128	0.119	0.119	0.108	0.231	0.231	0.171	0.164	0.164	0.161	0.161	0.227	0.175
B	0.188	0.188	0.265	0.128	0.119	0.119	0.108	0.231	0.231	0.171	0.164	0.164	0.161	0.161	0.227	0.175
C	0.038	0.038	0.053	0.077	0.071	0.071	0.081	0.077	0.077	0.114	0.109	0.109	0.032	0.032	0.045	0.068
D	0.038	0.038	0.018	0.026	0.024	0.024	0.027	0.015	0.015	0.019	0.018	0.018	0.032	0.032	0.045	0.026
E	0.038	0.038	0.018	0.026	0.024	0.024	0.027	0.015	0.015	0.019	0.018	0.018	0.016	0.016	0.023	0.022
F	0.038	0.038	0.018	0.026	0.024	0.024	0.027	0.015	0.015	0.019	0.018	0.018	0.016	0.016	0.023	0.022
G	0.047	0.047	0.018	0.026	0.024	0.024	0.027	0.015	0.015	0.019	0.018	0.018	0.032	0.032	0.045	0.027
H	0.063	0.063	0.053	0.128	0.119	0.119	0.135	0.077	0.077	0.114	0.109	0.109	0.097	0.097	0.045	0.094
I	0.063	0.063	0.053	0.128	0.119	0.119	0.135	0.077	0.077	0.114	0.109	0.109	0.097	0.097	0.045	0.094
J	0.063	0.063	0.027	0.077	0.071	0.071	0.081	0.039	0.039	0.057	0.055	0.055	0.097	0.097	0.091	0.065
K	0.063	0.063	0.027	0.077	0.071	0.071	0.081	0.039	0.039	0.057	0.055	0.055	0.065	0.065	0.045	0.058
L	0.063	0.063	0.027	0.077	0.071	0.071	0.081	0.039	0.039	0.057	0.055	0.055	0.065	0.065	0.045	0.058
M	0.038	0.038	0.053	0.026	0.048	0.048	0.027	0.026	0.026	0.019	0.027	0.027	0.032	0.032	0.023	0.033
N	0.038	0.038	0.053	0.026	0.048	0.048	0.027	0.026	0.026	0.019	0.027	0.027	0.032	0.032	0.023	0.033
O	0.038	0.038	0.053	0.026	0.048	0.048	0.027	0.077	0.077	0.029	0.055	0.055	0.065	0.065	0.045	0.050

Legends

A Laurel Run
B Poplar Run
C Marsh Run
D Blue Run
E Barbour Run
F Cooks Creek
G Pamunkey Creek
H Mine Run
I Mountain Run
J Wilderness Run
K Shotgun Hill Branch
L Unnamed trib. above Wilderness
M Beaver Run
N Colvin Run
O Church Run

Criteria- Drainage Area

Table D-17 .A Assigned Weights based on Pair wise Comparison of Alternatives

Alternative	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	1	3	0.500	2	3	0.200	0.200	0.200	0.333	5	7	3	2	4
B	1	1	3	0.500	2	3	0.200	0.200	0.200	0.333	5	7	3	2	4
C	0.333	0.333	1	0.500	2	1	0.200	0.200	0.200	0.333	5	7	3	2	4
D	2	2	2	1	2	3	0.200	0.200	0.200	0.333	7	7	4	3	5
E	0.500	0.500	0.500	0.500	1	0.333	0.143	0.143	0.143	0.200	2	3	1	1	1
F	0.333	0.333	1	0.333	3	1	0.200	0.200	0.200	0.333	3	4	2	3	3
G	5	5	5	5	7	5	1	0.500	0.333	3	7	7	5	5	7
H	5	5	5	5	7	5	2	1	0.333	3	7	9	5	5	5
I	5	5	5	5	7	5	3	3	1	3	7	9	5	5	5
J	3	3	3	3	5	3	0.333	0.333	0.333	1	5	7	4	4	4
K	0.200	0.200	0.200	0.143	0.500	0.333	0.143	0.143	0.143	0.200	1	3	0.333	0.500	0.500
L	0.143	0.143	0.143	0.143	0.333	0.250	0.143	0.111	0.111	0.143	0.333	1	0.200	0.333	0.250
M	0.333	0.333	0.333	0.250	1	0.5	0.200	0.200	0.200	0.250	3	5	1	4	3
N	0.500	0.500	0.500	0.333	1	0.333	0.200	0.200	0.200	0.250	2	3	0.250	1	0.333
O	0.250	0.250	0.250	0.200	1	0.333	0.143	0.200	0.200	0.250	2	4	0.333	3	1
Sum	*24.6*	*24.6*	*29.9*	*22.4*	*41.8*	*31.1*	*8.3*	*6.83*	*4*	*13*	*61.3*	*83*	*37.1*	*40.8*	*47.1*

Legends

A	Laurel Run	**E**	Barbour Run	**I**	Mountain Run	**M**	Beaver Run
B	Poplar Run	**F**	Cooks Creek	**J**	Wilderness Run	**N**	Colvin Run
C	Marsh Run	**G**	Pamunkey Creek	**K**	Shotgun Hill Branch	**O**	Church Run
D	Blue Run	**H**	Mine Run	**L**	Unnamed trib. above Wilderness		

Table D-18 B Normalized Weights Derived from Pair Wise Comparison of Alternatives

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
A	0.041	0.041	0.100	0.022	0.048	0.097	0.024	0.029	0.050	0.026	0.082	0.084	0.081	0.049	0.085	0.057
B	0.041	0.041	0.100	0.022	0.048	0.097	0.024	0.029	0.050	0.026	0.082	0.084	0.081	0.049	0.085	0.057
C	0.014	0.014	0.033	0.022	0.048	0.032	0.024	0.029	0.050	0.026	0.082	0.084	0.081	0.049	0.085	0.045
D	0.081	0.081	0.067	0.045	0.048	0.097	0.024	0.029	0.050	0.026	0.114	0.084	0.108	0.073	0.106	0.069
E	0.020	0.020	0.017	0.022	0.024	0.011	0.017	0.021	0.036	0.015	0.033	0.036	0.027	0.024	0.021	0.023
F	0.014	0.014	0.033	0.015	0.072	0.032	0.024	0.029	0.050	0.026	0.049	0.048	0.054	0.073	0.064	0.040
G	0.203	0.203	0.167	0.223	0.167	0.161	0.120	0.073	0.083	0.231	0.114	0.084	0.135	0.122	0.149	0.149
H	0.203	0.203	0.167	0.223	0.167	0.161	0.241	0.146	0.083	0.540	0.147	0.060	0.135	0.122	0.106	0.180
I	0.203	0.203	0.167	0.223	0.167	0.161	0.361	0.439	0.250	0.231	0.114	0.108	0.135	0.122	0.106	0.200
J	0.122	0.122	0.100	0.134	0.120	0.097	0.040	0.049	0.083	0.077	0.082	0.084	0.108	0.098	0.085	0.093
K	0.008	0.008	0.007	0.006	0.012	0.011	0.017	0.021	0.036	0.015	0.016	0.036	0.009	0.012	0.011	0.015
L	0.006	0.006	0.005	0.006	0.008	0.008	0.017	0.016	0.028	0.011	0.005	0.012	0.005	0.008	0.005	0.010
M	0.014	0.014	0.011	0.011	0.024	0.016	0.024	0.029	0.050	0.019	0.049	0.060	0.027	0.098	0.064	0.034
N	0.020	0.020	0.017	0.015	0.024	0.011	0.024	0.029	0.050	0.019	0.033	0.036	0.007	0.024	0.007	0.022
O	0.010	0.010	0.008	0.009	0.024	0.011	0.017	0.029	0.050	0.019	0.033	0.048	0.009	0.073	0.021	0.025

Legends

A Laurel Run
B Poplar Run
C Marsh Run
D Blue Run
E Barbour Run
F Cooks Creek
G Pamunkey Creek
H Mine Run
I Mountain Run
J Wilderness Run
K Shotgun Hill Branch
L Unnamed trib. above Wilderness
M Beaver Run
N Colvin Run
O Church Run

MATRIX- A

	Averaged Normalized Preferences for Alternatives Under Each Criteria							
Alternative	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**
A	0.055	0.090	0.081	0.019	0.009	0.075	0.175	0.057
B	0.047	0.090	0.081	0.079	0.009	0.075	0.175	0.057
C	0.057	0.090	0.081	0.081	0.081	0.075	0.068	0.045
D	0.048	0.010	0.081	0.038	0.081	0.016	0.026	0.069
E	0.054	0.010	0.059	0.084	0.081	0.010	0.022	0.023
F	0.015	0.024	0.008	0.081	0.081	0.075	0.022	0.040
G	0.011	0.094	0.008	0.081	0.081	0.075	0.027	0.149
H	0.052	0.094	0.075	0.079	0.009	0.075	0.094	0.180
I	0.049	0.094	0.075	0.029	0.081	0.075	0.094	0.200
J	0.027	0.094	0.075	0.027	0.081	0.075	0.065	0.093
K	0.036	0.094	0.075	0.079	0.081	0.075	0.058	0.015
L	0.365	0.094	0.075	0.079	0.081	0.075	0.058	0.010
M	0.066	0.014	0.075	0.081	0.081	0.075	0.033	0.034
N	0.060	0.096	0.075	0.081	0.081	0.075	0.033	0.022
O	0.060	0.010	0.075	0.081	0.081	0.075	0.050	0.025

MATRIX- B (Last Column Table B-1.B)

Criteria	Average Normalized Preferences
a	0.031
b	0.350
c	0.021
d	0.069
e	0.064
f	0.350
g	0.064
h	0.051

Legends

a	Proximity to Wetlands	**A**	Laurel Run	**I**	Mountain Run
b	Proximity to Protected Lands	**B**	Poplar Run	**J**	Wilderness Run
c	Proximity to Gas Pipelines	**C**	Marsh Run	**K**	Shotgun Hill Branch
d	Extent of Development	**D**	Blue Run	**L**	Unnamed trib. above Wilderness
e	Proximity to Pollution Source	**E**	Barbour Run	**M**	Beaver Run
f	Proximity to Archeological Site	**F**	Cooks Creek	**N**	Colvin Run
g	Proximity to Existing Infrastructure	**G**	Pamunkey Creek	**O**	Church Run
h	Drainage Area	**H**	Mine Run		

Table D-19 A Results of Ranking Locations for Reservoir using AHP

Alternatives	Normalized Preferences	Rank
Unnamed tributary above Wilderness Run	0.08695	First
Mountain Run	0.08567	Second
Mine Run	0.08362	Third
Poplar Run	0.08107	Fourth
Pamunkey Creek	0.07993	Fifth
Marsh Run	0.07865	Sixth
Wilderness Run	0.07764	Seven
Colvin Run	0.07731	Eight
Laurel Run	0.07713	Nine
Shotgun Hill Branch	0.07708	Ten
Cooks Creek	0.04946	Eleven
Beaver Run	0.04928	Twelve
Church Run	0.04854	Thirteen
Blue Run	0.02516	Fourteen
Barbour Run	0.02349	Fifteen

APPENDIX-E

McGuire Woods LLP Correspondence to Wiley|Wilson

**Re: Orange County Water Supply Plan, Alternatives Analysis
Dated November 6, 2006**

**Re: Orange County Water Supply Plan, Alternatives Analysis
Dated March 19, 2007**

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November 6, 2006

Timothy R. Wagner, P.E.
Project Manager
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2310 Langhorne Road
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Re: Orange County Water Supply Plan
Alternatives Analysis

Dear Mr. Wagner:

This responds to your request that I review the draft Alternatives Analysis dated October 2006 ("Analysis") for potential legal and permitting issues.

The final list of alternatives in the Analysis includes increased raw water storage and new groundwater wells as potential sources of additional water supply for the County.

A. Increased Raw Water Storage

The increased raw water storage alternative involves the construction of a reservoir on one or a combination of several small tributaries to the Rapidan River. Under this alternative, water would be pumped from the Rapidan River during periods of higher river flow and stored in the reservoir. The stored water would be either piped for treatment and distribution or released back into the Rapidan River where it would be withdrawn at a downstream intake for treatment and distribution.

The Analysis indicates that all of the tributaries under consideration are relatively small; however, there is little doubt that these tributaries are both State waters and waters of the United States. This is because "State waters" is broadly defined to include all waters in the State (*See* Va. Code § 62.1-3) and "waters of the United States" is broadly defined to include tributaries to interstate waters. *See* 40 C.F.R. § 122.3. Therefore, the reservoir and associated structures such as intakes and piping will require permits from the U.S. Army Corps of Engineers ("Corps"), the Virginia State Water Control Board ("SWCB"), and possibly the Virginia Marine Resources Commission ("VMRC"). It is unlikely that permits would be required for existing intake structures and related facilities such as pumping stations so long as they are not modified to increase their capacity. However, as discussed below, the Corps and the SWCB could establish a minimum instream flow requirement and impose restrictions in the permits for the reservoir and related facilities that would effectively limit the County's ability to increase withdrawals from existing intake structures even if these structures were not modified.

A Corps permit is required pursuant to Section 404 of the Clean Water Act (33 U.S.C. § 1344) for any dredge or fill activity in waters of the United States, which also includes wetlands. In addition to the water quality impacts, the Corps is required to consider all of the potential impacts of the project under the National Environmental Policy Act (42 U.S.C. § 4321 et seq.), including impacts on the environment, endangered species, and historic and cultural resources. The Corps can not issue its permit for the project until the SWCB has issued a certification pursuant to Section 401 of the Clean Water Act (33 U.S.C. § 1342) certifying that the project will not cause or contribute to a violation of water quality standards ("401 Certification"). The SWCB must also issue a Virginia Water Protection ("VWP") permit for the project pursuant to Va. Code § 62.1 -44.15:5. The VWP serves as the SWCB's 401 Certification and is required for projects involving water withdrawals and impacts to wetlands. Although VMRC likely will issue a permit for the water withdrawal, its review is very limited and should not be a significant factor in the approval process.

As you know, in recent years, there has been considerable controversy surrounding water supply reservoir projects in Virginia. The issues that have attracted the most attention and generated the greatest opposition have been impacts to wetlands and cultural resources, with the proposed Ware Creek and King William reservoir projects representing the best examples of what can go wrong with a reservoir project. These projects suggest that in the course of evaluating the alternative sites, wetlands and historical and cultural impacts should receive special attention. Sites with potentially significant impacts on wetlands and historic or cultural resources should be avoided, if possible.

The County should also consider and assess water rights issues pertaining to each alternative site. In Virginia, surface water rights are governed, in part, by the common law riparian doctrine under which riparian landowners are each entitled to reasonable use of the water flowing by their lands. These water rights could be used as a basis to challenge a project where another riparian landowner alleges his or her right of reasonable use will be impacted.

I understand that there are a number of properties in Orange County with conservation easements. Although there is no standard or prevailing form for such easements, they generally place significant limitations on the extent to which property can be subdivided or developed. Such limitations could preclude the use of the property for a reservoir or related facilities. Consequently, the land records for all the properties in and around the sites under consideration should be examined for the existence of conservation easements.

Protection of minimum instream flows and possible impacts on anadromous fish are potential issues at all of the reservoir sites; however, I would anticipate that they would not be significant obstacles in this case so long as the project did not involve withdrawing additional water from the Rapidan River during periods of low flow. In fact, the project could be viewed positively by resource agencies such as the Virginia Department of Game and Inland Fisheries if it is designed to release water back into the River during periods of low flow. Low flow augmentation is often viewed as one of the major benefits of offstream storage. Consequently, I would encourage you to try to design low flow augmentation into the project.

If a minimum instream flow ("MIF") has not already been established for the section of the Rapidan River downstream of the proposed reservoir site, I would expect the Corps and the SWCB to establish one during the permitting process for the project. The permits issued by these agencies would be conditioned to ensure that withdrawals associated with the reservoir did not contravene the MIF, but I would not expect this to be a significant issue with an offstream storage project, particularly one that included low flow augmentation as a component.

B. <u>New Groundwater Wells</u>

The General Assembly has authorized the Virginia Health Department ("VDH") VDH to regulate the quality and quantity of groundwater withdrawals intended for public drinking water supplies. *See* Va. Code § 32.1-174 (requiring that a permit application for a public waterworks include information about the source of the water supply). The statute requires permits for waterworks, which by definition serve at least 15 connections or an average of at least 25 individuals, and for private wells. *See* Va. Code § 32.1-167 through -176.7.[1]

VDH's waterworks regulations require a locality intending to utilize groundwater for drinking water purposes to apply for and obtain permission from VDH. *See* 12 VAC 5-590-280. The application must include, among other things, information relating to: (1) the needs of the community to be served; (2) current water consumption and trends; and (3) projected yield of the source. 12 VAC 5-590-200. If VDH engineers determine that the proposed location is suitable as a well site, the applicant is given tentative

[1] Under the Ground Water Management Act of 1992, Va. Code §§ 62.1-254 to -270, the Virginia Department of Environmental Quality ("DEQ") may regulate and restrict the quantity of groundwater withdrawals in areas where it believes unrestricted use jeopardizes public health or the environment. To date, DEQ has established two areas within the Commonwealth where such restrictions may occur – the Eastern Virginia Groundwater Management Area and the Eastern Shore Groundwater Management Area. *See* 9 VAC § 25-600-10 and 9 VAC § 25-620-10. Orange County is not included in either groundwater management area.

approval to drill a well. 12 VAC 5-590-840. Prior to obtaining a final operation permit, the applicant must also demonstrate that the water to be delivered from the well will not exceed certain bacteriological, physical, chemical and radiological levels. 12 VAC 5-590-820.

In addition to the VDH permit program, the County should also be aware of possible legal challenges by nearby property owners who may feel that their groundwater rights are threatened. As mentioned above, water rights as between landowners may be defined, in part, by the common law. Virginia courts have divided water into two general categories--surface water and groundwater.[2] The courts have established further distinctions between groundwater flowing through subterranean channels and water percolating through underlying soil and rock strata. Flowing groundwater is governed by the common law riparian doctrine discussed above. Percolating groundwater is treated differently, and the Virginia Supreme Court has not expressly adopted a standard. Therefore, the law is unsettled in this area.

Some recent Virginia trial courts have cited favorably to what is sometimes referred to as the American Rule of groundwater. Landowners could attempt to utilize this rule to restrict groundwater distribution off-site if such use actually interferes with their right to the use of subsurface water upon their lands. Louisa County experienced recently an example of this type of challenge pertaining to the use of water supply wells located near the County's Zion Crossroads growth area.

While groundwater is preferred by many localities due, in part, to the expense of surface water facilities, in this case, the County should analyze the potential for common law challenges and develop a technical strategy for minimizing them. We are available to assist with this as needed.

I hope this responds fully to your request. Please do not hesitate to contact me if you have any questions or need additional information.

Sincerely,

David E. Evans

[2] As discussed above, surface waters are governed, in part, by the common law riparian doctrine under which riparian landowners are each entitled to reasonable use of the water flowing by their lands.

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March 19, 2007

BY ELECTRONIC AND FIRST-CLASS MAIL

Timothy R. Wagner, P.E.
Project Manager
Wiley & Wilson, Inc.
2310 Langhorne Road
Lynchburg, VA 24501

Re: Orange County Water Supply Plan
Alternatives Analysis

Dear Mr. Wagner:

I write to supplement our letter of November 6, 2006 pertaining to the draft Alternatives Analysis dated October 2006 ("Analysis") for Orange County.

In our November 6 letter, we mentioned that common law rules in Virginia governing groundwater rights as between landowners have not been settled by the Virginia Supreme Court. However, our recent success defending Louisa County and the Louisa County Water Authority (collectively "Louisa" or "County") in a case involving groundwater rights may help clarify the nature of those rights and provide guidance for utilizing groundwater for public water supply in areas like Orange County, where groundwater can be found – as in Louisa – in fractured bedrock and saprolite.[1]

In Louisa, a group of landowners opposing development near Zion Crossroads sued Louisa, alleging a variety of claims. One claim focused on common law rules pertaining to groundwater withdrawals. The plaintiffs alleged that Louisa could not transfer groundwater for a use unconnected with the property from which it was withdrawn. The plaintiffs asked that the Court review and determine the reasonableness of Louisa's present and future groundwater use, absent any

[1] As discussed in our previous letter, Virginia courts differentiate between groundwater flowing through subterranean channels and water "percolating" through underlying soil and rock strata. Courts apply different legal standards depending upon which of these classifications the groundwater at issue is located. We understand that the groundwater in Orange County is found in fractured bedrock and in overlying saprolite, which would likely be viewed by a Virginia Court as "percolating" groundwater.

demonstration of harm to other groundwater users in the area, and claimed that Louisa had not adequately monitored groundwater.

The Court rejected the plaintiffs' groundwater claims. Instead, the Court applied a rule of reasonable use that several other Virginia trial courts had already cited with favor. Under this rule, a landowner may not withdraw and transfer groundwater for distribution and sale not connected with the beneficial ownership of the land if such use materially damages the groundwater uses of a neighbor. This rule is often referred to as the "American Rule" of groundwater use.

The Court held, in part, that Louisa's withdrawal of water was a beneficial use of the land and reasonable use of the water. The Court held also that, despite testimony from one adjacent landowner that some springs had diminished in recent months, there was no expert testimony that Louisa's use is having, or will have, a material impact on anyone's groundwater uses.

The Court's decision provides some valuable guidance in assessing the circumstances under which localities may safely utilize groundwater. First, the Court's decision helps clarify that merely transferring water off-site from a well is not likely a *per se* violation of the reasonable use rule. The Louisa case is not binding on other courts but will serve as useful precedent until the Supreme Court makes a definitive ruling on the subject.

Second, in order to oppose a locality's groundwater use, a challenger will need expert testimony by a hydrogeologist demonstrating material harm to a challenger's groundwater uses. In Louisa, the personal observations by a layperson were insufficient in the face of the County's expert testimony.

Third, adequate investigation and data collection is needed in order to assist the local government's or water authority's hydrogeologist in assessing sustainable use. During the Louisa trial, the County showed that it based its withdrawal rates on calculations accepted in the scientific community and approved by state regulators. The County showed also that it had constructed a comprehensive monitoring system and established a procedure both to detect and promptly remediate, if needed, any harm to nearby landowners. According to Virginia Health Department representatives, Louisa's monitoring system and procedures are more extensive than any other in the region.

Fourth, great care is needed in considering the terms of any local government approvals for future well facilities. In Louisa, some of the plaintiffs' claims were based on monitoring requirements described in a conditional use permit.

In sum, while the Louisa case does not settle all legal issues surrounding off-site groundwater use, it provides helpful guidance for developing technical strategies for minimizing potential challenges to groundwater uses in a locality. The Court's decision supports engaging in sufficient advance investigation of potential groundwater sites to reduce the risk for potential litigation and consideration of mitigation strategies should ongoing monitoring show impacts. We remain available to assist with this as needed.

Sincerely,

Stewart T. Leeth

STL/csr

cc: David E. Evans

APPENDIX-F

Preliminary Construction Cost Estimate for
Dam and Reservoir
Intake, Raw water Line and Pump
Future Expansion and Wetland Mitigation
and
Annual O&M Costs

Table F-1 A- Preliminary Construction Cost Estimate for Dam and Reservoir

		Mountain Run			Mine Run			Laurel-Poplar (combination)		
	Unit	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**
Mobilization & Demobilization	Job	1	$300,000	$300,000	1	$300,000	$300,000	1	$300,000	$300,000
Clearing	Acre	250	$1,200	$300,000	300	$1,200	$360,000	100	$1,200	$120,000
Clear & Grub	Acre	30	$1,500	$45,000	30	$1,500	$45,000	30	$1,500	$45,000
Pollution Control	Job	1	$50,000	$50,000	1	$50,000	$50,000	1	$50,000	$50,000
Stream Div. & Common	Job	1	$90,000	$90,000	1	$90,000	$90,000	1	$90,000	$90,000
Excavation, Common	C.Y.	10,000	$4	$35,000	10,000	$4	$35,000	10,000	$4	$35,000
Excavation, Rock	C.Y.	10,000	$15	$150,000	10,000	$15	$150,000	10,000	$15	$150,000
Earthfill	C.Y.	250,000	$2	$500,000	250,000	$2	$500,000	250,000	$2	$500,000
6" Diameter PVC Pipe	L. Ft.	1,500	$35	$52,500	1,500	$35	$52,500	1,500	$35	$52,500
Drain Fill Coarse & Fine	C.Y.	6,000	$30	$180,000	6,000	$30	$180,000	6,000	$30	$180,000
Concrete Reinf.	C.Y.	2,500	$300	$750,000	2,500	$300	$750,000	2,500	$300	$750,000
Steel Reine	Lbs.	425,000	$1	$212,500	425,000	$1	$212,500	425,000	$1	$212,500
Reserv. Drain Gate	Each	2	$35,000	$70,000	2	$35,000	$70,000	2	$35,000	$70,000
Riprap Bedding	Tons	2,000	$25	$50,000	2,000	$25	$50,000	2,000	$25	$50,000
Riprap	Tons	7,500	$35	$262,500	7,500	$35	$262,500	7,500	$35	$262,500
Metal Fabrication	Job	1	$100,000	$100,000	1	$100,000	$100,000	1	$100,000	$100,000
Hydro seeding	Acre	20	$2,000	$40,000	20	$2,000	$40,000	20	$2,000	$40,000
Land Acquisition	Acre	300	$10,000	$3,000,000	350	$10,000	$3,500,000	150	$10,000	$1,500,000
Re-routing Sewer interceptor	L.Sum									$50,00,000
Total Cost(2001)				$6,187,500			$6,747,500			$9,507,500
Total Cost (2006)*				$7,115,625			$7,759,625			$10,933,625
Total Cost (2010)*				**$7,858,125**			**$8,569,325**			**$12,074,525**

Table F-2 Preliminary Construction Cost Estimate for Intake, Raw water Line and Pump

		Mountain Run			Mine Run			Laurel-Poplar (combination)		
	Unit	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**
Intake	Each	1	$1,500,000	$1,500,000	1	$1,500,000	$1,500,000	1	$250,000	$250,000
Raw Water Line (to WTP and from Reservoir)	LF	2100	$120	$252,000	1500	$120	$180,000	400	$120	$48,000
Pump Station	Each	1	$700,000	$700,000	1	$700,000	$700,000	1	$700,000	$700,000
Total Cost				**$2,452,000**			**$2,380,000**			**$998,000**

Table F-3 Preliminary Construction Cost Estimate for Future Expansion and Wetland Mitigation

		Mountain Run			Mine Run			Laurel-Poplar (combination)		
	Unit	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**
Future Expansion WTP	MGD	2	$2,000,000	$4,000,000	2	$2,000,000	$4,000,000	2	$2,000,000	$4,000,000
Wetland Mitigation	Acres	24.13	$100,000	$2,413,000	26.96	$100,000	$2,696,000	8.12	$100,000	$812,000

Table F-4 Preliminary Estimate for Annual O&M Costs

		Mountain Run			Mine Run			Laurel-Poplar (combination)		
	Unit	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**	**Qty**	**Rate**	**Amount**
Dam & Reservoir	Each	1	$30,000	$30,000	1	$30,000	$30,000	1	$30,000	$30,000
Pumping Requirements	KWH/day	2015	$0.06	$44,129	1516	$0.06	$33,200	3692	$0.06	$80,855
Total Annual O&M				**$74,129**			**$63,200**			**$110,855**
Future Annual O&M										
Water Treatment Plant after Expansion	1000 gal	730000	$0.50	$365,000	730000	$0.50	$365,000	730000	$0.50	$365,000

APPENDIX-G

Virginia Water Protection Permit No. 02-1835
Special Conditions (Town of Orange, VA)

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

W. Tayloe Murphy, Jr.
Secretary of Natural Resources

Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 10009, Richmond, Virginia 23240
Fax (804) 698-4500 TDD (804) 698-4021
www.deq.state.va.us

Robert G. Burnley
Director

(804) 698-4000
1-800-592-5482

VWP Individual Permit Number 02-1835

Issuance Date: August 25, 2003
Effective Date: August 22, 2003
Expiration Date: August 22, 2018

VIRGINIA WATER PROTECTION PERMIT
ISSUED PURSUANT TO THE STATE WATER CONTROL LAW
AND SECTION 401 OF THE CLEAN WATER ACT

Based upon an examination of the information submitted by the owner and in compliance with § 401 of the Clean Water Act as amended (33 USC 1251 et seq.) and the State Water Control Law and regulations adopted pursuant thereto, the State Water Control Board (Board) has determined that there is a reasonable assurance that the activity authorized by this permit, if conducted in accordance with the conditions set forth herein, will protect instream beneficial uses and will not violate applicable water quality standards. The Board finds that the effect of the impacts, together with other existing or proposed impacts to wetlands, will not cause or contribute to a significant impairment to state waters or fish and wildlife resources.

Permittee: Town of Orange, Virginia

Address: 119 Belleview Avenue, Orange, VA 22960-1401

Activity Location: Orange County, Virginia

Activity Description: The operation of a water impoundment and supply intake on the Rapidan River in Orange County, Virginia.

The permitted activity shall be in accordance with this Permit Cover Page, the Part I - Special Conditions, and the Part II - General Conditions.

Ellen Gilinsky
Director, Department of Environmental Quality

August 22, 2003
Date

A. Authorized Activities

This permit authorizes:

1. The permanent placement of fill within no more than 2,020 square feet of the Rapidan River for the purposes of constructing a dam and fish passage.

2. The permanent placement of riprap material within no more than 4,000 square feet of the Rapidan River, below the ordinary water level, for the purposes of stabilizing a dam, fish passage, and stream banks.

3. The temporary placement of fill within no more than 4,200 square feet of the Rapidan River for construction of temporary coffer dams.

4. The excavation of fill material within no more than 1,100 square feet of the Rapidan River for the removal of the old diversion dam.

5. The excavation of fill within no more than 22,500 square feet of the Rapidan River for the removal of construction access areas.

6. The withdrawal of surface water from the Rapidan River, not to exceed a *maximum daily* withdrawal of 2.6 million gallons, a *maximum instantaneous* withdrawal rate of 1,800 gallons per minute, and a *maximum annual* withdrawal of 730 million gallons. Withdrawals shall be authorized only when the permit conditions in Part I, Section D are met.

7. The temporary use of mechanical equipment in surface waters when conducted according to the permit conditions herein.

B. Standard Project Conditions

1. The project activities shall be adhered to as described in the original Joint Permit Application, in responses to requests for information, in any subsequent submittals approved by DEQ, and in all permit conditions.

2. This permit is valid for **15 years** from the date of issuance. A new permit may be necessary for the continuance of the authorized activities or any permit requirement that has not been completed, including compensation provisions. An original permit term or re-issuance permit term, plus any extensions granted, cannot exceed the maximum of 15 years.

3. The permittee shall notify the DEQ-**Northern Regional** Office of any additional impacts to surface waters, including wetlands, or any change to the type of surface water impacts associated with this project. Any additional impacts to surface waters, including wetlands, or any change to the type of surface water impacts, shall be subject to individual permit review and/or modification of this permit. Compensation may be required.

4. The activities authorized by this permit shall be executed in a such a manner as to minimize any adverse impact on stream beneficial uses, as defined in § 62.1-10(b) of the Code of Virginia.

5. No activity shall substantially disrupt the movement of aquatic life indigenous to the water body, including those species that normally migrate through the area, unless the primary purpose of the activity is to impound water, or the activity is otherwise authorized by this permit. Culverts placed in streams shall be installed to maintain low flow conditions.

6. The activity shall not impede the passage of normal or expected high flows and the structure or discharge shall withstand expected high flows.

7. All excavation, dredging, and/or filling in surface waters shall be accomplished in a manner that minimizes stream bottom disturbances and turbidity increases.

8. Virginia Water Quality Standards shall not be violated in any surface water as a result of the project activities.

9. All construction, construction access (for example, cofferdams, sheetpiling, and causeways), and demolition activities associated with this project shall be accomplished in a manner that minimizes construction or waste materials from entering surface waters to the maximum extent practicable, unless authorized by this permit.

10. Untreated stormwater runoff shall be prohibited from directly discharging into any surface waters. In accordance with the Virginia Erosion and Sediment Control Handbook, Third Edition, 1992, appropriate best management practices (BMP) shall be deemed suitable treatment prior to discharge into surface waters.

11. All fill material shall be clean and free of contaminants in toxic concentrations or amounts in accordance with all applicable laws and regulations.

12. The permittee shall employ measures to prevent spills of fuels, lubricants, or other pollutants into surface waters. Wet or uncured concrete shall be prohibited from entry into flowing surface waters.

13. Machinery in temporarily impacted surface waters shall be placed on mats or geotextile fabric, or other suitable measures shall be implemented to minimize soil disturbance to the maximum extent practical. Mats or fabrics shall be removed as soon as the work is complete.

14. Erosion and sedimentation controls shall be designed in accordance with the Virginia Erosion and Sediment Control Handbook, Third Edition, 1992. These controls shall be placed prior to clearing and grading and maintained in good working order to minimize impacts to surface waters. These controls shall remain in place until the area stabilizes.

15. Any exposed slopes or streambanks shall be stabilized immediately upon completion of work in accordance with the Virginia Erosion and Sediment Control Handbook, Third Edition, 1992.

16. Construction monitoring, compensation success monitoring, and water withdrawal monitoring shall be conducted in accordance with the permit conditions in Part I, Sections D, E, and F.

C. Stream Modification and Streambank Protection

1. Redistribution of existing stream substrate for erosion control purposes is prohibited.

2. All material removed from the stream substrate shall not be disposed of in surface waters.

3. If applicable, riprap bank stabilization shall be of an appropriate size and design in accordance with the Virginia Erosion and Sediment Control Handbook, Third Edition, 1992.

4. For streambank protection activities, structures and backfill shall be placed as close to the streambank as practical. No material shall be placed in excess of the minimum necessary for erosion protection.

5. All streambank protection structures shall be located to eliminate or minimize impacts to vegetated wetlands to the maximum extent practical.

6. Asphalt and materials containing asphalt or other toxic substances shall not be used in the construction of submerged sills or breakwaters.

D. <u>Water Withdrawals</u>

1. The water withdrawal intake structure's screens shall be designed, constructed, and maintained to prevent the impingement or entrapment of fish. Should the screens result in excessive fish mortality, as determined by the State Water Control Board, the permittee shall undertake measures to eliminate mortality.

2. Water withdrawal rates and volumes shall comply with the limits set forth in Part I, Section A.5.

3. The permittee shall monitor stream flow on the Rapidan River by monitoring provisional data from the USGS Culpeper stream gage (Gage #01667500).

4. From **July 1st through November 15th** of each permit year, the permittee shall record withdrawal data using the table in Attachment A of this permit.

   When the previous year's total water withdrawal was *less than or equal to* 511 million gallons: The permittee shall enact mandatory conservation whenever the 14-day rolling average stream flow of the Rapidan River at the USGS Culpeper gage is, or falls below, 44 cubic feet per second (cfs). Mandatory conservation may be lifted once the 14-day rolling average at the Culpeper gage exceeds 44 cfs.

   When the previous year's total water withdrawal was *greater than* 511 million gallons: The permittee shall enact mandatory conservation whenever the 14-day rolling average stream flow of the Rapidan River at the USGS Culpeper gage is, or falls below, 63 cubic feet per second (cfs). Mandatory conservation may be lifted once the 14-day rolling average at the Culpeper gage exceeds 63 cfs.

   A 14-day rolling average shall be calculated by recording the stream flow rate at the Culpeper gage once per day, then adding 14 consecutive days of stream flow rates and dividing that sum by 14.

   Mandatory conservation measures shall consist of those outlined in Condition 2 in the Town of Orange Ordinance Number 02-08, Section 74-57(b), or the most current Town ordinances and/or conservation plans. Such ordinances/plans shall, at a minimum, specifically prohibit the watering of existing lawns during mandatory conservation periods. Conservation measures shall apply to **all users** of water withdrawn under this permit.

5. No more than 1.3 million gallons per day may be sold to out-of-basin customers.

E. Compensation

General:

1. The final compensation plan as approved by DEQ shall be an enforceable requirement of this permit (see Part I, Section F). Any deviation from the approved plan must be submitted to DEQ-**Northern Regional** Office and approved by DEQ in advance of implementation.

2. Planting of woody plants shall occur when vegetation is normally dormant unless otherwise approved in the final compensation plan.

3. Rooted seedlings or cuttings shall originate from a local nursery or be adapted to local conditions. Vegetation shall be native species common to the area, shall be suitable for growth in local wetland conditions, and shall be from areas within approximately 200 miles from the project site.

4. Undesirable plant species shall be identified and controlled as described in the abatement and control plan for undesirable plant species, such that they are not dominant species or do not change the desired community structure. The abatement and control plan shall include procedures to notify DEQ-**Northern Regional** Office of any undesirable plant species occurrences, methods of removal, and successful control.

5. Herbicides or algacides shall not be used in or immediately adjacent to the compensation site or sites without prior authorization by DEQ. All vegetation removal shall be done by manual means, unless authorized by DEQ in advance.

6. Point sources of stormwater runoff shall be prohibited from entering any compensation site prior to treatment by appropriate best management practices. Appropriate best management practices may include sediment traps, grassed waterways, vegetated filter strips, debris screens, oil and grease separators, and forebays.

7. If the compensation area fails to be established as per the specified performance criteria, the reasons for this failure shall be determined, and a corrective action plan, schedule, and monitoring plan shall be submitted to DEQ-**Northern Regional** Office for approval prior to or with the next required monitoring report. All problems shall be corrected by the permittee. Should significant changes be necessary to ensure success, the monitoring period shall be extended until success is achieved.

Stream Compensation:

8. The permittee shall compensate for approximately 24,520 square feet of stream impacts along the Rapidan River through streambed and streambank stabilization/restoration activities and riparian buffer restoration.

9. The success of the stream restoration shall be based on maintaining stream channel and streambank stabilization and riparian vegetation in accordance with the success criteria included in the approved final compensation plan.

10. Monitoring shall be required for **two consecutive years** once stream compensation construction activities have been completed. If the stream is found to be unstable or the riparian vegetation planting is not successful in the second monitoring year, then additional annual monitoring shall be required until all criteria have been successfully satisfied in accordance with the approved final compensation plan (see also Part I, Section F).

11. Photographs shall be taken at the compensation site from the permanent photo stations identified in the final compensation plan. The photograph orientation shall remain constant during all monitoring events, and at least one upstream and one downstream view shall be taken. Photographs shall be taken prior to compensation area construction activities, during instream and riparian construction activities, within **one week** of completion of activities, and **in August or September** of each monitoring year. Photographs shall be appropriately labeled as described in Part I, Section F.7.b.

12. The establishment of vegetation shall be indicated by percent cover monitored in August or September during each monitoring year as detailed in the final compensation plan.

13. The permittee shall document all wildlife or signs of wildlife observed at the compensation area during each monitoring event.

14. The permittee shall have the authority to use heavy equipment within the stream channel during restoration activities when site conditions prohibit access from the streambank or existing filled areas. The equipment shall be stationed on cobble bars and the activities conducted in the dry or during low flow conditions, whenever possible. All heavy equipment shall be placed on mats, geotextile fabric, or other suitable measures to minimize soil disturbance to the maximum extent practicable. Mats shall be removed as soon as the work is complete.

15. The installation of root wads, vanes, and other instream structures, shaping of the stream banks, and channel relocation construction shall be completed in the dry whenever practicable.

16. Bank slopes shall be stabilized to reduce stream bank erosion, where practical.

17. Riparian buffer restoration shall include the planting of a variety of native species currently growing in the site area, a minimum 10 feet from the edge of the stream on either side, where practical.

F. Required Notifications and Submittals

General:

1. All written communications required by this permit shall be submitted to the Virginia Department of Environmental Quality, **13901 Crown Court, Woodbridge, Virginia 22193** (DEQ-**Northern Regional** Office). The permit number shall be included on all correspondence.

2. All reports required by this permit and other information requested by DEQ shall be signed by the applicant or a person acting in the applicant's behalf with the authority to bind the applicant. A person is a duly authorized representative only if:

   a. The authorization is made in writing by a person described above; **and**

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, superintendent, or position of equivalent responsibility. A duly authorized representative may thus be either a named individual or any individual occupying a named position.

   If an authorization is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization shall be submitted to DEQ prior to or together with any separate information, or applications to be signed by an authorized representative.

3. All submittals required by this permit, and signed by the applicant, agent, or permittee, shall contain the following certification statement: "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

4. Any fish kills or spills of fuels or oils shall be reported **immediately** upon discovery. If spills or fish kills occur between the hours of 8:15 AM to 5:00 PM Monday through Friday, DEQ **Northern Regional** Office shall be notified at **703-583-3800**; otherwise, the Virginia Department of Emergency Management shall be notified at 1-800-468-8892.

5. Violations of Virginia Water Quality Standards shall be reported within **24 hours** to DEQ-**Northern Regional** Office at **703-583-3800**.

6. DEQ-**Northern Regional** Office shall be notified in writing when potential environmentally threatening conditions are encountered which require debris removal or involve potentially toxic substances. Measures to remove the obstruction, material, or toxic substance, or to change the location of any structure, are prohibited until approved by DEQ.

Construction:

7. DEQ-**Northern Regional** Office shall be notified in writing within **30 days** following the completion of all construction activities in permitted impact areas authorized under this permit. The notification shall include the following, as appropriate:

   a. A summary of permit non-compliance events or problems encountered, subsequent notifications, and corrective actions.

   b. A labeled site map depicting all impact areas and photo locations. The photographs shall document site activities and conditions, which may include installation and maintenance of erosion and sediment controls; construction access and staging areas; filling, excavation, and dredging activities; culvert installation; dredge disposal; and site stabilization, grading, and associated restoration activities. Photographs shall be taken within **one week** of construction completion. Each photograph shall be labeled to include the following information: permit number, impact area name (i.e. temporary coffer dam), date and time of the photograph, name of the person taking the photograph, photograph orientation (i.e. north), and a description of what the photograph captures.

Compensation:

8. DEQ-**Northern Regional** Office shall be notified in writing at least **ten days** prior to the initiation of compensation construction activities authorized under this permit so that inspections of the project can be planned, if deemed necessary. The notification shall include a projected schedule for completing the work.

9. The permittee shall submit a final stream compensation plan within a minimum of **30 days** before compensation site construction. The final plan shall include (at a minimum):
   a. The goals and objectives of the plan, in terms of replacement of functions and values and replacement of area (expressed in square feet).

   b. A detailed description of the stream bed and streambank stabilization activities (i.e., type of vane, root wad, or other instream structure, location).

   c. Riparian buffer plantings (i.e., scheme, species, width).

   d. Structures and features necessary for the success of the site.

   e. The schedule for compensation site construction.

   f. A location map, including latitude and longitude (to the nearest second) at the center of the site.

   g. A site access plan.

   h. A monitoring plan which provides 1) the proposed success criteria for streambed and streambank stabilization and riparian buffer success, and 2) the monitoring goals. Monitoring goals shall include physical stream measurements and/or surveys to determine stability of the stream, the location of photo stations, and the location of vegetation sampling points.

   i. An abatement and control plan for undesirable plant species, including, at a minimum, the species listed on DCR's Invasive Alien Plant Species of Virginia list, and including procedures to notify DEQ of any undesirable plant species occurrences, methods of removal, and successful control.

   j. An erosion and sedimentation control plan.

10. Construction shall be performed in accordance with the submitted plan and specifications. Any changes to the final compensation plan and specifications in permitted areas shall be submitted to DEQ-**Northern Regional** Office prior to construction activities.

11. A stream compensation monitoring report shall be submitted within **30 days** of completing the stream restoration work. The report shall include, the following:

a. A description of the work completed at the compensation site, including a location map that identifies the compensation area.

b. Properly labeled photographs as described in Part I, Section F.7.b.

c. Approximate stream dimensions *before and after* compensation work to include average width, length within the compensation area, average water depth, average bank height, and average bank slope. This information may be provided on a technical drawing of the compensation area.

12. Subsequent stream compensation monitoring reports shall be submitted by **November 30th** of each monitoring year. The report shall include, the following:

a. A location map that identifies the compensation area.

b. Properly labeled photographs as described in Part I, Section F.7.b.

c. Any changes in stream dimensions since completion of compensation site work, such as those resulting from storm events. This information may be provided on a technical drawing of the compensation site area.

d. Discussion of the success and/or failure of planted vegetation, and the establishment of voluntary vegetation.

e. Discussion of stream bank and/or channel stabilization.

f. Discussion of wildlife or signs of wildlife observed at the compensation site.

g. Discussion of alterations, maintenance, and corrective actions conducted at the stream compensation site.

Water Withdrawal:

13. The permittee shall report the water withdrawal data to DEQ-**Northern Regional** Office by **January 31st** of the year following each permit year by using the table provided in Attachment A of this permit. The data shall include: date and time, stream flow of Rapidan River at Culpeper gage (cfs), 14-day rolling average stream flow at Culpeper gage (cfs), indication of whether mandatory conservation is in effect, and the initials of the person recording the data.

14. Within **90 days** of permit issuance the permittee shall submit to DEQ-**Northern Regional** Office a stream flow monitoring plan that describes what measures the

permittee will implement to estimate the stream flow in the Rapidan River in the event that the Culpeper gage is damaged, disabled, or discontinued.

15. Applicable to users whose average daily withdrawal during any single month exceeds 10,000 gallons per day: The permittee shall report water withdrawals to DEQ-**Northern Regional** Office by **January 31st** of the next year, as required under State Water Control Board (SWCB) Water Withdrawal Reporting Regulation (9 VAC 25-200 et seq.). The annual monitoring report shall contain the following information: the permittee's name and address, the sources and locations of water withdrawal, the cumulative volume of water withdrawn each month of the calendar year, the maximum day withdrawal and the month in which it occurred, and the method of withdrawal measurement.

    Alternatively, for permittees subject to the Virginia Department of Health (VDH) Waterworks Regulations, annual reports to DEQ may include the source and location of water withdrawals, the type of use for the water withdrawn, and reference to the reports filed with VDH (containing monthly withdrawal data).

16. All records and information resulting from the monitoring activities required by this permit, including any records of USGS data and any maintenance activities to the withdrawal system, shall be retained for the life of the permit. This period of retention shall be extended automatically during the course of any unresolved litigation regarding the regulated activity or as requested by the State Water Control Board.

APPENDIX-H

Orange Water Conservation Ordinance 02 - 08

Amended - 08-2006

DRAFT
ORDINANCE NUMBER 02-08, AS AMENDED

BE IT RESOLVED by this Town Council of the Town of Orange that new Sections 74-56 through 74-59 of Town Code Article II of Chapter 74 be adopted:

Sec. 74-56. Authority to declare water emergencies.

During the continued existence of climatic, hydrological and other extraordinary conditions the protection of the health, safety and welfare of the residents of the Town of Orange may require that certain uses of water, not essential to public health, safety and welfare, be reduced, restricted or curtailed or prohibited. As the shortage of potable water becomes increasingly more critical, conservation measures to reduce consumption or curtail essential water use may be necessary.

The Town Manager, with the approval of the Orange Town Council, or its subsequent ratification within forty eight (48) hours is authorized to declare water emergencies in the town affecting the use of water.

Sec. 74-57. Water conservation measures.

After the declaration of a water emergency and upon a determination by the Town Manager of the existence of the following one or more conditions, the Town Manager shall take the following actions which shall apply to any person whose water supply is furnished from the Town of Orange water system:

(a) Condition 1: when moderate but limited supplies of water are available, the Town Manager shall, through appropriate means, call upon the general population to employ prudent restraint in water usage and to conserve water voluntarily by whatever methods available.

(b) Condition 2: The Town Manager is hereby further authorized during the duration of a water emergency for which voluntary measures would be insufficient under Special Conditions D4 of the Town's Permit No. 02-1835 Modification or under circumstances deemed appropriate by the Town Manager, to order the restriction or prohibition of any or all of the following uses of the water supply:

(i) The mandatory prohibition of the watering of existing outside shrubbery, trees, lawns, plants, home vegetable gardens, or any other vegetation, except from a watering can or other container not exceeding five (5) gallons in capacity. This limitation shall not apply to commercial greenhouses or nursery stocks, which may be watered in the minimum amount required to preserve plant life before 7:00 a.m. or after 8:00 p.m.

(ii) The mandatory prohibition of the washing of sidewalks, streets, driveways, parking lots, service station aprons, exteriors of homes or apartments, commercial or industrial buildings or any other outdoor surface, except where mandated by federal, state or local law.

(iii) The mandatory prohibition of the operation of any ornamental fountain or other structure making a similar use of water.

(iv) The mandatory prohibition of the use of water from fire hydrants for any purpose other than fire suppression, unless otherwise approved by the Town Manager.

(c) Condition 3: The Town Manager is hereby further authorized during the duration of a water emergency to implement one or more of the following:

(i) Industrial, institutional, commercial, governmental, wholesale and all other nonresidential customers shall be allotted a percentage reduction based on that customer's average monthly water consumption for the same billing period of the previous calendar year's consumption.

(ii) Individual residential customers shall be limited to a specific volume or percentage reduction of water per month.

If the allotted monthly water usage is exceeded, the customer shall be charged ten dollars ($10.00) for every one thousand (1,000) gallons of water consumed above the allotted volume. Where prior consumption data is not available the Town Treasurer shall estimate allocations based upon the data available from similar activities of equal intensity.

(iii) Declaration of a moratorium on new water connections.

(iv) Mandatory prohibition of washing of automobiles, trucks, trailers, or any other type of mobile equipment, except in licensed commercial vehicle was facilities.

(v) The filling of swimming or wading pools requiring more than five (5) gallons of water, or the refilling of swimming or wading pools which were drained after the effective date of the declaration of emergency, except that pools may be filled to a level of two (2) feet below normal, or water may be added to bring the level to two (2) feet below normal, or as necessary to protect the structure from hydrostatic damage.

(vi) To limit, or eliminate, the serving of drinking water in restaurants, except upon request.

(vii) To limit, or eliminate, the operation of any water – cooled comfort air conditioning that does not have water conserving equipment in operation.

(d) Condition 4: When crucially limited supplies of water are available, the Town Manger shall restrict the use of water to purposes which are absolutely essential to life, health and safety.

(e) The above restrictions, or any of them, shall become effective upon their being printed in any newspaper of general circulation in the Town of Orange, or broadcast upon any radio or television station serving the Town of Orange.

Upon implementation of (b), (c), or (d) the Town Manager shall establish an appeals procedure to review customer applications for exemptions from the provisions of subsections (b), (c), or (d) on a case by case basis and, if warranted, to make equitable adjustments to such provisions. The Town Manager shall also be empowered to establish regulations governing the granting of temporary exemptions applicable to all or some of the uses of the water supply set forth in subsections (b), (c), or (d). The Town Manager shall, in deciding applications, balance economic and other hardships to the applicant resulting from the imposition of water use restrictions or allocations against the individual and cumulative impacts to the water supply resulting from the granting of exemptions.

Sec. 74-58. Penalty.

Any person who shall violate any of the provisions of this Ordinance, or of any of the conservation regulations promulgated by the Town of Orange pursuant thereto, shall, upon conviction thereof, in addition to additional charges set forth in Section 74-57 subsection (c) be fined not less than one hundred dollars ($100.00), nor more than two thousand five hundred dollars ($2,500.00). Each act or each day's continuation of a violation shall be considered a separate offense. In addition to the foregoing, the Town Manager may suspend water service to any person continuing to violate the provisions of this ordinance or the regulations promulgated thereunder. If such water service is terminated, the person shall pay a reconnection fee of fifty dollars ($50.00) before service is restored.

Sec. 74-59. Notification of end of water emergency.

The Town Manager shall notify the Town Council when, in his or her opinion, the water emergency situation no longer exists. Upon concurrence of the Council, the water emergency shall be declared to have ended.

C E R T I F I C A T E

I hereby certify that this Ordinance was duly adopted, as amended, by the Town Council of the Town of Orange at a meeting the 28th day of August, 2006.

____

Wendy J. Chewning, CMC, Town Clerk

A. *Authorized Activities*

1. As indicated in the application dated September 22, 2006, received by DEQ on September 25, 2006, and deemed complete by DEQ on July 24, 2008, as well as additional submittals approved by DEQ, this permit authorizes the withdrawal of surface water from the Rapidan River, which shall not exceed a maximum *daily* withdrawal volume of 2,999,520 gallons and a maximum *annual* withdrawal volume of 1,094,800,000 gallons.

2. An *instantaneous* withdrawal rate of up to 3,000 gallons per minute shall be authorized during times when the 14-day rolling average flow exceeds 70 cubic feet per second (cfs), based on the stream flow measured by the Rapidan River at Culpeper gage. Once the 14-day rolling average flow falls below 70 cfs, the permittee shall implement whatever means necessary to reduce the instantaneous withdrawal rate to 2,000 gallons per minute or less. The 14-day rolling average flow shall be calculated in accordance with Part I.D.6.

B. *Permit Term*

1. This permit is valid for 15 years from the date of issuance. An extension of this permit term or a new permit may be necessary for the continuance of the authorized activities, including water withdrawals, or any permit requirement that has not been completed, including compensation provisions. The permit term, including any granted extensions, shall not exceed 15 years.

2. The permittee shall notify DEQ in writing at least 120 calendar days prior to the expiration of this permit if reissuance of the permit is desired.

C. *Standard Project Conditions*

1. The activities authorized by this permit shall be executed in such a manner that any impacts to stream beneficial uses are minimized. As defined in §62.1-10(b) of the Code, “beneficial use” means both instream and offstream uses. Instream beneficial uses include, but are not limited to, the protection of fish and wildlife habitat, maintenance of waste assimilation, recreation, navigation, and cultural and aesthetic values. Offstream beneficial uses include, but are not limited to, domestic (including public water supply), agricultural, electric power generation, commercial, and industrial uses. Public water supply uses for human consumption shall be considered the highest priority.

2. No activity shall substantially disrupt the movement of aquatic life indigenous to the water body, including those species that normally migrate through the area, unless the primary purpose of the activity is to impound water.

3. Flows downstream of the project area shall be maintained to protect all uses.

4. No activity shall cause more than minimal adverse effect on navigation, unless the project purpose is to construct an impoundment or culvert, and no activity shall block more than half of the width of the stream at any given time.

5. The activity shall not prevent the passage of normal or expected high flows, and any associated structure shall withstand expected high flows.

6. Virginia Water Quality Standards shall not be violated in any surface waters as a result of the project activities.

7. All required notifications and submittals shall be submitted to the DEQ office stated below, to the attention of the VWP permit manager, unless directed in writing by DEQ subsequent to the issuance of this permit:

   Attn: VWP Permit Manager (96-0271)
   Virginia Dept. of Environmental Quality
   Office of Wetlands and Water Protection
   P.O. Box 1105
   Richmond, Virginia 23218

8. All reports required by this permit and other information requested by DEQ shall be signed by the permittee or a person acting in the permittee's behalf, with the authority to bind the permittee. A person is a duly authorized representative only if *both* criteria below are met. If a representative authorization is no longer valid because of a change in responsibility for the overall operation of the facility, a new authorization shall be immediately submitted to DEQ.

   a. The authorization is made in writing by the permittee.

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, superintendent, or position of equivalent responsibility. A duly authorized representative may thus be either a named individual or any individual occupying a named position.

9. All submittals shall contain the following signed certification statement:

   "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

10. Any fish kills or spills of fuels or oils shall be reported to DEQ immediately upon discovery at 13901 Crown Court, Woodbridge, VA 22193, (703) 583-3800. If DEQ cannot be reached, the spill shall be reported to the Virginia Department of Emergency Management (DEM) at 1-800-468-8892 or the National Response Center (NRC) at 1-800-424-8802.

D. *Projects Involving Surface Water Withdrawals*

1. Water withdrawal rates and volumes shall comply with the limits set forth in Part I.A.

2. Water withdrawal monitoring and reporting activities shall comply with Part I.C, Part I.D, and Part II. All records and information that result from the monitoring and reporting activities required by this permit, including any records of maintenance activities to the withdrawal system, shall be retained in accordance with Part II.G.3. This period of retention shall be extended automatically during the course of any unresolved litigation regarding the regulated activity or as requested by the State Water Control Board.

3. To prevent the impingement and entrainment of fish eggs, larvae, and other aquatic life, the intake screens shall be so designed that screen openings are not larger than 1 millimeter in width and the screen face intake velocities are not greater than 0.50 feet per second.

4. The applicant shall submit within 30 days of permit reissuance any existing regional or local water supply conservation plans that apply to the service areas being supplied by the water withdrawn under this permit. Draft plans are acceptable to meet the requirements of this condition, provided that the final plans are also submitted to DEQ within 30 days of being finalized.

5. The permittee shall monitor withdrawals from the Rapidan River on a daily basis to confirm that the withdrawals are in compliance with the special conditions of this permit.

6. A 14-day rolling average of stream flow shall be calculated using the Rapidan River at Culpeper gage. If the 14-day rolling average flow falls to 33 cubic feet per second (cfs) or less, mandatory conservation measures are required, as detailed in Attachment A of this permit. At such time that the County of Orange, Virginia adopts a final drought response ordinance, the permittee may request a minor modification of this permit 96-0271 to specify the mandatory conservation measures adopted in that ordinance rather than those in Attachment A.

7. The permittee shall prepare an annual report to demonstrate compliance with the Part I.A.2, I.D.5, and I.D.6 of these special conditions. The report shall contain the stream flow in cubic feet per second (cfs) as measured at the Rapidan River at Culpeper gage, the calculated 14-day rolling average of the stream flow (cfs) based on that gage, the date when each measurement was taken, notation of any mandatory conservation measures in effect on the day of the measurement, and notation of any reduction in the instantaneous rate of withdrawal on the day of the measurement. The report shall be submitted to the address in Part I.C.7 by **January 31st** of the calendar year following the data collection or recordation.

8. Any violations of water withdrawal conditions shall be reported within one week of discovery by the permittee. The notification shall be submitted to the address in Part I.C.7.

9. The permittee shall revise the August 1997 RSA East Drought Water Conservation Plan and the August 1997 RSA East Water Withdrawal Operations and Maintenance Manual for DEQ approval to update the procedures, measurements, and calculations used to ensure that the special conditions of this permit are followed. The operations and maintenance manual shall include a contingency section that specifies what actions will be taken when required measurements cannot be taken for whatever reason. The conservation plan shall include the specific mandatory water conservation measures to be implemented and the enforcement mechanism for non-compliance by the users of water withdrawn under this permit. If one or more non-essential water uses is/are not applicable to the users served by the water withdrawn under this permit, such as, but not limited to, water served in restaurants, the permittee shall note the non-applicable non-essential uses in the annual report detailed in Part I.D.7. The revised plan and manual shall be submitted to DEQ within 90 days of this permit reissuance.

10. *For all permittees whose average daily withdrawal during any single month exceeds 10,000 gallons per day,* the water withdrawals shall be reported to DEQ by January 31st of the next year, as required under State Water Control Board (SWCB) Water Withdrawal Reporting Regulation (9 VAC 25-200 et seq.). The annual monitoring report shall contain the following information: the permittee's name and address, the sources and locations of water withdrawal, the cumulative volume of water withdrawn each month of the calendar year, the maximum day withdrawal volume and the month in which it occurred, and the method of withdrawal measurement. *For permittees subject to the Virginia Department of Health (VDH) Waterworks Regulations*, the annual reports to DEQ may include, as an alternative, the source and location of water withdrawals, the type of use for the water withdrawn, and reference to the reports filed with VDH that contain the monthly withdrawal data.

Mandatory Non-essential Water Use Restrictions

The following non-essential water uses will be prohibited during periods when the 14-day rolling average flow, based on the stream flow measured by the Rapidan River at Culpeper gage, falls to 33 cubic feet per second (cfs) or less. Please note the exceptions that follow each prohibited use, which the permittee may or may not allow. Water use restrictions shall not apply to the agricultural production of food or fiber, the maintenance of livestock including poultry, nor the commercial production of plant materials, provided that best management practices are applied to assure the minimum amount of water is utilized.

Unrestricted irrigation of lawns is prohibited.

- Newly sodded and seeded areas may be irrigated to establish cover on bare ground at the minimum rate necessary for no more than a period of 60 days. Irrigation rates may not exceed one inch of applied water in any 7-day period.
- Gardens, bedding plants, trees, shrubs and other landscape materials may be watered with hand held containers, hand held hoses equipped with an automatic shutoff device, sprinklers or other automated watering devices at the minimum rate necessary but in no case more frequently than twice per week. Irrigation should not occur during the heat of the day.
- All allowed lawn irrigation must be applied in a manner to assure that no runoff, puddling or excessive watering occurs.
- Irrigation systems may be tested after installation, routine maintenance or repair for no more than ten minutes per zone.

Unrestricted irrigation of athletic fields is prohibited.

- Athletic fields may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. at a rate not to exceed one inch per application or more than a total of one inch in multiple applications during any ten-day period. All irrigation water must fall on playing surfaces with no outlying areas receiving irrigation water directly from irrigation heads.
- Localized dry areas that show signs of drought stress and wilt (curled leaves, foot-printing, purpling) may be syringed by the application of water for a cumulative time not to exceed fifteen minutes during any twenty four hour period. Syringing may be accomplished with an automated irrigation system or with a hand held hose equipped with an automatic shutoff device at the minimum rate necessary.
- Athletic fields may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. during necessary overseeding, sprigging or resodding operations at the minimum rate necessary for a period that does not exceed 60 days. Irrigation rates during this restoration period may not exceed one inch of applied water in any seven-day period. Syringing is permitted during signs of drought stress and wilt (curled leaves, foot-printing, purpling).
- All allowed athletic field irrigation must be applied in a manner to assure that no runoff, puddling or excessive watering occurs.

- Irrigation is prohibited on athletic fields that are not scheduled for use within the next 120-day period.
- Water may be used for the daily maintenance of pitching mounds, home plate areas and base areas with the use of hand held containers or hand held hoses equipped with an automatic shutoff device at the minimum rate necessary.
- Skinned infield areas may utilize water to control dust and improve playing surface conditions utilizing hand held containers or hand held hoses equipped with an automatic shutoff device at the minimum rate necessary no earlier than two hours prior to official game time.

Washing paved surfaces such as streets, roads, sidewalks, driveways, garages, parking areas, tennis courts, and patios is prohibited.

- Driveways and roadways may be pre-washed in preparation for recoating and sealing.
- Tennis courts composed of clay or similar materials may be wetted by means of a hand-held hose equipped with an automatic shutoff device at the minimum rate necessary for maintenance. Automatic wetting systems may be used between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary.
- Public eating and drinking areas may be washed using the minimum amount of water required to assure sanitation and public health.
- Water may be used at the minimum rate necessary to maintain effective dust control during the construction of highways and roads.

Use of water for washing or cleaning of mobile equipment including automobiles, trucks, trailers and boats is prohibited.

- Mobile equipment may be washed using hand held containers or hand held hoses equipped with automatic shutoff devices provided that no mobile equipment is washed more than once per calendar month and the minimum amount of water is utilized.
- Construction, emergency or public transportation vehicles may be washed as necessary to preserve the proper functioning and safe operation of the vehicle.
- Mobile equipment may be washed at car washes that utilize reclaimed water as part of the wash process or reduce water consumption by at least 10% when compared to a similar period when water use restrictions were not in effect.
- Automobile dealers may wash cars that are in inventory no more than once per week utilizing hand held containers and hoses equipped with automatic shutoff devices, automated equipment that utilizes reclaimed water as part of the wash process, or automated equipment where water consumption is reduced by at least 10% when compared to a similar period when water use restrictions were not in effect.
- Automobile rental agencies may wash cars no more than once per week utilizing hand held containers and hoses equipped with automatic shutoff devices, automated equipment that utilizes reclaimed water as part of the wash process, or automated equipment where water consumption is reduced by at

least 10% when compared to a similar period when water use restrictions were not in effect.
- Marine engines may be flushed with water for a period that does not exceed 5 minutes after each use.

Use of water for the operation of ornamental fountains, artificial waterfalls, misting machines, and reflecting pools is prohibited.
- Fountains and other means of aeration necessary to support aquatic life are permitted.

Use of water to fill and top off outdoor swimming pools is prohibited.
- Newly built or repaired pools may be filled to protect their structural integrity.
- Outdoor pools operated by commercial ventures, community associations, recreation associations, and similar institutions open to the public may be refilled as long as:
  - Levels are maintained at mid-skimmer depth or lower,
  - Any visible leaks are immediately repaired,
  - Backwashing occurs only when necessary to assure proper filter operation,
  - Deck areas are washed no more than once per calendar month (except where chemical spills or other health hazards occur),
  - All water features (other than slides) that increase losses due to evaporation are eliminated, and
  - Slides are turned off when the pool is not in operation.
- Swimming pools operated by health care facilities used in relation to patient care and rehabilitation may be filled or topped off.
- Indoor pools may be filled or topped off.
- Residential swimming pools may be filled only to protect structural integrity, public welfare, safety and health and may not be filled to allow the continued operation of such pools.

Water may be served in restaurants, clubs, or eating-places only at the request of customers.

APPENDIX-J

RSA East Drought Water Conservation Plan

RSA EAST DROUGHT WATER CONSERVATION PLAN

DATE: 8/97

PURPOSE: This plan is designed to protect the available water supply in the Rapidan River during low flows as defined by the Virginia Department of Environmental Quality. RSA will measure the flows in the stream and implement the appropriate conservation measures as prescribed by this plan. The water consumption should drop appropriately following plan implementation and thus decrease the reliability on the river helping to preserve the integrity of the Rapidan River during the drought periods.

ORIGIN: This plan originated as a result of negotiations with DEQ and the ACOE during 1995 and 1996. The withdrawal permit was issued by DEQ on 2/19/97 and requested this plan to be submitted for approval within six months. Similarly, the ACOE has issued an Individual permit on 7/97 for construction of the expanded intake facilities.

FACTS: The Rapidan Service Authority maintains a water intake facility on the Rapidan River for the purpose of water supply for the citizens of eastern Orange County, especially, along the Route 3 Corridor including Lake of the Woods Subdivision and Wilderness Shores Subdivision. The permitted capacity of the withdrawal is 2.0 MGD at this location.

PLAN: The Rapidan Service Authority will monitor the Rapidan River's flow and take appropriate actions according to the river's level and flow. The water consumers will receive notices when actions are necessary to conserve water. With this plan, water will be conserved in an acceptable manner and demand on the river will be minimized during periods of low flow.

The Rapidan River will be monitored at the Intake station by RSA personnel and at the Culpeper River Gage Station during low flow conditions. When the river level drops below the 25 percent of the mean flow (133 cfs at the Culpeper gage), then daily monitoring of the gage will begin. When the 14 day rolling average of the streamflow at the Culpeper gage falls below 53 cfs, then RSA shall implement the first drought conservation action. This action will continue until the river level increases above the 53 cfs flow. When the 14 day rolling average of the streamflow at the Culpeper gage falls below 28 cfs, then RSA shall implement the second drought conservation action. This action will continue until the river level increase above the 28 cfs flow.

The first drought conservation action (called Phase I) shall include a notice in the Lake of the Woods weekly newsletter that water conservation by all consumers is encouraged, a water conservation notice put in all the monthly billing mailings to all customers, and a poster displayed at the East Office describing the voluntary water conservation efforts. If this first action level lasts for more than 30 days, then RSA will initiate meter testing procedures to properly monitor the water usage and replace inaccurate meters. Also, RSA will leave water conservation notices on the doorsteps of high water users as determined by the RSA staff.

The second drought conservation action (called Phase II) shall include a notice in the Lake of th Woods weekly and monthly newsletters that water conservation is mandatory for all consumers, a mailing to all customers describing the mandatory water conservation efforts, and signs posted at the front of each subdivision noting the conservation needs. If this second action level lasts for more than 30 days, then RSA will initiate leak detection procedures to minimize all losses of water. Also, RSA will contact high water users as determined by RSA staff and request water conservation measures by the consumers. If the RSA request is not satisfactorily complied with, then RSA will shut down the water service until the customer adheres to RSA's demands.

It is RSA's intent that in response to these conservation actions, each water user will lower his/her usage appropriately and, in turn, the system will survive the low flow situation with each user sharing in the responsibility.

SUMMARY OF CONSERVATION ACTIONS

RESPONSIBLE PARTIES	Q= 133 cfs *	(Phase I) Q= 53 cfs *	(Phase II) Q= 28 cfs *
RSA monitoring	daily	daily	daily
LOW newsletter	no	weekly	weekly + mon.
Notice to customers	no	yes	yes
RSA meter checks	no	yes	yes
Entrance signs	no	no	yes
RSA leak detection	no	no	yes
High users contacted	no	yes, after 30 days	

* These flows are measured on the Rapidan River at the Culpeper gaging station.

wolintake\drought

APPENDIX-K

Town of Gordonsville, Ordinance No. 23.19-02 through 12.19-05

TOWN OF GORDONSVILLE

ORDINANCE NUMBER 23.19-02 through 23.19-05

BE IT RESOLVED by this Town Council of the Town of Gordonsville that Section 23.19-02 of Town Code section 23 be adopted:

Whereas, the Town Council of the Town of Gordonsville, Virginia has determined that the continued existence of climatic, hydrological and other extraordinary conditions the protection of the health, safety and welfare of the residents of the Town of Gordonsville may require that certain uses of water, not essential to public health, safety and welfare, be reduced, restricted or curtailed or prohibited. As the shortage of potable water becomes increasingly more critical, conservation measures to reduce consumption or curtail essential water use may be necessary. Now, Therefore Be It ordained by the Town Council of the town of Gordonsville, Virginia sitting in emergency session on 21 Aug 02 that the following ordinance pertaining to water restrictions is hereby adopted on an emergency basis.

Section 23.19-02

The Town Administrator, with the approval of the Gordonsville Town Council, is authorized to declare water emergencies in the town affecting the use of water.

Sec. 23.19- 03 Water conservation measures.

After the declaration of a water emergency and upon a determination by the Town Administrator after consulting with the Council and with the existence of the following one or more conditions, the Town Administrator shall take the following actions which shall apply to any person whose water supply is furnished from the Town of Gordonsville water system:

(a) Condition 1: when moderate but limited supplies of water are available, the Town Administrator shall, through appropriate means, call upon the general population to employ prudent restraint in water usage and to conserve water voluntarily by whatever methods available.

(b) Condition 2: The Town Administrator is hereby further authorized during the duration of a water emergency for which voluntary measures would be insufficient to order the restriction or prohibition of any or all of the following uses of the water supply:

(i) Watering of outside shrubbery, trees, lawns, grass, plants, home vegetable gardens, or any other vegetation except from a watering can or other container not exceeding five (5) gallons in capacity. This limitation shall not apply to commercial greenhouses or nursery stocks, which may be watered in the minimum amount required to preserve plant life before 7:00 a.m. or after 8:00 p.m.

(ii) Washing of automobiles, trucks, trailers, or any other type of mobile equipment, except in licensed commercial vehicle wash facilities.

(iii) Washing of sidewalks, streets, driveways, parking lots, service station aprons, exteriors of homes or apartments, commercial or industrial buildings or any other outdoor surface, except where mandated by federal, state or local law.

(iv) The operation of any ornamental fountain or other structure making a similar use of water.

(v) The filling of swimming or wading pools requiring more than five (5) gallons of water, or the refilling of swimming or wading pools which were drained after the effective date of the declaration of emergency, except that pools may be filled to a level of two (2) feet below normal, or water may be added to bring the level to two (2) feet below normal, or as necessary to protect the structure from hydrostatic damage.

(vi) The use of water from fire hydrants for any purposes other than fire suppression, unless otherwise approved by the Administrator.

(vii) The serving of drinking water in restaurants, except upon request.

(viii) The operation of any water-cooled comfort air conditioning that does not have water-conserving equipment in operation.

(c) Condition 3: The Town Administrator is hereby further authorized during the duration of a water emergency to implement one or more of the following:

(i) Industrial, institutional, commercial, governmental, wholesale and all other nonresidential customers shall be allotted a percentage reduction based on that customer's average monthly water consumption for the same billing period of the previous calendar year's consumption.

(ii) Individual residential customers shall be limited to a specific volume or percentage reduction of water per month.

If the allotted monthly water usage is exceeded, the customer shall be charged ten dollars ($10.00) for every one thousand (1,000) gallons of water consumed above the allotted volume. Where prior consumption data is not available the Town Treasurer shall estimate allocations based upon the data available from similar activities of equal intensity.

(iii) Declaration of a moratorium on new water connections.

(d) Condition 4: When crucially limited supplies of water are available, the Town Administrator shall restrict the use of water to purposes, which are absolutely essential to life, health and safety.

(e) The above restrictions, or any of them, shall become effective upon their being printed in any newspaper of general circulation in the Town of Gordonsville, or broadcast upon any radio or television station serving the Town of Gordonsville.

Upon implementation of (b), (c), or (d) there shall be establish an appeals procedure to review customer applications for exemptions from the provisions of subsections (b), (c), or (d) on a case-by-case basis and, if warranted, to make equitable adjustments to such provisions. The Town Administrator shall also be empowered to grant temporary exemptions applicable to all or some of the uses of the water supply set forth in subsections (b), (c), or (d). The Town Administrator shall, in deciding applications, balance economic and other hardships to the applicant resulting from the imposition of water use restrictions or allocations against the individual and cumulative impacts to the water supply resulting from the granting of exemptions. Any decisions by the Town Administrator shall be eligible for appeal to the Town Council.
Sec 23.19-04 Penalty.

Any person cited for violations of the provisions of this Ordinance, or of any of the conservation regulations promulgated by the Town of Gordonsville pursuant thereto, shall, upon conviction thereof, in addition to additional charges set forth in Section 23.19-03subsection (c) be fined not less than one hundred dollars ($100.00), nor more than two thousand five hundred dollars ($2,500.00). Each act or each day's continuation of a violation shall be considered a separate offense. In addition to the foregoing, the Town Administrator may suspend water service to any person continuing to violate the provisions of this ordinance or the regulations promulgated there under. If such water service is terminated, the person shall pay a reconnection fee of forty dollars ($40.00) before service is restored.

Sec. 23.19-05. Notification of end of water emergency.

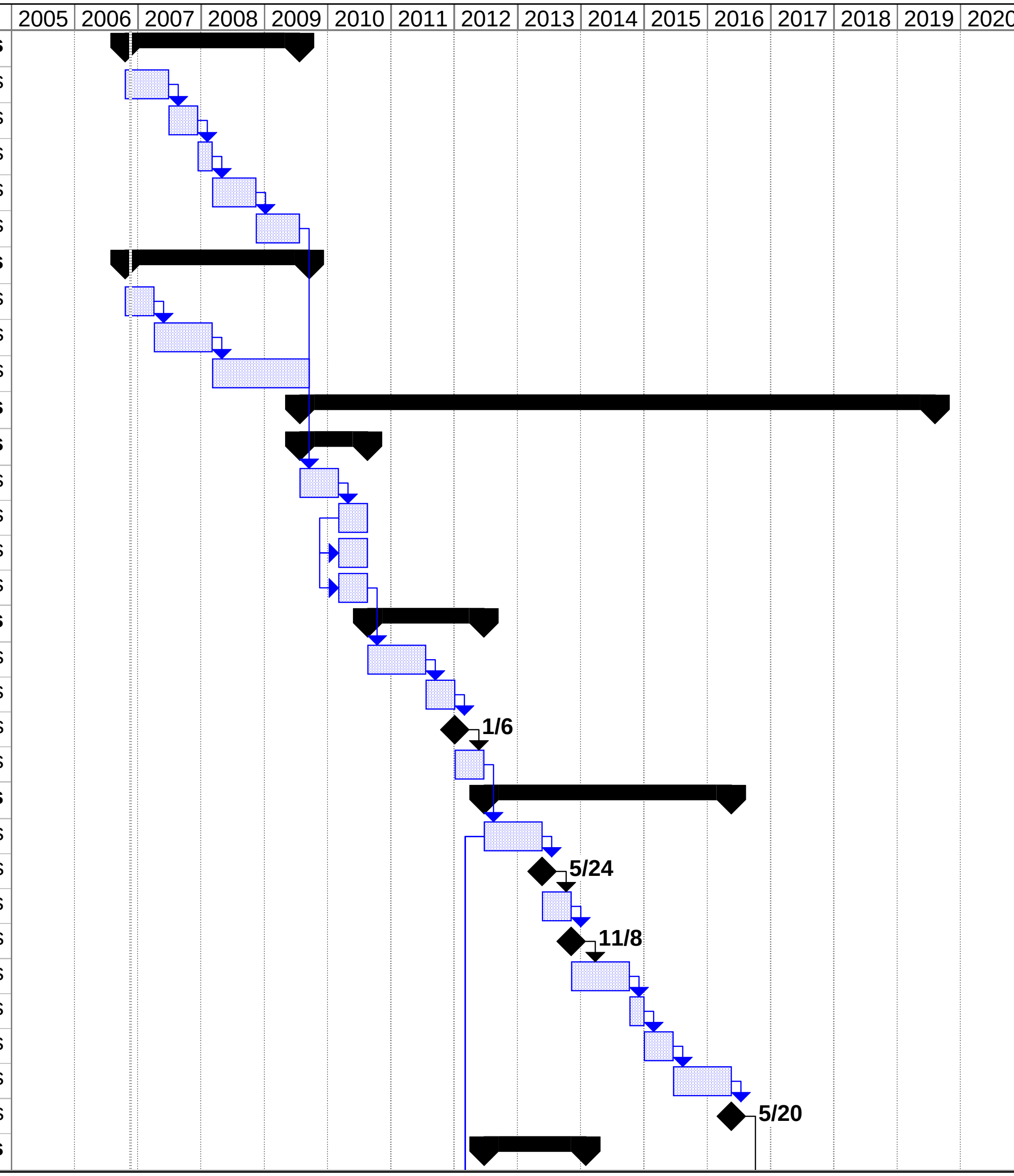
When in the opinion of the Town Administrator the water emergency situation no longer exists, their opinion shall be passed to the Town Council. Upon concurrence of the Council, the water emergency shall be declared to have ended.

Motion by Marilyn Steinke to approve the ordinance 23.19-02 through 23.19-05 as amended. Second by Vice Mayor Emily Winkey.

APPENDIX-L

Construction Schedule

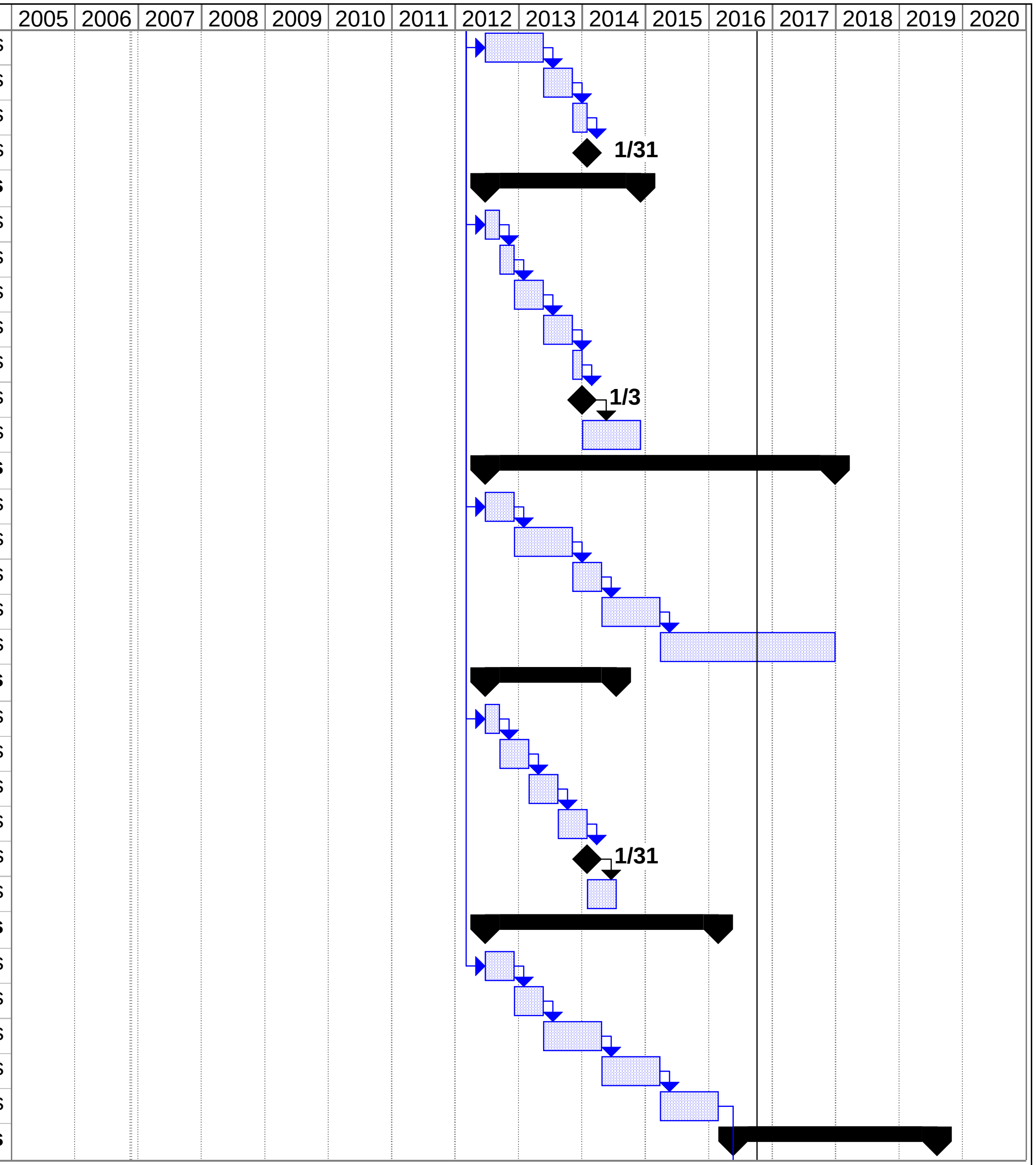
ID	Task Name	Duration
1	**Groundwater Development**	**36 mons**
2	Phase II - Geophysical Surveys	9 mons
3	Phase III - Test Well Drilling	6 mons
4	Phase IV - Convert Test Wells to Pro	3 mons
5	Phase V - Aquifer Testing/Wellhead F	9 mons
6	Distribution Improvements	9 mons
7	**RSA Wilderness Plant Permit Revisio**	**38 mons**
8	Prepare Plant Expansion Study	6 mons
9	Obtain revised WTP permit	12 mons
10	Plant Modifications	20 mons
11	**Construct New Reservoir and WTP**	**131 mons**
12	**Preliminary Res. Devel. Study**	**14 mons**
13	Identify Preferred Alternative	8 mons
14	Investigate Potential Wetland Impacts	6 mons
15	Investigate Potential Endangered Species Im	6 mons
16	Investigate Potential Cultural Resources Impa	6 mons
17	**Regulatory Review**	**24 mons**
18	Mitigation Site Search	12 mons
19	Meet Federal and State Agencies	6 mons
20	Interagency Pre-Application Conference	0 days
21	Respond to Agency Comments	6 mons
22	**404 Permit**	**51 mons**
23	Prepare 404 Permit	12 mons
24	File 404 Permit Application	0 days
25	Public Notice, Comments and Responses	6 mons
26	Public Meeting	0 days
27	Additional Studies	12 mons
28	Agency Conferences	3 mons
29	Prepare Document of Record and Final EA	6 mons
30	Prepare Draft 404 Permit with Conditions	12 mons
31	404 Permit Issues	0 days
32	**401 Water Quality Certification**	**21 mons**



Orange County Water Supply Plan
Proposed Planning Scenerio Schedule
Wed 11/15/06

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

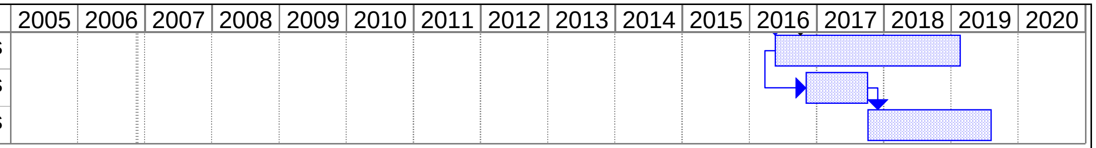
ID	Task Name	Duration
33	Prepare and File Withdrawal Applications	12 mons
34	Conduct Anti-Degradation Study	6 mons
35	Public Comment	3 mons
36	401 Water Quality Certification Issues	0 days
37	**Archeology**	**32 mons**
38	Obtain Landowner Permission	3 mons
39	Interagency Coordination	3 mons
40	Phase I	6 mons
41	Phase II	6 mons
42	Determination of Effect	2 mons
43	Memorandum of Agreement	0 mons
44	Data Recovery	12 mons
45	**Wetland/Stream Mitigation**	**72 mons**
46	Finalize Mitigation Sites	6 mons
47	Finalize Mitigation Plan	12 mons
48	Negotiate Options	6 mons
49	Implement Plan	12 mons
50	Monitoring of Sites	36 mons
51	**Endangered Species**	**27 mons**
52	Identify Habitat Protection Options	3 mons
53	Agency Review	6 mons
54	Prepare Biological Assessment	6 mons
55	Agency Review	6 mons
56	US FWS Biological Opinion	0 days
57	Implement Mitigation Plan	6 mons
58	**Land Acquisition**	**48 mons**
59	Boundary Surveys	6 mons
60	Title Examinations	6 mons
61	Appraisals	12 mons
62	Negotiations	12 mons
63	Closings or Condemnations	12 mons
64	**Dam, Res., and WTP Constr.**	**42 mons**



Orange County Water Supply Plan
Proposed Planning Scenerio Schedule
Wed 11/15/06

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

ID	Task Name	Duration
65	Reservoir Construction	36 mons
66	Water Distribution Improvements	12 mons
67	Water Treatment Plant Construction	24 mons



Orange County Water Supply Plan
Proposed Planning Scenerio Schedule
Wed 11/15/06

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

APPENDIX - M

Recommended Water Audit

Quantifying water losses as a ratio of unaccounted-for water to total input volume is no longer considered a reasonable approach for reporting water losses. While many water utilities in the United States are still using the UFW percentage method, the AWWA is now recommending against that for several reasons. First of all, expressing losses as a percentage of total input volume may be quite misleading, as water systems with lower demands will never be able to compete with those with larger demands. Additionally, no standardized definition for “unaccounted-for water” currently exists. Some utilities consider UFW as all water that is not metered and sold while others may consider it as only that water which is lost through leaks[1]. Since it is unclear how to calculate the percentage, this value is no longer considered as a reliable means of evaluating water loss. Measuring water loss as a percentage of total input volume also does not take into account system-specific parameters such as number of service connections, length of mains, operating pressure, etc.

The confusion as to how to quantify water losses came about, in part, as a result of the AWWA Leak Detection and Water Accountability Committee Report published in the July 1996 issue of the AWWA Journal. In this report, the committee recommended that all water and consumption losses be quantified in terms of volume and cost to the supplier, rather than in terms of percentage of input volume. However, they also made the recommendation that the benchmark level for unaccounted-for water be less than 10% of the input volume, implying that a percentage value should be used. These contradictory statements led to wide range inconsistency in reporting water loss values.

As a result of these inconsistencies, in 1997 the IWA (International Water Association) Task Force on Water Losses, a committee made up of members from five countries with nominated representation from AWWA, began a study to develop a standardized method for conducting water audits. The resulting IWA/AWWA Water Audit Method is now being recommended by the AWWA as the best practice method and will be incorporated into the next version of the AWWA M36 publication, *Water Audits and Leak Detection*, which is expected to be released in late 2006.

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[1] Beecher, Janice A., PhD. *Survey of State Agency Water Loss Reporting Practices*. Final Report to the American Water Works Association, Beecher Policy Research, Inc., January, 2002.

The IWA/AWWA Water Audit Method is a detailed, system-specific approach to determine water loss. It assumes that all water entering the distribution system can be accounted for, via metering or estimation, as either a use or a loss[2]. Therefore, the term "unaccounted-for water" has been dropped and replaced with a more definitive term, "non-revenue water." The water balance used for this method is shown in Figure **Error! No text of specified style in document.**-1.

Figure Error! No text of specified style in document.**-1 IWA/AWWA Water Balance**

(All data in volume for the period of reference, typically one year)

<table>
<tr><td rowspan="10">System Input Volume (corrected for known errors)</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metering</td></tr>
<tr><td colspan="5">Note: Figure taken from AWWA's website, Water Wiser: Water Loss Control http://www.awwa.org/waterwiser/waterloss/, last accessed 10/20/2006.</td></tr>
</table>

As shown on Figure **Error! No text of specified style in document.**-1, non-revenue water consists of all water that is not billed. All non-revenue water, however, is not

[2] AWWA website. *Water Wiser: Water Loss Control.* http://www.awwa.org/waterwiser/waterloss/, last accessed 10/23/2002.

considered water loss. Water loss is only that water which is not billed and not authorized by the water utility. Again, water losses are broken into two categories, apparent losses and real losses. The IWA/AWWA recommends quantifying water losses in terms of gallons/service connection/day for larger pressurized systems and in gallons/mile of mains/day for smaller pressurized systems. These normalized values provide system specific references for water loss reporting.

The IWA/AWWA water audit method recognizes several types of performance indicators for water loss comparisons as shown in Table Error! **No text of specified style in document.-1**. The indicators for real losses are of particular interest. The UARL (unavoidable annual real losses) is a theoretical reference value which represents the lowest practical value for leakage for a specific system, under which it would be uneconomical to detect and repair. The ILI (infrastructure leakage index) is a ratio of the normalized real losses for a given year to the URAL. According to the AWWA Water Loss Control Committee Report *Applying Worldwide BMPs in Water Loss Control*, while an ILI of 1.0 would be ideal, systems with ILI values between 2.0 and 8.0 represent reasonable control over their system leakage[3].

By adopting the IWA/AWWA recommended performance indicators, water utilities could estimate the effectiveness of their leakage control based on system-specific parameters and then target specific areas in need of improvement. This would allow for the determination of efficient and economical strategies for distribution system improvements, thereby leading to enhanced water conservation.

[3] AWWA Water Loss Control Committee. *Applying Worldwide BMPs in Water Loss Control*. AWWA Journal, Vol. 95, Issue 8, August, 2003.

Table Error! No text of specified style in document.**-1 Performance Indicators for Non-revenue Water and Water Losses**

Performance Indicator	Function	Comments
Volume of Non-revenue water as a percentage of system input volume	Financial - Non-revenue water by volume	Can be calculated from a simple water balance; good only as a general financial indicator
Volume of Non-revenue water as a percentage of the annual cost of running the water system	Financial - Non-revenue water by cost	Allows different unit costs for Non-revenue water components
Volume of Apparent Losses per service connection per day	Operational - Apparent Losses	Basic but meaningful indicator once the volume of apparent losses has been calculated or estimated
Real Losses as a percentage of system input volume	Inefficiency of use of water resources	Unsuitable for assessing efficiency of management of distribution systems
Normalized Real Losses - Gallons/service connection/day when the system is pressurized	Operational: Real Losses	Good operational performance indicator for target-setting for real loss reduction
Unavoidable Annual Real Losses (UARL)	UARL (gallons/day) = (5.41Lm + 0.15Nc + 7.5Lp) x P Where: Lm = length of water mains, miles Nc = number of service connections Lp = total length of private pipe, miles = Nc x average distance from curbstop to customer meter P = average pressure in the system, psi	A theoretical reference value representing the technical low limit of leakage that could be achieved if all of today's best technology could be successfully applied. A key variable in the calculation of the Infrastructure Leakage Index (ILI) It is not necessary that systems set this level as a target unless water is unusually expensive, scarce or both
Infrastructure Leakage Index (ILI)	Operational: Real Losses	Ratio of Current Annual Real Losses (CARL) to Unavoidable Annual Real Losses (UARL); good for operational benchmarking for real loss control.
Note: Table taken from AWWA's website, *Water Wiser: Water Loss Control* http://www.awwa.org/waterwiser/waterloss/. Last accessed 10/23/2006.		

The data presented in **Error! Reference source not found.** of this report represents the volume of non-revenue water as a percentage of total system input for each of Orange County's distribution systems. While this percentage may not represent an efficient means for quantifying water loss, it can provide a general basis for financial analysis. Since each of Orange County's systems has experienced some sort of water loss in the past six years, it may be economical to further investigate and narrow down the possible sources of the non-revenue water in an effort to determine a better estimate of total water losses.

Based on the newly identified best management practices for water loss measurement, it is unclear if the distribution systems in Orange County have acceptable levels of control over their water losses. Therefore, it is recommended that the distribution systems in Orange County consider conducting an IWA/AWWA water audit in order to gain a better understanding of their water loss conditions.

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