Water Supply Alternatives
Supplemental Evaluation

Prepared For

Prepared By

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Section I – Introduction

In planning for a future reliable water supply, Rivanna Water and Sewer Authority (RWSA) has for many years been evaluating water supply conditions and community needs. In support of this evaluation, extensive work has been completed by Vanasse Hangen Brustlin, Inc. (VHB) and O'Brien & Gere Engineers, Inc. (OBG). Most recently, RWSA retained Gannett Fleming, Inc. (GF) and VHB in the fall of 2003 to reevaluate the safe yield of existing supply facilities serving the Urban Service Area based on the most up-to-date information, including data collected during the severe 2002 drought, and to implement a previously adopted water supply plan. Initial activities included RWSA system safe yield investigations and South fork Rivanna Reservoir (SFRR) proposed pilot dredging plan review.

The findings resulting from this work indicated that the safe yield of the Urban Service Area is different from prior estimates. GF also recommends that the proposed SFRR pilot dredging project be delayed until the long-term cost of dredging can be re-evaluated. GF also recommends that additional alternate long-term solutions for increasing safe yield be investigated before seeking permits to make improvements to increase safe yield.

Concurrently, Ragged Mountain dam condition and rehabilitation options were being assessed for RWSA by GF. GF concluded that the Ragged Mountain dams will require immediate and extensive rehabilitation to meet current dam safety regulations. Virginia Department of Conservation and Recreation (DCR) is also considering operation and maintenance certificate renewal. RWSA must determine as soon as possible whether to rehabilitate the dams at their current capacities or at an expanded capacity to provide additional safe yield.

This report assesses potential water supply alternatives in light of the additional data and analyses now available. Although significant changes have occurred, much of the previously prepared work remains valid. Previously-assembled data and completed evaluations are reviewed and used when confirmed and appropriate. Previously-identified alternatives are reviewed based on currently-available data. Additional alternatives are developed based on current conditions and new data. These alternatives are evaluated with respect to order of magnitude cost estimates and environmental and other impacts that might inhibit regulatory approval. The evaluation summarized in this report was prepared to be reviewed with appropriate regulatory agencies. With regulatory agency concurrence, the appropriate concepts will be further analyzed in subsequent investigations. Those investigations are expected to be the basis for permitting of the most favorable alternative.

A. Background

In October 1997, VHB and OBG prepared reports analyzing the water supply available to RWSA's Urban Service Area and the projected demands that will be placed on that system through 2050. The *Supply Analysis* indicated the total system safe yield at the

time was approximately 12 million gallons per day (MGD), and that it would fall to approximately 4.5 MGD by 2050 due to continuing sediment accumulation in the SFRR. The assessment was based upon an understanding at that time that the SFRR was required to make a minimum constant release of 8 MGD, even during severe droughts, and that Sugar Hollow Reservoir would make no release. The assumption of an 8 MGD constant release at SFRR resulted in a 2050 safe yield of 0 MGD being assigned to that facility.

The *Demand Analysis* indicated that water demand in 1997 in the Urban Service Area was approximately 11 MGD. Using several different techniques, it projected that demand would grow to approximately 19.5 MGD in 2050, leaving an unsupplied water deficit in that year of approximately 15 MGD if no circumstances changed.

In February 2000, VHB and OBG completed a draft *Analysis of Alternatives* that was intended to compile the best information available about potentially viable means of reducing or eliminating the forecast water deficit. Among the alternatives examined was releasing 8 MGD or modeled natural inflow from SFRR during extreme droughts (whichever is less), rather than releasing 8 MGD constantly (as had been assumed in the *Supply Analysis*). It also examined cooperative adoption of an aggressive water conservation program by the RWSA, the City of Charlottesville (City), and Albemarle County Service Authority (ACSA). The *Analysis of Alternatives* concluded that implementation of these two measures would cut the projected 2050 deficit from 15 MGD to approximately 11.7 MGD.

In May 2001, VHB and OBG issued a revised draft report setting forth *Recommended Alternatives*. The report recognized that "8 MGD or inflow" was an appropriate release for SFRR, and recommended implementation of an aggressive water conservation program. It also recommended proceeding immediately with installation of crest controls at SFRR to raise its pool elevation by four feet. It was believed this would provide an additional 7 MGD of yield in 2050, and would enable RWSA to postpone implementation of other possible water supply projects until 2035 or later.

In 2002 and 2003, as RWSA analyzed these recommendations, adopted a water supply plan, and began to implement it, Central Virginia experienced one of the most severe droughts ever recorded. During the drought, the release regime actually followed by RWSA at SFRR proved closest to the "8 MGD or inflow" scenario. In addition, RWSA was releasing a minimum of 0.4 MGD from the Sugar Hollow Reservoir to the Moormans River. During the drought, the City, and the County adopted and implemented an aggressive, coordinated mandatory water conservation program.

The significant drop in RWSA's reservoir levels in 2002 indicated that the drought experienced was very severe and prompted a re-evaluation of the safe yield of the existing facilities and the expansion alternatives under consideration. In addition, more water use and sedimentation data were available.

In October 2003, RWSA retained GF and subconsultant VHB to update the prior findings. In January 2004, Gannett Fleming completed a *Safe Yield Study* re-evaluating

the yield of the system supplying the Urban Service Area including data from 1925 to 2003 (including the 2002 drought). As subsequently revised based on model enhancements and reported in *Safe Yield Study Supplement No. 1*, GF determined the safe yield of the Urban Service Area to be 12.8 MGD in 2002, and projected the yield would fall to 8.8 MGD in 2055. The assumed operating conditions included releases of 8 MGD or inflow from SFRR and 0.4 MGD (unless total available reservoir storage falls below 80%) from Sugar Hollow Reservoir. GF completed a *Demand Analysis for the Urban Service Area* in May 2004 that took water conservation efforts into account as part of its review of water demand and projected that water use in the Urban Service Area would rise to approximately 18.7 MGD by 2055. The net result is a projected water deficit of 9.9 MGD in 2055.

GF completed a *Dredging Report* in December 2003. This report was intended to review the previous dredging investigations and assess the likely outcomes of implementing dredging of the SFRR. Feasibility could not be confirmed and additional investigations were recommended. Preliminary findings indicated dredging costs are very high and additional water supply alternatives should be considered prior to implementing SFRR dredging.

Prior to its involvement with the Community Water Supply Program, GF was separately commissioned to assess the condition of the Ragged Mountain Dams with respect to present-day dam safety standards and to study the feasibility of upgrading the structures to meet these standards. The initial assessment found that both the Upper and Lower Ragged Mountain Dams have severely inadequate capacity for the spillway design flood, which in both cases is the Probable Maximum Flood (PMF). The structural stability of the earth fill buttress of the Lower Ragged Mountain Dam must yet be evaluated under earthquake conditions and may not meet design requirements during such extreme conditions. Since the current operational configuration for the Upper Dam (circa 1885) provides an unneeded system redundancy in impounding raw water, the study recommended that the Upper Dam be decommissioned by partially breaching its earth fill embankment. Four upgrade alternatives were conceptually developed for the Lower Ragged Mountain Dam (circa 1908) to address spillway capacity and structural stability deficiencies. These alternatives also included raising the Lower Reservoir by 3.2 feet to recapture the original storage capacity of the Upper Dam that would be lost due to its decommissioning.

Virginia Department of Conservation and Recreation (DCR), which is responsible for dam safety in Virginia, will soon decide whether to renew a two-year conditional operation and maintenance (O & M) certificate for this facility. The current water supply plan does not include corrective action at the Ragged Mountain Dams facility. Preliminary review during the Ragged Mountain Dams feasibility study indicates that there may be opportunity to expand the water supply storage at this location. Since the incremental cost for expansion over rehabilitation may be relatively small, such opportunities are being investigated so that the design and construction phases for this component could be implemented prior to mid-2006 (approximate expiration of two-year conditional O & M certificate, if issued).

Significant changes in important determining factors have occurred since the previous water supply plan was developed, making it necessary to reevaluate previous alternatives based on current information.

B. Report Purpose

This report documents the review process for reevaluation of the 1997 VHB list of 33 water supply alternatives. It also includes additional potential water supply projects identified based on current information. For the purposes of this report, these potential projects are considered "water supply components". Water supply components are considered in stand-alone or combination to satisfy the 2055 water demand deficit of 9.9 MGD. Appropriate water treatment plant improvement components are also developed. Water supply and treatment components are combined to comprise "water supply alternatives". Engineering and environmental aspects of each water supply alternative are identified through a preliminarily analysis. These results are scrutinized and a small group of projects determined to be the most reasonable alternatives that should be evaluated in greater detail identified. Additional investigations will be performed for this smaller group and the most favorable project for RWSA implementation will be selected.

It is not the purpose of this report to evaluate or modify the policy decisions or management practices approved by the RWSA Board of Directors in 2002 that were derived as an outgrowth of the earlier VHB and OBG studies. Instead, this report focuses more narrowly on an update and reevaluation only of safe yield and the alternatives for capital improvements to increase water supply safe yield of RWSA.

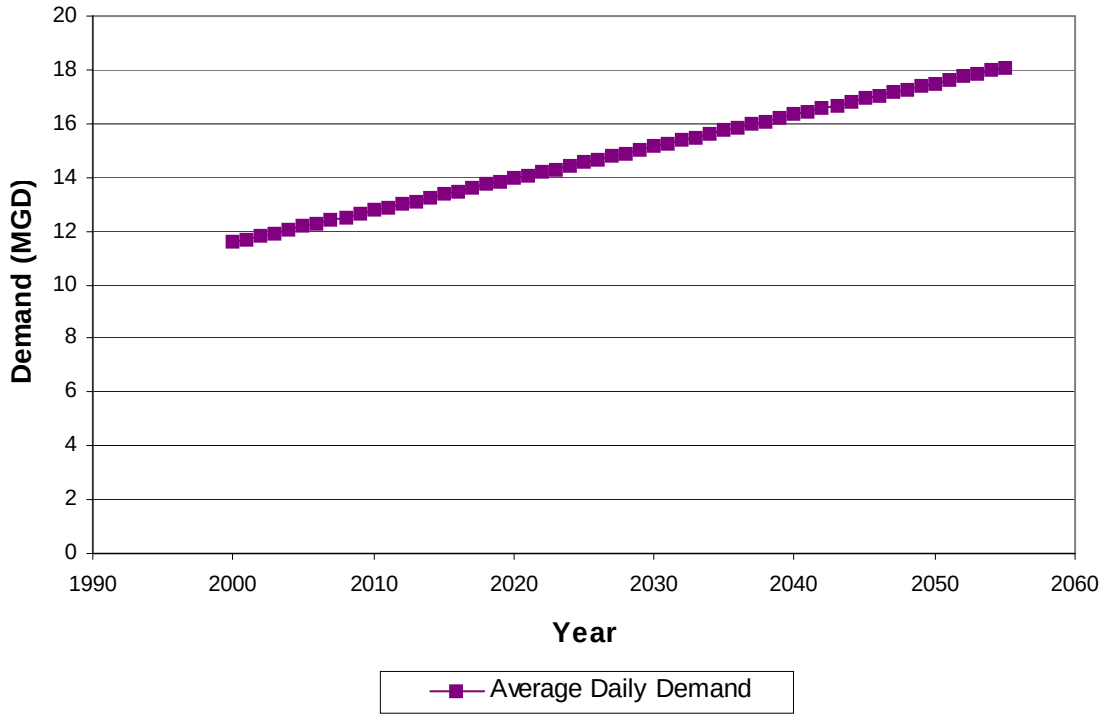
Section II – Demands/Safe Yield

GF completed safe yield investigations and water demand analysis for the RWSA Urban Service area. A 50-year water supply planning horizon is selected and set at 2055. Investigations utilize all currently available data including information available since the 1997 *Supply Analysis* and *Demand Analysis* were developed. Projected water demands for the RWSA Urban Service area are discussed in Part A. Projected safe yield of the existing RWSA Urban Service Area system is discussed in Part B. Graphs depicting both the projected value of safe yield and water demand from 2004 through 2055 are shown in Part C. The current water supply surplus diminishes over time and a 9.9 MGD water supply deficit exists in 2055.

A. Demand Projections

GF reviewed and updated the 1997 VHB *Demand Analysis* and presented the results in a May 2004 report entitled "*Demand Analysis for the Urban Service Area"*. The updated analysis evaluated data through 2003. The report concludes that the projected average daily demand for 2055 is 18.7 MGD and for 2025 is 14.6 MGD. Projected results of water conservation are included in these projections. Figure 2-1 presents the average daily demand curve developed for the RWSA system through 2055.

Figure 2-1
Projected Demand



In addition to the Urban Service Area, RWSA also operates several satellite water systems including one in the nearby Town of Crozet. Although owned by RWSA, the Crozet system is currently operated as a separate rate center. It relies entirely on the Beaver Creek Reservoir for its supply. Current water demand is approximately 0.30 MGD. Albemarle County planning staff project Crozet will reach a build-out population of 12,000 people by 2055. Based on historical per capita usage of water outside the Urban Service Area water demand in the Crozet system will reach approximately 1.1 MGD by 2055. Although 2055 water demands are projected at 1.1 MGD, it is possible that a large commercial or industrial water user could locate in the service area and place additional demand on the system. Con Agra food processing facility (a large water user) historically operated within the Crozet service area and shut down in the late 1990s. It is possible that this facility could be reoccupied at some time in the future and such demands be added to the system. The area surrounding Crozet is also rural and growth could exceed the build-out currently anticipated.

B. Existing Safe Yield and 2055 Safe Yield

GF also analyzed the safe yield expected from the existing RWSA water supply system and presented the results in a January 2004 report entitled "*Safe Yield Study*". Initial safe yield computations in this study resulted in an existing safe yield of 13.3 MGD. Subsequently, RWSA authorized GF to enhance the model and include additional watershed features for potential water supply alternative evaluation. These features include Beaver Creek Reservoir, Lake Albemarle and Chris Greene Lake. Although no change was made in the operating conditions, these more detailed investigations resulted in slightly lower safe yield estimate of 12.8 MGD for existing baseline operating conditions. This reduction is due to three elements. The enhanced model includes 3 reservoirs that were not in the January 2004 study. Runoff is captured in the 3 reservoirs that were previously considered unregulated runoff. Water that is retained in these reservoirs is subject to evaporation that results in water lost from the system. The third element is the Town of Crozet withdrawal from the Beaver Creek reservoir. Beaver Creek Reservoir water supply is currently not used by the RWSA Urban system and was also considered unregulated runoff in the January 2004 study.

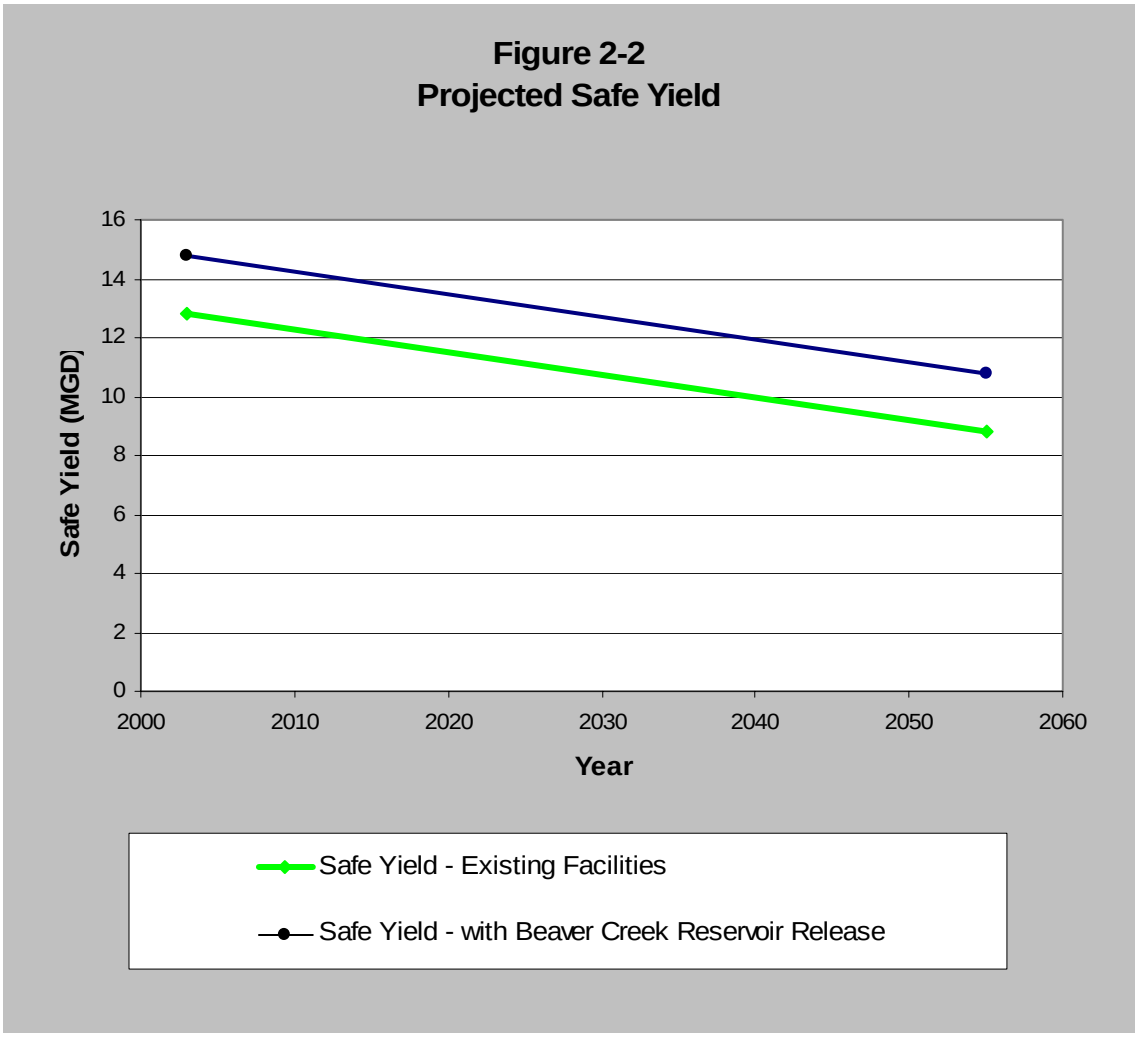
The water supply elements of the existing safe yield study that directly contribute to the safe yield include SFRR, Sugar Hollow Reservoir, Ragged Mountain Reservoirs, and a river intake on the North Fork Rivanna River. The safe yield study concludes that the safe yield is diminishing over time due to a significant loss of storage capacity at SFRR from sedimentation. When the system is analyzed using a release scenario at SFRR of 8 MGD or inflow and 0.4 MGD release from Sugar Hollow when total storage exceeds 80%, the existing safe yield of the system is 12.8 MGD. The 2055 safe yield is estimated at 8.8 MGD. Figure 2-2 presents the expected system safe yield for the existing facilities and current configuration during the identified planning horizon.

Safe yield is also projected for the existing Urban system elements plus a release from Beaver Creek Reservoir. Beaver Creek reservoir is currently used as a water supply for the Crozet system and flood control. Although not currently operated to directly provide water supply to the Urban Service Area, RWSA controls the water stored in Beaver

Creek Reservoir. Additional safe yield for the Urban Service Area is available if outlet controls are modified for flexible operation and water released in the Mechums River. This water could be recaptured at SFRR although some volume may be lost in transmission by the Mechums River.

This study is developed on the basis that available safe yield in Beaver Creek Reservoir beyond 1.1 MGD can be used in the Urban system at least in the earlier years of the 50-year plan, while recognizing that the allocation of supply to the Crozet system may exceed this projection in the later years of this plan depending on actual growth. The additional safe yield made available by the described release scenario is approximately 2.6 MGD assuming the current reservoir pool levels and recreational uses can be maintained. Figure 2-2 presents the expected safe yield for the existing facilities and current configuration plus a 2.6 MGD release form Beaver Creek reservoir.

Figure 2-2
Projected Safe Yield



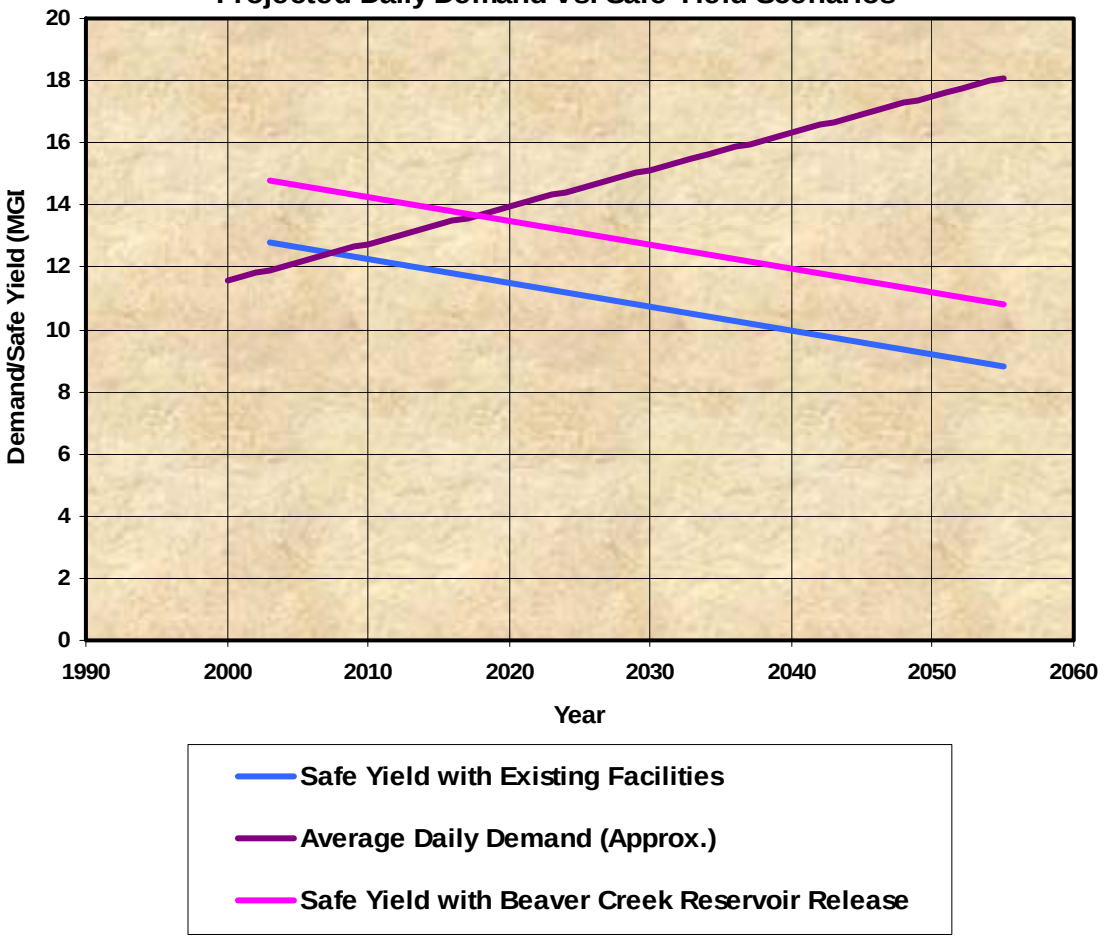
C. Supply Deficit

The water demand and safe yield projections are shown in the graph below. The RWSA safe yield currently exceeds the water demand of the existing facilities and current

configuration. The current surplus is projected to diminish and be gone in 2008. Beyond that time, the average daily demands will exceed the safe yield and a water supply deficit begins. It should be noted that if no action is taken to expand water supplies, extreme demand management measures potentially impacting the local economy may be necessary to satisfy RWSA demands beyond 2008. The supply deficit is determined by subtracting the expected safe yield of the existing facilities from the average daily demand. In the RWSA Urban system, the projected 2055 supply deficit is 9.9 MGD. Figure 2-3 presents a comparison of Safe Yield and Demand for the RWSA Urban System.

As discussed above, RWSA could modify outlet controls on the Beaver Creek Reservoir, and make an additional 2.6 MGD safe yield available to the Urban service area. Figure 2-3 presents a comparison of Safe Yield with a Beaver Creek Reservoir Release and Demand for the RWSA Urban system. If these changes were made, the point in time when the supply and demand curves cross is extended to approximately 2018.

Figure 2-3
Projected Daily Demand vs. Safe Yield Scenarios



Section III - Alternatives Evaluation Approach

As discussed in Section II, there is a projected raw water deficit for the RWSA Urban Service Area. A review of existing water treatment plant (WTP) capacity indicates similar deficits exist. Satisfaction of the overall water supply deficit involves identifying raw water components that can increase the safe yield of the system and coordinated water treatment components of sufficient capacity that can provide finished water to the RWSA transmission system. Alternatives for satisfying the raw water deficit are formulated by either stand-alone components or combining various components to produce 9.9 MGD of additional safe yield in the year 2055. Water treatment components are selected using various combinations of existing WTPs, expanded WTPs, and new WTPs. The methodology for developing the components and the alternatives is discussed in the following sections.

For the purposes of this report a water supply component is defined as a raw water project that provides an increase in RWSA safe yield. It may provide a portion of, or the entire water supply deficit. Those components that provide only a portion of the deficit must be combined with other components to satisfy the projected 2055 deficit. A water treatment plant component is defined as a water treatment project that provides a portion of, or all of, the overall RWSA treatment plant capacity needed.

A water supply alternative is defined as a project that includes:

1. a stand-alone raw water supply component or combination of components that satisfy the projected 9.9 MGD deficit in 2055; and
2. a stand alone WTP or combination of existing and/or expanded WTPs that satisfy the WTP capacity requirements in 2055.

Previous investigations used the term alternative to represent any water supply project that could provide additional safe yield. This term is only used in Part A below to discuss previous investigations. Previously developed VHB "alternatives" are evaluated. Favorable projects advance in this study as a water supply component.

A. Water Supply Component Methodology

Significant work on water supply project development was completed by VHB and OBG in the last 5 years. Their report entitled *Water Supply Project Analysis of Alternatives* was completed in February 2000 and submitted to RWSA and discussed with regulators. Thirty-three (33) alternatives were identified, one of which was a "no action" alternative. The "no action" alternative is typically included in reports of this nature and assumes that the existing system will be maintained but no corrective measures aimed at increasing the raw water capacity of the system will be implemented.

Some of the projects can satisfy the entire 9.9 MGD deficit. Others provide only a portion of the deficit and must be considered in combination.

GF began its work by reviewing the 33 VHB alternatives identified in the February 2000 report and assessing the appropriateness of advancing each raw water component based on current conditions. Reasonable alternatives are selected for additional evaluation as a

water supply component in this investigation and are highlighted in bold text. Commentary is provided for each VHB alternative that is not advanced.

VHB #1. Dredge South Fork Reservoir
- **Advanced.**

VHB #2. Reduce Sediment Load into SFRR
- **Advanced.**

VHB #3. Alternative Release Scenarios at SFRR
- This alternative was listed by VHB based on a 2000 safe yield operating rule of zero release at South Fork Rivanna Dam.
- Current investigations are based on a 8 MGD or inflow release scenario at SFRR
- Since current safe yield investigations include this operating rule, this alternative is already a part of the 2004 baseline conditions.

VHB #4. Add 4 ft. crest gates on South Fork Rivanna Dam
- **Advanced**

VHB #5. Add 8 ft. crest gates on South Fork Rivanna Dam
- **Advanced**

VHB #6. Use SFRR as a Pumped Storage Reservoir
- VHB determined this project is not feasible
- Not advanced

VHB #7. Up to 5 ft. drawdown of Chris Greene Lake
- **Drawdown is defined as the lake level below full**
- **Advanced**

VHB #8. 20 ft. drawdown of Chris Greene Lake
- Current recreation uses would be eliminated during a drawdown of this magnitude
- RWSA does not own the facility and if purchased would be required to provide equal alternative recreation area (i.e. build a new lake), therefore similar options are considered in new dam options
- Water quality is reportedly poor (high iron and manganese) in depths exceeding 5 ft.
- Not advanced

VHB #9. Use of Chris Greene Lake as a pumped storage reservoir
- VHB determined this project is not feasible
- Not advanced

VHB #10. Use Beaver Creek Reservoir to Supplement Flows in Mechums River
- **Gannett Fleming projects additional safe yield is available**
- **Advanced**

VHB #11. Dredge Sugar Hollow Reservoir
- VHB projected increase in safe yield is negligible
- Not advanced

VHB #12. Conversion of Ragged Mtn. to Pumped Storage Reservoir
- **Advanced**

VHB #13. Pumpback to Mechums River

- **This option is pumped back from Moores Creek WWTP discharge (water reuse)**
- **Advanced**

VHB #14. Pumpback to Moormans River

- This option is a pumpback from Moores Creek WWTP discharge
- Only one WWTP discharge pump back option is advanced by Gannett Fleming
- See alternative 13 (above).

VHB #15. Water Conservation

- Water conservation was considered an alternative in the 2000 VHB report.
- The May 2004 *Demand Analysis for the Urban Service Area* recognizes aggressive water conservation measures were implemented during the 2002 drought and includes an additional 5% projected reduction in water demand by 2055.
- The projected 9.9 MGD water supply deficit accounts for water conservation as reduced water demand and no additional alternatives are necessary.

VHB #16. Growth Management

- Growth management is a matter of policy and not appropriately considered as a water supply alternative.
- Water demands are projected based on long term trends and events that influence them.

VHB #17. Drought Management-demand side

- Drought management refers to a specific plan or plans to temporarily reduce water demands during rare periods of severely limited water supply.
- Conventional water supply planning approaches, and current Commonwealth of Virginia requirements, indicate water supplies should be developed to satisfy projected demands. Therefore, drought management is implemented only during occasions of very severe droughts.
- RWSA has initiated drought management procedures and expects to continue developing these policies. RWSA will fully implement the necessary modifications associated with the water supply expansion project eventually selected.

VHB #18. Drought Management – supply side

- VHB safe yield developed based on operating conditions that do not maximize safe yield.
- Gannett Fleming safe yield estimates are based on optimum operation of existing resources
- Not advanced (already addressed in January 2004 safe yield)

VHB #19. Leak Detection and Meter Calibration

- Leak detection and meter calibration are water system activities that affect demand not supply.

- Leak detection and meter calibration influence unaccounted-for water (normally defined as the difference in metered consumption and total amount of water supplied to the distribution system).
- The City of Charlottesville has undertaken an aggressive leak detection program in recent years and the University of Virginia located and repaired leak sources. Some of these improvements are located behind the meter and simply reduce metered consumption.
- While a short term reduction in unaccounted-for water was observed, more recent values have rebounded. Therefore, it is best to use an average over a long period of time.
- RWSA unaccounted-for water (difference in raw water production and metered sales) varies from year to year and averages 13.3% since 1982. This percentage includes WTP production and usage. Compared to industry performance for similar water systems, this is a low unaccounted-for water percentage and will be difficult to reduce. Therefore, water demands are projected using the 13.3% value.
-

VHB #20. Aquifer Storage and Recovery
- VHB determined this project is not feasible due to low yield.
- Not advanced

VHB #21. Conventional Withdrawal of Groundwater
- VHB determined this project is not feasible
- Not advanced

VHB #22. Construct Dam on Buck Mountain Creek
- **Advanced**

VHB #23. Construct Dam on Preddy Creek
- One new dam option is advanced in current investigations. Buck Mtn, Creek Dam selected. See alternative 22(above).

VHB #24. Construct Dam on Moormans River
- One new dam option is advanced in current investigations. Buck Mtn, Creek Dam selected. See alternative 22(above).

VHB #25. Construct Dam on North Fork Rivanna River
- One new dam option is advanced in current investigations. Buck Mtn, Creek Dam selected. See alternative 22(above).

VHB #26. Construct Dam on Mechums River near Lake Albemarle
- One new dam option is advanced in current investigations. Buck Mtn, Creek Dam selected. See alternative 22(above).

VHB #27. Construct Dam on Mechums River near Midway
- One new dam option is advanced in current investigations. Buck Mtn, Creek Dam selected. See alternative 22(above).

VHB #28. Construct Dam on Buck Island Creek
- One new dam option is advanced in current investigations. Buck Mtn, Creek Dam selected. See alternative 22(above).

VHB #29. James River Withdrawal at Scottsville
- **Advanced**

VHB #30. Rivanna River Withdrawal

- **Advanced**

VHB #31. Mechums River Withdrawal

- VHB projected increase is minimal
- Gannett Fleming includes Mechums River as a part of some pumped storage options
- Not advanced as a stand-alone component

VHB #32. Regional Cooperation with Rapidan Service Authority

- No cooperative projects were identified by VHB that would provide increased safe yield to RWSA
- Rapidan Service Authority was identified as a potential cooperative party but they required additional water supply at that time. They have since implemented their own project.
- VHB concluded that adding additional demand to the RWSA project would likely generate a larger and more environmentally damaging project.
- This cooperative project is not advanced but an alternate regional project is identified. Fluvanna and Louisa Counties are currently developing a water supply project and a cooperative approach with RWSA will be considered.

VHB #33. No-Action

- **Advanced for Regulatory purposes.**

Twelve (12) alternatives from the 2000 VHB *Analysis of Alternatives* report, that are highlighted above in bold text, are advanced as water supply components in this investigation. In addition, Gannett Fleming identified six (6) more components including:

1. Add crest gates at South Fork Rivanna Dam to meet the full deficit;
2. Use available storage in Lake Albemarle;
3. Raise Ragged Mountain Reservoir;
4. Construct new pumped storage facility at Rocky Creek;
5. Expand Sugar Hollow Reservoir; and
6. Regional Cooperation with Fluvanna and Louisa Counties for a James River withdrawal.

This results in eighteen (18) water supply components deemed worthy of additional consideration. These components are detailed and discussed below.

B. Water Supply Components

The eighteen (18) water supply components deemed worthy of additional consideration were each evaluated to determine their respective estimated increases in the 2055 safe yield over baseline conditions. Table 3-1 is a list of the 18 water supply components. It does not include the water treatment work that would be required for each to be implemented.

Table 3-1: Raw Water Supply Components for Alternatives

Components	Brief Description	Predicted Increase in 2055 Safe Yield (MGD)[1,2]
1. No Action: Current (2002) Safe Yield = 12.8 MGD Projected (2055) Safe Yield = 8.8 MGD	Continued SFRR sedimentation will occur. Requires Sugar Hollow to Ragged Mountain/Observatory WTP piping maintenance and/or replacement. Will require Ragged Mountain rehab.	0
2. Dredge SFRR	Various dredge options analyzed	up to 5.1
3. Reduce Sediment Load into SFRR	Various safe yield increases would be associated with a range of sediment load reduction values. A maximum of 4 MGD safe yield increase would be associated with complete sediment removal of all projected future sediment accumulation.	unpredictable
4. Add 4 ft. Crest Gates on South Fork Rivanna Dam		3.3
5. Add 8 ft. Crest Gates on South Fork Rivanna Dam		7.2
6. Add Crest Gates on South Fork Rivanna Dam to Meet Full Deficit		9.9
7. Drawdown of Chris Greene Lake (5 ft. Drawdown)	Recreational lake – Public acceptance issues	0.5[3]
8. Use Beaver Creek Reservoir as Raw Water Source	Existing outlet structure modifications are required	2.6[4]
9. Use Available Storage at Lake Albemarle	Lake Albemarle not owned by RWSA – Land acquisition costs	0.7
10. Raise Ragged Mountain Reservoir Dam		9.1
11. Raise Ragged Mountain Reservoir & Convert to Pumped Storage Reservoir		9.9
12. Pumpback From Moores Creek WWTP to SFRR Tributary	Reuse issue – VDH concerns. Increase in safe yield assumes a 1:1 ratio between WWTP effluent and additional safe yield.	9.9
13. Construct New Dam at Buck Mountain		9.9
14. Construct New Pumped Storage Facility at Rocky Creek		9.9
15. James River Withdrawal	Includes raw water intake and piping only	9.9
16. Rivanna River Withdrawal	VHB reported safe yield increase. Gannett Fleming to re-evaluate	unpredictable
17. Regional Cooperation – Fluvanna/Louisa Counties – James River Withdrawal	Withdrawal in Fluvanna Co.	9.9
18. Expand Sugar Hollow Reservoir		7.3

Notes:

1. All increases in 2055 safe yield include a release requirement of the lesser of 8 MGD or inflow from SFRR.
2. Based on projected 2055 water demand of approximately 18.7 MGD, the total increase required in the 2055 safe yield is 9.9 MGD.
3. Assumes no release requirement at Chris Greene Lake or that release can be captured at the North Fork Rivanna River intake. Operating rules must be established.
4. Beaver Creek increase in Safe Yield is based on a demand of 1.1 MGD for Crozet. The reported increase in safe yield is the theoretical maximum attainable increase. The actual increase will be dependent on: (1) the actual operating policy; (2) resolution of equity issues reached by RWSA through the City and ACSA; and (3) determination of extent releases may be captured without streambed losses to SFRR.

The following sections are brief descriptions of the raw water components:

Component 1. No Action

For the No Action alternative, RWSA takes no action to secure additional raw water or restrict the use of treated water to their user base. The No Action alternative would therefore result in no new water source being developed. In light of projected RWSA needs, the No Action alternative is not a viable alternative. Under this alternative, mandatory water use restrictions will be required with increasing frequency and increased risk of system failure as reservoir storage continues to be depleted due to sedimentation. System failure during a severe drought would become probable and may also occur during dry periods that are not as severe. There is no safe yield benefit provided by the No Action alternative. The No-Action alternative would therefore result in the inability of the public water supply system to meet future water demand. Safe yield would fall to 8.8 MGD in 2055 assuming stream releases of 8 MGD or inflow to SFRR and 0.4 MGD at Sugar Hollow whenever the capacity exceeds 80% of total capacity, while demand would increase to create a net deficit of 9.9 MGD. Safe yield operating conditions include using water stored in Sugar Hollow Reservoir after SFRR is no longer spilling. During these conditions, water released from Sugar Hollow Reservoir is recaptured at SFRR. During periods of plentiful flow, Sugar Hollow water release continues downstream of SFRR.

Component 2. Dredge SFRR to Maintain 2002 Usable Storage Volume

This component consists of dredging the SFRR to remove variable amounts of sediment to increase safe yield. It has been estimated that a 40% reduction in the reservoir's capacity has occurred since construction (approximately 450 MG of useable storage lost). Future storage volume loss is based on historical information and estimated to be 15.14 MG of storage per year. At that rate, over 750 MG of water supply storage will be lost during the planning period (in addition to the 450 MG already lost). The effect of this sedimentation is included in the established 2055 water supply system deficit of 9.9 MGD. To gain the most safe yield increase from this component, all of the accumulated sediment would have to be removed and maintenance dredging performed to maintain that volume. Since complete sediment removal is unlikely, GF estimates approximately 60% of the currently accumulated sediment (approximately 450 MG of useable storage lost) can be removed and 100% of the future sediment accumulation in the SFRR (approximately 750 MG). This results in a net of approximately 85% removal of total accumulated sediment by 2055. This means that approximately 85% of the original useable storage volume (1250 MG) would be available. If this could be accomplished, an estimated 5.1 MGD increase in safe yield would be realized. Although a significant increase in safe yield might be realized, there are no combinations of additional low safe yield components (Lake Albemarle, Beaver Creek Reservoir Release, and Chris Greene Lake) that can be added to this option to add up to the established 9.9 MGD deficit. However, it may be possible to combine this component with other larger yield projects to develop a reasonable alternative. Feasibility and cost issues are uncertain. Prominent issues relate to: location of available land for low environmental impact disposal; costs and logistics of transportation of removed material; and potential market for the material. GF provided additional information to RWSA in a letter report dated December 31, 2003.

Component 3. Reduce Sediment Load into SFRR

Reducing the sediment load into the SFRR would decrease the sediment accumulation and slow the associated storage volume loss. To try to accomplish this, various methods might be employed including, for example, settling basins or detention ponds; vegetative filter strips and buffers; and land use controls such as erosion and sedimentation control or stormwater management. The safe yield increase achieved would be directly proportional to the reduction in the sediment loading in the SFRR that could be achieved. Based on the calculations performed during the safe yield study, there will be approximately 4 MGD of safe yield lost between 2003 and 2055 due to sedimentation in the SFRR. Thus, for example, if 75% of that sedimentation could be eliminated by the various methods described for this component, then there should only be about 1 MGD of safe yield lost by 2055, thus resulting in a net gain in safe yield of 3 MGD. Numerous reports have been published on controlling the sediment accumulation and there is no apparent solution that can easily be implemented. It is likely that a combination of facilities would be necessary including a large main-stem settling basin located at the upstream end of the reservoir. This would be an in-stream facility with a volume large enough to allow efficient sediment capture and sufficient operating space for sediment removal. The performance of such facilities is very difficult to predict with any degree of accuracy. Environmental impacts would be significant as a new pool would have to be created in a natural stream and wetland. Sediment disposal issues would also have to be addressed. Although this project could potentially provide an increase in safe yield, feasibility is highly uncertain and environmental effects would be substantial. Therefore, it is not recommend for further consideration.

Component 4. Add 4 ft. Crest Gates on South Fork Rivanna Dam

This component includes the installation of 4 ft. crest gates on the existing South Fork Rivanna Dam in order to increase the storage capacity of the SFRR. The crest gates would add approximately 590 MG of usable storage to the SFRR, making the safe yield increase in 2055 approximately 3.3 MGD.

Component 5. Add 8 ft. Crest Gates on South Fork Rivanna Dam

This component is similar to the previous component in that it will involve the installation of crest gates on the South Fork Rivanna Dam in order to increase storage capacity. The height of 8 ft. was selected because it was originally investigated in the February 2000 VHB/OBG report. The increase in safe yield associated with this component is 7.2 MGD. This component will not meet the deficit on its own and must be combined with other components. Based on preliminary evaluations, environmental impacts (submerged wetlands) increase dramatically when the crest gate height is increased above 4 feet; therefore, no alternatives are developed with this component.

Component 6. Add Crest Gates on South Fork Rivanna Dam to Meet Full Deficit

This component involves raising the spillway crest at the South Fork Rivanna Dam to a height required to meet the required raw water deficit in the year 2055. This component would result in the total satisfaction of the projected deficit, therefore increasing the 2055

safe yield by 9.9 MGD. Although this component will meet the deficit on its own environmental impacts increase dramatically when the crest gate height is increased above 4 feet; therefore, no alternatives are developed with this component.

Component 7. Drawdown of Chris Greene Lake (5 ft. Drawdown)

This component would utilize a 5 ft. drawdown of Chris Greene Lake to supplement flows in the North Fork Rivanna River, thus the released water would be captured at the river intake for the North Fork Rivanna WTP, or to be piped directly to the North Fork Rivanna WTP. Chris Greene Lake is used as a recreational body of water and its drawdown would involve periodic interference with that use. The increase in 2055 safe yield associated with this component is 0.5 MGD. This projected increase is significantly lower than the projected gains listed in the VHB/OBG report from February 2000, which predicted an increase in safe yield of 2.9 MGD. The higher potential increase reported by OBG associated with Chris Greene Lake is explained by several factors including:

- OBG performed its investigation prior to the 2002 drought which was more severe than the previous drought of record in the North Fork Rivanna River. If the OBG analysis were repeated using the 2002 data, a significantly lower increase would be expected.
- OBG assumed no limit on the amount of source water that could be taken from the river and provided a 1 MGD flowby. GF assumptions reflect current operating conditions that include a 2 MGD withdrawal limit and no flowby requirement.
- The 2.9 MGD increase includes supplemental flow from Chris Greene Lake and additional available flow in the river above the historical North Fork Rivanna River intake safe yield of 0.6 MGD (as determined by OBG). Most of the increase is attributable to additional available river flow.

GF evaluated the potential for increased withdrawal from the North Fork Rivanna River and determined that no increase in yield is available assuming modern flowby requirements. Accordingly the only increase in yield for this component is attributable directly to the storage in Chris Greene Lake.

Reportedly, Chris Green Lake was originally developed with federal funds. Any modifications may require governmental agency approval and alterations that impact existing recreation facility use may require replacement or repayment of some or all of the funds used to construct the Lake. Recreational activities are primarily swimming.

The yield of this component is minimal and it cannot be reasonably combined with any other component to satisfy the water supply deficit. Accordingly, it is not developed in any alternative.

Component 8. Use Beaver Creek Reservoir as Raw Water Source

Beaver Creek Reservoir is the main source of drinking water for the Crozet system, which is also owned and operated by RWSA. The water from the Beaver Creek Reservoir would be released to the South Fork Rivanna River and SFRR via Mechums River. The increase in 2055 safe yield to the Urban system associated with this

component is 2.6 MGD while accounting for the projected ultimate water demand of 1.1 MGD in the Crozet system. The actual increase could be less, depending on the operating conditions between RWSA's Crozet and Urban Service Area systems. A large commercial/industrial user or land development beyond currently anticipated ultimate demand could also influence the availability of the 2.6 MGD. Furthermore, this estimate assumes that all water released from Beaver Creek would be available for recapture and use at SFRR without streambed loss during droughts. Due to these uncertainties, it is highly desirable to develop additional RWSA Urban System water supply projects that do not require this component as a permanent part of the 2055 safe yield. However, this source of water could be used as an interim measure to allow time to develop financing, design, and construction of other projects, since the Crozet demands currently are well below the total Beaver Creek Reservoir yield. Potential stream bed losses could be evaluated during such temporary use.

Beaver Creek Reservoir is a multi-use reservoir originally constructed by United States Soil Conservation Service (SCS). The height of the dam reportedly allows for more flood storage than is required. GF has been unable thus far to confirm this report. Preliminary investigations indicate additional yield may be available for water supply if the normal pool can be raised and adequate flood control still provided. Detailed hydrologic and hydraulic calculations are necessary to confirm this availability. If, for example, 20% of the currently dedicated flood component of the dam were available for a pool increase, a potential increase of 0.5 MGD may be possible.

Reportedly, Beaver Creek Reservoir was originally developed with federal funds. Any modifications may require governmental agency approval and alterations that impact existing recreation facility use may require replacement or repayment of some or all of the funds used to construct the Lake. Recreational activities are primarily related to fishing.

Component 9. Use Available Storage at Lake Albemarle

This component involves the use of water from Lake Albemarle to supplement flows to the SFRR via the Mechums River. The dam was reportedly constructed in 1938 and is a 32-foot-high earth fill embankment with a concrete overflow spillway. If water from Lake Albemarle could be obtained by RWSA, there could be land acquisition costs and balancing of recreational land uses with water supply. The configuration and condition of the dam also indicate significant rehabilitation may be required at some time before the end of the planning horizon. Given the age and likely deficiencies, it is appropriate to assume that this dam must be replaced if incorporated into a water supply alternative. Poor water quality may also create water treatment challenges. The increase in 2055 safe yield due to implementation of this component would be 0.7 MGD. This component cannot reasonably be combined with any other component to satisfy the water supply deficit and is not developed in any alternative.

Component 10. Raise Ragged Mountain Reservoir Dam

This component would involve raising the Lower Ragged Mountain Dam approximately 50 ft. While it is possible to raise the dam by larger heights, increased water supply

vulnerability would exist due to the excessively long drawdown recovery time for reservoirs of this size at this location. Drawdown recovery time is the period of time that it would take for the reservoir to refill following a drought. This component would take the place of any rehabilitation work required for maintenance of the existing dam as provided for in the No Action component. The maximum increase in safe yield for this component is 9.1 MGD based upon an increase in dam height of 50'. The drawdown recovery time of the reservoir at this height can be as long as 7 years based on available data. A more severe drought in any one year or a combination of fairly severe droughts that occur close together could cause drawdown recovery time to exceed 7 years. If the reservoir is not full when the drought occurs, the calculated safe yield may not be available. Since pumped storage reduces the drawdown recovery time and reduces the height of the dam (and associated environmental impacts), no stand-alone alternative will be developed with this component. Lesser dam height increases will be developed and considered in combination with other water supply components. These combinations are developed in the alternatives presented in Section III.D. Any dam height increase over about 13 ft. will begin to submerge the Interstate Route 64 box culvert and at certain increased heights, submerge a portion of the I-64 highway embankment. Significant dam height increases will pond water on both sides of the embankment and completely submerge the box culvert. The highway embankment is about 140 ft. in height and the contemplated submergence should not affect the highway performance. Although it appears this option is technically feasible, additional investigations of the embankment to withstand submerged conditions during variable pool heights and VDOT discussions are necessary if this component is advanced.

Component 11. Raise Ragged Mountain Reservoir & Convert to Pumped Storage Reservoir

This component would involve raising the Lower Ragged Mountain Dam and converting the reservoir to a pumped storage facility. The conversion to pumped storage would be beneficial due to the comparatively small drainage area that feeds the reservoir. Even with pumped storage, the estimated drawdown recovery time of the reservoir is estimated to be up to 3 years. The increase in safe yield with an increase in dam height of 50 feet and a pump station on Mechums River would be 9.9 MGD.

Component 12. Pumpback from Moores Creek WWTP to SFRR Tributary

This component involves the indirect use of wastewater as a source of potable water. Indirect use of wastewater involves advanced treatment of sewage effluent from wastewater treatment plants to a high degree of purity, and blending the treated effluent with natural source water. Indirect potable reuse refers to projects that discharge recycled water to a water body before reuse. Direct potable reuse is the use of recycled water for drinking water purposes directly after treatment. While indirect potable reuse is currently practiced in numerous locations within the United States, direct potable reuse is currently not an accepted practice. This alternative would include upgrading the existing Moores Creek WWTP to enhance effluent quality. While the specific improvements to the WWTP are not known at this time, it is assumed that there will be a need for additional nutrient (nitrogen and phosphorus) removal as well as the possibility for additional tertiary treatment processes. In addition, pumping station(s) and pipeline(s) would need

to be constructed to convey the wastewater from the Moores Creek WWTP to a discharge point in the watershed upstream of the SFRR. At this preliminary stage of alternative development, a formal selection hasn't been made as to which body of water would receive the treated effluent. If this alternative were deemed promising, more research would be done. A selection would then be made based on various factors including the distance the treated effluent needs to be pumped to the discharge point; the distance between the discharge point and the SFRR (also considered in terms of travel time); and the average flow and other environmental characteristics of the receiving water body.

The February 2000 report produced by VHB and OBG suggested the reuse of treated water from the Moores Creek WWTP as a potential long-term water supply alternative. The project includes discharging the WWTP effluent into the Mechums River or Moormans River. The alternative would result in the WWTP effluent eventually entering the SFRR after flowing approximately 12.5 miles and 22 miles, respectively. Current GF inquires indicate the Virginia Department of Health (VDH) is most concerned about the degree of dilution and travel or residence time between the discharge location and the WTP intake. VDH also noted the lack of specific details regarding additional treatment beyond the addition of filters for the alternatives in the February 2000 report. Nutrient removal, disinfection, and other various advanced treatment processes would need to be accomplished if this alternative could be made acceptable to VDH.

The increase in the 2055 safe yield associated with this component could be as much as 12 MGD. It could also be developed at a lesser rate consistent with the 9.9 MGD water supply deficit. The alternative's safe yield benefit should be capable of satisfying the projected RWSA demand deficit based on the assumption that the water treated at Moores Creek WWTP will increase in proportion to the demand. Conceivably, the advanced treatment processes at Moores Creek WWTP would be considered operational only during severe drought events.

Component 13. Construct New Dam at Buck Mountain

This component involves the construction of a new dam that would supply water to the South Fork Rivanna WTP. Previously considered sites were considered and Buck Mountain site selected as representative of the new dam options. Within this site, the final location for the dam and reservoir could be refined to further reduce any adverse impacts. If this option emerges as favorable, additional new sites should be considered and the least environmentally damaging, practicable option selected. It is assumed that any new dam would be constructed to meet the entire 2055 deficit of 9.9 MGD.

Component 14. Construct New Pumped Storage Facility at Rocky Creek

This component involves the construction of a new pumped storage facility that would supply water to the South Fork Rivanna WTP. Several potential pumped storage sites were evaluated as part of this analysis and Rocky Creek was selected as the most favorable site based on currently available information. The storage facility would be located on Rocky Creek, with a pump station located on Moormans River or Doyles River. Water would be pumped from the Moormans River during high flows and stored in the reservoir located on Rocky Creek. During low flow periods water would be

released from the Rocky Creek reservoir into the Moormans River and on to the SFRR. It is assumed that any new pumped storage facility would be constructed to meet the entire deficit of 9.9 MGD.

Component 15. James River Withdrawal

In the VHB report, this component consists of constructing a raw water intake in the James River near Scottsville and pumping facilities to deliver the water to the RWSA Urban Service Area. This component assumes the continued use of the SFRR and water treatment plant to provide adequate quantities of drinking water to the service area. Previous studies discussing the use of the James River as a raw water source were reviewed. Two reports were identified. A Camp Dresser and McKee (CDM) report was completed in 1977 and the VHB report in 2000. Both confirmed feasibility and estimated cost. The CDM approach included phasing. VHB did not. The 2000 VHB report estimated capital cost at $72 million. Construction cost was comparatively high and reliability questions were raised.

The VHB/OBG report refers to a report produced in 1988 by the Virginia Water Control Board entitled "James River Water Supply Plan". In that report, the 1Q30 flow in the James River is reported at approximately 340 MGD. Therefore, it can be assumed that the James River will provide adequate quantities of water during drought conditions, which makes this a viable alternative from a water supply perspective. The increase in 2055 safe yield associated with this component is 9.9 MGD.

Gannett Fleming develops this component as a stand-alone option and in combination with other reasonable components. A WTP would be included near Scottsville so that a treated water transmission main could be installed through the center of southern Albemarle County, thus making public water supply available to an area that is currently unserved. Phasing options will be developed.

Component 16. Rivanna River Withdrawal

This component was included to explore whether there might be some additional water available in the Rivanna River for withdrawal near the Glenmore Country Club located a little over 5 miles downstream of the Moores Creek WWTP. The VHB report indicated a safe yield increase is possible based primarily on the WWTP discharge. GF estimates the regulatory requirement for flow-by on the Rivanna River at this location will be approximately 20% of the average flow. Applying this restriction, there is no flow available at this location during the drought of record. There may actually be flow primarily comprised of WWTP discharge since natural flow is minimal during that period. Even if a withdrawal were approved, the quality of the water would be comparable to the water reuse option dismissed earlier in this investigation. Therefore no alternatives will be developed with this water supply component.

Component 17. Regional Cooperation – Fluvanna/Louisa Counties – James River Withdrawal

This component is similar to the component described in Component #15, but instead of being a stand-alone option for RWSA, it includes regional cooperation with Fluvanna and

Louisa Counties. This could be accomplished in several ways including: the project described in Component # 15 above could be expanded to include the water demands for Fluvanna and Louisa Counties; the currently planned Fluvanna/Louis Counties project could be expanded to include the RWSA needs; or an alternate project could be developed such as an intake and WTP at Scottsville that would serve all needs and finished water lines serving each project run separately. Expanded projects would likely result in a larger overall project, but some of the upfront construction costs as well as the operating and maintenance costs would be shared with the other government entities. It can be assumed that there is enough water available for withdrawal from the James River to satisfy the projected water demands of the groups involved, thus the increase in safe yield for the RWSA Urban Service Area would be at least 9.9 MGD. Additional discussion is included with formulated alternatives.

Component 18. Expand Sugar Hollow Reservoir

This component considers large raises in the dam height at Sugar Hollow. Dam height raises over about 50 feet result in a reservoir that is oversized for the contributing watershed. That is to say that the additional safe yield gained per gallon of additional storage added goes down dramatically above that threshold. Large increases in safe yield are possible but drawdown recovery times for each configuration selected in the water supply alternative should be considered. Drawdown recovery is not likely to be critical with the large contributing watershed. Preliminary estimates indicate the maximum drawdown recovery time for a stand-alone option based on the current data period would be approximately 2 years. This component should be sized based on specific need in combination with other components to satisfy the water deficit. Federal Park Lands may also be impacted by dam height increases of 20-30 ft. or more.

C. Treatment Plant Components

In addition to the need for increased safe yield of the Urban Service Area system, it is also necessary to properly revise, expand, and distribute the water treatment capacity of the system in order to treat the raw water at the locations it will be available. Each water supply alternative requires unique treatment conditions. For example, the existing Observatory WTP and possibly the Scottsville WTP would no longer be needed if a James River withdrawal option were fully implemented. Over time the conditions within each alternative will also change. For example, if Ragged Mountain is significantly raised, over time, a greater portion of the system safe yield will be provided by Ragged Mountain since SFRR will accumulate more sediment and lose storage. The Observatory WTP must be expanded to accommodate these conditions. There will also be operational variations for optimizing process efficiencies during a severe drought. The Urban Service Area currently utilizes three (3) water treatment plants (WTPs): South Fork Rivanna WTP, North Fork Rivanna WTP, and Observatory WTP. The three treatment plants have capacities of 12 MGD, 2 MGD, and 7.7 MGD, respectively, which results in an overall system treatment capacity of 21.7 MGD. As discussed in Section II, the 18.7 MGD projected water demand in the year 2055 is the average daily demand. Considering a historical RWSA peaking factor of about 1.5, the peak daily demand in the year 2055 is projected to be 28.1 MGD. If an alternative contains only one WTP, it can be sized at

28.1 MGD. However, alternatives containing more than one WTP may require additional capacity to allow for the operational issues discussed above. Since the safe yield model does not currently allow for predicting flow from each component in the system, engineering judgment is applied to estimate required WTP capacities.

Based on the number of WTPs currently in the system, there are few options for increasing the water treatment capacity. Table 3-2 is a summary of the various treatment plant options available for consideration. It should also be noted that WTP construction can be done in a phasing scenario, thus allowing the overall project costs associated with an alternative to be spread over the course of many years. The phasing approach is discussed in further detail in Section III.D.

Table 3-2: Potential Water Treatment Options

Proposed Action	**Description**
No Action	No action taken – Observatory WTP must be rehabilitated
Expand Observatory WTP with No Added Basins (structures)	Expand Observatory WTP through process efficiency upgrades
Expand Observatory WTP	Expansion of WTP by addition of new basins to increase capacity
Expand South Fork Rivanna WTP	Expand South Fork Rivanna WTP to increase capacity
Close Observatory WTP and Construct New WTP	New WTP to satisfy projected water demands
Expand North Fork Rivanna WTP	Expand North Fork Rivanna WTP to increase capacity

Notes:

1. Projected water demand for the RWSA Urban Service area in 2025: 14.5 MGD/21.8 MGD (Average Daily Flow (ADF)/Peak Daily Flow (PDF)).
2. Projected water demand for the RWSA Urban Service area in 2055: 18.7 MGD/28.1 MGD (ADF/PDF)

As seen in Table 3-2, the Observatory WTP is in need of rehabilitation and will require extensive work in order to keep it operational. Therefore, any alternative developed must address the possibilities of rehabilitation, expansion, or closing the Observatory WTP. Also discussed in Table 3-2 is the possibility of expanding the North Fork Rivanna WTP. This option was deemed impractical due to the lack of additional water to be withdrawn from the intake structure currently in use, as seen in Table 3-1, Component #16.

D. Alternatives Formulated to Meet 2055 Demand

Eighteen (18) water supply components are identified and discussed in Section III.B. Eight (8) of those components are not developed in the alternatives below. The reasons for their dismissal are discussed in that section. The remaining ten (10) water supply components are included in alternatives that satisfy the 2055 demand deficit.

Alternatives are formed by a logical step process. The first step is to identify feasible water supply components that are considered "stand alone" options, meaning that they can provide the required 9.9 MGD of additional safe yield on their own. The second step is to identify reasonable combinations of two feasible water supply components that can provide the required additional safe yield. The third step is to identify reasonable combinations of three feasible water supply components that can provide the required additional safe yield. Additional steps would be to identify combinations of more components.

In identifying combinations of two feasible water supply components that can provide the required additional safe yield, only one expanded or new reservoir is included, as multiple new reservoirs would only increase environmental impacts and costs. Further, relatively low environmental impact and low cost components should be combined with larger components. For this reason, the Beaver Creek Reservoir component was selected for combination with other components to reduce the overall size of facilities and allow additional combinations.

The logic to identify combinations of three components is similar to that of two components. Any scenario should include only one new or raised dam, excluding crest gates, and two other relatively low environmental impact and low cost components. Based on the components identified, the logical combinations of three components included Beaver Creek Reservoir, 4-foot crest gates on the South Fork Rivanna Reservoir, and another major project to make up the remaining required safe yield.

On a case by case basis, additional discussion is included with the component discussions in Section III.B. and with the alternatives summaries below.

All water supply alternatives are then combined with appropriate water treatment components that meet the associated peak day demands.

The following is a brief description of the alternatives developed for this report.

1. No Action

This option includes only the rehabilitation and maintenance of the current raw water supply and water treatment configuration. The Observatory WTP would need to be rehabilitated to maintain its current capacity of 7.7 MGD; the Ragged Mountain Dam would need to be rehabilitated; and the pipeline connecting Ragged Mountain Dam and the Sugar Hollow Reservoir would need to be replaced to maintain their existing capabilities. It is assumed that the replacement pipeline will be placed in the same right-

of-way as the existing pipeline and that the costs associated with the demolition of the existing pipeline includes disposal costs.

2. Construct New Dam at Buck Mountain

This option includes the construction of a new dam to satisfy the 9.9 MGD deficit between the projected safe yield and water demand in 2055. The dam would be constructed approximately 1.5 miles upstream of the confluence with the South Fork Rivanna River. The dam would be constructed with an approximate mean water surface elevation of 456 feet. This option would result in the need for expansion of the South Fork Rivanna WTP to a total treatment capacity of 24 MGD. This option also requires that Observatory WTP be rehabilitated to its current capacity of 7.7 MGD in order to handle the projected water demands. The Ragged Mountain Dam would need to be rehabilitated and the pipeline connecting Ragged Mountain Dam and Sugar Hollow Reservoir would also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured. The cost associated with the demolition of the existing pipeline includes disposal costs. Also associated with this alternative is the need to replace roadways and bridges affected by the new reservoir.

3. Construct New Dam at Buck Mountain + Beaver Creek Reservoir

This option includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the South Fork Rivanna River and the construction of a new dam at Buck Mountain. The mean surface water elevation for this storage volume is approximately 452 feet. These two measures combined will result in an increase in 2055 safe yield of 9.9 MGD. This option requires that the Observatory WTP be rehabilitated to its current capacity of 7.7 MGD and requires an initial expansion of the South Fork Rivanna WTP to 18 MGD followed by a later expansion to 24 MGD in order to handle the projected water demands. The Ragged Mountain Dam will need to be rehabilitated and the pipeline connecting it to the Sugar Hollow Reservoir will also need to be replaced. It is assumed that the replacement pipeline will be placed along a similar alignment as the existing pipeline and right of way secured. The costs associated with the demolition of the existing pipeline include disposal cost. Also associated with this alternative is the need to replace roadways and bridges affected by the new reservoir.

4. Construct New Pumped Storage Facility at Rocky Creek

This option includes the construction of a new storage facility on Rocky Creek with an anticipated mean water surface elevation of 796 feet. A pump station would be located on the Doyles River or Moormans River and it is assumed that electrical services will need to be extended to the new pump station. In addition to the pump station, an intake structure will need to be constructed, as well as a pipeline to convey the raw water to the pumped storage facility. It is also anticipated that raw water from the new facility will be discharged upstream of the SFRR and treated at the South Fork Rivanna WTP. This option requires that the Observatory WTP be rehabilitated to its current capacity of 7.7 MGD and that the South Fork Rivanna WTP expanded to 24 MGD in order to handle the projected water demands. The Ragged Mountain Dam would need to be rehabilitated and the pipeline connecting Ragged Mountain Dam and Sugar Hollow Reservoir would also

need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and that the cost associated with the demolition of the existing pipeline includes disposal cost.

5. Construct New Pumped Storage Facility at Rocky Creek + Beaver Creek Reservoir

This option includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR and the construction of a new storage facility on Rocky Creek and a pump station located on Doyles River or Moormans River, which will require electrical service. A pipeline will connect the new pump station to the pumped storage facility. It is anticipated that the mean water surface elevation for the Rocky Creek reservoir would be 786 feet. Raw water from the new facility would be discharged to the SFRR via the Moormans River and treated at the South Fork Rivanna WTP. This option requires that the Observatory WTP be rehabilitated to its current capacity of 7.7 MGD and that the South Fork Rivanna WTP is expanded to 24 MGD in order to handle the projected water demands. The Ragged Mountain Dam and pipeline connecting it to the Sugar Hollow Reservoir would also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost.

6. James River Intake

This option includes the construction of a raw water intake structure and new WTP in order to treat water taken from the James River. This option anticipates an intake located along the James River near Scottsville, a new water treatment plant located near Scottsville, and finished water pump stations and pipeline located along a highway route to connect to existing distribution system in the Urban Service Area. The new WTP would have a capacity of 10 MGD until an expansion to 20 MGD is needed to meet the increasing demands. This option assumes that the Ragged Mountain Dam, the pipeline connecting the Sugar Hollow Reservoir to the Ragged Mountain Reservoir, and Observatory WTP will eventually be taken out of service by RWSA and the South Fork Rivanna WTP will be kept at its current capacity of 12 MGD. However, due to the length of time it is estimated that the new WTP and pipeline from the James River will take to be completed, it will be necessary to rehabilitate Ragged Mountain Dam so that it will temporarily remain in service. It will also be necessary to maintain Observatory WTP and the pipeline from Sugar Hollow to Ragged Mountain on an interim basis. Once the new WTP is operational, the Observatory WTP will be demolished. The Scottsville WTP may also be decommissioned and included with this project if feasible. This work includes the removal of structures to 3 feet below grade and backfilling. The cost estimate assumes no contaminated soils exist or hazardous materials cleanup is required. The ground storage tank located at the Observatory WTP will remain in service, but the pipeline connecting the WTP to the tank will be capped thus allowing in the tank to "float" on the distribution system. Ragged Mountain Dam will remain in order to provide a recreational body of water, but will no longer be used as a raw water source once the James River water system is fully operational. The cost estimate includes an easement along one-half of the pipeline length.

7. James River Intake + Beaver Creek Reservoir

This option includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR and the construction of a raw water intake structure and new WTP in order to treat water taken from the James River. This option anticipates an intake located along the James River near Scottsville, a new water treatment plant located near Scottsville, and finished water pump stations and pipelines located along a highway route to connect to existing pipelines in the Urban Service area. The new WTP would have a capacity of 9 MGD until an expansion to 15 MGD is needed to meet the increasing demands. This option also requires an expansion of the South Fork Rivanna WTP to 15 MGD. This option assumes that the Ragged Mountain Dam, the pipeline connecting the Sugar Hollow Reservoir to the Ragged Mountain Reservoir, and Observatory WTP will eventually be taken out of service. The Scottsville WTP may also be decommissioned and included with this project if feasible. However, due to the length of time it is estimated that the new WTP and pipeline from the James River will take to be completed, it will be necessary to rehabilitate Ragged Mountain Dam so that it will temporarily remain in service. It will also be necessary to maintain Observatory WTP and the pipeline from Sugar Hollow to Ragged Mountain on an interim basis. Once the new WTP is operational, the Observatory WTP will be demolished. This work includes the removal of structures to 3 feet below grade and backfilling. The ground storage tank located at the Observatory WTP will remain in service, but the pipeline connecting the WTP to the tank will be capped thus allowing the tank to "float" on the distribution system. Ragged Mountain Dam will remain in order to provide a recreational body of water, but will no longer be used as a raw water source once the James River water system is fully operational.

8. Regional Cooperation with Fluvanna County and/or Louisa County

This option involves a partnership with Fluvanna and Louisa Counties, hereinafter referred to as the Fluvanna project, in constructing and operating a James River raw water source and water treatment plant. At this time, a permit has been sought by Fluvanna with a maximum withdrawal rate of 6 MGD. Several options were evaluated by Fluvanna. Option 1 is the preferred alternative. The raw water intake is tentatively planned to be located immediately downstream of the Route 15 bridge at Bremo Bluff. An existing 24-inch pipeline owned by East Coast Transport Inc. (ECTI) extends from the intake site to a location west-central Fluvanna County. Fluvanna plans to share this pipeline with ECTI as a raw water source to a location near the intersection of routes 649 and 6. A WTP would be constructed at that location. Treated water would be delivered along Route 15 north and on to the women's prison near Zion Crossroads, which is approximately 3 miles from the RWSA Urban Service Area. If RWSA were to enter into an agreement with Fluvanna and Louisa Counties, the pending project and permit application would need to be revised in order to supply the amount of raw water required for all three entities. Although Fluvanna has identified their preferred project, a joint project with RWSA would require additional reviews. Several potential configurations are identified in the component summary in Section III.B. Since it is likely that evaluation of this option and negotiation of a successful joint project would take time, this option should assume that the Ragged Mountain Dam and Observatory WTP will be

kept in service and the South Fork Rivanna WTP will be kept at its current capacity of 12 MGD.

9. Regional Cooperation with Fluvanna County and/or Louisa County + Beaver Creek Reservoir

This alternative is similar to that discussed in Alternative #8 with the exception that the raw water withdrawal rate could be lowered by approximately 2.6 MGD based on the water being supplied to the RWSA Urban Service Area via the Beaver Creek Reservoir. This option involves a partnership with Fluvanna and Louisa Counties in constructing and operating a James River raw water source and water treatment plant. At this time, a permit has been sought by Fluvanna with a maximum withdrawal rate of 6 MGD. Several options were evaluated by Fluvanna. Option 1 is the preferred alternative. The raw water intake is tentatively planned to be located immediately downstream of the Route 15 bridge at Bremo Bluff. An existing 24-inch pipeline owned by ECTI extends from the intake site to a location in west-central Fluvanna County. Fluvanna plans to share this pipeline with ECTI as a raw water source to a location near the intersection of routes 649 and 6. A WTP would be constructed at that location. Treated water would be delivered along Route 15 north and on to the women's prison near Zion Crossroads, which is approximately 3 miles from the RWSA Urban Service Area. If RWSA were to enter into an agreement with Fluvanna and Louisa Counties, the pending permit application would need to be revised in order to supply the amount of raw water required for all three entities. Although Fluvanna has identified their preferred project, a joint project with RWSA requires additional reviews. Several potential configurations are identified in the component summary in Section III.B. Since it is likely that evaluation of this option and negotiation of a successful joint project would take time, this option should assume that the Ragged Mountain Dam and Observatory WTP will be kept in service and the South Fork Rivanna WTP will be kept at its current capacity of 12 MGD.

10. Raise Ragged Mountain Dam with Pumped Storage

This option would raise the water elevation in the Lower Ragged Mountain reservoir by 43 feet to a pool elevation of 684 feet in order to alleviate the 9.9 MGD deficit between the projected safe yield and water demand in 2055. The pumped storage facility will be supplied with raw water from the existing pump station location on the Mechums River. The pump station will need to be rehabilitated and electrical service will need to be extended out to the pump station. There is a current pumping restriction placed on the Mechums Pump Station which states withdrawals from the river can be made up to a rate of 2 MGD when the river is flowing at a rate of 33 cubic feet per second (cfs) or more. The withdrawal restriction is increased to 4 MGD when the river is flowing at a rate of 66 cfs or more. The maximum estimated drawdown recovery time based on the available data is 3 years. Raising the Ragged Mountain Reservoir will result in the inundation of the existing culvert located under I-64 and the I-64 embankment. Therefore, this alternative includes provisions for providing embankment stabilization, a new culvert, and an access road from I-64 to the portion of the Ragged Mountain Reservoir that will otherwise be isolated. As part of this option, the Observatory WTP rehabilitation and the Ragged Mountain Dam replacement would both have to be implemented immediately so that they remain in working order. The pipeline connecting Ragged Mountain Reservoir

to the Sugar Hollow reservoir would also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. In time, the Observatory WTP would be expanded to 10 MGD and then to 18 MGD in order to provide adequate flows of treated water to meet increasing demands. Under this option, the South Fork Rivanna WTP would remain at its current capacity of 12 MGD.

11. Raise Ragged Mountain Dam + Beaver Creek Reservoir

This option includes rehabilitation and raising of Lower Ragged Mountain Dam by 42 feet to a pool elevation of approximately 683 feet by replacing Lower Ragged Mountain with a new dam and includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR. The maximum estimated drawdown recovery time based on available data is 5.5 years. Raising the Ragged Mountain Reservoir will result in the inundation of the existing culvert located under I-64 and the I-64 embankment. Therefore, this alternative includes provisions for providing embankment stabilization, a new culvert, and an access road from I-64 to the portion of the Ragged Mountain Reservoir that will otherwise be isolated. This option would necessitate replacing the pipeline between Sugar Hollow Reservoir and Ragged Mountain Reservoir. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. This option requires an expansion of the South Fork Rivanna WTP to a capacity of 15 MGD. Also required is the rehabilitation of Observatory WTP to its current capacity of 7.7 MGD followed by expansions to 10 MGD and 15 MGD when deemed necessary. Also associated with this alternative is the need for roadway replacements due to the increase in pool elevation at the Ragged Mountain Reservoir.

12. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir

This option includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR and requires an increase in the water elevation in the Lower Ragged Mountain reservoir of 37 feet to a pool elevation of approximately 678 feet and refurbishing a pump station located on the Mechums River. There is a current pumping restriction placed on the Mechums Pump Station which states withdrawals from the river can be made up to a rate of 2 MGD when the river is flowing at a rate of 33 cubic feet per second (cfs)or more. The withdrawal restriction is increased to 4 MGD when the river is flowing at a rate 66 cfs or more. The maximum estimated drawdown recovery time based on available data is 2 years. Raising the Ragged Mountain Reservoir will result in the inundation of the existing culvert located under I-64 and the I-64 embankment. Therefore, this alternative includes provisions for providing embankment stabilization, a new culvert, and an access road from I-64 to the portion of the Ragged Mountain Reservoir that will otherwise be isolated. As part of this option, the Observatory WTP and the Ragged Mountain Dam will both have to be rehabilitated immediately so that they remain in working order. The pipeline connecting Ragged Mountain Reservoir to the Sugar Hollow Reservoir will need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing

pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. In time, the Observatory WTP will be expanded to 10 MGD and then to 15 MGD in order to provide adequate flows of treated water due to increasing demands. Under this option, the South Fork Rivanna WTP will require an expansion to 15 MGD.

13. Raise Ragged Mountain + Beaver Creek Reservoir + 4 ft. Crest Gates on SFRR

This option includes installing a crest gate or bladder at the South Fork Rivanna Dam that is 4-feet high, implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR, and requires raising the water elevation in the Lower Ragged Mountain reservoir by 28 feet. The maximum estimated drawdown recovery time based on available data is 6 years. Raising the Ragged Mountain Reservoir will result in the inundation of the existing culvert located under I-64 and the I-64 embankment. Therefore, this alternative includes provisions for providing embankment stabilization, a new culvert, and an access road from I-64 to the portion of the Ragged Mountain Reservoir that will otherwise be isolated. As part of this option, the Observatory WTP and the Ragged Mountain Dam would both have to be rehabilitated immediately so that they remain in working order. The pipeline connecting Ragged Mountain Reservoir to the Sugar Hollow Reservoir would need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. In time, the Observatory WTP would be expanded to 12 MGD in order to provide adequate flows of treated water to meet increasing demands. South Fork Rivanna WTP would require an expansion to 18 MGD. Also included in this alternative is the need to relocate some roadways and one bridge due the increase in the pool elevation at the SFRR.

14. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir + 4 foot Crest Gates on SFRR

This option includes installing a crest gate or bladder at the South Fork Rivanna Dam that is 4-feet high, implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR raising the water elevation in the Lower Ragged Mountain reservoir 27 feet, and rehabilitating the pump station on the Mechums River. There is a current pumping restriction placed on the Mechums Pump Station which states withdrawals from the river can be made up to a rate of 2 MGD when the river is flowing at a rate of 33 cubic feet per second (cfs) or more. The withdrawal restriction is increased to 4 MGD when the river is flowing at a rate equal to or greater than 66 cfs or more. The maximum estimated drawdown recovery time based on available data is 2 years. Raising the Ragged Mountain Reservoir will result in the inundation of the existing culvert located under I-64 and the I-64 embankment. Therefore, this alternative includes provisions for providing embankment stabilization, a new culvert, and an access road from I-64 to the portion of the Ragged Mountain Reservoir that will otherwise be isolated. As part of this option, Observatory WTP and Ragged Mountain Dam will both have to be rehabilitated immediately so that they remain in working order. The pipeline connecting Ragged Mountain reservoir to the Sugar Hollow reservoir will need to be replaced. GF assumes that the replacement pipeline would be placed along a similar

alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. In time, the Observatory WTP would be expanded to 12 MGD in order to provide adequate flows of treated water to meet increasing demands. South Fork Rivanna WTP would require an expansion to 18 MGD. Also included in this alternative is the need to relocate some roadways and one bridge due the increase in the pool elevation at the SFRR.

15. Raise SFRR

This option consists of raising the SFRR 11 feet to a pool elevation of approximately 393 feet with a crest gate or bladder in order to satisfy the need for additional raw water storage and safe yield in 2055. Included in this option is the expansion of the South Fork Rivanna WTP to a capacity of 24 MGD and the rehabilitation of the Observatory WTP to its current capacity of 7.7 MGD. The Ragged Mountain Dam and pipeline connecting the Ragged Mountain Reservoir to the Sugar Hollow Reservoir would also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. Associated with this alternative is the need to replace some roadways and bridges that would be affected by increasing the SFRR elevation by 11 feet.

16. Raise SFRR + Beaver Creek Reservoir

This option includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR Reservoir and raising the SFRR 9-feet to a pool elevation of 391 feet with a crest gate or bladder in order to satisfy the need for additional raw water storage and safe yield in 2055. Included in this option is the expansion of the South Fork Rivanna WTP to an interim capacity of 18 MGD and ultimate capacity of 24 MGD. Observatory WTP would require rehabilitation to its current capacity of 7.7 MGD. The Ragged Mountain Dam and pipeline connecting Ragged Mountain Reservoir to the Sugar Hollow Reservoir will also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. Also associated with this alternative is the need to replace some roadways and bridges affected by a raise in the SFRR pool elevation.

17. Pumpback from Moores Creek WWTP to SFRR Tributary

This option consists of pumping highly treated effluent from Moores Creek WWTP to either Ivy Creek or Mechums River, both of which are tributaries of the South Fork Rivanna River. This alternative assumes that there is a need for advanced wastewater treatment at the Moores Creek WWTP which will produce an effluent that is acceptable for this use. A pump station and pipeline would need to be installed in order to convey the WWTP effluent to the receiving body of water. The South Fork Rivanna WTP would need to be expanded to a capacity of 24 MGD, while the Observatory WTP would need to be rehabilitated to maintain its current capacity of 7.7 MGD and the Ragged Mountain Dam would need repairs in order to stay in operation. The pipeline connecting the Ragged Mountain Reservoir to the Sugar Hollow Reservoir would also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar

alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost.

18. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir

This option includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR and pumping highly treated effluent from Moores Creek WWTP to either Ivy Creek or Mechums River, both of which are tributaries of the SFRR. This alternative assumes that there is a need for advanced wastewater treatment at the Moores Creek WWTP which will produce an effluent that is acceptable for this use. A pump station and pipeline would need to be installed in order to convey the WWTP effluent to the receiving body of water. South Fork Rivanna WTP will need to be expanded to an interim capacity of 18 MGD and an ultimate capacity of 24 MGD. Observatory WTP will need to be rehabilitated to its current capacity of 7.7 MGD and the Ragged Mountain Dam will need repairs in order to stay in operation. The pipeline connecting the Ragged Mountain reservoir to the Sugar Hollow reservoir will also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost.

19. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir + 4 foot Crest Gates on SFRR

This option includes installing a crest gate or bladder at the South Fork Rivanna Dam that is 4-feet high, implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR, and pumping highly treated effluent from the Moores Creek WWTP to either Ivy Creek or Mechums River, both of which are tributaries of the South Fork Rivanna River. This alternative assumes that there is a need for advanced wastewater treatment at the Moores Creek WWTP which will produce an effluent that is acceptable for this use. A pump station and pipeline would need to be installed in order to convey the WWTP effluent to the receiving body of water. The South Fork Rivanna WTP would need to be expanded to an interim capacity of 18 MGD and an ultimate capacity of 24 MGD. Observatory WTP would need to be rehabilitated to its current capacity of 7.7 MGD and the Ragged Mountain Dam would need repairs in order to stay in operation. The pipeline connecting the Ragged Mountain reservoir to the Sugar Hollow reservoir would also need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. Also included in this alternative is the need to relocate some roadways and one bridge due the increase in the pool elevation at the SFRR.

20. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir

This option includes raising Sugar Hollow Reservoir by 66 feet to a pool elevation of 1041 feet by replacing the existing Sugar Hollow dam with a new dam slightly downstream from the existing dam and includes implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR. The maximum estimated drawdown recovery time based on available data is 2 years. The expansion of Sugar

Hollow reservoir would necessitate replacement of the existing pipeline between the Sugar Hollow and Ragged Mountain Reservoirs, rehabilitation of Observatory WTP at 7.7 MGD and expansion of the South Fork Rivanna WTP to an interim capacity of 18 MGD and an ultimate capacity of 24 MGD. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. Ragged Mountain Dam would also have to be rehabilitated.

21. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir + 4 foot Crest Gates on SFRR

This option includes installing a crest gate or bladder at the South Fork Rivanna Dam that is 4-feet high, implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the South Fork Rivanna River, and raising Sugar Hollow Reservoir by 46 feet by replacing the existing Sugar Hollow dam with a new dam slightly downstream from the existing dam. The maximum estimated drawdown recovery time based on available data is less than 2 years. The expansion of Sugar Hollow reservoir would necessitate replacement of the existing pipeline between Sugar Hollow and Ragged Mountain Reservoirs with a larger diameter pipe, rehabilitation of the Observatory WTP at 7.7 MGD and expansion of the South Fork Rivanna WTP to an interim capacity of 18 MGD and an ultimate capacity of 24 MGD. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of the existing pipeline includes disposal cost. Ragged Mountain Dam would also have to be rehabilitated. Also included in this alternative is the need to relocate some roadways and one bridge due the increase in the pool elevation at the SFRR.

22. Dredge SFRR + Beaver Creek Reservoir + Add 4 foot Crest Gates on SFRR

This alternative includes dredging the SFRR to maintain a useable storage volume of 1070 MG, or about 85% of the original useable storage volume (1250 MG), by the year 2055. Also included in the alternative is the installation of a crest gate or bladder at the South Fork Rivanna Dam that is 4-feet high, and implementing outlet controls at Beaver Creek Reservoir to allow the flow to discharge to the SFRR. Immediate implementation of the 4' crest gates on SFRR and the addition of raw water from the Beaver Creek Reservoir will provide enough additional safe yield to potentially delay additional improvements until the year 2034. To assure safe yield is maintained throughout the planning period, dredging would start by about 2020. Approximately 30 MG of sediment will need to be removed from the SFRR annually from 2020 through 2055 to meet the desired goal. It should be noted that after the year 2055, annual dredging of approximately 15 MG of sediment must continue in order to maintain the useable storage volume. A capitalized cost associated with the additional dredging after year 2055 has been estimated at $10,500,000. As part of this alternative, the Observatory WTP and the Ragged Mountain Dam would both have to be rehabilitated immediately so that they remain in working order at their current capacities. The pipeline connecting Ragged Mountain Reservoir to the Sugar Hollow Reservoir would need to be replaced. GF assumes that the replacement pipeline would be placed along a similar alignment as the existing pipeline and right of way secured and the cost associated with the demolition of

the existing pipeline includes disposal cost. The South Fork Rivanna WTP would require an expansion to 24 MGD. Also included in this alternative is the need to relocate some roadways and one bridge due the increase in the pool elevation at the SFRR.

Table 3-3 is a summary of the 22 alternatives developed by GF and designates what the resulting ultimate (year 2055) WTP capacities will be at the various WTPs in the system. This table illustrates where the additional water treatment capacities will be located, thus indicating if there needs to be a plant rehabilitation, expansion, or new construction.

Table 3-3: Ultimate (2055) Required Plant Capacity by Water Supply Option

Water Supply/Treatment Alternatives	South Fork Rivanna WTP (MGD)	North Fork Rivanna WTP (MGD)	Observatory WTP (MGD)	New WTP (MGD)
1. No Action	12	2	7.7	0
2. Construct New Dam at Buck Mountain	24	2	7.7	0
3. Construct New Dam at Buck Mountain + Beaver Creek Reservoir	24	2	7.7	0
4. Construct New Pumped Storage Facility at Rocky Creek	24	2	7.7	0
5. Construct New Pumped Storage Facility at Rocky Creek + Beaver Creek Reservoir	24	2	7.7	0
6. James River Intake	12	2	0	20
7. James River Intake + Beaver Creek Reservoir	15	2	0	15
8. Regional Cooperation with Fluvanna/Louisa Counties	12	2	7.7	15
9. Regional Cooperation with Fluvanna/Louisa Counties + Beaver Creek Reservoir	15	2	7.7	12
10. Raise Ragged Mountain Dam with Pumped Storage	12	2	18	0
11. Raise Ragged Mountain Dam + Beaver Creek Reservoir	15	2	15	0
12. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir	15	2	15	0
13. Raise Ragged Mountain Dam + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	18	2	12	0
14. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	18	2	12	0
15. Raise SFRR high enough to provide all required additional storage	24	2	7.7	0
16. Raise SFRR + Beaver Creek Reservoir	24	2	7.7	0
17. Pumpback from Moores Creek WWTP to SFRR Tributary	24	2	7.7	0
18. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir	24	2	7.7	0
19. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	24	2	7.7	0
20. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir	24	2	7.7	0
21. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	24	2	7.7	0
22. Dredge SFRR + Beaver Creek reservoir + Add 4 ft. Crest Gates on SFRR	24	2	7.7	0

Section IV – Alternatives Analysis Methodology

After formulating the alternatives, it is necessary to evaluate them based on criteria that will identify the most practicable and least environmentally damaging alternative. This section of the report summarizes the initial evaluation to develop a "short list" of alternatives for more detailed analysis. The following sections will discuss the criteria utilized for the initial evaluation of the twenty-two (22) alternatives.

A. Estimated Total Project Cost

An alternative's cost is a relevant and important consideration in assessing whether a project is feasible and practical. The following is a list of the cost estimating items identified for the alternatives, as well as a brief description of each and a listing of the applicable alternatives. All costs are capital costs and the electrical costs for various alternatives consider pumping water from the raw water source to a connection point in the Urban Service Area.

1. Land Acquisition

a. Description/Methodology: Determined by identifying parcels affected by alternative and the assessed value of the parcels as listed on the Albemarle County website. Cost estimated based upon Albemarle County tax assessment data with an adjustment factor of 1.5 to account for the current market conditions in Albemarle County. Land acquisition costs estimated for alternatives also includes any building values if the building is located in the alternative's projected land areas.

b. Alternatives Applied To: Alternatives 2, 3, 5, 7, 9, 10, 12, 14, 16, 17, 18, 19, 20, and 21.

2. Easements

a. Description/Methodology: For any alternative that requires an extensive pipeline, it has been assumed that half of the pipeline length would be outside of existing right-of-ways, therefore requiring the purchasing of easements. The easement costs have been estimated at $5/linear foot of easement required.

b. Alternatives Applied To: Alternatives 4, 5, 6, 7, 8, 9, 10, 12, 14, 17, 18, and 19.

3. Clearing

a. Description/Methodology: Clearing acreage determined by the surface area of the proposed alternative or the additional area associated with an expansion of an existing reservoir. A unit cost of $2,500 per acre was used in the cost estimates.

b. Alternatives Applied To: Alternatives 2, 3, 5, 7, 9, 10, 12, 14, 16, 17, 18, 19, 20, and 21.

4. Road Relocation

a. Description/Methodology: A quantity, in linear feet, was determined by looking at USGS quadrangle maps and the roadways affected by the proposed

alternatives. A unit cost of $240 per linear foot of road was used in the cost estimates. All roads are assumed to be 24 feet wide (1 lane each direction), based on past roadways designed and constructed in Virginia.

b. Alternatives Applied To: Alternatives 2, 9, 16, and 21.

5. Bridge Replacement

a. Description/Methodology: A quantity, in linear feet, was determined by looking at USGS quadrangle maps and bridges affected by the proposed alternatives. A review of VDOT records of existing bridges was performed to determine bridge impacts and replacement requirements. A unit cost of $2,400 per linear foot of bridge was used in the cost estimates. All bridges are assumed to be 24 feet wide (1 lane each direction) based on past bridges designed and constructed in Virginia.

b. Alternatives Applied To: Alternatives 2, 7, 14, 18, 19, 20, and 21.

6. Utility Relocation

a. Description/Methodology: A linear footage of utilities that needs to be relocated was estimated based on the proposed surface area of the alternative's reservoir. A unit cost of $82 per linear foot was used in the cost estimates and was determined based on trenching and pipe material costs listed in RS Means. Linear footage of utility relocations was estimated to be equal to the linear footage of roadway relocations listed for a given alternative.

b. Alternatives Applied To: Alternatives 2, 7, 9, and 14.

7. Electrical Extension

a. Description/Methodology: Based on the location of various alternatives that will require new electrical service, a linear footage was determined for the electrical extensions. A unit cost of $196 per linear foot was used in the cost estimates and was estimated by utility pole and wiring costs listed in RS Means.

b. Alternatives Applied To: Alternatives 3, 4, 5, 10, 11, 12, and 18.

8. New Dam Construction

a. Description/Methodology: Based on limited site-specific quantity estimates and unit prices from past comparable projects.

b. Alternatives Applied To: Alternatives 2 and 9.

9. New Pumped Storage Facility Construction

a. Description/Methodology: The estimate is based on limited site-specific quantity estimates and unit prices from past comparable projects.

b. Alternatives Applied To: Alternatives 3 and 10.

10. Raise Dam Elevation

a. Description/Methodology: The estimate is based on limited site-specific quantity estimates and unit prices from past comparable projects.

b. Alternatives Applied To: Alternatives 5, 7, 12, 14, 16, 17, 18, 19, 20, and 21.

11. Beaver Creek Flow Controls

a. Description/Methodology: A lump sum cost of $500,000 was applied to alternatives that include using raw water from the Beaver Creek Reservoir. The cost value was obtained from the VHB/OBG report dated February 2000 and generally confirmed by Gannett Fleming.

b. Alternatives Applied To: Alternatives 9 – 21.

12. WWTP Treatment Process Upgrade

a. Description/Methodology: It is anticipated that there will need to be various forms of advanced treatment (tertiary treatment, nutrient removal, etc.) at the Moores Creek WWTP in order for the plant effluent to be discharged upstream of the SFRR. A lump sum cost of $3,000,000 was applied to this cost. The $3,000,000 includes installation of new tertiary denitrification filters, implementation of additional nutrient removal at the aeration basins (expanded volume at the basins), and additional chemical feed facilities.

b. Alternatives Applied To: Alternatives 6, 13, and 20.

13. New WTP Construction

a. Description/Methodology: Based on sound engineering judgment and experience, a cost of $2.00 per gallon of treated water capacity was applied to alternatives that require a new WTP to be constructed. A cost reduction of 5% ($0.10 per gallon) was estimated for regional cooperation where a larger plant would be built. The cost includes only the plant construction and does not include water intake, raw water pumping & piping, or finished water pumping and piping.

b. Alternatives Applied To: Alternatives 4, 8, 11, and 15.

14. WTP Expansion

a. Description/Methodology: Based on sound engineering judgment and experience, a cost of $1.50 per gallon of treated water was applied to alternatives that require an expansion of an existing WTP.

b. Alternatives Applied To: All except Alternative 4.

15. Pump Station

a. Description/Methodology: Based on sound engineering judgment and experience, a lump sum cost was assigned to pump stations based on pumping capacity and total dynamic head (TDH). These pump stations are listed separately because they are either pump stations to handle flows from the Moores Creek WWTP, finished water from the James River WTP, or finished water being pumped from the Fluvanna County regional cooperation alternative. The costs associated with these pump stations are $2,000,000 for stand-alone alternatives, $1,750,000 for alternatives that include Beaver Creek Reservoir, and $1,500,000 for alternatives that include both Beaver Creek and the 4 foot crest gates on SFRR.

b. Alternatives Applied To: Alternatives 4, 6, 8, 11, 13, 15, and 20.

16. Electrical Costs

a. Description/Methodology: For alternatives that include a pump station, electrical costs were developed based on the average flow rate required for pumping over the course of the planning horizon (50 years) and a unit cost of $0.0481 per kilowatt hour (kWh).

b. Alternatives Applied To: Alternatives 3, 4, 5, 6, 8, 10, 11, 12, 13, 15, 18, and 20.

17. Pipeline

a. Description/Methodology: The costs associated with installing new pipelines from Sugar Hollow Reservoir and Ragged Mountain Reservoir was estimated by assuming a base cost of $5.00/inch diameter of pipe/linear foot of pipeline, with additional costs added in for rocky terrain (additional $2.00/inch diameter/linear foot), creek crossings (100 linear feet/creek crossing at $20/inch diameter/linear foot), and road crossings (same costs as creek crossings but with an additional $0.50/inch diameter/linear foot of pipeline added for select fill).

b. Alternatives Applied To: Alternatives 5, 6, 7, 8, 9, 10, 12, 14, 17, 18, and 19.

18. Intake Structure

a. Description/Methodology: For alternatives that require a raw water intake structure (James River Intake and Pumped Storage Facilities), a cost of $1,000,000 was estimated for the intake structure, including pumps but not electrical costs associated with the pumps.

b. Alternatives Applied To: Alternatives 3, 4, 8, 10, 11, and 15.

19. Rehabilitation of Ragged Mountain Dam

a. Description/Methodology: Based on February 2003 Gannett Fleming, Inc. Feasibility Study Report, a cost of $3,500,000 was estimated for rehabilitating the Ragged Mountain Dam to the original storage volume.

b. Alternatives Applied To: Alternatives 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 20, and 21.

20. Demolition of Pipeline from Sugar Hollow Reservoir to Ragged Mountain Reservoir

a. Description/Methodology: It has been determined that the pipeline between Sugar Hollow Reservoir and Ragged Mountain Reservoir needs to be replaced in order to remain in operation. A lump sum of $1,000,000 was estimated for the costs associated with the demolition and disposal of the existing pipeline.

b. Alternatives Applied To: All except Alternatives 4 and 11.

21. Rehabilitation of Observatory WTP

a. Description/Methodology: The costs associated with rehabilitating the Observatory WTP in order to maintain operable conditions are estimated at $5,000,000. This cost was not applied to alternatives that require an expansion of the Observatory WTP.

b. Alternatives Applied To: All except Alternative 4, 5, 11, 12, 17, 18, and 19.

22. Replace Pipeline from Sugar Hollow Reservoir to Ragged Mountain Reservoir

a. Description/Methodology: The costs associated with installing a new 24-inch diameter pipeline from Sugar Hollow Reservoir and Ragged Mountain Reservoir was estimated at $11,283,600 (66,000 linear feet at $171/linear foot). This cost was determined by assuming a base cost of $5.00/inch diameter of pipe/linear foot of pipeline, with additional costs added in for rocky terrain (additional $2.00/inch diameter/linear foot), 1 creek crossing (100 linear feet/creek crossing at $20/inch diameter/linear foot), and 3 road crossings (same costs as creek crossings but with an additional $0.50/inch diameter/linear foot of pipeline added for select fill).

b. Alternatives Applied To: All except Alternatives 6 and 7.

23. Engineering, Permitting, and CM

a. Description/Methodology: Used to estimate the costs associated with engineering, legal (permitting), and construction management services. Calculated at 20% of the total costs estimated for the other factors associated with the alternative.

b. Alternatives Applied To: All.

24. Rehabilitation of Mechums Pump Station & Intake

a. Description/Methodology: For the alternatives that include converting the Ragged Mountain Reservoir into a pumped storage facility, the Mechums Pump Station (PS) and intake requires rehabilitation. A lump sum cost has been estimated at $1,000,000.

b. Alternatives Applied To: 5, 12, and 18.

25. Demolition of Observatory WTP

a. Description/Methodology: Based on previous reports, the square footage of the Observatory WTP was determined and a cost of $15/square foot was applied to the demolition and disposal of materials. An assumption that all building and concrete tank demolition will be to 3 feet below grade. Backfill costs were estimated at $4/cubic yard. Also included in this cost item is initial soils testing for contaminants (with the assumption that no hazardous, toxic, or radiological wastes are discovered) and the capping of the pipeline from the WTP to the ground level storage tank. The storage tank will continue to remain in service, being fed only by the existing system.

b. Alternatives Applied To: Alternatives 4 and 11.

26. Environmental Mitigation

a. Description/Methodology: <u>Wetland Mitigation:</u> Many of the raw water alternatives considered affect jurisdictional wetlands and as a result, these impacts must be mitigated through the creation or restoration of new wetland habitat. Previous cost analyses conducted for Rivanna have used a unit price for wetland creation of $100,000 per acre. This value includes considerations for land acquisition, design, permitting, construction and performance monitoring and compares conservatively with large scale mitigation costs incurred by VDOT and

other municipalities. Accordingly, we have continued to apply this unit price for the purposes of this analysis.

Another potential alternative for mitigating unavoidable wetland impacts is a monetary contribution to the COE Wetland Trust Fund. Based on discussions with the COE manager, in-lieu-of fees for the Charlottesville area are in the $60,000 per acre range. However, prior to allowing the applicant to use the Trust Fund, the agencies require a rigorous analysis of opportunities for accomplishing the mitigation on-site, or in close proximity to the proposed impacts. Depending on the selected alternative and the associated level of impact and the lack of opportunities in proximity to the impact area, the agencies may allow in-lieu-of payment again rendering our estimate at $100,000 per acre conservative and appropriate at this level of investigation.

Stream Mitigation: Recently, the state and federal regulatory agencies have begun to look specifically at project effects on stream channels and require in-kind mitigation for any necessary impacts. A determination of mitigation requirements is now dependant on the application of the COE Stream Attribute Methodology. This approach assesses the condition of the impacted channel and provides a measure of the level of mitigation that will be required. Costs for mitigation can vary widely, ranging from the establishment of stream-side riparian buffers through simple plant installation, to full scale corridor restoration through the application of natural channel design principals.

For the purposes of this analysis, we have attempted to cover the widely variable costs that are likely to be incurred by RWSA, as certainly any mitigation proposal will include a range of proposed actions. Stream corridor restoration, at the high end of the range, would involve land or easement acquisition, design, construction and performance monitoring and has been estimated at $450 per foot. In developing this estimate, we have applied a conservative estimate of $250 per linear foot of channel for construction, $2,000 per acre for land or easement acquisition and another $200 per linear foot for design, survey of easement boundaries and performance monitoring. We believe this to be a conservative estimate that captures all potential expenditures. Simple planting of stream-side riparian corridors has been estimated at approximately $150 per foot. To calculate the total mitigation costs for stream impacts, we then applied the $450 value to half of the impact linear footage and the $150 value to the remaining half of impact footage, yielding an estimate that acknowledges a range of elements that are likely to be included in the mitigation package presented to the agencies.

Similar to the wetland mitigation, the COE also has a Stream Trust Fund, where an in-lieu-of fee is paid to compensate for stream impacts. The COE reports that the range of fees charged for participation is highly dependant on the character of the impacted stream and can range from $90 per foot for degraded systems to $200+ per linear foot for higher quality systems. Again, the use of this fund is determined by the agencies and the applicant must document that there are no

suitable opportunities available for on-site or watershed area compensation before they will allow the applicant to use the fund. Accordingly, we believe the costing approach described in the preceding paragraphs to be a reasonable and conservative estimate for budgeting and alternative evaluation purposes at the current level of study.

b. Alternatives Applied To: Listed under Alternatives 2-21, although some have no impact.

27. Dredging

a. Description/Methodology: GF evaluated dredging costs associated with a proposed pilot dredging project and documented the findings in a December 31, 2003 letter report. Although additional investigations were performed, costs could not be firmly determined at this level of study.

b. Alternatives Applied To: Alternative 22.

28. Access Road

a. Description/Methodology: The costs associated with constructing an access road from I-64 to the portion of the Ragged Mountain Reservoir that will otherwise be isolated. A uniform cost of $8 per linear foot was estimate.

b. Alternatives Applied To: Alternatives 10, 11, 12, 13, and 14.

29. Culvert

a. Description/Methodology: Alternatives that include raising Ragged Mountain Reservoir result in inundation of the existing culvert under I-64 and the roadway embankment. An additional 48" diameter culvert is included at a cost of $300 per linear foot for 742 feet by way of horizontal boring.

b. Alternatives Applied To: Alternatives 10, 11, 12, 13, and 14

30. Embankment Stabilization

a. Description/Methodology: Alternatives that include raising Ragged Mountain Reservoir result in inundation of the existing culvert under I-64 and the roadway embankment. In order to maintain slope stability, a cost of $521 per linear feet was estimated for a wall structure.

b. Alternatives Applied To: Alternatives 10, 11, 12, 13, and 14

A detailed breakdown of the estimated project costs can be found in Appendix A of this report.

B. Wetlands Impacts

The U.S. Army Corps of Engineers has regulatory authority over waters of the United States including adjacent wetlands. Within the Commonwealth of Virginia, the Virginia Department of Environmental Quality (DEQ) has jurisdiction over state waters, including wetlands. For regulatory purposes, wetlands are defined as "those areas that are inundated or saturated by surface or ground water 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. Wetlands generally include "swamps, marshes, bogs, and similar areas" (33CFR328.3b). In order to be considered jurisdictional, a wetland must exhibit all three of the following: the presence of hydrophytic vegetation, hydrologic indicators, and hydric soils, although these parameters alone do not necessarily make a wetland jurisdictional.

Several methods were used to establish approximate wetland areas within the potential limits of impact associated with a particular alternative:

First, the previous impact analysis was reviewed for those alternatives that have carried over to the current study. The previous effort employed limited field reconnaissance in addition to review of the following sources to produce mapped wetland and stream boundaries that were incorporated in a Geographic Information Systems (GIS) platform to generate estimated impacts. This work represents a more accurate determination than relying solely on National Wetland Inventory (NWI) mapping. Data sources:

- National Wetland Inventory (NWI) maps – U.S. Fish and Wildlife Service
- Aerial infrared photographs, 1994 – U.S. Department of Agriculture Farm Service Agency
- Albemarle County soils mapping – U.S. Soil Conservation Service
- Topographic maps – U.S. Geographic Survey

Second, the most recent NWI maps were consulted for all alternatives. This allowed the study team to incorporate any updated information into the previous analysis, as well as determine estimated impacts for alternatives not previously considered. This analysis included distinguishing among various types of wetlands (e.g. forested, scrub-shrub, or emergent) where such data were available, thereby allowing a more accurate estimation of mitigation requirements.

Finally, given the prominence in the previous recommended strategy of the 4 foot crest controls, more detailed analysis was performed around the SFRR. Specifically, the study team performed field analysis to verify and supplement the impacts identified in the 2003 wetland report produced by Malcolm Pirnie. This involved a combination of photo-interpretation and actual wetland delineation and flagging consistent with the Corps Manual. Results were field mapped, and a wetland report was produced to document findings.

C. Stream Impacts

As with wetlands, the COE has jurisdiction over "waters of the United States" pursuant to the provisions of the Clean Water Act and the Rivers and Harbors Act. The DEQ has jurisdiction over state waters pursuant to the State Water Control Law. Stream impacts occur where new or increased reservoir pool levels result in a replacement of riverine characteristics by lacustrine characteristics.

Regulatory requirements for impact methodology have changed somewhat since the previous analysis, to the extent that stream impacts are now identified separately from wetland acreage. Previously, the acreage of the stream impacts would have been included with wetland acreage to produce one impact area. The current analysis, consistent with regulatory requirements, has produced separate categories for wetland impacts and linear feet of stream impacts. For consistency, this methodology has been applied to all alternatives in the current study, including those that have carried over from prior work.

Because of this, wetland impact figures in previous reports may appear substantially larger than in the current analysis. The actual impacts however, remain essentially the same; they are simply categorized differently. The implications for permitting remain unchanged, while mitigation costs have increased substantially.

Stream impacts were calculated using NWI maps, USGS Quad Sheets, aerial photography, and data from the previous analysis.

D. Logistical Issues

Logistical issues deal with any matters that will have an impact on the practical implementation of the alternative in question. These include the following:

- Roadway relocation – alternatives that require relocation or realignment of a roadway can incur substantial cost and time delay.
- Residential displacements – Albemarle County's GIS database, which includes the most up-to-date information on residential development, was used to count the residences that would be displaced by a particular alternative. In the City of Charlottesville, no displacements are anticipated.
- Bridge replacement – the study team used topographic mapping, existing bridge plans, inspection reports, and proposed water elevations to assess the potential need for replacement of the Ivy Creek Bridge at SFRR.

E. Cultural Resources

Federal authorities are required to evaluate the potential impact of their actions (i.e. issuance of permits) on historic sites and properties either listed or eligible for listing on the National Register of Historic Places as defined by the National Historic Preservation Act.

A file search was conducted at the Virginia Department of Historic Resources (DHR) to identify previously recorded architectural properties and archaeological sites that might be affected by each alternative as appropriate. Records on file at DHR for each

site/property were consulted for additional information when available. No field reconnaissance was conducted except as described below for SFRR. Potential impacts are therefore based solely on available information; data are presented at the stage to provide preliminary information about the types of resources that could potentially be impacted. Detailed additional analysis will be required regardless of which alternative is selected for implementation.
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Given its prominence in the previous recommended strategy, the 4 foot crest controls warranted additional study regarding cultural resources. Specifically, a Phase I Cultural Resources Survey was performed in the proposed areas of inundation. The survey identified several sites for which follow-up efforts may be necessary.

F. Threatened or Endangered Species

Plant, animal, or insect species officially classified as “threatened” or “endangered” are protected at the state and federal levels. Agencies with regulatory authority regarding these issues in Virginia include the U.S. Fish and Wildlife Service, the Virginia Department of Game and Inland Fisheries, and the Virginia Department of Agriculture and Consumer Services. A comprehensive database containing known occurrences of rare, threatened, and/or endangered plant and animal species in Virginia is maintained by the Virginia Department of Conservation and Recreation’s Natural Heritage Program and is updated regularly.

In order to evaluate potential impacts to these resources, requests for inventory information were made to the Natural Heritage Program in the spring of 2004. Evaluation of the preliminary alternatives was performed based upon available information contained in the database at the time of the request.

In addition to the database information, the study team reviewed a 1998 report by the Virginia Department of Game and Inland Fisheries. The report documents field surveys of the upper Rivanna River watershed and the upper James River tributaries, for the presence of freshwater mussel species, some of which are listed as threatened and/or endangered. Furthermore, a mussel survey was completed in October 1996 by Phil Stevenson in Buck Mountain Creek. Finally, the Department of Game and Inland Fisheries has conducted a survey in Ivy Creek and determined that the 4 foot crest controls would not impact the James spinymussel. Each alternative was evaluated based on the results of those surveys.

G. Other Environmental Impacts

Other impacts relate to any issues unique to the study area, such as designated trout waters, pristine habitats or systems, and groundwater recharge or aquifer systems.

H. Land Acquisition Requirements

While the cost associated with land acquisition has been included in the cost estimates for

the alternatives, it was deemed important to include the acreage assumed for each alternative for informational purposes.

Section V – Analysis Results

Using the methodologies discussed in Section IV, each of the alternatives was analyzed to assess cost, impacts, and other relevant information. The results of that analysis are outlined below, and summarized in Table 5-1. Table 5-2 provides an abbreviated summary of the results that contains the key determining factors.

It should be noted that wetland impact estimates for the 4 foot crest gates are based on more detailed field observation than other alternatives. While the wetland impacts of this alternative therefore are likely to be fully reflected in the available data, we consider it likely that the wetland impacts of the other alternatives may be somewhat greater than the figures stated for each.

Alternative 1 – No Action

The No Action alternative assumes necessary rehabilitation and maintenance of existing facilities, but no additions to the sources of raw water supply. Its projected cost is $31.2 million.

Based on review of available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Raw Water Demand*. The No Action alternative would fail to meet the projected demand for raw water. Based on this consideration, **it is recommended that this option NOT be considered for more detailed analysis**.

Alternative 2 - Construct a New Dam at Buck Mountain Creek

This alternative involves construction of a new dam on Buck Mountain Creek to create a reservoir sufficient in size to meet the 2055 supply deficit of 9.9 million gallons per day (MGD). Based on the preliminary analysis done to-date, the projected cost of this alternative is $109.7 million.

Based on a review of available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to the James spinymussel*. The species is federally listed as an endangered species, and it has been confirmed as a resident in the project area.
- *Impacts to wetlands*. An estimated 25 acres would be impacted, requiring avoidance if possible, and in any event appropriate compensatory mitigation. .

This figure is not based on a wetland delineation but results from limited field observation.

- *Impacts to stream habitat.* Approximately 40,000 linear feet of stream and associated habitat would be impacted; mitigation may be required.

Based on the impacts to the James spinymussel and the high level of anticipated impacts to wetlands and linear feet of stream habitat, **it is recommended that this option NOT be considered for more detailed analysis**.

Note: Buck Mountain Creek was used as a representative reservoir option (other locations could be selected). It is likely that other locations would involve similar impacts to streams and wetlands (and possibly listed species); they would therefore not be carried forward on similar grounds.

Alternative 3 – Construct a New Dam at Buck Mountain Creek + Beaver Creek Reservoir

This alternative includes construction of a smaller dam on Buck Mountain Creek combined with use of Outlet Controls to allow discharge from Beaver Creek Reservoir into the South Fork Rivanna River. It also includes plant expansion and replacement of the Ragged Mountain Dam. Based on analysis to-date, the projected cost of this alternative is $105.0 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands.* Because the dam height for this alternative is lower than Alternative 2, it can be estimated that fewer than 25 acres would be impacted, requiring avoidance if possible, and in any event appropriate mitigation. This figure is not based on a wetland delineation but results from limited field observation.
- *Impacts to stream habitat.* Approximately 32,000 linear feet of stream habitat would be impacted.
- *Impacts to the James spinymussel.* This listed species has been documented in the project area.

The primary considerations for this alternative are impacts to wetlands, stream habitat and the James spinymussel. In addition, the use of Beaver Creek does not significantly lessen the impacts of the reservoir, and would preclude future use of Beaver Creek to meet demands in the Crozet area. **It is recommended that this option NOT be considered for more detailed analysis.**

Alternative 4 – Construct a New Pumped Storage Facility at Rocky Creek

This alternative includes a new storage facility on Rocky Creek. Additional enhancements to existing facilities would also be required. Based on the preliminary analysis done to-date, the projected cost of this alternative is $105.5 million.

Based on a review of available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to stream habitat*. Approximately 7,400 linear feet of stream would be impacted by this alternative. Mitigation may be required.
- *Impacts to the listed species*. Although there have been historical sightings of two listed bird species in the vicinity of the project, their preferred habitat may not be impacted by the alternative. In addition, the James spinymussel has been documented in Rocky Creek downstream of the proposed facility. Additional research may be required.

Based on impacts to stream habitat and potential impacts to listed species, this alternative cannot be recommended above the Ragged Mountain Pumped Storage alternative which is being considered for more detailed analysis; therefore **it is recommended that this alternative NOT be considered for more detailed analysis.** Although this alternative involves less impacts to wetland acreage than alternatives considered for more detailed evaluation, it involves much greater impacts to linear feet of streams and associated habitat. These impacts would occur in unaltered aquatic ecosystems, and their cumulative effects outweigh the wetland impacts of alternatives considered for further evaluation, which in some cases include reservoir fringe wetlands that will be inundated and will likely re-colonize at the new pool levels.

Note: Rocky Creek was used as a representative pumped storage reservoir option (other locations could be selected). It is likely that other locations would involve similar impacts to stream habitat (and possibly listed species); they would therefore not be considered for more detailed analysis on similar grounds.

Alternative 5 – Construct New Pumped Storage Facility at Rocky Creek + Beaver Creek Reservoir

Construction of a smaller pumped storage facility at Rocky Creek, combined with the use of Outlet Controls at Beaver Creek Reservoir would meet the 2055 supply deficit. In addition to required improvements at those two locations, this alternative includes plant capacity expansion and replacement of the Ragged Mountain Dam. Its cost based on analysis to-date is projected at $98.1 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to stream habitat*. Approximately 6,300 linear feet of stream would be impacted. Mitigation may be required.
- *Impacts to listed species*. Although there have been historical sightings of two listed bird species in the vicinity of the project, their preferred habitat may not be impacted by the alternative. Additionally, the James spinymussel has been documented in Rocky Creek downstream of the proposed facility. Additional research may be required.

Based on impacts to stream habitat and potential impacts to listed species, this alternative cannot be recommended above the Ragged Mountain Pumped Storage alternative. In addition, the use of Beaver Creek does not significantly lessen the impacts of the pumped storage facility, and it would preclude the future use of Beaver Creek to meet demands in the Crozet area. Therefore **it is recommended that this alternative NOT be considered for more detailed analysis.** Although this alternative involves less impacts to wetland acreage than alternatives considered for more detailed evaluation, it involves significant impacts to linear feet of streams and associated habitat. These impacts would occur in unaltered aquatic ecosystems, and their cumulative effects outweigh the wetland impacts of alternatives considered for further evaluation, which in some cases include reservoir fringe wetlands that will be inundated and will likely re-colonize at the new pool levels.

Note: Rocky Creek was used as a representative pumped storage reservoir option (other locations could be selected). It is likely that other locations would involve similar impacts to stream habitat (and possibly listed species); they would therefore not be considered for more detailed analysis on similar grounds.

Alternative 6 – James River Intake

This option includes a new raw water intake on the James River and a new water treatment plant. The initial capacity of the WTP would be 10 MGD, and eventually expanded to 20 MGD to accommodate future demands. Based on analysis to-date, the projected cost of this alternative is $109.5 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands*. Wetland impacts are estimated to be 5 acres; additional minor impacts associated with stream crossings may occur. Avoidance (if possible) and compensatory mitigation would be required.
- *Impacts to listed species.* Potential impacts to threatened or endangered species are unknown at this time; additional study would be required. The pipeline associated with this alternative would cross multiple perennial streams, raising the potential for impacts to mussel species. Additional data

(along with actual design details) would be required if this alternative is selected for implementation.

Based on its ability to meet the projected water deficit, its potential for expansion, and the limited impacts to wetlands and streams, **it is recommended that this option be considered for more detailed analysis.** Although this alternative has greater wetland acreage impacts than certain alternatives not being considered for further evaluation, it does not include the significant impacts to linear feet of stream and habitat associated with those alternatives.

Alternative 7 – James River Intake + Beaver Creek Reservoir

This alternative involves using discharges from Beaver Creek to supplement a pipeline intake on the James River. The projected cost based on analysis to-date is $102.7 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands*. Wetland impacts are estimated to be 5 acres; additional minor impacts associated with stream crossings may occur.
- *Impacts to listed species.* Potential impacts to threatened or endangered species are unknown at this time; additional study would be required. The pipeline associated with this alternative would cross multiple perennial streams, raising the potential for impacts to mussel species. Additional data (along with actual design details) would be required if this alternative is selected for implementation.

This alternative has similar impacts to the stand alone James River Intake option. It would also preclude the potential future use of Beaver Creek in the Crozet system beyond 1.1 MGD. However, the Beaver Creek Release scenario has not firmly been determined at this level of study. Therefore, **it is recommended that this option be carried forward as part of the detailed analysis of Alternative 6.**

Alternative 8 – Regional Cooperation with Fluvanna/Louisa Counties

This alternative includes a partnering arrangement to operate a James River intake and a water treatment plant. Since this alternative is similar to Alternative 6 and holds promise for lesser overall impacts to the environment and may be lesser expense, it is appropriate to investigate the potential of this option; it **therefore will be considered for more detailed analysis**.

Alternative 9 – Regional Cooperation + Beaver Creek Reservoir

This alternative is similar to #8, and results in similar impacts. It would also preclude the potential future use of Beaver Creek in the Crozet system beyond 1.1 MGD. However, the Beaver Creek Release scenario has not firmly been determined at this level of study. Therefore, **it is recommended that this option be carried forward as part of the detailed analysis of Alternative 8.**

Alternative 10 - Raise Ragged Mountain Dam with Pumped Storage

This alternative calls for raising the lower dam at Ragged Mountain reservoir by 43 feet and supplementing the reservoir with a pumped storage system. The additional supply would be pumped from Mechums River into the Ragged Mountain reservoir. The pumped storage method combined with the proposed dam height would supply the needed 9.9 MGD in safe yield to meet the 2055 demand. It should be noted that the reservoir's drawdown recovery time is long, and even with pumped storage, would be an estimated three years. Based on analysis to-date, the projected cost of this alternative is $81.7 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands*. Wetland impacts are estimated to be approximately 5 acres for the reservoir with minor impacts due to the pipeline. Avoidance (if possible) and compensatory mitigation would be required.
- *Impacts to stream habitat*. Approximately 2,300 linear feet of stream habitat would be impacted; mitigation may be required.
- *Impacts to listed species.* Although there have been historical sightings of two listed bird species in the vicinity of the project, their preferred habitat may not be impacted by the alternative. Additional research may be required. The James spinymussel resides in Mechums Creek; intake design and operation may require special provision to avoid impacts.
- *Interstate 64.* The proposed pool level is a higher elevation than an existing culvert under I-64, so that the reservoir would inundate property on both sides of the roadway. The roadway embankment at this location is roughly 140 feet high, so the pool would not approach the roadway surface. Coordination with the Virginia Department of Transportation would be required.

Based on the minimal impacts anticipated with this alternative, **it is recommended that this option be considered for more detailed analysis**. Although this alternative has greater wetland acreage impacts than certain alternatives not being considered for further evaluation, it does not include the significant impacts to linear feet if stream and habitat associated with those alternatives.

Alternative 11 – Raise Ragged Mountain Dam + Beaver Creek Reservoir

This alternative is similar to Alternative 12, except that it does not involve pumped storage. Because it has a slightly higher dam height, the associated impacts would likely be greater. The maximum drawdown recovery time for this alternative is estimated at 5 years based on available records. It would also preclude the potential future use of Beaver Creek in the Crozet system beyond 1.1 MGD. However, the Beaver Creek Release scenario has not firmly been determined at this level of study. Therefore, **it is recommended that this option be carried forward as part of the detailed analysis of Alternative 10. Project components related to Beaver Creek Release and pumped storage will be determined in further detailed study.**

Alternative 12 – Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir

This alternative proposes supplementing a pumped storage facility at Ragged Mountain with discharges from Beaver Creek Reservoir. It also includes rehabilitation and expansion of existing facilities throughout the system. Based on analysis to-date, its projected cost is $78.7 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands*. Wetland impacts are estimated to be 5 acres for the reservoir with minor impacts due to the pipeline.
- *Impacts to stream habitat*. Approximately 2,200 linear feet of stream habitat would be impacted; mitigation may be required.
- *Impacts to listed species.* Although there have been historical sightings of two listed bird species in the vicinity of the project, their preferred habitat may not be impacted by the alternative. Additional research may be required. The James spinymussel resides in Mechums Creek; intake design and operation may require special provision to avoid impacts. .
- *Interstate 64.* The proposed pool level is a higher elevation than an existing culvert under I-64, so that the reservoir would inundate property on both sides of the roadway. The roadway embankment at this location is roughly 140 feet high, so the pool would not approach the roadway surface. Coordination with the Virginia Department of Transportation would be required.

This alternative has similar impacts and costs to the Ragged Mountain with pumped storage option. It would also preclude the potential future use of Beaver Creek in the Crozet system beyond 1.1 MGD. However, the Beaver Creek Release scenario has not firmly been determined at this level of study. Therefore, **it is recommended that this option be carried forward as part of the detailed analysis of Alternative 10. Project components related to Beaver Creek Release and pumped storage will be determined in further detailed study.**

Alternative 13 – Raise Ragged Mountain Dam + Beaver Creek Reservoir + 4 foot Crest Gates at SFRR

This option is similar to Alternative 14 except that is does not include pumping water from the Mechums River and it requires raising the Ragged Mountain Dam by 28 feet instead of 27 feet. Based on analysis to-date, the projected cost of this alternative is $82.1 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands.* Approximately 38 acres of wetlands would be impacted as a result of this alternative; avoidance (if possible) and compensatory mitigation would be required.
- *Impacts to stream habitat.* This alternative would inundate 18,200 linear feet of stream. Mitigation may be required.
- *Impacts to listed species.* Online databases indicate the presence of this species in Ivy Creek above the reservoir within the area of inundation. A field survey by the Virginia Department of Game and Inland Fisheries has indicated that the species is not present in this area. Although there have been historical sightings of two listed bird species in the vicinity of the project, their preferred habitat may not be impacted by the alternative. Additional research may be required.
- *Interstate 64.* The proposed pool level is a higher elevation than an existing culvert under I-64, so that the reservoir would inundate property on both sides of the roadway. The roadway embankment at this location is roughly 140 feet high, so the pool would not approach the roadway surface. Coordination with the Virginia Department of Transportation would be required.
- *Phasing.* Implementation of this alternative may be phased by using Beaver Creek and 4' crest gates to delay raising Ragged Mountain Reservoir. However, immediate rehabilitation would be necessary due to its current condition.

Although this alternative involves greater impacts to wetlands and stream habitats than other alternatives being considered for more detailed analysis, the potential exists for phasing implementation in a manner that could result in substantial cost savings. However, drawdown recovery time is estimated to be 6 years. It may also be worthwhile to consider the additional cost associated with adding a pumped storage component to this alternative to reduced drawdown recovery time. To determine phasing potential and further consider project details, **it is recommended that this option be considered for more detailed analysis.**

Alternative 14 – Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir + 4 foot Crest Gates at SFRR

By raising Ragged Mountain Dam by 27 feet, pumping water from the Mechums River, implementing discharges from Beaver Creek Reservoir, and installing 4 foot crest Gates at SFRR; RWSA could meet the 2055 demand for raw water. This option also proposes rehabilitation, expansion, and replacement of various facilities. Based on analysis to-date, its projected cost is $91.6 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands.* Approximately 38 acres of wetlands would be impacted as a result of this alternative; avoidance (if possible) and compensatory mitigation would be required.
- *Impacts to stream habitat.* This alternative would inundate roughly 18,200 linear feet of stream habitat. Mitigation may be required.
- *Impacts to listed species.* Online databases indicate the presence of this species in Ivy Creek above the reservoir within the area of inundation. A field survey by the Virginia Department of Game and Inland Fisheries has indicated that the species is not present in this area. Although there have been historical sightings of two listed bird species in the vicinity of the project, their preferred habitat may not be impacted by the alternative. Additional research may be required.
- *Interstate 64.* The proposed pool level is a higher elevation than an existing culvert under I-64, so that the reservoir would inundate property on both sides of the roadway. The roadway embankment at this location is roughly 140 feet high, so the pool would not approach the roadway surface. Coordination with the Virginia Department of Transportation would be required.
- *Phasing.* Implementation of this alternative may be phased by using Beaver Creek and 4' crest gates to delay raising Ragged Mountain Reservoir. However, immediate rehabilitation would be necessary due to its current condition.

Alternative 13 is similar to Alternate 14 and is identified for additional consideration because it involves similar impacts with a smaller cost. However, the technical aspects of Alternative 13 must be evaluated in greater detail and a pumped storage component may be added. Therefore, **it is recommended that this option be carried forward as part of the detailed analysis of Alternative 13. Project components related to Beaver Creek Release and pumped storage will be determined in further detailed study.**

Alternative 15 – Raise SFRR 11 Feet

Raising the SFRR by 11 feet would meet the 2055 need for raw water storage. This alternative would also include plant capacity expansion and replacement of the Ragged Mountain Dam. Based on analysis to-date, the projected cost of this alternative is $9.3 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands*. This alternative would impact approximately 47 acres of wetlands, requiring avoidance if possible, and in any event appropriate compensatory mitigation.
- *Impacts to stream habitat*. Approximately 35,700 linear feet of stream would be impacted; mitigation may be required.
- *Bridge replacement*. The 11 feet rise would require replacement of the Ivy Creek Bridge; although replacement does not appear necessary at this level of study, further analysis of the Route 743 bridge would be required if this alternative advances.
- *Impacts to the James spinymussel*. Upstream inundation could potentially impact this listed species.

Based on the wide ranging impacts associated with the 11 feet pool increase, **it is recommended that this alternative NOT be considered for more detailed analysis.**

Alternative 16 – Raise SFRR + Beaver Creek Reservoir

Raising the SFRR dam by 9 feet in conjunction with implementing Outlet Controls at Beaver Creek Reservoir would satisfy the 2055 demand for raw water. This alternative also consists of expansion of plant capacity and replacement of the Ragged Mountain Dam. Based on analysis to-date, its projected cost is $98.6 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands*. Wetland analysis was not performed for this alternative because available mapping was not of sufficient detail. Nevertheless, it can be anticipated that this alternative would impact fewer than the 47 acres of wetlands associated with the 11 feet crest increase. This would require avoidance if possible, and in any event appropriate compensatory mitigation.
- *Impacts to stream habitat*. Alternative 14 would impact fewer linear feet than the 11 feet increase, which was 35,700; mitigation may be required.

- *Bridge replacement*. The 9 feet rise would require replacement of the Ivy Creek Bridge; although replacement does not appear necessary at this level of study, further analysis of the Route 743 bridge would be required if this alternative advances.
- *Impacts to the James spinymussel*. Upstream inundation could potentially impact this listed species.

Based on the wide ranging impacts associated with the 9 feet pool increase, **it is recommended that this alternative NOT be considered for more detailed analysis.**

Alternative 17 – Pumpback from Moores Creek WWTP to SFRR Tributary

This alternative consists of pumping highly treated effluent to a tributary of the South Fork Rivanna River. Capacity expansions and rehabilitation of existing facilities would also be necessary. Based on analysis to-date, the projected cost of this alternative is $91.2 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Regulatory context*. The Virginia Department of Health (VDH) has indicated that this alternative does not represent the best source of raw water and therefore would not satisfy VDH regulations.
- *Impacts to wetlands.* Approximately 2 acres of wetlands would be impacted, requiring avoidance (if possible) and compensatory mitigation. Minor impacts associated with stream crossings would also occur.
- *Impacts to the James spinymussel.* The James spinymussel resides in the Mechums River, one of the potential tributaries to which the effluent would be pumped.

Based on regulatory concerns and potential impacts to the James spinymussel, **it is recommended that this option NOT be considered for more detailed analysis.**

Alternative 18 – Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir

This alternative proposes supplementing a reuse option with discharges from Beaver Creek Reservoir. It also includes expansion and rehabilitation of various system facilities. Based on analysis to-date, its projected cost is $91.6 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Regulatory context*. The Virginia Department of Health (VDH) has indicated that this alternative does not represent the best source of raw water and therefore would not satisfy VDH regulations.
- *Impacts to wetlands*. Approximately 2 acres of wetlands would be impacted with additional minor impacts associated with stream crossings. Avoidance (if possible) and compensatory mitigation would be required.
- *Impacts to the James spinymussel.* The James spinymussel resides in the Mechums River, one of the potential tributaries to which the effluent would be pumped.

This alternative has similar impacts to the stand alone pumpback option. Based on its higher cost along with the concerns relative to that alternative, **it is recommended that this option NOT be considered for more detailed analysis.**

Alternative 19 – Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir + 4' Crest Gates at SFRR

This alternative contemplates pumping highly treated effluent to a SFRR tributary and supplementing that supply by discharging water from Beaver Creek Reservoir and installing 4 foot Crest Gates at SFRR. It also includes expansion, rehabilitation, and replacement of various facilities. Its projected cost based on analysis to-date is $110.6 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Regulatory context*. The Virginia Department of Health (VDH) has indicated that this alternative in their view does not represent the best source of raw water.
- *Impacts to wetlands.* Approximately 35 acres of wetlands would be impacted as a result of this alternative: avoidance (if possible) and compensatory mitigation would be required. Additional minor impacts could occur at stream crossings.
- *Impacts to stream habitat.* This option would inundate approximately 16,000 linear feet of stream habitat.
- *Impacts to the James spinymussel.* Online databases indicate the presence of this species in Ivy Creek above the SFRR within the area of inundation. A field survey by the Virginia Department of Game and Inland Fisheries has indicated that the species is not present in this area. The species is present in the Mechums River, one of the possible pumpback tributaries.

Based on regulatory concerns along with potential impacts to the James spinymussel, **it is recommended that this option NOT be considered for more detailed analysis.**

Alternative 20 – Expand Sugar Hollow Reservoir + Beaver Creek Reservoir

This option includes raising the pool level at Sugar Hollow by 66 feet by increasing the height of the existing dam or replacing it with a new facility immediately downstream. The additional raw water from this action would be supplemented by discharges from Beaver Creek Reservoir. Replacement, rehabilitation, and expansion of various facilities would also be necessary. Based on analysis to-date, the projected cost is $125.6 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to stream habitat.* The new pool level would inundate approximately 4,900 linear feet of the Moorman's River, which includes special regulation trout waters as well as stocked trout waters. Mitigation may be required.
- *Impacts to federal property.* This alternative would inundate approximately 65 acres of the Shenandoah National Park.

Based on impacts to stream habitat and federal property, **it is recommended that this option NOT be considered for more detailed analysis.**

Alternative 21 – Expand Sugar Hollow Reservoir + Beaver Creek Reservoir + 4 foot Crest Gates at SFRR

This alternative includes raising Sugar Hollow Reservoir by 46 feet by increasing the height of the existing dam or constructing a new dam immediately downstream of the existing. In addition, it includes discharges at Beaver Creek Reservoir and 4 foot Crest Gates at SFRR. It also includes expansion, rehabilitation, and replacement of various facilities. Based on analysis to-date, its projected cost is $127.9 million.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands.* Approximately 33 acres of wetlands would be impacted as a result of Alternative 21.
- *Impacts to stream habitat.* Approximately 18,700 linear feet of stream habitat would be impacted, including the Moorman's River, which includes special regulation and stocked trout waters. Mitigation may be required.
- *Impacts to federal property.* This alternative would inundate approximately 50 acres of federal property.
- *Impacts to the James spinymussel.* Online databases indicate the presence of this species in Ivy Creek above the SFRR within the area of inundation. A field survey by the Virginia Department of Game and Inland Fisheries has indicated that the species is not present in this area.

Based on impacts to stream habitat, **it is recommended that this option NOT be considered for more detailed analysis.**

Alternative 22 - Dredge SFRR + Outlet Controls at Beaver Creek Reservoir + 4 foot Crest Gates at SFRR

This alternative considers installing crest gates at SFRR and supplementing the resulting safe yield by implementing releases from Beaver Creek and instituting a dredging program. Implementation of the dredging component of this alternative would be logistically difficult and its costs highly sensitive to assumptions made regarding the drying, transport and disposal of dredged spoil. More investigation will be required before any meaningful cost guidance can be provided.

Based on available data and assumptions to-date, the following highlights figure prominently in our assessment of this alternative:

- *Impacts to wetlands.* Approximately 38 acres of wetlands would be impacted as a result of this alternative' avoidance (if possible) and compensatory mitigation would be required.
- *Impacts to stream habitat.* This option would inundate approximately 16,000 linear feet of stream habitat.
- *Impacts to the James spinymussel.* Online databases indicate the presence of this species in Ivy Creek above the SFRR within the area of inundation. A field survey by the Virginia Department of Game and Inland Fisheries has indicated that the species is not present in this area. The species is present in the Mechums River, one of the possible pumpback tributaries.
- *Phasing.* Implementation of this alternative may be phased by using Beaver Creek and 4' crest gates to delay raising Ragged Mountain Reservoir. However, immediate rehabilitation would be necessary due to its current condition.

While the environmental effects associated with this alternative appear greater than those of some others, the potential exists for significant cost savings due to potential phased implementation of its components. This alternative therefore will be considered for more detailed analysis in order to permit more refined assessment of the costs associated with the dredging component and the overall phased cost of the alternative.

Table 5-1: Analysis of Selected Alternatives (Page 1 of 2)

Potential Alternative	Estimated Total Project Cost (Millions)	Wetlands Impacts (ac)				Stream Impacts (LF)	Logistical Issues	Potential Impacts to Previously Identified Cultural Resources		Previously Identified Threatened or Endangered Species in Vicinity ***	Other Considerations	Land Acquisition Requirement (acres)
		Forested	Emergent	Scrub	Total			Structures	Arch.			
1. No Action	$31.2				0		Doesn't satisfy water deficit	0	0			0
2. Construct New Dam at Buck Mountain	$109.7	UA	UA	UA	25	40,000	9240 l.f. - roadway 1320 l.f. – bridge 3 buildings	4	1!	James spinymussel,		664
3. Construct New Dam at Buck Mountain + Beaver Creek Reservoir	$105.0	UA	UA	UA	<25	32,000	9240 l.f. – roadway 1320 l.f. – bridge 3 buildings	4	1!	James spinymussel	Crozet demand	330
4. Construct New Pumped Storage Facility at Rocky Creek	$105.5	0	0	0	0	7,400	1 building	0	0	James spinymussel Bewick's wren, Loggerhead shrike		135
5. Construct New Pumped Storage Facility at Rocky Creek + Beaver Creek Reservoir	$98.1	0	0	0	0	6,300	1 building	2	0	James spinymussel Bewick's wren, Loggerhead shrike	Crozet demand	116
6. James River Intake	$109.5	UA	UA	UA	5	+/- 32 streams crossings	None	10**	1	Unknown		30
7. James River Intake + Beaver Creek Reservoir	$102.7	UA	UA	UA	5	+/- 32 streams crossings	None	10**	1	Unknown	Crozet demand	30
8. Regional Cooperation with Fluvanna/Louisa Counties	N/A	UA	UA	UA	UA	?	None	unknown	unknown			Unknown
9. Regional Cooperation with Fluvanna/Louisa Counties + Beaver Creek Reservoir	N/A	UA	UA	UA	UA	?	None	2	unknown		Crozet demand	Unknown
10. Raise Ragged Mountain Dam with Pumped Storage	$81.7	1	4	0	5	2,300	I-64 issues	0#	0	Peregrine falcon, Loggerhead shrike	I-64 issues	120
11. Raise Ragged Mountain Dam + Beaver Creek Reservoir	$69.0	1	4	0	5		None	2#	0	Peregrine falcon, Loggerhead shrike	I-64 issues Lengthy fill time Crozet demand	102

Table 5-1: Analysis of Selected Alternatives (Page 2 of 2)

Potential Alternative	Estimated Total Project Cost (Millions)	Wetlands Impacts (ac)				Stream Impacts (LF)	Logistical Issues	Potential Impacts to Previously Identified Cultural Resources		Previously Identified Threatened or Endangered Species in Vicinity ***	Other Considerations	Land Acquisition Requirement (acres)
		Forested	Emergent	Scrub	Total			Structures	Arch.			
12. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir	$78.7	1	4	0	5	<2,300	None	2#	0	Peregrine falcon, Loggerhead shrike	I-64 issues Crozet demand	102
13. Raise Ragged Mountain Dam + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	$82.1	6	14	18	38	18,200	688 l.f. – roadway 420 l.f. - bridge	2#	10*	James spinymussel, !! Peregrine falcon, Loggerhead shrike	I-64 issues Lengthy fill time Crozet demand	190
14. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	$91.6	6	14	18	38	<18,200	688 l.f. – roadway 420 l.f. - bridge	2#	10*	James spinymussel, Peregrine falcon, Loggerhead shrike	I-64 issues Possible phasing: low short term $	190
15. Raise SFRR high enough to provide all required additional storage	$99.3	11	11	25	47	35,700	834 l.f. – roadway 420 l.f. - bridge	0	10*	James spinymussel		300
16. Raise SFRR + Beaver Creek Reservoir	$98.6	< 11	< 11	< 25	< 47	< 35,700	792 l.f. – roadway 420 l.f. - bridge	0	10*	James spinymussel	Crozet demand	300
17. Pumpback from Moores Creek WWTP to SFRR Tributary	$91.2	UA	UA	UA	2	+/- 20 streams crossings	None	unknown	unknown	James spinymussel		5
18. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir	$91.6	UA	UA	UA	2	+/- 20 streams crossings	None	unknown	unknown	James spinymussel	Crozet demand	5
19. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	$110.6	7	10	18	35	+/- 20 streams crossings + 16,000 LF	688 l.f. – roadway 420 l.f. - bridge	unknown	unknown	James spinymussel !!	Crozet demand	120
20. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir	$125.6	0	0	0	0	4,900	None	4	0		Trout stream, federal property Crozet demand	75
21. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	$127.9	5	10	18	33	18,700	688 l.f. – roadway 420 l.f. - bridge	4	10*	James spinymussel !!	Trout stream, federal property Crozet demand	170
22. Dredging SFRR + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR	N/A	5	15	18	38	16,000	None	0	0	James spinymussel !!		N/A

* The number of archaeological sites associated with SFRR is artificially high in comparison to the others because this reservoir was surveyed recently for the project. Intensive survey of the other alternatives would likely results in similar numbers of archaeological resources.

** The James River pumped storage route is within two historic districts that are on the National Register of Historic Places. Multiple individual properties are along this route.

RWSA has reported 2 structures of potential concern at Ragged Mountain, but these are not recorded with the VDHR.

! The Buck Mountain Reservoir alternative has at least 1 unrecorded archaeological site identified during the SFRR survey by Gray & Pape.

***The Bewick's wren, loggerhead shrike, and peregrine falcon are bird species with wide ranging habitat preferences. Listings in the table indicate historical sightings in the vicinity, although the preferred habitat may not be impacted by the alternative.

!! Online database indicates presence. DGIF survey determined absence.

UA – Unavailable.

Table 5-2: Key Determining Factors for Selected Alternatives

Potential Alternative	Estimated Cost (millions)	Wetlands Impacts (acres)	Stream Impacts (linear feet)	Threatened or Endangered Species	Other Issues
1. No Action	$31.2	N/A	N/A	*	Does not satisfy water deficit
2. New Dam at Buck Mountain Creek	$109.7	25	40,037	!	
3. New Dam at Buck Mountain Creek + Beaver Creek Reservoir	$105.0	<25	31,624	!	
4. Pumped Storage at Rocky Creek	$105.5	0[1]	7,355	*	
5. Pumped Storage at Rocky Creek + Beaver Creek Reservoir	$98.1	0[1]	6,343	*	
6. James River Intake	$109.5	5	32 stream crossings	Unknown	
7. James River Intake + Beaver Creek Reservoir)	$102.7	5	32 stream crossings	Unknown	
8. James River (Regional Cooperation)	N/A	Unknown	Unknown	Unknown	Unknown
9. James River (Regional Cooperation + Beaver Creek Reservoir)	N/A	Unknown	Unknown	Unknown	Unknown
10. Raise Ragged Mountain Dam with Pumped Storage	$81.7	4.8	2,284	*	Inundates I-64 culvert
11. Raise Ragged Mountain Dam (No Pumped Storage) + Beaver Creek Reservoir	$69.0	>4.8	>2,284	*	Inundates I-64 culvert
12. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir	$78.7	<4.8	<2,284	*	Inundates I-64 culvert
13. Raise Ragged Mountain Dam (No Pumped Storage) + Beaver Creek Reservoir + 4 foot Crest Gates SFRR	$82.1	38	18,151	*	Inundates I-64 culvert
14. Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir + 4 foot Crest Gates SFRR	$91.6	<38	<18,151	*	Inundates I-64 culvert
15. Raise SFRR to Provide All Required Additional Storage	$99.3	46.7	35,712	*	
16. Raise SFRR + Beaver Creek Reservoir	$98.6	<46.7	<35,712	*	
17. Pumpback from Moores Creek WWTP to SFRR Tributary	$91.2	2	20 stream crossings	*	
18. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir	$91.6	2	20 stream crossings	*	
19. Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir + 4 foot Crest Gates at SFRR	$110.6	35.21	16,022 + 20 stream crossings	*	
20. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir	$125.6	0[1]	4,913		Inundates federal property
21. Expand Sugar Hollow Reservoir + Beaver Creek Reservoir + 4 foot Crest Gates SFRR	$127.9	33.21	18,735	*	Inundates federal property
22. Dredging SFRR + Beaver Creek Reservoir + 4 foot Crest Gates on SFRR	N/A			*	

* Listed species have been identified in the project vicinity
! Listed species have been identified in the project footprint
[1] Available mapping does not show wetlands (other than stream channel) in the project footprint. It is likely that field-based analysis would indicate presence of wetlands.

Section VI – Summary of Concepts Proposed for Further Analysis

Introduction

During the analysis process, numerous alternatives were investigated at a preliminary level. Five specific alternatives are recommended for further detailed evaluation including:

Alternative 6.	James River Intake;
Alternative 8.	Regional Cooperation with Fluvanna/Louis Counties;
Alterntive 10.	Raise Ragged Mountain Dam with Pumped Storage;
Alternative 13.	Raise Ragged Mountain Dam + Beaver Creek Reservoir Release + Add 4 foot Crest Gates on SFRR; and
Alternative 22.	Dredging + Beaver Creek Reservoir + Add 4 foot Crest Gates on SFRR.

Each was judged on its merits and a recommendation made as to whether to consider the alternative for more detailed analysis. Underlying these five specific alternatives are four basic concepts that have emerged as having the most promising potential to deliver the needed raw water supply to the Urban System through 2055.

- An Intake on the James River
  - which could be a RWSA stand alone project or a regional project with Fluvanna and Louis Counties)
- Raising the Dam at Ragged Mountain Reservoir
  - May or may not require other components
- Use of Crest Gates at SFRR
  - must be used in combination with other components
- Dredging
  - must be used in combination with other components

Due to the uncertainties remaining at this level of study, Beaver Creek Reservoir may be used in some fashion in conjunction with any of these concepts even though it could not alone supply the total needed yield throughout the planning period. Therefore, similar alternatives that include a Beaver Creek Release remain under consideration.

Further, more detailed analysis of these 4 concepts and potential variations of each will include the individual alternatives recommended for further analysis, and will also allow RWSA to select the best version of each concept for future water supply. Operational details (and in particular the use of Beaver Creek, discussed below) can then be determined for the selected concept. The 4 concepts, and the rationale for carrying them forward, are described below.

Beaver Creek

Although not advanced as an individual supply concept, this facility requires additional investigation and may play a role in the eventual concept that RWSA chooses to pursue.

Because RWSA could currently use a projected 2.6 MGD from the reservoir for the Urban Service Area without affecting its ability to serve the Crozet system, a Beaver Creek Reservoir Release could serve as an interim measure while a long term solution is being constructed. In this sense, the RWSA Urban System would "borrow" this supply from the Crozet system for temporary use in the Urban Service Area.

Further study may indicate that Beaver Creek Reservoir could serve as an integral part of a long- term solution in conjunction with one or more of the 4 water supply concepts. It may be possible that some of the flood storage capacity of Beaver Creek could be used for supply purposes. This would involve raising the normal pool level of the reservoir, which is currently significantly below the spillway in order to provide emergency storage to control flood waters. In effect, Beaver Creek Reservoir volume would be reallocated so that some of its originally designated flood control volume would be reallocated to RWSA Urban Water Supply. At this time the details of this scenario are not known and maintenance of recreational use must be reviewed; additional analysis is required and will be conducted as the study moves forward.

Reportedly, Beaver Creek Reservoir was originally developed with federal funds. Any modifications may require governmental agency approval and alterations that impact existing recreation facility use may require replacement or repayment of some or all of the funds used to construct the Lake. Additional investigations are necessary to determine specific limitations and requirements.

Supply Concepts

James River Intake

By constructing an intake on the James River, RWSA could meet demands through the 2055 period. The concept carries a substantial cost, but because the proposed improvements are limited to a pipeline and a treatment plant (as opposed to a dam), its impacts are relatively minor. Furthermore, should this concept be pursued, it is possible that a cooperative arrangement with neighboring localities could be reached to lower costs and develop a source of regional water supply.

The environmental impacts of a stand alone versus a cooperative option are likely to be very similar. The proposed analysis will therefore provide RWSA the information needed to decide whether the intake **concept** should be pursued. If at

that point a regional cooperation arrangement can be worked out, RWSA would have the flexibility to pursue it.

Raising the Dam at Ragged Mountain Reservoir

RWSA currently faces a situation in which it must take some action regarding the Ragged Mountain dam for safety purposes. Although a rehabilitation-only option is possible, the potential to raise the height of the dam as part of the rehabilitation project is also possible and could result in economies-of-scale savings or phased improvements. This concept has the potential to meet the full 2055 supply deficit, and incurs relatively minor impacts. The proposed pool level would inundate a culvert under Interstate 64, and this scenario would need to be discussed with the Virginia Department of Transportation.

All of the Ragged Mountain Alternatives (except those involving crest gates, which are discussed below) have similar impacts. This concept includes various options on raising the dam and using pumped storage, which decreases the drawdown recovery time and preserves use of Beaver Creek for potential future demands at Crozet. Should this concept be selected, the use of Beaver Creek as an interim measure could be investigated.

Crest Gates at SFRR

The use of 4 foot crest gates at SFRR combined with other alternatives could meet long term water demand. Although this concept involves more environmental impacts than the others, it may convey a significant cost benefit; if implementation of the crest gates combined with Beaver Creek releases can significantly delay implementation of a more costly option, its value could be greatly enhanced.

This concept includes raising Ragged Mountain dam (with pumped storage) as well as releases from Beaver Creek reservoir. In addition to environmental impacts, the focus of rigorous analysis for this concept will be the specific cost implications, which will help determine whether this concept is selected.

Dredging

Based on currently available information, we cannot rule out the possibility that, supplemented by other supply sources, dredging may comprise a viable concept to meet long term demand, and could provide some flexibility in terms of phasing improvements.

At present, this concept would have to involve implementing 4’ crest gates at SFRR as well as releases from Beaver Creek Reservoir to provide the required safe yield. Once demand approaches the new supply capacity, dredging would be

implemented. Initially it is possible that dredging could be an intermittent event, used every several years for instance. Towards the end of the planning period, however, dredging would become a constant activity.

Conclusion

Four basic concepts have emerged as having the most promising potential to deliver the needed raw water supply to the Urban System through 2055 including:

- An Intake on the James River, which could be a RWSA stand alone project or a regional project with Fluvanna and Louisa Counties;
- Raising the Dam at Ragged Mountain Reservoir, which may or may not include pumped storage;
- Use of Crest Gates at SFRR, which must be used in combination with other components; and
- Dredging, which also must be used in combination with other components.

Additional investigations are necessary to determine the optimum version of each concept to satisfy the 2055 projected water supply deficit. Important factors in this regard are determining whether a safe yield increase is available from Beaver Creek Reservoir through raising the normal pool level and whether some portion of the current safe yield of Beaver Creek Reservoir may be available to the Urban Service Area through 2055. An increase above the currently available Beaver Creek Reservoir release may be possible if the flood storage volume is reallocated and the normal pool level increased for water supply. Other important considerations include: identifying operational scenarios and confirming WTP capacities and raw water transmission capabilities; investigating dredging feasibility and cost; and evaluating benefits of pumped storage at Ragged Mountain reservoir.

After the above issues are investigated, the best version of each concept will be developed and further investigated in a detailed manner in the next stage of analysis, provided all concepts remain viable. A single preferred project will then be identified and permit applications made.

APPENDIX A

ALTERNATIVES COST ESTIMATES

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 1 - No Action				
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Engineering, Permitting, and CM (20%)				$4,157,200
Subtotal				$24,943,200
Project Contingencies (25%)				$6,235,800
TOTAL				$31,179,000
Alternative 2 - Construct New Dam at Buck Mountain				
New Dam - Pool Elevation = 456 ft.	1	lump sum	$11,925,500	$11,925,500
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Clearing	325	acres	$2,500	$812,500
Land Acquisition	1	lump sum	$2,972,073	$2,972,073
Road Relocation	9240	l.f.	$240	$2,217,600
Bridge Replacement/Construction	1320	l.f.	$2,400	$3,168,000
Utilities Relocation	9240	l.f.	$82	$757,680
Environmental Mitigation	1	lump sum	$12,473,285	$12,473,285
Engineering, Permitting, and CM (20%)				$14,622,528
Subtotal				$87,735,166
Project Contingencies (25%)				$21,933,791
TOTAL				$109,668,957
Alternative 3 - Construct New Dam at Buck Mountain + Beaver Creek Reservoir				
New Dam - Pool Elevation = 452 ft.	1	lump sum	$11,111,400	$11,111,400
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Clearing	282	acres	$2,500	$705,000
Land Acquisition	1	lump sum	$2,972,073	$2,972,073
Environmental Mitigation	1	lump sum	$9,799,320	$9,799,320
Road Relocation	9240	l.f.	$240	$2,217,600
Bridge Replacement	1320	l.f.	$2,400	$3,168,000
Utilities Relocation	9240	l.f.	$82	$757,680
Engineering, Permitting, and CM (20%)				$14,003,415
Subtotal				$84,020,488
Project Contingencies (25%)				$21,005,122
TOTAL				$105,025,610

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 4 - Construct New Pumped Storage Facility at Rocky Creek				
New Dam - Pool Elevation = 796 ft.	1	lump sum	$21,888,400	$21,888,400
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Clearing	146	acres	$2,500	$365,000
Land Acquisition	1	lump sum	$419,352	$419,352
Environmental Mitigation	1	lump sum	$2,243,275	$2,243,275
Elec. Extension	1320	l.f.	$196	$258,720
Pipeline (18" Diameter)	22000	l.f.	$90	$1,980,000
Easements	11000	l.f.	$5	$55,000
Intake Structure	1	lump sum	$1,000,000	$1,000,000
Electrical Costs	1	lump sum	$3,369,545	$3,369,545
Engineering, Permitting, and CM (20%)				$14,073,058
Subtotal				$84,438,350
Project Contingencies (25%)				$21,109,588
TOTAL				$105,547,938
Alternative 5 - Construct New Pumped Storage Facility at Rocky Creek + Beaver Creek Reservoir				
New Dam - Pool Elevation = 786 ft.	1	lump sum	$17,285,200	$17,285,200
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Clearing	127	acres	$2,500	$317,500
Land Acquisition	1	lump sum	$354,241	$354,241
Environmental Mitigation	1	lump sum	$1,934,615	$1,934,615
Elec. Extension	1320	l.f.	$196	$258,720
Pipeline (18" Diameter)	22000	l.f.	$90	$1,980,000
Easements	11000	l.f.	$5	$55,000
Intake Structure	1	lump sum	$1,000,000	$1,000,000
Electrical Costs	1	lump sum	$2,909,640	$2,909,640
Engineering, Permitting, and CM (20%)				$13,076,183
Subtotal				$78,457,099
Project Contingencies (25%)				$19,614,275
TOTAL				$98,071,374

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 6 - James River Intake				
Intake Structure	1	lump sum	$1,000,000	$1,000,000
Land Acquisition (WTP and Intake Structures)	20	acres	$10,000	$200,000
New WTP Construction (20 MGD)	20000000	gallons	$2.00	$40,000,000
Pump Station	1	lump sum	$2,000,000	$2,000,000
Electrical Costs	1	lump sum	$9,511,814	$9,511,814
Pipeline (36" Diameter)	79200	l.f.	$189	$14,968,800
Easements	39600	l.f.	$5	$198,000
Demolition of Observatory WTP	1	lump sum	$269,907	$269,907
Backfill at Observatory WTP	5508	c.y.	$4	$22,032
Demolition of Pipeline From SH to RM Reservoir	1	lump sum	$250,000	$250,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Elec. Extension	1320	l.f.	$196	$258,720
Environmental Mitigation	1	lump sum	$1,000,000	$1,000,000
Engineering, Permitting, and CM (20%)				$14,435,855
Subtotal				$87,615,128
Project Contingencies (25%)				$21,903,782
TOTAL				$109,518,909
Alternative 7 - James River Intake + Beaver Creek Reservoir				
Pipeline (36" Diameter)	79200	l.f.	$189	$14,968,800
Easements	39600	l.f.	$5	$198,000
Land Acquisition (WTP and Intake Structures)	20	acres	$10,000	$200,000
Intake Structure	1	lump sum	$1,000,000	$1,000,000
New WTP Construction (15 MGD)	15000000	gallons	$2.00	$30,000,000
WTP Expansion (SF WTP to 15 MGD)	3000000	gallons	$1.50	$4,500,000
Pump Station	1	lump sum	$1,750,000	$1,750,000
Electrical Costs	1	lump sum	$10,201,743	$10,201,743
Elec. Extension	1320	l.f.	$196	$258,720
Demolition of Observatory WTP	1	lump sum	$269,907	$269,907
Backfill at Observatory WTP	5508	c.y.	$4	$22,032
Demolition of Pipeline From SH to RM Reservoir	1	lump sum	$250,000	$250,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Environmental Mitigation	1	lump sum	$1,000,000	$1,000,000
Engineering, Permitting, and CM (20%)				$13,523,840
Subtotal				$82,143,042
Project Contingencies (25%)				$20,535,760
TOTAL				$102,678,802

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 10 - Raise Ragged Mountain Dam with Pumped Storage				
Dam Raise = 43 feet; Pool Elevation = 684 ft.	1	lump sum	$15,579,000	$15,579,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
WTP Expansion (Observatory WTP to 18 MGD)	10300000	gallons	$1.50	$15,450,000
Clearing	132	acres	$2,500	$330,000
Land Acquisition	1	lump sum	$493,630	$493,630
Access Road	500	l.f.	$8	$3,815
Culvert	742	l.f.	$300	$222,600
Embankment Stabilization	1000	l.f.	$521	$521,000
Environmental Mitigation	1	lump sum	$1,274,620	$1,274,620
Elec. Extension	3750	l.f.	$196	$735,000
Pipeline (24" Diameter)	26400	l.f.	$120	$3,168,000
Easements	13200	l.f.	$5	$66,000
Rehab Mechums PS & Intake	1	lump sum	$1,000,000	$1,000,000
Electrical Costs	1	lump sum	$3,369,545	$3,369,545
Engineering, Permitting, and CM (20%)				$10,899,842
Subtotal				$65,399,052
Project Contingencies (25%)				$16,349,763
TOTAL				$81,748,815
Alternative 11 - Raise Ragged Mountain Dam + Beaver Creek Reservoir				
Dam Raise = 42 feet; Pool Elevation = 683 ft.	1	lump sum	$15,278,800	$15,278,800
WTP Expansion (Observatory WTP to 15 MGD, SF WTP to 15 MGD)	10300000	gallons	$1.50	$15,450,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Clearing	132	acres	$2,500	$330,000
Land Acquisition	1	lump sum	$493,630	$493,630
Access Road	500	l.f.	$8	$3,815
Culvert	742	l.f.	$300	$222,600
Embankment Stabilization	1000	l.f.	$521	$521,000
Environmental Mitigation	1	lump sum	$1,274,620	$1,274,620
Engineering, Permitting, and CM (20%)				$8,867,686
Subtotal				$55,228,151
Project Contingencies (25%)				$13,807,038
TOTAL				$69,035,189

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 12 - Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir				
Dam Raise = 37 feet; Pool Elevation = 678 ft.	1	lump sum	$13,655,300	$13,655,300
WTP Expansion (Observatory WTP to 15 MGD, SF WTP to 15 MGD)	10300000	gallons	$1.50	$15,450,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Clearing	112	acres	$2,500	$280,000
Land Acquisition	1	lump sum	$419,586	$419,586
Access Road	500	l.f.	$8	$3,815
Culvert	742	l.f.	$300	$222,600
Embankment Stabilization	1000	l.f.	$521	$521,000
Environmental Mitigation	1	lump sum	$1,274,620	$1,274,620
Elec. Extension	3750	l.f.	$196	$735,000
Pipeline (24" Diameter)	26400	l.f.	$120	$3,168,000
Easements	13200	l.f.	$5	$66,000
Rehab Mechums PS & Intake	1	lump sum	$1,000,000	$1,000,000
Electrical Costs	1	lump sum	$2,909,640	$2,909,640
Engineering, Permitting, and CM (20%)				$10,498,312
Subtotal				$62,989,873
Project Contingencies (25%)				$15,747,468
TOTAL				$78,737,341
Alternative 13 - Raise Ragged Mountain Dam + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR				
Dam Raise = 28 feet; Pool Elevation = 669 ft.	1	lump sum	$10,881,400	$10,881,400
WTP Expansion (Observatory WTP to 12 MGD, SF WTP to 18 MGD)	10300000	gallons	$1.50	$15,450,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
4 ft. Crest Gates; SFRR Pool Elevation = 386 feet	1	lump sum	$989,000	$989,000
Clearing	181	acres	$2,500	$452,500
Land Acquisition	1	lump sum	$1,510,118	$1,510,118
Access Road	500	l.f.	$8	$3,815
Culvert	742	l.f.	$300	$222,600
Embankment Stabilization	800	l.f.	$521	$416,800
Environmental Mitigation	1	lump sum	$10,847,055	$10,847,055
Road Relocation	688	l.f.	$240	$165,120
Bridge Replacement	420	l.f.	$2,400	$1,008,000
Engineering, Permitting, and CM (20%)				$10,946,482
Subtotal				$65,678,890
Project Contingencies (25%)				$16,419,722
TOTAL				$82,098,612

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 14 - Raise Ragged Mountain Dam with Pumped Storage + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR				
Dam Raise = 27 feet; Pool Elevation = 668 ft.	1	lump sum	$10,647,000	$10,647,000
WTP Expansion (Observatory WTP to 12 MGD, SF WTP to 18 MGD)	10300000	gallons	$1.50	$15,450,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
4 ft. Crest Gates; SFRR Pool Elevation = 386 feet	1	lump sum	$989,000	$989,000
Clearing	176	acres	$2,500	$440,000
Land Acquisition	1	lump sum	$1,510,118	$1,510,118
Access Road	500	l.f.	$8	$3,815
Culvert	742	l.f.	$300	$222,600
Embankment Stabilization	800	l.f.	$521	$416,800
Environmental Mitigation	1	lump sum	$10,847,055	$10,847,055
Road Relocation	688	l.f.	$240	$165,120
Bridge Replacement	420	l.f.	$2,400	$1,008,000
Elec. Extension	3750	l.f.	$196	$735,000
Pipeline (24" Diameter)	26400	l.f.	$120	$3,168,000
Easements	13200	l.f.	$5	$66,000
Rehab Mechums PS & Intake	1	lump sum	$1,000,000	$1,000,000
Electrical Costs	1	lump sum	$1,585,291	$1,585,291
Engineering, Permitting, and CM (20%)				$12,207,960
Subtotal				$73,247,759
Project Contingencies (25%)				$18,311,940
TOTAL				$91,559,699
Alternative 15 - Raise SFRR High Enough to Provide All Required Additional Storage				
Dam Raise = 11 feet; Pool Elevation = 393 ft.	1	lump sum	$3,435,000	$3,435,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Clearing	249	acres	$2,500	$622,500
Land Acquisition	1	lump sum	$4,181,688	$4,181,688
Environmental Mitigation	1	lump sum	$17,903,660	$17,903,660
Road Relocation	834	l.f.	$240	$200,160
Bridge Replacement	420	l.f.	$2,400	$1,008,000
Utilities Relocation	834	l.f.	$82	$68,388
Engineering, Permitting, and CM (20%)				$13,241,079
Subtotal				$79,446,475
Project Contingencies (25%)				$19,861,619
TOTAL				$99,308,094

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 16 - Raise SFRR + Beaver Creek Reservoir				
Dam Raise = 9 feet; Pool Elevation = 391 ft.	1	lump sum	$2,538,000	$2,538,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Clearing	224	acres	$2,500	$560,000
Land Acquisition	1	lump sum	$4,181,688	$4,181,688
Environmental Mitigation	1	lump sum	$17,903,660	$17,903,660
Road Relocation	792	l.f.	$240	$190,080
Bridge Replacement	420	l.f.	$2,400	$1,008,000
Utilities Relocation	792	l.f.	$82	$64,944
Engineering, Permitting, and CM (20%)				$13,146,474
Subtotal				$78,878,846
Project Contingencies (25%)				$19,719,712
TOTAL				$98,598,558
Alternative 17 - Pumpback from Moores Creek WWTP to SFRR Tributary				
WWTP Tertiary Treatment Upgrades	1	lump sum	$3,000,000	$3,000,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Pipeline (24" Diameter)	47520	l.f.	$133	$6,320,160
Easements	23760	l.f.	$5	$118,800
Pump Station	1	lump sum	$2,000,000	$2,000,000
Electrical Costs	1	lump sum	$10,245,489	$10,245,489
Environmental Mitigation	1	lump sum	$400,000	$400,000
Engineering, Permitting, and CM (20%)				$12,094,090
Subtotal				$72,964,539
Project Contingencies (25%)				$18,241,135
TOTAL				$91,205,674
Alternative 18 - Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir				
WWTP Tertiary Treatment Upgrades	1	lump sum	$3,000,000	$3,000,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Pipeline (24" Diameter)	47520	l.f.	$133	$6,320,160
Easements	23760	l.f.	$5	$118,800
Pump Station	1	lump sum	$1,750,000	$1,750,000
Electrical Costs	1	lump sum	$10,245,489	$10,245,489
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Environmental Mitigation	1	lump sum	$400,000	$400,000
Engineering, Permitting, and CM (20%)				$12,144,090
Subtotal				$73,264,539
Project Contingencies (25%)				$18,316,135
TOTAL				$91,580,674

Cost Item	Quantity		Unit Cost	Total Cost
	No.	Unit		
Alternative 19 - Pumpback from Moores Creek WWTP to SFRR Tributary + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR				
WWTP Tertiary Treatment Upgrades	1	lump sum	$3,000,000	$3,000,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
Pipeline (24" Diameter)	47520	l.f.	$133	$6,320,160
Easements	23760	l.f.	$5	$118,800
Pump Station	1	lump sum	$1,500,000	$1,500,000
Electrical Costs	1	lump sum	$10,245,489	$10,245,489
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
4 ft. Crest Gates; SFRR Pool Elevation = 386 feet	1	lump sum	$989,000	$989,000
Clearing	114	acres	$2,500	$285,000
Land Acquisition	1	lump sum	$1,201,599	$1,201,599
Environmental Mitigation	1	lump sum	$9,619,710	$9,619,710
Road Relocation	688	l.f.	$240	$165,120
Bridge Replacement	420	l.f.	$2,400	$1,008,000
Engineering, Permitting, and CM (20%)				$14,747,776
Subtotal				$88,486,654
Project Contingencies (25%)				$22,121,663
TOTAL				$110,608,317
Alternative 20 - Expand Sugar Hollow Reservoir + Beaver Creek Reservoir				
Dam Raise = 66 feet; Pool Elevation = 1041 ft.	1	lump sum	$39,359,400	$39,359,400
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
Clearing	98	acres	$2,500	$245,000
Land Acquisition	1	lump sum	$267,964	$267,964
Environmental Mitigation	1	lump sum	$1,498,465	$1,498,465
Road Relocation	12800	l.f.	$240	$3,072,000
Engineering, Permitting, and CM (20%)				$16,745,766
Subtotal				$100,474,595
Project Contingencies (25%)				$25,118,649
TOTAL				$125,593,244
Alternative 21 - Expand Sugar Hollow Reservoir + Beaver Creek Reservoir + Add 4 ft. Crest Gates on SFRR				
Dam Raise = 46 feet; Pool Elevation = 1021 ft.	1	lump sum	$31,522,100	$31,522,100
Rehab Ragged Mountain Dam	1	lump sum	$3,500,000	$3,500,000
Demolition of Existing Pipeline	1	lump sum	$1,000,000	$1,000,000
Replace Pipeline From SH to RM Reservoir	66000	l.f.	$171	$11,286,000
Rehab Observatory WTP	1	lump sum	$5,000,000	$5,000,000
WTP Expansion (SF WTP to 24 MGD)	12000000	gallons	$1.50	$18,000,000
Beaver Creek Flow Controls	1	lump sum	$500,000	$500,000
4 ft. Crest Gates; SFRR Pool Elevation = 386 feet	1	lump sum	$989,000	$989,000
Clearing	182	acres	$2,500	$455,000
Land Acquisition	1	lump sum	$1,401,803	$1,401,803
Environmental Mitigation	1	lump sum	$10,447,175	$10,447,175
Road Relocation	688	l.f.	$240	$165,120
Bridge Replacement	420	l.f.	$2,400	$1,008,000
Engineering, Permitting, and CM (20%)				$17,054,840
Subtotal				$102,329,038
Project Contingencies (25%)				$25,582,259
TOTAL				$127,911,297