Thomas Jefferson Water Resources Advisory Committee
A technical advisory committee under the joint sponsorship of the
Thomas Jefferson Soil and Water Conservation District and Thomas Jefferson Planning District Commission

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Sediment Sources and Mitigation Strategies, South Fork Rivanna Reservoir Watershed: Analysis and Recommendations

June 5, 2001

This report was assembled in response to a request for technical assistance from the Albemarle County Engineering Department dated August 10, 2000 (attached).

Background

The South Fork Rivanna Reservoir (SFRR) is an instream reservoir furnishing a substantial portion of the raw water supply to the Charlottesville and Albemarle County, Virginia Urban Service area. The rapid rate of sedimentation of this reservoir is prompting water planners to search for ways to secure a reliable future water supply. Present water demand is expected to exceed the safe yield of the water supply system by the year 2002. By the year 2050, the forecasted demand of a projected population of 110,000 will be twice what existing facilities could supply during critical periods of drought. A key factor in this mismatch in water supply/demand is the steady loss of capacity in SFRR, which is losing usable storage at the rate of 1.4% per year due to deposition of sediment on the bottom of the reservoir.

The declining capacity of the reservoir due to sedimentation has long been recognized. For many years, Albemarle County has restricted residential and industrial development within the reservoir watershed so as to minimize runoff of sediment and other pollutants. At the same time, the County has worked in partnership with the Thomas Jefferson Soil & Water Conservation District and the Virginia Department of Forestry to promote agricultural and forestry practices within the watershed that minimize pollutant runoff. It is not clear to what extent these efforts have reduced the rate at which sediment has accumulated in the reservoir, but all indications are that sedimentation continues to be a significant problem.

Water supply planners (VHB, 2000; 2001) are presently studying a variety of alternatives with which to meet the projected future water demand. Among these are alternatives that would restore SFRR's capacity, by dredging and removing sediment from the reservoir, and/or by installing a 4- or 8-foot bladder on top of the SFRR dam to raise the pool and create new "top storage." Other alternatives such as constructing a new reservoir on Buck Mountain Creek, and pumping recycled waste water from the Moores Creek treatment plant to the upper Mechums River, are contingent upon continued use of existing or expanded intakes and treatment facilities at the SFRR dam. It seems clear that whatever course of action is ultimately chosen in the water supply planning process, SFRR will continue to be an integral component of the supply system for the foreseeable future, and there will be an ongoing need to deal with the sedimentation issue.

Previous Work: What Is Known About Sedimentation of the Reservoir?

South Fork Rivanna Reservoir (SFRR) is an elongate, shallow body of water, completed in 1966 to receive runoff from a watershed area of 261 square miles. With an area of less than one square mile, the reservoir is very small relative to the size of the watershed that drains into it. Five distinct sub-watersheds are recognized. Ranked by land size and mean streamflow, these are: Mechums River, Moormans River, Buck Mountain Creek, Ivy Creek, and lands riparian to SFRR. In terms of the estimated sediment load each contributes to SFRR, however, the rank of the subwatersheds shifts to the following: Mechums, Moormans, Ivy Creek, and a virtual tie between riparian lands and Buck Mountain Creek.

Over the years since the reservoir was constructed, as concern has mounted about decline in usable capacity, several studies and bathymetric surveys have been conducted to investigate the origin, transport to, and deposition of sediment within the reservoir (Glasbey, 1981; Black and Veatch, 1994; Sobeck, 1999). Although the results of the various studies and surveys differ quantitatively, there is general agreement that the rate of sediment yield is higher from pastureland than from forest, and higher from developed areas, for example, Ivy Creek, than from either of these. Glaspey (1981) and Black and Veatch (1994) derived similar results for predicted sediment yield, and the predicted yields correlate fairly well with bathymetric measurements of sediment thickness on the bottom of SFRR. Sobeck, (1999) applies a sediment transport model and concludes that common annual peak flows in the Mechums River—and not rare and major storm events, scour out and transport sand particles already resident in geologic formations in the bed and banks of river, contributing half the overall sediment load to the SFRR.

While the previous studies provide a basis for beginning to understand the sedimentation problem, in some respects they raise as many questions as they answer. Further geologic investigations are essential, for example, to clarify Sobeck's (1999) conclusions, to the extent that his modeling and analysis did not consider the role of silt-and clay-size sediment. According to Glaspey (1981), clay is the dominant sediment in SFRR. The research of Hjulstrom (1939) demonstrated that erosion of clay requires the kind of energy which great storms generate.

Importantly, all investigators report a paucity of information on stream flow and sediment transport at exceptionally high flows, e.g., during the several hurricanes which have visited the area since 1966. This is critical, for lacking actual measurements at the upper end of rating curves, the correlation of watershed sediment yield to sediment deposited in the reservoir has been obtained largely by extrapolation from other watersheds and by drawing rating curves to obtain a "best fit." None of the previous studies have included mineralogical and petrologic analyses that could trace reservoir sediment to geologic sources in the watershed. Further, a search of files, reports and publications reveals no determination of trapping efficiency of the SFRR, and it appears that currently available data are insufficient to enable this to be readily determined.

Significance of Adequate Information In Water Supply Planning:

The feasibility of reducing the sedimentation of SFRR, through either engineering or nonstructural means, rests on identifying the sources of sediment. What part is derived from overland flow? If significant in amount, is the overland contribution attributable to a particular geologic formation, or land use/management practice? What part of the sediment in SFRR derives as wash load or bank cuttings from floodplains?

If mineralogical analyses prove, as Sobeck asserts, that sand already resident in the Mechums streambed is the major contributor of sediment to SFRR, planners might focus more on engineering solutions, such as sediment traps in-channel.

If the investigation indicates that a high volume of sand and silt is being scoured from the floodplain, it would be appropriate to focus remediation on land use, land management and soil conservation practices within the floodplain. It is noteworthy that the Mechums River flows through well-developed floodplain scroll along an 8-mile reach extending from near Batesville downstream to just east of Lake Albemarle, and this appears to be the locus of considerable stream bank erosion and sloughing. Confirmation of severe bank cutting would lend support to bank stabilization measures.

If it is found that major storms mobilize clays, and that clays—not sand and silt, are the major culprits in sedimentation of SFRR, then remediation might focus on reducing erosion in upland areas of the Mechums watershed, which are underlain by clay-rich soils. If clays do play a significant role, it might be appropriate to investigate the feasibility of constructing an outlet in the SFRR dam to enable sluicing of fine-grained suspended sediment through the reservoir during and following major floods.

<u>A Model for Further Research:</u>

Accepting the conclusions of earlier workers that the bulk of the sediment load in SFRR comes from Mechums River and Ivy Creek drainages, further research should address the following questions:

What proportion of the sediment load in the SFRR is derived by erosion of the wetted perimeter of the main stem & tributary channels, as opposed to overland sheet erosion & transport across the riparian zone?

What proportion of the sediment load is derived from main stem as opposed to upper tributary areas of the watershed?

Of the sediment load derived from within channel erosion, what proportion represents remobilization of alluvial material bordering the stream channels? What is the role of the extensive floodplain of the Mechums River in contributing sediment to SFRR? The large volume of sediment contained in the floodplain—if eroded and transported—would seem to offer a continuing supply of material for filling SFRR.

Is there a significant contribution of sediment load from erosion of solid bedrock formations in stream channels or elsewhere, as opposed to erosion of unconsolidated surficial geologic deposits?

What is the role of extreme weather events in mobilization & transport of sediment in different parts of the basin system? What proportion of the overall sediment load in SFRR is brought in during rare extreme events?

<u>Research elements</u>

Geologic mapping:

- Map the distribution of alluvial and other surficial deposits.
- Determine the linear extent of stream channel bordered by alluvial deposits.
- Compile existing mapping of bedrock geologic formations.

Core drilling:

- Obtain representative core samples from soils and saprolite over different bedrock types, outside of the riparian zone
- Obtain core samples representative of alluvial deposits throughout the Mechums River basin.
- Obtain core samples from SFRR and from the Lickinghole Creek, Beaver Creek and Lake Albemarle impoundments.

Erosion susceptibility mapping:

- Using a standard testing methodology, measure erodibility of soil/saprolite profiles associated with representative geologic, slope and land cover regimes within the watershed.
- Create erosion susceptibility map on the basis of empirical data on erodibility, and soils, geology geologic and land cover mapping.
- Compare derived erodibility factors with published indices of erodibility, in order to develop correlations and allow extrapolation to other areas.

Determine the role of major storm events in sediment transport:

- Measure turbidity, suspended load, and bed load within the SFRR basin during bank-full weather event(s).
- Data points should include stations in the lower, middle & upper main stem Mechums River plus second & third order tributaries.
- In addition, measurements should be performed immediately below the SFRR dam.

Monitoring:

- Establish a network of graduated stakes to be used to directly measure over time, the erosion rates of stream channels, stream banks, riparian zones, alluvial flood plains, and basin uplands.
- Monitoring sites should be selected to reflect a representative variety of geology, slope and land cover.

Analysis:

- Use mineralogical data from cores to track provenance of sediment, and, in consideration of erosion susceptibility mapping, delineate areas of the watershed that are potentially the greatest contributors of mobilized sediment.
- Use monitoring data to refine erosion susceptibility mapping, and to evaluate the effectiveness of sediment mitigation strategies.
- Evaluate sediment transport data in order to determine the trapping efficiency of reservoir. Use this information in determining the utility of installing a sluice at

the SFRR dam to allow flushing of suspended load during and following major wet weather events.

Economics of Sediment Containment Strategies

Ultimately, it is going to be necessary to assess sediment containment strategies in terms of relative costs and benefits. Planners will need to examine various approaches (riparian buffers, steam bank stabilization, flood plain management, forebays, etc), not only within the context of information produced by the above study, but also in the context of other alternatives that have been proposed to address future water supply needs. In order to perform such an evaluation, it will be desirable to attempt cost and benefit analysis of each strategy. Because of the difficulties in measuring downstream environmental benefits, calculation of traditional benefit/cost ratios and internal rates of return is not feasible.

One approach that could be used would be to rank and compare the alternative sediment mitigation strategies on the basis of cubic yard of contained sediment per dollar expenditure. Cubic yards of sediment can then be converted to gallons of reservoir water gained per dollar expenditure. Sediment Another factor that weighs into the downstream benefits that accompany reduced sediment load is the cost of water treatment at the SFRR intake and treatment facility. Foster and others (1987) found that a
10% reduction in annual gross soil erosion resulted in a 4% reduction in annual water treatment costs.

Practical Focus of the Proposal:

In order to secure funding, it is important that a research proposal to address the sedimentation issue have a practical focus aimed at producing usable information in a timely fashion. The research outlined above could be carried out in concert with field testing of actual mitigation strategies. For example, sediment contribution rates could be measured for vegetated riparian buffers of various compositions widths, and for different land covers on alluvial flood plains. This would provide information of immediate and practical use to land and water planners and managers. In identifying specific sources of sediment deposited in the SFRR—and evaluating the relative importance of these various sources, the program will enable planners to apply land management and conservation measures the most cost effective manner.

The proposed study has the potential to contribute workable tools with which to manage the sedimentation problem, both within the SFRR watershed and beyond. Although the study would focus on a small portion of the Virginia Piedmont, the information developed will have high transfer value to many other local and regional watersheds. Sedimentation is a prime water quality concern for the entire Chesapeake Bay watershed and, more broadly, throughout the Piedmont of the southeastern US.

Framework for carrying out the proposed research:

The proposed research involves gathering and analyzing technical data having to do with geology and hydrology, in conjunction with installing and monitoring pilot mitigation practices. There are activities where considerable technical sophistication will be required, and other activities that could be carried out by relatively untrained individuals. While some research elements may produce useful information within a relatively short time period, some activities, such as erosion monitoring and assessing the effectiveness of sediment mitigation practices, will need to be carried out over periods of years. Outside funding sources should be sought, but *long term commitment of local resources will be essential in order for the project to succeed*.

It seems appropriate that an existing local institutional entity, or partnership of local entities, serve as umbrella to orchestrate the project. The umbrella organization(s) would secure funding and manage the project, bringing in technical expertise and manpower as indicated from local, State and Federal government agencies, private sector consultants, and citizen groups. Existing institutional entities that could logically provide project oversight include:

Rivanna Water and Sewer Authority
Albemarle County Engineering Department
Thomas Jefferson Soil & Water Conservation District.

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COUNTY OF ALBEMARLE

DEPARTMENT OF ENGINEERING & PUBLIC WORKS

MEMORANDUM

TO: Alyson Sappington, Thomas Jefferson Soil and Water Conservation District

FROM: Stephen Bowler, Watershed Manager

DATE: 10 August 2000

SUBJECT: Request for Assistance /Cooperation on the Streambank Sediment Issue

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As you know, sedimentation is a problem in Albemarle County and the Central Piedmont of Virginia region in general. Locally, the South Fork Rivanna Reservoir (SFRR) is filling at a rate of 13 million gallons per year. This loss of capacity is a major impetus for the Charlottesville/Albemarle community's water supply search process. Many of the options under consideration in the water supply search process involve continued use of the SFRR. The sediment problem in the reservoir is going to remain an important issue. At the same time, sediment deposition also damages the biological communities of area streams. On a regional scale, sediment is a major pollutant to the Chesapeake Bay.

The recent draft James River Tributary Strategy reports that sediment loads in the James River basin, and particularly the Central Piedmont of Virginia, are disproportionately high. The authors suggest that much of the sediment may be coming from the stream valleys (where it was deposited during earlier periods of deforestation and intensive agriculture) rather than from the wider landscape. Studies have found the proportion of stream sediment attributable to streambank sources to range from values as low as 5% to more than two thirds of the total load. We don't know what the proportion is in our region. If the proportion falls at the higher end of the scale, the impact of traditional, landscape-oriented BMP implementation may be less than previously hoped and other strategies to reduce sediment loads may be needed.

As a county it is important for us to understand the relative contribution of the streambanks versus the general landscape to the total stream sediment load. However, studying the problem is a large task best addressed on a regional scale. I hope that the soon-to-be-formed Water Resources Advisory Committee (WRAC) and the TJSWCD will consider assisting us in developing a plan to study streambank erosion. One possible first step would be to gather together some of the technical experts on the topic for a "sediment summit" in the fall of 2000. At such an event we could consider the general problem, possible methods of study, and potential funding sources. Please share this request with the new committee and your Board of Directors. I look forward to any thoughts from the WRAC and TJSWCD on the topic.

SB/nh

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