INDEPENDENT TECHNICAL REVIEW TEAM
RAGGED MOUNTAIN DAM

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Independent Technical Review Team
Ragged Mountain Dam Design and Construction

1.0 Introduction

This letter Report summarizes the findings and recommendations developed in the first meeting of the Independent Technical Review Team (ITRT) held on March 10, 11, and 12 in Charlottesville to assess the status of the design and planning associated with the new Ragged Mountain Dam. During the meetings on March 10 and March 11, 2009, the ITRT heard presentations by Gannett Fleming, Inc. on the status of the design and the basis of the cost estimates and by Schnabel Engineering regarding their limited assessment of the Gannett Fleming, Inc. design and cost estimate. The ITRT visited the dam site and inspected select rock cores on March 10, 2009.

The primary objective to be addressed by the ITRT is to advise Rivanna Water and Sewer Authority (RWSA) as to how to minimize the construction cost of the Dam while achieving the Project's fundamental goals of realizing best value for money, assuring dam safety, minimizing environmental impacts, minimizing local community impacts including the impact on the local access road, Camp Holiday Trails, local residents and the Highway I-64 embankment, assuring long term performance of the structure and providing the capability to impound useable storage of 2.19 billion gallons of water.

The ITRT has organized this report into five (5) main topics and a series of subtopics for consideration by Rivanna.

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2.0 Contractual, Administrative and Project Management Issues

2.1 The Design Engineer

The Project must have a Designer, whose duties and responsibilities will cover a wide range of activities as detailed in subsequent sections. The work of the Designer, Gannett Fleming, is currently suspended and, notwithstanding the initiative involving the ITRT, the Project is not advancing. The ITRT strongly recommends that design-related work be resumed as a priority. If, for no other reason than to allow accurate cost estimating of the favored option (or options) to commence, RWSA may elect to resume operations with Gannett Fleming or to procure a new Designer. The ITRT observes that, with the notable exception of the "high budget estimate" issue which arose in August 2008, the work done to date is of satisfactory quality and has in fact progressed logically to a 25% complete stage, when judged in aggregate. Furthermore, the acquisition of a new Designer would further delay the Project by several months and result in inevitable "start up" inefficiencies by the new Designer.

2.2 Contractor Procurement Process and Contract Organization

There are currently two schools of thought regarding how the Project should be bid:

- As one contract, with a number of subcontracts,
- As two or more standalone contracts, each focusing on its own specialty, or group of specialties.

In very simple terms, this Project involves the following major groups of activities:

- Foundation stripping, dewatering and surface preparation.
- Rock grouting and other cutoff activities.
- Constructing the dam.

Every Project has its own unique set and balance of risk factors which impact the design, construction, and performance of the dam and, of course, it is these very factors which also govern the cost. While not wishing to downplay other factors which are very important (for example the ***Logistical Issues*** detailed in Section 4), the ITRT believe that the main risk factor is the variability of the subsurface conditions and, in particular, the elevation at which the rock of suitable quality for building the dam on is reached. Therefore the contract, or contracts, must be set up in a way which most efficiently and responsively addresses and shares risks associated with the site conditions.

In addition, the ITRT recommends that any and all contractor(s) be pre-qualified for their specific project tasks. This will assure a level of construction quality meeting the site and project requirements and enable selection of the lowest responsive bid for construction of the dam.

The ITRT note the following pros and cons of the two basic alternative approaches:

	One Contract	Two or More Contracts
Pros	• No contractual interface between successive main contractors. • Continuity of project management.	• More chance of having "best in class" contractor. • Contracts easier to control and budget.
Cons	• Contractor will mark-up subcontractors. • No "firewall" if early tasks turn sour. • May not obtain the best specialty subcontractors.	• Owner must manage multiple contractors. • May extend construction period. • May create conflicts between contractors.

On this Project, the approach selected must be consistent with the need to primarily manage the geological risk. If a multiple-contract system were to be used, the second, (RCC) contractor, would be presented with a fully-excavated, treated, dewatered, and grouted site upon which to build the dam. The selection of the approach should wait until after the project design is further developed.

2.3 Site Assessment during Excavation and Treatment

The ITRT recommends that representatives of the Designer be present full time on site during the site preparation phase to "sign off" on the depth and adequacy of this operation in real time. These field representatives would comprise at least one engineering geologist and one dam design engineer. This will remove disputes or uncertainties about quantity or suitability of work, and will prevent the design from being driven by fear of claims. In this regard, although the Designer's best estimate of "excavation elevation" must be shown in the contract documents (the accuracy of which will reflect the intensity of the site investigation), sufficient flexibility must be maintained in the contract documents and schedule of rates to ensure that the geological risk is not passed on to the excavation contractor, insofar as quantity of excavation is concerned.

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The ITRT notes that it is common to allow drilling and grouting to commence only after the rock surface has been fully cleaned and treated in any one area. However there may well be a case, given the geological heterogeneity of the Project, to conduct the drilling and grouting after the initial cleaning and leveling, thereby enabling the results of the drilling and grouting to be used to more closely define final excavation and treatment limits.

3.0 Technical Issues

3.1 Roller Compacted Concrete (RCC) Dam Design

The RCC Dam design is in the very early stages of development and subject to change as part of the natural evolution of the engineering process. For example, the ITRT would expect the Dam to have a gallery, crest-to-gallery drains, foundation drains and facings consistent with the climatic conditions and aesthetic qualities of the Dam site. Also, consideration should be given to a steeper downstream slope of the Dam, as the current 0.8:1 slope may not be necessary depending on which load cases are driving the design, and to optimization of spillway width.

The Gannett Fleming 30% design drawings currently show a conventional concrete stepped downstream face which the ITRT considers quite satisfactory and attractive. For the upstream face, the 30% drawings show precast concrete panels with an attached geosynthetic liner. This is a technically acceptable approach, but the ITRT expects that alternative approaches may allow for the same performance at a lower cost. Facing decisions should be made after completing evaluation of alternatives, considering overall best value for the RCC dam.

3.2 RCC Mix Design

The RCC Mix Design has not yet been developed for the Project and the Mix Design performance criteria are not yet specified. The mix design is a key factor that influences the cost of RCC and therefore, the ITRT recommends that this aspect of the design proceed over the next six months. It is recognized that the borrow source for the aggregate must be defined before this work proceeds, as discussed below in Section 4.1.

3.3 RCC Test Pad

Gannett Fleming and Schnabel agree on the need for an RCC Test Pad. Schnabel says that a pad costing $300,000 is not necessary. The ITRT also supports construction of a test pad, but suggests that the RCC Test Pad could be constructed as one of the early tasks by the successful contractor after he has mobilized to the site and has aggregate available from the designated source. The RCC Test Pad should use the selected facing systems, designated forming systems, selected water stops and jointing system and the designed bedding mix. Diamond saw cuts should be included in the Test Pad program to verify compaction procedures, lift thickness, facing system quality and overall craftsman work quality. Indeed, the Test Pad should be used for training local labor in the intricacies of RCC construction.

3.4 Dam Foundation

Review of the site characterization presented by Gannett Fleming and Schnabel in Project documentation and in this meeting has led the ITRT to an initial evaluation of the foundation for the proposed Dam on the planned alignment. In the opinion of the ITRT, the Dam can be founded on the bedrock located beneath the soil and weathered bedrock that can generally be removed with conventional earth moving equipment. Once grouted, the deeper weathered bedrock zones should have little impact on the long-term safety and performance of the Dam, considering that some seepage is acceptable to the Authority.

The granite and granite-gneiss bedrock at this site, similar to other sites in the Piedmont Region, has undergone significant differential weathering and will have an irregular surface profile. Gannet Fleming's geotechnical engineers and engineering geologists should emphasize to the dam designers and to the contractors bidding the Project that the excavation, cleanup, and treatment will involve considerable detailed excavation with a variety of equipment, including hand excavation, to properly prepare the foundation. Grouting of the foundation will require competent, pre-qualified grouting specialists and excellent Project specifications. This should be considered in preparation of the Project documents and construction observation procedures.

3.5 Alternative Dam Alignments

Gannett Fleming has identified a dam location and dam type based on site consideration and conditions. It is understood that the current alignment was set by assuming the existing Dam and the existing control structures downstream of the existing Dam are to remain operational during construction, and the crest length of the new Dam is to be minimized. Minor adjustments to the current dam alignment could be considered if foundation conditions in other parts of the valley are superior and result in a less costly Project. Such alignments were discussed during the ITRT meeting by Gannett Fleming and Schnabel, as well as amongst the ITRT members. Foundation conditions on the left abutment may improve upstream of the planned alignment, based on the MASW results along Section E-E and the existing dam performance. This assumption could be economically checked by performing additional geophysical testing on the left valley slope, upstream of the currently planned alignment.

3.6 Investigations

Gannett Fleming has performed a significant amount of field investigations that have led to a general understanding of the foundation conditions beneath the current alignment. This understanding has been addressed in the ITRT meeting by both Gannett Fleming and Schnabel. Additional field investigations should be considered for developing the final alignment of the dam and for preparing the design plans, specifications and bidding package.

It is understood that Gannett Fleming has proposed additional investigations to further define the weathering conditions of the bedrock, consisting of additional borings and downhole geophysics testing. In the opinion of the ITRT, another, different approach should be considered.

Initially, the field investigations should further develop the existing data by performing field mapping and engineering geology interpretation of the new dam site. An experienced field engineering geologist with more than 10 years of dam foundation investigation and evaluation should perform this task. This mapping should consider the performance of the existing Dam, its construction photographs and observed seepage downstream of the Dam. Strikes and dips (discontinuities) of many additional joints, fractures and foliation planes can be measured on outcrops in and near the dam footprint. These should be plotted on a stereo net to enable visual identification of major rock structures, as well as the scatter of the data. This additional geologic investigation can lend understanding to the persistence and location of weathered bedrock conditions between borings.

Together with the engineering geology mapping, the upper 25 to 30 feet of the core should be classified by the Rock Mass Rating (RMR) method, in addition to the ASCE rating that Gannet Fleming has used. The RMR is more commonly used than ASCE classification and has more universal understanding.

Test pits can be used to develop further understanding of the depth to bedrock that is suitable for foundation and, at the same time, the irregularity of the bedrock surface that is likely to exist as the construction contractor excavates for the foundation. It can give the designer the understanding to define the bedrock condition (strength, weathering, quality) for preparing the design parameters and subsequently the foundation excavation depths and preparation criteria. It will be important to have an understanding of difficulty that the contractor will experience in excavation and cleanup of the foundation surface, as well as the preparation required for grouting, leveling concrete and dental concrete placement, and for RCC placement.

The existing test pits were excavated with a small tracked backhoe, making relatively narrow and shallow excavations for observation and mapping. The next phase of test pit exploration should use a backhoe similar to one that may be used for excavation of the dam foundation, such as a Caterpillar Model 315 backhoe. The test pits should be at least 2 bucket widths wide and extend over lengths of up to 100 feet. They should be large enough to be considered test trenches. Once excavated and investigated, the test pits can be backfilled after sufficient data have been recorded to enable understanding of the subsurface conditions by the design engineers, and by the contractors bidding the Project. Example test pit locations are presented below.

Approximate Location	Orientation	Length	Recording
Valley bottom, axis (7+00 to 8+00)	Parallel to axis	50 Feet	Surveying/logging/photos
Valley bottom, axis (7+00 to 8+00)	Normal to axis	50 Feet	Surveying/logging/photos
Left valley, mid slope (9+00 to 11+00)	Parallel to axis	100 feet	Surveying/logging/photos
Right valley, mid slope (4+00 to 6+00)	Parallel to axis	100 feet	Surveying/logging/photos
Valley bottom, dam toe (7+00 to 7+50)	Normal to axis	40 feet	Surveying/logging/photos

Additional geophysical methods and borings could be considered in specific areas for additional information, after geologic mapping and test pits have been completed. At this time, the ITRT does not consider these to be needed, but would like to participate in discussions for the additional geophysics and borings, if planned.

An overall evaluation of the site geology can be improved by performing a linear analyses of geologic structures from Remote Imaging data sets. LiDAR imagery, satellite photos, stereo-pair photos can all add to an engineering geologist's capability to characterize the site.

3.7 Observation During Construction

As discussed in Section 2.3, determination of foundation levels during construction should be made by experienced professionals observing the excavations and having detailed knowledge of the dam design and the site geology. Such professionals should be able to make evaluations of the exposed foundation materials and provide suggestions for further excavation, additional explorations, and completion of excavations to meet design requirements.

3.8 Drilling, Grouting and Cutoff

The ITRT confirms that the preliminary "wing" cutoff concept recently developed by Gannett Fleming should be abandoned. This concept is unusual in the extreme and not cost effective. While sharing Gannett Fleming's concern about the potential for seepage induced erosion through the abutments at the left and right extremities of the Dam, we believe the risk can be adequately managed by appropriate excavation, and drilling and grouting practices, supplemented, if necessary, in particularly deeply weathered areas, by "spot" treatments involving deeper excavation and backfilling. In addition, as sketched by Schnabel Engineering at the meeting (see attached Figure 1), the width of the abutment ridge comprising of overburden overlying extremely hard rock is equivalent to that of a typical earth fill dam. We see no inherent problem in this regard.

The ITRT recommends that a grout curtain be installed under the Dam and across its abutments, a length of about 1,400 lin. ft. The curtain would comprise angled holes and would generally extend about 60 feet below rockhead. Primary grout holes would extend deeper to provide additional exploration. Two rows would be used under the control part of the Dam (approximately 600 lin. ft.), and at particularly poor areas on either side. This curtain should be engineered to the highest practical qualitative standards, and must be implemented by a properly experienced and resourced specialty contractor.

Particularly deep zones of weathering identified by the drilling and grouting may have to be excavated and concreted.

Alternatively, some type of jet grouting may be found useful in deeply weathered areas. Bearing in mind that the fine-medium sand and silts infilling certain fissures may not be amendable to balanced Type III grouts, studies should be conducted towards establishing their critical gradients capable of causing erosion under service conditions. In this regard, it should be noted that the rock mass fissure sets appear to have considerable variation in width, direction and tortuosity. There is no evidence, as yet, of any major structural faults (as opposed to joints) which would require special attention.

3.9 I-64 Embankment Issues

The highway fill for the I-64 highway at mile post 116 is about 140 feet high and will be inundated to depths of about 25 and 40 feet for the normal high water level and the 100 year flood level, respectively. The highway has been evaluated by Gannett Fleming and mitigation alternatives have been developed.

Little information has been found on the design and construction of the highway fill; however, investigations indicate that the fill is principally an excavated rock fill with fragment sizes ranging up to cobble and boulder size. It is capped by fine grained earthfill and underlain by shallow alluvium and residual soils with bedrock at depths of 10 to 15 feet below the fill. It is understood that up to about 2 feet of settlement have been observed in the culvert near the center of the embankment. It may be valuable to compare the design grades of the fill with surveyed grades to evaluate the amount of settlement that has occurred in the fill and foundation soils since the construction of the fill in the 1960's. This could be accomplished by obtaining a current survey of the fill surface in an area of grade control used during construction and comparing it to the design grades. Analyses by Gannett Fleming show that the fill will perform well under the loading of the planned inundation, up to the 100 year flood level.

It is understood that VDOT desires to achieve visual inspection of the culvert beneath the fill on a regular basis and has suggested alternatives, such as a new culvert located at the normal water level, that are very expensive. The ITRT suggest that there are other technologies available at less cost that should be evaluated.

In the opinion of the ITRT, the approach to selecting an alternative for mitigation of the inundation should be based on the normal pool and 100 year flood levels. The mitigation should be designed to meet performance criteria of VDOT.

As mentioned in Section 5.0 of this Report, the ITRT suggests considering that this component of the work be performed by a "local" engineering firm with a history of working with VDOT, and an understanding of their procedures and requirements.

4.0 Logistical Issues

4.1 Source of Aggregate for RCC

The ITRT understands that the current Gannett Fleming design will require about 225,000 tons of processed aggregate and over 10,000 tons of flyash for use in the RCC mix. The flyash will be sourced off-site and hauled to the site from one of several possible locations. On the other hand, the aggregate could be (1) sourced off-site and hauled to the site or (2) sourced from an on-site borrow area. Some of the major issues to be addressed with the aggregate source include the following:

- Truck traffic (at least 11,000 large truck loads) over local roads, including the site access road, during the period of less than one year.
- Location of the borrow area and the impact on local residents.
- An on-site borrow area will require site re-dress unless the borrow area is below the normal lower pool level of the new Ragged Mountain Reservoir.
- Impact on schedule of RCC mixing and RCC quality if an off-site source is used (presumably an on-site source would be developed on a schedule and quality basis consistent with the RCC placement schedule and be under direct control of the RCC contractor).
- Schedule and issues associated with local permitting, if any.

The ITRT recommends that the potential on-site borrow sites be further evaluated and that this issue be addressed in the near term, as the source of aggregate is a key factor in the cost and schedule for the Project. Furthermore, the design of the RCC mix cannot proceed until the aggregate source is defined and samples are made available for crushing tests and laboratory strength tests of the RCC. Defining the source will require field investigations that should be conducted within the next six months.

4.2 Access Roads and Safety

It is clear that providing safe traffic routes to and from the site will be a major logistic challenge given the projected traffic usage and the status of the existing roads and bridges. Long and heavy vehicles and trailers will be necessary for the mobilization and demobilization of the major equipment items, while the delivery of the RCC material components will necessitate frequent journeys, probably round the clock, of smaller trucks. In addition, there will be a significant increase in traffic caused by personnel vehicles due to the substantial work force which will be employed. This work force will also require designated parking areas.

The ITRT therefore recommends that the Designer finalize construction access concepts so that the nature and cost of the required improvements can be quickly identified and communicated to all stakeholders. This plan must also specifically address the issues of the Camp Holiday Trails and other educational facilities in the area.

4.3 Lowering of Lake Level during Construction

As noted in Section 6.0, it may well be advantageous to the Project to have the lake lowered during construction (while, of course, still providing sufficient storage capacity to satisfy RWSA's commitments). Lowering the lake would facilitate spoils disposal and handling, and provide more scope for staging and on-site borrow areas. Such areas would be submerged upon reservoir raising following Dam completion.

From the technical viewpoint, lowering of the lake elevation would help reduce dewatering requirements during foundation excavation and will reduce the artesian condition which may be caused by the lake itself.

5.0 Schedule and Sequencing Issues

5.1 Overall Construction Schedule

The original schedule for the Project called for the Dam to be completed by 2011 to allow for reservoir filling in the fall of 2011. The ITRT advises that, with the current hiatus in the design work and the overall uncertainty of the geotechnical/geological conditions, as discussed in this Report, Rivanna should plan for a later completion date, perhaps as late as late 2012 or early 2013.

5.2 Permitting Process and Schedule

The ITRT suggests that a permit schedule be developed that allows for an assessment of the remaining permit flow path, including all of the local permits, even though many may be the obligation of the construction contractor. The ITRT is particularly concerned with the permitting requirements for site borrow areas, air quality permits, dewatering, stream diversion, stream crossings, erosion and sediment control, noise control, working hours, wide loads, and the like.

5.3 Near-term Objectives: Summary

The ITRT recommends that, to meet the overall project schedule, several items should be completed within the next six months. Those items are as listed below:

- Geologic mapping and site interpretation.
- Field exploration by test pits and geophysics.
- Reclassification of the core samples into the RMR classification system.
- RCC aggregate and flyash identification and evaluation.
- Traffic and site access issue identification and evaluation.
- Development of permitting schedule.

6.0 Risk Management and Potential for Cost Reduction

At several places in this Report, the concept of risk management has been discussed, since it impacts on the design, the construction, the performance and the cost of the Dam. In broad perspective, the project is neither especially difficult, nor large, and the foundation conditions can be managed using appropriate, reliable, well known methodologies. Another very important positive is the fact that, due to the national economic situation, construction prices have stopped escalating and in fact may even be falling from those in the summer of 2008 in certain areas. As noted in Section 2.0, design of the favored option, or options, requires further development before an accurate current cost estimate can be made. However, the ITRT offers the following broad suggestions for addressing risk management and the resulting cost savings potential:

- Revise the current conceptual design for the foundation excavation, surface preparation and seepage cutoff construction. In particular, the "wing wall" concept should be abandoned, in favor of more intense grouting, supplemented by removal/replacement in deeply weathered zones.

- Conduct further site investigation, but focused heavily on delineating rockhead elevations suitable for foundations. On this project, further expenditure on drilling may not be as cost effective or informative as investments in test pits or trenches, desk studies, field mapping and shallow geophysical investigations. As much of the foundation should be exposed as early as possible to assist in foundation evaluations.

- Create contract documents which allocate equably the risk of excavation and foundation treatment. Ensure strong on site, real time decision making by the Designer.

- Fundamentally reassess the location, shape, and composition of the dam, with due consideration for the sourcing of the RCC components.

- Consider making the I-64 highway embankment issue a separate parallel track project in terms of its design and construction.

- The overriding goal of the contractor procurement process should be to best match the contractor capabilities to the major work items and risk areas. In this regard, the choice of the contractor(s) involved in the foundation work will be critical. There are many ways in which the contracts can be delineated and created.

- Investigate potential advantages in lowering the reservoir during construction.

7.0 Closing

The members of the Independent Technical Review Team appreciate the opportunity to be of assistance to the Authority in this assignment and the hospitality extended to us during this meeting.

The next meeting, RM-2, will be scheduled in the near future.

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