

City of Charlottesville, Virginia  
Ragged Mountain Project

B&V Project 168539  
August 30, 2010

Ms. Lauren Hildebrand  
Director of Utilities  
City of Charlottesville  
Department of Public Works  
305 4<sup>th</sup> Street, N.W.  
Charlottesville, VA 22903

**Subject: Opinion of Probable Construction Costs for  
Modifying the Lower Ragged Mountain Dam  
Ragged Mountain Project**

Dear Ms. Hildebrand:

As requested by the City of Charlottesville (City), Black & Veatch prepared an Opinion of Probable Construction Costs (OPCC) for three feasible upgrade alternatives for the Lower Ragged Mountain Dam (LRMD). These upgrade alternatives include an approximate 45-foot increase to the reservoir level; a 13-foot increase to the reservoir level; and modifications to satisfy current Virginia dam safety regulations. This letter provides a brief description of the alternatives and assumptions supporting the OPCC.

**BACKGROUND**

In a July 30, 2010 letter to the City, Black & Veatch indicated raising the LRMD up to approximately 45 feet was feasible. The intention was to indicate that the Lower Ragged Mountain Reservoir level could be raised to Elevation (El.) 686 feet, therefore, providing a similar stored volume to the proposed new Ragged Mountain Dam (RMD). The necessary dam raise to accommodate this reservoir raise is approximately 51 feet. With proper design and construction, Black & Veatch believes the LRMD can be raised approximately 51 feet.

As requested, Black & Veatch prepared an OPCC for three separate alternatives for upgrading the LRMD. These alternatives include the following:

1. 45-foot Reservoir Raise (51-foot raise to the dam) – a 45-foot increase to the reservoir level that nearly equals the water storage volume of the envisioned new RMD.
2. 13-foot Reservoir Raise (19-foot raise to the dam) – a 13-foot increase to the reservoir level that equals the maximum increase before modifications to the I-64 embankment are considered necessary.
3. Limited Dam Raise – breaching of the Upper Ragged Mountain Dam (URMD) and modifications to the LRMD to satisfy current Virginia dam safety regulations and that restore historic water storage volumes.

Where appropriate, we referenced previous construction cost estimates to provide items of work, material quantities and unit prices to create as directly comparable an OPCC to the new RMD estimate as possible. Specifically, we referenced estimates from the following sources:

- Letter to Mr. Tom Frederick from Schnabel Engineering LLC regarding review of Gannett Fleming's RMD design and cost estimate dated September 19, 2008; and
- Preliminary Design Report (Appendix D), New RMD, Schnabel Engineering, LLC, May 14, 2010.

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There are other issues that could influence the configuration of the LRMD upgrade alternatives that were not incorporated at this time. These include the following:

- The recently signed Senate Bill 276 provides for a reduction in the magnitude of the maximum spillway design flood for dams constructed or permitted before July 2010. Prior to this legislation, the maximum spillway design flood, defined as the probable maximum flood (PMF), was the standard applied to the LRMD. Considering Senate Bill 276, the maximum design flood is redefined as runoff resulting from 90 percent of the probable maximum precipitation (rather than 100 percent). Therefore, the amount of water coming in to a reservoir will be less; and the spillway size necessary to safely manage the flow will be smaller. The spillway configurations assumed for the alternatives presented herein are, therefore, slightly larger than would be required under the current dam safety regulations.
- A July 27, 2010 memorandum from the Rivanna Water & Sewer Authority describes the methodology behind lowering the new Ragged Mountain Reservoir level about 3 ft while retaining the previously required storage volume. Development of a new stage-storage curve for the Lower Ragged Mountain Reservoir may indicate that a lower reservoir level is also applicable to the upgraded LRMD.

With further analysis, these items can be incorporated into the alternatives if desired by the City.

#### **ALTERNATIVE 1: 45-foot Reservoir Raise (51-foot LRMD Raise)**

Alternative 1 was developed based, in part, on information from several sources including:

- Report, Feasibility Study Upgrading the Ragged Mountain Dams, Gannett Fleming, February 28, 2003 (note that there were several missing appendices);
- Memorandum, Concept Development – Ragged Mountain Reservoir Expansion, Gannett Fleming, February 16, 2005; and
- Letter to Mr. Tom Frederick from Schnabel Engineering LLC regarding review of Gannett Fleming's Ragged Mountain Dam design and cost estimate dated September 19, 2008.

The existing LRMD dam crest elevation is about El. 644. With an assumed new reservoir level of about El. 686, the upgraded LRMD crest elevation is expected to be about El. 695 based on previous studies. The 51-foot dam raise considers installation of post-tensioned anchors through the existing dam to improve short-term stability; removal of the earth buttress; foundation excavation; foundation preparation and grouting; and construction of a downstream raise using roller-compacted concrete (RCC). Sketches of the configuration are provided in Attachments A and B. Black & Veatch performed very limited stability analyses supporting this alternative and no other analyses were completed by Black & Veatch. Rather, we referenced results from previous studies where needed.

Some specific elements of Alternative 1 are described below.

- Based on our review of the available subsurface data, a traditional gravity dam section is considered to be stable assuming a 0.8H:1V downstream slope.
- The alternative considers installation of post-tensioned anchors through the existing concrete dam crest in to the underlying bedrock. When installed, these anchors will allow removal of the existing earth buttress while maintaining a useable reservoir level. The anchors would also be extended through the dam raise to tie the RCC to the existing dam to aid in overall stability.

- On the left abutment, a reasonable foundation surface for a relatively short gravity dam was assumed at an average depth about 15 feet below ground surface. Although there are rock outcrops in the area, no supporting subsurface information was available.
- Along the right abutment, the depth to a reasonable foundation surface for a gravity dam could be up to 45 feet below ground surface. To avoid significant excavation, the RCC gravity section was truncated and a traditional zoned earth dam section used to complete the right abutment.
- Previous studies identified the potential for seepage around the dam and through the abutments. Although Black & Veatch did not evaluate the likelihood, a line item of \$400,000 was included in the OPCC to address potential abutment seepage.
- The new principal spillway is shown as 100-ft wide with an ogee crest.
- The existing outlet tower will be modified to accommodate a 45-foot rise in the reservoir level. The specific modifications needed to the tower controls and outlet pipe were not developed. In a 2003 feasibility study for upgrading the LRMD, Gannett Fleming indicated a \$42,000 line item for improvements to the outlet works. This estimate was increased to \$100,000 to accommodate a larger tower raise and escalation.
- Alternative 1 also considers road improvements to the existing access road and Reservoir Drive. Without specific information regarding the details behind these improvements, the Alternative 1 OPCC includes the same items and values as presented in the May 14, 2010 Preliminary Design Report.

The OPCC was developed by dividing the project into numerous items and pricing each item through a single lump sum amount or estimating quantities and unit prices. For ease of comparison, appropriate items, unit prices, and lump sum costs from previous cost estimates were used in preparation of the Black & Veatch OPCC. The OPCC is calculated assuming 2010 dollars without escalation.

For projects at this level of definition (less than 15 percent), the expected accuracy range for an OPCC is between -15 percent and +20 percent on the low side and -30 percent to +50 percent on the high side. This is in accordance with a Class 4 estimate as defined by AACE International Recommended Practice No. 18R-97. Given the level of effort by others in developing items of work and unit prices, Black & Veatch assigned an accuracy of -10 percent to +30 percent to the OPCC.

The OPCC shown in Attachment C indicates a range of construction costs from \$12.7M to \$18.3M with engineering and construction administration costs of about \$3.1M. Similar to previous estimates for the new RMD, this cost range does not consider costs associated with environmental restoration or modifications to the I-64 embankment.

#### **ALTERNATIVE 2: 13-foot Reservoir Raise (19-foot LRMD Raise)**

Similar to Alternative 1, Alternative 2 was developed based on information provided in the several sources mentioned above. A 13-foot rise in the reservoir level, to about El. 654, was identified by the City as a point of interest because it corresponds to the largest increase without requiring modifications to the I-64 embankment.

A normal reservoir level of El. 654 will require a new dam crest of about El. 663 assuming a 100-foot wide principal spillway. The major elements of this alternative are similar to those for Alternative 1. Some specific elements of the configuration are described below.

- Based on our review of the available subsurface data, a traditional gravity dam section is considered to be stable assuming a 0.8H:1V downstream slope.

- The alternative considers installation of post-tensioned anchors through the existing concrete dam crest in to the underlying bedrock. When installed, these anchors will allow removal of the existing earth buttress while maintaining a useable reservoir level. The anchors would also be extended through the dam raise to tie the RCC to the existing dam to aid in overall stability.
- A reasonable foundation surface for a relatively short gravity dam was assumed at a depth about 5 to 10 feet below ground surface for the left abutment and 10 to 15 feet for the right abutment.
- The new principal spillway is assumed to be 100-ft wide with an ogee crest. Without updated hydrologic and hydraulic calculations, a revised spillway width can not be reasonably developed. Therefore, although Alternative 2 is smaller, the same spillway scheme was assumed for cost estimating purposes.
- The existing outlet tower will be modified to accommodate a 13-foot rise in the reservoir level. The specific modifications needed to the tower controls and outlet pipe were not developed. In a 2003 feasibility study for upgrading the LRMD, Gannett Fleming indicated a \$42,000 line item for improvements to the outlet works. This estimate was increased to \$100,000 to accommodate escalation.
- Alternative 2 also considers road improvements to the existing access road and Reservoir Drive. Without specific information regarding the details behind these improvements, the Alternative 2 OPCC includes the same items and values as presented in the May 14, 2010 Preliminary Design Report for the new RMD.

The OPCC for Alternative 2 was developed by dividing the project into similar items as listed for Alternative 1. Appropriate items, unit prices, and lump sum costs from previous cost estimates were used in preparation of the Black & Veatch OPCC. The OPCC is calculated assuming 2010 dollars without escalation.

As mentioned under Alternative 1, Black & Veatch assigned an accuracy of -10 percent to +30 percent to the OPCC. The OPCC shown in Attachment D indicates a range of construction costs from \$7.1M to \$10.3M with engineering and construction administration costs of about \$1.7M. Environmental restoration is not considered in this estimate and modifications to the I-64 embankment are not required.

### **ALTERNATIVE 3: Limited LRMD Raise**

The limited LRMD raise alternative satisfies the current Virginia dam safety regulations. Currently, the Upper and Lower Ragged Mountain Dams have significantly undersized spillways. To address these concerns, the URMD will be breached and decommissioned resulting in a single Ragged Mountain Reservoir. The LRMD will be upgraded to safely manage the required spillway design flood.

In February 2003, a report entitled *Feasibility Study for Upgrading the Ragged Mountain Dams* presented several alternatives for addressing the undersized spillway at the LRMD. Black & Veatch reviewed each alternative and believes that the most economical and safe approach to increasing spillway capacity is through construction of a side-channel spillway. The crest of the upgraded dam and spillway will be about El. 656 and El. 644, respectively. The new reservoir level will be set about 3 feet higher than the current reservoir level in order to regain lost storage from breaching the URMD. The alternative is described in greater detail on Pages 66-68 of the 2003 study.

The OPCC for Alternative 3 was developed by reviewing the estimate prepared in 2003 and preparing a revised list of lump sum and unit priced items that constitute the project. Appropriate items, unit prices, and lump sum costs from previous cost estimates were used in preparation of the Black & Veatch OPCC.

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As mentioned under Alternative 1, Black & Veatch assigned an accuracy of -10 percent to +30 percent to each OPCC. The OPCC is calculated assuming 2010 dollars without escalation. The OPCC presented in Attachment E indicates a range of construction costs from \$4.4M to \$6.3M with engineering and construction administration costs of about \$1.1M. Environmental restoration and modifications to the I-64 embankment are not considered necessary for this alternative.

The alternatives presented in this letter were developed based on previously completed studies. Additional studies are needed to verify several major elements of the alternatives including the spillway dimensions and the need for extending the anchors in to the dam raise.

Should you have any questions or need clarification, please do not hesitate to contact me at 301-921-8244 or at [zamenskyg@bv.com](mailto:zamenskyg@bv.com).

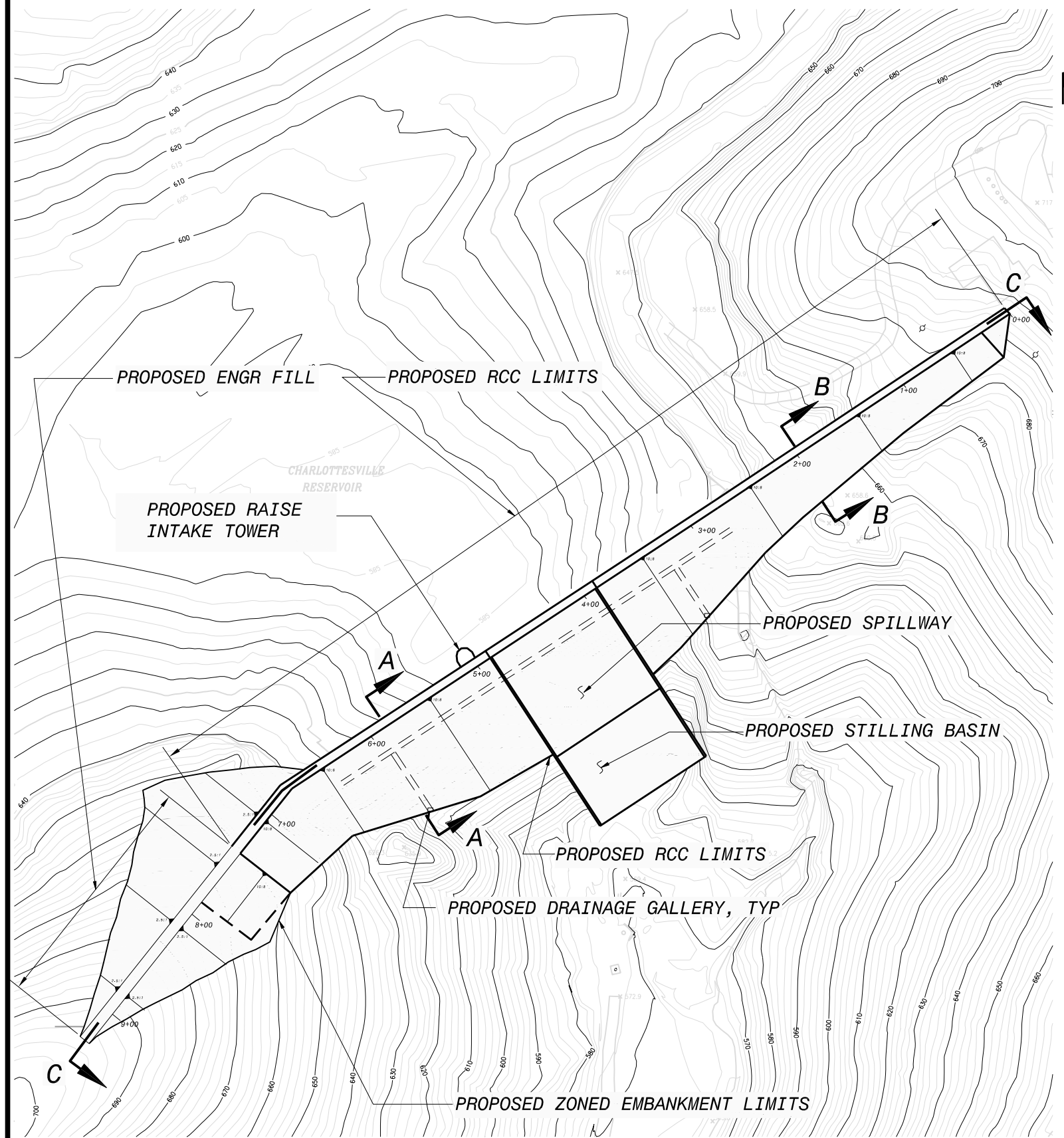
Very truly yours,  
BLACK & VEATCH



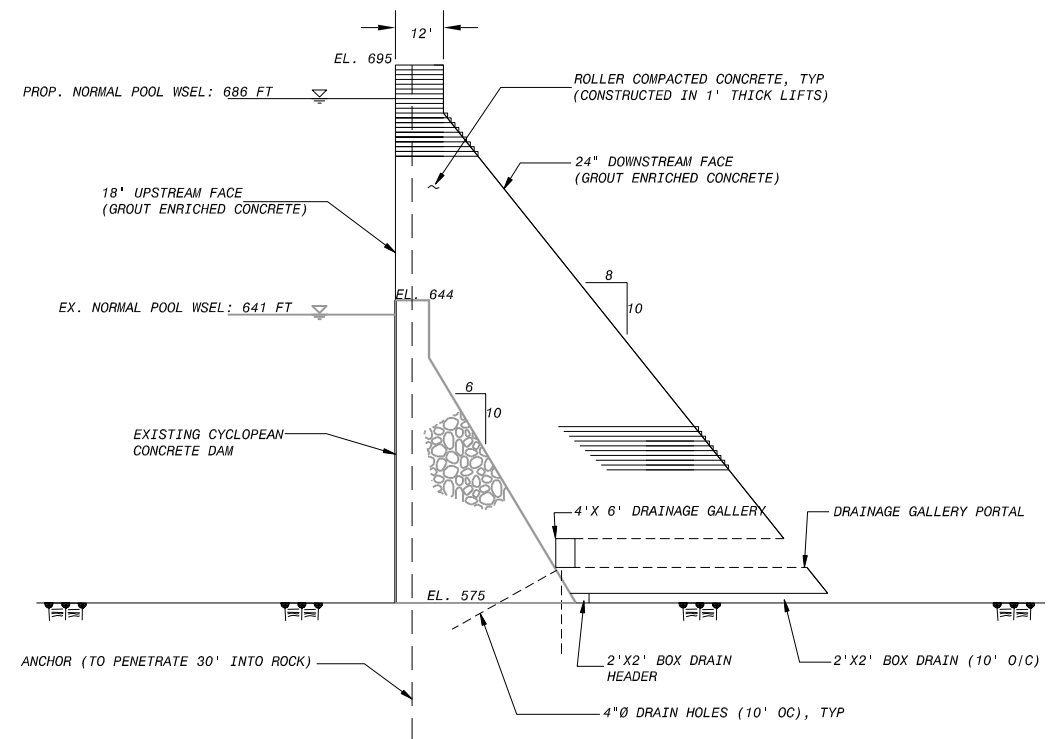
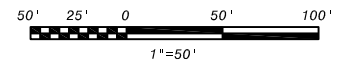
Gregory A. Zamensky, P.E.  
Regional Practice Leader  
Dams, Levees and Reservoirs Practice

Attachments    A – Plan and Sections of Alternative 1  
                      B – Profile of Alternative 1  
                      C – Alternative 1 OPCC  
                      D – Alternative 2 OPCC  
                      E – Alternative 3 OPCC

cc:       File  
          Rich Gorny, Black & Veatch  
          Doug Brinkman, Black & Veatch

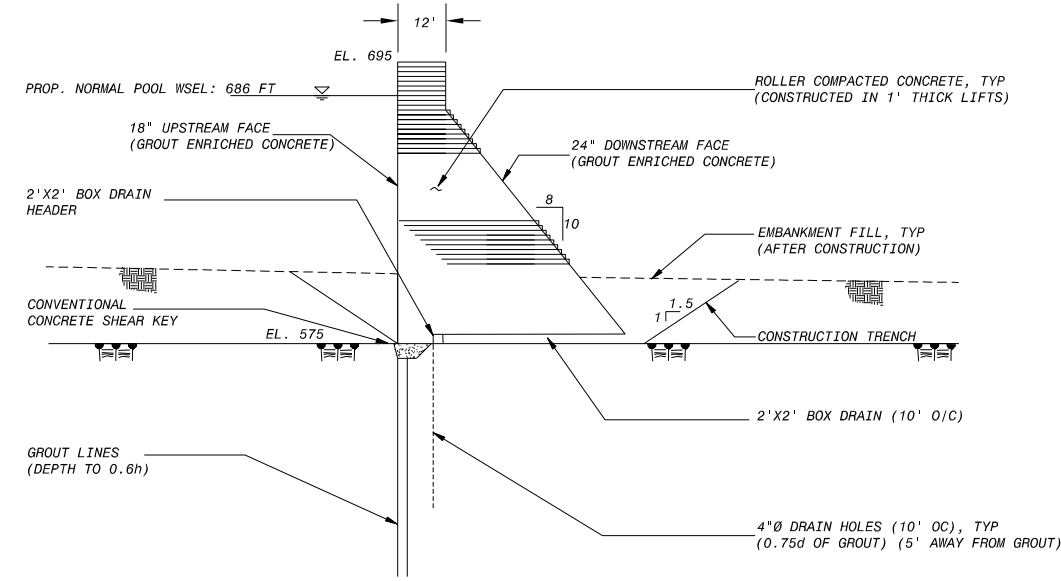


**PLAN**



**SECTION A-A**

PROPOSED CS ALONG EXISTING CYCLOPEAN DAM



**SECTION B-B**

PROPOSED CS ALONG PROPOSED ABUTMENT EXTENSION

NO.	BY	CHK	APP

DATE	REVISIONS AND RECORD OF ISSUE	DATE	BY	CHK	APP

**BLACK & VEATCH**  
 Black & Veatch Corporation  
 Gaithersburg, Maryland

RAGGED MOUNTAIN DAM STUDY

ALTERNATIVE 1 PLAN AND SECTIONS

DESIGNED: GZ
DETAILED: TH
CHECKED: GZ
APPROVED: RG
DATE: 08/25/2010
PROJECT NO. 168539

ATTACHMENT A

PRELIMINARY - NOT FOR CONSTRUCTION



**ATTACHMENT C**  
**OPINION OF PROBABLE CONSTRUCTION COSTS**  
**LOWER RAGGED MOUNTAIN DAM RAISE**  
**ALTERNATIVE 1: 45-FT RESERVOIR RAISE (51-FT DAM RAISE)**

Item	Description	Units	Quantity	Unit Price	Extension	Notes/Reference
1	Mobilization & Demobilization					
	a. General (6.5%)	LS	1	\$ 837,000	\$ 837,000	
	b. Bonds & Insurance (3%)	LS	1	\$ 386,000	\$ 386,000	
2	Care & Diversion of Water					
	a. Erosion and Sediment Control	LS	1	\$ 150,000	\$ 150,000	
	b. Foundation Dewatering/Water Control	LS	1	\$ 200,000	\$ 200,000	
3	Clearing & Grubbing					
	a. Dam, buttress, access road	AC	2	\$ 6,000	\$ 12,000	Unit price Ref. 1,3
4	Reservoir Clearing	AC	100	\$ 8,000	\$ 800,000	Quantity Ref. 1, Unit price Ref. 3
5	Demolition of Existing Structures					
	a. Miscellaneous Structures	LS	1	\$ 10,000	\$ 10,000	Quantity and unit price Ref. 1, 3
	b. Removal of Upper Dam	LS	1	\$ 200,000	\$ 200,000	Quantity and unit price Ref. 1, 3
	c. Removal of Old Piping	LS	1	\$ 50,000	\$ 50,000	Quantity and unit price Ref. 1, 3
6	Excavation					
	a. Unclassified Excavation (buttress and abutments)	CY	64000	\$ 5	\$ 320,000	Unit price Ref. 1, 3
	b. Rock Excavation	CY	8600	\$ 20	\$ 172,000	Unit price Ref. 1, 3
7	Foundation Preparation					
	a. Rock Trimming	CY	1700	\$ 75	\$ 128,000	Unit price Ref. 1, 3
	b. Foundation Cleaning	SY	5100	\$ 40	\$ 204,000	Unit price Ref. 1, 3
	c. Concrete preparation (existing dam face)	SY	2000	\$ 180	\$ 360,000	Contractor input
8	Foundation Drilling & Grouting					
	a. Grout Curtain Below Dam	SF	20000	\$ 25	\$ 500,000	Unit price Ref. 1, 3
	b. Abutment Seepage Treatment (allowance)	LS	1	\$ 400,000	\$ 400,000	
9	Post-tensioned Anchors	LF	2650	\$ 350	\$ 928,000	
10	Fill					
	a. Common Earth (shell fill, backfill)	CY	12000	\$ 4	\$ 48,000	Unit price Ref. 1, 3
	b. Select Fill (Core)	CY	1300	\$ 6.5	\$ 8,000	Unit price Ref. 1, 3
	c. Filter/Drain	CY	2500	\$ 65	\$ 163,000	Unit price Ref. 1, 3
11	Slope Protection (earth section, right abutment)					
	a. Class 1 Riprap	CY	2500	\$ 80	\$ 200,000	Unit price Ref. 1, 3
	b. Riprap Bedding	CY	800	\$ 45	\$ 36,000	Unit price Ref. 1, 3
12	Conventional Concrete					
	a. Structural Concrete (retaining walls, tower extension)	CY	350	\$ 750	\$ 263,000	Unit price Ref. 1, 3
	b. Downstream Facing Concrete (spillway section)	CY	1000	\$ 450	\$ 450,000	Unit price Ref. 2
	c. Dental Concrete	CY	1700	\$ 250	\$ 425,000	Unit price Ref. 1, 3
13	Steel Reinforcing Bars (170 lbs / cy)	LB	230000	\$ 0.80	\$ 184,000	Unit price Ref. 1, 3
14	Roller Compacted Concrete					
	a. RCC In-place	CY	43000	\$ 85	\$ 3,655,000	Unit price Ref. 2
	b. RCC Trial Placement	LS	1	\$ 150,000	\$ 150,000	Unit price Ref. 2
	c. Grout Enriched RCC	CY	2800	\$ 90	\$ 252,000	Contractor input
15	Bedding Mix	LS	1	\$ 300,000	\$ 300,000	Price reduced from Ref. 2 value, smaller footprint
16	Dam Construction Joints	LS	1	\$ 100,000	\$ 100,000	Unit price Ref. 2
17	Drilled Foundation Drains	LF	7300	\$ 40	\$ 292,000	Unit price Ref. 2
18	Outlet Works Modifications	LS	1	\$ 100,000	\$ 100,000	Unit price escalated from Ref. 4
19	Instrumentation	LS	1	\$ 200,000	\$ 200,000	Unit price Ref. 2
20	Rock Lined Swale	LF	1500	\$ 60	\$ 90,000	Quantity and unit price Ref. 1
21	Utility Relocation	LS	1	\$ 125,000	\$ 125,000	Unit price escalated from Ref. 4
22	Landscaping and Site Restoration	LS	1	\$ 100,000	\$ 100,000	
23	Roadways					
	a. Reservoir Drive Upgrades	LS	1	\$ 250,000	\$ 250,000	Quantity and unit price Ref. 1, 3
	b. Traffic Control	LS	1	\$ 150,000	\$ 150,000	Quantity and unit price Ref. 1, 3
	c. Roadway Surfacing	SY	7000	\$ 12	\$ 84,000	Quantity and unit price Ref. 1, 3
	d. Access Road Improvements	LS	1	\$ 200,000	\$ 200,000	Quantity and unit price Ref. 1, 3
24	Unlisted Items (5%)	LS	1	\$ 613,000	\$ 613,000	
<b>Subtotal - Construction Costs</b>				<b>\$</b>	<b>14,095,000</b>	
<b>Construction Cost Variance (-10%)</b>				<b>\$</b>	<b>12,686,000</b>	
<b>Construction Cost Variance (+30%)</b>				<b>\$</b>	<b>18,324,000</b>	
25	Engineering Services					
	a. Geotechnical Study, Engineering Design (10%)	LS	1	\$ 1,410,000	\$ 1,410,000	
	b. Construction Oversight (12%)	LS	1	\$ 1,691,000	\$ 1,691,000	

References

- <sup>1</sup> RMD, Earthen Embankment Dam, Preliminary Opinion of Cost, Schnabel Engineering, May 10, 2010
- <sup>2</sup> Appendix B, Package 2 Ragged Mountain RCC New Dam, Schnabel Engineering, September 19, 2008
- <sup>3</sup> Earthen Dam Phased Construction Assessment Report, Schnabel Engineering, July 19, 2010
- <sup>4</sup> Feasibility Study for Upgrading the Ragged Mountain Dams, Gannett Fleming, February 28, 2003



**ATTACHMENT D**  
**OPINION OF PROBABLE CONSTRUCTION COSTS**  
**LOWER RAGGED MOUNTAIN DAM RAISE**  
**ALTERNATIVE 2: 13-ft RESERVOIR RAISE (19-FT DAM RAISE)**

Item	Description	Units	Quantity	Unit Price	Extension	Notes/Reference
1	Mobilization & Demobilization					
	a. General (6.5%)	LS	1	\$ 469,000	\$ 469,000	
	b. Bonds & Insurance (3%)	LS	1	\$ 217,000	\$ 217,000	
2	Care & Diversion of Water					
	a. Erosion and Sediment Control	LS	1	\$ 150,000	\$ 150,000	
	b. Foundation Dewatering/Water Control	LS	1	\$ 200,000	\$ 200,000	
3	Clearing & Grubbing					
	a. Dam, buttress, access road	AC	2	\$ 6,000	\$ 12,000	Unit price Ref. 1,3
4	Reservoir Clearing	AC	30	\$ 8,000	\$ 240,000	Quantity scaled from Ref. 1, Unit price Ref. 3
5	Demolition of Existing Structures					
	a. Miscellaneous Structures	LS	1	\$ 10,000	\$ 10,000	Quantity and unit price Ref. 1, 3
	b. Removal of Upper Dam	LS	1	\$ 200,000	\$ 200,000	Quantity and unit price Ref. 1, 3
	c. Removal of Old Piping	LS	1	\$ 50,000	\$ 50,000	Quantity and unit price Ref. 1, 3
6	Excavation					
	a. Unclassified Excavation (buttress and abutments)	CY	41000	\$ 5	\$ 205,000	Unit price Ref. 1, 3
	b. Rock Excavation	CY	4500	\$ 20	\$ 90,000	Unit price Ref. 1, 3
7	Foundation Preparation					
	a. Rock Trimming	CY	1000	\$ 75	\$ 75,000	Unit price Ref. 1, 3
	b. Foundation Cleaning	SY	2800	\$ 40	\$ 112,000	Unit price Ref. 1, 3
	c. Concrete preparation (existing dam face)	SY	2000	\$ 180	\$ 360,000	Contractor input
8	Foundation Drilling & Grouting					
	a. Grout Curtain Below Dam	SF	7500	\$ 25	\$ 188,000	Unit price Ref. 1, 3
9	Post-tensioned Anchors	LF	2050	\$ 350	\$ 718,000	
10	Fill					
	a. Common Earth (backfill)	CY	1000	\$ 4	\$ 4,000	Unit price Ref. 1, 3
	b. Select Fill	CY	1000	\$ 6.5	\$ 7,000	Unit price Ref. 1, 3
11	Conventional Concrete					
	a. Structural Concrete (retaining walls, tower extension)	CY	250	\$ 750	\$ 188,000	Unit price Ref. 1, 3
	b. Downstream Facing Concrete (spillway section)	CY	850	\$ 450	\$ 383,000	Unit price Ref. 2
	c. Dental Concrete	CY	1000	\$ 250	\$ 250,000	Unit price Ref. 1, 3
12	Steel Reinforcing Bars (170 lbs / cy)	LB	187000	\$ 0.80	\$ 150,000	Unit price Ref. 1, 3
13	Roller Compacted Concrete					
	a. RCC In-place	CY	15000	\$ 85	\$ 1,275,000	Unit price Ref. 2
	b. RCC Trial Placement	LS	1	\$ 150,000	\$ 150,000	Unit price Ref. 2
	c. Grout Enriched RCC	CY	2100	\$ 90	\$ 189,000	Contractor input
14	Bedding Mix	LS	1	\$ 200,000	\$ 200,000	Price reduced from Ref. 2 value, smaller footprint
15	Dam Construction Joints	LS	1	\$ 100,000	\$ 100,000	Unit price Ref. 2
16	Drilled Foundation Drains	LF	4200	\$ 40	\$ 168,000	Unit price Ref. 2
17	Outlet Works Modifications	LS	1	\$ 100,000	\$ 100,000	Unit price escalated from Ref. 4
18	Instrumentation	LS	1	\$ 100,000	\$ 100,000	Unit price scaled from Ref. 2
19	Rock Lined Swale	LF	1500	\$ 60	\$ 90,000	Quantity and unit price Ref. 1
20	Utility Relocation	LS	1	\$ 125,000	\$ 125,000	Unit price escalated from Ref. 4
21	Landscaping and Site Restoration	LS	1	\$ 100,000	\$ 100,000	
22	Roadways					
	a. Reservoir Drive Upgrades	LS	1	\$ 250,000	\$ 250,000	Quantity and unit price Ref. 1, 3
	b. Traffic Control	LS	1	\$ 150,000	\$ 150,000	Quantity and unit price Ref. 1, 3
	c. Roadway Surfacing	SY	7000	\$ 12	\$ 84,000	Quantity and unit price Ref. 1, 3
	d. Access Road Improvements	LS	1	\$ 200,000	\$ 200,000	Quantity and unit price Ref. 1, 3
23	Unlisted Items (5%)	LS	1	\$ 344,000	\$ 344,000	

<b>Subtotal - Construction Costs</b>	<b>\$ 7,903,000</b>
<b>Construction Cost Variance (-10%)</b>	<b>\$ 7,113,000</b>
<b>Construction Cost Variance (+30%)</b>	<b>\$ 10,274,000</b>

24	Engineering Services					
	a. Geotechnical Study, Engineering Design (10%)	LS	1	\$ 790,000	\$ 790,000	
	b. Construction Oversight (12%)	LS	1	\$ 948,000	\$ 948,000	

References

- <sup>1</sup> RMD, Earthen Embankment Dam, Preliminary Opinion of Cost, Schnabel Engineering, May 10, 2010
- <sup>2</sup> Appendix B, Package 2 Ragged Mountain RCC New Dam, Schnabel Engineering, September 19, 2008
- <sup>3</sup> Earthen Dam Phased Construction Assessment Report, Schnabel Engineering, July 19, 2010
- <sup>4</sup> Feasibility Study for Upgrading the Ragged Mountain Dams, Gannett Fleming, February 28, 2003

**ATTACHMENT E**  
**OPINION OF PROBABLE CONSTRUCTION COSTS**  
**LOWER RAGGED MOUNTAIN DAM RAISE**  
**ALTERNATIVE 3: LIMITED DAM RAISE**

Item	Description	Units	Quantity	Unit Price	Extension	Notes/Reference
1	Mobilization & Demobilization					
	a. General (6.5%)	LS	1	\$ 289,000	\$ 289,000	
	b. Bonds & Insurance (3%)	LS	1	\$ 134,000	\$ 134,000	
2	Care & Diversion of Water					
	a. Erosion and Sediment Control	LS	1	\$ 150,000	\$ 150,000	
	b. Foundation Dewatering/Water Control	LS	1	\$ 50,000	\$ 50,000	
3	Clearing & Grubbing					
	a. Dam, buttress, access road	AC	1	\$ 6,000	\$ 6,000	Unit price Ref. 1,3
4	Reservoir Clearing	AC	10	\$ 8,000	\$ 80,000	Quantity Ref. 1, Unit price Ref. 3
5	Demolition of Existing Structures					
	a. Miscellaneous Structures	LS	1	\$ 10,000	\$ 10,000	Quantity and unit price Ref. 1, 3
	b. Removal of Upper Dam	LS	1	\$ 200,000	\$ 200,000	Quantity and unit price Ref. 1, 3
	c. Removal of Old Piping	LS	1	\$ 50,000	\$ 50,000	Quantity and unit price Ref. 1, 3
6	Excavation					
	a. Unclassified Excavation	CY	2500	\$ 5	\$ 13,000	Unit price Ref. 1, 3
	b. Rock Excavation	CY	15525	\$ 75	\$ 1,164,000	Quantity Ref. 4
7	Conventional Concrete					
	a. Structural Concrete (walls, slab)	CY	780	\$ 750	\$ 585,000	Quantity Ref. 4, Unit price Ref. 1, 3
	b. Mass Concrete (dam crest, weir)	CY	1450	\$ 450	\$ 653,000	Quantity Ref. 4, Unit price Ref. 2
	c. Dental Concrete	CY	300	\$ 250	\$ 75,000	Quantity Ref. 4, Unit price Ref. 1, 3
8	Steel Reinforcing Bars (170 lbs / cy)	LB	133000	\$ 0.80	\$ 106,000	Unit price Ref. 1, 3
9	Utility Relocation	LS	1	\$ 125,000	\$ 125,000	Unit price escalated from Ref. 4
10	Outlet Works Modifications	LS	1	\$ 100,000	\$ 100,000	Unit price escalated from Ref. 4
11	Instrumentation	LS	1	\$ 50,000	\$ 50,000	
12	Rock Lined Swale	LF	1500	\$ 60	\$ 90,000	Quantity and unit price Ref. 1
13	Landscaping and Site Restoration	LS	1	\$ 50,000	\$ 50,000	
14	Roadways					
	a. Reservoir Drive Upgrades	LS	1	\$ 250,000	\$ 250,000	Quantity and unit price Ref. 1, 3
	b. Traffic Control	LS	1	\$ 150,000	\$ 150,000	Quantity and unit price Ref. 1, 3
	c. Roadway Surfacing	SY	7000	\$ 12	\$ 84,000	Quantity and unit price Ref. 1, 3
	d. Access Road Improvements	LS	1	\$ 200,000	\$ 200,000	Quantity and unit price Ref. 1, 3
15	Unlisted Items (5%)	LS	1	\$ 212,000	\$ 212,000	
<b>Subtotal - Construction Costs</b>				<b>\$</b>	<b>4,876,000</b>	
<b>Construction Cost Variance (-10%)</b>				<b>\$</b>	<b>4,388,000</b>	
<b>Construction Cost Variance (+30%)</b>				<b>\$</b>	<b>6,339,000</b>	
16	Engineering Services					
	a. Geotechnical Study, Engineering Design (10%)	LS	1	\$ 488,000	\$ 488,000	
	b. Construction Oversight (12%)	LS	1	\$ 585,000	\$ 585,000	

References

- <sup>1</sup> RMD, Earthen Embankment Dam, Preliminary Opinion of Cost, Schnabel Engineering, May 10, 2010
- <sup>2</sup> Appendix B, Package 2 Ragged Mountain RCC New Dam, Schnabel Engineering, September 19, 2008
- <sup>3</sup> Earthen Dam Phased Construction Assessment Report, Schnabel Engineering, July 19, 2010
- <sup>4</sup> Feasibility Study for Upgrading the Ragged Mountain Dams, Gannett Fleming, February 28, 2003