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Water Resources Engineers
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August 28, 2024

Mrs. Wendy Ryan
Western Divide Water Conservation District
818 Taughenbaugh Blvd, Suite 101
Rifle, CO 81650

Subject: **Flannery Dam and Deer Creek Dam Assessment, Wheeler Project No. 1883.06**

Dear Wendy,

This letter was prepared by W. W. Wheeler & Associates, Inc. (Wheeler) for the Western Divide Water Conservation District to document Wheeler's field assessment and recommendations from the site visit to the Flannery Dam on August 19, 2024.

Wheeler performed a field assessment of the Flannery Dam located in Garfield County, Colorado, about 35 mins southwest of Glenwood Springs. The attendees for the site investigation included the dam owner Steve Beckley, Wendy Ryan from BBA Water Consultants, Inc., John Treacy and Nicholas Gidley from W. W. Wheeler and Associates. The purpose of the field assessment was to observe the current condition of Flannery Reservoir and its appurtenant structures and provide recommendations on potential modifications or repairs to be considered.

Flannery Dam Background Information

Flannery Reservoir was constructed in 1990 and is a privately owned storage reservoir that is located within the upper reaches of the Three Mile Canyon, a tributary of the Roaring Fork River. The reservoir provides approximately 105 acre-feet of storage and has a surface area of approximately 24 acres. Flannery Dam is a 15-foot-high earth embankment with 2 open channel spillways located at the left abutment and the right abutment respectively. The dam has a 24-inch-diameter CMP outlet that is operated by a slide gate located in the reservoir and accessed by a deteriorating catwalk. The reservoir also has a 12-inch-diameter siphon system that pumps water from the reservoir over to 3-mile Creek. The dam is considered by the Colorado Division of Water Resources Dam Safety (DWR) to be a Significant Hazard Jurisdictional Dam. Outflows from the spillways and the outlet works flow downstream and into Hughes Reservoir. The reservoir is filled by snowmelt runoff from the 1,421acer drainage basin. Previous DWR inspections have indicated that Flannery Dam has a Conditional Full Storage designation, indicating that full storage is allowed in the reservoir provided certain conditions are met. The actions required by the DWR to maintain full storge are as follows:

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1. Consider additional grading of the outlet discharge channel to improve drainage and to better assess potential seepage concerns.
2. Continue to remove driftwood and debris from the upstream slope and spillway channels.
3. Clear trees and brush from the crest, downstream slopes and spillways.
4. Prepare plans and specifications to rehabilitate the outlet works

Flannery Dam Assessment

On the date of the field assessment, the reservoir level was measured to be 3 feet below the crest of the dam, with minor flows running through the left abutment spillway. The weather was calm and sunny and about 70 degrees. Our assessment and recommendations for Flannery Dam are provided in the following sections and photographs taken are included in Appendix A.

Dam Crest & Upstream and Downstream Slopes

The upstream slope was observed to be in satisfactory condition with no major observed issues. The upstream slope protection riprap is very large and there does not appear to be adequate bedding under the riprap. The lack of adequate bedding under the riprap could lead to potential embankment erosion and reduced stability. There were no signs of wave erosion during this assessment. Minor vegetation was also observed growing between the riprap. The Owner has done a good job recently in maintaining this and it will have to be continued on an annual basis. The dam crest (elevation 8365) was observed to be in satisfactory condition. The dam crest was measured to have a nominal width of 15 feet. The crest has signs of animal trails that will need to be maintained to prevent settlement or low spots from developing. The downstream slope is relatively flat with approximately 3:1 side slope. There were no signs of cracking or bulges observed. Minor vegetation growing on the slope. Previous inspection reports have indicated seepage along the downstream slope near the discharge pipe. However, no signs of seepage were observed.

Spillways

The primary spillway, located in the left abutment and has an earth cut (no formal control) invert approximately 3.5 feet below the dam crest (8361.5). This spillway is a trapezoidal earth cut with an average bottom width of 5-feet and nearly vertical side slopes (less than 1.5:1). The spillway channel was observed to be full of woody vegetation and debris that should be cleared to allow for maximum capacity. The secondary spillway, located in the right abutment, is an earth cut spillway (no formal control) that is approximately 5-feet wide and has a crest elevation of 8364. The secondary spillway was dry. Debris and dense vegetation were observed in the spillway.

Outlet Works & Siphon

The outlet consists of a 24-inch-diameter CMP pipe that is approximately 120 feet in length. There appears to be a 24-inch slide gate submerged in the reservoir that controls the outlet discharge. The outlet was operated by the Owner during the investigation and is in considered to be in satisfactory condition. The gate stem and bracing appear to be bent and starting to corrode which could be the reason for stiffer operation. The 24-inch diameter CMP pipe is 30

years old and corrosion and deterioration of the bottom of the pipe is likely. The discharge channel should be graded to show positive drainage away from the outlet. There is a 12-inch diameter siphon system that consists of an upstream valve in the reservoir and a downstream control valve. The upstream valve was submerged but was open. This valve was not operated during the inspection. The downstream valve is typically cracked to keep the siphon operational. The Owner operated the downstream valve during the inspection. There is a measurement flume downstream of the siphon system that has a large boulder in the upstream portion of the flume, thus preventing proper operation of the flume.

Assessment Recommendations

Based on our observations, and conversations during the site investigation, we have developed the following recommendations for consideration for Flannery Dam. These recommendations are as follows:

1. Due to the remote location of this dam, any construction or modifications should consider the complexity of site access as part of the design improvements. Remote accessibility will result in potential higher construction costs.

2. The 24-inch diameter CMP is over 30 years old. It is recommended that the outlet pipe should be lined with a smaller HDPE pipe and the annular space be grouted. Installation of a CIPP liner could be difficult due to access issues. Our recommendation would be to line the outlet with a 12-inch diameter pipe and grout the annular space. The liner pipe material could be PVC pipe that can snap together, thus allowing for smaller pieces to be transported to the site and inserted into the host pipe. Grout can be mixed on-site and pumped around the annular space. Based on DWR Rule 4.14, outlet drawdown of 5 reservoir feet in 5 days, reducing the outlet will still meet this DWR requirements. This recommendation would require an engineered design and submittal to DWR.

3. The outlet gate appeared to be corroding and bent, thus making operation more difficult. It is our consideration that the outlet gate should be replaced with a new 12-inch slide gate mounted inside a concrete vault. The concrete vault will provide winter and weather protection for the gate. Our recommendation would include the installation of a precast manhole vault that could be brought up in smaller pieces. The vault would then be installed to protect the new outlet gate as well as the siphon valve. This recommendation would require an engineered design and submittal to DWR.

4. Replace the existing outlet works catwalk with a new stable catwalk with appropriate handrailing.

5. Install a reservoir staff gage. Per DWR Rule 7.7.2.2, all dams should have a staff gage.

6. Install a 2-foot-deep concrete control sill in the left spillway. This is the primary spillway for the dam, and installation of a cutoff wall will reduce erosion potential. Consideration

should be given to grading the downstream channel and armoring the slopes in areas where erosion is evident.

7. Provide positive drainage in the outlet works discharge channel.

8. Remove the rock in the siphon flume.

9. Continue to remove vegetation and debris on an annual basis from the dam as well as in the left and right spillways.

The potential of enlarging the dam was discussed during the assessment. Enlargement of a dam would incur significant design costs and construction costs. For an enlargement of an existing Significant Hazard dam, the design requirements would fall under Rule 7 and include the following:

1. A new hazard classification analysis based on the newly proposed dam height,
2. Updating the spillway hydrologic hazard classification, and sizing the spillways accordingly,
3. Performing subsurface investigations, including drilling at least 3 borings and providing a geotechnical report.
4. Design Report, Design Specifications and Design Drawings.
5. Cost Opinion of the modification of the dam.

In addition to the engineering analysis, as part of the dam enlargement modification design, the following elements would have to be included as part of the design:

1. New spillway improvements to pass the IDF
2. Raising the dam crest
3. New outlet works modification
4. Installation of a toe drain and filter diaphragm on the downstream slope.
5. Installation of station markers on the crest
6. Installation of staff gage

Cost Opinion Development Approach

Wheeler has developed feasibility-level cost opinions for the above recommendations at Flannery Dam. A summary of the opinion of probable direct construction and indirect project costs for Flannery Dam is provided in Attachment B.

The cost opinions were generated utilizing Wheeler's experience with similar dam construction, as well as contractor's budgetary estimates, and the 2024 R.S. Means Heavy Civil Estimating Guide. The costs are considered Class 4 cost opinions under the Association for the Advancement of Cost Engineering (AACE) Accuracy Matrix (USSD, 2012). Unlisted items were estimated at 10-percent of the direct construction cost. Unlisted items are included to provide a contingency for construction items that are typically included in the final design work scope that cannot be estimated at this stage of project development. Construction

contractor mobilization, bonds, general conditions administration, and insurance were estimated at approximately 10-percent of the direct construction cost. The indirect construction project costs include budgets for non-construction items that are or would be required to complete the project, such as design engineering; a construction change order contingency; and construction administration and engineering.

A summary of the development of the indirect project cost elements is provided below.

1. **Construction Contingency -** A change order contingency equivalent to 15-percent of the opinion of probable direct construction cost total was included. This change order contingency is included to address changes to construction quantities or unexpected changes that normally occur during a large heavy civil construction project.

2. **Final Design Engineering -** Final design engineering is based on previous projects with similar modifications. Final design will include the preparation of detailed construction drawings, construction specifications, and a design summary report that documents the engineering analysis completed to support the design. These design documents will require review and approval by the Colorado Office of the State Engineer, Dam Safety Branch

3. **Construction Administration and Engineering -** The construction administration and engineering costs were estimated as 10-percent of the sum of the direct construction cost plus the change order contingency. This budget would include construction administration activities that are normally required by the Colorado Dam Safety Branch Rules for dam construction such as on-site construction observation, materials testing, progress meetings & reports, and preparation of a final construction report and Record Drawings.

Please let us know if you have any questions or comments.

Sincerely,

W. W. Wheeler & Associates, Inc.

John J. Treacy III, P.E.

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Attachment A

Site Assessment Photographs

Photo 1. View of the upstream slope looking left from the right abutment. Note the large riprap and vegetation growing in the riprap.

Photo 2. View of upstream slope looking right from the left abutment.

Photo 3. Close up view of the large riprap along the upstream slope with vegetation growing between the riprap.

Photo 4. View of the upstream slope riprap looking left from the outlet works catwalk.

Photo 5. View of the dam crest looking left from the right abutment. Note the animal trail along the crest.

Photo 6. View of the dam crest and downstream slope looking right from the left abutment.

Photo 7. View of the apparent control section of the primary spillway located near the left abutment. Note the woody debris and vegetation in the spillway.

Photo 8. View looking upstream at the approach channel of the primary spillway. Again note the vegetation and debris in the spillway.

Photo 9. View looking downstream of the primary spillway.

Photo 10. View of the primary spillway bank erosion. This erosion is downstream of the dam but should potentially be armored with riprap to reduce erosion over time.

Photo 11. View of the approach channel of the secondary spillway located near the right abutment.

Photo 12. View looking down the discharge channel of the secondary spillway located near the right abutment.

Photo 13. View of the outlet control gate and siphon system access walkway. Note that walkway should be repaired and stabilized for a safe access to operate the gate.

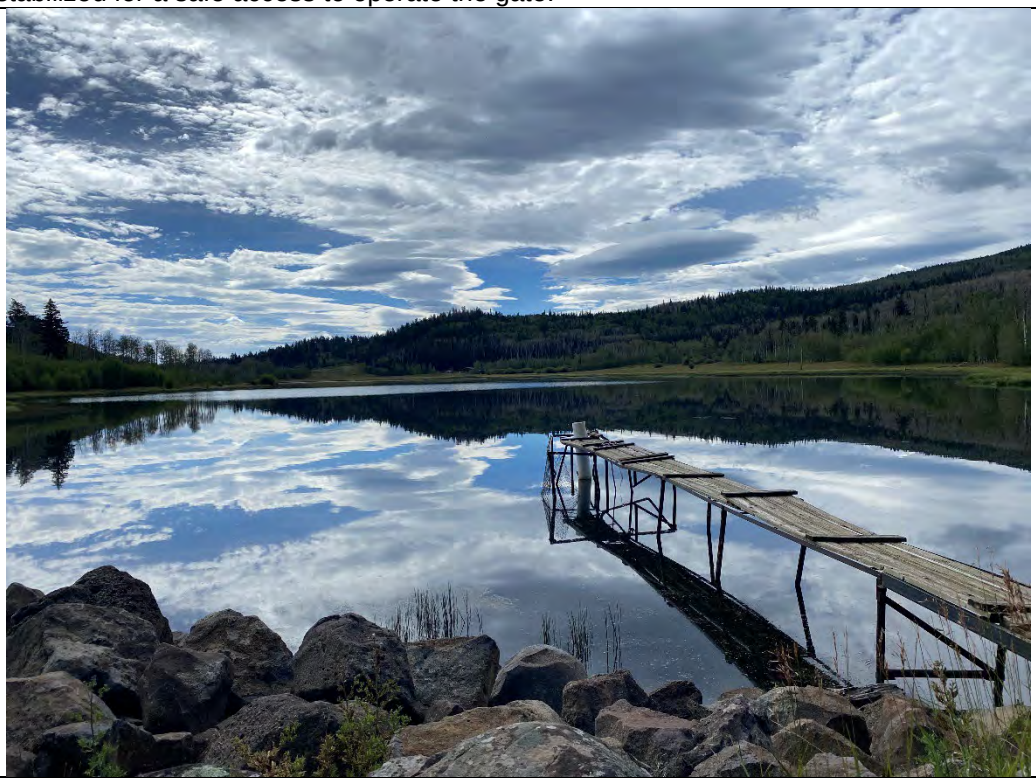

Photo 14. Another view of the outlet gate and siphon valve access walkway.

Photo 15. Close up of the existing outlet works gate operator. Note that gate is fully exposed in reservoir and appears to be slightly bent and showing signs of corrosion.

Photo 16. View looking down into the reservoir at the outlet gate. Notice the bend in the gate frame, indicating the gate is likely bent as well.

Photo 17. View of the 24-inch CMP outlet discharge conduit.

Photo 18. View of the outlet discharge channel looking downstream.

Photo 19. Close up view of the 24-inch CMP Outlet Pipe. The invert of the pipe appears to be eroding.

Photo 20. View of the downstream area.

Photo 21. View of the reservoir area and surrounding drainage basin.

Photo 22. View of the reservoir looking upstream from the outlet works walkway.

Photo 23. View of the siphon air vent, located approximately ¾ mile from the dam.

Photo 24. View of the downstream valve for the siphon system. Note the Owner opening the valve.

Photo 25. View of the large boulder located in the downstream measuring flume.

Attachment B

Cost Opinion

Flannery Dam
ENGINEER COST OPINION
Western Divide Water Conservation District

Item No.	Description	Unit	QTY.	Unit Price	Total Cost
Mobilization					
1	Mobilization, Bonds, Insurance & General Conditions	LS	1	$40,000	**$40,000**
Site Preparation Work					
2	Clear and Grub	AC	1	$2,000	$2,000
3	Temporary Reservoir Control	LS	1	$10,000	$10,000
4	Dewatering	LS	1	$10,000	$10,000
	Subtotal				**$22,000**
Spillway Modifications					
5	Spillway Cutoff Excavation	CY	4	$50	$200
6	Furnish and Install Spillway Cutoff wall	CY	2	$800	$1,600
7	Spillway Channel Grading	CY	100	$25	$2,500
8	Furnish and Install Spillway Riprap	CY	50	$200	$10,000
	Subtotal				**$14,300**
Outlet Works Liner and Vault					
9	Outlet Works Liner - including Pipe cleaning, video inspection, pipe installation, pipe grouting, and end seals installation	LF	120	$600	$72,000
10	Furnish and Install Manhole vault	LS	1	$15,000	$15,000
11	Furnish and Install New 12-inch Slide Gate	LS	1	$3,000	$3,000
12	Remove Existing Catwalk	LS	1	$5,000	$5,000
13	Furnish and Install New Access Walkway	LS	1	$6,000	$6,000
14	Downstream Channel Grading	CY	20	$25	$500
15	Furnish and Install Terminal Structure Riprap	CY	5	$200	$1,000
	Subtotal				**$102,500**
Staff Gage Installation					
16	Furnish and Install Staff Gage	LS	1	$2,000	$2,000
	Subtotal				**$2,000**
DIRECT CONSTRUCTION SUBTOTAL (DCS)					**$179,000**
17	Outlet Works Modification Engineering Design	LS	1	$25,000	$25,000
18	Construction Contingency (15% Construction Total)				$27,000
19	Construction Administration and Engineering (10% of DCS + 10% Con. Contingency)				$21,000
TOTAL INDIRECT PROJECT COSTS					**$73,000**
TOTAL ESTIMATED CONSTRUCTION COST					**$252,000**