FINAL CONSTRUCTION REPORT
FOR
MOUNTAIN LAKE DAM SPILLWAY REPLACEMENT PROJECT

CONSTRUCTION FILE NO. C-2076A
MOUNTAIN LAKE DAM - DAM ID: 110107
WATER DIVISION 2 – WATER DISTRICT 11
LAKE COUNTY, COLORADO

Prepared for:
Office of the State Engineer
Division of Water Resources
Dam Safety Branch
1313 Sherman Street
Denver, CO 80203

W. W. WHEELER
& ASSOCIATES, INC.
Water Resources Engineers
3700 S. Inca Street | Englewood, CO 80110-3405

October, 2018

Executive Summary

This report was prepared to document the construction of the Mountain Lake Dam Spillway Replacement Project and to meet the Final Report requirements of the Colorado Division of Water Resources, Dam Safety Branch, Office of the State Engineer (SEO). The Mountain Lake Dam is owned and operated by the Parkville Water District and is used as one of their water supply sources. Mountain Lake Dam is located east of Leadville at the base of Mosquito Pass within Lake County in the SW ¼ of Section 15, Township 9 South, Range 79 West of the 6th Principal Meridian. The objective of the Project was to improve deficiencies in the spillway as identified by the SEO, which required replacing the existing (original from the early 1900's) spillway with a new, larger riprap-lined spillway located further away from the downstream abutment of the dam. In addition, a new concrete control wall was located in the spillway channel at the dam face and provides a control structure to direct the spillway flow into the spillway channel.

The work done on this Project included excavating an entirely new spillway channel, well away from the downstream abutment of the dam, and lining the spillway channel with rock riprap to form an erosion-resistant channel to contain the normal discharge from the dam, as well as any emergency flows resulting from exceptional precipitation and/or snow melt events. In addition to the spillway channel, a one-foot thick concrete control wall was located in line with the upstream face of the dam, providing a defined spillway invert elevation and erosion protection for the rest of the spillway channel. Additional project work included filling in low spots on the dam crest.

Construction took place generally between August 7, 2018 and September 7, 2018. Mountain Structures Co. (MSC) was selected by Parkville Water District as the construction contractor and on-site Construction Engineering was performed by W. W. Wheeler and Associates, Inc. (Wheeler) personnel.

This construction report documents that the Project was constructed in general conformance with the Specifications and Drawings that were approved by the SEO. The report also includes representative construction photos; the Record Drawings; construction materials testing data; a description of the construction; a discussion of construction challenges; and Wheeler's key conclusions and recommendations.

The State Engineer's representative in this area, John Hunyadi, performed a final inspection on September 10, 2018 after substantial completion of the Project and his report is included in the Appendices to this report. His report noted no concerns with the construction of this project and represents the Substantial Completion Inspection for this Project. Final SEO project approval awaits the submittal of the Record Drawings and this Report.

Mountain Lake Dam Spillway Replacement Project

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Introduction

This is the Final Construction Report for the Mountain Lake Dam Spillway Replacement Project. The report was prepared to meet the Final Report requirements of the Colorado Division of Water Resources Dam Safety Branch, Office of State Engineer (SEO).

Background

Mountain Lake Dam is a small size (22-foot high), significant-hazard dam located east of the Town of Leadville, CO at the base of Mosquito Pass. The dam is situated in Lake County on an un-named tributary to Evans Gulch. The dam was originally constructed in 1889 and was enlarged to its present size and elevation in 1906. The original construction details are not clear: the enlargement was an earthen embankment dam. Appurtenant structures include a spillway and low-level outlet. The dam impounds approximately 128 acre feet (revised value from latest lake survey) and is used for water supply for the Town of Leadville. The previously-used outlet system was replaced last year with new concrete inlet and outlet structures, replacement of a section of original 8-inch cast iron pipe with new 12-inch ductile iron pipe, and a new slide-gate valve on the upstream face of the dam.

The original dam construction included a rock-lined "notch" cut into the right abutment of the dam that was used for the spillway for the dam. Normal operation of the dam is to allow excess water to flow out the spillway. The low-level outlet works valve is normally closed and is typically only opened during the winter months when the stream flow is naturally reduced and the reservoir water is required to supply raw water to the municipal treatment system.

Deficiencies in the dam that have been previously identified by the SEO include the lack of a spillway control structure (there was no defined structure in the original spillway, only a rough channel), the fact that the previous spillway channel was constructed close to the downstream abutment of the dam and had minimal flow capacity, and an uneven crest elevation. These issues were addressed by this Project.

Objective and Scope of Work

The purpose of this Project was to improve the overall safety of the dam by moving the spillway location away from the dam embankment and increasing the capacity to convey the design flood event. This was considered to be the most urgent item requiring improvement. The alignment of the new spillway channel would be less likely to impact the dam embankment.

The spillway channel was sized based on a recent hydrology report from W. W. Wheeler & Associates, which is attached in Appendix D.

An additional feature of the new spillway was the installation of a new concrete control wall at the upstream face. This wall has a 5-foot wide (at the base) trapezoidal shape to provide a control section for the spillway flow and keep the flow from eroding the dam embankment.

One final project item was to add additional fill material to the crest of the dam. This work item was required to raise some low spots on the dam crest and widen it slightly. Road-base material was used to raise the crest and the fill was compacted after being placed.

Project Team

Dam Owner: Parkville Water District, Leadville, CO
General Manager: Greg Teter

Project Design and Construction Engineers:
Key member of the Project team involved in the construction engineering of the spillway replacement project included:

1. Doug MacLaren, P.E., Project Manager and Engineer-of-Record, W. W. Wheeler & Associates.
2. Steve Maly, P.E., Principal, W. W. Wheeler & Associates.

The construction contractor was Mountain Structures Co. (MSC) of Leadville, CO. Key members of the MSC construction team included:

1. Frank Crum, President
2. John Crum, Site Superintendent

Description of Construction

Construction Overview

Key components of the construction of the Mountain Lake Dam Spillway Replacement Project are summarized below. Because of the relatively straight-forward work involved, no detailed descriptions of the work items are provided. Key project work items included:

1. Lowering the reservoir level to about 5-feet below the normal high-water line to allow for construction work to occur in the dry.
2. Excavation of a new spillway channel. It is noted that some channel excavation occurred last year when obtaining additional dam embankment fill material for the outlet project constructed during that year.
3. Processing on-site materials to provide as much of the channel-lining riprap material as possible.
4. Placement of imported riprap (and bedding) material to line the new spillway channel. Bedding gravel was placed on the excavated channel at the control wall and for a distance of approximately 100-feet downstream of the control wall. Only imported riprap was used in the bedded section.
5. Placement of road base material on the dam crest to fill in some low spots that were noted last year during the outlet works project. This brought up the entire dam crest to the minimum crest elevation (11,392.0 feet). The fill was only a few inches in depth, so no compaction specification was used. The material was well compacted by a sheep foot roller.
6. Addition of processed "fine" material along the toe of the buttress filter created last year as part of the new outlet works project. The placement of this fill material was not in the original Scope of Work for the project, but the material was available and it was useful to fill in the slope below the buttress filter.

7. Reclamation of the area disturbed during construction by the placement of straw mulch and seed mix.

Construction Challenges

The Mountain Lake Dam Outlet Modification Project was completed without any significant setbacks or problems. A few noteworthy issues are described in the following paragraphs.

On-site Riprap Material

The on-site material (rocks and cobbles left over from last year's outlet replacement project) was processed (screened) for use in the spillway channel. It was thought that a large amount of the riprap material required for the spillway channel could be obtained from this material, but the amount obtained was only about 20% of the total amount required.

Material Procurement

The purchased riprap came from a local gravel quarry (ACA in Buena Vista), but the vendor could not supply the material fast enough to keep the project moving forward. They stated that all of their delivery trucks were busy on other jobs, and they could not keep up with demand. It was necessary for Mountain Structures and even Parkville Water District to provide haul trucks to move the material to the project site.

In addition, the purchased riprap was sometimes over-sized for what was requested. The supplier provided a submittal gradation for the riprap material (9-inch D50) that was acceptable for the project. Some of the received material was larger than indicated by the gradation provided. The larger material was more difficult to handle and place than the more properly sized material.

Construction Changes

There were not any significant changes to the Colorado SEO Approved Drawings and Specifications. The alignment of the spillway channel was slightly different than shown on the project drawings, but this was minor and does not affect the safety of the dam. The Record Drawings for the project show the final alignment of the spillway channel. The final elevation of

the spillway channel invert below the control wall was a bit different than designed. This does not present any concerns as the spillway invert just downstream from the wall was constructed at a slope even greater than the minimum 2% slope required to allow for the design flow to occur at the water elevation desired. The rest of the spillway slope varied slightly from the design slope, but this is not critical to the performance of the spillway. It is noted that the spillway channel invert is hard to measure accurately as the riprap rock size was large and varied in shape, and therefore made it difficult to accurately survey. Since the project was completed, the flow from the lake is now going through the spillway, and the flow is contained in the spillway channel.

Construction Observation and Testing

Construction Observation

Wheeler personnel were at the Project site periodically during construction. Typically, a Wheeler Engineer was at the site at least once a week during construction. Wheeler personnel were available for additional visits if and when required. The Parkville Water District General Manager also made frequent visits to the Project site, typically daily.

Concrete Testing

Concrete slump, air content, density, temperature and compressive strength tests were performed by Kumar and Associates. Because of the small amount of concrete used in this project (approximately 5 cubic yards total) a single concrete test was used to verify the batch mix (the concrete was placed in a single pour). The concrete supplied to the site had a higher slump than specified, but was accepted by the Engineer and was placed without any problems. The concrete strength as determined by test cylinders came back as acceptable. Concrete test results are provided in the Appendix to this report.

Dam Crest Survey

The crest of the dam was surveyed by a Professional land Surveyor, registered with the State of Colorado. The survey determined that all of the dam crest is at or above the required elevation of 11,397.0 feet.

Reservoir Fill and Monitoring Plan

Because the spillway replacement project did not impact the dam itself, it was not necessary to generate a SEO-approved reservoir fill and monitoring plan. However, the reservoir level was returned to normal slowly over a period of several weeks. This reduced any loading on the dam due to the rising water level. The reservoir re-filled very slowly, due to the lack of natural inflow. The lake took approximately 4 weeks to reach the new spillway after the construction was completed and the outlet valve closed. Water has now reached the spillway, and the spillway is operating as designed. After refilling, there was no indication of stress to the dam embankment noted.

The Mountain Lake Dam Spillway Replacement Project did not change the reservoir's normal or emergency storage volumes or operations that are documented in the Emergency Action Plan.

Conclusions and Recommendations

As a result of the Project construction observations and testing performed by Wheeler and Kumar personnel, Wheeler offers the following post-construction conclusions and recommendations regarding the Mountain Lake Spillway Replacement Project:

1. The Project was constructed in general conformance with the Drawings and Specifications that were approved by the Colorado Dam Safety Branch SEO.
2. The amount of material on site that was suitable for use as riprap in the spillway channel proved to be less than anticipated, requiring more imported material than planned.
3. Material procurement was delayed due to prior commitments from the suppliers to other projects. It was necessary to provide trucks to haul the riprap material from the source to the project site.
4. It was difficult to get the proper sized riprap from the supplier. The submittal approved for this material showed a range of sizes from 6-inch to 15-inch for "9-inch D50" riprap, but some of the material delivered to the site was larger than 15-inch. This worked well for protecting the spillway channel from erosion, but made placement more difficult than expected.

Representative Construction photos are provided in Appendix A.

A summary of construction materials testing completed during the project is provided in Appendix C.

The Record Drawings are provided in Appendix B.

Limitations

The construction engineering documentation provided in this report is based on representative material tests and observations of the Wheeler construction engineering team during construction of the Mountain Lake Dam Spillway Replacement Project. The information in this report is based on our best knowledge and judgment and, in part, from information provided by others. Our design and construction engineering services were conducted in accordance with generally accepted dam engineering practices. Variations can and do occur in foundation soils and rock, geologic materials, concrete materials, and earthwork materials used for the project. It is common for hydraulic structures to leak, settle, and crack to some degree and the objective of our work was to minimize these performance issues to the extent practical. As a result, there is no expressed or implied warranty or guarantee of the performance of this Project. The members of the Wheeler Engineering team are also not responsible for the liability associated with the interpretation of the information presented in this report by others.

References

1. Colorado Division of Water Resources, (CO DWR, 2007), *Rules and Regulations for Dam Safety and Dam Construction*, Denver, CO, January 2007.
2. Mountain Lake Dam Hydrology Report and Spillway Hydraulic Evaluation, W. W. Wheeler & Associates, July 21, 2017

APPENDIX A

CONSTRUCTION PHOTOS

Concrete form work for Control Wall, View to Southwest

Rebar for Control Wall being installed, view to East

Completed Control Wall before backfilling, View to West

View of spillway channel downstream of Control Wall showing bedding and riprap before placement, View to West

Picture showing riprap size, note clipboard for scale

Riprap staged by spillway channel prior to placement, View to Southeast

Riprap being placed in spillway channel, View to South

Completed Riprap Channel, View to South

Completed spillway in operation, View to East

Dam crest with new fill, View to South

APPENDIX B

RECORD DRAWINGS

MOUNTAIN LAKE DAM

SPILLWAY REPLACEMENT PROJECT

WATER DIVISION 2, DISTRICT 11, LAKE COUNTY, COLORADO

SECTION 15, T9S, R79W

DAM ID: 110107

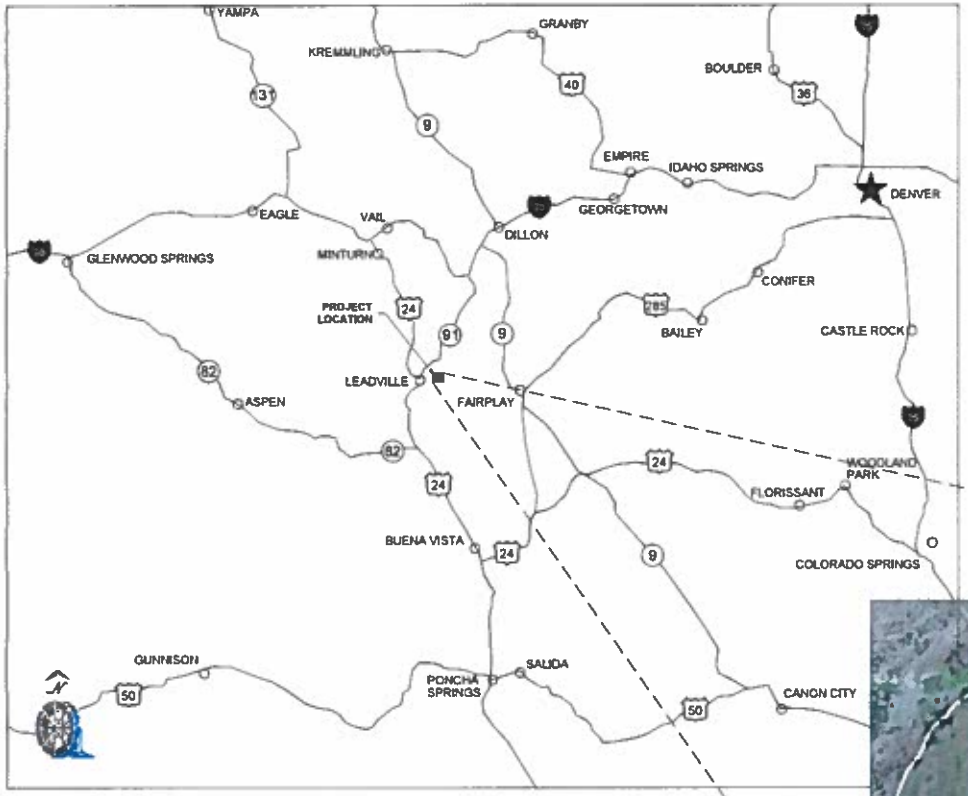
PREPARED FOR

PARKVILLE WATER DISTRICT

LEADVILLE, CO

BY

W. W. WHEELER AND ASSOCIATES, INC.



PROJECT LOCATION MAP

(NOT TO SCALE)

PROJECT VICINITY MAP

Scale in Feet

I HEREBY DECLARE THAT THESE PLANS FOR MOUNTAIN LAKE DAM SPILLWAY REPLACEMENT PROJECT WERE PREPARED UNDER MY DIRECT SUPERVISION.

RESPONSIBLE DESIGN ENGINEER:
W. W. WHEELER & ASSOCIATES, INC.

DOUGLAS J. MACLAREN — COLO. PE NO. 26375

STATE ENGINEER APPROVAL

APPROVED ON THE 31ST DAY OF JULY 2018.

KEVIN G. REIN
STATE ENGINEER

BY:
WILLIAM T. MCCORMICK, III CO PE 29127
CHIEF, COLORADO DAM SAFETY

THESE PLANS REPRESENT THE AS-CONSTRUCTED CONDITIONS OF THE MOUNTAIN LAKE DAM SPILLWAY REPLACEMENT PROJECT TO THE BEST OF MY KNOWLEDGE AND JUDGMENT BASED IN PART ON INFORMATION FURNISHED BY OTHERS AS OF THE 15th DAY OF OCTOBER, 2018.

DOUGLAS J. MACLAREN — COLO. PE NO. 26375

C-2076A

No	Date	Made	Checked	Remarks
1	05/18	SAS	DCH	FOR REVIEW
2	06/18	SAS	DCH	ISSUED FOR BIDDING
3	07/18	SAS	DCH	ISSUED FOR CONSTRUCTION
4	10/18	SAS	DCH	RECORD DRAWING

Sheet No.	Drawing No.	Title

RECORD DRAWING

W. W. WHEELER & ASSOCIATES, INC
Water Resources Engineers
3990 S. Inca Street | Englewood, CO 80110-2409
303-761-1480 | Fax 303-761-2868

MOUNTAIN LAKE DAM
SPILLWAY REPLACEMENT PROJECT
COVER SHEET AND
LOCATION MAPS

Owner	PARKVILLE WATER DISTRICT
Designed by	DCH
Drawn by	SAS
Checked by	SMM
Last Date	10/29/2018
Project No.	960.10.00
Sheet No.	1 of 7
Drawing No.	G1

APPENDIX C

CONCRETE TEST RESULTS

APPENDIX D

SEO CONSTRUCTION INSPECTION REPORT

COLORADO
Division of Water Resources
Department of Natural Resources

Dam Safety Branch

CONSTRUCTION INSPECTION REPORT

PROJECT INFORMATION			
Dam Name:	Mountain Lake	Inspector:	JEH
DAMID:	110107	Date:	10 SEP 2018
C-#:	C-2076A	Time on Site:	2
Dam Owner:	Parkville Water District	Contact:	Greg Teter
Engineer:	WW Wheeler	Contact:	Doug MacLaren
Contractor:	Mountain Structures	Contact:	John & Frank Crum
Approved Plans & Specifications On-site? ☑ Yes ☐ No		Engineer Following Const. Obs. Plan? ☑ Yes ☐ No	

INSPECTION PARTICIPANTS	
Inspection Participants:	CWCB also on-site, Rachel Pittinger

CONDITIONS	
Reservoir:	~2-ft below spillway elevation
Weather:	Partly Cloudy, Calm, 60F
Equipment:	Excavator, grizzlies

CONSTRUCTION STATUS	
Work Completed to Date:	• SEO FINAL WALKTHROUGH
Work in Progress:	• Final erosion control efforts in place spreading hay over disturbed surface.
Work Planned and est. Timeframe:	• Work is essentially completed.

OBSERVATIONS AND DISCUSSION	
Purpose of Inspection:	SEO FINAL WALKTHROUGH
Items Inspected:	Entire Project inspected: • Concrete control weir appears well placed. No signs of cracking or settlement observed. • Only about 15 to 20% of on-site processed riprap used as spillway armoring. This includes about the downstream most 100-ft of the channel. • The largest diameter rocks from on-site were used at the channel terminus/confluence with the outlet channel to act as partial energy dissipators. • From the on-site riprap area extending upstream, the remainder of the material was imported D50-9inch riprap. The material is sound granite, angular. • As per the plans only about the first 150-ft of the channel below the control weir has gravel bedding filter material. • The dam crest appears completely leveled out per the plans and well compacted.

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