DEVELOPING A SEDIMENT MANAGEMENT PLAN FOR PAONIA RESERVOIR

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INTRODUCTION/BACKGROUND

Paonia Dam and Reservoir are located on Muddy Creek, a tributary of the North Fork Gunnison River in western Colorado (Figure 1). Based on the most recent bathymetric survey of the entire reservoir, conducted in June 2013, the estimated average annual rate of sedimentation has been 101 acre-feet per year (Collins, 2014). Since dam closure in 1962, nearly 25% of the reservoir's original 20,950 acre-foot capacity has been lost to sediment deposition. At that rate the reservoir would be completely filled with sediment in another 150 years, gradually reducing the available pool over time. Long before sediment levels reach the full pool elevation however, reservoir intakes and outlet works are affected, adversely impacting project operations. In 2010, the outlet works became plugged with sediment and debris, emphasizing the urgency of formulating an effective sediment management plan for the impending deposition problem.

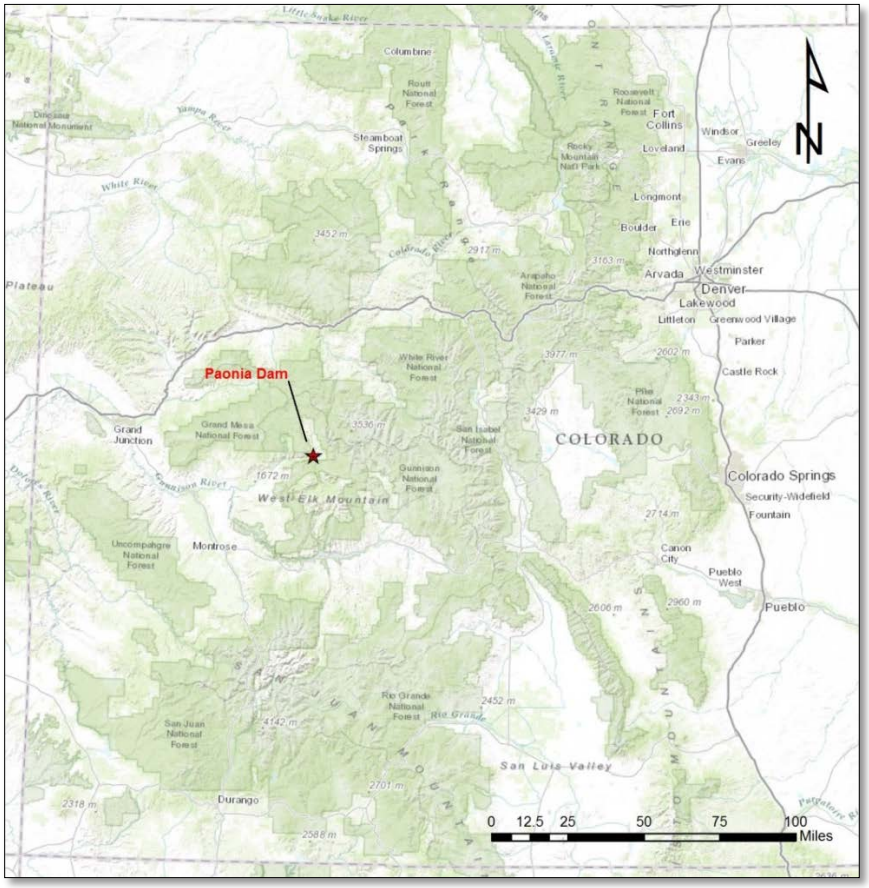

Figure 1 Paonia Dam and Reservoir on Colorado's western slope approximately 150 miles southwest of Denver

Although occasional sediment flushing was performed as early as 1997, starting in 2010-2011, annual operations were changed to include keeping the reservoir low and flushing sediment through the outlet works in early spring before filling the pool for irrigation (Denison, 2015). Until fall 2014 the flushing strategy through the long, narrow reservoir (pool is approximately 3 miles long and 0.2 miles wide) successfully maintained the outlet works, preventing them from becoming plugged. Reservoir drawdown in late-October revealed the reservoir dead pool had completely filled with sediment and the outlet works were plugged with cohesive sediment and submerged debris. Due to the recent discovery of accelerated sediment deposition rates, the original study objectives of developing a long-term plan to manage inflowing and deposited sediment more efficiently were altered to include short-term strategies for water delivery during the upcoming 2015 irrigation season.

Figure 2 Sediment deposition at Paonia Reservoir outlet works intake tower, October 2014

The Sedimentation and River Hydraulics Group of Reclamation's Technical Service Center in Denver, Colorado is leading an effort to study the past and current sediment issues at Paonia Dam and Reservoir, evaluate feasible sediment management alternatives, and formulate a plan for future operations and monitoring. The original study was built on historical and recently collected data, and the existing knowledge base to develop a comprehensive, sustainable sediment management plan. The initial study plan was executed in three phases:

- **Phase 1** consisted of an initial site visit to map and sample existing reservoir bottom sediments, a preliminary site evaluation upstream and downstream of the dam, establishment of time-lapse photo sites, and taking initial ground-based photos. Pebble counts were collected in Muddy Creek upstream of the reservoir and ground surveys were conducted for a limited distance upstream of the reservoir and downstream of the dam;
- **Phase 2** included a bathymetric survey of the entire underwater portion of Paonia Reservoir (June 2013) and 7 miles of the river downstream of the dam (May 2013), and collection of underwater core samples of reservoir bottom sediments. The bathymetric survey was used to generate a current area-capacity relationship for the reservoir and establish a baseline for comparing future data and other monitoring tasks; and
- **Phase 3** involved the evaluation of current and past operations and sediment management practices, investigation of feasible sediment management methods, focusing on those best suited for Paonia Dam and Reservoir, and providing recommendations for future sediment management operations and project monitoring. Survey and sediment data collected during previous phases were used to construct a one-dimensional mobile bed model to numerically simulate sediment transport for evaluating past, present, and potential future sediment management options.

The 2014 sediment deposition occurred during the execution of Phase 3 of the original study plan. Phase 3 analyses and tasks were modified to accommodate the new information. A reconnaissance visit/visual site inspection and GPS topographic survey were performed in November 2014. The new topography data was used for determining the additional volume of sediment and for numerical model calibration and validation. The immediate focus of the numerical model changed from simulating typical hydrographs for evaluation of long-term sediment management operations to mimicking likely spring runoff scenarios and dam operations for formulating potential short-term water delivery solutions. Once a short-term fix is identified and implemented, the numerical modeling efforts will be redirected towards the formulation and evaluation of possible long-term sediment management solutions.

2014 SEDIMENT DEPOSITION ISSUES

Beginning in 2011, Paonia Reservoir has been drawn down each year in late fall for outlet inspection, then again in early spring for sediment flushing prior to irrigation season. Reservoir drawdown in October 2014 revealed approximately 10 feet of sediment had deposited at the intake tower since June 2013, raising the lake bottom 6 feet above the sill of the outlet works (Figure 3). The June 2013 bathymetric survey measured the reservoir bottom elevation 4 feet below the outlet works sill. Figure 3 shows the steady loss of storage capacity along with the consistent increase in reservoir bed elevation at the outlet works (Western Engineers, Inc., 2006). While effective for flushing sediment through the dam outlet, yearly drawdown of the reservoir likely increased deposition rates in the dead pool.

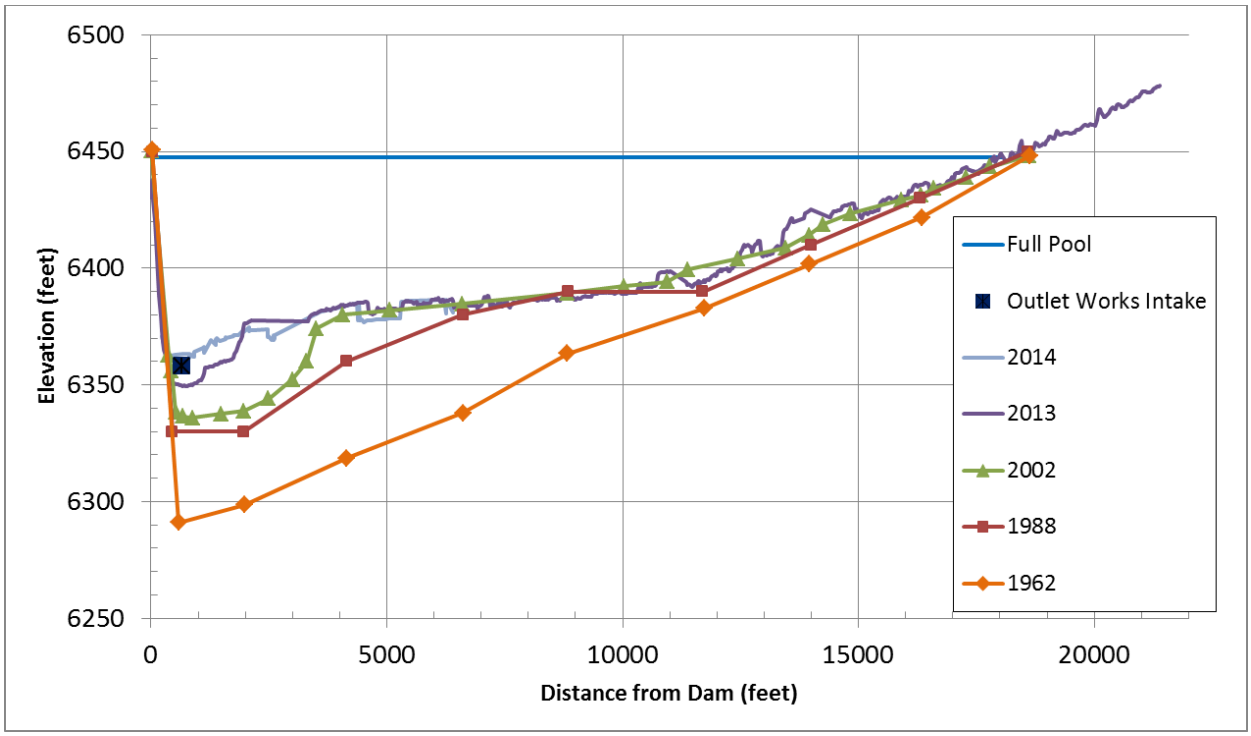

Figure 3 Paonia Reservoir survey profiles since dam closure in 1962

In 2014, increased sediment inflows resulting from high spring runoff caused the delta front to migrate more than 1,200 feet downstream towards the dam, over-filling the dead pool and partially burying the outlet works intake tower (Figure 4). Fire Mountain Canal Company and Northern Water Conservancy District crews immediately began 10-hour daily shifts removing the sediment and debris around the inlet tower using a long-reach excavator while clearing the trash racks by hand (Figures 5 and 6). Even at low flows, constant excavation and clearing were required to maintain an open outlet. Each morning when maintenance crews returned to the site, submerged debris and fine, cohesive sediments had blocked the intake tower trash racks as much as 6 feet above the sill elevation, backing water upstream.

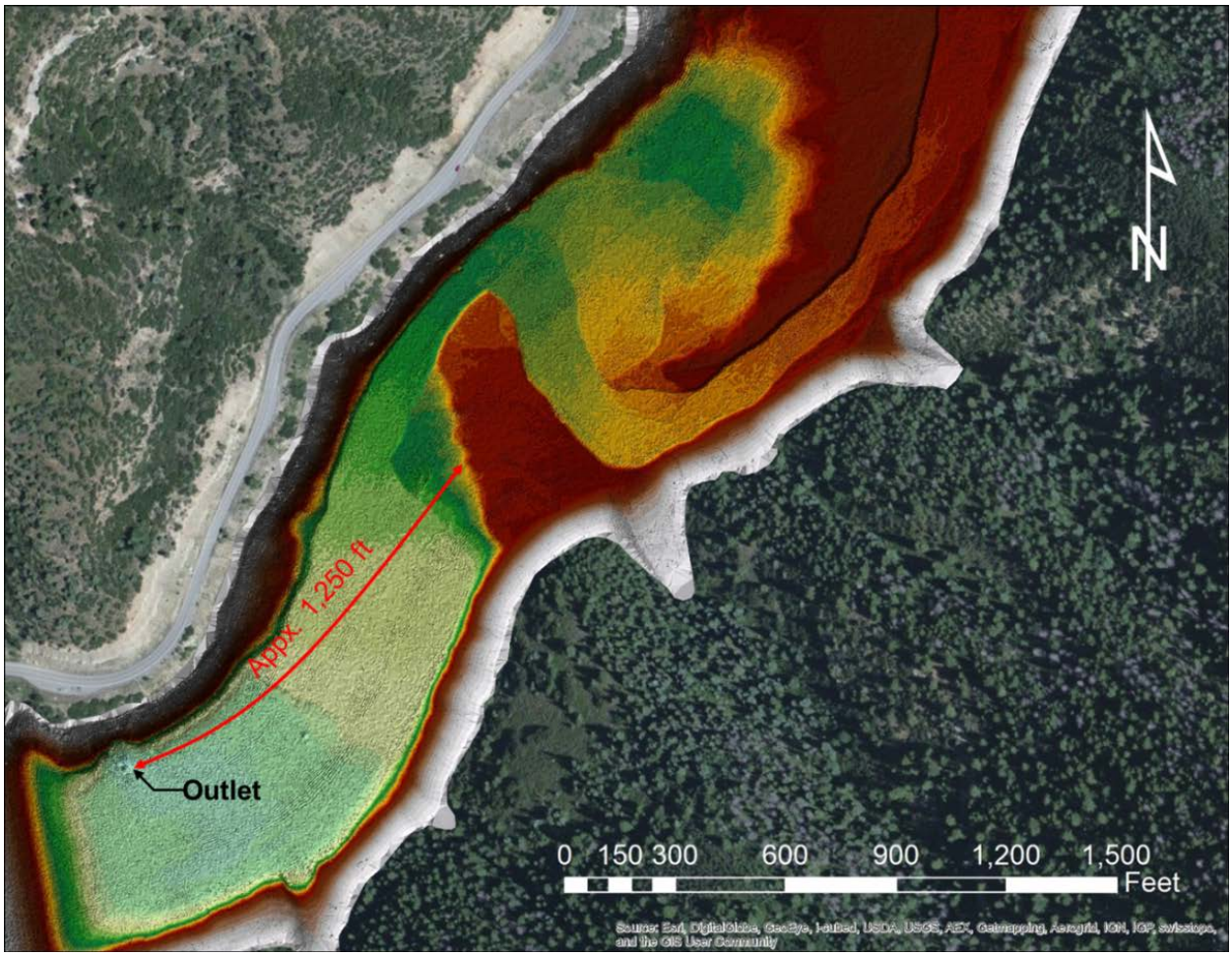

Figure 4. Plan view map of lower Paonia Reservoir showing the delta front in June 2013 and the migration distance required to partially bury the intake tower of the outlet works

Figure 5 Long-reach excavator removing sediment and debris from intake tower at Paonia Reservoir, November 2014

Figure 6 Manual clearing of intake tower trash racks to maintain open outlet works at Paonia Reservoir, November 2014

Manual clearing of debris and sediment around the outlet works occurred for over two weeks until sediment levels near the outlet works intake remained at or near sill level overnight and until ice began forming in the low flow channel near the tower. The outlet works high pressure gates were then closed and the water surface elevation of the reservoir returned to normal winter operation levels, several feet above the top of the intake tower, to avoid any issues with ice.

FUTURE SEDIMENT MANAGEMENT ENDEAVORS

For Spring 2015 dam operations, and for the future of Paonia Reservoir, several short- and long-term reservoir sediment management options are currently being investigated:

- Proposed Short-Term Management Analyses/Options:
    - Debris Management
    - Minimum Pool Level to Force Deposition at Upstream Delta
    - Temporary Siphon System to Maintain Irrigation Releases
- Proposed Long-Term Management Analyses/Options:
    - Outlet Works Modification/Replacement for Sediment Sluicing
    - Sediment Sluicing Efficiency with Numerical Sediment Transport Modeling
- Analyses of Downstream Impacts (e.g. Fisheries, Infrastructure)
- **GOAL**: **Sustainable Management of Reservoir Sediments**

REFERENCES

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