Example of Sediment Removal Site – Paonia Dam and Reservoir

Guardians of the Reservoir Sediment Removal Competition

Location: Paonia Dam and Reservoir are located on Muddy Creek, a tributary of the North Fork Gunnison River in western Colorado

Figure 1.—Aerial view of Paonia Dam and Reservoir

Figure 2.—Aerial view of Paonia Dam and Reservoir. Arrow points to the outlet works intake structure.

Reservoir Area: Approximately 315 surface acres at full pool

Amount of Sediment: Approximately 8.75 million cubic yards. Based on the most recent bathymetric survey of the entire reservoir, conducted in June 2016, the estimated average annual rate of sedimentation has been 100 acre-feet per year (161,000 cubic yards per year). Since dam completion in 1962, nearly 26% of the reservoir's original capacity has been lost to sediment deposition. At that rate,

the reservoir pool availability would gradually reduce and be completely filled with sediment in another 150 years. Long before sediment levels reach the full pool elevation, reservoir intakes and outlet works will be affected, adversely impacting project operations. Current sediment depths near the intake structure are upwards of 80 feet.

Figure 3.—Original construction photograph of the outlet works intake structure.

Figure 4.— Original construction photograph of the outlet works intake structure and dam.

Figure 5.— 2017 photograph looking upstream. Arrow points to the outlet works intake structure.

Figure 6.— 2017 photograph showing clearing around intake structure.

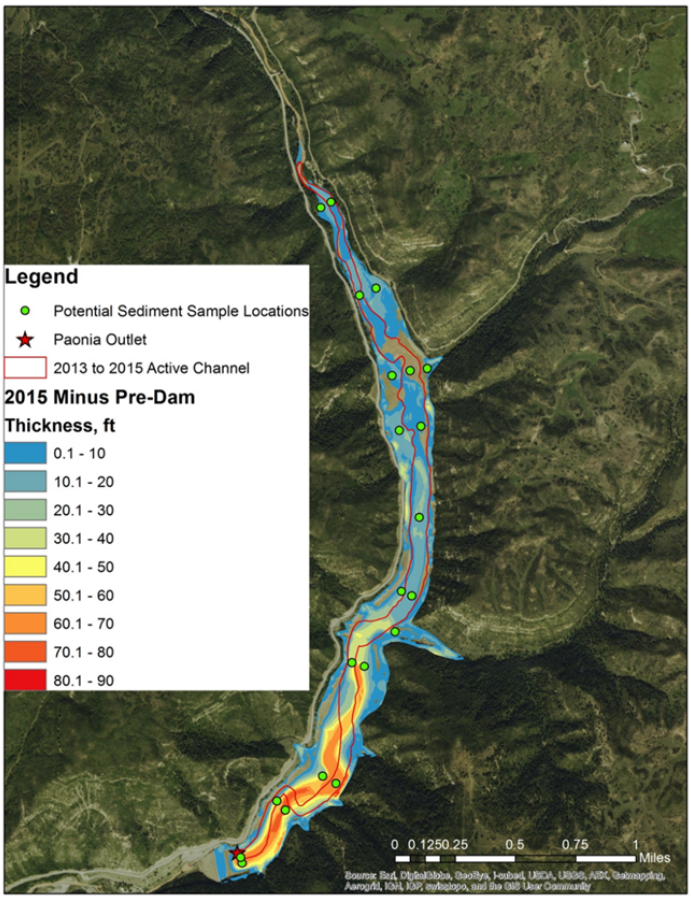

Figure 7.— Approximate sediment depths in Paonia Reservoir.

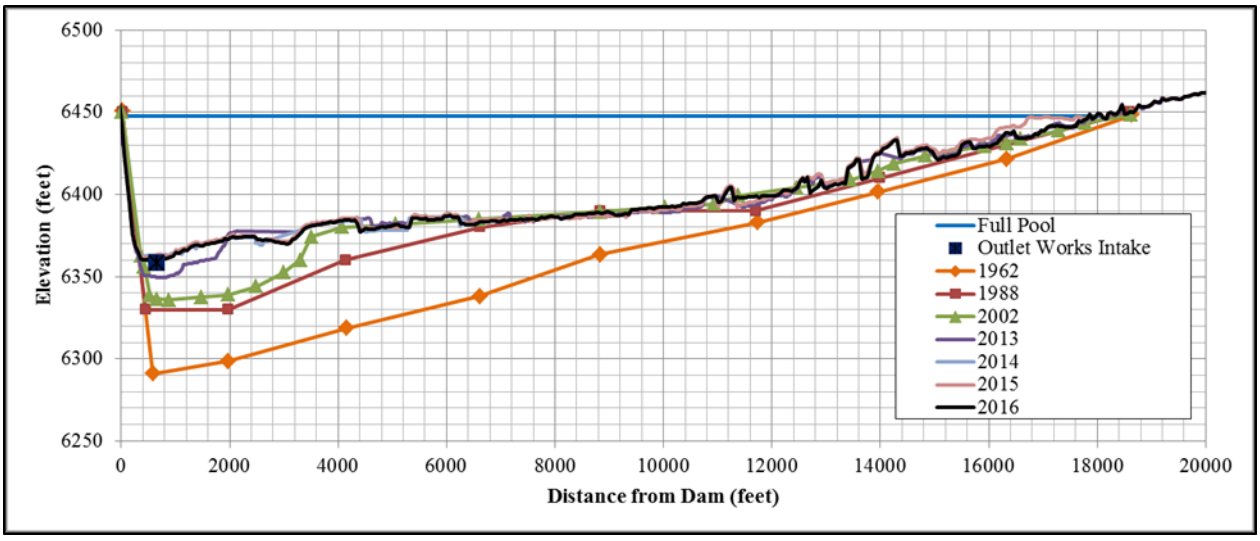

Figure 8.— Profile of Paonia Reservoir showing sediment historical sediment levels.

Sediment Sampling and Testing: Soil physical properties, in-place water content and unit weight, erodibility, and abrasivity tests were performed on seven VibeCore samples collected at six locations in June 2016. Sediment sampling sites were located based on the following criteria:

- Near the entrance of the reservoir,
- Upstream of, near, and downstream of tributary Inputs (e.g. Williams Creek and Deep Creek),
- Deepest portion of the reservoir,
- Near the reservoir outlet works, and
- If possible, in transverse areas of the reservoir where active channel conditions have not been recently observed

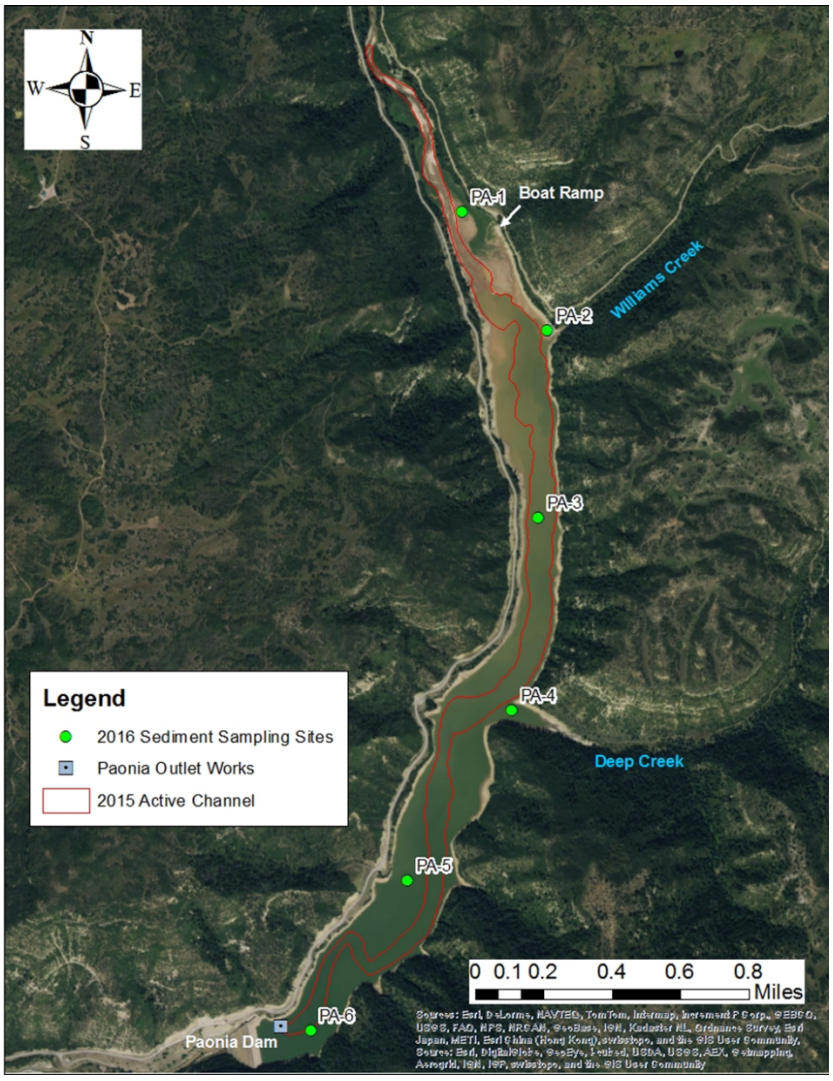

Figure 9.— Sediment Sampling Locations.

The break between sands and fines of 0.075 mm (#200 US Standard sieve) was used for analysis of the sediment samples. The following Unified Soil Classification System (USCS) categories were used to characterize the sandy material in the 2016 sediment samples:

- SP-SM – Poorly Graded Sand with Silt;
- SM – Silty Sand; and
- S(ML) – Sandy Silt.

Collected reservoir sediments ranged from lean and fat clays to dirty sands. Many of the sands analyzed contained appreciable amounts of fines and none were classified as clean sands (less than 5% fines). Fines materials were categorized as one of three classifications:

- ML – Silt;
- CL – Lean Clay; or
- CH – Fat Clay.

Most of the fine-grained sediments contained less than 10% sand. All sediments were described as saturated and very soft when the analyses began.

VibeCore samples were extracted, then divided into separate samples at distinct material type boundaries. Each individual sediment sample was analyzed separately for grain size distribution, liquid limit, and plasticity index. The majority of sediment collected and analyzed was characterized as fine material (smaller than 0.075 mm) although thin layers of predominantly sand-sized material were present in several samples. Median grain sizes (D_{50}) ranged from 0.0025 mm (classified as fat clay) to 0.4825 mm (classified as silty sand). Liquid limits ranged from 28 to 57 with an average of 43, while the Plasticity Index of the samples varied between 7 and 38 and averaged 21.

Submerged jet erosion testing (in compliance with ASTM D-5852) was performed on sediment core samples from five of the six Reservoir sites. Jet tests indicated that the majority of the sediment sampled fell into the "Very Erodible" class, likely due to the relatively low densities of the sampled material. Critical shear stresses of the jet tested materials varied between 6.8×10^{-9} and 0.022 psf, with an average of 0.0062 psf.

Abrasivity tests were conducted (in accordance with ASTM G75) on isolated sand lenses from three core samples: one collected near the middle of the reservoir (location PA-3) and two collected near the dam outlet structure (locations PA-6 and PA-7). Abrasivity is a measure of the ability of sediment particles to wear down man made materials through corrosion and mechanical erosion. Results indicated that the reservoir sands in all three samples tested were in the "Highly Abrasive" category with Miller Numbers (relative rate of wear indexes) ranging from 161.9 to 285.0.

Sensitivity of Wildlife: Downstream fish populations are a major concern. Significant sediment releases will only be permitted during high flows associated with spring runoff to protect the downstream fish habitats.

Seasonal nature of water flow: Seasonal flow ranges from <10 cfs during low flow, and 2,800 cfs during high flow. Average flow per month (rounded to nearest ten cfs) for the previous 33 years seen below:

Month	Incoming Flow (cfs)
January	20
February	30
March	70
April	300
May	590
June	300
July	70
August	30
September	30
October	30
November	30
December	20

Access and power supplies: Access at Paonia Dam and Reservoir is very limited. Highway 133, a two-lane mountain road runs along the north side of the reservoir. However, the access roads to the dam itself do readily accommodate larger vehicles or equipment. There is a boat ramp approximately 2 miles upstream of the dam. However, the reservoir is only high enough to use the boat ramps a few months of the year during spring runoff. There is limited access to power at the dam.

Other relevant information: Reclamation is currently modifying the outlet works. Upon completion, the most likely sediment management technique utilized will be spring sluicing. During runoff season the reservoir will be lowered such that run of the river will be restored and a large portion of the incoming sediment load will be carried downstream. Releases will need to be monitored such that more sediment is not released than is entering the reservoir at any one time. Sediment releases in the spring during high river flows is the natural sediment cycle for this river basin.

Note that the sediment within the existing delta contains a large amount of woody debris. The woody debris is stick or twig size but there is a great deal that accumulates at the intake structure. During the construction of interim repairs of the intake structure in the Fall 2017, the removal of sediment and woody debris build up required two workers working constantly to keep the intake structure clear.

Figure 10.— Clearing sediment and woody debris from the intake structure in 2014.