Accumulation of Sediment in Paonia Reservoir and its Effect on Storage Capacity

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Background

- Sediment accumulation causes decreased water storage in reservoirs which strips away supply and flood control benefits. It also frequently decreases the efficiency and quality of dam machinery.
- Increased sediment upstream causes flooding, water logging, and ecological harm.
- Decreased sediment downstream causes bed degradation, bank failure, and structural abrasion.
- As human population increases, so does the demand for fresh water and the reliance on storage reservoirs.
- As sediment increases, so does the cost of repairs and management of these facilities.

Methods

- General data accumulation from USGS water data site, Google Earth maps, and shapefile manipulation.
- A kmz file of Paonia Reservoir was uploaded onto Google Earth and national hydrography dataset files, imagery files, and a 30m digital elevation file was downloaded from The National Map. This data was used to observe the reservoir's watershed, tributaries, and flowlines.
- Three Digital Elevation Models (DEM's) were produced and used to observe the height difference of the reservoir between June and July of 2020.
- The instantaneous discharge rate in cubic feet per second and the suspended sediment discharge rate in kilograms per day (converted from short tons per day) were observed for two gauge sites and plotted against each other.
- For the Muddy Creek site, the bedload sediment discharge in short tons per day was also plotted.
- A linear fit was then put on the graph by using the equation **Qss = 1334.64 * Q + 210239; where Qss is in kg per day, and Q is in cfs.**
- Historical data from North Fork Gunnison River (downstream) was obtained from USGS.
- Gunnison daily discharge data in cfs was divided in half and used to calculate the total accumulation in cubic meters. This measurement was then used with the original capacity value to determine the percent of sediment accumulated.
- **NDWI=(G-NIR)/(G+NIR)** (Normalized Difference Water Index (NDWI)) is derived from the Green (G) and Near-Infrared (NIR) channels to observe the amount of water.

Future work

- Calculate percent error of sediment accumulation, then calculate the true percent of sediment accumulated in the reservoir. The 45.45% is the theoretical percent; the result is measuring sediment accumulation if all sediment were being trapped.
- The calculated percent could be used to determine the "lifespan" of the reservoir if sediment growth was constant.
- Apply the trends of Paonia Reservoir to similar locations in the United States. A long-term average of suspended sediment, reservoir storage, reservoir elevation, turbidity, and sediment discharge could be taken to further the data analysis of other locations.
- DEM's and water surface edge extraction could be used to calculate how much the water supply is reduced due to the sediment buildup. We would be able to observe the water surface levels over time with the DEM's to support the calculated percent of sediment collection.

Datasets

USGS water data was collected from three water gauges around Paonia Reservoir. Suspended sediment discharge and instantaneous discharge data were taken from the Muddy Creek and Anthracite Creek gauges. Daily discharge data was taken from the Gunnison gauge downstream. DEM's were derived from CIDR and the hydrography dataset from The National Map.

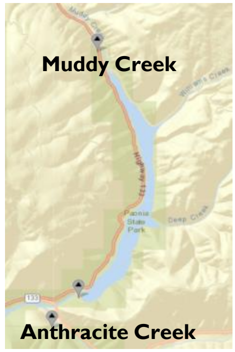
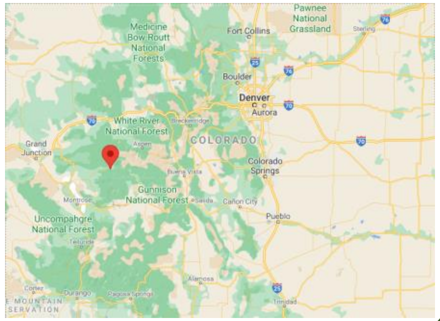


Fig. 1: Paonia Reservoir gauges.

Fig. 2: Paonia Reservoir reference map



Results and Discussion

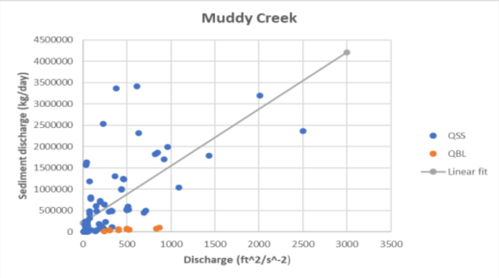


Fig 3 (top): Suspended Sediment Discharge (QSS) and Discharge of Bedload (QBL)

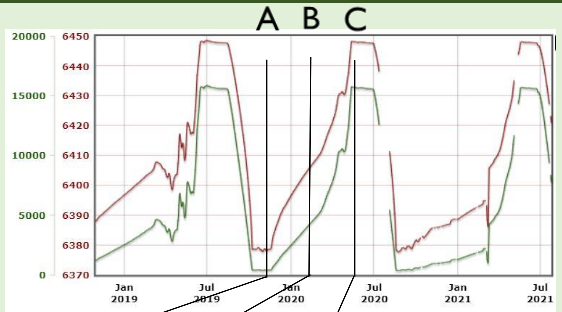


Fig 4 was taken from USGS and shows storage capacity.
Red- Daily mean surface elevation (feet)
Green- Daily mean reservoir storage (acre-feet)

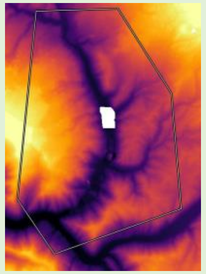
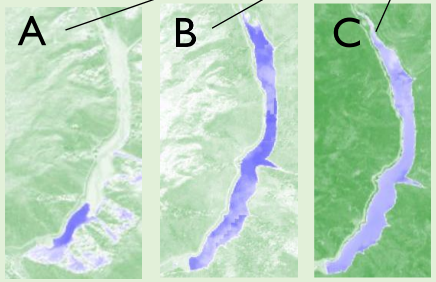


Fig 5 (left) shows QGIS and satellite imagery, and tributaries for the Paonia reservoir.
Fig 6 (right) shows the three DEM's covering Paonia Reservoir



Original capacity of the reservoir and the maximum accumulation, both in meters cubed, showed that the reservoir is 45.45% full.

No substantial results were taken from the QGIS or DEM data. The DEM's were for June, July, and October of 2020 and only two of them overlapped in the desired reservoir location. The uncertainty of the DEM's for water height data made it difficult to deduct any results.

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