Arkansas River Sedimentation Study

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Introduction:

- In October of 1986, a massive storm located in the central plains forced emergency flood actions to be taken by the US Army Corps of Engineers Tulsa District (USACE-SWT). As a result, substantial amounts of water flooded the Arkansas River Basin and into Lake Keystone near Tulsa, OK. At Keystone Dam, counter-measures were taken by releasing a maximum of 300,000 ft^3/s of water for a 12 hour period of time. For several days afterwards, water discharge was around 100,000 ft^3/s. Thus, the high volume and velocity of water released during this event was accredited for scouring the river channel downstream of Keystone dam.
- Due to upcoming development along the river in Tulsa County, it is necessary that flood elevations relative to different storm size events be accurately determined. The City of Tulsa is considering adoption of the 1986 flood elevation, which illustrates the base flood flow plus one foot. A hydraulic model will be created for planning and development to determine adequacy of this policy; to create the model, changes in the streambed elevation due to deposition and erosion within the river need to be determined.
- The objective was to use FIS stream profile data from 1986 and HEC-RAS data from 2005 to map changes in the riverbed in the Tulsa County reach in order to determine total estimated sediment deposition and scouring. Sediment samples were also collected to quantify particle size of eroded and deposited sediment.

Methods:

- 1986 Flood Insurance Study Flood Profiles and 2005 HEC-RAS data provided by USACE-SWT were digitized to create an overlay map of riverbed elevation over river miles 509 to 527 (Figure 1). Cross-sectional area and width (W) was compiled from the floodway data profiles.

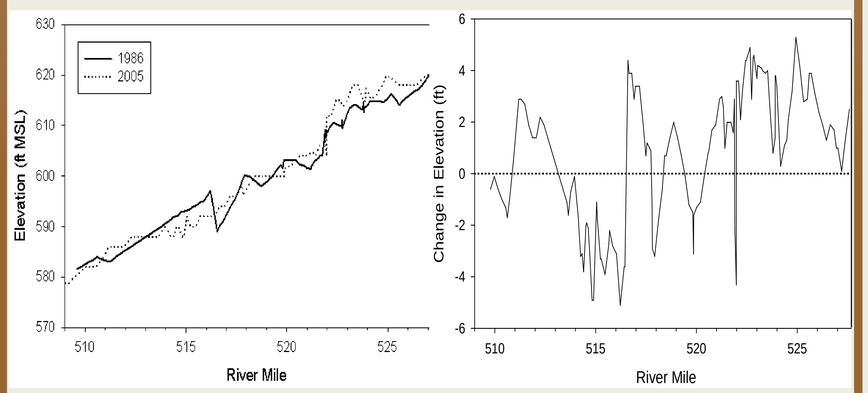

Figure 1: Riverbed elevation of Arkansas River over river miles for 1986 and 2005 (left) and change in the elevation (right).

- Estimates of total erosion (E) and deposition (D) were calculated based on W, change in height (Δh), and distance between cross-sections (ΔL):

$$E \text{ or } D = \sum_{i=1}^{n} W \, \Delta h \, \Delta L \qquad (1)$$

- Seven sediment samples were collected from sites on the river (Figure 2 and 3). They were allowed to air dry and then sieved using no. 10 (2.000 mm), 20 (0.850 mm), 40 (0.425 mm), 50 (0.300 mm), 60 (0.250 mm), 100 (0.150 mm), and 200 (0.075 mm) size sieves. The weight of the soil retained on each sieve for each sample was recorded in order to determine particle size distribution. Sample 1 was taken from an inactive channel and was not used for this study.

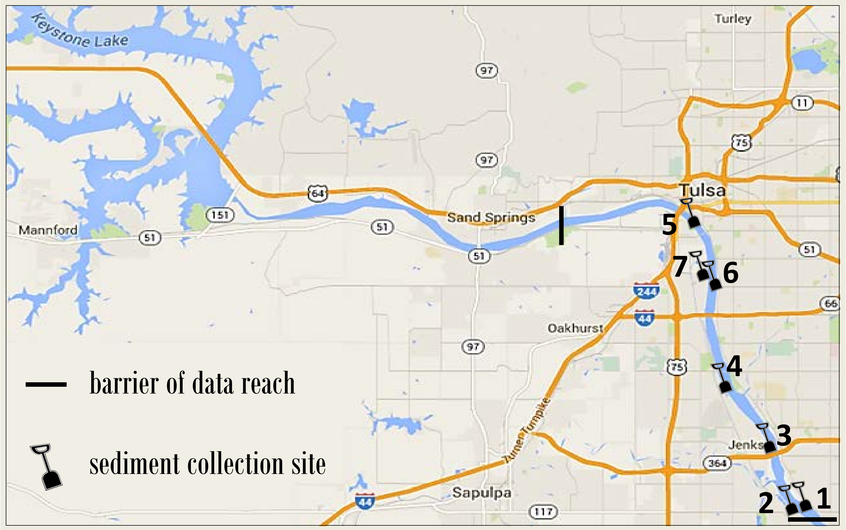

Figure 2: Illustration of the Arkansas River flowing through Tulsa County in Oklahoma from Keystone Lake including sample locations.

Figure 3: Location of riverbed samples.

- Particle size distribution was plotted corresponding to the percent passing each sieve (Figure 2). The average diameter, d_{50}, of the samples was also computed.

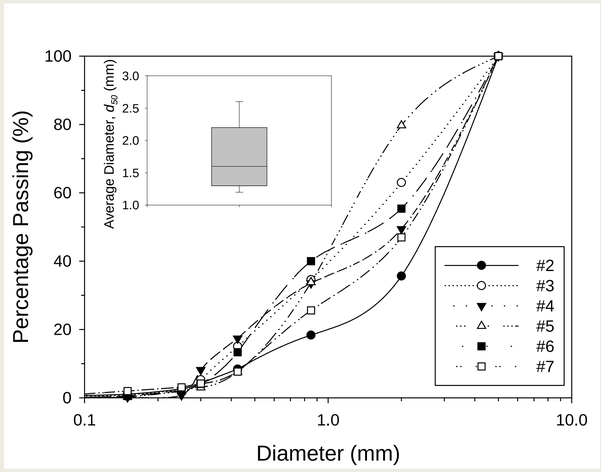

Figure 3: Particle size distributions of sediment samples from the Arkansas River.

Results and Conclusion:

- There are significant differences in the riverbed elevation between 1986 and 2005. Above Zink low-water dam (RM 522), only deposition has occurred according to the bed elevation data provided. Therefore, it is hypothesized that high velocity "hungry" water released from Keystone dam eroded sediment directly downstream of the dam and then deposited these particles when the flow was obstructed by Zink dam. Downstream of Zink dam are localized areas of erosion and deposition most likely influenced by bridges and road crossings.
- Equation (1) was utilized to calculate the net erosion and deposition through the Arkansas River reach. The total deposition through the studied reach was 2.44 x 10^8 ft^3 of sediment. When considering only above river mile 522.0, the total deposition was 1.27 x 10^8 ft^3, or 52% of the total deposition across all the river miles. The total erosion through the studied reach was 1.12 x 10^8 ft^3 with all the erosion occurring downstream of river mile 522.
- As expected, the particle size distribution of this deposited sediment, or sediment making up the riverbed, was a majority of sand and fine gravel. The median average particle diameter of the six analyzed samples was approximately 1.5 mm, close to the upper limit of sand (2 mm).

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