Historical Channel Change and Disturbance Zone Formation in the Big River, SE Missouri

Marc R. Owen and Robert T. Pavlowsky
Ozarks Environmental and Water Resources Institute (OEWRI)
Missouri State University

Introduction

- Historical mining in the Old Lead Belt of St. Francois County, Missouri resulted in widespread contamination of fluvial sediment with lead (Pb) in the Big River watershed (MDNR, 2007; Roberts et al., 2009; Pavlowsky et al., 2010; Figures 1 and 2).
- Over the past 120 years, sediment-laden floods deposited relatively large quantities of Pb in alluvial deposits along the Big River contaminating both the in-channel deposits (bar and bed) and floodplain soils.
- To address the long-term risk of sediment Pb contamination in the Big River, management plans to monitor and mitigate mining-related contamination need to contain elements that address the geomorphic processes involved in the transport, deposition, and long-term storage of contaminated sediment.
- Major tailings piles within the Old Lead Belt have been stabilized and capped, however, a major source of mining-related Pb to the main stem channel of the Big River is the remobilization Pb from historical floodplain storages by channel instability and accelerated bank erosion caused by hydrologic and geomorphic disturbances.
- These actively eroding channel areas associated with large gravel bar accumulations and unstable banks have been previously described as active reaches, disturbance reaches, sedimentation zones, or disturbance zones (Jacobson, 1995; Martin and Pavlowsky, 2011). For this study, the term "disturbance zone" will be used to refer to these features.
- The purpose of this study is to determine the spatial distribution, morphology, and timing of disturbance zones formation along the Big River. The objectives of the study are:
  1. Use a series of historical aerial photographs to identify and classify disturbance zones and stable reaches along the main stem of the Big River and;
  2. Describe the spatial variability, temporal variability, size, and types of disturbance zones and to access longitudinal patterns.
- Once the locations, dimensions, and behavior of disturbance zones in the Big River are understood, managers can use this information to develop remediation plans and protect aquatic resources.

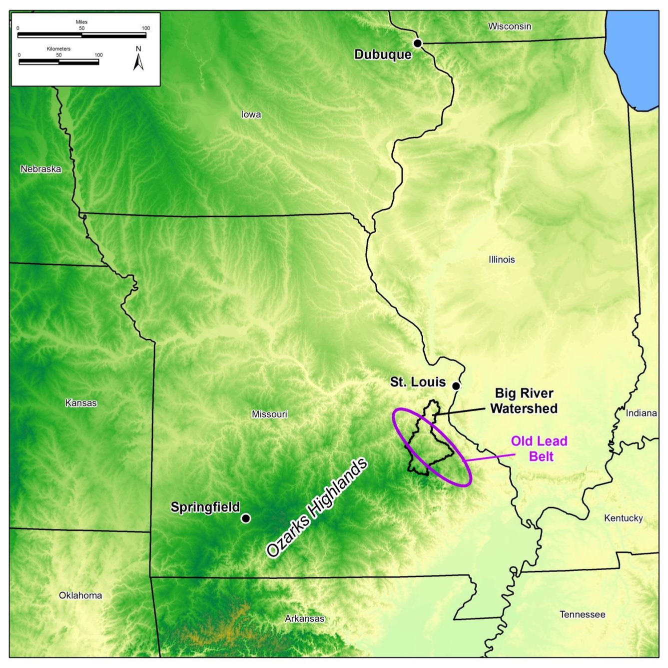

Figure 1. Project location in the Ozarks of Missouri.

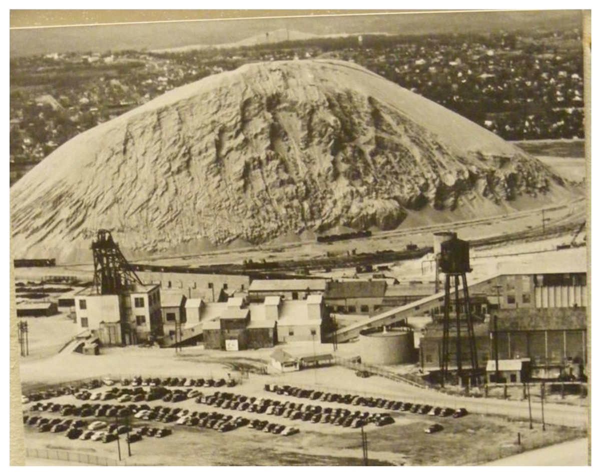

Figure 2. There is a long history of mining in the Old Lead Belt. This is the Federal mine-mill complex located near Park Hills, MO in the 1940s.

Study Area

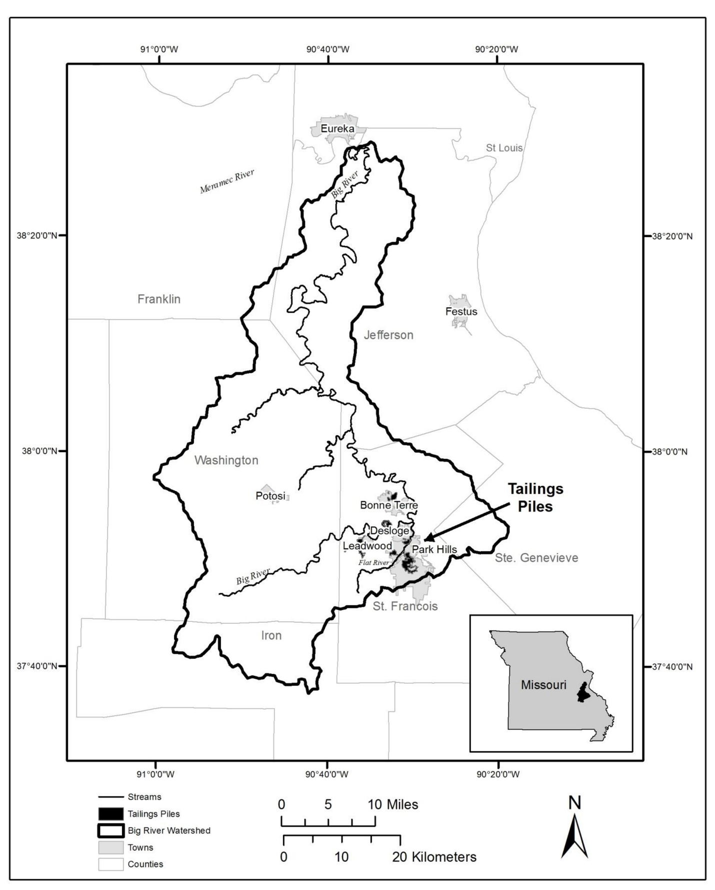

Figure 3. Big River watershed in SE, Missouri.

- The Big River (2,500 km^2) primarily drains the Salem Plateau of the Ozarks Highlands before it flows into the Meramec River near Eureka, Missouri (Figure 3).
- The Big River is a typical, low-gradient, riffle-pool Ozarks stream with a gravel/cobble bed and floodplains composed mainly of silt-loam overbank deposits of variable thickness over buried channel bar deposits (Figure 4).
- The present channel is inset into an entrenched valley meander belt where vertical and horizontal channel stability is somewhat controlled by bedrock when the channel flows along the valley margin in contact with bedrock bluff lines (Figure 5).

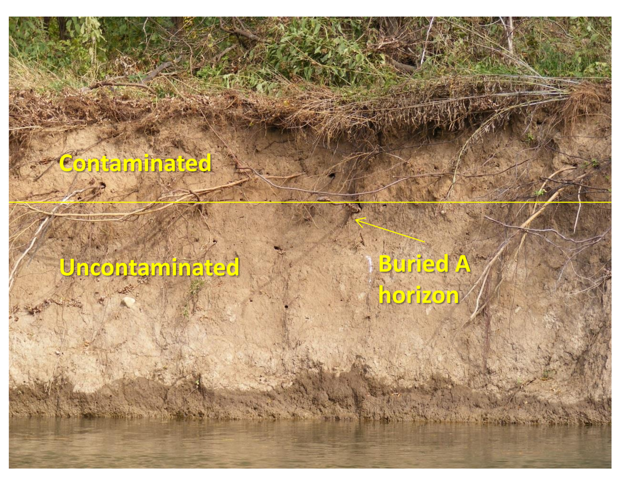

Figure 4. Fine-grained floodplain deposits can be contaminated from 2-3 meters deep.

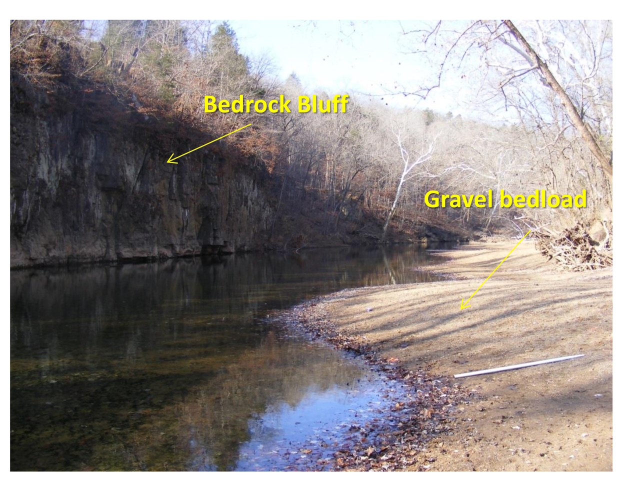

Figure 5. Channel migration can be controlled along bedrock bluffs at the valley margin.

Methods

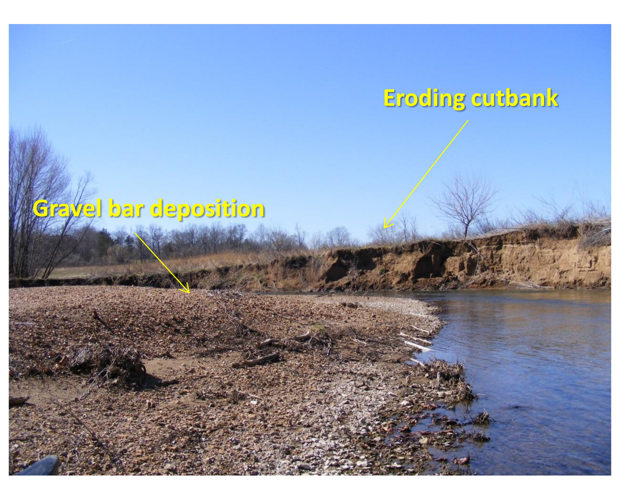

Figure 6. Example of a disturbance zone showing bank erosion and gravel bar deposition causing rapid channel changes and remobilizing contaminated sediment.

- Aerial photographs used for this project are categorized into five sets for historical channel change analysis. The five sets are; 1) 1937, 2) 1954, 3) 1976, 4) 1991, and 5) 2007 and represents the average year for that set of photos.
- Older photo sets were scanned and rectified using standard methods in ArcGIS software.
- Visible channel features were digitized from each photo set and overlaid for spatial analysis.
- For this study, disturbance zones were identified as channel reaches where the meander belt width changes were >1.5 times that of the upstream reach in areas of excessive bank erosion, large gravel bar accumulations and rapid channel change (Figure 6).
- After each disturbance zone was identified, they were classified based on morphological characteristics and direction of change by year-to-year layer analysis based on disturbance types found in the Ozarks reported by Martin and Pavlowsky (2011) (Figure 7).
- The four types are: (1) extension, (2) translation, (3) cutoff and (4) mega bars.
- An **extension** is when a channel meander grows laterally across the valley floor increasing the length of the channel.
- A **translation** is when the meander shape stays the same, but it migrates up or downstream with no net change in channel length through the reach.
- A **cutoff** occurs when a new channel is formed at the neck of a large meander and the loop in the meander is bypassed creating an oxbow lake.
- Finally, a **mega bar** is the term used for a reach where large accumulations of gravel have created an overly wide area in the channel where large center bars or point bar complexes are located.

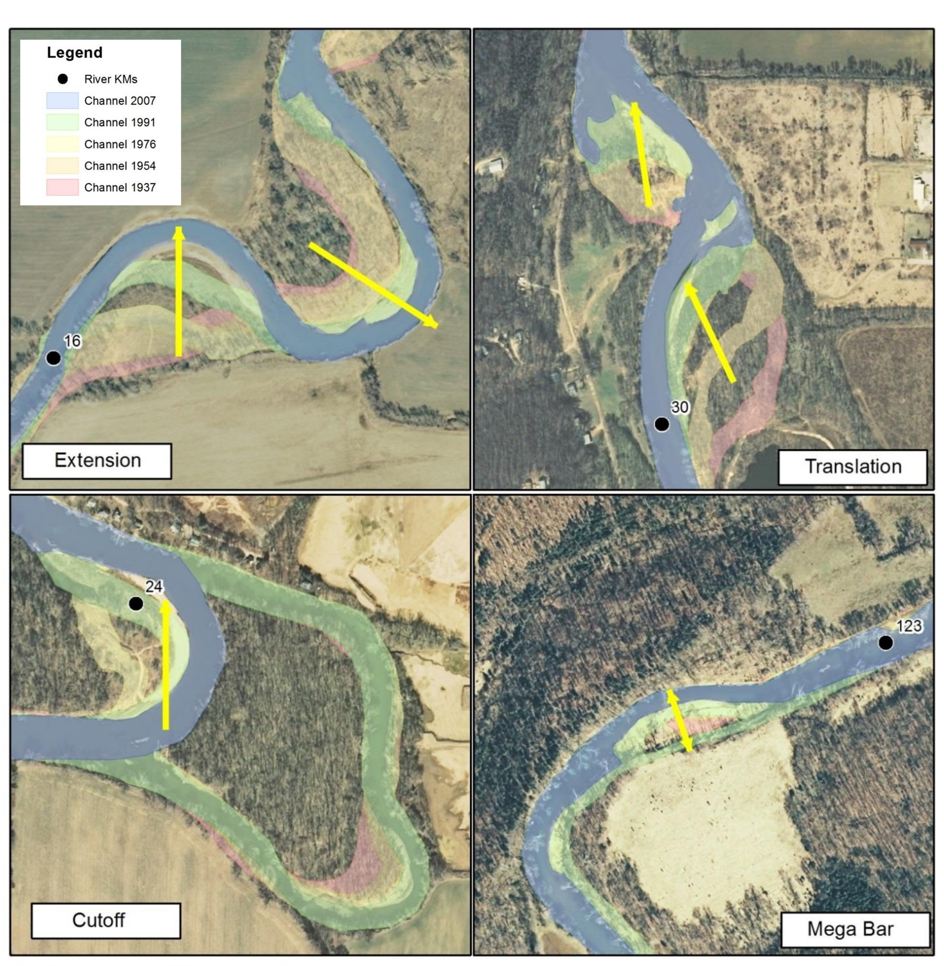

Figure 7. Examples of disturbance zone types found in the Big River, A) Extensions, B) Translations, C) Cutoff, and D) Mega Bars.

Results

Disturbance Zone Frequency, Type, Size and Timing

- There are a total of 85 disturbance zones along the lower 186 km of the main channel of the Big River for an average density of approximately 0.45/km, or 1 disturbance zone for every 2.2 km of stream channel.
- The total length of disturbance zones (approx. 57.1 km) covers about 31% of the entire length of the river (Figure 8A).
- Mega bars make up about 78% of the total number of disturbance zones along the Big River (Figure 8B). Of the remaining, extensions make up 13%, translations 7% and cutoffs only 2%.
- Of the total number of disturbance zones identified, 54% are small with an area of <50,000 m^2, 26% are medium size with areas 50,000-100,000 m^2, 16% are large with areas from 100,000-200,000 m^2 and 4% are very large with areas >200,000 m^2 (Figure 8C).
- Almost 74% of the disturbance zones identified were observed in the 1937 aerial photo (Figure 8D). Of the remaining, 11% were from 1954, 8% in 1976, 3% in 1991, and 4% in 2007.

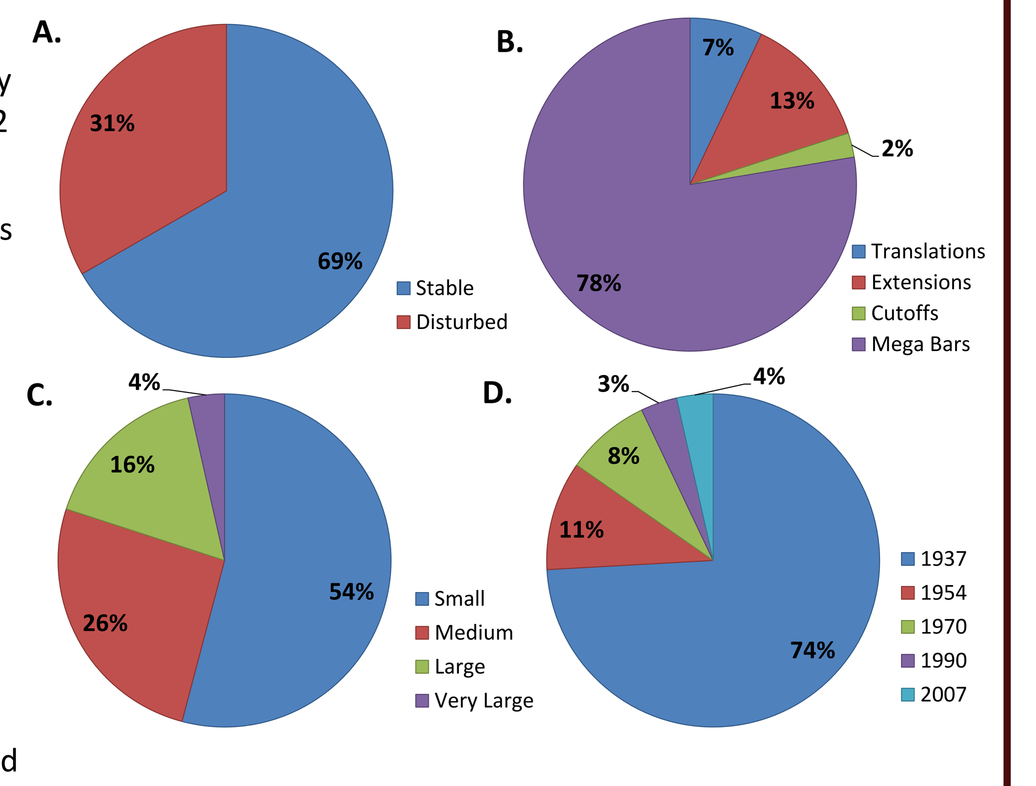

Figure 8. Disturbance zone A) frequency, B) type, C) size, and D) timing in the Big River main channel.

Downstream variability in disturbance zones

- Disturbance zones appear to grow longitudinally rather than laterally, as width is less variable in contrast to length. The exception are cutoffs, which are much wider than most other types of disturbance zone (Figures 9 and 10).
- In general, the length of different types of disturbance zones tends to increase along Big River in the following order: mega bars < or = translations and cutoffs < extensions (Figure 10).
- These trends suggest that the size of disturbance zones in the Big River are probably controlled by sediment transport capacity rather than channel instability.
- The longitudinal growth of disturbance zones may also indicate a geomorphic response to downstream shifts in bar forms and/or sediment waves pulsing through the system.
- While mega-bars are the most common type of disturbance zone in the Big River, more extensions, translations, and cutoffs occur below R-km 100 (33%) than above (8%). This change, and the increase in size to a lesser extent, appears to be associated with the significant increase in drainage area below Mineral Fork at R-km 99 (Figure 11).
- Furthermore, the abrupt increase in valley width between R-km 70 and R-km 25 also appears to be an important factor in the type of disturbance zone where the channel has more freedom to move across the valley without be obstructed by the valley wall (Figure 12).

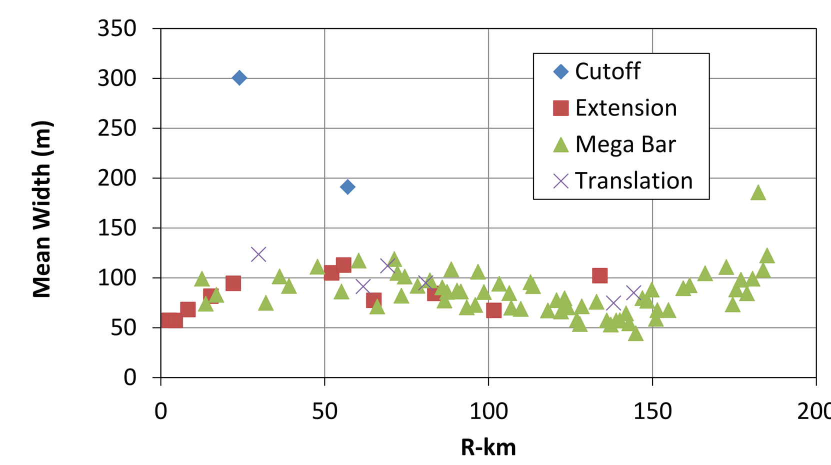

Figure 9. Downstream variability in mean disturbance zone width by type.

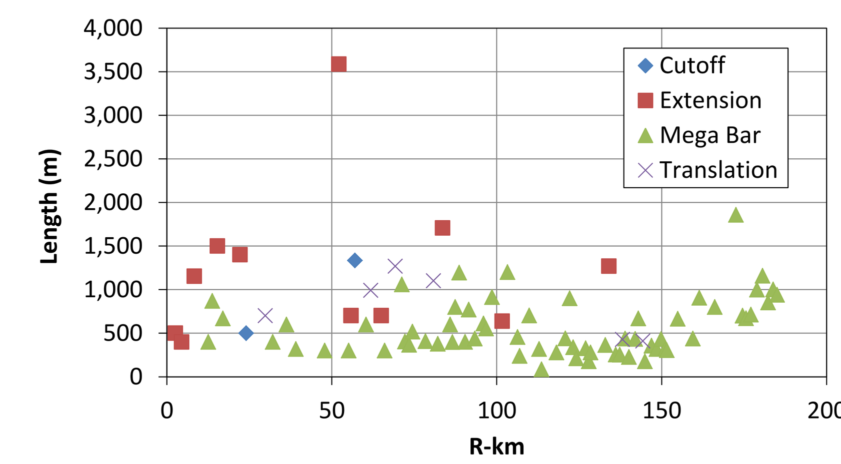

Figure 10. Downstream variability in disturbance zone length by type.

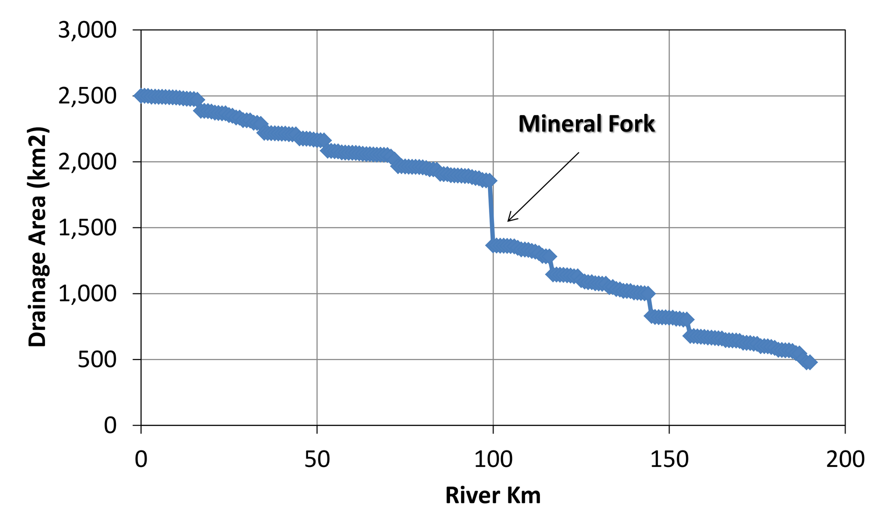

Figure 11. Downstream changes in drainage area. Contributing area increase about 30% below Mineral Fork at river km 99.

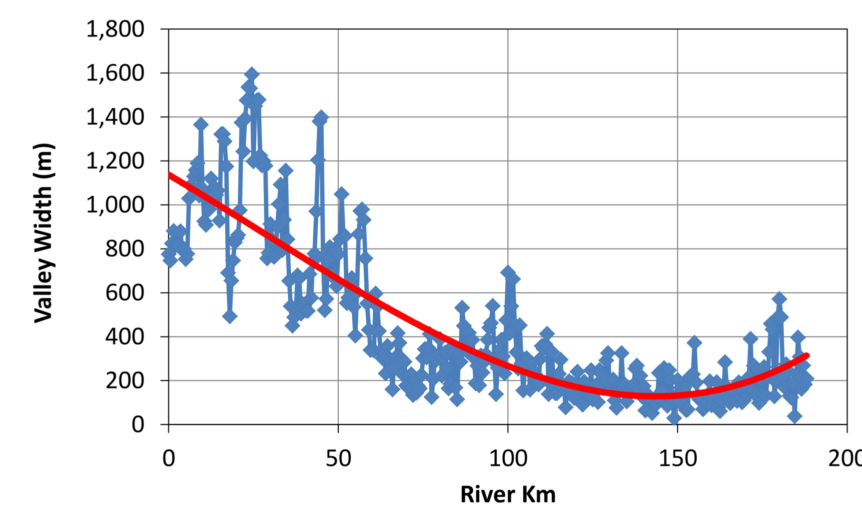

Figure 12. Downstream changes in valley width .

Conclusions

- About 30% of the main channel is classified as disturbance zones, with an average spacing of 1 every 2.2 km of stream channel.
- Mega bars are the most common disturbance zone type, but other types increase in frequency below the confluence with Mineral Fork.
- The majority of disturbance zones are small (<50,000 m^2), but larger disturbance zones are more common in lower 99 km of the river.
- About 74% of the disturbance zones were first observed in the 1937 photo set and only 4% occurring since 1990.
- Sediment transport capacity seems to be the most important controlling factor on size of disturbance zones and valley width may be more of a control on the type.
- Once the locations, dimensions, and behavior of disturbance zones in the Big River are understood, managers can use this information to develop remediation plans and protect aquatic resources.

References

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