# Report for 2005KY50B: Effects of Reservoir Releases on Riverbank Erosion

Publications

- There are no reported publications resulting from this project.

Report Follows

## Problem and Research Objectives

This project evaluated the influence of Green River Lake Dam located near Campbellsville, Kentucky on the hydrology and bank stability of the Upper Green River of Kentucky. Alteration of natural river flow regimes by dams can have negative impacts on river channel morphology and aquatic ecosystems. These environmental costs must be balanced against the water resource benefits provided by dams and reservoirs. Changes in riverbank stability and channel width are commonly observed downstream of dams. These geomorphic impacts can lead to degradation of habitat and impairment of riparian and aquatic biological communities.

The Upper Green River is of particular concern because of impacts on threatened and endangered species, and because of federal and state soil conservation programs aimed at improving water quality in the river. Several flood control reservoirs were built in the Green River Basin during the middle of the 20$^{th}$ century to regulate flows on the Green and Ohio Rivers. The geomorphic effects of Green River Lake Dam are undocumented and thus poorly understood. This project analyzed the historical impacts of the dam on bank stability and provided new information on the effects of hydrological modification by flood control reservoirs on channel dynamics in large alluvial river systems. These results will be valuable in planning flood control operations and land use practices that minimize the negative geomorphic and ecological effects of flow regulation.

The scientific objectives of this research were to document historical rates of channel migration, changes in channel width, and spatial patterns of recent bank instability on the upper Green River, and to relate these geomorphic changes to patterns of hydrologic modification by Green River Lake Dam.

## Methodology

*Hydrologic Modification*: The hydrological impacts of Green River Lake were evaluated by analyzing available daily streamflow records from USGS gaging stations at Greensburg and Munfordville, Kentucky. Analysis entailed comparing flow regimes during pre-dam and post-dam periods of record, along with information on climatic variability during these periods.

*Historical Pattern of Channel Change:* Due to the time and effort involved in obtaining and analyzing aerial imagery, analysis of historical channel change was restricted to the tailwater reach of the Green River, defined as the reach between the dam and the confluence with Russell Creek. This part of the river is most likely to have had significant, dam-related hydrologic alteration (this geographic focus is a modification to the analysis described in the original proposal). Rates of channel migration and channel width changes were estimated from sequences of aerial photographs (USDA aerial photography field office). Imagery from 1955, 1964, 1983, 1991, and 2004 were used in this analysis. Digital scans of older aerial photos were georeferenced and orthorectified using 2004 NAIP (National Agricultural Information Program) imagery as the geographic reference. Series of images were analyzed by automated classification algorithms (*Erdas Imagine*) and by manual assessment of changes in channel width. Bank stability for periods before and after flow regulation by the dam was compared to the observed changes in hydrologic regime between pre- and post-dam periods.

*Recent Streambank Instability:* Locations of recent streambank instability were mapped, in part by using a previous survey of bank erosion locations provided by faculty in the Department of Biology at Western Kentucky University. This survey, and additional surveys of bank erosion locations were used to select sites for detailed study where erosion pins were inserted into steep, eroding banks, and bank planform geometry was mapped in order to monitor bank retreat in relation to flow fluctuations in the future.

**Principal Findings and Significance**

*Hydrologic Modification*: Analysis of daily streamflow records from the Greensburg and Munfordville gages revealed a pattern of hydrologic alteration consistent with the flood control objectives of the dam. Peak flows during the post dam period of record (after 1970) are lower and less frequent at both gage sites. Flow duration curves were altered at both Greensburg and Munfordville in a similar fashion, with the proportions of low and high flows reduced, and the proportions of intermediate level flow correspondingly increased (Tables 1 and 2). These changes reflect the retention of runoff for flood abatement objectives and the mandatory minimum release from the dam for water supply purposes. These changes correspond to increases in the duration and frequency of in-channel flows and thus could be expected to contribute to decreased bank stability during the post-dam period.

**Table 1. Hydrologic Alteration at the Greensburg, KY gaging site**

| Summary of Mean Daily Flow Records, Green River @ Greensburg, KY | Pre-Dam (1940-1969) | Post-Dam (1970-1975) |
|---|---|---|
| N (days) | 11050 | 2099 |
| **Low Flows, Q < 2 cms** | | |
| Average # days/yr | 84 | 5 |
| Proportion of days | 0.23 | 0.014 |
| **In-Channel Flows, Q = 100 - 200 cms** | | |
| Average # days/yr | 15 | 57 |
| Proportion of days | 0.04 | 0.155 |
| **High Flows, Q > 200 cms** | | |
| Average # days/yr | 9 | 2 |
| Proportion of days | 0.025 | 0.005 |
| **Maximum Mean Daily Flow (cms)** | 1621 | 244 |

**Table 2. Hydrologic Alteration at the Munfordville, KY gaging site**

| Summary of Mean Daily Flow Records, Green River @ Munfordville, KY | Pre-Dam (1915-1969) | Post-Dam (1970-2003) |
|---|---|---|
| N (days) | 16194 | 11961 |
| **Low Flows, Q < 5 cms** | | |
| Average # days/yr | 44.5 | 3.7 |
| Proportion of days | 0.12 | 0.01 |
| **Intermediate Flows, Q = 100 - 300 cms** | | |
| Average # days/yr | 50.3 | 99.3 |
| Proportion of days | 0.14 | 0.27 |
| **High Flows, Q > 600 cms** | | |
| Average # days/yr | 4.7 | 2.0 |
| Proportion of days | 0.013 | 0.005 |
| **Maximum Mean Daily Flow (cfs)** | 2086 | 1780 |

*Historical Pattern of Channel Change:* Analysis of imagery for the tailwater reach revealed surprisingly little evidence of significant channel migration or bank erosion since 1955. The most prominent changes occurring appear to be the modification and/or erosion of islands. The evidence of island erosion and modification does not appear to be correlated with hydrologic modification during the post-dam period. Identification of changes in bank position is limited by the resolution and geospatial accuracy of the imagery and by differences in shadow and image quality. Given these limits, observed changes in bank position, and thus evidence of bank erosion and channel migration, appear to be within the margin of error for the analytical techniques for most of the tailwater reach. For those locations where channel change is apparent, it appears that changes in riparian vegetation, often associated with agriculture, are a significant factor. Thus, the initial results of this work suggest that flow regulation by Green River Lake Dam has not significantly modified channel width, planform geometry, or channel migration rates within the study reach. It is possible that progressive change due to the dam is occurring, but is too slow to produce significant planform changes over 50 years.

*Recent Streambank Instability:* Field surveys of bank erosion suggest that the occurrence of local accelerated bank erosion is more frequent along the portion of the Upper Green River upstream of the confluence of Little Barren River. This pattern may reflect a combination of hydrologic and geomorphic factors, but the explanation remains uncertain. Enhanced bank erosion in river segments nearer to the dam is consistent with the hypothesis that hydrologic alteration has induced bank instability in the tailwater reach. However, the apparent stability of this river segment as revealed by the aerial imagery analysis suggests that other factors, such as riparian land use, may be just as important.