Extended Abstract: Tracking the River Bed's Response to Channel Mining on the Lower Missouri River

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Introduction

Since the 1930s, large stretches of the lower Missouri River have experienced in-channel commercial sand and gravel mining with annual totals over the last 20 years of more than 5 million tons. As part of a study to understand the localized, short-term impacts of mining on the river, the acute depression in the riverbed caused by a cutter head dredge was surveyed using a multibeam echosounder. Multiple surveys were collected over the course of two weeks until the depression was no longer evident. Repeated, detailed surveys of a marked removal of a known quantity of bed material provides a visible depiction of the channel's localized geomorphic response to the dredging disturbance. This extended abstract documents the lateral extent, depth, and location of the depression over time and provides insight into the morphological behavior of this large, sand bed river.

Methods

In order to assess the spatial and temporal changes that dredging induces in the river bed in the immediate area of the dredging operation, daily multibeam hydrographic surveys were collected immediately following and in the localized vicinity of a discrete dredging event. As conditions and schedules allowed, daily surveys were continued until effects of dredging were no longer evident. The multibeam survey crew mobilized immediately following cessation of dredging at an actively dredged location. The area surveyed within the channel extended from 0.2 miles upstream to 0.2 miles downstream of the dredge location.

The Lexington Reach from river mile (RM) 315-317.5 was the area targeted for this survey effort. The depression created from a commercial suction cutter head dredge is the focus of this analysis. This data provides information for management actions on regulation of commercial dredging.

The survey equipment for this effort includes a sounding system comprised of an R2Sonic 2024 multibeam echo sounder with user selected frequency from 200 kHz to 450 kHz and 700 kHz UHR with capability to log Water Column and True Pix (side scan), POS MV 320 V5 inertial aided DGPS with optional RTK. Sound velocity measurements are obtained from Odom Digibar Pro SV profiler and a Valport Mini SV Probe at the head. Navigation and data collection are accomplished with HYPACK/HYSWEEP. This data was collected to yield 1-foot point spacing in the resulting point cloud.

Results

The extraction location, extraction quantity, the extents, the depth, and depression location for a dredge event occurring on 16 July was tracked over time at Lexington Bend at RM 316.2. Surveys were collected starting on 16 July 2018 and ending on 6 August 2018. No additional dredging occurred in the surveyed area during the 22 days following the 16 July survey event. While the depressions from several dredging events from a week prior to the 16 July event are evident in the survey data, the dredge hole resulting from the 16 July dredge event, which occurred a few hours prior to the hydrosurvey, is the focus of this analysis. Also, note that the surveys were collected during a time of fairly constant water surface elevations that dropped no more than 2 feet over the course of the surveys (Figure 1).

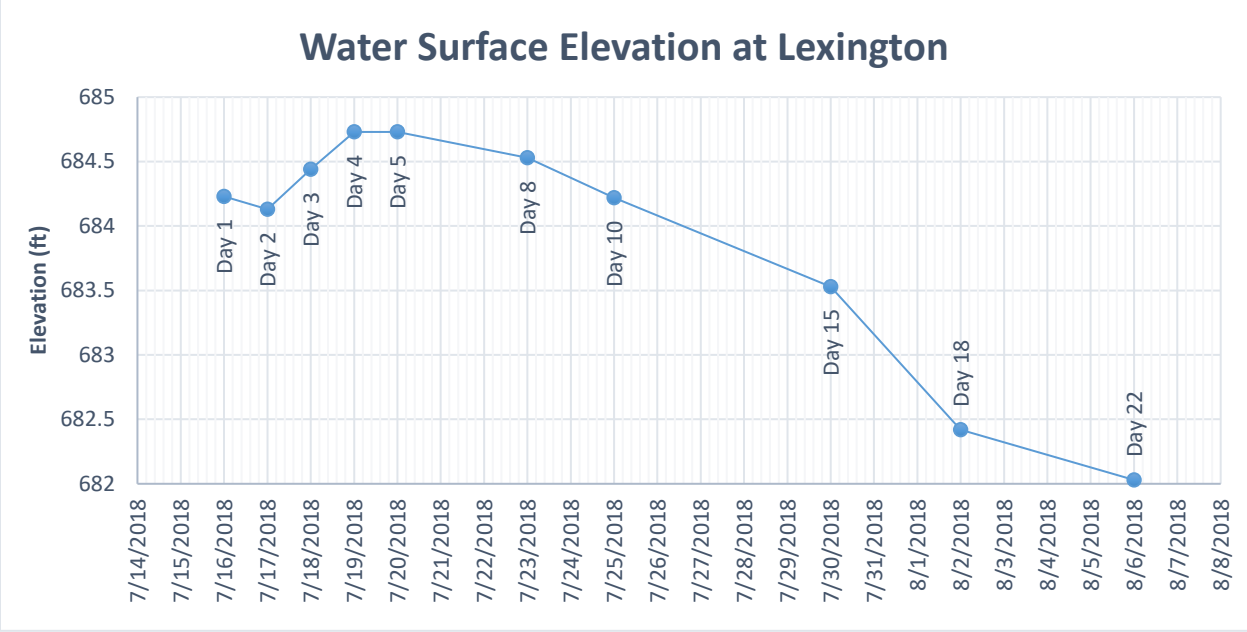

Figure 1. Water Surface Elevation at Lexington on surveyed days (Day 1 = day of dredging event)

The translation and attenuation of the dredge hole occurs in a very dynamic system. For example, natural variability in bed elevations, as indicated by repeated cross section, single beam surveys under steady flow conditions, can be as high as 6 feet. Notwithstanding, the multibeam surveys employed for this analysis provide sufficient resolution to describe the dredge hole's initial dimensions as well as its translation and attenuation over time. This dredge hole analysis uses multibeam data with 1-ft bed elevation spacing and captures more of the bedform scale features that are not evident in cross section based data. For instance, dune heights up to 3 feet are apparent in this multibeam survey data. While the spatial scale is relatively small in this analysis, it is important to keep in mind the natural trends that are occurring at the larger scale. This analysis aims to characterize the effects of one discrete dredging event and will be used to develop a methodology for future surveys which will ultimately provide a better understanding of the effects of commercial dredging on the Missouri River system as a whole.

Extraction Location and Quantity

A total of 750 tons was removed from the bed during this targeted dredge event. The initial dredge depression extended about 230 feet upstream to downstream and averaged about 25 feet wide. Typical cutter head suction dredges start downstream and pull themselves upstream by the use of anchors as the dredge cuts into the bed. The two points plotted in the graphic below (Figure 2) mark the start (downstream) and stop (upstream) location of the dredge path. About 3 tons per linear foot were dredged at this location.

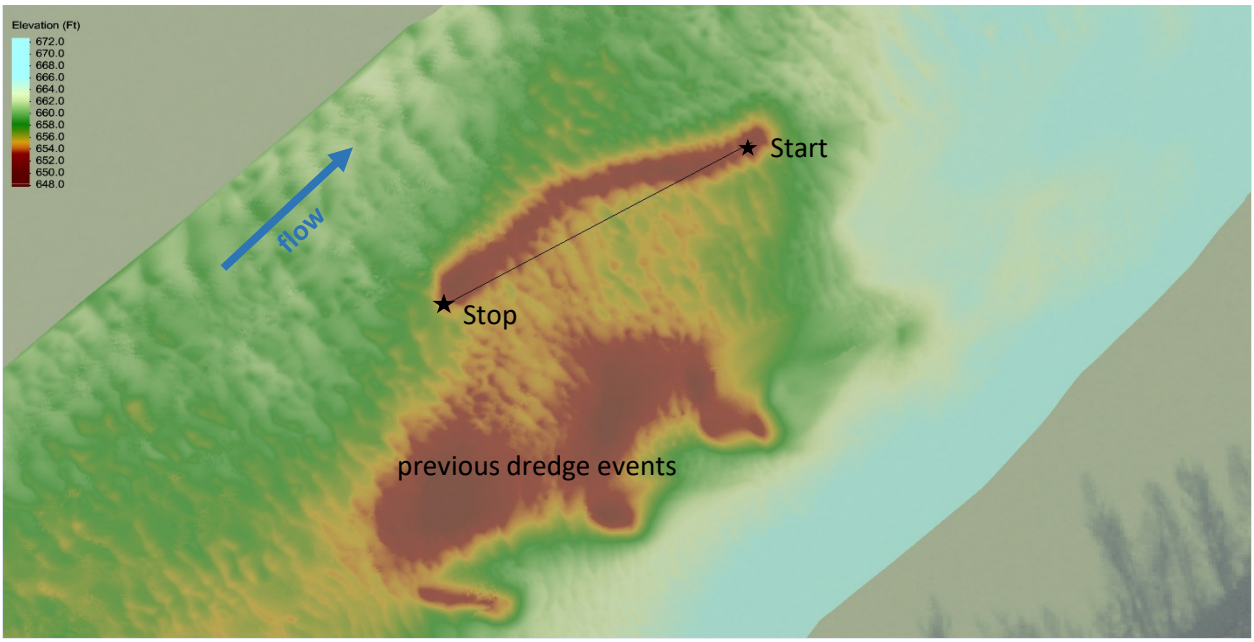

Figure 2. Day 1 Dredge Hole Survey at Lexington with Dredge Start/ Stop Locations

Extents and Depth

The extent and depth of the depression were measured for each subsequent survey. Days 1-8 are plotted below (Figure 3). Surveys collected after Day 8 are not shown because the effects of dredging were no longer evident. Over time the depression migrates downstream, reduces in depth, segments, and widens laterally.

At an average river discharge of about 100kcfs, the surveys show that each day the dredge hole migrated downstream about 20-40 feet and widened about 10 feet until the hole completely attenuated. The downstream travel distance from Day 1 to Day 8 is approximately 200 feet. The dredge hole depth attenuated about 1 foot per day until the hole depth was about 3 feet and then attenuated at a much slower rate for the next 5 days. Where the dredge hole overlaps with the hole from prior dredging events, it appears the downstream migration distance increased. The initial depression immediately following dredging is narrow, long, and deep. Over time the depression becomes shallower and widens which increases the impacted footprint across an area more than double that of the initial depression.

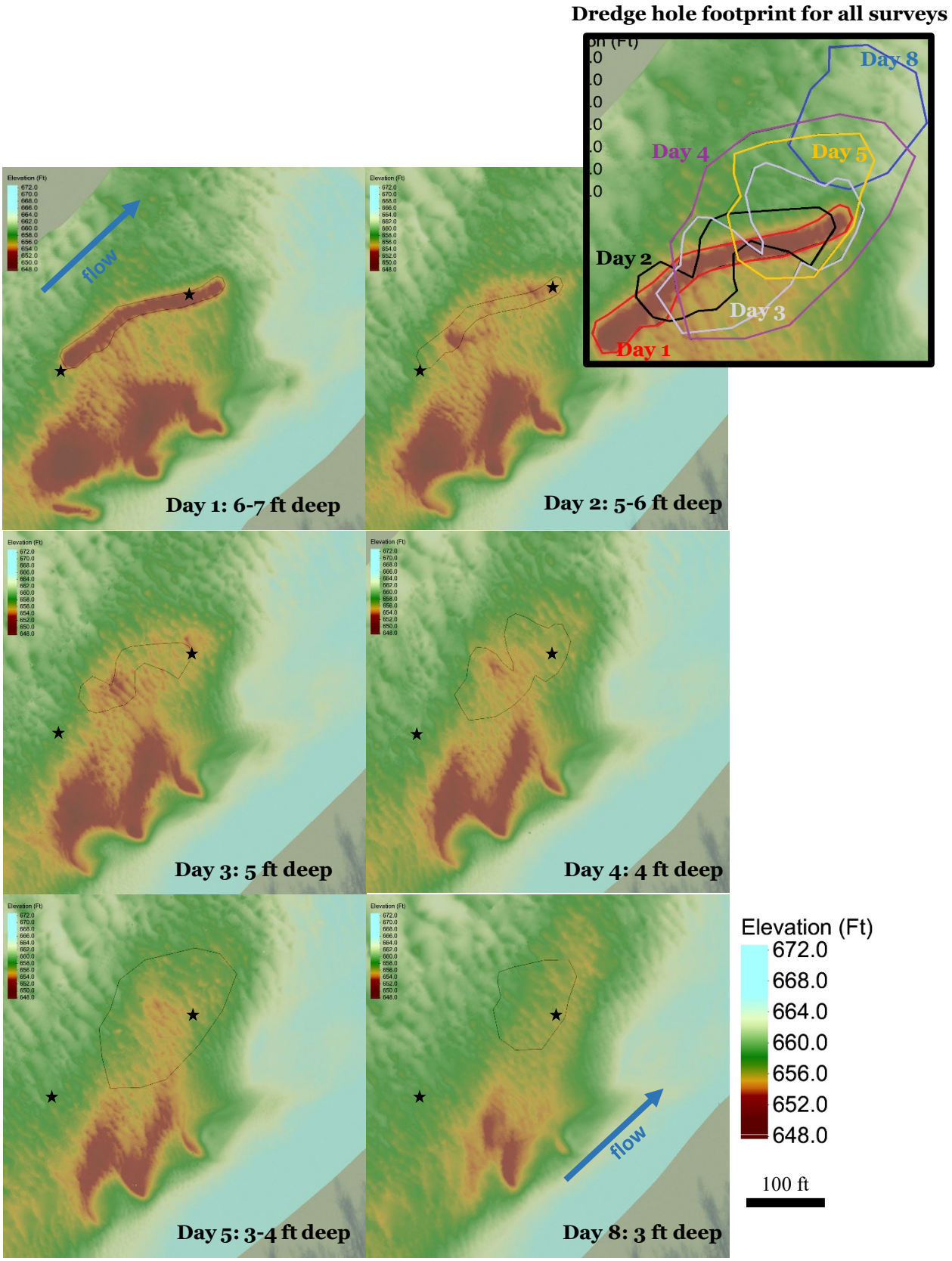

Figure 3. Dredge hole migration. Outline indicates preceding survey's dredge hole extents.

Limitations

The information presented in this abstract documents the attenuation of a single dredge hole under a specific set of conditions. Further data are required to generalize rates of attenuation to other dredge hole sizes, configurations, locations, discharge conditions, and dredging methodologies. Furthermore, this analysis only describes the localized, short-term effects of channel mining, not the long-term, reach-scale cumulative effects of multiple dredging events over years.

Conclusions

At a fairly constant river discharge of about 100kcfs, the depression created from a dredge event that removed 750 tons from a narrow 230 foot long segment of the riverbed persisted for over 8 days. The depression migrated 200 feet downstream, reduced in depth, and widened in lateral extents, resulting in an impacted area nearly double the size of the initial footprint. This information along with future examination of other dredge holes provides insight to the localized, short-term geomorphic response of the sandbed to commercial sand and gravel mining.