Prepared in cooperation with the
KANSAS WATER OFFICE

Geomorphic Effects of Overflow Dams on the Lower Neosho River, Kansas

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The purpose of this report is to characterize the geomorphic (channel-changing) effects of overflow dams on the lower Neosho River channel in southeastern Kansas. Specifically, the report describes the types, upstream and downstream extents, and stability of the geomorphic effects in relation to site-specific, human-caused and natural conditions that may affect the channel's response to the overflow dams.

INTRODUCTION

Along the lower Neosho River in southeastern Kansas, a series of 12 concrete overflow (low-water) dams have been constructed that extend across the full width of the river channel (figs. 1 and 2). Most of the overflow dams were built for water-supply purposes to serve nearby towns. The present-day (1999) overflow dams were constructed mostly in the 1930's or 1950's. However, some of the dams were predated by earlier versions. For example, at Humboldt the original overflow dam was a rock structure built in 1875 in association with a mill. Aerial photographs from 1937–38 indicate that earlier versions of dams also existed at Erie (just downstream from the present dam), Oswego, and Chetopa (fig. 2). Typically, the overflow dams range in height from about 3 to 6 feet above the low-flow water surface. An exception is the dam at Burlington, which has a height of about 15 feet.

An understanding of the geomorphic effects of overflow dams on the Neosho River channel is important for several issues, including the protection of riparian (streamside) resources, protection of wildlife habitat (for example, the instream habitat for the threatened Neosho madtom, *Noturus placidus*), and bank stabilization related to property loss, general aesthetics, and recreation. Also, such information may be important to the site selection, design, and construction of future overflow dams.

DESCRIPTION OF STUDY AREA

The focus of this study was the 180-mile reach of the Neosho River between John Redmond Dam and the Kansas-Oklahoma State line (fig. 2). Throughout this reach the Neosho River is characterized by a meandering, gravel-bed channel. The channel slope averages about 1.2 feet per mile, and bank height varies from about 15 to 30 feet. The channel bed frequently is situated on erosion-resistant bedrock. Alluvium in the Neosho River Valley averages about 25 feet in thickness and is typified by silt and clay with a basal layer of sand and gravel that averages about 3 feet in thickness. The bank materials consist mostly of cohesive silt and clay that are relatively resistant to erosion compared to sand banks. Also, the banks typically have partial-to-complete mature tree cover that may enhance or reduce bank stability at specific locations.

John Redmond Dam, located about 3 miles upstream from the Burlington over-flow dam (fig. 2), was

Figure 1. Overflow dam at Neosho Falls, Kansas (location shown in figure 2).

OVERFLOW DAM HYDRAULICS AND RELATED GEOMORPHIC EFFECTS ON A RIVER CHANNEL

Overflow dams result in upstream and downstream changes in a river channel. Upstream from the dams a backwater pool is created, the depth and extent of which depends on the height of the individual dam and the slope of the channel (fig. 3, opposite page). Within this backwater reach of the river, the decrease in flow velocity may result in some deposition of material on the channel bed. As the water flows over the dam, its velocity and erosive power increase. The potential consequences of these effects include increased channel bed and bank erosion immediately downstream from the dam as the river expends the extra energy. Most of the erosion occurs during high flows when the river's erosive power is greatest. Bed erosion may create a plunge pool at the base of the dam, with the formation of companion depositional bars just downstream as the river loses its ability to transport the scoured bed load (fig. 3). The depositional bars may divert the flow toward or away from the banks. Bank erosion results in channel widening and also may contribute to the formation of the depositional bars. The form and downstream extent of these effects vary from site to site as affected by human-caused and natural conditions that may either promote or inhibit the river's response to the overflow dams.

completed by the U.S. Army Corps of Engineers in 1964. Downstream changes in the streamflow regime attributed to the operation of John Redmond Dam have included a decrease in the magnitude of peak flows and an increase in the magnitude of low flows (Studley, 1996). Also, post-dam suspended-sediment concentrations have been substantially reduced immediately downstream from the dam. Farther downstream, these effects are moderated by several tributaries that contribute unregulated flow to the Neosho River. A recent study by Juracek (1999) found that the operation of John Redmond Dam has had little effect on the stability of the downstream Neosho River channel.

METHODS

Aerial photographs were used to assess the geomorphic effects of overflow dams on the lower Neosho River channel. Bankfull channel width was used as the primary indicator variable to compare channel form upstream and downstream from the dams. Analysis of channel change was completed using winter 1990–91 leaf-off color aerial photographs (scale 1:12,000) that were enlarged from 35-millimeter slides (fig. 4). The 1990–91 photographs were taken during a period of low flow, and thus channel features were more visible. For each site, bankfull channel width was interpreted approximately 1 mile upstream and downstream from the dam, traced on a scale-stable mylar overlay, and digitized. Primary indicators used in the delineation of bankfull channel width included breaks in slope, the tops of point bars, and changes in vegetation.

The aerial photographs, combined with onsite inspection, were used to determine the location and type of human-caused or natural conditions that might obscure channel response in the vicinity of the dams. Human-caused conditions included structures in or along the channel and channel

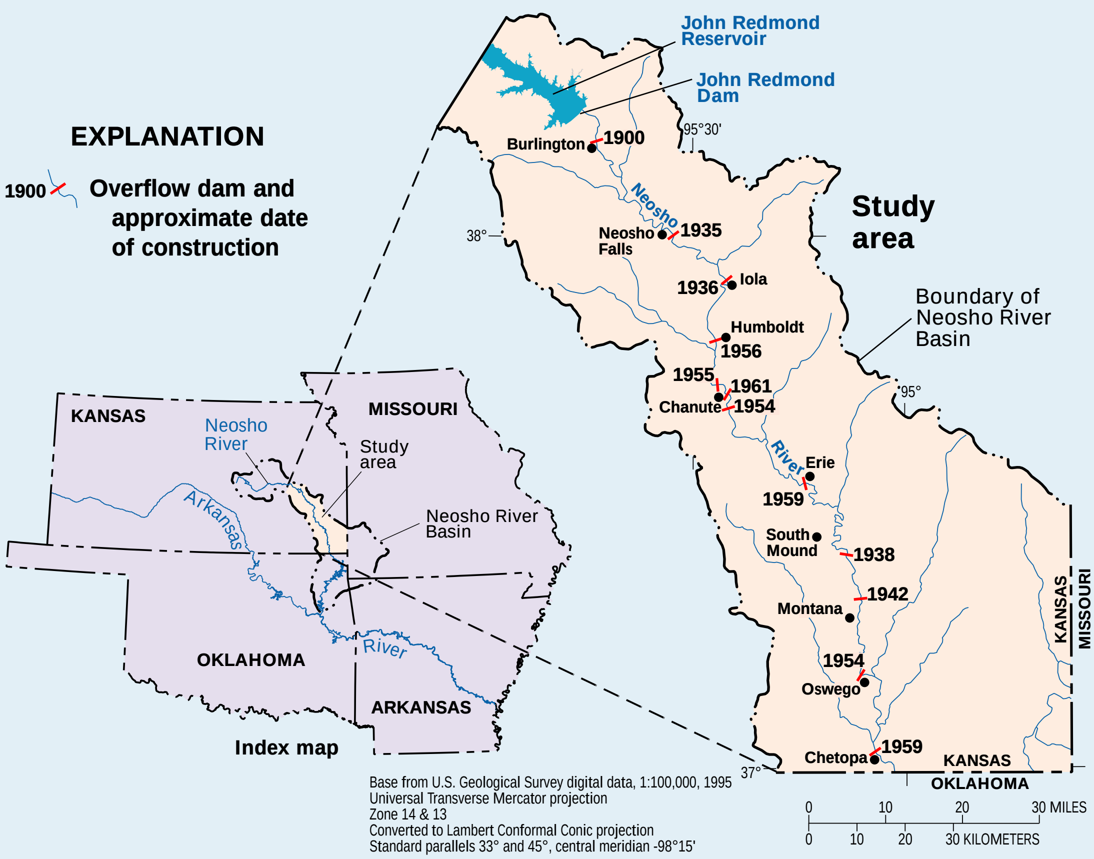

Figure 2. Location of Neosho River Basin, study area, and overflow dams.

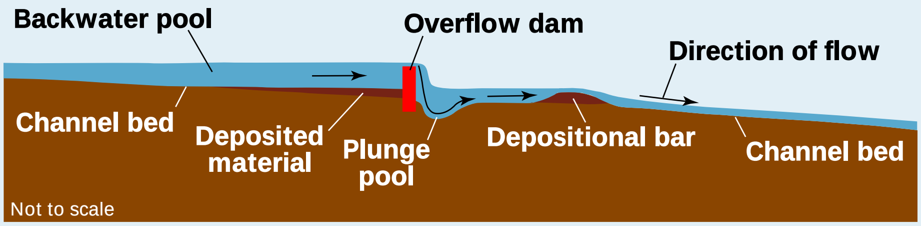

Figure 3. Overflow dam hydraulics and geomorphic effects.

modifications such as the addition of riprap (large rocks used to protect banks from erosion). Natural conditions included split channels, hard points (that is, locations where the channel is situated along the valley wall), and bedrock.

Analysis of the photograph-derived channel information included an assessment of the changes in bankfull channel width and the shape of the channel upstream and downstream from the dams. These measurements then were used to estimate the upstream and downstream extent of variation attributed to the dams. To the extent possible, older aerial photographs and onsite inspection were used to assess the stability of the channel changes over time. The results then were interpreted in relation to site-specific human-caused and natural conditions that may affect the channel response. In the following discussion, the designation of right and left channel bank was made looking in the downstream direction.

GEOMORPHIC EFFECTS

Results of the aerial-photograph analyses indicate that the geomorphic effects of the overflow dams appear to be limited to a short reach of river channel located immediately downstream from the dams. This geomorphic-response zone typically is confined to the first 1,000 feet downstream from the dams. Within the geomorphic-response zone at each site, channel widening has occurred to some degree (fig. 5), except where limited by riprap, concrete wall, and (or) bedrock.

The most pronounced widening was observed at the Burlington and Neosho Falls sites, with approximate dam construction dates of 1900 and 1935, respectively. The widening at these two locations may be attributed in part to the relatively old age of the overflow dams (that is, time for geomorphic response) and the absence of extensive riprap, concrete wall, or bedrock on the channel banks downstream from the dams. The bridge and associated riprap just downstream from the dam at Neosho Falls were not constructed until the mid-1970’s; therefore, about 40 years of geomorphic-response time had transpired at this location prior to the construction of these features.

At Burlington, three additional factors may have contributed to the channel widening. First, the height of the dam is about three times greater than the typical height of the dams at the other 11 sites. Thus, the water flowing over the dam likely achieves greater velocity and erosive power. Second, the width of the dam is substantially greater than the apparent original channel width, and this may have contributed to the pronounced widening at this location. Finally, the formation of a large tree-covered rock bar likely contributed to the channel widening by diverting flow toward the banks.

Substantial channel widening in the geomorphic-response zone also was

Figure 4. Leaf-off aerial photograph (scale 1:12,000) of the lower Neosho River channel near Burlington, Kansas, December 1990. Photograph from U.S. Department of Agriculture's Farm Service Agency.

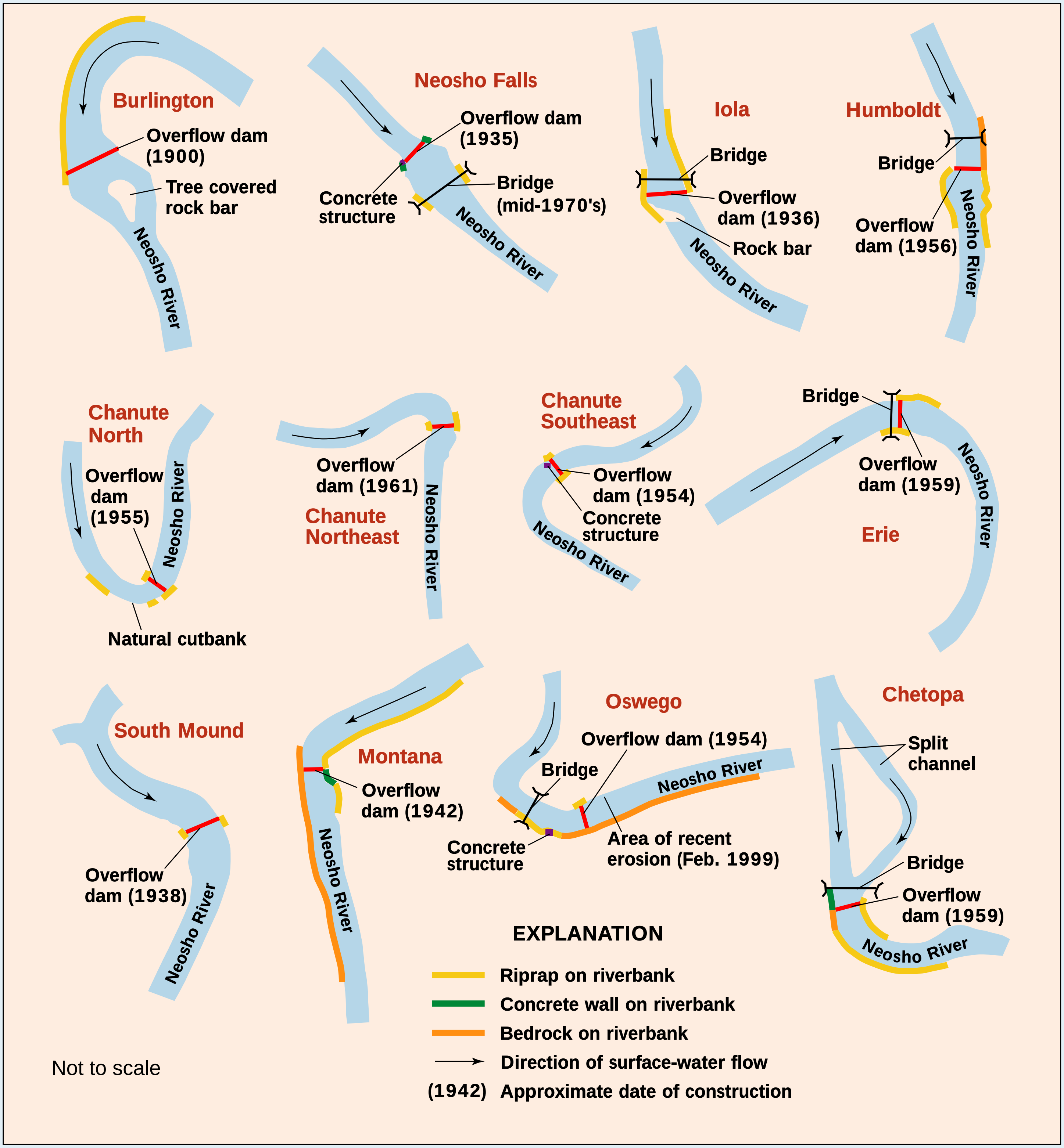

Figure 5. Shapes of the Neosho River channel, human-caused and natural conditions, and evidence of channel widening downstream from the 12 overflow dam sites. Location of dam sites shown in figure 2.

observed at the Humboldt, Chanute Northeast, Erie, and South Mound sites (fig. 5). At Humboldt and Erie, both banks were stabilized with riprap at some undetermined date. However, the shapes of the channel indicate that considerable bank erosion had occurred before the riprap was added. At the South Mound site, the rapidly migrating channel eroded around the dam on the right bank in 1995. It appears that, unless stabilized, the channel eventually will completely bypass the dam at this location.

Moderate to minimal channel widening was observed in the geomorphic-response zone at the remaining sites. At Iola, additional erosion of the right bank is limited by

Figure 6. Erosion on left bank of Neosho River just downstream from riprap at Oswego overflow dam. Location of Oswego overflow dam shown in figure 2.

riprap as well as a rock bar that may have been artificially constructed to divert flow away from the bank. At the Chanute Southeast site, a small area of active cutbank erosion on the right bank appears to be due in part to the diversion of flow around an in-channel concrete structure just downstream from the dam. Otherwise, channel widening at this site is minimal. The 1991 aerial photograph showed only a slight widening of the channel in the response zone at Oswego. However, recent onsite inspection (February 1999) discovered rapid left-bank erosion in progress within the response zone (fig. 6). The erosion at this site had removed all tree cover along the affected bank and was advancing into cropland.

At some locations, such as the Montana and Chetopa sites, channel change in the geomorphic-response zone has been limited by some combination of riprap, concrete wall, and bedrock (fig. 5). The widening evident on the left bank downstream from the concrete wall at the Montana site appears to be the result of the original construction design rather than a reaction to bank erosion. At Chetopa, the riprap on the cutbank side (right bank) of the channel immediately downstream from the dam may have diverted the bank erosion to the opposite bank, resulting in the widening evident on the left bank farther downstream (fig. 5). Onsite inspection indicated at least some bank erosion immediately downstream from riprap at all 12 sites.

The effects of the overflow dam at the Chanute North site appear to be indeterminate due to riprap and the location of the dam with respect to the natural cutbank (right bank) (fig. 5). Given that maximum erosion tends to occur on the outer bank just downstream from the apex of a channel meander, the erosion observed on the right bank downstream from that dam may be due simply to normal cutbank erosion. At this and other sites, the control afforded by the dam and associated riprap may be inhibiting channel migration.

The stability of the channel change in the geomorphic-response zone was difficult to assess due to a lack of older leaf-off aerial photography and uncertainty regarding the timing of riprap construction in relation to the date of dam construction. However, there is some evidence to suggest that, where not inhibited by riprap, concrete wall, or bedrock, channel changes at several dam sites are in progress. Typically at these sites, steep erodible banks are being replaced by gentle, stable banks within the response zone (fig. 7). The steep erodible banks appear to consist mostly of silt, whereas the gentle, stable banks appear to consist mostly of coarser grained sand and gravel. These channel changes were particularly evident at Neosho Falls. Eventually, where site conditions permit, the channel within the response zone may evolve into an approximately stable form characterized by a larger bankfull channel width and gentler bank slopes compared to the channel immediately upstream and downstream from the response zone.

CONCLUSIONS

Aerial photographic evidence indicated that most of the overflow dams have had substantial geomorphic effects on the Neosho River channel. Examples of such evidence include channel widening and (or) the presence of channel gravel bars immediately downstream from the majority of the dams.

Overall, the combination of aerial-photograph analyses and onsite inspection indicated moderate to pronounced channel widening in the geomorphic-response zone immediately downstream from the overflow dam at 8 of 12 sites. Also, within the response zone, steep erodible banks are gradually being replaced by gentle, stable banks. Where uninhibited by riprap, concrete wall, and (or) bedrock, channel adjustment within the response zone is ongoing. Conversely, where riprap, concrete wall, and (or) bedrock are in place, channel adjustment has been effectively minimized. However, as evidenced at Chetopa, it is possible that the suppressed channel change may reappear farther downstream.

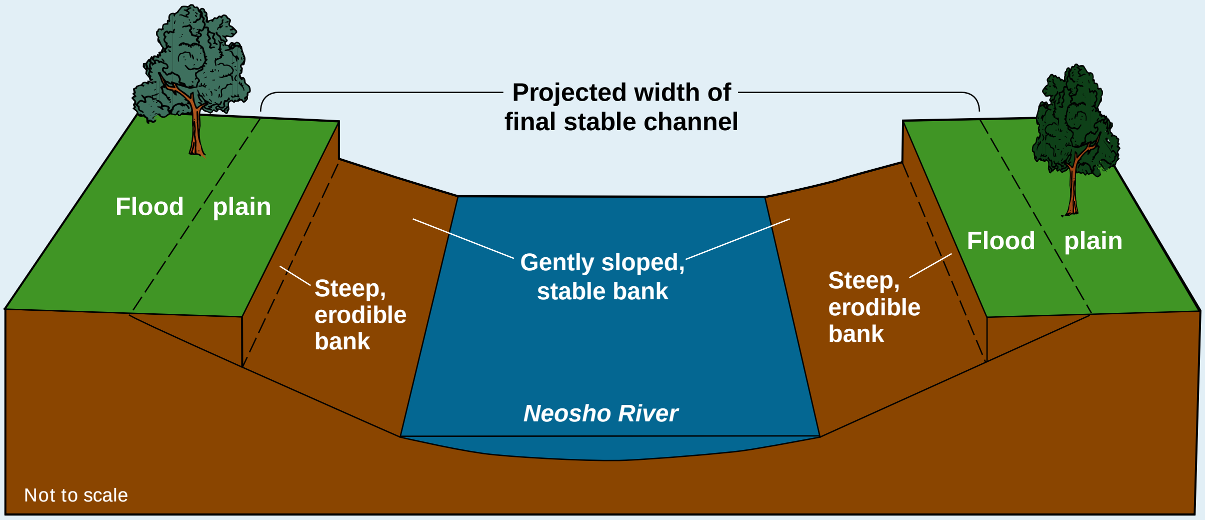

Figure 7. Channel change within the geomorphic-response zone.

This study describes the potential geomorphic consequences of constructing an overflow dam across a river channel. Results indicated that localized human-caused and natural conditions can substantially affect the river channel's response to an overflow dam. The information provided is important for several issues, including the protection of riparian resources and habitat, bank stabilization, and the site selection and design of future overflow dams.

ACKNOWLEDGMENTS

The study described by this report was done by the U.S. Geological Survey in cooperation with the Kansas Water Office and was supported in part by the Kansas State Water Plan Fund. The author also gratefully acknowledges the aerial photographs provided by the U.S. Department of Agriculture's Farm Service Agency.

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