RESULTS OF ONGOING STUDY OF MISSOURI RIVER BED DEGRADATION

Chapter XXX: CRP WATER SURFACE AND COMMERCIAL DREDGING VOLUME COMPARISONS
1990 VS. 2002 AND 2005

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CRP WATER SURFACE AND COMMERCIAL DREDGING VOLUME COMAPRISONS

1.0 KEY TERMS

BSNP: Missouri River Bank Stabilization and Navigation Project. The BSNP, or channelized portion of the river, spans from river mile 0 to 750, or from the mouth near St. Louis, MO to near Sioux City, IA. Kansas City and Omaha District maintain the BSNP downstream and upstream of Rulo, NE (mile 498), respectively.

Dike: Rock and/or timber-pile structures for the BSNP built approximately perpendicular to flow.

Revetment: Rock and/or timber-pile structures for the BSNP built approximately parallel to flow.

CRP: Construction Reference Plane (CRP) is a sloping datum representing the stage, or water surface elevation met or exceeded 75% of the time during navigation season (April to November). Dike and Revetment structures from the BSNP are built and maintained to elevations corresponding to CRP in feet. For example, a dike built to +3 CRP would be protruding three feet above the water surface when the river is flowing at CRP stage, and a dike built to –2 CRP would be submerged two feet below the water surface.

Sill: Riverward portion of a dike, typically designed lower than the landward portion of the dike at 1-feet to 3-feet below CRP.

Channel Width to Sills: Distance between revetment and riverward dike tips, per 1994 design criteria for the BSNP that increases with drainage area. Channel width to sills is 750-feet from mile 0 to 130 at the Osage River, 650-feet from mile 130 to 250 at the Grand River, 600-feet from mile 250 to mile 367 at the Kansas River, 550-feet from mile 367 to 498 at Rulo, and 500-feet upstream of mile 498.

Corps of Engineers Regulatory District Boundaries: St. Louis District is Missouri River mile 0 to 50, Kansas City District is mile 50 to 498, and Omaha District Boundary is the remainder of the river upstream of mile 498. Regulatory issues commercial dredging permits.

2.0 INTRODUCTION

Water surface elevations are monitored annually along the channelized portion of the Missouri River, or the downstream 750 miles between Ponca, NE and the Mouth. If repeated variations of more than a foot are observed, CRP is updated. CRP has been updated most recently in Kansas City District in 1990, 2002, and 2005. Omaha District updated CRP in 1988-89, 2001, and 2006; however, because the focus of the analysis is in Kansas City District, for the remainder of this memo Omaha and Kansas City District CRP updates are referred to as 1990, 2002, and 2005, respectively. In general, CRP elevations have been dropping between Rulo and the Mouth (mile 498 to mile 0), stable to slightly raising from mile 498 to mile 670, and dropping upstream of mile 670.

It is hypothesized that an observed drop in water surface elevation could be attributed to a number of factors. Three of which include dam construction, commercial dredging, and the flooding of the 1990's. A report from the Meade Laboratory, most recently updated in 2001, shows that degradation effects as result of the dams occur upstream of mile 635 (USACE NWO 2001). Therefore, it is assumed observed drops in water surface elevation downstream of Rulo are result of factors other than dam construction.

Commercial sand dredging is allowed in St. Louis and Kansas City Regulatory Districts, and is also allowed in Omaha District; however, dredgers are not allowed to mine sand from below the river bed in Omaha District. Therefore, commercial dredging has developed only in Kansas City and St. Louis Districts.

3.0 METHODS

Discharge is not constant for each CRP revision; therefore, the 1990 and 2002 CRP elevations were "flow adjusted" to match the 2005 discharges. Table 1 presents CRP flows and the corresponding flow adjustments for 1990 and 2002 CRP. Flow adjustments were first computed at each gage, interpolated by river mile between gages, then added to the published CRP elevations. For the end points, flow adjustments were held constant both upstream of Sioux City and downstream of Herman. Flow adjustment was done for the purpose of comparing water surface profiles at the same discharge at each CRP update.

TABLE 1: CRP DISCHARGES AND FLOW ADJUSTMENTS

Gage	River Mile	1990 CRP Discharge (cfs)	2002 CRP Discharge (cfs)	2005 CRP Discharge (cfs)	2005 - 1990 Discharge (cfs)	1990 CRP Flow Adjustment (ft)	2005 - 2002 Discharge (cfs)	2002 CRP Flow Adjustment (ft)
Sioux City	732.2	30,000	30,000	30,000	0	0.00	0	0.00
Decatur	691.0	30,200	31,000	31,000	800	0.20	0	0.00
Omaha	615.9	31,000	33,400	33,400	2400	0.63	0	0.00
Neb. City	562.6	36,000	37,500	37,500	1500	0.33	0	0.00
Rulo	498.1	36,500	38,900	38,900	2400	0.60	0	0.00
St. Joe	448.2	37,500	41,200	40,600	3100	0.80	-600	-0.13
KC	366.1	43,000	46,000	44,200	1200	0.30	-1,800	-0.42
Waverly	293.4	43,500	46,800	45,100	1600	0.30	-1,700	-0.30
Boonville	197.1	46,000	50,600	48,300	2300	0.40	-2,300	-0.40
Hermann	97.9	54,000	59,500	55,900	1900	0.30	-3,600	-0.53

NOTE: Flow adjustments use 2005 rating curves and historic CRP discharges. Adjustments were interpolated between gages.

Commercial dredging quantities were compiled from data provided by both Kansas City and St. Louis District regulatory groups. Figure 1 presents a dual axis plot showing CRP change between the flow-adjusted 1990 and 2002 CRP elevations and 2005 CRP elevation, and location and amount of dredging from 1990 to 2005. Dredging quantities were summed by reach, starting at the downstream end. It should be noted that CRP elevation at mile zero is controlled by Chain of Rocks Dam on the Mississippi River, and that backwater influences approximately the lower 15 miles of the Missouri River, which somewhat skews water surface profiles and CRP elevations in the area.

Commercial dredging quantities were summed cumulatively for the entire river, and were converted to volume using a unit weight of 93 pounds per cubic feet, or 1.26 tons/cubic yard. CRP changes were converted to a volume as channel length times channel width to sills times change in flow-adjusted CRP elevations. Channel width to sills was selected for the computations because the area between the dike tips and revetments (1) is uncontrolled by river structures and the most susceptible to erosion, (2) conveys over 95% of the flow at CRP discharge, (3) is the area where commercial dredgers mine sand. Figures 2 and 3 present the volumetric comparison for 1990 to 2005 and 2002 to 2005, respectively.

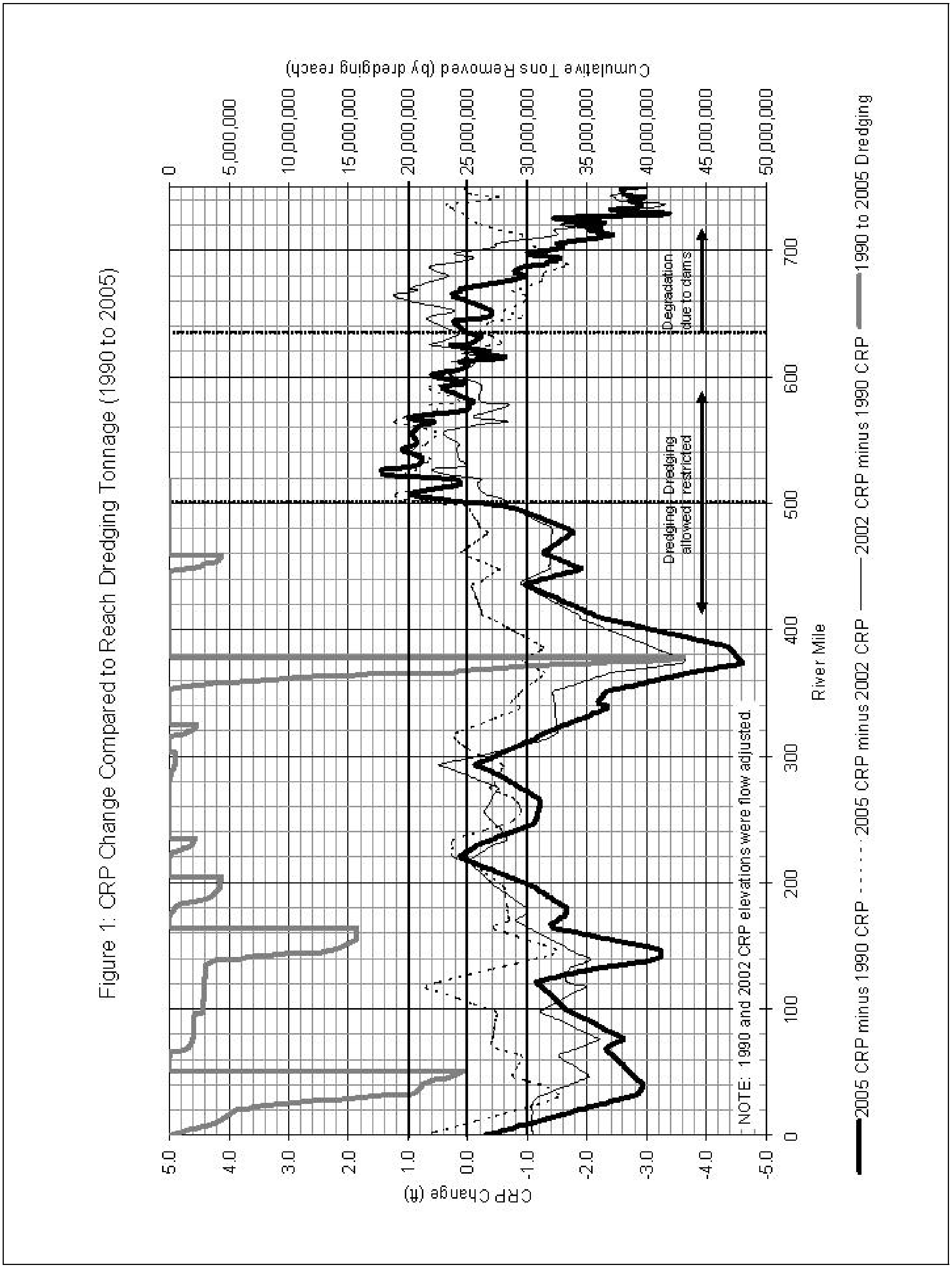

Figure 1: CRP Change Compared to Reach Dredging Tonnage (1990 to 2005)

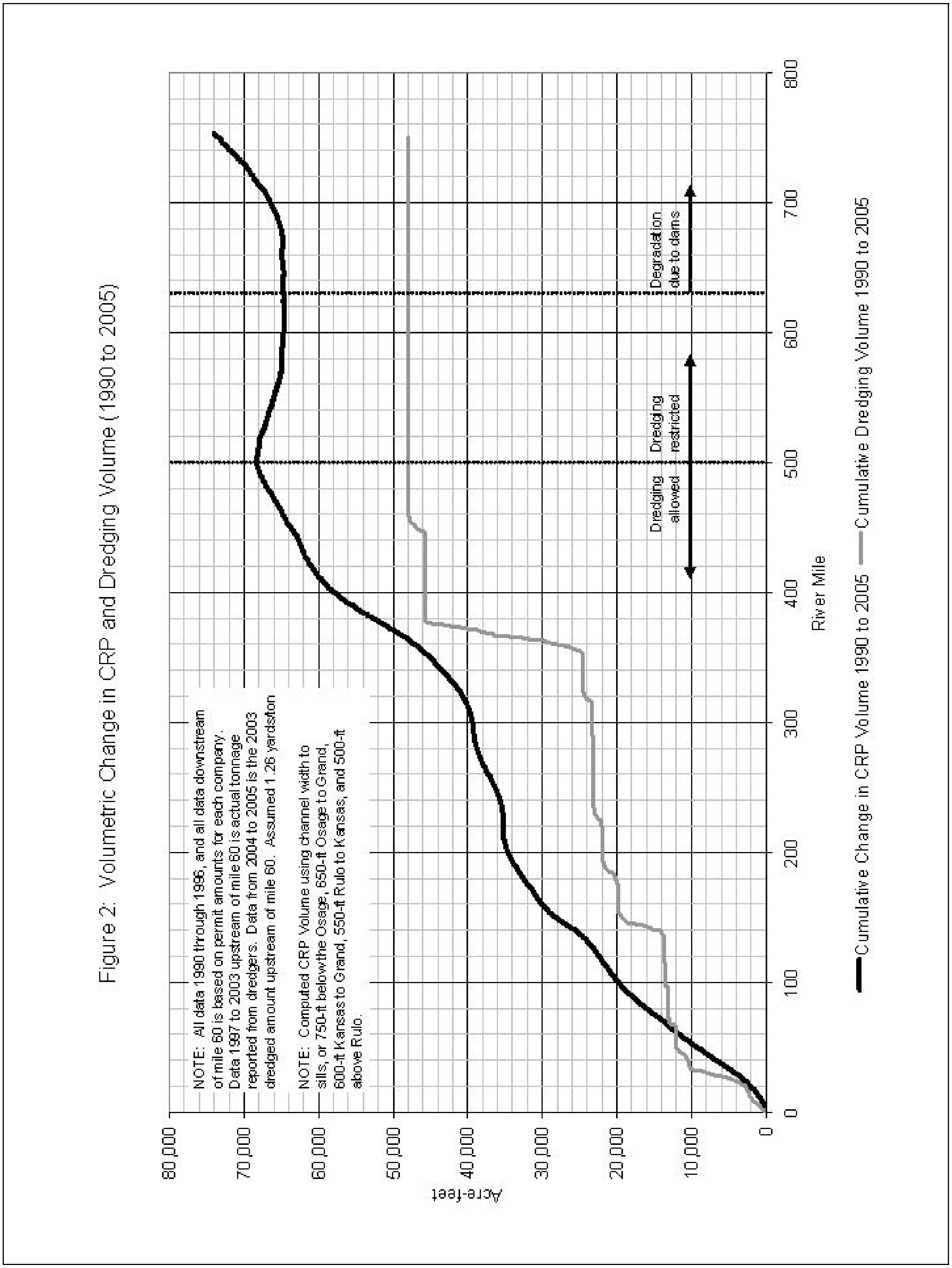

Figure 2: Volumetric Change in CRP and Dredging Volume (1990 to 2005)

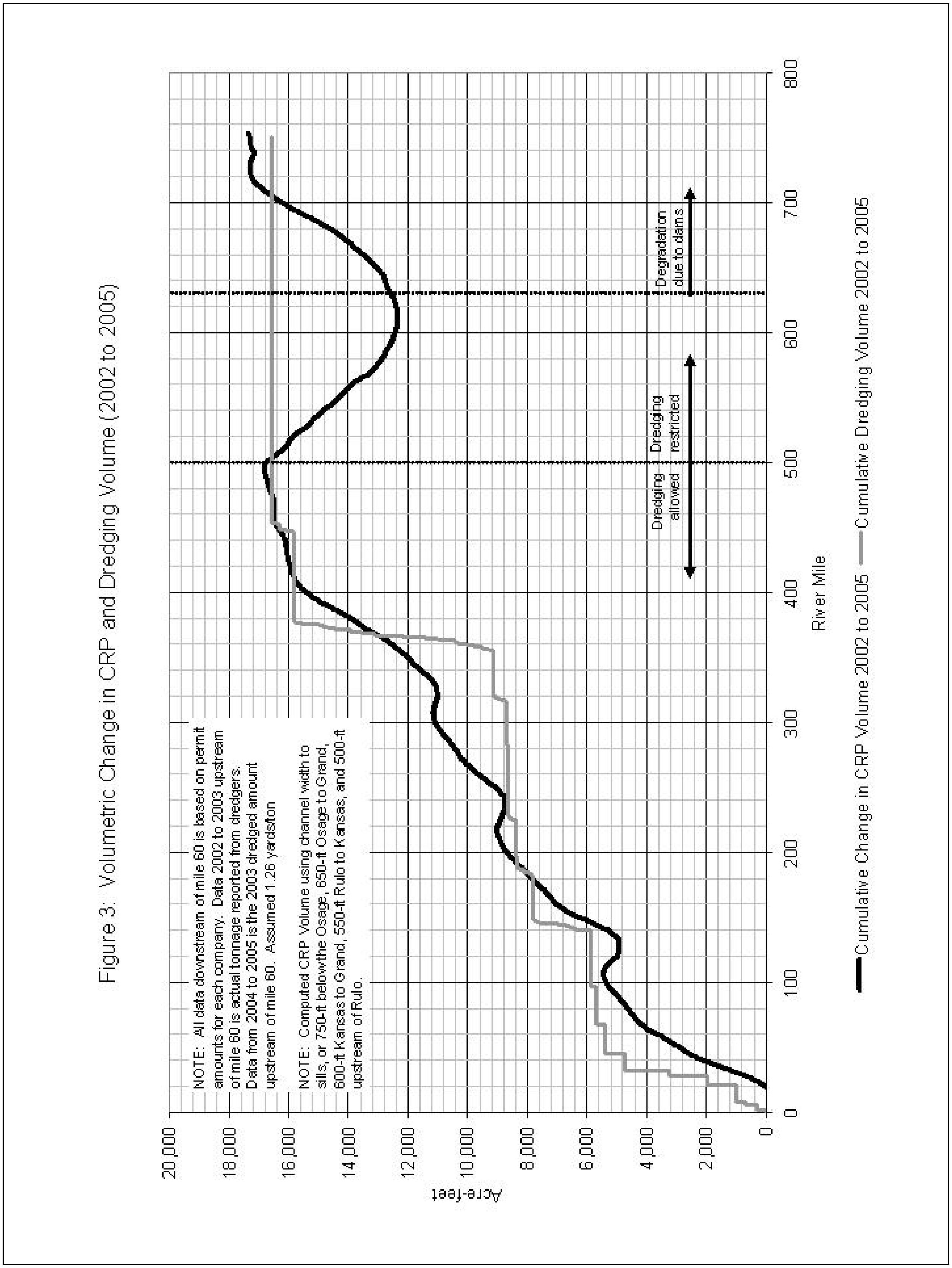
Figure 3: Volumetric Change in CRP and Dredging Volume (2002 to 2005)
NOTE: All data downstream of mile 60 is based on permit amounts for each company. Data 2002 to 2003 upstream of mile 60 is actual tonnage reported from dredgers. Data from 2004 to 2005 is the 2003 dredged amount upstream of mile 60. Assumed 1.26 yards/ton
NOTE: Computed CRP Volume using channel width to sills, or 750-ft below the Osage, 650-ft Osage to Grand, 600-ft Kansas to Grand, 550-ft Rulo to Kansas, and 500-ft upstream of Rulo.
Dredging allowed
Dredging restricted
Degradation due to dams
Acre-feet
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
100
200
300
400
500
600
700
800
River Mile
Cumulative Change in CRP Volume 2002 to 2005
Cumulative Dredging Volume 2002 to 2005

4.0 DISCUSSION

CRP change appears to be greatest at locations were commercial dredging is the most intensive, especially St. Charles, Jefferson City, and Kansas City. Exceptions include the area upstream of mile 635 where degradation has been attributed to dams, and near mile 250 as observed 2002 to 2005. Dredging volume is less than 1990 to 2005 volumetric CRP change, though the curves have similar shape in Figure 2; while 2002 to 2005 dredging volume and volumetric CRP change appear to be of similar magnitude. Volumetric CRP change in both Figures 2 and 3 appears to be greatest downstream of Rulo where commercial dredging is allowed.

Figure 2 shows approximately 68,200 acre-feet of volumetric CRP change between Rulo and the mouth, and an additional 5,900 acre-feet of volumetric CRP change upstream of Rulo. Accordingly, volumetric CRP change equates to approximately 8.6 acre-feet/mile/year where dredging is allowed versus approximately 1.4 acre-feet/mile/year where dredging is restricted. Approximately 47,900 acre-feet of sediment was mined from the river downstream of Rulo from 1990 to 2005, or roughly 6.0 acre-feet/mile/year, which is approximately 70% of the observed volumetric CRP change.

Similarly, Figure 3 shows approximately 16,800 acre-feet of volumetric CRP change between Rulo and the mouth, and only an additional 600 acre-feet of volumetric CRP change upstream of Rulo. Accordingly, volumetric CRP change equates to approximately 8.4 acre-feet/mile/year where dredging is allowed versus approximately 0.6 acre-feet/mile/year where dredging is restricted from 2002 to 2005. Approximately 16,500 acre-feet of sediment was mined from the river downstream of Rulo from 2002 to 2005, or roughly 8.3 acre-feet/mile/year, which equates to approximately 98% of the observed volumetric CRP change.

Major Missouri River flood events occurred in 1993, 1995, 1996, and 1997. As a result, a portion of the observed degradation from 1990 to 2005 could be attributed to scouring during flood events, among other factors. As no significant Missouri River flood events occurred from 2002 to 2005, it is assumed that flooding did not contribute to degradation during that time period. However, it should be noted that significant Grand River flood events occurred in 2002 and 2004. The 2002 and 2004 floods were the second highest stage and the fourth highest flow (143,000 cfs) observed at Sumner, MO for the period of record 1909 to 2006, respectively. High Grand River flows could explain the observed drop in CRP near mile 250 shown on Figure 1 from 2002 to 2005. Degradation upstream of mile 635 occurred only during the 1990 to 2002 time period, and little occurred 2002 to 2005, probably due to the difference in peak flows during the two time periods. Only areas with high dredging intensity experience a drop in CRP in both time periods.

Dredging intensity has increased from an average of 5.2 acre-feet/mile/year from 1990 to 2001, to 8.3 acre-feet/mile/year from 2002 to 2005 downstream of Rulo. Continued dredging at the 2002 to 2005 rate would remove enough material to lower the bed of the river approximately 1-foot every 10 years as averaged over the lower 498 mile length.

5.0 REFERENCES

1. USACE NWO (2001). Investigation of Channel Degradation 2001 Update, Missouri River Gavins Point Dam to Platte River Confluence.

2. USACE NWK and NWO 1990, 2002, and 2005 CRP.

3. USACE NWK and MVS Missouri River Commercial Dredging/Location Reports and Permits.