NATIONAL ACADEMY OF SCIENCES
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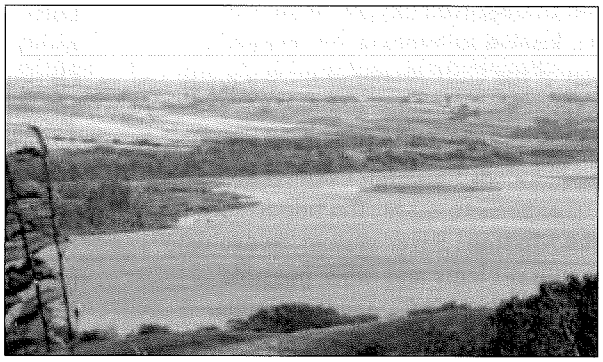
REPORT BRIEF

Missouri River Planning

Recognizing and Incorporating Sediment Management

A better understanding of the processes of sediment transport, erosion, and deposition in the Missouri River will be useful in furthering river management objectives, such as protection of endangered species and development of water quality standards, a new report from the National Research Council finds. Historically, the flow of sediment in the Missouri River has been just as important as the flow of water for a variety of river processes. The construction of dams and river bank control structures on the Missouri River and its tributaries, however, has markedly reduced the volume of sediment transported by the river. These projects have had several ecological impacts, most notably on some native fish and bird species that depended on habitats and landforms created by sediment flow. This report describes the historic role of sediment in the Missouri River, evaluates current habitat restoration strategies, and discusses possible sediment management alternatives.

Historically, the flow of sediment in the Missouri River has been as important as the flow of water for a variety of river functions. The sediment has helped form a dynamic network of islands, sandbars, and floodplains, and provided habitats for native species. Further downstream, sediment transported by the Missouri and Mississippi Rivers has helped build and sustain the coastal wetlands of the Mississippi River delta.



Source: National Park Service

Over the past century, the volume of sediment transported downstream and to the Gulf of Mexico by the Missouri and Mississippi River system has declined by more than one-half. The numerous dams and bank stabilization projects constructed along the river and its tributaries in the early twentieth century have trapped huge amounts of sediment in reservoirs behind dams and in the floodplain areas behind the embankments. The reduced flow of sediment is changing the river landscape and causing the loss of habitat for some native fish and bird species.

Concern about declines in the populations of two bird and one fish species prompted the U.S. Fish and Wildlife Service to issue a biological opinion in 2000 (amended in 2003), recommending the restoration of river habitats to avoid jeopardizing the continued existence of these species. In response to the biological opinion, the U.S. Army Corps of Engineers began constructing restoration projects along the lower Missouri River in the early 2000s, re-mobilizing some of the sediments that had been trapped by the dams and bank stabilization projects.

In the state of Missouri, however, the Missouri Clean Water Commission ordered a halt to the Corps' projects. The state commission expressed concerns that nutrients, such as phosphorus, carried by the re-introduced sediments could exacerbate nutrient and sediment pollution both within the river and

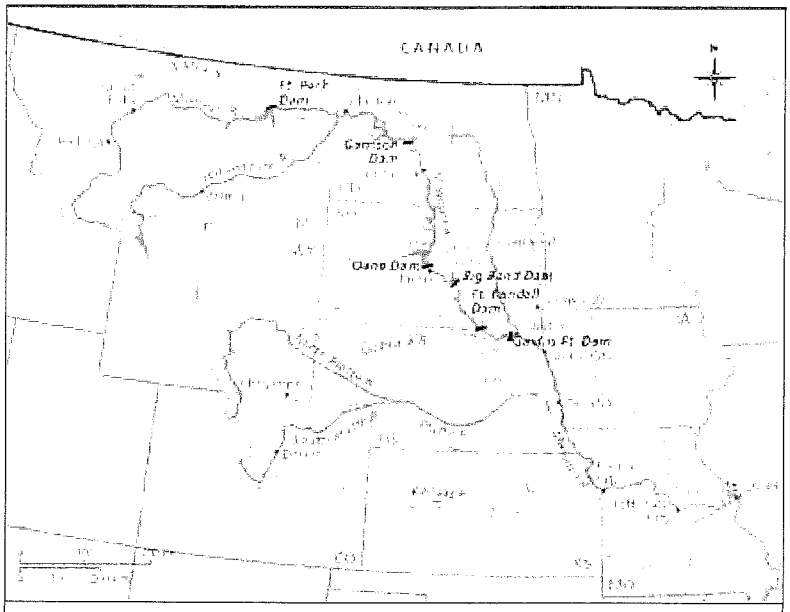


Figure 1. The Missouri River basin. Tributary streams, dams, and reservoirs are shown.

downstream in the northern Gulf of Mexico. Excess nutrients can cause the overgrowth of algae that leads to the depletion of dissolved oxygen in the water. This condition, known as hypoxia, has created a seasonal region of the Gulf devoid of most aquatic life known as the "dead zone."

At the request of the U.S. Army Corps of Engineers, the National Research Council convened a committee of experts to assess the importance of sediment in the Missouri River system, to evaluate habitat restoration projects and other possible sediment management actions, and to consider implications for water quality in the river and in the northern Gulf.

The Importance of Sediment

The Corps of Engineers' Missouri River dam construction and bank stabilization projects have provided many benefits in the form of flood control, hydropower, water supply, and support of commercial navigation. The projects also have impacted river ecology, and are affecting the long-term stability of local infrastructure. For example, the reduced sediment in the system has allowed the river bed to erode, with the potential to undermine levees and bridge foundations and to lower water levels at municipal water intakes.

Sediment is the building material for river structures such as sandbars and islands. Connections between the river and its floodplains form the basis of nesting habitats for bird species and support a diverse array of river channel depths and flow velocities (see Figure 2). Survival and reproduction of some native species has been affected by reduced sediment flows and concentrations (see Box 1). As a result, two native bird species, the piping plover and the least tern; and one native fish, the pallid sturgeon, are listed under the Federal Endangered Species Act.

Sediment Management in the Missouri River

To improve habitat conditions for endangered bird and fish species, the Corps of Engineers initiated projects to reconstruct emergent sandbar and shallow water habitats, and in this process have discharged sediment into the Missouri River. The committee reviewed alternatives for improved management of these current projects, and possible future actions to reintroduce sediment to the Missouri River. Options include removal of bank stabilization structures, changes in commercial dredging, bypassing sediment around dams, removing dams, and increasing the flow of sediment from tributaries (see Box 2).

Several financial and technical constraints would impede implementation of any of these alternatives. Economic activities, a substantial transportation infrastructure, and homes, farms, and communities all rely on the existing system of dams and bank

Box 1. Environmental Stressors on Endangered Species

Changes in the transport and deposition of sediment are not the only environmental variables that affect bird and fish species in the Missouri River. These animals are also affected by stressors such as changes in water flow and temperature, river bed elevation and channel structure. The understanding of the relative importance of the many environmental stressors on these endangered species is limited, making it difficult to predict which restoration projects, such as habitat construction or new water release schedules, might be most beneficial to threatened populations.

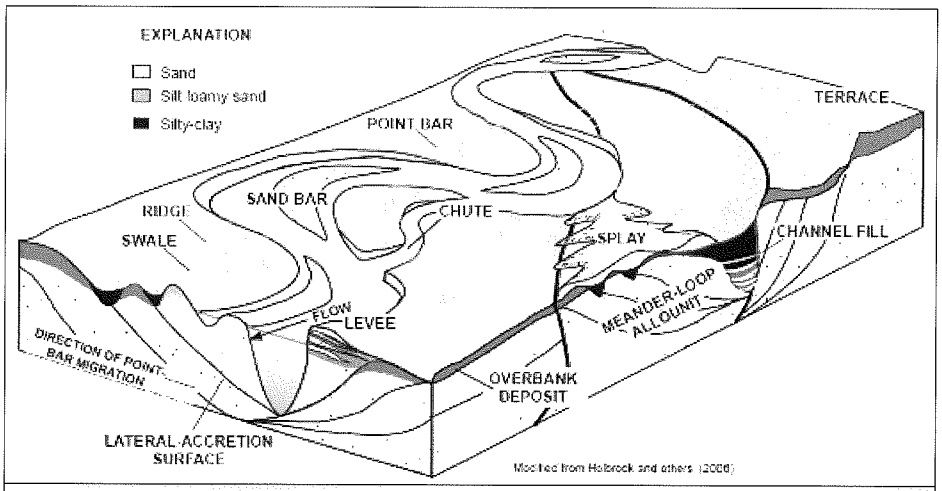


Figure 2. A generalized cross-section of the pre-regulation Missouri River. The flow of sediment and water forms river structures such as sandbars and islands.
Source: Jacobson, R. B., K. A. Chojnacki, and J. M. Reuter, 2007. Land Capability Potential Index (LCPI) for the Lower Missouri River Valley: U.S. Geological Survey Scientific Investigations

stabilization structures. This makes it unlikely that most Missouri River valley residents would find major reconfigurations of the river channel acceptable. The bypassing of sediment around dams may be technically feasible, but this option would be expensive, and would have little potential to significantly increase supplies of sediment transported downstream.

Implications for Coastal Louisiana

Before 1900, the Missouri-Mississippi River system transported an estimated annual average of about 400 million metric tons of sediment down to the Louisiana coast. In contrast, from 1987 to 2006, this transport averaged just 145 million metric tons per year. Many parties in coastal Louisiana are interested in ways to increase sediment transport with the hope of restoring wetland ecosystems of the Mississippi delta. The amount of sediment that could be added to the river by the Corps' restoration projects is estimated at 34 million tons per year, roughly a 10-20 percent increase in current sediment flow volume, but less than the roughly 400 million metric tons that made the downstream journey before construction of dams, channels, and bank stabilization projects.

Implications for Water Quality

The report considers the significance of Missouri River sediment management actions on the nutrient load delivered down river and on Gulf of Mexico hypoxia. Sediment added to the river will contain nutrients such as phosphorus. An upper bound estimate of the increased phosphorus loadings to the Gulf of Mexico from Corps' projects is 6 to 12 percent. In reality, actual phosphorus loadings caused by these projects would be less than this estimate, as not all the sediment and associated phosphorus would make it all the way through the river system to the Gulf of Mexico. Current studies suggest that at least a 20 percent increase in nutrients would be necessary to see a distinct increase in the hypoxic area. The report thus concludes that Corps' restoration projects will not significantly change the size of the "dead zone" in the Gulf.

Reconciling water quality objectives with native species recovery goals is an important factor in sediment management decisions for the Missouri River. For example, the Missouri Clean Water Commission contends that sediment discharges from habitat construction projects violate state water quality standards. Under the Clean Water Act, water quality managers are expected to create water quality standards that are protective of the river's uses, and native species habitat is one use that could be protected. In that case, nutrient and sediment water quality criteria to protect that use should recognize that the river historically carried sediments and nutrients, and characteristics of those historical sediment conditions would be considered in the process of developing water quality standards for the Missouri River.

Research to Support Decision Making

The Missouri River basin once was a site of extensive research on sediment processes in large rivers, and an large body of historical Missouri River sediment data has been amassed. Although there are important ongoing studies on sediment dynamics being conducted in the basin, including collaborative efforts between Corps of Engineers and United States Geological Survey, over time there has been a decline in data collection, analyses, archiving, and accessibility. In general, relevant data

Box 2. Adaptive Management for the Missouri River

The Fish and Wildlife Service in its Biological Opinion instructed the Corps of Engineers to operate restoration projects using adaptive management principles—a process of assessing progress towards goals and adjusting future management actions based on results.

Clear assessment of the progress of Missouri River restoration projects is challenging for many reasons, not the least of which is that the reversal or slowing of declines in threatened bird and fish species cannot be accomplished or recognized immediately.

In order to implement a more structured, systematic approach to the management of restoration projects, performance objectives based on clearly specified ecological and biological goals, such as trends in the populations of the three endangered species, should be agreed upon. The development of conceptual ecological models of the species and communities of species could serve as a framework to test and predict the relative influence of environmental variables on species survival. The report notes that because of the great uncertainties of the outcomes associated with the habitat construction projects, they may not fully meet the requirements of the Biological Opinion. As a result, and consistent with adaptive management principles, alternative actions—that may eventually be implemented—should be developed.

are diffuse and scattered, existing in a variety of locations and formats. The report thus recommends that the Corps of Engineers and the U.S. Geological Survey collaborate to better synchronize data collection, evaluation, and archiving, for example by developing a more comprehensive and accessible database. Furthermore, creating a "sediment budget"—an accounting of sediment transport, erosion, and deposition for the length of the Missouri River—would provide a foundation for planning, designing, and monitoring the results of various sediment and river management activities.

With regard to higher-level policy and river operations matters, many river management decisions involve competing stakeholder values and interests. Corps of Engineers decision making authorities are now more widely shared than in the past. For example, a multi-stakeholder group—the Missouri River Recovery Implementation Committee—was established in 2008 as a basin-wide collaborative forum. The report recommends continuing assessment of the effectiveness of the Missouri River Recovery Implementation Committee. The report also suggests that agencies and stakeholders recognize that the appropriate role of the scientific community is to predict likely consequences of different actions, but not to propose preferred actions.

Read or purchase this report and locate information on related reports at http://dels.nas.edu/wstb

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The National Academies appointed the above committee of experts to address the specific task requested by the U.S. Army Corps of Engineers. The members volunteered their time for this activity; their report is peer-reviewed and the final product signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.

For more information, contact the Water Science and Technology Board at (202) 334-3422 or visit http://dels.nas.edu/wstb. Copies of *Missouri River Planning: Recognizing and Incorporating Sediment Management* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.