Sediment in the Missouri Basin - Understanding the relationship of sediment to differing agency missions – September 15, 2017

Sediment is a natural and beneficial part of the ecosystem and, at times, is an environmental contaminant contributing to detrimental environmental problems in river basins. In 2009, the U.S. Environmental Protection Agency (2009) estimated that excessive sediment was the leading cause of water body impairment in the United States. Osterkamp and others (2004) estimated that sediment attributed damages exceed $20 billion annually. Sediment is sometimes a carrier (by adsorbing chemicals), linked with, and/or indicator of additional water quality contaminants (e.g. PCBs, dioxin, pesticides, heavy metals, hydrocarbons, phosphorus, bacteria).

Sediment, as an issue, is common to all of the Missouri River Basin Interagency Roundtable (MRBIR) community. However, it is viewed by each agency through the lens of each agency's unique mission. Sediment monitoring in river systems is useful in determining the effects of wildfires, floods, construction and remediation activities, levee failures, and land use change (Wood, 2014).

This document is a resource for understanding those unique missions to the MRBIR Executives. Through this document, the Executives can identify agencies with which they could establish and enhance collaborative opportunities in the Missouri Basin.

SEDIMENT ISSUES

- Sediment is a natural constituent of the ecosystem and is inherently linked to functions and processes. In the Missouri Basin, sediment conditions since European disturbances (e.g. 80-90+% beaver loss, landuse change from grassland to monoculture cropland, increased use of grazing lands) have greatly increased the levels of sediment throughout the basin, which is un-natural and is causing problems.
    - Sediment is the general name for a wide diversity of mineral materials that can have unique and differing parent rock, mineral composition, and chemical make-up ranging from very large boulders to very minute clay particles. Sediment can be the result of a natural erosion force on the landscape or the result of artificial (either intentional or unintended) modification of the landscape
    - Sediment is transported both as suspended load (moves within water column) and as bedload (moves on the riverbed). It can be deposited and re-eroded from banks and the riverbed.
    - Excessive sedimentation is a water quality pollutant that impairs waterbodies by degrading aquatic habitat, causing reservoirs to fill at accelerated rates, altering river morphology and is the primary transporter of toxic organic chemicals, heavy metals, and nutrients
    - Balanced levels of sediment are the integral building blocks of aquatic (rivers, lakes, reservoirs, and wetlands) ecosystems and a key component for ecological restoration of parts of the Missouri River, providing turbidity and other building blocks needed for fish and wildlife habitat and for the protection of existing infrastructure, such as bridges and pipelines, that require stable bed elevation; excess sediment in reservoirs threaten infrastructure longevity, municipal water intakes, reservoir health, flood control, power generation, and recreation
- Sediment processes within the basin are highly variable, not closely monitored, and not adequately understood.

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POINTS TO CONSIDER

In North America alone, the physical, chemical, and biological damage attributable to sediment, nutrients, and sediment-associated water-quality constituents has been estimated to range from $20-$50 billion annually. Examples of the damages and mitigation resulting from sediment and sediment associated water-quality constituents include:

- The construction of main-stem dams and bank control structures has dramatically altered the amount of turbidity and suspended- and bed-load sediment in the Missouri River.
- The lack of sediment being passed through reservoirs and associated formation of bars and islands is likely one of the key reasons the piping plover, least tern, and potentially pallid sturgeon are currently listed as threatened or endangered species.
- Reduced levels of natural sediment, due to main-stem dams and bank control structures, has and is contributing to Missouri River streambed degradation in some reaches and is identified as contributing to wetland loss along the Gulf Coast.
- The sum total of sedimentation issues exceeds the scope of mission for each individual agency
    - A common definition of the preferred sediment characteristics depends upon the mission of the agency and perhaps differs within different groups within an agency.
    - The issue of sediment is significant enough that no single agency feels it falls entirely within the scope of their mission.

MRBIR AGENCY PERSPECTIVES

- Bureau of Indian Affairs (BIA)
    - The construction of the main-stem dams has created multiple sediment related issues impacting tribes along the Missouri River.
    - Tribes with intakes on the Missouri River for water supply are at risk of build-up clogging those intakes.
    - The lack of sediment pass-through due to dam construction has changed erosion patterns along the banks leading to loss of land mass for some tribes. The erosion has also threatened structures such as sewage lagoons potentially creating a contamination hazard to the river.
    - The dams have also caused flooding on tributaries that run through reservations disturbing old sediment that contains mining contaminants impacting water quality.

- U.S. Environmental Protection Agency (EPA)
    - The Clean Water Act identifies sediment and siltation as the leading cause of impairment in the Nation's rivers and streams, with nutrients listed as the fifth leading pollutant (U.S. Environmental Protection Agency, 2007).
    - Nutrients are a water quality issue associated with sediment and siltation.

- U.S. Fish and Wildlife Service (FWS)
    - Degradation from loss of sediment transport has reduced available wetlands adjacent to the Missouri river.

- Sediment and turbidity is an integral part of threatened and endangered species that us the Missouri river corridor.

- National Park Service (NPS)
  - Sediment supply and distribution processes are essential to maintaining the natural aesthetic and cultural values of the Missouri River.
  - Sediment, as the result of a natural erosion force on the landscape, is a key component for ecosystem sustainability and ecological restoration of the Missouri River, providing turbidity and other building blocks needed for fish and wildlife habitat and for the protection of existing infrastructure, such as bridges and pipelines, that require stabile bed elevation.
  - Sediment is a crucial component to a free-flowing river channel and essential to maintaining the natural processes that lead to the 98-mile segment of the Missouri River from Pickstown, South Dakota to Ponca, Nebraska being established as part of the Wild and Scenic Rivers System and included as unit of the National Park System.
  - An impeded sediment system from human-caused factors (e.g. dam formation) requires increased management intervention and reliance on relatively costly mechanical measures to create sand bar habitat necessary to sustain the perpetuation of imperiled wildlife species (listed T&E species including the Interior Least tern and Piping plover) in accordance with recovery plans.
  - An altered sediment regime minimizes the creation and fluctuation of emergent sand bars, which are highly desirable by the public for water-based recreational purposes.
  - Reduced levels of natural sediment has and is contributing to Missouri River streambed degradation in some reaches and is identified as contributing to wetland loss along the Gulf Coast.

- U.S. Bureau of Reclamation (USBR)
  - Sediment accumulation in reservoirs can have multiple adverse effects, including:
    - Loss of storage capacity.
    - Reduced water supply reliability.
    - Reduced or loss of use of recreation infrastructure, such as marinas and boat ramps.
    - Increased frequency of infrastructure (e.g., campgrounds) flooding at reservoirs.
    - Sediment adversely impacts dam outlet works and turbines.
  - Channel aggradation/degradation affect intake performance at diversions.

- Western Area Power Administration (WAPA)
  - Sediment accumulation in reservoirs adversely effects power production through:
    - Loss of storage capacity.
    - Reduction to Power Generation Capacity.
    - Reduction of Electric Energy Production.

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- US Geological Survey (USGS)
    - Monitors and measures sediment and sediment associated water-quality constituent loads in assessing the quality of U.S. waters.
    - Sediment and sediment associated water-quality constituents affect ecosystems far from the point of origin. Understanding the processes that occur along that course is fundamental to the agency mission.
    - Develops both analytical and monitoring methods for better understanding of sediment and sediment associated water-quality constituents.
    - Channel aggradation/degradation affects the stability of stage/discharge ratings causing stream discharge computation inaccuracies.
    - Investigates the source and fate of sediment and sediment associated water-quality constituents.
    - Evaluates the effectiveness of sediment-related management practices and trends over time.
    - Monitors the effects of sediment and associated nutrient loads in the Gulf Hypoxia Zone.

- Federal Emergency Management Agency (FEMA)
    - FEMA is impacted through disaster recovery when sediment in the reservoirs impact flood control.
    - Channel bed aggradation/degradation impacts infrastructure such as bridges, utility crossings, etc. which ties back to disaster damage, disaster recovery, and resilience.
    - Degree of sedimentation following a flood is a determining factor in cost of clean up and recovery.

- Bureau of Land Management (BLM)

    - Sediment can influence the BLM's ability to carry out its mission both negatively and positively.
    - Throughout the Upper Missouri Watershed (including the Upper Missouri River Breaks National Monument) the river is listed as impaired due in part to sedimentation. Since the BLM is obligated to not further impair water quality, this listing can limit our ability to manage for uses that could result in an increase in the rate of sediment production.
    - Equilibrium between discharge and sediment is vital for maintaining a stable channel dimension, pattern, and profile.
        - This dynamic equilibrium is essential to riparian function, which requires balanced hydrologic, geomorphic (including sediment transport), and vegetative attributes to function properly.
        - The BLM has a land health standard requiring that riparian areas be functioning properly given their geomorphic setting. An adequate supply of sediment is critical to meeting this standard.
    - Sediment is often necessary to build riparian habitat along the river through the Upper Missouri River Breaks National Monument (UMRBNM) reach. Due to the constrained nature of this reach, riparian communities are often limited due to the lack of depositional

areas. These depositional areas often occur where the valley bottom widens a little bit or at tributary junctions where sediment availability may increase. Sediment is essential to the maintenance and development of these limited riparian areas.

- The Presidential Proclamation creating the UMRBNM required the BLM to protect the "objects of the Monument." Some of the identified "objects" are the cottonwood forest along the Missouri River, Judith River, and Arrow Creek. As these cottonwoods are typically associated with the fairly uncommon depositional areas, maintaining the appropriate sediment regime is important to meet our obligations under the proclamation.
- The riparian areas and cottonwood forest associated with sediment deposition are popular campsites along the river. Maintaining recreational opportunities is an important part of the BLM's multiple use mandate.

- The National Historic Preservation Act directs us to protect historic properties. Erosion and sediment deposition throughout history have impacted cultural sites, most notably archaeological sites.
  - Sites continue to be buried by fluvial and alluvial deposits. As the river channel moves, the cultural landscape is slowly modified, eroding sites and transporting some artifacts, stranding some cultural sites, distancing them from historic river channels, and altering the vegetative setting associated with the historic sites. This is more evident upriver from Great Falls where the Missouri River has moved miles from its historic location than in the more entrenched Upper Missouri National Wild & Scenic River.
- Properly functioning (BLM land health standard) riparian condition is directly and indirectly linked to viable fish and wildlife habitat.
  - Sediment scour and deposition processes construct in-stream habitat (e.g. riffle/run/pools) variability that fish, amphibian, reptile, and invertebrates depend on.
  - Terrestrial vegetation in the riparian area is maintained by those same processes which provides habitat for a suite of terrestrial wildlife and also influences in-stream habitat.
  - The federally ESA-listed Pallid Sturgeon is habitat limited in the Lower Missouri River and North Dakota in part due to a lack of sediment stemming from a natural flow regime.

- Department of Transportation (DOT)

  - Sedimentation can affect the efficiency of road and rail drainage systems leading to water covering those transportation corridors.
  - Sedimentation and erosion affects the design of highway and rail infrastructure.
    - Degradation of streambeds can undermine the structural integrity of automotive, railway, and pipeline crossings at streams and rivers.
    - Aggradation of streambeds affect the navigability of streams under automotive, railway, and pipeline crossings.

- U.S. Army Corps of Engineers (USACE)

- Aggradation on the flood plain decrease flood capacity and increase flood stages.
- Channel aggradation/degradation affects the maintenance of navigational infrastructure.
- Sediment accumulation in reservoirs can have multiple adverse effects, including:
    - Loss of storage capacity.
    - Reduced water supply reliability.
    - Water Quality impacts.
    - Reduced or loss of use of recreation infrastructure, such as marinas and boat ramps.
    - Increased ground water levels and the related impacts to adjacent land use.
- Sediment adversely impacts dam outlet works and turbines.

- Natural Resources Conservation Service (NRCS)
    - Natural or geologic erosion rates produce natural levels of sedimentation, although natural rates of erosion and levels of sedimentation may vary dramatically across space and through time. Since the arrival of Europeans in the Missouri River Basin in the early 1800s, human-induced land-use changes have accelerated soil erosion and sedimentation to levels much higher than prior naturally-occurring rates.
    - In 1935, Congress established the Soil Conservation Service with a key charge to reduce soil erosion and the resulting sedimentation. Although substantial reductions in soil erosion and sedimentation have been achieved since the Dust Bowl Days of the 1930s, there remains considerable need to further reduce the human-induced accelerated soil erosion and sedimentation that continues today. "Computer modeling simulations indicate that conservation practice use in the Missouri River Basin during the period 2003 to 2006 reduced sediment, nutrient, and pesticide losses from farm fields. However, there remain significant opportunities for reducing nonpoint agricultural sources of pollution." ("Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Missouri River Basin," 2012, http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/pub/?cid=stelprdb1048705).
    - There are many, many different types of soils across the Missouri Basin, each with its own unique characteristics (e.g. grain size, % organic matter, cation exchange capacity, chemical make-up, and more). Sediment characteristics vary based on the parent soil material from which it originates.
    - Today, excess sedimentation due to human-induced accelerated soil erosion is occurring in the large majority of the Missouri River Basin, and many rivers and streams within the Missouri River Basin are impaired due to the resulting excessive sediment. "Movement of sediment, nutrients, pesticides, and pathogens into surface water supplies and leaching of nutrients into groundwater remain concerns." (Soil and Water Resources Conservation Act "RCA Appraisal, 2011" http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/rca/)
    - Working with agricultural producers to voluntarily implement a system systems of conservation practices on cropland and grazing land is the key foundational piece to

successfully addressing the accelerated soil erosion and sedimentation, in many cases, simultaneously addressing other high priority issues such as drought, flooding, and water quality. Numerous NRCS conservation practices can be implemented by agricultural producers to help control accelerated erosion and sedimentation. (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/)

- U.S. Forest Service (USFS)
  - Sedimentation and erosion on USFS lands is largely influenced by the proper design of roads and drainage systems associated with them.
  - Excessive sediment can have adverse effects on wildlife habitat in streams and rivers on USFS lands.
  - Sediment and debris flows can be significant hazards following wildfires on USFS lands.

- National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS)
  - During the 2011 Missouri River flood, excessive sediment loads moving downstream in the main channel caused continual changes to the river bottom profile between the banks, which led to increasing the uncertainty in NOAA National Weather Service river forecast predictions.
    - NWS stage and flow forecasts at some 23 locations along the lower Missouri River are dependent upon the ability to capture accurate stage-discharge relationships throughout the reach. The accuracy of short-term deterministic forecasts, for both low-flow as well as high-flow regimes; as well as the utility of longer-range (weeks to months) water supply outlooks, would be enhanced through a better understanding, and predictability, of the hydrodynamics associated with this movable-bed system.
    - The reduction of the natural sediment loading along the main stem Missouri River often results in tributary streambed degradation. NWS forecast services at tributary locations tied to non-measured stations (some of which have lost DCPs due to budget constraints) must be discontinued due to the rapid deterioration of the historic stage-discharge relationship previously defined for the tributary station.

- U.S. Coast Guard (USCG)
  - Sedimentation and sediment transport affects the navigability of Missouri River and tributaries.
  - Sedimentation can negatively impact the operations of ports and marinas in the basin.

MANAGEMENT GOALS AND STRATEGIES

- Federal agencies will collaborate to move towards sediment management goals based upon early 1800s reference conditions which reduce or eliminate excessive sediment throughout the Missouri Basin, by supporting and implementing healthy soil practices to address root cause of excess sediment, in order to clean up impaired waters, support native species and maintain a sustainable ecosystem.

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- MRBIR cooperating agencies will work collaboratively to develop strategies to restore or maintain turbidity and sediment levels to define and meet optimal reference conditions in the main-stem Missouri river and the reservoirs in harmony with authorized purposes for the MRBIR.
- Sediment management should be considered as part of the adaptive management program of the Missouri River Recovery Program.
- Passing captured sediment downstream through/past reservoirs should be considered as a sediment management strategy.

POSSIBLE SCIENCE, CULTURAL, AND MANAGEMENT NEEDS TO CONSIDER

- A comprehensive sediment budget based on natural sources needs to be developed for the Missouri River and its major tributaries to aid future resource management decisions
- A comprehensive suspended- and bed-sediment monitoring program within the basin is necessary to understand the sedimentation process

REFERENCES

Castro, J and Reckendorf, F., 1995, Effects of Sediment on the Aquatic Environment: Potential NRCS Actions to Improve Aquatic Habitat - Working Paper No. 6; Natural Resources Conservation Service; Oregon State University, Department of Geosciences; August 1995. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/?cid=nrcs143_014201

Osterkamp, W.R., Heilman, Phil, and Gray, J.R., 2004, An invitation to participate in a North American sediment monitoring network: Eos, Transactions American Geophysical Union, v. 85, no. 40, p. 386–388.

U.S. Environmental Protection Agency, 2009, National water quality inventory—Report to Congress, 2004 reporting cycle, January 2009: Office of Water, Washington, D.C., EPA 841-R- 08-001, 43 p.

Wood, M.S., 2014, Estimating suspended sediment in rivers using acoustic Doppler meters: U.S. Geological Survey Fact Sheet 2014-3038, 4 p., *http://dx.doi.org/10.3133/fs20143038*.