THE EBB AND FLOW OF POLICY, ECONOMICS, AND SCIENCE:

AN ANALYSIS OF POLICY DRIVERS

IN THE MISSOURI RIVER BASIN

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THE EBB AND FLOW OF POLICY, ECONOMICS, AND SCIENCE:

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ABSTRACT

The Missouri River basin underwent a major transformation when the United States Congress approved the Flood Control Act of 1944 and the Bank Stabilization and Navigation Project of 1945. Generations removed from those national policy decisions, the long-term effects are now quantifiable. The Missouri River basin contains a degraded ecosystem, power imbalances among stakeholders, and a conflicting set of management parameters. Using a political ecology approach, this research deconstructs the drivers of river management policy from 1803 to 2013, to understand the connections between economics and policy, the impact on the development of the basin, and consequences for the ecological health of the Missouri River.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the College of Arts and Sciences, have examined a thesis titled, “The Ebb and Flow of Policy, Economics, and Science: An Analysis of Policy Drivers In the Missouri River Basin”, presented by Kelly A. Thompson, candidate for the Master of Science degree, and certify that their opinion is worthy of acceptance.

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It is with gratitude to many people that I complete my research and present this thesis. I would first like to thank my 3-year old daughter, Lola. She began this journey with me and helped me understand the value of time, my place on the continuum, and the significance of my research. It is a cliché but it does take a village to raise a child especially when that child's mom is pursuing a graduate degree. To the entire village I say thank you. To my husband, Ross, I thank you for your patience, your grace under the pressure of a crying 2-month old while I attended class, and most importantly your ability to find words of encouragement for me in my most fragile of times. To my sister, your time caring for Lola while I pursued my research is invaluable and I will be forever grateful. To my mom, words never seem enough to express the gratitude for providing encouragement at every step of the way. To my dad, thank you for being there in some of the most helpful of times.

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CHAPTER 1

INTRODUCTION

1.1 Overview

The use and value of the United States' river basins change over time. The Missouri River basin provides no exception. Spanning 529,350 square miles of the central Great Plains, the Missouri River basin is the largest watershed in the United States. Its stretch over one-sixth of the area of the U.S. is home to 10 million people, just 3 percent of the nation's population. Once the geopolitical battleground between Spain, France, and the United States, the Missouri River basin is now a contested expanse among federal government agencies and the stakeholders, communities, and Tribal Nations who exist within it. Not unlike most major river basins in the United States, it is prone to jurisdictional battles, competing economic interests, and fundamentally differing views on how and for whom to manage its mainstem river. The result is a highly altered ecosystem, a fragmented management regime, and a marked lack of public consensus as to how the resources within the basin should be managed. The purpose of this research is to understand the drivers that influence policy in the Missouri River basin.

The Missouri River basin became part of the United States through the 1803 purchase of the Louisiana territory from France. Then U.S. President Thomas Jefferson desired control over ports and a route to the Pacific Ocean for the purpose of commerce (Jefferson, 1793). Through the 15 million dollar purchase of 830,000 square miles, roughly four cents per acre, the United States became owner of land rich in minerals and ripe for agriculture; the water valued for its ability to provide navigational routes to increase America's wealth (Kastor, 2002). Jefferson would employ Meriwether Lewis and William Clark to explore the Missouri River soon after. While Lewis and Clark's journey from the spring of 1804 to the fall of 1806 would reveal no direct passage to the Pacific Ocean it would provide a detailed account of the landscape and shoreline of the Missouri as well as descriptions of the flora and fauna (Osgood, 1964). Lewis's writings reveal a river that was difficult to navigate because of its frequent change in course, exposed tree roots, rising sandbars (Biddle, 1814). Estimates by the U.S. Geological Survey suggest that historically the main channel relocated itself by more than 2,000 feet in some areas (U.S. Geological Survey, 2010). But despite the difficulty in navigation that the natural conditions of the river provided and the inability to establish settlements and farm from the resulting shift in sediment, the Missouri's central location in the newly acquired land would be seen as a useful trade route for commerce during the westward expansion of the territory and its land would eventually be cultivated for agriculture.

The federal government led the development of the Missouri River into a navigation highway despite early concerns that the structural changes and fiscal expenditures would hardly be worth any possible national gains (Worster, 2001). The 1824 Supreme Court decision in *Gibbons v. Ogden* established the federal government's power to regulate interstate commerce, which included river navigation. The General Survey Act of 1824 and the River and Harbors Act of 1824, authorized the U.S. Army Corps of Engineers (Corps of Engineers) to lead the transformation of "unruly rivers" into tamed navigable channels for commerce (Schneiders, 1999). In 1832, the River and Harbors Act would be amended to include funds for the alteration of the Missouri River. These alterations began as removal of sandbars and snags and would lead to smoothing curvatures in the bend of the river and reducing its width so as to concentrate the flow cutting a deeper channel to improve navigation (U.S. Corps of Engineers, 2012). Subsequent Acts would authorize further alteration of the Missouri River. The 1933 National Industrial Recovery Act, devised by President Franklin D. Roosevelt and his administration, provided funds to begin construction of the first mainstem dam located in Fort Peck, Montana (Linenberger, 1998).

The most severe alteration to the Missouri River channel occurred with the passage of the Flood Control Act of 1944 and the Rivers and Harbors Act of 1945. The Flood Control Act of 1944 authorized the construction of the five of the six mainstem dams on the river and gave the Corps of Engineers eight specific purposes, in no particular order, for which to manage the project which include fish and wildlife, flood control, irrigation, navigation, power, recreation, water quality, and water supply (United States 78th Congress, 1944). The inclusion of the eight authorized purposes was a compromise between two competing management plans for the basin. One plan proposed by U.S. Army Corps of Engineers' Brigadier General Lewis Pick emphasized flood control and navigation. A second plan proposed by William Sloan, head of the U.S. Bureau of Reclamation, emphasized irrigation, power generation, recreation, and fish and wildlife. The U.S. Congress did not prioritize the purposes. As often is the case in large river basins, the management plan for the mainstem river became a compromise of conflicting objectives (Gupta, 2008).

The Rivers and Harbors Act of 1945 established the Bank Stabilization and Navigation Project. The project channelized 735 miles of the lower Missouri from Sioux City, Iowa, to St. Louis, Missouri, for the purpose of navigation and urban and agricultural development of the floodplain (U.S. Corps of Engineers, 2012). Under this project, the sediment rich, meandering river that, in some places, was as wide as two miles became a highly controlled 300-foot wide and nine foot deep channel. Channelization shortened the river by 72 miles ultimately creating a loss of 127 miles of river shoreline habitat and a loss of 168,000 acres of aquatic habitat. In total, nearly 354,000 acres of meandering river habitat were lost to floodplain development (National Academies Press, 2011).

From the 1930s through the 1950s, public sentiment for constructing the Missouri River's mainstem dams and channelizing the lower portion of the river was largely positive ("Building the Fort Peck dam," 1936). Floods in the lower stretches of the Missouri River during the late 1800s and early 1900s were catastrophic both in terms of the economic losses and the loss of life (National Oceanic and Atmospheric Administration, 2012). To the public, stabilizing the Missouri River meant no more floods. The federal government fueled the narrative by framing the engineering of dams and channelization as a victory over nature and a pride inspiring national legacy for future generations (U.S. Corps of Engineers, 2007). The construction process that began in 1933, on Fort Peck dam in Fort Peck, Montana, the first dam along the mainstem of the Missouri River, was revered for its job creation during the Great Economic Depression ("Building the Fort Peck dam," 1936). The federal government along with state, local, and private entities saw resource development in the Missouri River basin as a path to economic prosperity. When Franklin D. Roosevelt spoke in 1934 at the construction site of Fort Peck dam he concluded his speech with these words, "Before American men and women get through with this job, we are going to make every ounce and every gallon of water that falls from the Heaven and the hills count before it makes its way down to the Gulf of Mexico" (Roosevelt, 1934).

The most abundant opposition to dam construction in the basin came from the citizens and Native American tribes who inhabited the land along the upper Missouri River. Their land would be flooded by the impoundment of water (Lawson, 1982). However, the federal government felt this was a small price to pay for the thousands of acres of farmland that would be created, the irrigation that would be possible, and the navigation path that would be cleared to help farmers in the Great Plains move their goods (Lawson, 1982). It would take only thirty years to complete all six of the mainstem dams.

By the 1960s public awareness of environmental issues was on the rise. The notable deterioration of the nation's waterways became a concern of the federal and state governments under the Federal Water Pollution Control Act of 1956 and the Water Quality Act of 1965 (U.S. Environmental Protection Agency, 2010). A more extensive review of the legislative history of water quality standards is provided in Chapter 3. What would grow out of these legislative acts and ultimately serve as having the greatest environmental impact in the basin would be the establishment of the National Environmental Policy Act (NEPA) of 1969. NEPA requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions (U.S. Environmental Protection Agency, 2010). To meet NEPA requirements federal agencies prepare a detailed statement known as an Environmental Impact Statement (EIS) outlining the impacts of federal projects. Critics argue that most EIS documents fail to report environmental impacts over a long enough time range (Lapping, 1975).

By 1981, the 735-mile navigation channel along the lower Missouri would be complete. A severe national three-year drought between 1987 and 1989 that covered 36 percent of the United States impacted the Missouri River basin hardest in 1988 and continued throughout the Great Plains until 1992 (National Oceanic and Atmospheric Administration, 2013). Low-flow conditions in the Missouri River impacted river flows and reservoir levels in the upper basin states. The U.S. Corps of Engineers' operation of the reservoir system during the drought became a point of controversy for the upper basin states of Montana, North Dakota, and South Dakota. In 1989, the three upper basin states sued the Corps of Engineers prompting a review of the Master Water Control Manual, the governing document for operation of the mainstem river system (State of South Dakota v. Hazen, 1990). This review served as the impetus for incorporating adaptive management techniques and would also begin a significant conversation on the impact of streamflow on the basin ecosystem.

Streamflow alteration has a significant negative effect on ecological changes to a riverine ecosystem (Poff & Zimmerman, 2010; Graf, 1999). The size of change in flow alteration is associated with the level of risk of ecological change from pre-management conditions of a river (Poff & Zimmerman, 2010). In the case of the Missouri, dams and channelization not only alter the flow, but significantly impact the sediment and organic nutrients from bank erosion and violent flooding. These sediments filled the water giving the river the name, "The Big Muddy" (National Research Council, 2011). Before completion of the mainstem dams, the Missouri River carried 140 million tons of sediment per year past Yankton, South Dakota (National Research Council, 2011). After completion of the dams, the river carried just 4 million tons per year (National Research Council, 2011). Shallow water wetlands, exposed sand bars, stagnant backwaters, and free flowing main channels provided services such as giving homes to nearly 160 species of wildlife and over 150 species of fish (U.S. Army Corps of Engineers, 2010). The pre-management sediment concentration and transport, water quantity, and flow necessary for the river processes and services that supported habitats for native riverine flora and fauna have been lost (National Research Council, 2011). The streamflow alteration in the upper Missouri River is so great that the ecosystem, once that of a river, is now considered to be a lotic, or lake, ecosystem (U.S. Geological Survey, 2010). Reports note ecological loss including three million acres of natural river habitat alteration; 51 of 67 native fish species are considered rare, uncommon, or decreasing; reproduction of cottonwoods, historically the dominant floodplain tree, have largely ceased; and aquatic insects which represent a key link in the food chain have been reduced by 70 percent (Missouri River Recovery Program, 2011; Scott, Auble, & Friedman 1997).

In 2009, Congress provided first year funding for the Missouri River Authorized Purposes Study (MRAPS) (U.S. Institute for Environmental Conflict Resolution, 2011). The study is the first federally mandated review of the eight authorized project purposes since their inception. As part of the review, the Corps of Engineers through the U.S. Institute for Environmental Conflict Resolution assessed public perception of river management. The surveys asked respondents to rate the importance of the eight authorized purposes of the Missouri River. The 2010 results of one survey (Appendix A) found water quality, water supply, fish and wildlife habitat, and recreation to be the highest. Flood risk management, power generation, irrigation, and navigation ranked lowest. The second survey (Appendix A) results ranked flood risk management the highest, but navigation again ranked last (The Osprey Group, 2010). While the surveys are inconclusive as to the primary purpose for which the river should be managed, they do find that navigation is consistently ranked last among a sample of residents throughout the entire basin. These findings are again consistent with public opinion expressed during a series of meetings throughout the Missouri River basin in response to the record floods during the summer of 2011 (M. Farmer, personal communication, November 1, 2011). The Corps of Engineers held eight meetings throughout the basin states to give residents an opportunity to express their concerns regarding the 2011 management of the Missouri River. The opinions expressed by farmers of small farms, local groups who focus their efforts on water quality, concerned citizens of metropolitan centers, and some local government officials were consistent with conclusions of the 2010 surveys ranking navigation as the lowest priority for the basin (The Osprey Group, 2010).

Among the eight authorized purposes, navigation is the primary purpose for which the Corps of Engineers manages the Missouri River and managing the river for navigation is detrimental to the seven other authorized purposes especially in cases of extreme hydrological events. As will be discussed in Chapter 2, the severe alteration of the river for the purpose of navigation has serious ecological repercussions for the entire basin as well. By understanding the drivers of policy in the Missouri River basin, this investigation seeks to reveal, if any, the uneven distribution of power found in the basin and its effects on the management and ecological health of the Missouri River.

Furthermore, this research presupposes that there is direct correlation between severe hydrological events and policy.

1.2 The Basin

The Missouri River basin (Fig.1) is one of great division. Most of its 529,350 square miles exist within the United States with only 9,700 square miles located in Canada. The basin spans all or parts of 10 states, 2 Canadian provinces, and 28 Native American Tribal Reservations (U.S. Geological Survey, 2010). It is not only divided by international and national boundaries but also by climate, physiography, land use, population, economics, and laws governing the right to water use.

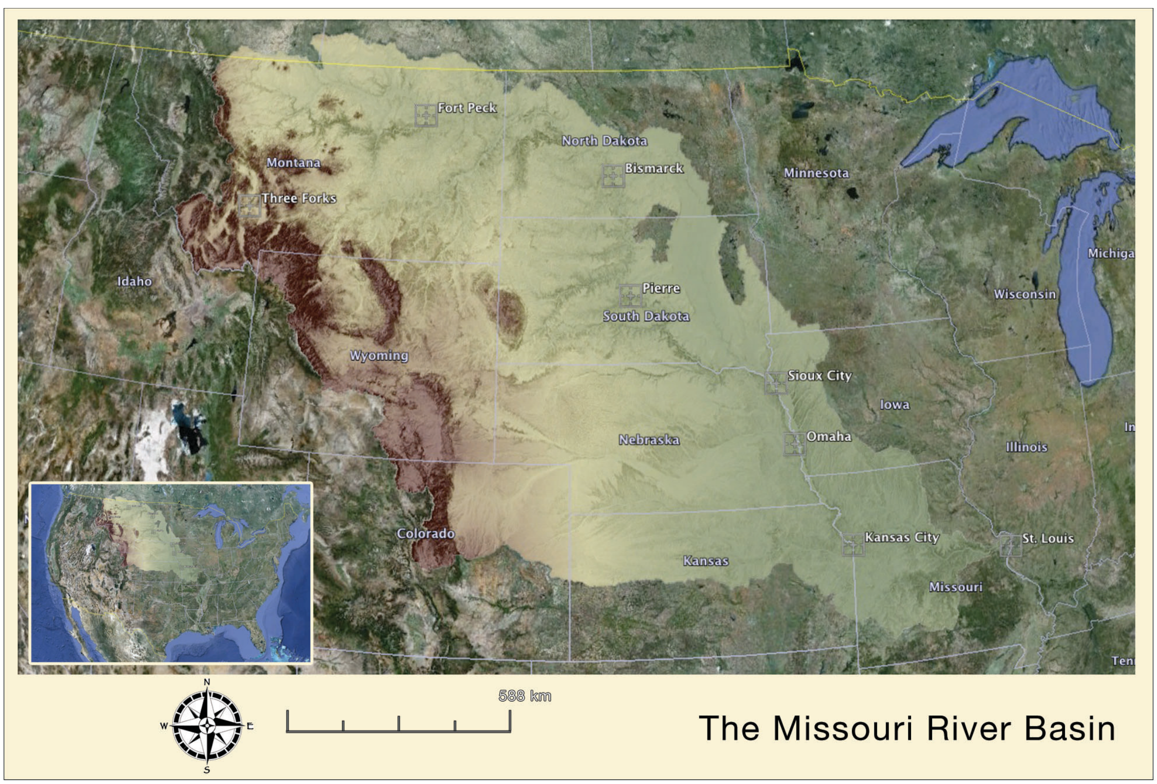


Figure 1. The Missouri River basin in North America. (National Operational Hydrologic Remote Sensing Center, 2012)

The Missouri River basin drains one-sixth of the continental United States. It is comprised of three major physiographic regions, the Rocky Mountain System, the Interior Plains, and the Interior Highlands (Patrick, 1998). Some scholars offer a further physiographic distinction by breaking the Interior Plains into the Great Plains and Central Lowlands (Winston & Criss, 2003). Of the total area of the basin the Rocky Mountain System comprises 11 percent of its land. Of the 87 percent of land dominated by the Interior Plains, 70 percent is within the Great Plains and 17 percent in the Central Lowlands. The Interior Highlands accounts for just 2 percent of the land (Galat, Berry, Peters, & White, 2005).

The variation in climate throughout the basin is due to the topographic and geographic variations (Sprague, Clark, Rus, Zelt, Flynn, & Davis. 2006). The Rocky Mountains offer a cold and moist climate whereas the Interior Plains are considered semiarid to humid from west to east. Most precipitation occurs as rain during the spring and summer although significant snowfall can occur in the Rocky Mountains during the winter. The 100th meridian (Fig. 2) aptly marks the boundary between the arid climate of the west and the more humid climate of the east (U. S. Geological Survey, 2011). It also serves as the dividing line for prevailing state water laws. States east of the 100th meridian base their modern day statutory system for governing water on the riparian doctrine. Under that doctrine, a landowner may make reasonable use of the water on the riparian land if the use does not interfere with reasonable uses of other riparian landowners (Getches, 2009). In contrast, states west of the 100th meridian adhere to the prior appropriation doctrine. The doctrine considers water to be a public resource owned by no one. Water rights are based on the time a person applies a specific quantity of water to a beneficial use (Getches, 2009). In addition to the two opposing water doctrines, some states have elected to base their statutory system on a combination of the two. The Missouri River basin contains three riparian states, Missouri, Iowa, and Minnesota; three prior appropriation states, Montana, Wyoming, and Colorado; and four states which use a hybrid system, North Dakota, South Dakota, Nebraska, and Kansas (Getches, 2009).

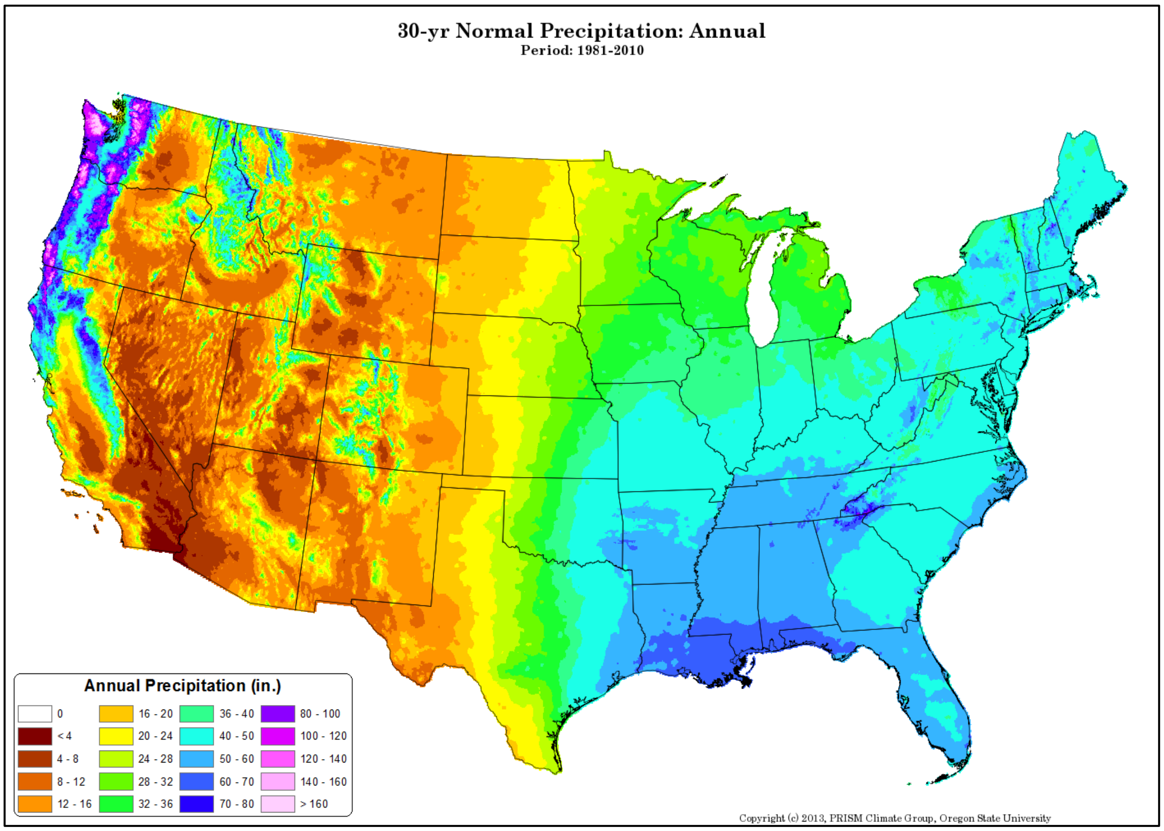


Figure 2. Average precipitation levels in the United States from 1981-2010. States with an annual precipitation less than 20 inches falls to the west of the 100th meridian. States with an annual precipitation greater than 24 inches falls to the east of the 100th meridian. (PRISM Climate Group, 2013)

The drainage basin contains 47 rivers contributing to the mainstem river of the basin, the Missouri River (Galat et al., 2005). The river flows 2,341 miles from its headwaters at the confluence of the Gallatin, Madison, and Jefferson Rivers in the Rocky Mountains at Three Forks, Montana, through the Great Plains, to its confluence with the Mississippi River at St. Louis, Missouri (U.S. Geological Survey, 2010). Prior to channelization and dam construction, the Missouri was a shallow river and in some areas it maintained a braided pattern with no single, distinct river channel. It was prone to frequent flooding posing risks for the urban areas along the lower stretch of the river and negating agricultural use of floodplains (Schneiders, 1999). The mainstem of the river is divided into three distinct regions based on contemporary hydrology. The upper unchannelized zone that extends roughly 460 miles from the headwaters of the Missouri River accounts for 33 percent of the river's length (U.S. Geological Survey, 1998). The middle portion or "interreservoir" portion of the river is known for its impoundment of water through six mainstem dams. This stretch of the river accounts for 35 percent of its length and is principally known as a lotic ecosystem due to the stationary nature of the water. The lower stretch of the Missouri River begins at Sioux City, Iowa, and ends at the confluence with the Mississippi River in St. Louis, Missouri. This 32 percent of the river is referred to as the "channelized" portion being altered by channelization, bank stabilization, and floodplain levees (U.S. Geological Survey, 1998; Galat et al., 2005). The purpose of this introduction of the mainstem is to locate the river and define the hydrological divisions within it. Further discussion on flow and floodplain dynamics and the impact on the ecosystem of the Missouri River can be found in Chapter 2.

Before settlement in the Missouri River basin, 90 percent of the land was considered prairie. The dominant plant communities consisted of tallgrass, mixed, and shortgrass prairie. Woodlands were confined to riparian zones along streams and around wetlands with the exception of the Ozark Highlands and the Rocky Mountains (Hesse, in Kusler and Daly, 1989). Today, the basin is 37 percent cropland, 30 percent grassland, 13 percent shrub, 11 percent forested, and 9 percent developed (Revenga et al., 1998). Within 3 miles of the mainstem river, 17 percent of the land is developed (Revenga et al., 1998). Row crops and pasture comprise over half of the land use in the basin (Sprague et al., 2006). The basin is a primary food-producing region producing approximately 46% of U.S. wheat, 22% of its grain corn, and 34% of its cattle. Approximately 117 million acres are cropland, with 12 million acres under irrigation (Mehta, 2011). Thus, almost 90% of the basin's cropland is entirely dependent on precipitation. Documented land-surface resources within the basin from west to east are:

> Rocky Mountain range and forest, western range and irrigated agriculture, northern Great Plains spring wheat, western Great Plains range and irrigated agriculture, central Great Plains winter wheat and range, central feed grains and livestock and east and central general farming and forest. (Slizeski et al, 1982; Galat et al., 2005)

The approximate value of crops and livestock produced in the basin was over $100 billion in 2008 (Mehta, 2011).

The basin is divided between upper and lower at Sioux City, Iowa. The upper basin contains the six mainstem dams and reservoirs. Of the 10 million people who live within the basin, population in the upper basin states is sparse (Fig. 3) (U.S. Geological Survey, 2010). It is home to 28 tribal nations. The economy of the region is divided between services, wholesale-retail activities, and government activities. River related tourism and recreation are a large component of the service sector for the upper basin.

Commercial centers along the upper stretch of the Missouri are Great Falls, Montana, Williston, North Dakota, Bismarck, North Dakota, Pierre, South Dakota, and Yankton, South Dakota but are not tied to the river for their livelihoods. In contrast, the lower basin contains major metropolitan centers of commerce including Sioux City, Iowa, Omaha, Nebraska, Kansas City, Missouri, and St. Louis, Missouri. These dense population centers stretch along the 735-mile navigation channel (Fig. 3). The economy of the Kansas City area alone is greater than the combined economies of Montana, North Dakota, and South Dakota. The rural population of the basin has been on the decline since the beginning of the twentieth century. Urban areas in the basin have seen population growth over the same time period (National Research Council, 2002).

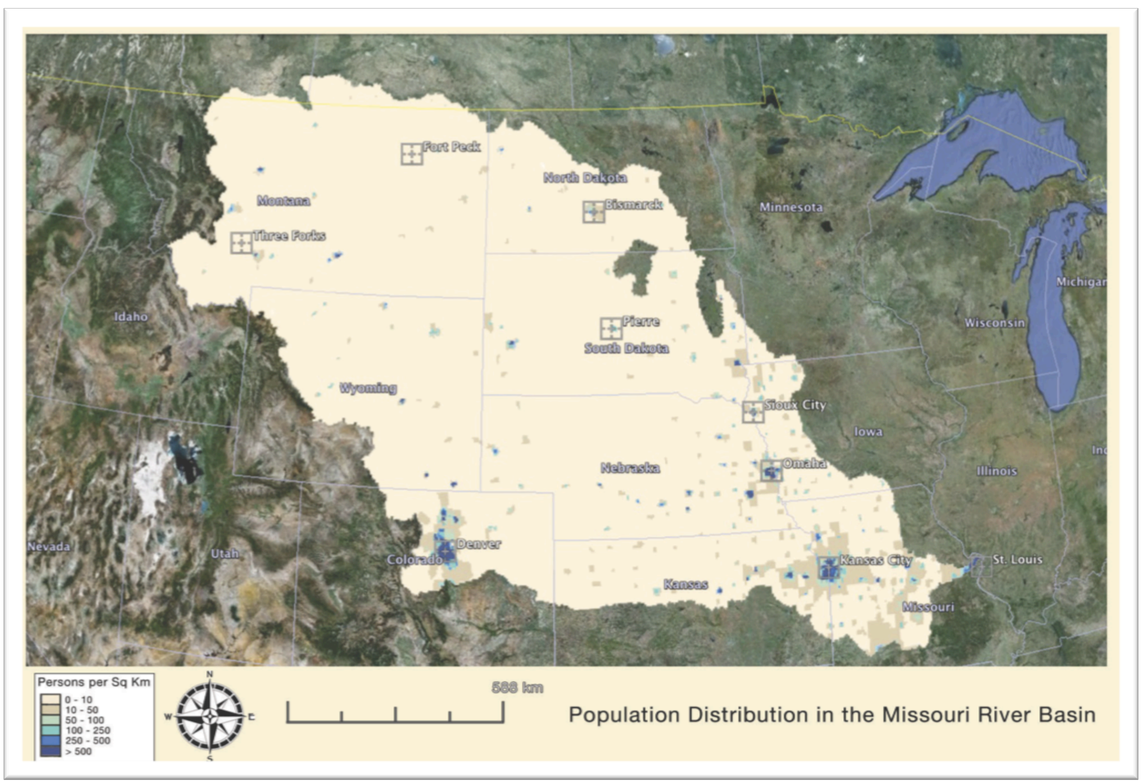


Figure 3. Population distribution in the Missouri River basin. (National Operational Hydrologic Remote Sensing Center, 2012)

1.3 Geographic Approach: Political Ecology

Political ecology provides an approach to understanding the economic and political drivers of environmental issues. The field does this through its focus on both ecological processes and the political economy, the relationship between economic and political processes, in a defined area (Gregory, Johnston, Pratt, Watts, & Whatmore, 2009). Practicing political ecology requires researchers to focus on issues of power through three key components (Gregory et al., 2009; Robbins, 2011). The first component is the historical, political, and economic analysis of resource management. The second component is the spatial account of environmental change that links decision-makers to spatial variations in environmental structure. The third component is the employment of the core-periphery model, which is a geographic model used to explain the unequal distribution of costs and benefits and can be specifically used to explain development and exploitation of resources.

The field of political ecology emerged from human geography and the inter-disciplinary studies of nature-society relations (Neumann, 2005). The seminal work of Piers Blaikie (1985) in *The Political Economy of Soil Erosion in Developing Countries* and his work with Harold Brookfield (1987) in *Land Degradation and Society* provided the foundation for the current understanding of the field (Robbins, 2011). Blaikie and Brookfield (1987) employed the political economy framework to analyze environmental issues presupposing that degradation of the environment was a result of historical government polices. During the 1990s, work in the field advanced around issues of environmental constructs and how alternative approaches to policy could expose power structures and even change the status quo (Leach & Mearns, 1996; Peet & Watts, 1996; Hempel, 1996). The field has received harsh criticism since its inception in the 1970s for its leanings toward a liberal political movement, being too heavily focused on the developing world, and lacking a practical application outside of academia (Wolf, 1972; Atkinson, 1991; Walker, 2006). The contribution of this research speaks specifically to the criticism by focusing on the United States rather than a developing region and offers practical applications for the outcomes of the research discussed in Chapter 5.

As of this writing, there has been no attempt to apply the field of political ecology towards an understanding of the narrative of the Missouri River basin. A scientific, legal, and economic literature review of the basin reveals isolated areas of focus within each discipline but a lack of interdisciplinary research. Recent scientific literature takes the form of hydrological, ecological, and climatically focused studies. In the field of law, the unique geography of the Missouri River basin and contentious relationship between federal and state powers give legal scholars a limitless research area (Davidson, 2011; Tarlock, 1997). To a lesser extent, the basin receives attention in economics.

Political ecology provides a framework to consider the political, economic, and ecological processes in the Missouri River basin and view them on a multi-scalar level (Zimmerer & Bassett, 2003). This research works from the premise that a combination of science, law, and economics are the drivers of policy in the Missouri River basin. Through this analysis, the drivers will be deconstructed to understand who holds the power in the basin and to understand how decisions are being made for the basin, how these compare to the eight authorized purposes for which the basin is managed, and how to influence change in the basin.

CHAPTER 2

RIVER BASIN MANAGEMENT

2.1 Streamflow

Streamflow is considered to be a primary driver of the processes needed for sustaining the life of aquatic biota (Richter et al., 2003, Poff et al., 1997). Scholars have studied and documented the relationship between the life stages of species and a dynamic flow regime concluding that biological processes depend upon a dynamic flow regime (Poff et al., 1997; Galat et al., 1998; Middleton, 2002). The effects of land use and hydrological alteration on large river systems, those with a drainage area greater than 97,000 square miles, are measured by the changes to the natural dynamics of a system that are required for diverse and productive biological communities, specifically the distribution and quality of aquatic and terrestrial habitats, their associated biotic communities, and the channel's capacity to carry nutrients, sediments, and water (Taylor, Bolgrien, Angradi, Pearson, & Hill, 2013). Poff and Zimmerman conducted a thorough review of literature on the ecological consequences of flow alteration and successfully demonstrated that alteration in streamflow has a negative effect on ecological changes (2010; Johnson, Milewski, & Higgins, 1996). Those negative effects are examined further in this chapter.

The Missouri River ecosystem experienced a significant transformation during the twentieth century. Before regulation of the Missouri River, the river was a series of braided channels, containing numerous sandbars, islands, log jams, snags, whirlpools, secondary channels around bars, and unstable banks (U.S. Geological Survey, 2010). The main channel could range from 1,000 to 10,000 feet wide during normal flow periods to 25,000 to 35,000 feet wide during floods (Schneiders, 1999). The river periodically overflowed its banks allowing water to spread across the floodplain connecting the main channel to its floodplain and backwaters. New channels would be created as the river moved over the floodplain. These natural changes in river flow were responsible for the variations in the river's location, form, and volume of sediment transported (National Research Council, 2002).

The variable nature of the river's hydrology depends upon the climate of the basin. Precipitation in the basin ranges from a mean of 36 to 104 centimeters per year. January and February receive the lowest amounts of precipitation, roughly 1.7 centimeters in comparison to a mean of 8 centimeters in the month of June alone (Galat et al., 2005). Historically, flooding was common and the turbidity of the river was high. The large amount of sediment transported in the Missouri River gave it the nickname the "Big Muddy" (National Research Council, 2002). The river had an annual period of high streamflow during the spring and summer due to snowmelt and rain. The seasonal increase in runoff began in March from the prairie snowmelt and continued due to local rainfall. Streamflow peaked in June from the Rocky Mountain snowmelt and rainfall at lower elevations (National Research Council, 2002). The river depth was greatest during these peaks and would see its shallowest level during the months of December and January (National Research Council, 2002).

The natural pulse of the river triggered spawning in native river fish, promoted productivity in the upper river reaches, and inundated backwaters and wetlands which provided seasonal nursery and feeding areas for fish and migratory birds (Junk et al., 1989). River management describes the interaction between the advancement and retraction of water onto the floodplain enhancing biological productivity and maintains diversity as the flood-pulse concept (Bayley, 1995). During a flood, nutrients mineralize and dissolve. Those nutrients suspended in sediment travel from the main river to the floodplain (Amoros & Bornette, 2002). Without this seasonal pulse the sediment scouring and deposition that continually reshape the channel and connect the floodplain to the river are lost and can result in severe modification of aquatic communities (Crane, 2005; Nilsson, Reidy, Dynesius, & Revenga, 2005).

Streamflow graphs from U.S. Geological Survey demonstrate the highly variable nature of the pre-management river and the highly altered flow regime after impoundment and channelization of the mainstem (Appendix B). Research using Lewis and Clark expeditionary data as well as nineteenth century river stage records from the Missouri River Commission, the U.S. Department of Agriculture Weather Bureau, and the U. S. Army Corps of Engineers establishes similar pre-management hydrology featuring gradual daily stage changes with high stages in the spring and early summer (Ehlmann and Criss, 2006). By 1955, four of the six mainstem dams along the upper stretch of the Missouri River would be complete. The USGS hydrographs show a marked lack of streamflow variability by the same year. The naturally dynamic and highly variable flow of the Missouri River was significantly altered to lower the spring flood pulse and increase flows from August until December to accommodate the navigation season in the lower stretch of the river (Pegg, Pierce, Roy, 2003).

The Missouri River is but one example of the hydrologic alteration that occurred in U.S. river basins during the twentieth century. The Corps of Engineers and the Bureau of Reclamation along with local, state, and private entities constructed hundreds of dams to help control river flows and reduce streamflow variability. In any given year, 60 percent of the United States' entire river flow can be stored behind those dams (Hirsch et al., 1990). The six dams (Table 1) of the Missouri River have the capacity to impound 74 million acre-feet of water, roughly 66 billion gallons of water (Missouri River Natural Resources Committee, 1998).

Table 1. Summary of engineering data for the Missouri River mainstem reservoirs. (U.S. Army Corps of Engineers, 1998)

Dam (Construction Began) (In Operation)	**Reservoir**	**Storage Capacity (acre-feet)**	**Drainage Area (sq. mi.)**	**Surface Area (acres)**	**Length (miles)**	**Depth (feet)**	**Power Generation (kW)**
Fort Peck (1933) (1940)	Fort Peck Lake	18,700,000	57,500	245,000	134	220	185,250
Garrison (1946) (1955)	Lake Sakakawea	23,800,000	181,400	382,000	178	180	517,750
Oahe (1948) (1962)	Lake Oahe	23,500,000	243,490	370,000	231	205	786,000
Big Bend (1959) (1964)	Lake Sharpe	1,900,000	250,000	56,884	80	78	494,300
Fort Randall (1946) (1953)	Francis Case Lake	5,400,000	263,480	102,000	107	140	320,000
Gavins Point (1952) (1955)	Lewis and Clark Lake	492,000	279,480	31,400	28	45	132,300

In 1933, as part of the New Deal, the Public Works Administration authorized the creation of the Fort Peck Dam (Fig. 4) in Fort Peck, Montana. The Flood Control Act of 1944, authorized the Garrison Dam (Fig. 5), in Garrison, North Dakota, the Oahe Dam (Fig. 6) in Pierre, South Dakota, the Big Bend Dam (Fig. 7) in Fort Thompson, South Dakota, the Fort Randall Dam (Fig. 8) in Pickstown, South Dakota, and the Gavins Point

Dam (Fig. 9) straddling the Nebraska-South Dakota border near Yankton, South Dakota. These dams fragmented the fluvial system of the Missouri River creating a severe impact on the river sediment discharge (Graf, 1999; Hudson, 2008; National Research Council, 2011).

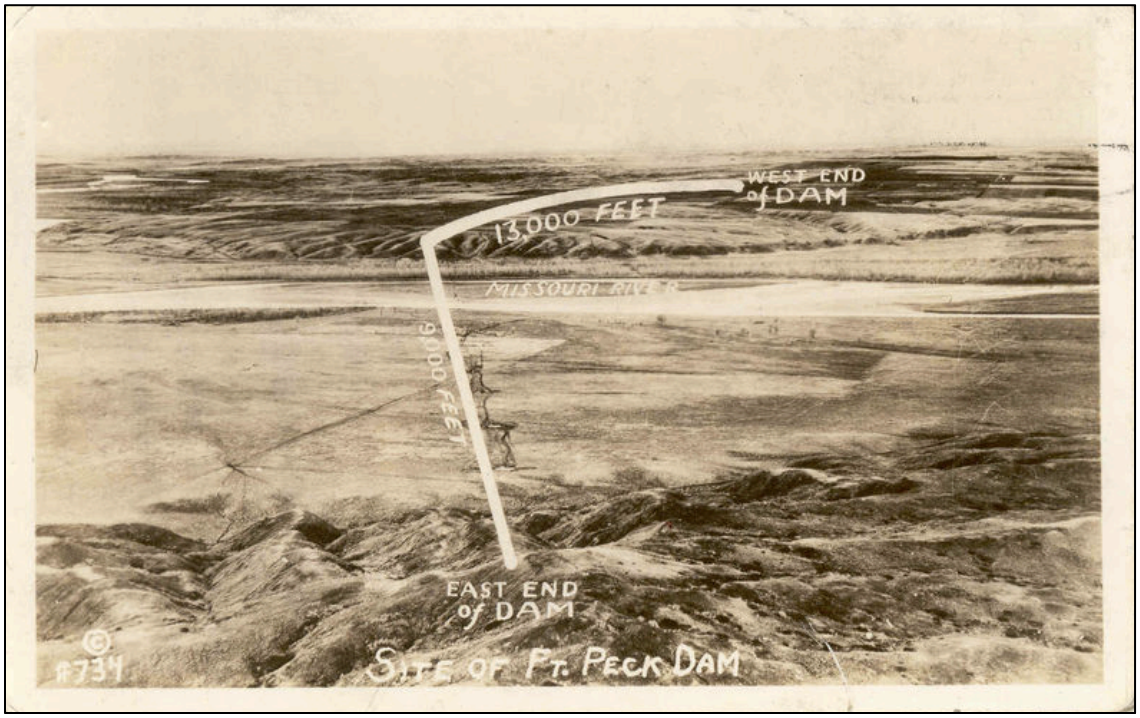


Figure 4. The top photo shows the proposed site of Fort Peck dam and lake in 1935 looking northwest. The bottom photo is of the dam and lake in 2009. (Fort Peck dam, 1935; U.S. Army Corps of Engineers, 2012)

Figure 5. Top photo is of the Garrison dam and Lake Sakakawea site in 1946, at the western edge of proposed dam looking east along the axis of future dam. The bottom photo is of Lake Sakakawea and the Garrison dam in 1999, looking south to the Missouri River. (U.S. Corps of Engineers, 1946; Wark, 1999)

Figure 6. Top photo is of the proposed Oahe dam site in 1946, looking west. The bottom photo is of Lake Oahe, Oahe dam, spillway, and hydroelectric plant. (University of Kansas, 1946; U.S. Army Corps of Engineers, 1999)

Figure 7. Big Bend dam in Fort Thompson, South Dakota. Top photo displays the proposed site of the dam taken from the northwest looking south. Bottom photo taken from the southwest looking north. (U.S Army Corps of Engineers, 1999)

Figure 8. Fort Randall dam in Pickstown, South Dakota. The top photo taken from the east side of the dam looking west during construction. The bottom photo taken from the west side looking east. (U.S. Army Corps of Engineers, 1999)

Figure 9. Gavins Point dam in Yankton, South Dakota. Top photo taken from the south looking northeast at the proposed site. Bottom photo taken from the south looking north. (U.S. Army Corps of Engineers, 1999; Ziegler, 2013)

With the exception of a federally designated "Wild and Scenic" 59-mile stretch of river below Gavins Point dam in Yankton, South Dakota, to Ponca, Nebraska, the Missouri becomes a highly channelized waterway. Under the Bank Stabilization and

Navigation Project, 735 miles of the lower Missouri River considered to be the stretch of water from Sioux City, Iowa, to St. Louis, Missouri, is channelized to a width of 300 feet and a depth of nine feet for the purpose of navigation and urban and agricultural development of the floodplain (National Research Council, 2011). An example of the channelization process on the Missouri River can be seen in Figure 9. These four photographs from the same vantage point at Indian Cave Bend, Nebraska, on the Missouri River were taken in 1934, 1935, 1946, and 1977. The top photo displays a non-channelized river. The two following photos demonstrate the construction of brush dikes and the naturally occurring vegetative processes that occurred. The bottom photo reveals a substantially altered river and habitat area in which agricultural fields replaced the natural vegetation cover (National Research Council, 2011).

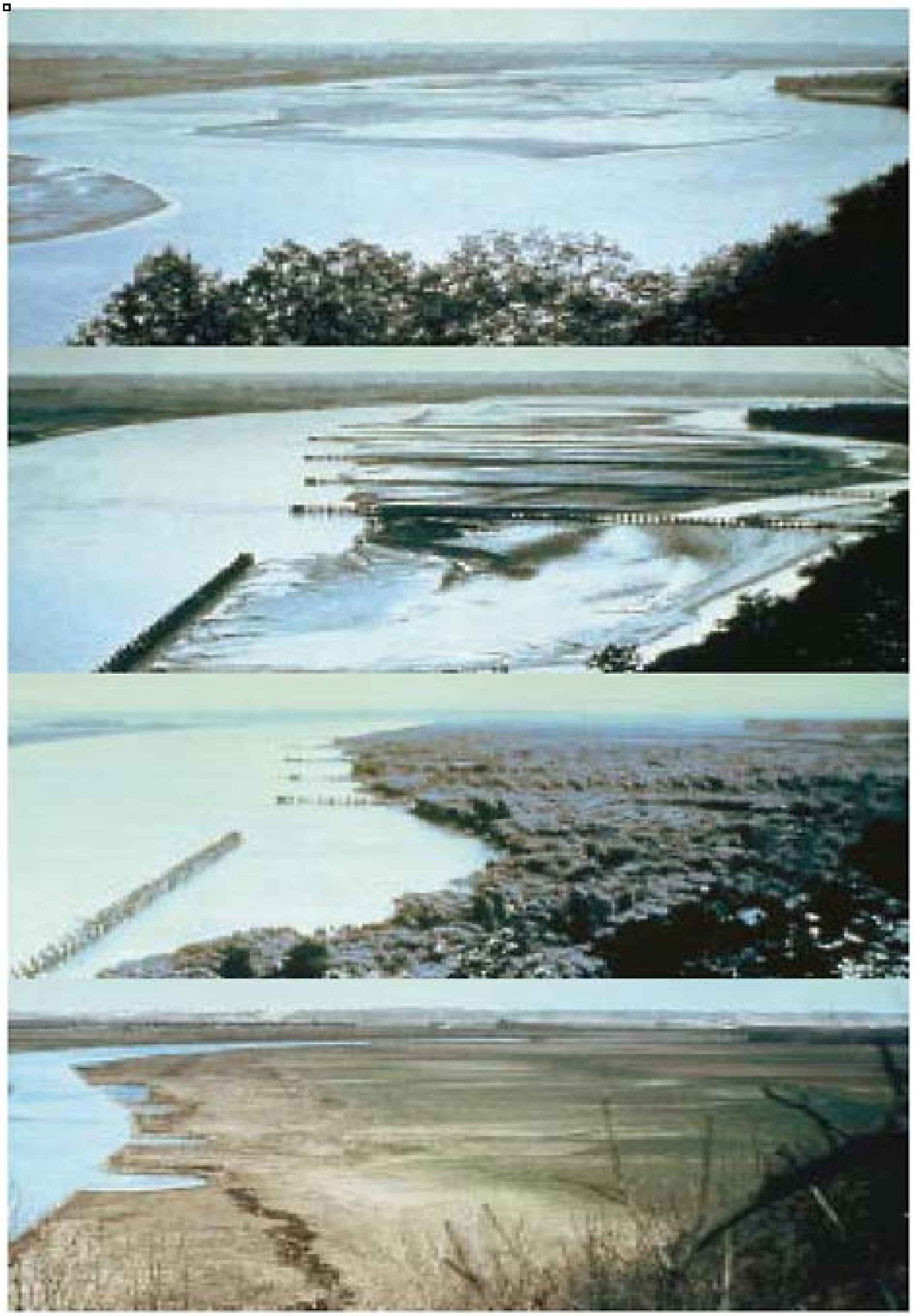


Figure 10. The narrowing and channelization process along the lower Missouri River at Indian Cave Bend, Nebraska, in 1934, 1935, 1946, and 1977. (National Research Council, 2011)

Channelization shortened the river by 72 miles ultimately creating a loss of 127 miles of river shoreline habitat and a loss of 168,000 acres of aquatic habitat. Nearly 354,000 acres of meandering river habitat were lost to urban and agricultural floodplain development (National Academies Press, 2011). Today, the Missouri River is listed as one of America's most endangered rivers due to the risk its outdated flood management poses to human life (American Rivers, 2012). The threat the engineered dams posed to endangered species, specifically to the pallid sturgeon, placed the Missouri River on that same list from 1995 to 2002 (American Rivers, 2011).

Table 2. Missouri River ranking on *America's Most Endangered Rivers* report. (American Rivers, 1996, 1997, 1998, 1999, 2000, 2001, 2001, 2002, 2011, 2012)

Year	Rank	Threats
1995	5	Navigation, Agricultural Runoff
1996	4	Dams, Flood Control
1997	1	Navigation
1998	2	Channelization, Dams
1999	2	Channelization, Dams, Bank Stabilization, Poor Grazing Practices
2000	2	Dam Operations
2001	1	Dam Operations
2002	1	Dam Operations
2012	4	Outdated Flood Management

Biological indicators are processes, species, or communities that can be used to monitor the health of an environment or ecosystem (Holt & Miller, 2011). In large river ecosystems the most common indicators used for biomonitoring are periphyton, benthic macroinvertebrates, and fish (Li, Zheng, Liu, 2010). Periphytons act as a vital part of the food webs found in river ecosystems (Lowe & Pan, 1996). They reproduce quickly and have a very short life cycle and thus can reflect short-term impacts and sudden changes in the environment (Barbour, Gerritsen, Snyder, Stribling, 1999). Benthis macroinvertebrates are a key component in aquatic food webs that link organic matter and nutrient resources with higher trophic levels. Their habitats are relatively static and as such they are used to monitor the ecological conditions of a specific site. Additionally, the community structure can change in response to environmental disturbances (Gray, 1989). Fish are at the top of the aquatic food web and are consumed by humans making them a vital means for monitoring contamination (Barbour, Gerritsen, Snyder, Stribling, 1999). They have a long life cycle and are mobile making them a good indicator of long-term effects and broad habitat conditions. Change in community structure for fish can reflect a holistic account of environmental health (Karr, 1981; Harris, 1995; Shields, Knight, Cooper, 1995).

Fish have played a critical role in monitoring the health of the ecosystem in the Missouri River (Fish and Wildlife Service, 2003). Fish are acknowledged as useful in evaluating biological integrity for their long lifespans, diversity, easy identification, and ability to transmit toxicity data (Grabarkiewicz & Davis, 2008). In addition, researchers have used fish as biological indicators since the early 1900s in varying capacities that produced a large body of literature on fish occurrences, habits and habitats Ortman, 1909; Forbes & Richardson, 1913; Brinley, 1942; Trautman, 1957; Grabarkiewicz & Davis, 2008). The pallid sturgeon became the most publicized biological indicator for the health of the Missouri River ecosystem (U.S. Fish and Wildlife Service, 2003). In 2003, the Fish and Wildlife Service issued an amended biological opinion stating that the Corps of

Engineers management of the Missouri River continues to be detrimental to the habitat of the endangered pallid sturgeon (U.S. Fish and Wildlife Service, 2003). This opinion discussed in greater detail in section 2 of this Chapter served as the impetus for changes to spring water releases from the upstream reservoirs of the Missouri River system.

2.2 Adaptive Management

The theory of adaptive management has been discussed among scholars of ecosystem management for over three decades (Holling, 1978; Walters, 1986; Pahl-Wostl, 1995; Lee, 1999). It was conceived as a way to overcome the traditional "command and control" approach to water management that prevailed in the United States from the 19th to 21st century (Groenfeldt, 2010). Generally defined, it is an "approach to natural resource management that promotes carefully-designed management actions, assessment of these actions' impacts, and subsequent policy adjustments." (National Research Council, 2002, p. 107). The approach employs the ecological, economic, and socio-political arenas to test hard and soft path approaches (Hafele & Burk, 1976; Brewer, 1975; Gleick, 2003; Prato, 2003). It gives consideration to scale, looking at water from the basin level and ultimately considers the natural flow regime to be the foundation for sustaining the ecological health of a river system (Biswas, 2009; Postel & Richter, 2003).

Adaptive management became a part of the Corps of Engineers' vernacular in 2004. The adoption of this water management approach came after the upper basin states of Montana, North Dakota, and South Dakota, filed suit against the Corps of Engineers for alleged mishandling water releases from the Oahe dam during the drought of the late 1980s which in turn spurred an internal review of the Corps of Engineers' *Master Water*

Control Manual (*Master Manual*). The review of the *Master Manual* culminated in the early 2000s when in 2002, a report produced by the National Academies Press titled, *The Missouri River Ecosystem: Exploring the Prospects for Recovery*, recommended the use of an adaptive management approach to reverse ecological decline in the Missouri River. While the report offered a recommendation to mitigate the loss of species and habitat along the Missouri River, it would be an Amended Biological Opinion offered by the United States Fish and Wildlife Service (Fish and Wildlife Service) that would significantly change the managed water releases from the six mainstem dams along the Missouri River.

The Amended Biological Opinion on the United States Army Corps of Engineers' Missouri River System operations called for, among other things, a bimodal spring pulse release from Gavins Point Dam for the benefit of the endangered pallid sturgeon. The pallid sturgeon was placed on the endangered list in 1990, along with the piping plover in 1986, and the least tern in 1985 (Army Corps of Engineers, 2004). Thus, the Amended Biological Opinion was the result of an thirteen-year effort conducted under section 7 of the Endangered Species Act which requires, "Federal agencies to consult with the USFWS when the agency's proposed actions may affect the status of species listed as endangered or threatened" (Fish and Wildlife Service, 2003, p. 17). In 2006, the Corps of Engineers amended its *Master Manual* to comply with the Fish and Wildlife Service's Biological Opinion (National Academies Press, 2011).

In 2009, the Corps of Engineers implemented the Missouri River Recovery and Mitigation Program (MRRP) as a part of the adaptive management process to specifically create, as stated on the MRRP website, "A sustainable ecosystem supporting thriving populations of native species while providing for current social and economic values" (U.S. Army Corps of Engineers, 2011). The MRRP (Fig. 11) encompasses projects that work towards recovery and restoration of the Missouri River resources. The stated goals of the project are to:

> Implement a more natural flow regimen to benefit native fish and wildlife while seeking balance with social, economic and cultural resources. Ensure that managemt decisions are based on the best available science. Establish collaborative stakeholder processes and educational opportunities to provide insight and recommendations on recovery activities. (U.S. Army Corps of Engineers, 2011)

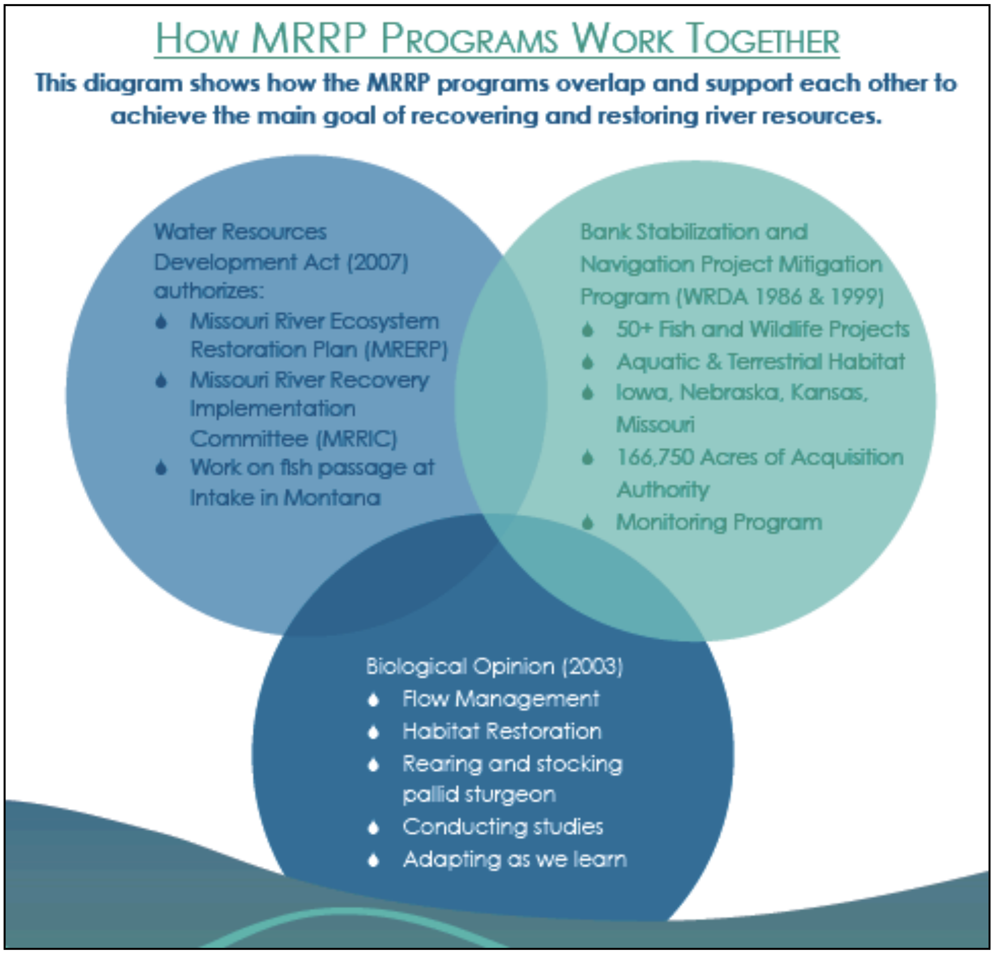


Figure 11. The Corps of Engineers interpretation of how the MRRP Program work together to recover and restore river resources. (U.S. Corps of Engineers, 2011)

The Missouri River Ecosystem Restoration Plan (MRRP) and the Missouri River Recovery Implementation Committee (MRRIC) are being championed as the definitive example of the Corps of Engineers implementation of adaptive management (REF). The MRRP is a long-term study conducted by the Corps of Engineers in partnership with the Fish and Wildlife Service, to identify actions required to, "mitigate losses of aquatic and terrestrial habitat; recover federally listed species under the Endangered Species Act; and restore the ecosystem to prevent further declines among other native species" (Missouri River Recovery Program, 2013). The goal is to provide a natural resource baseline assessment to help guide the Corps of Engineers' mitigation, restoration, and recovery efforts for the Missouri River for the next 30 to 50 years (Missouri River Recovery Program, 2013).

The Missouri River Recovery Implementation Committee, first established in 2008, serves as the basin-wide collaborative forum tasked with developing a shared vision and comprehensive plan for the recovery of the Missouri River (Missouri River Recovery, 2012). Specifically, members make recommendations and provide direction on the Missouri River Ecosystem Recovery Plan and the Missouri River Recovery and Mitigation Program. The 70 selected members of the committee are stakeholders representing non-government interests, American Indian Tribes, federal agencies, and selected basin states (Table 3). Twenty-eight of the 70 members represent stakeholder interests which include agriculture, at-large or other interests such as cultural and historic preservation, conservation districts, environmental and conservation organizations, fish and wildlife interests, flood control, hydropower, irrigation, local government, major tributaries, navigation, recreation, thermal power, water quality, water supply, and waterway industries. Eighteen American Indian Tribes are represented as well as 15 federal agencies and eight states. Two states, Colorado and Minnesota, are not represented among the members (Missouri River Recovery Program, 2013).

Table 3. Missouri River Recovery Implementation Committee Members as of October 2013. (Missouri River Recovery Program, 2013)

STAKEHOLDERS

Interest	Name	City, State
Agriculture	Don Borgman	Lenexa, KS
Agriculture	David Sieck	Glenwood, IA
At Large	Randy Asbury	Higbee, MO

At Large	Brad Walker	St. Louis, MO
Conservation Districts	Jack Majeres	Dell Rapids, SD
Conservation Districts	Richard Iversen	Culbertson, MT
Conservation Districts	Brian Lovett	Cheyenne, WY
Environmental/Conservation Org	Thomas Ball	St. Louis, MO
Environmental/Conservation Org	Paul Lepisto	Pierre, SD
Fish and Wildlife	Jim Becic	Omaha, NE
Fish and Wildlife	Jason Skold	Omaha, NE
Flood Control	Robert Vincze	Andover, KS
Flood Control	Daniel Kuenzel	Washington, MO
Hydropower	Thomas Graves	Wheat Ridge, CO
Irrigation	Buzz Mattelin	Bulbertson, MT
Local Government	William Lay	Fayette, MO
Local Government	Franklyn Pogge	Kansas City, MO
Major Tributaries	Ross Silcock	Lincoln, NE
Major Tributaries	Arthur Gehnert	Glendive, MT
Navigation	Lynn Muench	St. Louis, MO
Navigation	Vicki Richmond	Kansas City, MO
Recreation	Terry Fleck	Bismarck, ND
Recreation	Patricia Hagen	St. Louis, MO
Thermal Power	Brian Barels	Columbus, NE
Water Quality	John Pozzo	St. Louis, MO
Water Quality	Marian Maas	Bellevue, NE
Water Supply	Michael Armstrong	Lenexa, KS
Water Supply	Skip Meisner	Sioux City, IA
Waterway Industries	David Shorr	Jefferson City, MO
Waterway Industries	Kenneth Reeder	St. Joseph, MO

AMERICAN INDIAN TRIBES

Tribe	**Name**	**City, State**
Cheyenne River Sioux Tribe	Robert Walters	Eagle Butte, SD
Chippewa-Cree Indians of the Rocky Boy's Reservation	Jim Morsette	Box Elder, MT
Crow Tribe of Montana	William Big Day	Crow Agency, MT
Eastern Shoshone Tribe of the Wind River Reservation	Baptiste Weed	Fort Washakie, WY
Flandreau Santee Sioux Tribe	Elizabeth Wakeman	Flandreau, SD
Fort Belknap Indian Community	John Allen	Harlem, MT
Fort Peck Assiniboine and Sioux Tribes	Deb Madison	Poplar, MT
Iowa Tribe of Kansas and Nebraska	Alan Kelley	White Cloud, KS
Lower Brule Sioux Tribe	Michael Jandreau	Lower Brule, SD
Northern Arapahoe Tribe		

Oglala Sioux Tribe of the Pine Ridge Reservation	Daniel Two Bulls	Pine Ridge, SD
Ponca Tribe of Nebraska	Phil Wendzillo	Niobrara, NE
Prairie Band of Potawatomi of Kansas	Virgina LeClere	Mayetta, KS
Sac and Fox Nation of Missouri in Kansas and Nebraska	Fredia Perkins	Reserve, KS
Santee Sioux Nation	Roger Trudell	Niobrara, NE
Spirit Lake Sioux Nation	Robert Thompson	Fort Totten, ND
Standing Rock Sioux Tribe	Joseph Smith	
Three Affiliated Tribes of Mandan, Hidatsa and Arikara Nation	Barry Benson	New Town, ND
Winnebago Tribe of Nebraska	Darwin Snyder	Winnebago, NE
Yankton Sioux Tribe	Jody Allen Zephier	Marty, SD

STATE AGENCIES

State	Name	City, State
Iowa	Shawn Shouse	Lewis, IA
Kansas	David Barfield	Topeka, KS
Missouri	Harry Bozoian	Jefferson City, MO
Montana	Tim Bryggman	Helena, MT
Nebraska	Shuhai Zheng	Lincoln, NE
Norht Dakota	Michelle Klose	Bismarck, ND
South Dakota	John Lott	Pierre, SD
Wyoming	Sue Lowry	Cheyenne, WY

FEDERAL AGENCIES

Agency	Name	City, State
Bureau of Indian Affairs	Edward Parisian	Billings, MT
Bureau of Land Management	Theresa Hanley	Billings, MT
Bureau of Reclamation	Rae Olsen	Billings, MT
Environmental Protection Agency	Damon Frizzell	Kansas City, KS
Federal Highway Administration	Brian Yanchik	Summerville, SC
Nationa Weather Service/NOAA	Wendy Pearson	Kansas City, MO
Natural Resources Conservation Service	Verlon Barnes	Omaha, NE
US Army Corps of Engineers	David Ponganis	Portland, OR
US Coast Guard	Byron Black	St. Louis, MO
US Fish and Wildlife Service	Michael Thabault	Lakewood, CO
US Geological Survey	Michael Slifer	Rolla, MO
USDA Forest Service	Mark Goeden	Bismarck, ND
Western Area Power Administration	Robert Harris	Billings, MT

To understand the spatial representation of non-government interests, federal and state interests, and tribal interests in the Missouri River basin, the MRRIC member locations were geo-referenced on a base map of the conterminous United States (Fig. 12). As observed, the lower basin states in the channelized section of the river have the most non-governmental stakeholder representatives. Among the lower basin states, the state of Missouri contains the highest number of members of all basin states suggesting that population density drives membership. The most represented interests among the channelized non-governmental stakeholders are local governments, water supply, water quality, flood control, waterway industries, and navigation. There are two points located outside of the Missouri River basin map that represent the Federal Highway Administration office in Summerville, South Carolina, and the Army Corps of Engineers Northwestern Division headquarters located in Portland, Oregon. The Northwestern Divison of the Corps of Engineers oversees the water resource projects, military construction, and environmental restoration activities in the Missouri River basin. There is also a Missouri River regional office located in Omaha, Nebraska (U.S. Army Corps of Engineers, 2013).

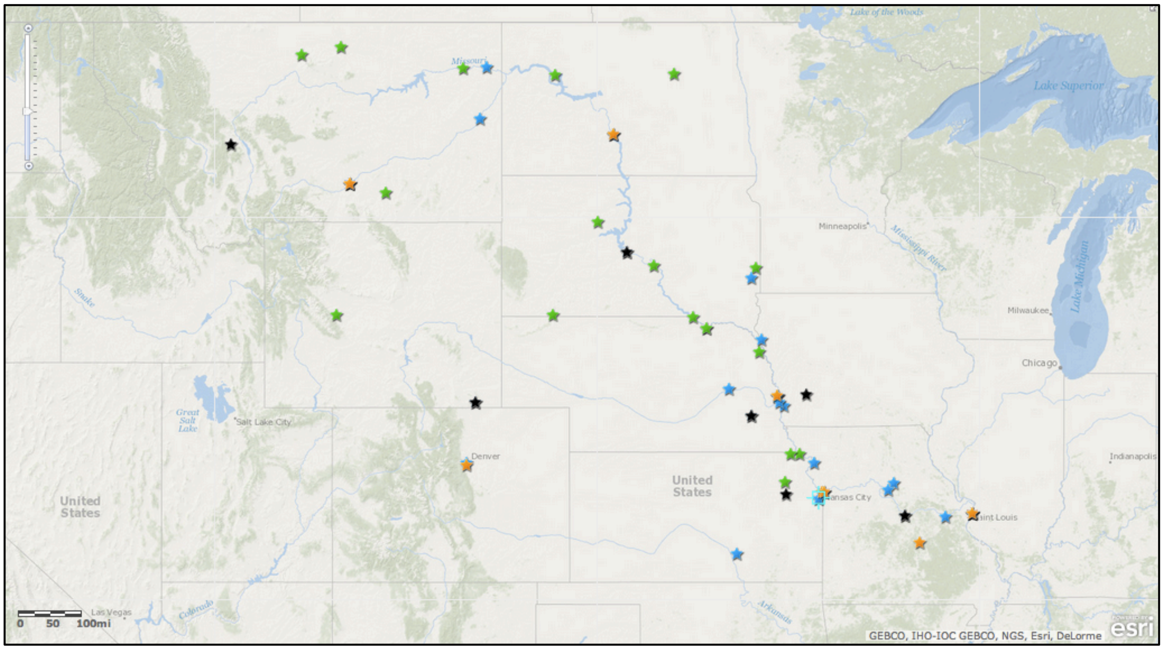


Figure 12. Spatial distribution of the Missouri River Recovery Implementation Committee. (Missouri River Recovery Program, 2013)

The spatial distribution of representation in the basin is imbalanced. The MRRIC Committee distribution is a geographically inequitable representation of stakeholders. Additionally, public meetings held to discuss the U.S. Army Corps of Engineers' annual operating plan for the Missouri River mainstem reservoir system produced high volume participation in five of the eight meetings. Meeting locations are rotated annually and reach both stakeholders and members of the public in the lower and upper basin. Locations for the 2011 public meetings, in response to the severe flooding, were Omaha, Nebraska, St. Joseph, Missouri, Overland Park, Kansas, Jefferson City, Missouri, Glasgow, Montana, Bismarck, North Dakota, Pierre, South Dakota, and Sioux City, Iowa. According to Monique Farmer, Public Affairs Officer for the U.S. Army Corps of Engineers' Omaha District office of the Northwestern Division, "It is typical for three of the eight annual meetings to be held in or near Missouri every year" (personal communication, October 24, 2011). The distribution of annual meetings illustrates another imbalance in basin-wide representation. Interests in Missouri receive a higher number of opportunities to express their concerns.

CHAPTER 3

LEGAL OR POLITICAL FRAMEWORK/HISTORY

3.1 Federal Development of the Basin, 1803-1930

The United States federal government became the owner of more than half of the nation's land through the Treaty of Guadalupe Hidalgo and the Louisiana Purchase of 1803. The entire extent of the Missouri River basin was acquired through the Louisiana Purchase alone. The General Land Office created in 1812 was responsible for the surveying, platting, and sale of these acquired public lands. Visions of prosperity, from agriculture to mining, fueled land development in the 19^{th} century. Two congressional acts, the Homestead Act of 1862 and the Mining Act of 1866, were instrumental in the development of the Missouri River basin. The Homestead Act granted settlers 160 acres in exchange for a nominal fee and a 5-year commitment to cultivate a percentage of the land. The Mining Act of 1866 allowed free exploration and occupation of all public lands.

As the homestead boom hit eastern Montana and the western Dakotas so too did dryfarming. Farmers' Institutes were created to bring together farmers, personnel from the Agricultural Experiment Station and the doctrine of dryfarming. The climate science that guided the early frontier settlers to move farming to semi-arid regions was based on the notion that farming brought more rain to a region. Essentially, humans could adapt their environment to meet their needs. The homesteaders lacked the historical data and the analytical tools to understand climate variations in the region.

Early settlement in the Great Plains during the early 1900s saw an unusually wet period. When these early non-farming settlers brought with them crops for humid climates and attempted cultivation on tracts of land that would prove to be too small, dryfarming, or scientific soil culture, experts stepped in to promote farming in the region as a means of changing the climate through cultivation and that a dry period could be endured due to moisture that was saved in the soil from earlier wet periods. (Libecap, et al., 2002) Dryfarming was promoted by agricultural experiment stations, state and local governments, Dry Farming Congress, and to some degree by the United States Department of Agriculture (Libecap, et al., 2002). The region's railroads contributed funding to these experimental methods of farming as well as trains to go from town to town to demonstrate the technique. The promotion of dryfarming coupled with the promise of gold in California began to give even the most doubtful of men and women solace from the trials and tribulations of moving west.

However, not everyone was convinced that the nation's natural resources should be used for commerce. Land development and the subsequent demand on water resources beginning in the mid-1800s led a contingent of scientists, explorers, and scholars to express caution in the use of the nation's natural resources (Worster, 2001). John Wesley Powell, as head of the newly formed United States Geological Survey (USGS), declared to the 1872 Senate Select Committee on Irrigation and Reclamation of Arid Lands:

> …you must accept the facts of nature and adapt. Above all, you must realize that whoever controls water in an arid country controls society. Fix it in your Constitution that no corporation – no body of men – no capital can get possession and right to your waters. Hold the waters in the hands of the people. (Stegner, 1992, p. 230)

Powell's words were not enough to halt the belief that American settlers were destined to spread across the continent.

As land in the Missouri River basin was developed, water demand increased. The Homestead Act became a tool for manipulation by those looking to gain control of water resources. The jurisdiction over water resources became a point of controversy between state and federal powers as well. But in 1824, the Supreme Court landmark decision in the case of Gibbons v. Ogden (22 U.S. 1) firmly cemented federal power over water resources. The decision held that the power to regulate interstate commerce, including the channels of interstate commerce, was granted to Congress by Article 1, Section 8 of the Commerce Clause (Ferguson, 1987). The ruling further defined 'commerce' as more than mere trade of commodities but also navigation. Congress appropriated funds through the General Survey Act of 1824 and the River and Harbors Act of 1824, authorizing the Corps of Engineers to transform natural flowing rivers into navigable channels for commerce (Schneiders, 1999). In 1832, the River and Harbors Act would be amended to include funds for the alteration specifically of the Missouri River. The Swamp and Overflowed Land Act of 1850 provided a means for putting millions of acres of land into agricultural use, ultimately exacerbating the flood problem. To some, 1879 marked the turning point in the long battle to garner federal support for flood control. From that time forward, Congress gradually increased federal government responsibility to develop flood control throughout the nation. Between 1879 and 1917, federal money funded some flood control work recommended by the Mississippi River Commission. But throughout this period, Congress insisted that the Commission focus on navigation with its incidental benefits of bank stabilization, surveys, and gaging assisting in flood control.

Initially, these alterations of the lower Missouri River included removal of snags, rocks, bars, and any other obstructions in the river to steamboat traffic. The River and Harbors Acts would grow more robust in their level of river modification but it was the River and Harbors Act of 1882 that set the foundation for the systematic change to the Missouri River. In the Act, Congress appropriated funds to protect concave bends from erosion, stabilization and uniformity of channel by dikes, and the removal of snags. Additionally, low water widths and depths were specified for various stretches of the river from Kansas City, Missouri to the mouth of the Mississippi. The Act also created the Missouri River Commission. The Commission, a five member organization, was charged with continuing the long range plan of improvement along the river by surveying the area, creating detailed maps, and maintaining a river channel and depth that would support commerce (Penry, 2013). The Missouri River Commission was abolished after the passage of the River and Harbors Act of 1902 that placed control of the river into one Corps of Engineers district office (U.S. Army Corps of Engineers, 1915). Bank stabilization and navigation projects continued along the lower stretch of the Missouri River under the River and Harbors Acts of 1912, 1917, 1925, 1930, 1935, and 1945 (U.S. Geological Survey, 1998). The River and Harbors Act of 1945 authorized funds for construction of the 735-mile navigation channel from Sioux City, Iowa, to the Missouri River's confluence with the Mississippi in St. Louis, Missouri (U.S. Geological Survey, 1998).

3.2 Federal Regulation of Flow, 1930 – Present

Until the 1930s, the upper and lower Missouri River were largely managed and developed independently of each other. The River and Harbors Acts were administered along state and congressional district lines without much consideration given to the river as a system. Under Herbert Hoover's presidency from 1929 to 1933, there would be a paradigm shift in river management plans. Rivers would be considered systems. The river system would be used to increase economic development, most notably by becoming channels for transportation.

The upper stretch of the Missouri would be most impacted beginning in the early 1930s. After a drought in the basin, the Corps of Engineers developed and submitted a plan to build a dam near Fort Peck, Montana, to supplement flows in the river below Sioux City, Iowa, to maintain barge traffic. In response to the Great Economic Depression, Congress passed the National Industrial Recovery Act in 1933, authorizing the President of the United State to stimulate economic recovery. The Act established the Public Works Administration (PWA), which was a public works construction agency placed under the direction of the Secretary of the Interior and charged with building "certain useful public works" including electricity generating dams, major warships, schools, and hospitals. The work was done in an effort to provide employment, stimulate the economy, and improve morale among Americans (National Industrial Recovery Act, 1933). One of the first PWA projects to be authorized under President Franklin D. Roosevelt was the construction of the Corps of Engineers' proposed dam along the Missouri River. The Fort Peck Dam and Lake were constructed to generate hydroelectric power, control flooding, promote irrigation, and navigation (National Research Council, 2011).

The Bureau of Reclamation activities in the Missouri River basin were much different in scope. The drought of the 1930s and unsustainable agricultural practices that created the Dust Bowl focused the Bureau of Reclamation's attention on more storage, irrigation, and hydropower opportunities in the basin (Pisani, 2002). Their plans promoted the conservation ideology of the time and presupposed that their efforts would increase population in the West (Mitchell, 1905). In 1943, three severe floods occurred flooding 1,570,000 acres of farmland, inundating downtown Omaha, Nebraska, its airport, which was vital to the war effort, and causing an estimated 100 million dollars in damage (Nebraska Department of Natural Resources, 2012).

The Flood Control Act of 1944 brought together the Bureau of Reclamation's plan for development of the Missouri River Basin's water resources, authored by William Glenn Sloan who headed the Billings, Montana Bureau of Reclamation office, as well as the Army Corps of Engineers' plan, authored by Lewis A. Pick then the director of the Missouri River office of the Corps of Engineers, and authorized appropriations to each of the agencies for construction of the initial stages. The Act states:

> …it is hereby declared to be the policy of the Congress to recognize the interests and rights of the States in determining the development of the watersheds within their borders and likewise their interests and rights in water utilization and control, as herein authorized to preserve and protect to the fullest possible extent established and potential uses, for all purposes, of the waters of the Nation's rivers; to facilitate the consideration of projects on a basis of comprehensive and coordinated development; and to limit the authorization and construction of navigation works to those in which a substantial benefit to navigation will be

realized therefrom and which can be operated consistently with appropriate and economic use of the waters of such rivers by other users (United States 78th Congress, 1944).

Implementation of the Act for the Missouri River Basin became the sole responsibility of the Corps of Engineers (United States 78th Congress, 1944).

3.3 The Paradox of Water Allocation

Legal scholars refer to the Missouri River basin as a paradox (Davidson, 2011; Tarlock, 1997). Conflict over water is understood to be conflict over scarcity of the resource (Wolf, 1998). In the case of the Missouri River basin there is an ample amount of water yet there is no shortage of conflict. The 100th meridian stands as the divide in the prevailing state water laws. States east of the 100th meridian base their modern day statutory system governing water on the riparian doctrine. Under that doctrine, each landowner may make reasonable use of the water on the riparian land if the use does not interfere with reasonable uses of other riparian landowners (Getches, 2009). In contrast, states west of the 100th meridian adhere to the prior appropriation doctrine, which considers water to be a public resource owned by no one. Water rights are based on the time a person applies a specific quantity of water to a beneficial use (Getches, 2009). In addition to the two opposing water doctrines there are states that base their statutory system on a combination of riparian law and prior appropriation doctrine. The Missouri River basin contains three riparian states, Missouri, Iowa, and Minnesota; three prior appropriation states, Montana, Wyoming, and Colorado; and four states which use a hybrid system, North Dakota, South Dakota, Nebraska and Kansas.

States have the power to administer water rights within their own political boundaries. In the case of interstate waters, there are three recognized approaches to water allocation; the judicial approach, the congressional approach, and interstate compacts. The judicial approach requires that a suit for equitable apportionment be brought by the states in the U.S. Supreme Court. The congressional approach requires an act of Congress to allocate water. Interstate compacts, however, are state negotiated agreements that determine a specific allocation of water for each state and are ultimately approved by Congress. Interstate compacts are the traditional approach used in western states' water allocations. Often times, these compacts create a new governmental agency, which is responsible for administering the shared resource. Examples of such functioning agencies include the Interstate Commission on the Potomac River Basin in existence since 1940, the Great Lakes Commission established in 1955, and the Delaware River Basin Commission created in 1961.

Basin commissions continue to exist as the coordinator between Federal agencies and the basin states. But in the case of the Missouri River basin, the states and federal government have been ineffective in their efforts to develop a basin-wide governance structure. Beginning in 1972, multiple commissions have been established and then dissolved due to their lack of focus and inability to review and coordinate large projects for consistency with other basin resource management objectives (Committee on Missouri River Ecosystem Science, 2002). The Basin has seen the beginning and dissolution of the Missouri River Basin Commission, the Missouri Basin States Association, the Missouri River Basin Association, the Missouri River Natural Resources Committee and most recently, the Missouri River Association of States and Tribes which currently does not include the state of Missouri among its members (Missouri River Association of States and Tribes, 2011).

The Missouri River basin states are unable to form an interstate compact due to an exhibited inability to cooperate over river issues due to starkly contrasting geographic regions and fundamentally differing views on water management (Tarlock, 1997). It is left to judicial decision-making paired with congressional authorization to determine authority, responsibility, and allocation within the basin. Between the 1990s and early 2000s, an unprecedented 18 judicial decisions occurred regarding allocation. In 2005, the federal Court of Appeals for the 8th Circuit placed administrative control squarely with the Corps of Engineers, solidifying the Corps as "water master" of the Missouri River (National Research Council, 2011). Today, the Missouri River is generally characterized as a regulated river, rather than a fully allocated one despite the division between riparian and prior appropriation doctrine. It is held as the most unnatural of rivers within the U.S. due to the dredging, filling, dam construction, and total disregard for the basin's ecological system (American Rivers, 2011).

3.4 Water & Environmental Quality

The Rivers and Harbors Act of 1899, is often referenced as the first environmental legislation of rivers. Section 10 of the Act made it illegal to create an obstruction in the waterway, excavate, or fill the channel in a way that would hinder the navigation route (U.S. Environmental Protection Agency, 2012). A superficial reading of the Act may lead one to think that the legislation was an effort to keep rivers clean. Given the federal efforts to create clear navigation routes through previous Rivers and Harbors Acts, this was only a continuation to advance commerce and not a consideration of environmental degradation of a waterway (Uhlmann, 2009). The degradation of American water quality was eventually explicitly addressed with the enactment of the Federal Water Pollution Control Act of 1948, which gave attention to pollution from solid and liquid wastes. Amendments to the Act in 1956, gave federal authority over water quality in interstate streams. The Act was again amended in 1965 and became known as the Water Quality Act, which created the first water standards and mandated a water quality assessment program of the nation's waters (U.S. Environmental Protection Agency, 2010).

The late 1960s and early 1970s saw a rise in public awareness of environmental issues and subsequent policy action. In 1969, when the Cuyahoga River caught fire in Cleveland, Ohio, due to oil pollution, serious consideration was given to the quality of national waterways. According to a report from the Federal Water Pollution Control Administration in 1969, "The lower Cuyahoga has no visible signs of life, not even low forms such as leeches and sludge worms that usually thrive on wastes". ("America's Sewage System," 1969). The Cuyahoga River incident ultimately led to the reorganization and expansion of the Federal Water Pollution Control Act in 1972, commonly known as the Clean Water Act. The Clean Water Act (33 U.S.C. §1251 et seq.) establishes, "the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters". The U.S. Environmental Protection Agency (EPA) is charged by the U.S. Congress to administer much of the Act. However, the EPA shares responsibility with the Corps of Engineers for administering and enforcing Section 404, which establishes a program to regulate the discharge of dredged and fill into waters of the United States. The Corps of Engineers administers the day-to-day program, including individual permit decisions and jurisdictional determinations, develops policy, and enforces provisions of Section 404. The EPA develops and interprets criteria used in evaluating permit applications, identifies activities that are exempt from permitting, reviews and comments on permit applications, enforces Section 404 provisions, and has authority to veto the Corps of Engineers' permit decisions (U.S. Environmental Protection Agency, 2010).

In addition to the Clean Water Act, the EPA also administers the National Environmental Policy Act (42 U.S.C. §4321 et seq.). Written in 1969, the National Environmental Policy Act, or NEPA, establishes a national framework for protecting the environment. NEPA requires federal agencies to, "integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions" (U.S. Environmental Protection Agency, 2010). To meet NEPA requirements federal agencies prepare a detailed statement known as an Environmental Impact Statement (EIS), which are, "assessments of the likelihood of impacts from alternative courses of actions" (U.S. Environmental Protection Agency, 2010). A critical consideration made in the NEPA is the recognition of natural resources of floodplains and the insistence that they be incorporated into the federal decision-making process.

The federal environmental legislation movement continued into the 1970s. In 1973, Congress passed the Endangered Species Act (ESA). The ESA protects animal and plant species from extinction by preserving the ecosystems in which they exist and providing conservation programs to help continue their populations. The U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service administer the ESA. The Fish and Wildlife Service is responsible for terrestrial and fresh water species. The National Marine Fisheries Service is responsible for marine and anadromous species. The ESA has become a critical piece of the Missouri River basin narrative but not without controversy. When a species is proposed for listing as endangered or threatened under the ESA, the Fish and Wildlife Service is responsible for finding areas that meet the definition of "critical habitat" for the species. An area designated as a critical habitat contains features essential for the conservation of said species. Under Section 7 of the ESA, federal agencies are required to consult with the Fish and Wildlife Service on projects they carry out, fund, or authorize to ensure their actions will not adversely affect or destroy critical habitat (Fish and Wildlife Service, 2013).

In the Missouri River basin, the least tern, piping plover, and pallid sturgeon are listed as endangered. During the review of the Corps of Engineers' *Master Manual*, the Fish and Wildlife Service issued a Biological Opinion in 2003, that found that the operation of Missouri River mainstem system jeopardizes the existence of the pallid sturgeon leading to extinction of the species (Missouri River Association of States and Tribes, 2011). The Fish and Wildlife Service identified the recovery area as the entire stretch of the mainstem. Additionally, the Fish and Wildlife Service implemented the Bank Stabilization and Navigation Program Fish and Wildlife Mitigation program, which includes Nebraska, Iowa, Kansas, and Missouri, in the restoration of habitat for fish and wildlife for species lost due to the bank stabilization and navigation projects along the 735-mile mainstem channel.

3.5 Current Legal Issues

In addition to the current ecological degradation issues in the basin, water managers examine how to handle increasing demands on water resources from population growth. The Missouri River basin's reservoir system creates a perceived water surplus (Fig. 13) that has water stressed areas looking to trans-basin and inter-basin diversions as the answer. The 1944 Flood Control Act defines "surplus water" as water stored in a Corps of Engineers' reservoir that is not required because the "authorized" need for the water never developed. Figure 13 is the most recent profile of the Missouri River reservoir system describing the level to be permanently maintained in a reservoir, the perceived surplus, and levels constituting flood storage (LaRandeau, 2013).

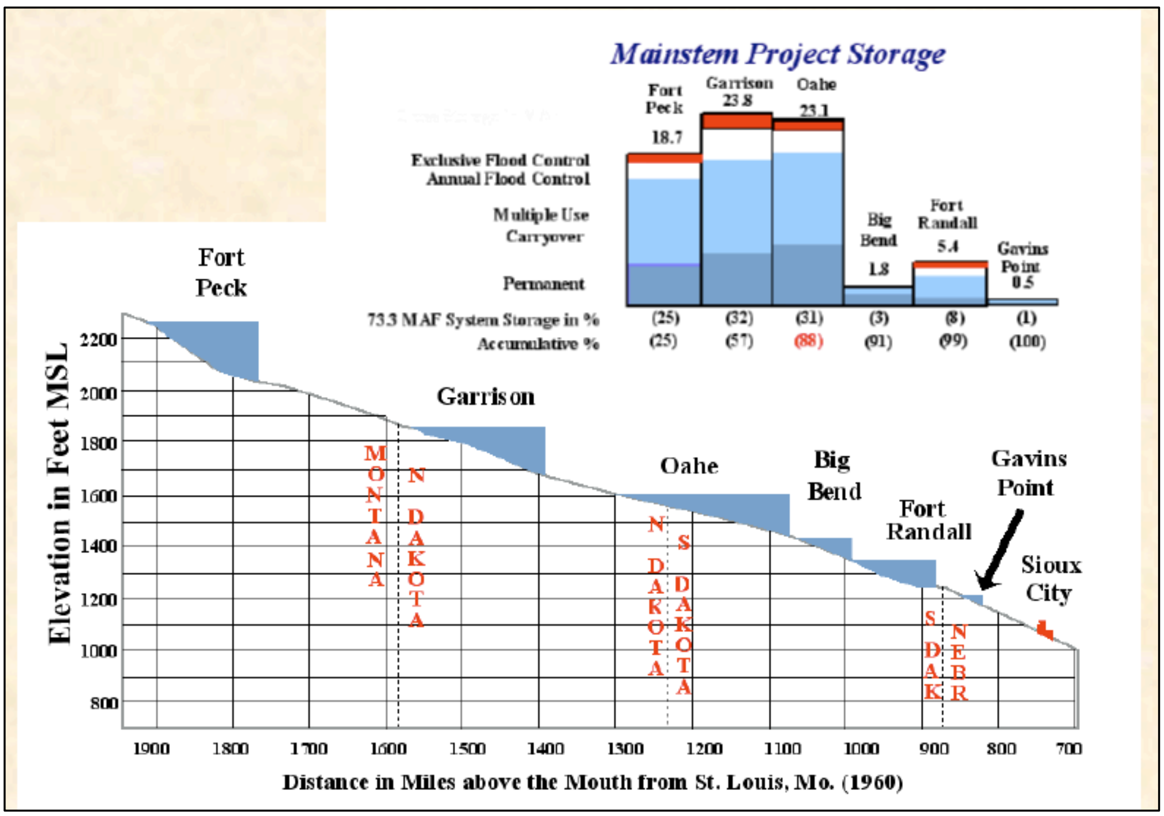


Figure 13. A profile of the Missouri River mainstem reservoir system. (LaRandeau, 2013)

Since 2002, the Bureau of Reclamation and the Corps of Engineers have been in the midst of a legal battle with the state of Missouri and the Province of Manitoba, Canada, to bring water from the Missouri River basin to the growing population of Minot, North Dakota, and surrounding rural populations. The project, now known as the Northwest Area Water Supply Project, would convey 15,000 acre-feet of water per year from Lake Sakakawea, in the Missouri River Basin, via a buried 45-mile long pipeline to Minot and 10 surrounding counties in northwestern North Dakota in the Hudson Bay basin (U. S. Bureau of Reclamation, 2010).

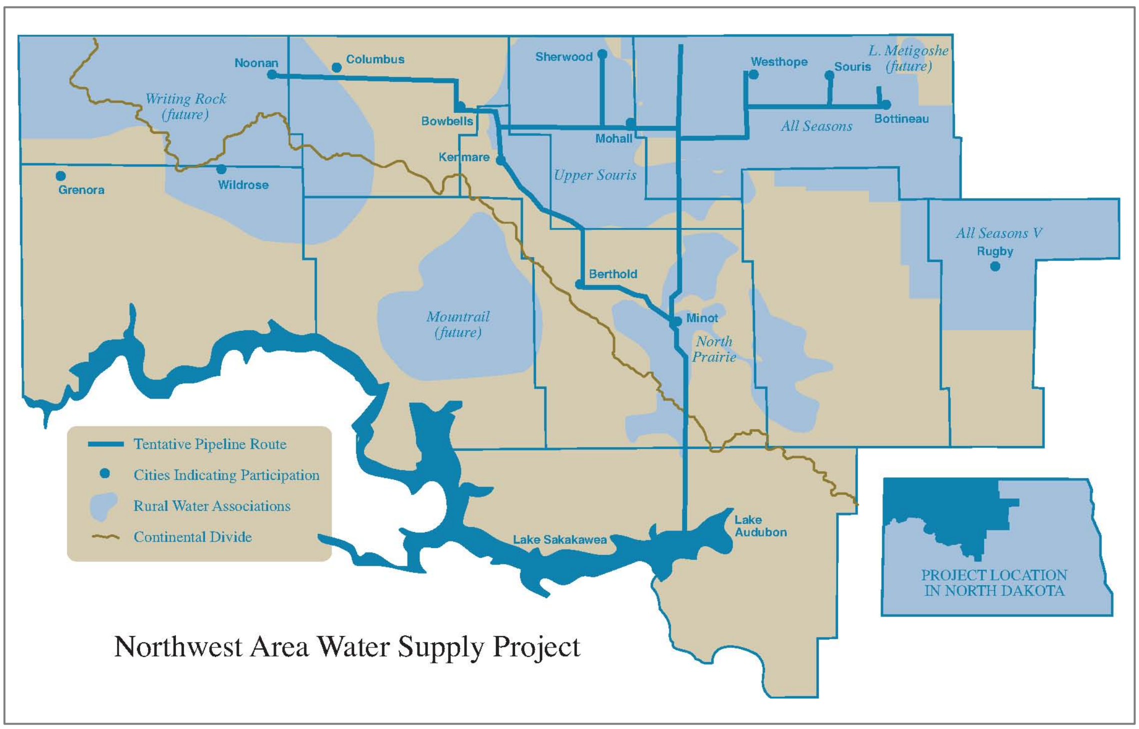


Figure 14. The NAWS Project pipeline with areas proposed to use diverted water. (North Dakota State Water Commission, 2010)

The project began 30-years ago as the Garrison Diversion. Since its beginnings, this proposed diversion has stirred controversy at the local, state, national and international levels. Controversy exists between the federal governments of Canada and the United States, and the governments of the Province of Manitoba and the state of North Dakota. Within the boundaries of the United States, conflicts over the diversion exist between irrigation uses, endangered species protections, conservation, development and the rights of Native American tribes (Zellmer, 2004).

Actual construction on the project did not commence until 2002 (Federal Register, 2010). As of this writing, most of the infrastructure is in place including a two million gallon storage reservoir, a high-volume pumping station, and most segments of the distribution system but it is a federal judge's ruling that is keeping the project from going online. The Bureau of Reclamation is responsible for complying with the National Environmental Policy Act (NEPA) and other applicable federal laws (Bureau of Reclamation Sites). As part of that compliance, they are required to submit an Environmental Impact Statement (EIS). The EIS the Bureau of Reclamation prepared was for the Hudson Bay basin, however no EIS was submitted for the Missouri River basin. The Province of Manitoba and the state of Missouri separately brought suit against the Bureau of Reclamation and the Corps of Engineers. The Province of Manitoba objected to the Bureau's conclusion that impacts from the trans-basin diversion would be insignificant or could be easily mitigated and maintained (Province of Manitoba, 2005).

Likewise, the state of Missouri's complaint asks for, "preliminary and permanent injunctive and declaratory relief" against the United States Department of Interior, the Bureau of Reclamation, and the United States Army Corps of Engineers for violations of the National Environmental Policy Act. Missouri also argues that the planned diversion would cause economic harm to the state, diminish the flow, which the state relies upon for navigation, and cause imminent harm to Missouri citizens.

It is now a judicial ruling that has placed the project on hold. In March of 2010, the court issued an order in favor of the Province of Manitoba and the state of Missouri and imposed an injunction on the Bureau of Reclamation. The court found the EIS inadequately examined: "(1) Cumulative impacts of water withdrawals on Lake Sakakawea and the Missouri River, and (2) consequences of transferring potentially invasive species into the Hudson Bay Basin" (Federal Register, 2010, p. 48987). The Bureau of Reclamation is beginning work on a Supplemental Environmental Impact Statement and has provided opportunities for stakeholders to submit comments. A sample of comments follows from the U.S. EPA:

> To assess cumulative impacts, the EIS should characterize the pre- and post-project condition, including reasonably foreseeable future actions (RFFAs), and identify a baseline. EPA recommends the EIS analyze effects on the demand for water, in-Iake/in-stream water quantity, water quality, wetlands, the aquatic community, groundwater, and recreational usage with quantitative measures when possible and qualitative ones when not. With regard to climate change analysis, EPA recommends the EIS I) qualitatively discuss the link among greenhouse gases (GHGs), climate change, and impacts on water resources, 2) include a summary discussion of ongoing and projected regional climate change impacts relevant to the action area based on U.S. Global Change Research Program assessments and 3) identify any potential need to adapt the proposed action to

> these effects as well as any potential impacts from the proposed action that may be exacerbated by climate change. The EIS should also discuss GHG emissions that may be generated by the proposed action. (U.S. Environmental Protection Agency, 2010, p. 107)

Additionally, the Missouri Department of Natural Resources submitted comments that reiterated the comments of the EPA and added that there was no comprehensive depletion analysis for the Missouri River basin.

In October 2012, the province of Manitoba and the state of Missouri filed a joint status report claiming that newly proposed construction for the project could impact the environmental impact study violating the NEPA (Harris, 2013). As a result of the newly filed report, the federal judge in the case ruled that the injunction remain in place. As of this writing, no further action has been taken and the decision as to whether the proposed diversion will be allowed remains open (Harris, 2013).

The NAWS project as outlined serves to illustrate the legal complexity of a project in the basin. There are two other proposed projects, which could follow the legal complexity of the NAWS project. The first is the Missouri River Reuse Project proposed by the Bureau of Reclamation to divert 600,000 acre feet of water from the Missouri River for reuse in western Kansas and along the Front Range of Colorado. The diverted water would be used to fill surface reservoirs and recharge the Ogallala aquifer, an aquifer whose waters are being depleted for irrigation and a diversion to Texas discussed in Chapter 4. The water diverted to the Front Range would be used for municipal, commercial, and industrial use with return flows allocated for agricultural irrigation (U.S. Bureau of Reclamation, 2013)

The other contentious issue in the basin resulting from the Corps of Engineers' rulemaking process beginning in 2012, is the project known as the Missouri River Water Storage Allocation Study. It intends to manage and sell what the Corps of Engineers deem a surplus from the reservoirs in the Missouri River basin (U.S. Corps of Engineers, 2013). States in the basin argue that the Corps of Engineers does not own the water and that they do not have the authority to charge for water flowing within their boundaries. North Dakota, particularly, is strongly in opposition of the Corps of Engineers' proposed actions. The state would like the water resource to be available for the fracking industry's water demand (Zellmer, 2013).

At the core of each of the projects described herein is the demand placed on water by population and economic growth. The reliance upon and proposal of engineered solutions in each of these projects is predictable given the historical emphasis on creating population density in the West and the United States' continuing efforts to dominate natural resources for economic gain. It appears that the growing public discourse on environmental issues, federal legislation protecting environmental quality, and stated shifts in water management away from engineered solutions to more systematic, adaptive solutions among federal managers is not an effective strategy for creating solutions beyond mobilizing water for wealth generation. This disconnect necessitates an examination of the economic drivers to fully interpret the political economy of the Missouri River basin.

CHAPTER 4

ECONOMIC REVIEW OF THE MISSOURI RIVER BASIN

4.1 Value of Natural Resources

For most of the nation's history expanding demand for water could be satisfied by developing new supplies. From dams to pipelines to deeply drilled wells, Americans used hard path, engineered solutions to meet their demands for water. The most notable of these hard path solutions is the Hoover Dam. A civil engineering spectacle, the Hoover Dam has made life in what was once known as 'The Great American Desert' possible creating green spaces where arid lands once stood (Gleick, 2002). Lesser known yet innovative for its re-appropriation of the technologies and business models developed by oil baron, T. Boone Pickens, are the wells and pipelines reaching into the depths of the Texas Panhandle region of the Ogallala Aquifer to pump water from the aquifer to the growing population of Houston, Texas (Mesa Water Sites, 2010). Beyond the initial dollars of constructing these hard path solutions, the environmental and societal cost is enormous. The Hoover Dam combined with over-allocation and climate change has so changed the flow of the Colorado River that it no longer reaches the Gulf of Mexico as it once did (United States Geological Survey, 2010). As for the Ogallala Aquifer, it is being depleted at a faster rate than it can recharge itself causing the water table to lower to depths that have become unreachable (U.S. Geological Survey, 2010).

Water is a renewable but limited resource. The hydrological cycle demonstrates a closed loop system where water moves through the water cycle from evaporation and evapo-transpiration to condensation to precipitation. For a better understanding of the hydrologic processes in terms of managing water resources, the hydrologic cycle needs to be viewed at a wide range of scales and as having a great deal of variability in time and space. Precipitation falls nearly everywhere, but its distribution and abundance is highly variable. Similarly, evaporation and transpiration return water to the atmosphere nearly everywhere, but evaporation and transpiration rates vary considerably according to climatic conditions and regional topography (U.S. Geological Survey, 2011). The hydrological cycle holds no value in neoclassical economic theory in part because society pays very little for the water it uses.

Neoliberal economic theory fails to accurately label the cost and benefits associated with the environment and natural resources. The measure of economic growth is a flawed indicator that does not account for the use and depletion of natural resources and in many cases it even rewards. According to a report published by the non-partisan Commission on Geosciences (1994),

> …the costs of reducing the adverse effects of natural resource depletion and environmental degradation [are] ordinary investment and consumption expenditures. Damages caused by pollution affect estimates of national income only to the extent that they influence productivity and even those effects are not separately identified in the accounts. Waste disposal services provided by air, land, and water in absorbing pollution are assigned a zero value because no one charges for them. The benefits of maintaining natural resources and a clean environment, such as preservation of biodiversity and enhanced recreation opportunities, are ignored for the same reason." (p. 205)

Without an adequate accounting system for natural resources, there is no alert for the public or decision-makers of the problems with the management of national resource assets. Even mainstream economists believe that society has failed to adequately account for quality of life as well as environmental impact and depletion of resources (Stiglitz, 2010).

National income accounting systems employed by governments to measure macroeconomic performance are both economically and politically impactful. The quarterly gross domestic product (GDP) thrusts policymakers into action, news analysts into economic experts, and public political debate ensues. Neoliberal economics holds GDP as the definitive source for measuring the success and failure of a country. By definition, GDP places value exclusively on market activities (Bureau of Economic Analysis, 2009). One of the underlying faults of GDP to adequately gauge the health of an economy is its inability to record changes in environmental quality or the quantity of natural resource reserves.

There have been attempts to account for natural resources. When President Reagan issued Executive Order 12291 (1981) requiring federal agencies to conduct a Regulatory Impact Analysis (RIA) of proposed major regulation, environmental economics was born (Birol et al., 2010). The approach employs cost-benefit analysis to derive a monetary value for a specific resource. The flaw is that it does not necessarily value the quality of the resource (Birol et al., 2010). Similarly, scholars began to view resources in terms of economic security and international security (Gleick, 2003). This ultimately led to a call for a new, multi-disciplinary approach to ecosysterm service valuation. Out of this emerged ecological economics which is a transdisciplinary field of academic research that aims to address the interdependence and coevolution of human economies and natural ecosystems over time and space." (Xepapadeas, 2008)

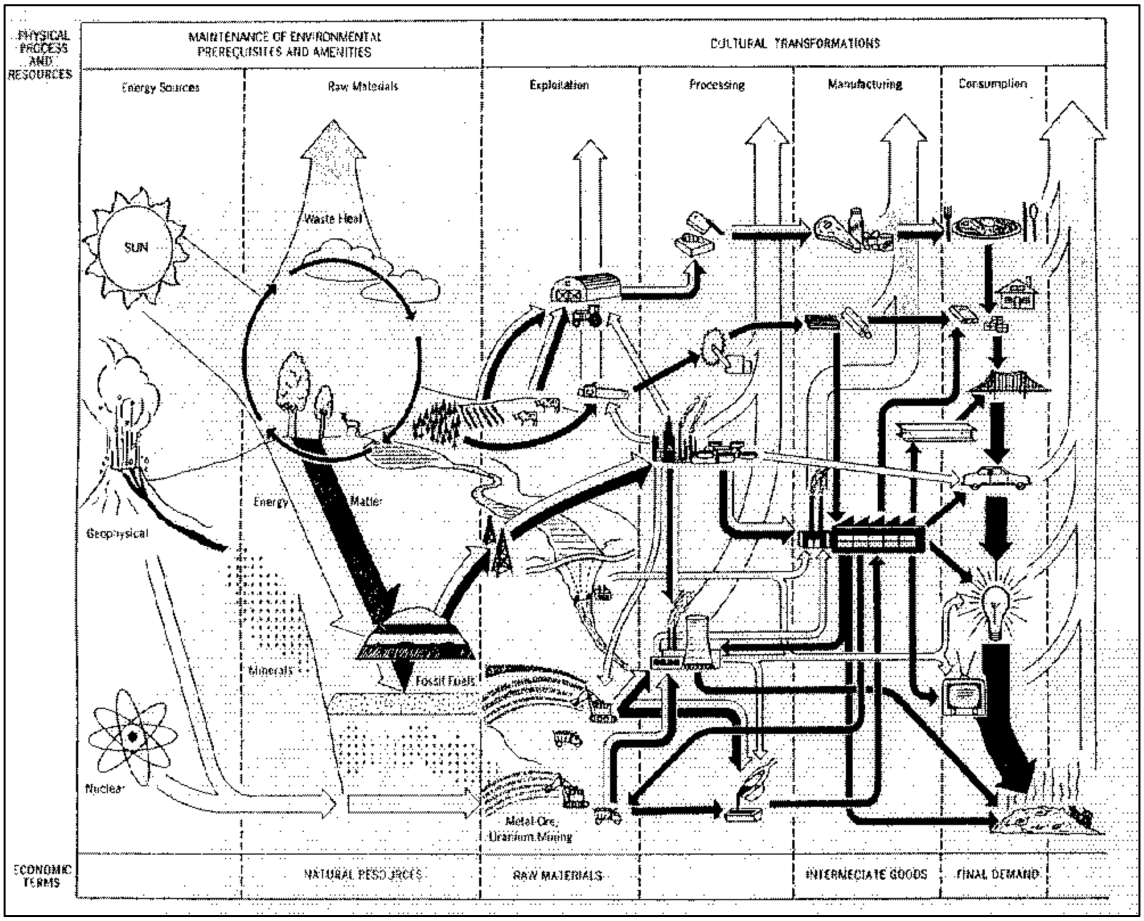


Figure 15. A Biophysical perspective on water. (Hall & Klitgaard, 2006)

If the hydrological cycle is viewed through a biophysical perspective (Fig. 15), the proper functioning of the cycle is critical to the wealth generation within the economy. The conceptual challenges of valuing ecosystem services involve explicit description and adequate assessment of the link between the structure and function of natural systems and the goods or services derived by humanity. The isolation of the Missouri River from its floodplain caused by river regulation structures has in many stretches largely eliminated the flood pulse and its ecological functions and services. As a result of these changes, the production and the diversity of the ecosystem have both markedly declined.

4.2 Economic Drivers

As discussed in Chapter 3, legislation significantly impacted the ecological health of the Missouri River. To understand the impetus for the legislation it is important to deconstruct the economic forces within and outside of the basin that influenced legislation. The Jeffersonian ideas guiding development in the west were predicated from two notions, that the land would be cultivated for agriculture and the water developed for navigation (Jefferson, 1803). Steamboat navigation would be the first technology to enter into the Missouri. In 1818, the Secretary of War authorized the Yellowstone Expedition to travel along the Missouri to the mouth of the Yellowstone and set up an outpost as protection of the northwestern region of fur trade. The steamboats entered into the Missouri River near St. Louis, Missouri, in 1819. Three steamboats began the voyage but none would make it to their destination. The steamboats traveled to Jefferson City, Missouri where one of the boats, ironically named the Thomas Jefferson, succumbed to the waters of the Missouri. The two others would make it to the confluence with the Kaw River in Kansas City, Missouri, and have to postpone their voyage until the following autumn. The Western Engineer left in the late summer of 1919 and made it only as far as William Clark's Missouri Fur Company trading post near Council Bluffs, Iowa.

The first steamboat to successfully navigate along the Missouri River from St. Louis, Missouri, to Bismarck, North Dakota, was named the Yellowstone. The American Fur Company sought to dominate the fur trade business and to do that meant traveling west. John Jacob Astor, head of the American Fur Company, dispatched the Yellowstone in 1832 to Fort Union, Montana, near the mouth of the Yellowstone River. The use of the steamboat allowed the American Fur Company to surpass its competition and create a monopoly in the western fur trade (Oviatt, 1949).

The congressionally appropriated funds for the river and harbors projects largely came from the sale of public lands through the Homestead Act. From 1829-1837, President Andrew Jackson approved 5 million dollars in river and harbors improvements for those waterways that met two criteria, that they were interstate rivers and vital to national interest. Interpretation of national interest at this time largely meant the push for economic growth. Jackson vetoed measures that were "for the improvement of streams that are not navigable, that are not channels of commerce" (Paskoff, 2007, p. 58). Revenues from public land sales would fund removal of river obstructions, which would in turn open up a previously non-navigable stretch of the river and more land to sell. The relationship between land sales and river improvements was one of mutual benefit. There was a direct correlation between land sales and the formation of towns in four states along western rivers at that time, Ohio, Indiana, Missouri, and Mississippi (Paskoff, 2007). As population grew so too did the political influence of the area. Congress designated appropriations for river and harbors for specific states in proportion to each state's population. Railroad companies bought public land in the West from the federal government. With the railroad companies becoming a large owner in western lands, the federal government's land sales dwindled. This loss in profits meant a reduction in capital for the federal government and a decrease in spending towards the improvement of river and harbors.

The domination of the western fur trade by only one company limited the amount of steamboat traffic traveling along the Missouri River. Much of the traffic along the river was by the government to determine the military feasibility of the route. But with the discovery of gold in the West came a surge in steamboat traffic to the Dakotas by the mid-1860s (Fig. 16). This time, the freight being carried were supplies for mining camps. Trade by the river was reported to be between $7,500,00 and $8,000,000 annually. Steamboat navigation along the Missouri River would soon see a decline due in part to the railroad industry. The opening of the Sioux City and Pacific Railroad line in 1868 made inland freight travel a less costly, faster, and less dangerous trip (Oviatt, 1949).

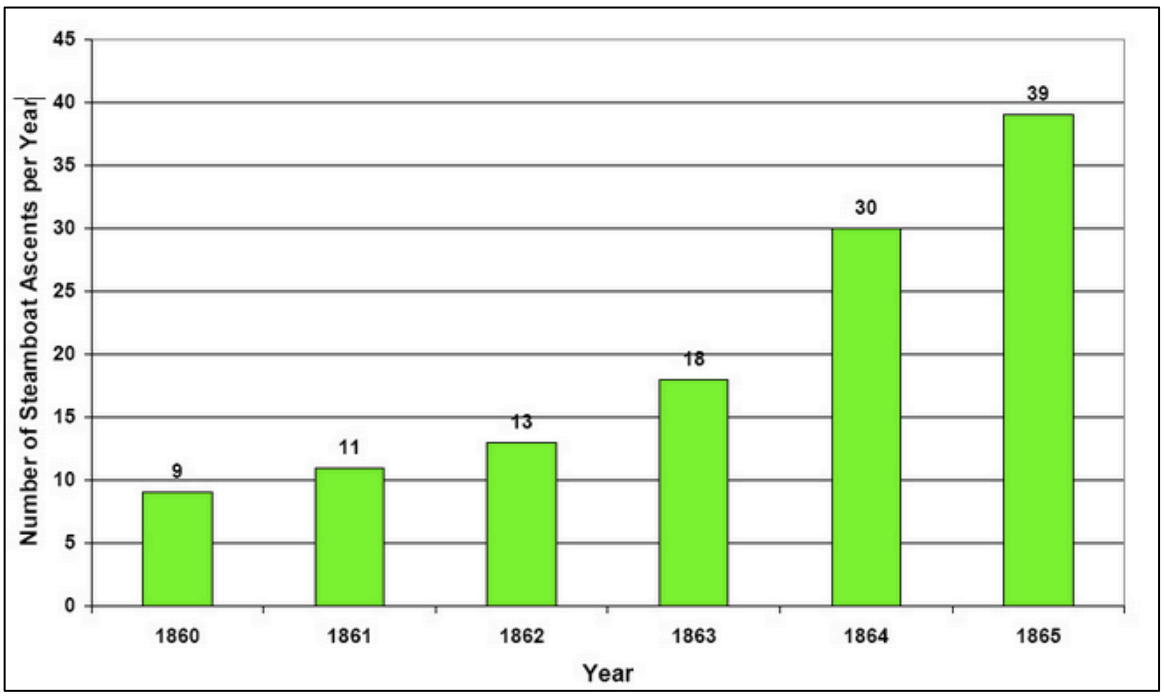


Figure 16. Increase in Steamboat Traffic Along the Missouri River, 1860-1865. (Western Cover Society, 2013)

Attention shifted from navigation to land use as an economic driving force in the late 1800s. The 1877 Desert Land Act passed to encourage and promote economic development of arid land in the West (Landstrom, 1954). Some members of the administration saw the Act as an attempt to gain control of water (Ganoe, 1937). The tracts of land being sold were narrow and bordering the river. Livestock interests were primarily investing in the land but by the late 1880s the cattle industry was in decline due to overstock and severe winter weather and the cattle industry began to receive press attention for their manipulation of the Desert Land Act (Ganoe, 1937).

Proponents of irrigation championed the idea of repealing the Desert Land Act. The National Irrigation Association, the lobbying arm of the irrigation industry, primarily funded by the railroad industry, fought for the repeal. The railroad industry believed that cultivation of the arid lands by way of irrigation would increase population. The growing population's energy needs could be met by harnessing the power of the river into hydroelectric power. The National Irrigation Association supported the Reclamation Act of 1902, a federal law enacted to appropriate funds from the sale of public lands in the West towards irrigation projects. The Act encouraged more people to settle in the West by harnessing the limited precipitation in the area and converting arid lands into productive agricultural land (Taylor, 1958).

The Bureau of Reclamation administered the Reclamation Act of 1902. The promise of irrigated lands and the promotion of dryfarming techniques as discussed in Chapter 3, gave farmers in the West new hope for agriculture (Strom, 2011). The Bureau of Reclamation began irrigation projects by placing pumping barges in the river and extending pipelines out and to the land (Fig. 17). What farmers would soon learn was that the cost of pumping water to land was higher than the yield on the crops they grew (Strom, 2011). As a result, the population growth that had been anticipated by the efforts to the upper Missouri River basin was not realized. Urban population grew three times faster than the rural population from 1900 to 1910 and five times faster from 1910 to 1920 (Gibson, 1998). From 1920 to 1930, the nation's rural population declined by 1.2 million people (Gibson, 1998).

Figure 17. Pumping barge in the Missouri River in North Dakota. (Strom, 2011)

Despite problems to populate areas in the upper stretch of the Missouri River, the lower Missouri saw an increase in population and expanding economic opportunities during the late 1800s and early 1900s. Agricultural production flourished during the late 19th century due to new scientific farming techniques. Navigation along the Missouri

River created opportunity for farmers to expand into external markets. The urban centers along the Missouri River experienced a population growth due to industrialization. The increased presence of populations living near the river and the cultivation of the floodplain for agricultural use resulted in the flood prone Missouri River having an increased impact on human population and the economy. Urban centers along the lower Missouri saw major flooding in 1844, 1881, and 1903. The federal response to the major flooding in 1844 was to enact the Swamp and Overflowed Land Act of 1850 which made building and maintaining levees the responsibility of the state. The federal appropriation of funding came through the Rivers and Harbors Acts in the late 1800s and early 1900s but was concentrated on efforts to remove navigational obstructions.

While floods dominated much of the public discourse and concerned the localized areas in which they occurred, there was a much larger vision brewing for the United States' river basins. The period from 1890 to 1930, referred to as the Progressive Era in American politics, saw an increase in activism and policies that supported efficiency in industry, society, and government. Solutions to these perceived problems of waste incorporated science and engineering to modernize and make systems run efficiently. This idea permeated the thinking from industry to natural resources.

A major proponent of this ideology was President Theodore Roosevelt. President from 1901 to 1909, Roosevelt led one of the biggest international waterway navigation projects, The Panama Canal. The construction of the Canal beginning in 1903, created a water trade route between the east and west coasts of North America leading to expansion into foreign markets. The Canal wouldn't be complete until 1914. There was considerable work to be done to create efficient navigation routes within the borders of the United States. In 1907, President Roosevelt appointed an Inland Waterways Commission to study the nation's waters as a system of interconnected areas. The goal of the report was to understand how water could be utilized for multiple purposes. Specifically, the report was to answer how water could solve the transportation problem that resulted from the increased cost in moving freight by rail and the overcrowding at rail terminals (Pisani, 2006). The preliminary and final reports submitted in 1909 and 1910, urged the continuation of investigations and projects by the Corps of Engineers and opposed improvements not essential to navigation. The use of the inland waterways to transport supplies during World War I furthered the cause for developing stable, reliable navigation routes.

Herbert Hoover, the Secretary of Commerce during the 1920s, continued efforts to build a national waterway transportation route. Hoover's many speeches given throughout the United States, as both Secretary of Commerce and as the 1929 Republican presidential candidate, touted the importance of water systems to economic stability of the country (Clements, 2010). In 1924, Congress incorporated the Inland Waterways Corporation to demonstrate the feasibility of inland water transportation and offer barge service on the Mississippi, Illinois, Missouri, and Warrior Rivers (U.S. Department of Commerce, 1950). In a 1926 speech Hoover said, "True conservation of water is not the prevention of use. Every drop of water that runs to the sea without yielding its full commercial returns to the nation is an economic waste" (Glennon, 2002, p. 13).

The Mississippi River basin, of which the Missouri is a major tributary, was an important source of raw materials, manufactured goods, and agriculture. The entire Mississippi River region produced 80 percent of the nation's coal, 50 percent of its manufactured goods, and 70 percent of its agricultural products (Clements, 2010). From 1900 to 1920, the nation's agricultural products increased in value by 300 percent, the value of its farmland by 400 percent. After World War I, crop prices dropped significantly. In the early 1920s, farmers looked for answers and found them in Secretary of Commerce Herbert Hoover's proposal to lower their fixed costs by creating a nationwide inland water navigational route for their goods (Clements, 2010). By 1926, 7,000 of the nation's 25,000 miles of potentially navigable waterways had been made navigable. Hoover believed the nation needed a way to connect these transportation routes and proposed comprehensive water projects for the Mississippi, Missouri, Columbia, Colorado, Rio Grande, Hudson, Arkansas, Tennessee, and Cumberland Rivers as well as the Great Lakes and the Central Valley of California (Clements, 2010). The critical component of the plan was the maintenance of six to nine foot levels in the channels. In 1944, the vision for a river system that provided multiple beneficial uses, most notably a channel for transportation, became a formal development and management plan for the Missouri River. From 1944 to 1981, six dams with a storage capacity of 74 million acre-feet of water and a 735-mile navigation channel were constructed but the economics of commercial transportation and development changed over the course of those 37 years. Navigation saw its peak along the Missouri River in 1977. Commercial barge traffic moved just over 3 million tons of freight along the channel, most of it being sand, gravel, and waterway materials. By 2010, the most current reporting year for an uninterrupted navigation schedule, the number had dwindled to just 250,000 tons (Hanson Professional Services Inc., 2011). Despite the marked decrease in tonnage, the navigation channel remains the primary driver of streamflow rates along the Missouri River. To facilitate a reliable channel, water from the upstream reservoirs is released to maintain the depth and width of water from Sioux City, Iowa, to St. Louis, Missouri (Hanson Professional Services Inc., 2011). The navigation season length is 8 months starting at the end of March and ending in the beginning of December. The historic streamflow graphs (Appendix B) illustrate the high level of alteration to flow that has occurred to maintain the channel.

CHAPTER 5

DISCUSSION

5.1 Application of Political Ecology

During the course of this research the Missouri River basin saw a historic flood and a historic drought. A 30-year legal battle over water diversion continued and two new contentious water projects were proposed. A 15-year federal review of the eight authorized purposes for which the mainstem of the basin has been managed for nearly 70 years culminated in a report that found those purposes may no longer be serving the interests of stakeholders in the basin and that the effects of streamflow alteration have severely altered the ecological processes along the river. The federal water managers in the basin adopted a new water management paradigm but implementation of the paradigm, including a baseline study of natural resources, continues to be defunded in Congress. The use and value of the Missouri River basin remains as divided as the climate and physiography of the basin itself.

The current environmental issues facing the Missouri River basin do not live in isolation from the economic and political contexts in which they were created. From the early writings of Thomas Jefferson, we can see the foundation upon which development of the basin was created. The land would be cultivated for agriculture and the water would be used for navigation. Nearly 210 years later, the basin, specifically the mainstem river, continues to be managed for those two primary purposes. Despite early warnings in the 1800s and the early 1900s, of the peril in disconnecting a river from its floodplain and cultivating the floodplain for agriculture and population use, plans continued to engineer the river for navigation and irrigation (White, 1945; Stegner, 1992). Today, the decline in species populations along the Missouri River can be linked to the severe alteration made to the river. The destructive flooding, as most recently as 2011, is a result of the river being disconnected from its floodplain, the necessity to maintain flows in the lower stretch of the river for navigation, and the effort to cultivate and urge populations to exist within or near the floodplains. This research concludes that the elaborate Missouri River system of dams, levees, and a 735-mile channel, despite a stated management for eight authorized purposes is managed for the primary purpose of navigation.

The scientific research contained in Chapter 2 focused on the geographic area of the Missouri River basin to understand the processes that occur within and their connectedness. However, the policy and economic research for the Missouri River basin in Chapters 3 and 4 extended beyond the basin boundaries. The reason is simply that ecological processes occurring inside the basin are connected to economic and political processes occurring inside and outside the boundaries of the basin. It seems the Missouri River is managed not for the stakeholders in the basin but for navigation and shipping interests in the Mississippi River basin. The Missouri River is a major tributary of the Mississippi and its managed flow is needed to maintain the reliable shipping channel of the Mississippi River (Corps of Engineers, 2004).

5.2 Key Stakeholders

Key stakeholders in the Missouri River basin are those individuals, groups, organizations, or agencies that interest over the management of the land and water resources in the Missouri River basin. Stakeholder interests are varied and offer opposing views on how and for whom the Missouri River should be managed. Implementation of an adaptive management strategy by the Corps of Engineers served as an attempt to bring representatives of stakeholder interest to one table to discuss management of the mainstem river. To ensure success of an adaptive management strategy, support for the framework must be achieved at all levels of stakeholder participation. Federal, state, and local governments, industry, environmental interests, and residents must not only be given room at the table but must be given the amount of representation for which makes sense. Formation of the Missouri River Recovery Implementation Committee is an attempt to bring those interests together. The mere formation of a committee does not demonstrate an equitable distribution of power among the stakeholders. Congress continually defunds the projects in which the Committee is in charge of, the Missouri River Ecosystem Restoration Plan and the Missouri River Authorized Purposes Study. The Missouri River Authorized Purposes Study promised a hydrological data assessment and hydrological model by 2012 but funding for the study ended in 2011 (Corps of Engineers, 2011). In 2012, Congress suspended funding for the Missouri River Ecosystem Restoration Plan and redirected funds to levee repair as a consequence of the flooding in 2011. Both projects were drafted by Sen. Byron Dorgan of North Dakota and had the support of states within the upper stretch of the Missouri River. The state of Missouri's congressional delegation consistently votes to defund these projects thereby supporting navigation as the primary authorized purpose for managing the Missouri River. There is a clear power asymmetry between the upstream and downstream users in the basin.

5.3 Drivers of Policy

This research presupposed that there would be a direct correlation between flood events and policy. The question as to the correlation between high precipitation events and policy decision-making led to a temporal analysis of flood events and policy change. Data from peak flows for 16 sites along the Missouri River were analyzed against the historical timeline of policy implementation in the basin to find that there is not a strong correlation. When compared to the economic interest influencing policy outlined in Chapters 3 and 4, it is more obvious that Rivers and Harbors Acts as well as Flood Control Acts were used to promote commercial navigation interests.

The Corps of Engineers, the world's largest public engineering, design, and construction management agency made up of 38,000 civilian and military personnel, created an elaborate system along the Missouri (U.S. Government Accountability Office, 2010). Ideally, the engineering of the Missouri River was to benefit many interests but in practice it has served specific interests over others. The Corps of Engineers has been used as a tool to manipulate natural systems for industry. They engineered a system to create an agricultural production center with channels for sending goods to external markets both domestic and foreign.

5.4 Conclusion

This research began as an investigation to understand the drivers of policy in the basin. This research employed a political ecology framework as the tool to deconstruct the way in which the basin has been managed over the course of American history. As discussed, political ecology seeks to analyze resource management through a historical, political, and economic perspective. The framework also analyzes links between spatial variations in the environment and decision-makers as well as offers an analysis of the unequal distribution of costs and benefits associated with development of a specific geographic area.

Critics of political ecology find the field grounded in a left leaning political movement, emphasizing use only in the developing countries, and lacking in practical application. This research serves as a direct response to those criticisms. First, the research methods employed do not provide a partisan political review but rather use an historical methodology to demonstrate the approach to water management in the basin. Second, this approach deconstructs the political economy over the history of the United States to understand how a natural resource has been valued beyond early development of a country. Third, this research concludes that there is an imbalance of power in the basin. Power is held by the congressional legislators representing the state of Missouri and the transportation industry's interest in the water for navigation purposes in the Mississippi basin. Legislation created by Sen. Byron Dorgan of North Dakota was epic but without the support of Missouri legislators there will be no change in the management of the basin. The drivers of policy in the Missouri River basin, both historically and contemporary, are based on economic interest.

The move from mere water management or conflict management between humans and between humans and their environment, to water resiliency would mark a fundamental paradigm shift. Understanding the significance of streamflow variability and using adaptive management strategy supported by consistent policies in the Missouri River is paramount to achieving a healthier ecosystem. However No other basin in the United States could be more perfectly suited for an interdisciplinary approach to its problems than the Missouri River basin. The Missouri River serves as an example of society's changing attitudes towards freshwater resources. The question of whether our society and its economic structure, laws, and policies will allow for long-term, sustainable solutions to protect fresh water resources remains.

APPENDIX A

PUBLIC PERCEPTION STATISTICAL ANALYSIS

STATISTICS FROM THE PERSONAL INTERVIEWS

The personal interviews were semi-structured and relied on an interview guide. Most of the questions were open-ended and allowed for qualitative responses. There were a limited number of quantitative questions that provided some statistical data. These data are summarized below.[6]

1. Rating of Purposes (on a scale of 1 to 10, where 10 indicates extremely important)

Weighted Average Rating of Eight Purposes	
Purpose	Rating
Flood risk management	8.9
Water supply	8.7
Water quality	8.4
Power generation	8.2
Fish & wildlife habitat	7.2
Recreation	6.6
Irrigation	5.7
Navigation	5.2

2. Are there changes needed in how the Corps manages the system?

Yes	83.8%
No	7.4
Don't know or not sure	8.8
Total	100.0%

3. How would you characterize the extent of the change needed?

Major	47.4%
Moderate	19.3
Incremental or minimal	29.8
Don't know or not sure	3.5
Total	100.0%

[6] Based on 82 personal interviews. Most, but not all interviewees, responded to all statistical questions.

STATISTICS FROM THE ELECTRONIC SURVEY

The electronic survey used a Survey Monkey instrument. It was a short survey and asked primarily for quantitative information. One question was open-ended. The statistical data from the survey are shown below.[7]

1. Please tell us how you rate the following eight purposes -- on a scale from "not at all important" to "extremely important:" (Note: a similar 1 to 10 scale was used with 10 equating to extremely important).

Weighted Average Rating of Eight Purposes	
Purpose	Rating
Water quality	9.0
Water supply	9.0
Fish & wildlife habitat	8.8
Recreation	8.5
Flood risk management	8.2
Power generation	8.1
Irrigation	6.2
Navigation	4.4

2. Are there purposes not adequately addressed?

Yes	43.9%
No	22.8
Don't know or not sure	33.3
Total	100.0%

3. Are changes needed in how the Corps of Engineers manages the Missouri River system?

Yes	82.7%
No	6.6

[7] Based on 520 surveys partially or completed filled out through April 9, 2010.

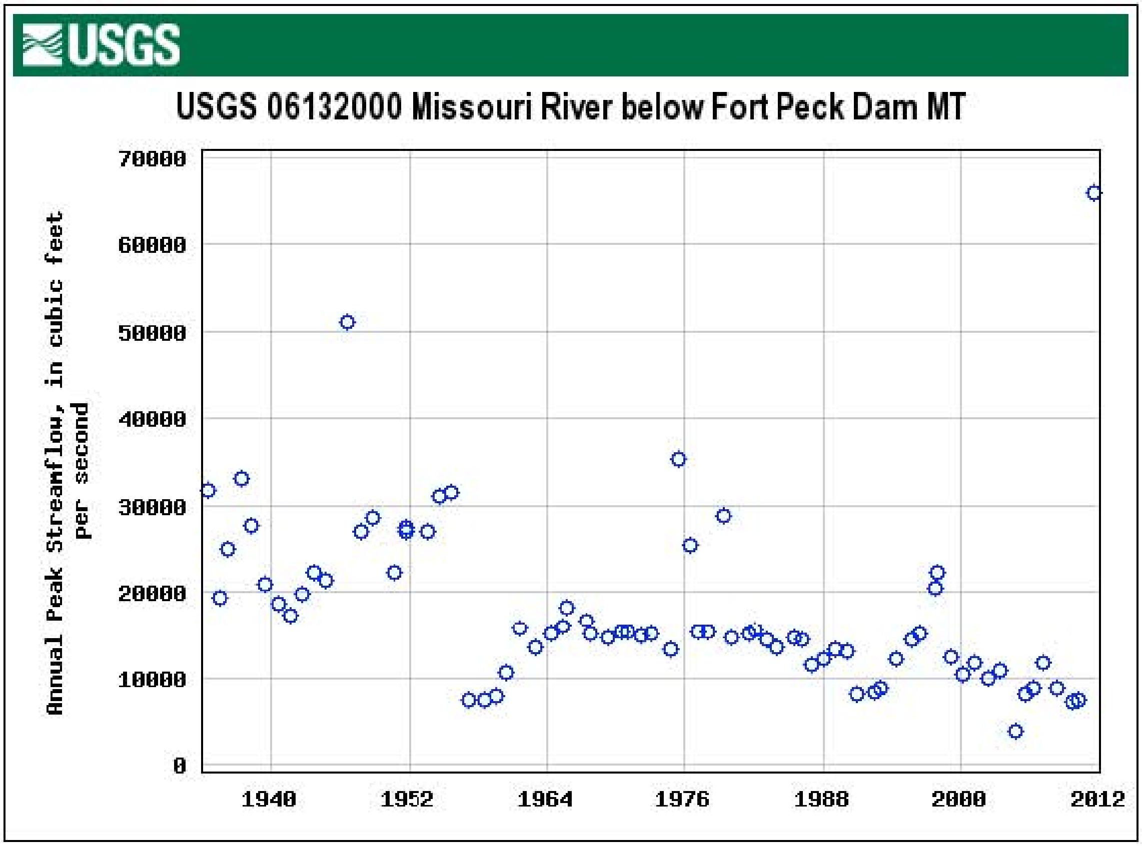
Don't know or not sure	10.6
Total	99.9%

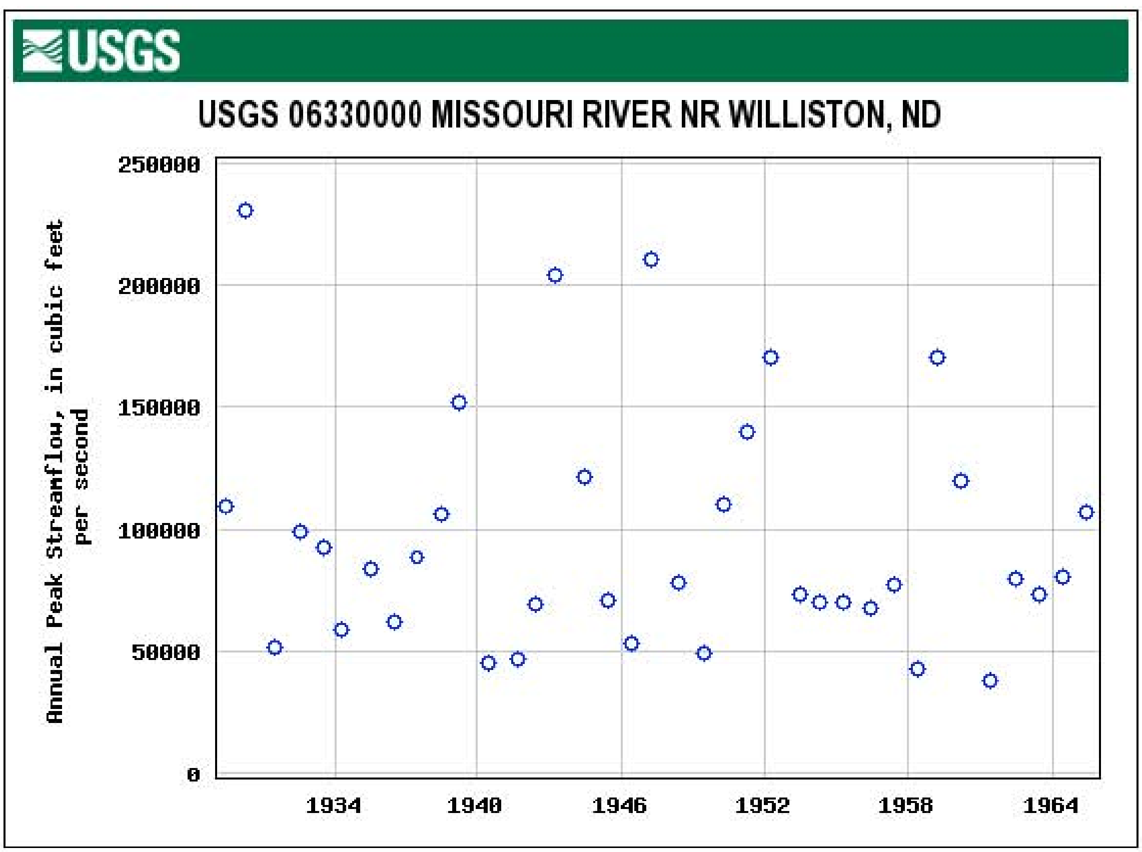
4. How would you describe the changes needed in how the Corps manages the Missouri River system?

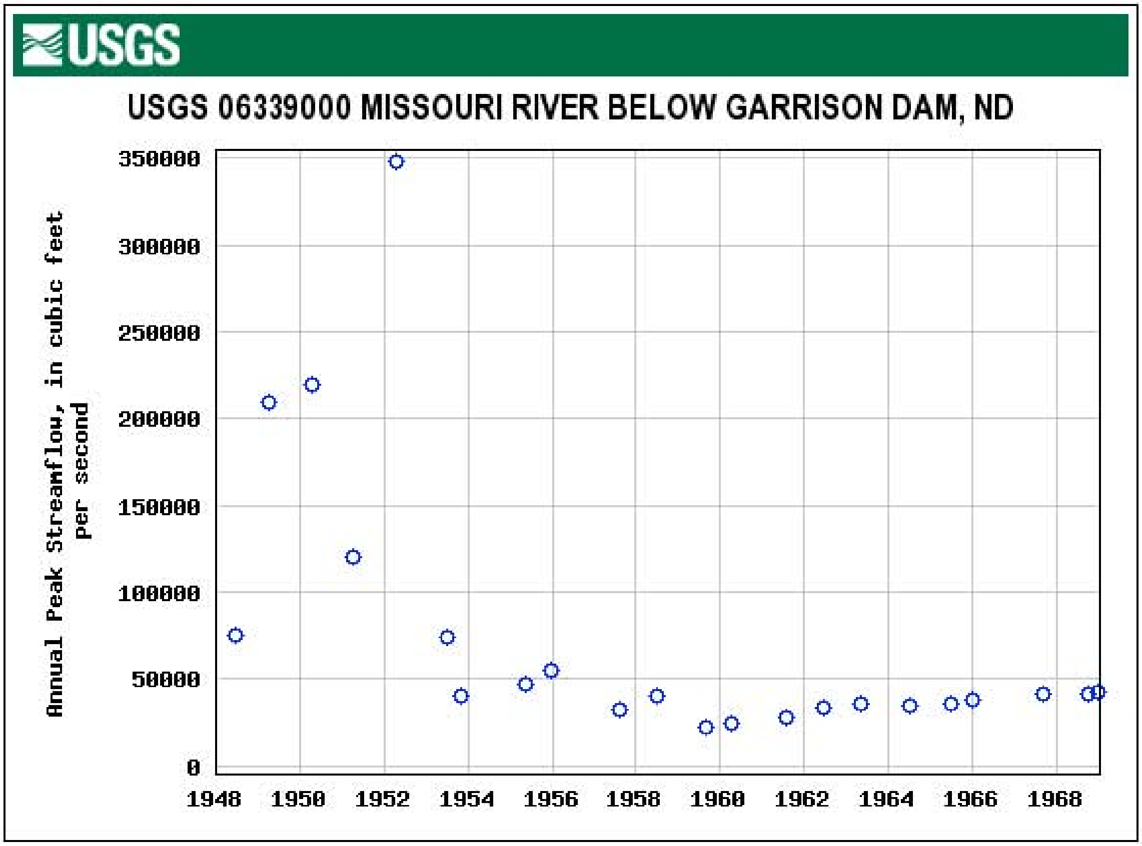
Major change is needed	38.8%
Moderate change is needed	45.7
Incremental or minimal change is needed	10.6
No change is needed	4.9
Total	100.0%

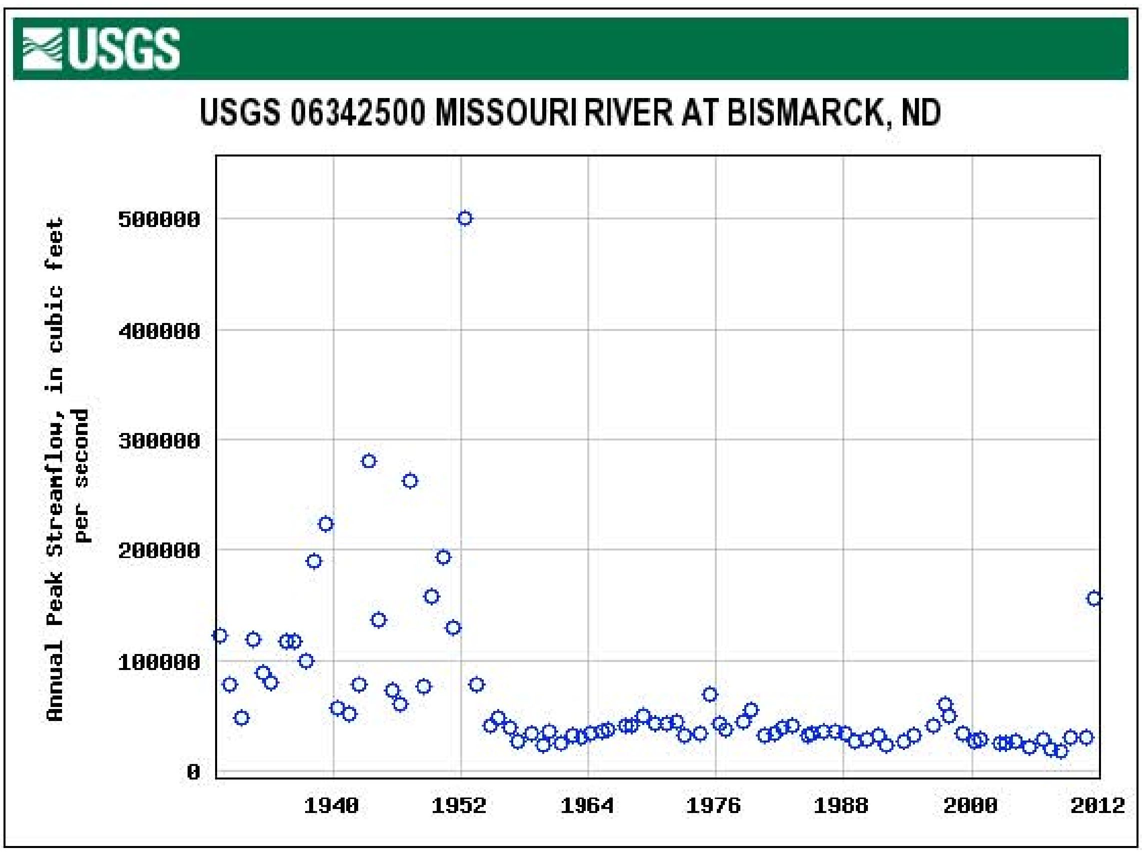
APPENDIX B

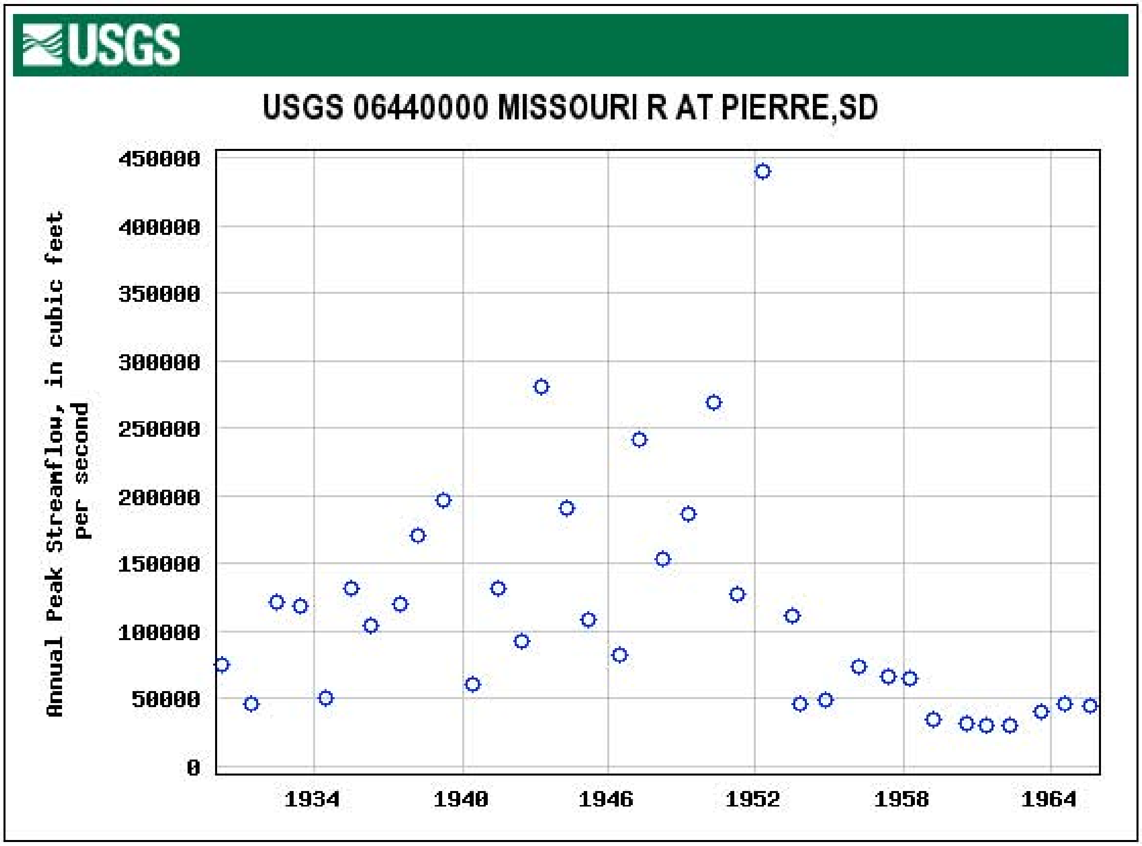
PEAK STREAMFLOW GRAPHS FOR SITES WITH DATA BEFORE IMPOUNDMENT AND CHANNELIZATION OF THE MISSOURI RIVER

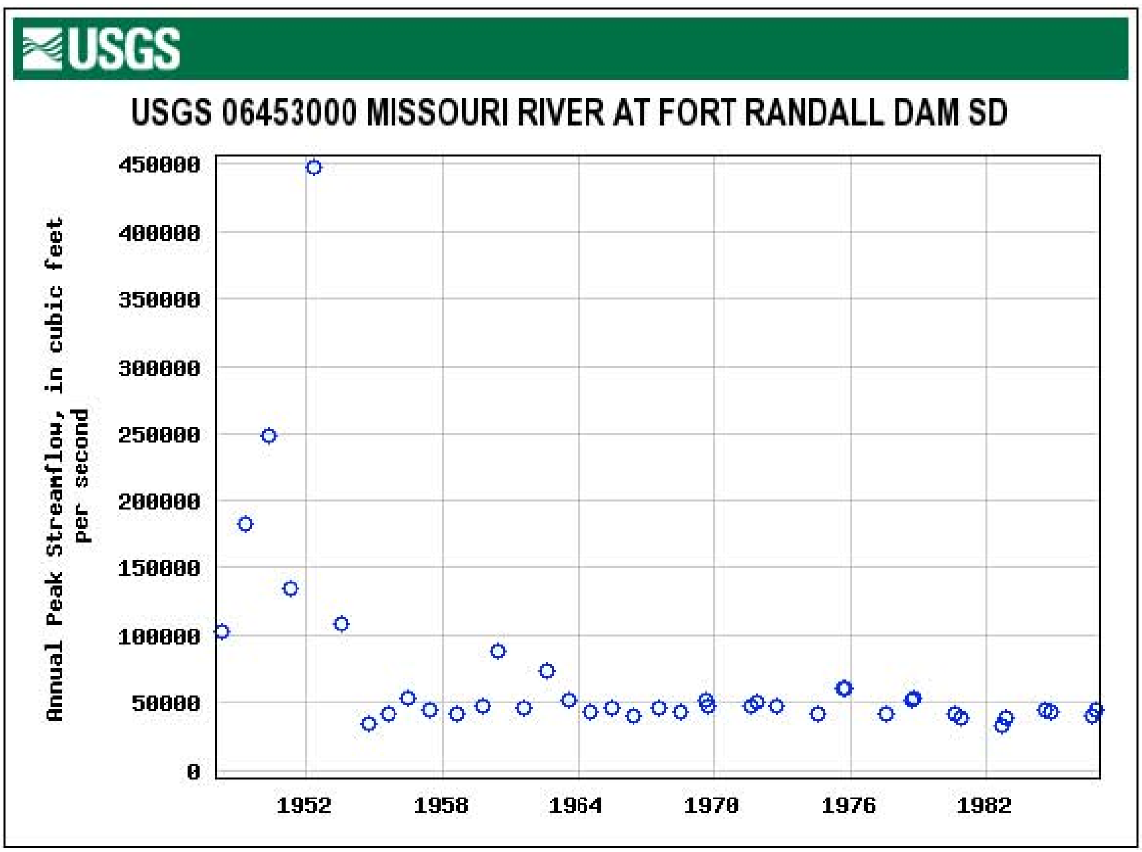

USGS
USGS 06132000 Missouri River below Fort Peck Dam MT
Annual Peak Streamflow, in cubic feet per second
70000
60000
50000
40000
30000
20000
10000
0
1940
1952
1964
1976
1988
2000
2012

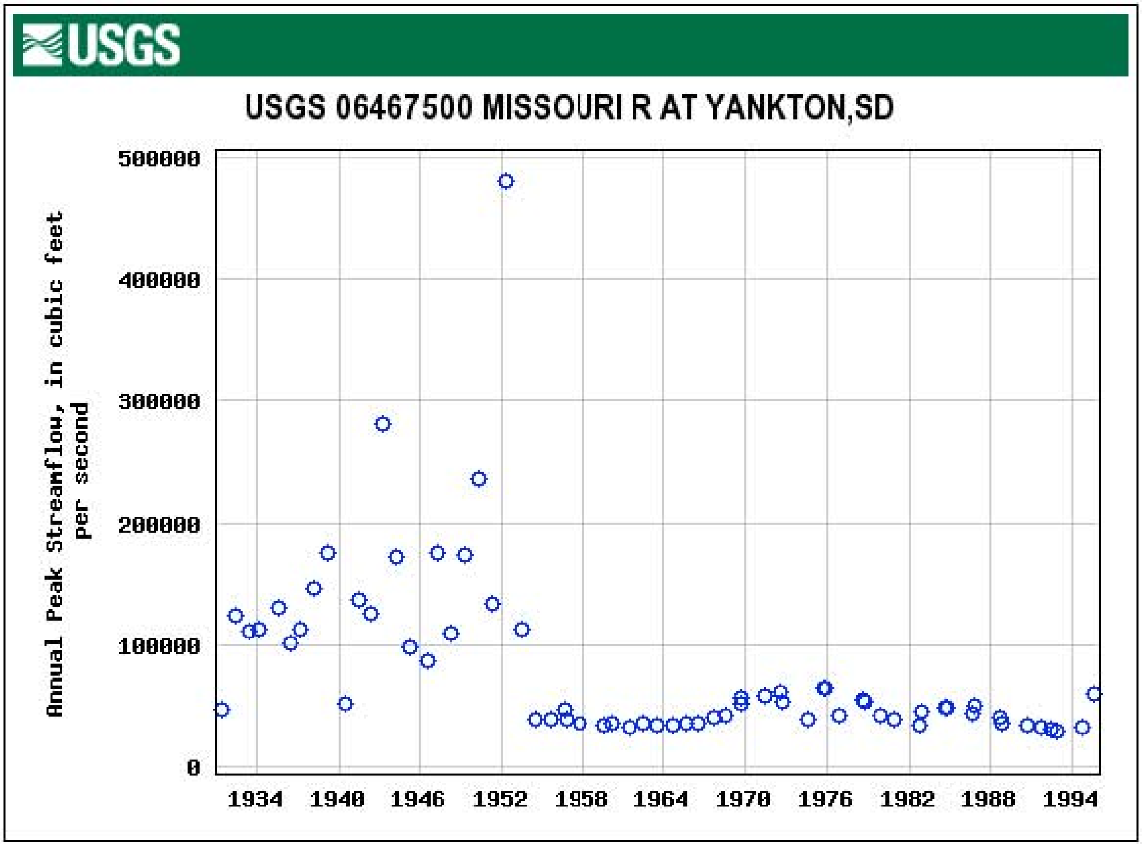

USGS
USGS 06330000 MISSOURI RIVER NR WILLISTON, ND
Annual Peak Streamflow, in cubic feet per second
250000
200000
150000
100000
50000
0
1934
1940
1946
1952
1958
1964

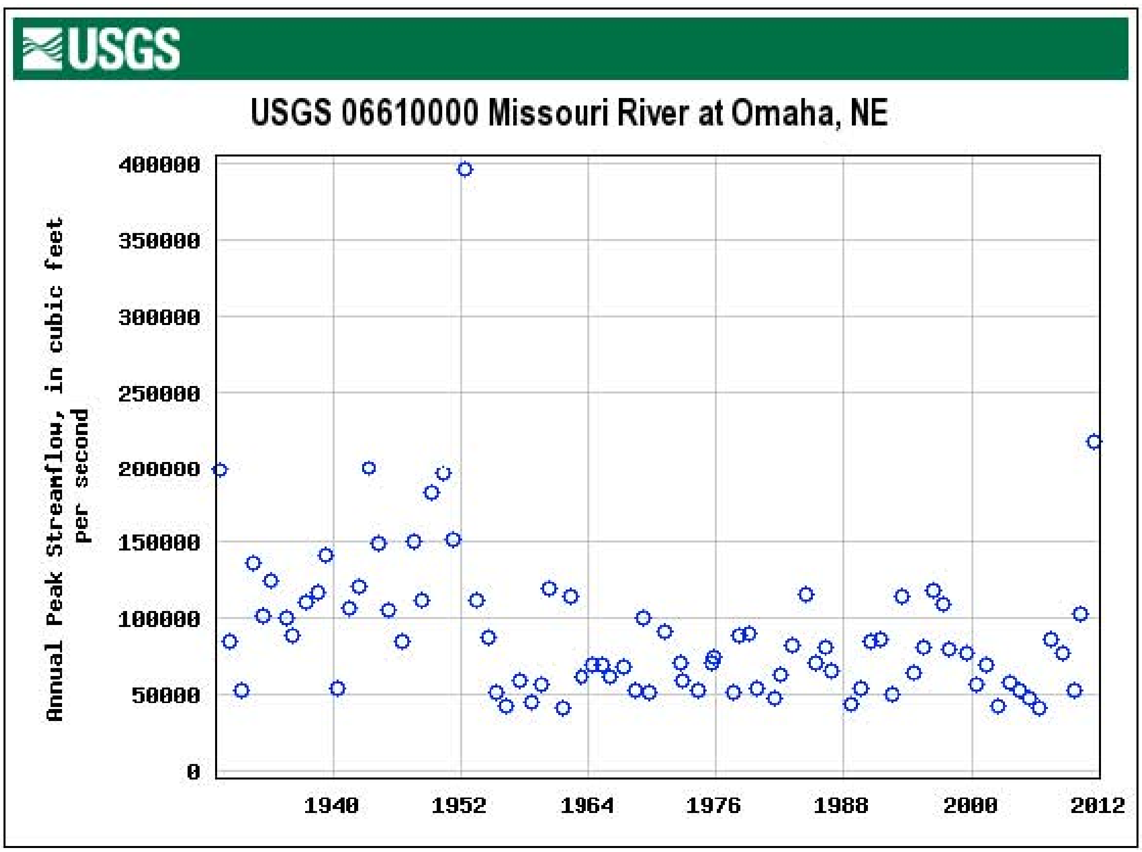

USGS
USGS 06339000 MISSOURI RIVER BELOW GARRISON DAM, ND
Annual Peak Streamflow, in cubic feet per second
350000
300000
250000
200000
150000
100000
50000
0
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968

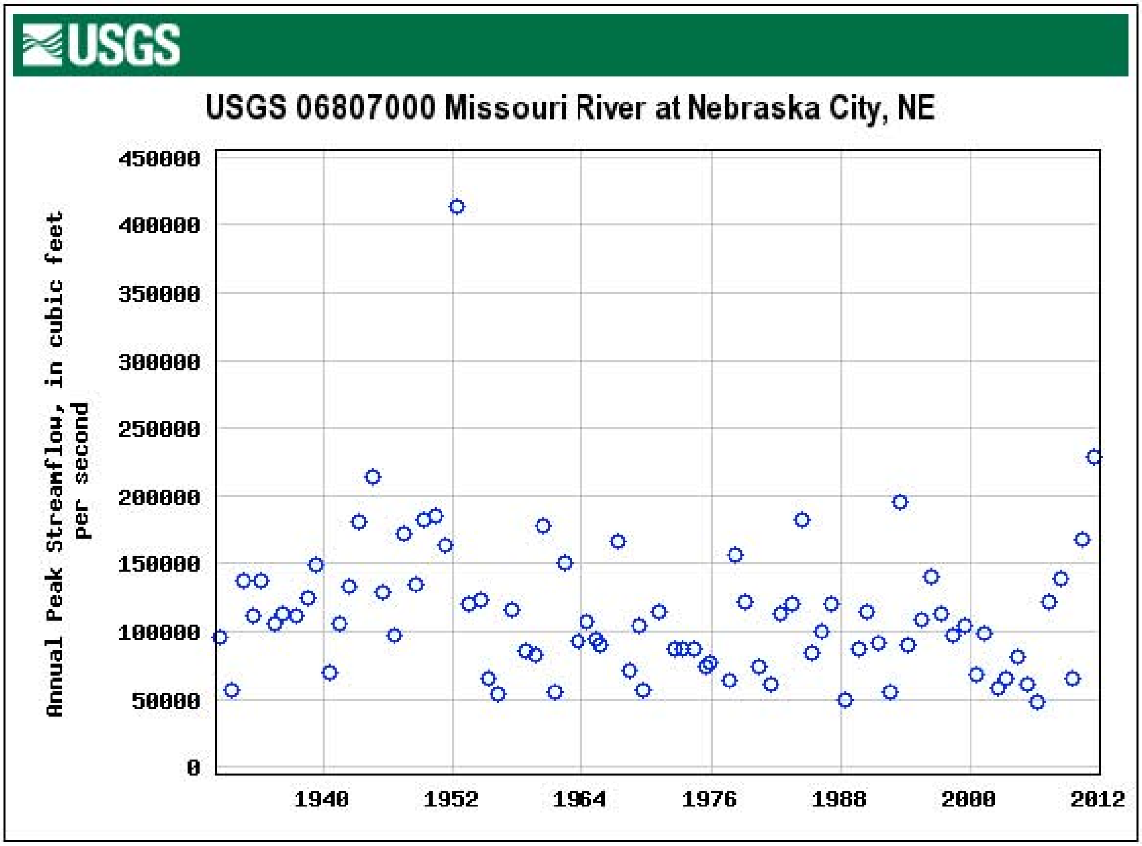

USGS
USGS 06342500 MISSOURI RIVER AT BISMARCK, ND
Annual Peak Streamflow, in cubic feet per second
500000
400000
300000
200000
100000
0
1940
1952
1964
1976
1988
2000
2012

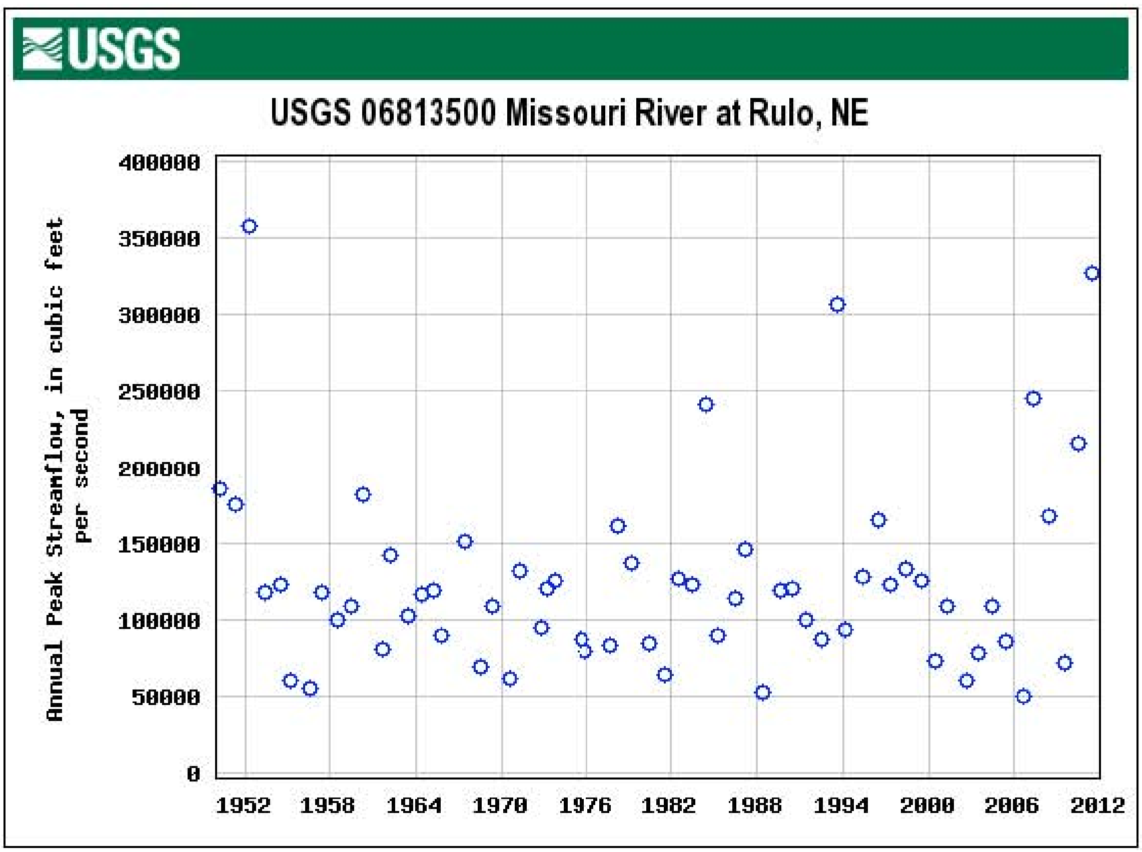

USGS
USGS 06440000 MISSOURI R AT PIERRE,SD
Annual Peak Streamflow, in cubic feet per second
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
1934
1940
1946
1952
1958
1964

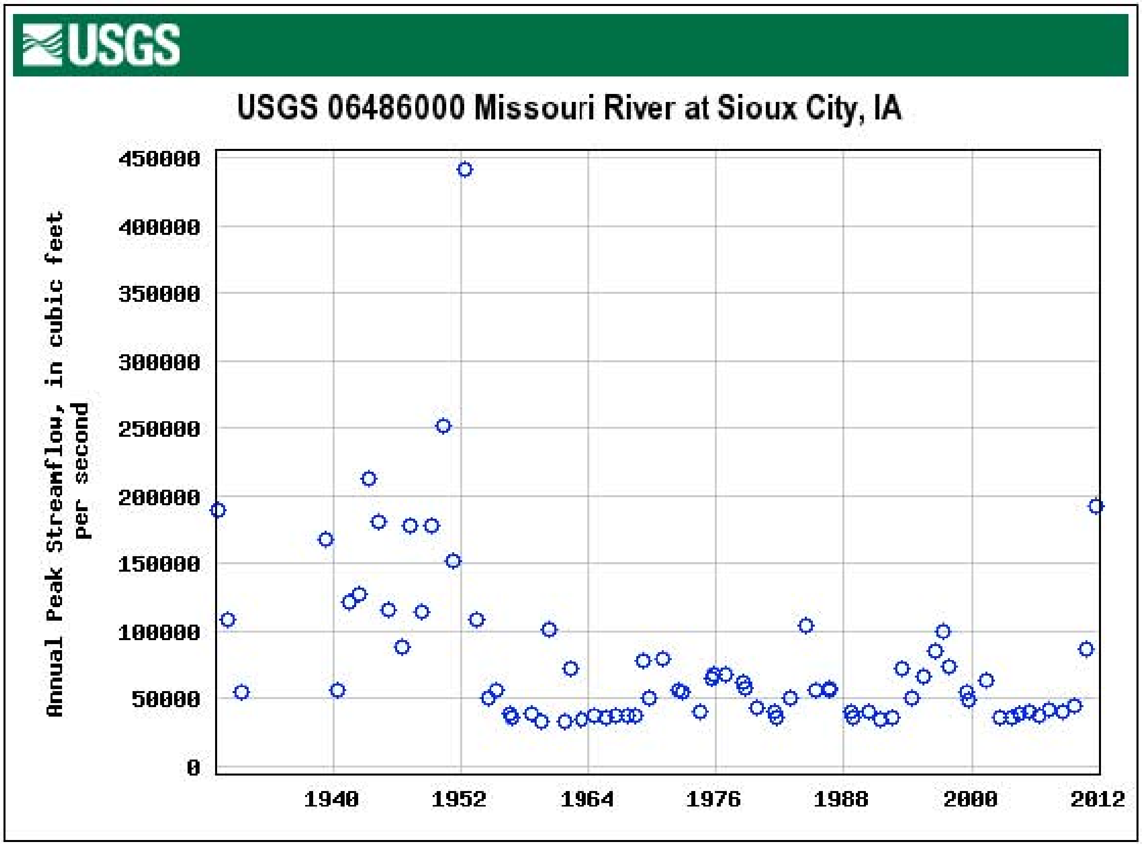

USGS
USGS 06453000 MISSOURI RIVER AT FORT RANDALL DAM SD
Annual Peak Streamflow, in cubic feet per second
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
1952
1958
1964
1970
1976
1982

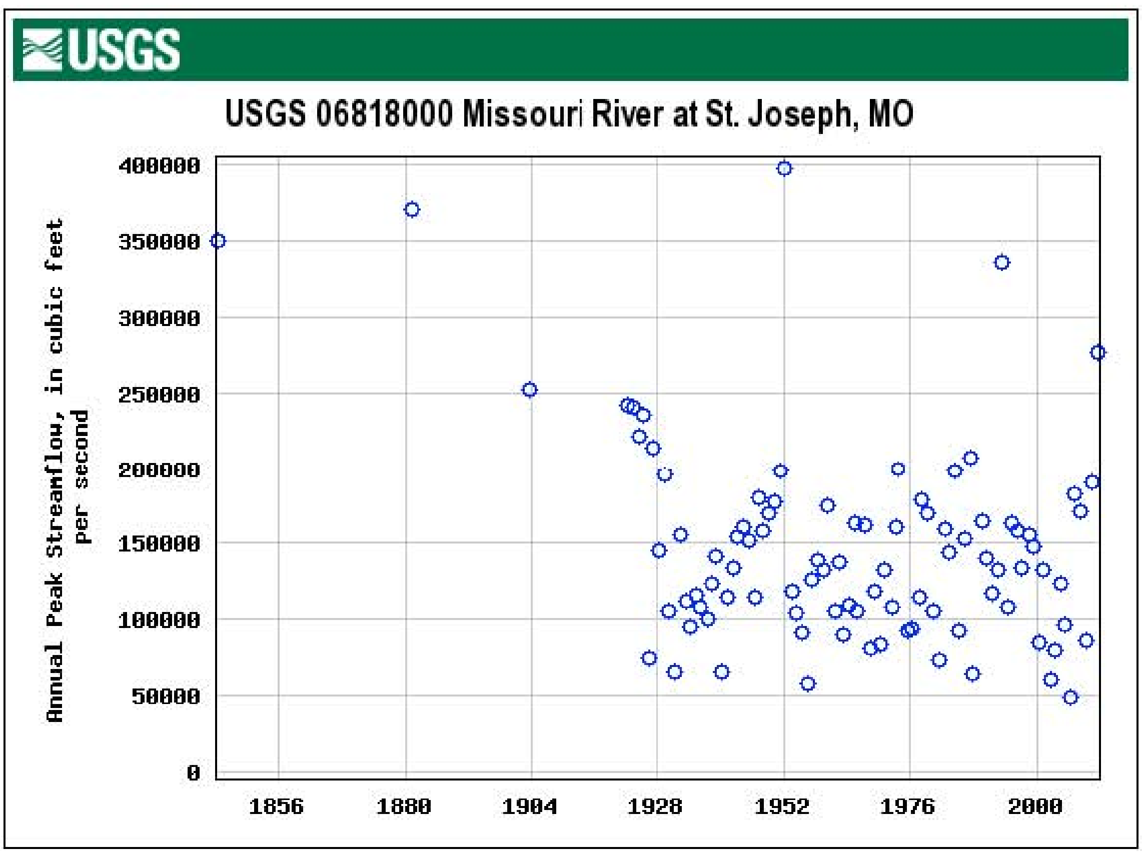

USGS
USGS 06467500 MISSOURI R AT YANKTON,SD
Annual Peak Streamflow, in cubic feet per second
500000
400000
300000
200000
100000
0
1934
1940
1946
1952
1958
1964
1970
1976
1982
1988
1994

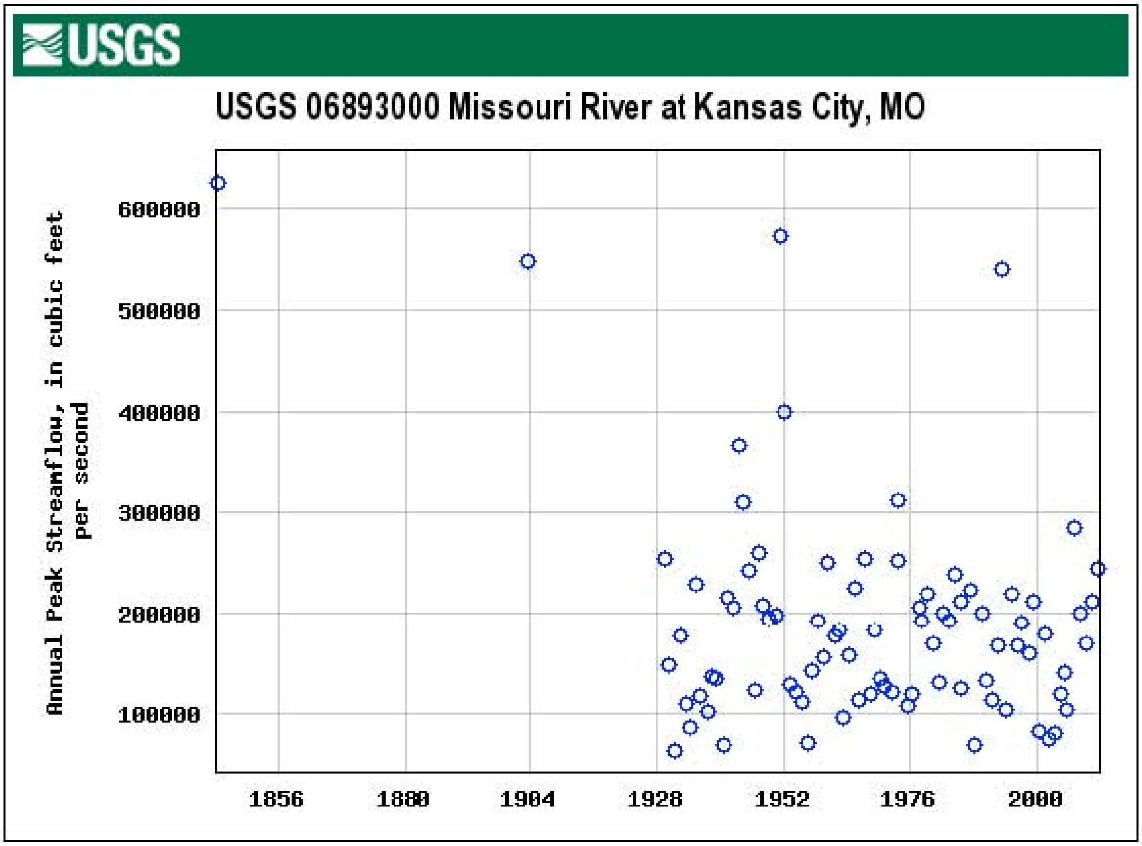

USGS
USGS 06610000 Missouri River at Omaha, NE
Annual Peak Streamflow, in cubic feet per second
400000
350000
300000
250000
200000
150000
100000
50000
0
1940
1952
1964
1976
1988
2000
2012

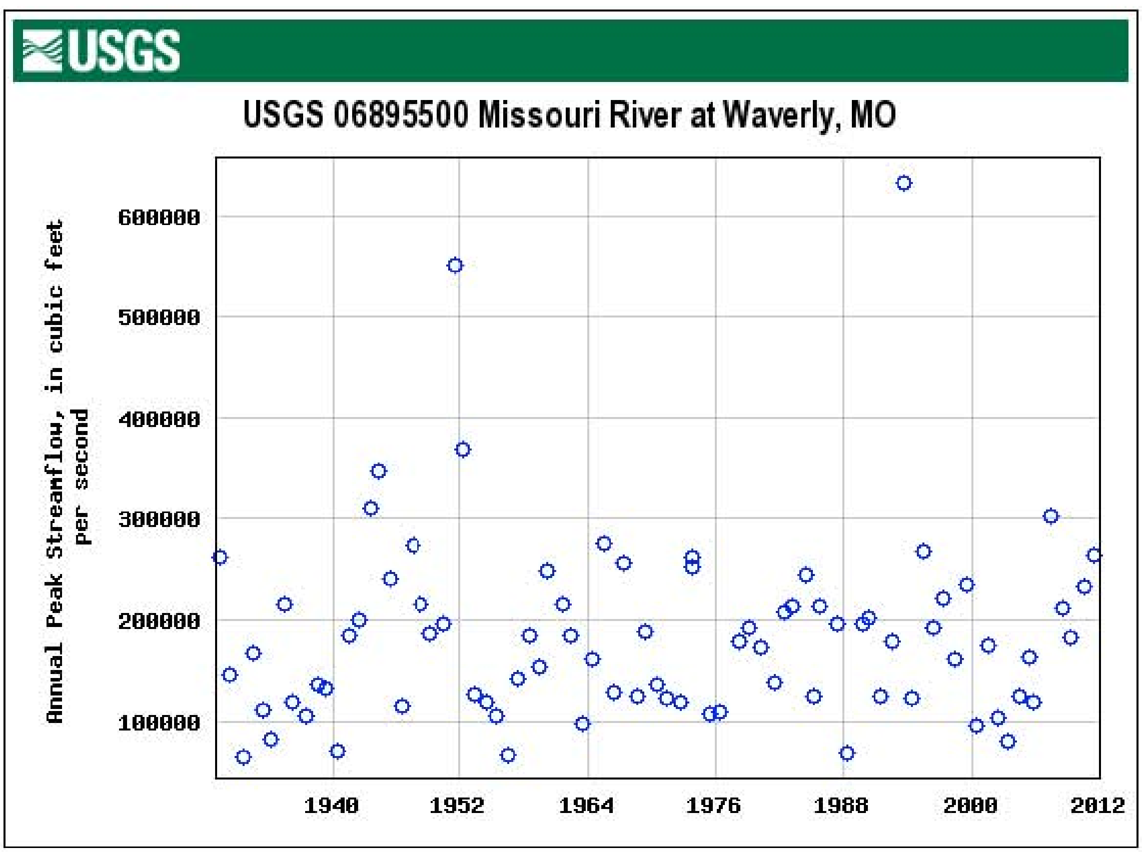

USGS
USGS 06807000 Missouri River at Nebraska City, NE
Annual Peak Streamflow, in cubic feet per second
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
1940
1952
1964
1976
1988
2000
2012

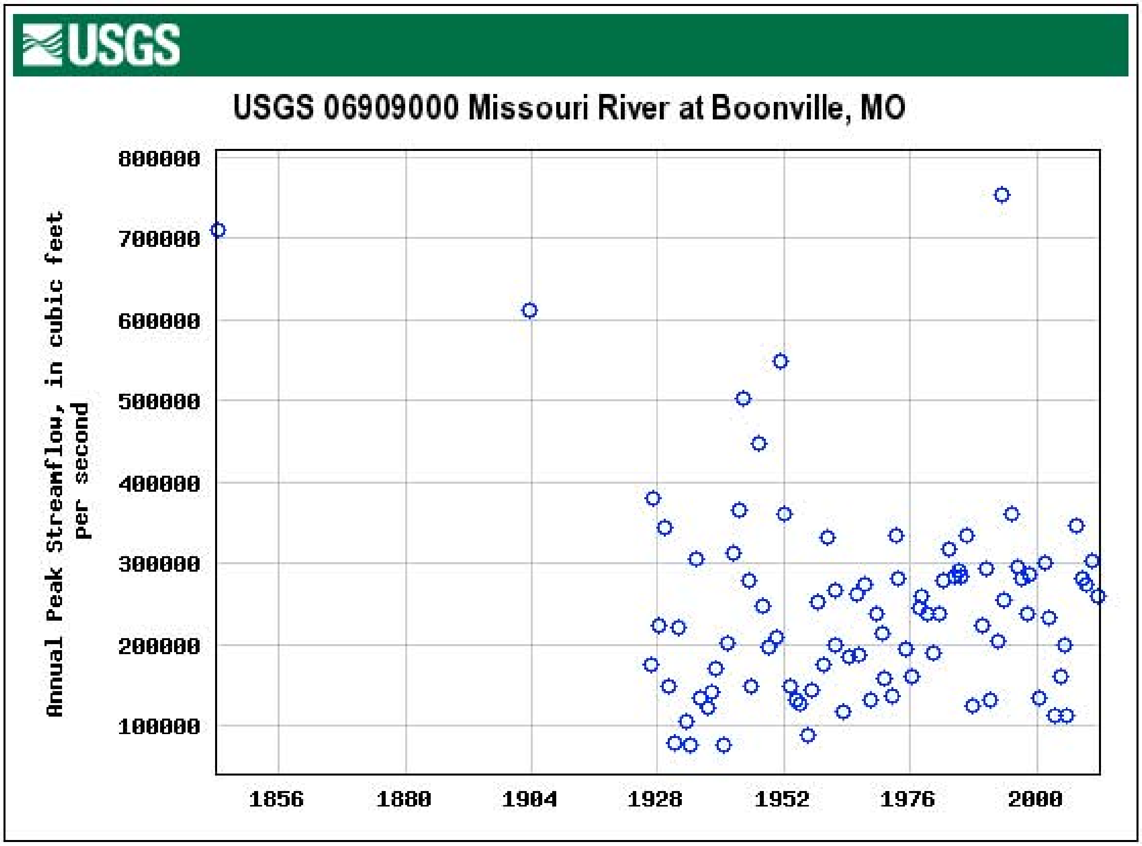

USGS
USGS 06813500 Missouri River at Rulo, NE
Annual Peak Streamflow, in cubic feet per second
400000
350000
300000
250000
200000
150000
100000
50000
0
1952
1958
1964
1970
1976
1982
1988
1994
2000
2006
2012

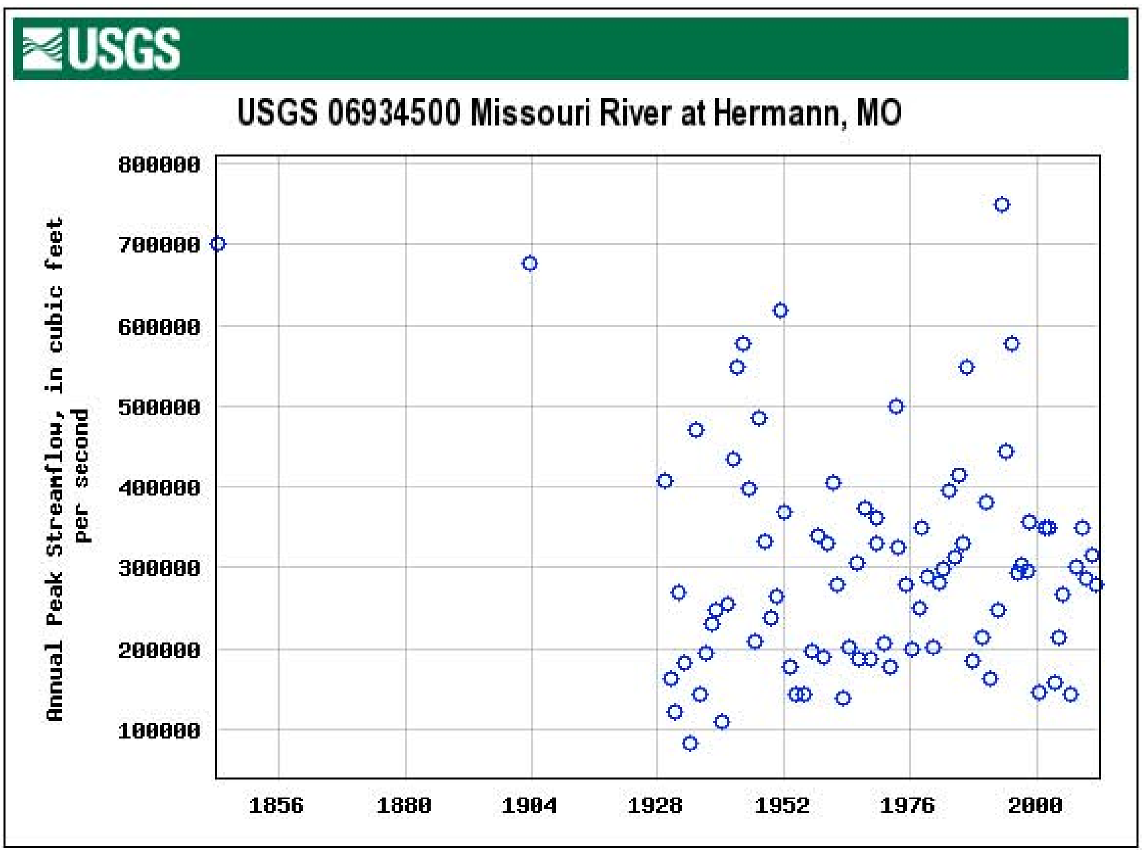

USGS
USGS 06486000 Missouri River at Sioux City, IA
Annual Peak Streamflow, in cubic feet per second
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
1940
1952
1964
1976
1988
2000
2012


USGS
USGS 06818000 Missouri River at St. Joseph, MO
Annual Peak Streamflow, in cubic feet per second
400000
350000
300000
250000
200000
150000
100000
50000
0
1856
1880
1904
1928
1952
1976
2000


USGS
USGS 06893000 Missouri River at Kansas City, MO
Annual Peak Streamflow, in cubic feet per second
600000
500000
400000
300000
200000
100000
1856
1880
1904
1928
1952
1976
2000


USGS
USGS 06895500 Missouri River at Waverly, MO
Annual Peak Streamflow, in cubic feet per second
600000
500000
400000
300000
200000
100000
1940
1952
1964
1976
1988
2000
2012


USGS
USGS 06909000 Missouri River at Boonville, MO
Annual Peak Streamflow, in cubic feet per second
800000
700000
600000
500000
400000
300000
200000
100000
1856
1880
1904
1928
1952
1976
2000


USGS
USGS 06934500 Missouri River at Hermann, MO
Annual Peak Streamflow, in cubic feet per second
800000
700000
600000
500000
400000
300000
200000
100000
1856
1880
1904
1928
1952
1976
2000

APPENDIX C

MAJOR HYDROLOGICAL EVENTS & POLICIES IMPACTING THE MISSOURI RIVER BASIN, 1844 -2013

Year	Hydrological Event	State(s) Impacted	Policy	Purpose of Legislation
1844	Heavy rainfall during May and June throughout the lower Missouri River basin.	Kansas, Missouri		
1850			Swamp & Overflowed Land Act	Established certain lands as wetlands that were unfit for cultivation and granted states the right to sell the land to independent parties for purpose of commerce. The resulting revenue was required to be used for levee construction.
1851	Record rainfall from the months of May to August.	Nebraska, Iowa, Kansas, Missouri		
1882			Rivers and Harbors Act	Protection of concave bends from erosion, stabilization and uniformity of channel by dikes, and the removal of snags
1899			Rivers and Harbors Act	Makes it illegal to create an obstruction in the waterway, excavate, or fill the channel in a way that would hinder the navigation route
1902			Rivers and Harbors Act Reclamation Act	Places control of the river into one Corps of Engineers district office Appropriated funds from the sale of public lands in the West towards irrigation projects.
1903	Heavy rainfall in May led to flooding along lower Missouri basin.	Kansas, Missouri		
1903			Panama Canal Act	Key to revival of

			(Legislation outside of basin but with impact upon the Missouri River)	waterway transportation; Prohibits railroad industry from owning, controlling, or operating a water carrier through the canal.
1907			Inland Waterways Commission created; President Theodore Roosevelt introduces concept of water as a system, having multiple beneficial uses.	
1912			Rivers and Harbors Act	Bank stabilization and navigation projects
1914			Panama Canal opens	Leads to demand for 9-foot channel along the upper Mississippi tributaries.
1916			Creation of House Committee on Flood Control	
1917			Flood Control Act Rivers and Harbors Act	First flood control act; sets foundation but does not directly appropriate funds to the Missouri River basin Bank stabilization and navigation projects
1924			Congress incorporates Inland Waterways Corporation	
1925			Rivers and Harbors Act	Bank stabilization and navigation projects
1927	Major flooding in the Mississippi River basin	Missouri; Lower Mississippi basin states		
1927			308 Report	Corps of Engineers directed to evaluate nation’s water resources.
1930			Rivers and Harbors Act	Bank stabilization and navigation

				projects
1930 – 1941	Drought			
1935			Rivers and Harbors Act	Bank stabilization and navigation projects
1943	Three separate flood events occur throughout the basin states.	Montana, North Dakota, South Dakota, Nebraska, Iowa, Missouri		
1944			Flood Control Act (Pick-Sloan Plan)	Establishes the Missouri River system of impoundment and channelization; gives eight authorized management purposes
1951	Two month period of high precipitation followed by intense rainfall during a 72-hour period in July.	Kansas, Missouri	Federal government initiates study for a national flood insurance program.	
1952	Rapid melting of snow cover from the Rocky Mountains	Montana, North Dakota, South Dakota, Nebraska, Iowa		
1954			Watershed & Flood Protection Act	Establishes cooperation between federal, state, and local governments in flood control
1954-1961	Drought			
1963			Repeal of Inland Waterways Corporation Act	
1969			National Environmental Policy Act (NEPA)	Establishes the Environmental Impact Statement (EIS) as process for federal projects affecting quality of human environment
1972			Federal Water	Establishes

			Pollution Control Act (Clean Water Act)	regulation of discharge of pollutants into U.S. waters
1973			Flood Disaster Protection Act	Mandates flood insurance protection
1978			Passage of Inland Waterways Revenue Act	Imposed barge fuel tax and created the Inland Waterways Trust Fund
1984	Large areas in the basin received high amounts of precipitation during May and June.	Montana, South Dakota, Nebraska, Iowa		
1986			Water Resources Development Act of 1986	Increased commercial waterway user fuel tax.
1987-1992	Drought			
1993	A high water table due to a wet period in the fall of 1992, above normal snow accumulation, rapid spring melt, and heavy rainfall from May to July resulted in "The Great Flood of 1993"	Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, Missouri		
2000-2007	Drought			
2011	Rocky Mountain snowmelt coupled with heavy precipitation in the upper Missouri produced flooding throughout the entire basin.	Montana, North Dakota, South Dakota, Nebraska, Iowa, Missouri		
2012	Drought			

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Fig. 4. Fort Peck dam [Photograph]. (1935). Retrieved September 29, 2013 from http://www.fortpeckdam.com/gallery/index.php

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VITA

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