3. DESCRIPTION OF EXISTING ENVIRONMENT

This section describes the Mainstem Reservoir System and the Lower River reaches of the Missouri River and the environmental resources and economic uses that are likely to be affected by changes in the current Water Control Plan (CWCP). As previously stated, there are impacts to Native American Reservations with operation of the CWCP. These impacts, as well as impacts to the public, are discussed and compared to the impacts of the other alternatives. The environmental resources described in this section include hydrology; sedimentation, erosion, and ice processes; water quality; wetland and riparian vegetation; wildlife resources; and fish. The economic uses described include flood control; water supply; hydropower; recreation; and navigation. Socioeconomic issues as well as historic properties and Native American cultural resources are also discussed.

Identified Reservations affected along the Mainstem Reservoir System and the Lower River reaches from upstream to downstream are as follows: Fort Peck Reservation, Fort Berthold Reservation, Standing Rock Reservation, Cheyenne River Reservation, Lower Brule Reservation, Crow Creek Reservation, Yankton Reservation, Ponca Tribal Lands (not Reservation land), Santee Reservation, Omaha Reservation, Winnebago Reservation, Iowa Reservation, and Sac and Fox Reservation. Reservations located along Missouri River tributaries are as follows: Wind River Reservation, Fort Belknap Reservation, Blackfeet Reservation, Northern Cheyenne Reservation, Rocky Boys Reservation, Turtle Mountain Reservation, Crow Reservation, Fort Totten Reservation, Flandreau Reservation, Pine Ridge Reservation, Rosebud Reservation, Sisseton Reservation, Kickapoo Reservation, and Potawatomi Reservation.

3.1 GENERAL DESCRIPTION OF THE MISSOURI RIVER—FORT PECK LAKE TO ST. LOUIS

The Mainstem Reservoir System and Lower River reaches extend from Fort Peck Lake in eastern Montana downstream to the confluence with the Mississippi River at St. Louis (Figure 3.1-1). Six large dams and their associated lakes are the major features of the Mainstem Reservoir System. The most downstream dam, Gavins Point Dam, is located at river mile (RM) 811, as measured from the mouth of the river at St. Louis (Figure 3.1-2). Fort Peck Dam, the uppermost dam, is located at RM 1772. The lakes formed by the dams vary in length from 25 miles to 231 miles. The average operating elevations of the mainstem projects are near the top of their carryover multiple-use pools. The top of the multiple-use pool at Fort Peck is at 2,234 feet mean sea level (msl) and at Gavins Point is at 1,204.5 feet msl. The surface of the six lakes at normal operating pool elevation totals 990,000 acres. Lake Oahe is the largest at 312,000 acres, and Lewis and Clark Lake is the smallest at 24,000 acres.

Between and below the dams are segments of the Missouri River that range in length from 811 miles for the Lower River below Gavins Point Dam to 0 miles between Big Bend Dam and Lake Francis Case. The section below Fort Peck Dam flows unchannelized for 204 miles before entering the Lake Sakakawea delta (at normal lake elevations). Below Garrison Dam, the river flows 87 miles, passing the city of Bismarck, North Dakota, before entering Lake Oahe. Of the next 425 miles, only 5 miles below Oahe Dam near Pierre, South Dakota, remains a river; the remaining 420 miles consists of Lake Oahe, Lake Sharpe, and Lake Francis Case. Below Fort Randall Dam, the river flows unchannelized for 44 miles to Lewis and Clark Lake. Below Gavins Point Dam, the river flows for 77 mostly unchannelized miles to Sioux City, Iowa. From 2 miles upstream of Sioux City, the river is channelized for commercial navigation for 734 miles to St. Louis (Figure 3.1-3).

The six dams and their associated lakes affect the geomorphological, ecological, social, cultural, and economic conditions along the Missouri River. The flood control capacity provided by the lakes greatly reduces the potential for the devastating floods that have historically occurred along the river. Releases from water stored in the lakes and the confining effect of the river structures below Sioux City provide for commercial barge navigation. Storage and release of water provide a water supply for Tribal water rights; thermal powerplant cooling; and municipal, industrial, and agricultural uses. Hydroelectric powerplants at each dam provide large amounts of hydropower to meet a significant portion of the electricity demands of the region. The lakes and river reaches provide for millions of visitor days of recreational use each year. The local and regional economies benefit from dollars generated by the infrastructure and activities associated with the Mainstem Reservoir System and the Lower River. Major cities and population centers are associated with and depend on the river and mainstem reservoirs for water, electricity, flood control, and recreation. As previously identified, there are twelve Native American Reservations and one area identified as Tribal land located directly on the Mainstem Reservoir System and the Lower River. The river system exemplifies an important cultural, ecological, and economic resource for many of the people on these Reservations. The river and mainstem reservoirs provide a wide diversity of ecological habitat for many aquatic and terrestrial animal and plant species, including many fish species that support important sport fisheries in the river and lakes and many wildlife species that support hunting in the basin. Mainstem Reservoir System operations also affect many of the native aquatic and terrestrial species in the basin. Some species are now rare or even Federally listed as threatened or endangered under the Endangered Species Act (ESA).

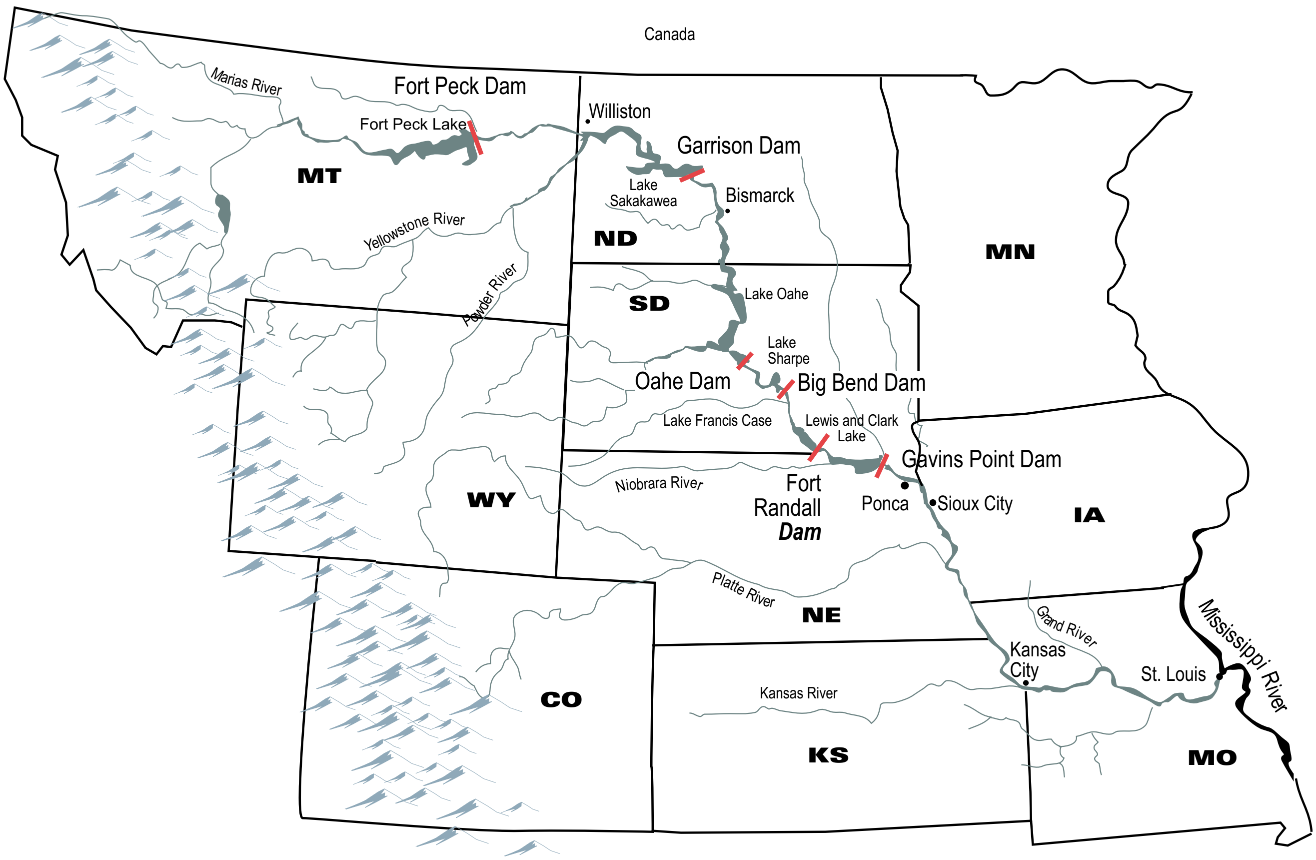

Figure 3.1-1. Missouri River Mainstem Reservoir System.

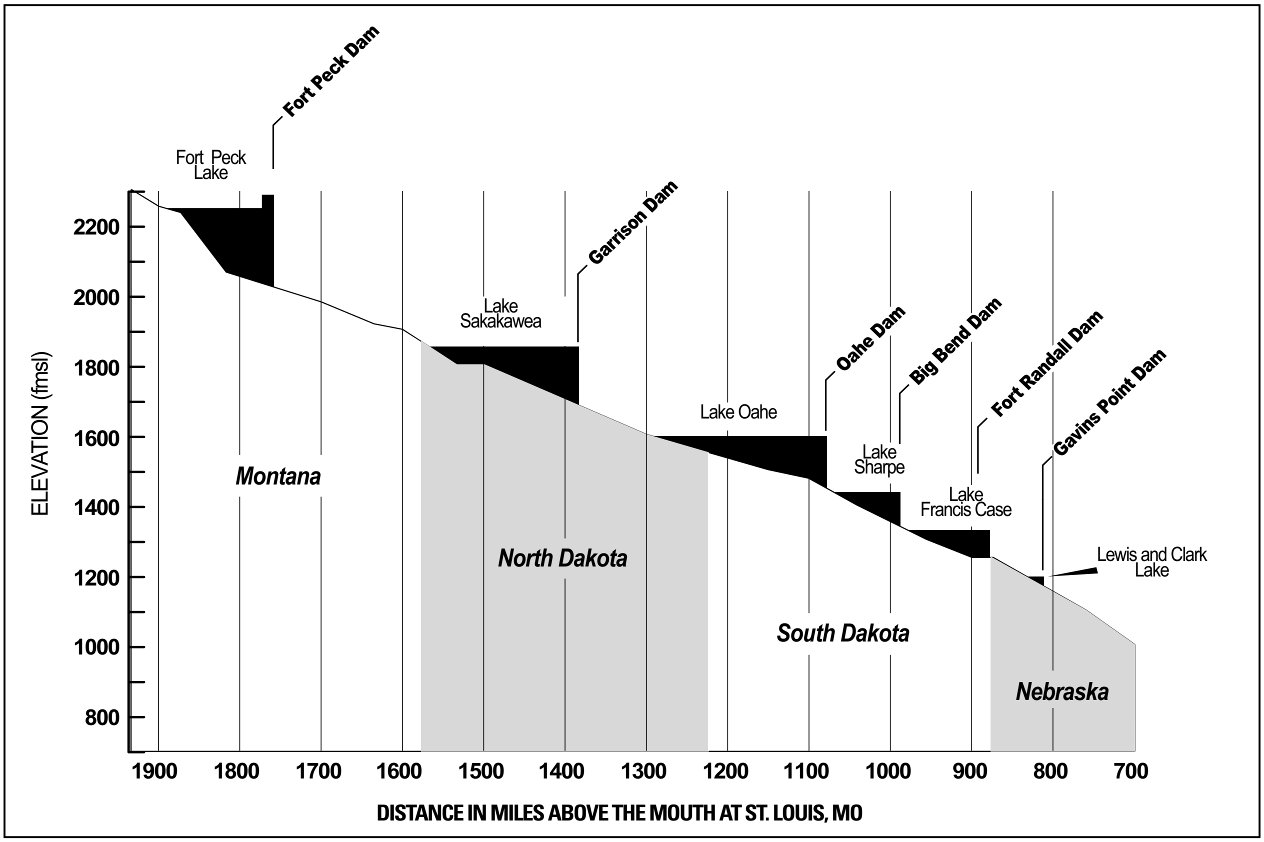

Figure 3.1-2. Profile of Missouri River Mainstem Reservoir System reservoirs.

Figure 3.1-3. Missouri River navigation channel from Sioux City to St. Louis showing target flow locations.

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3.2 THE MAINSTEM RESERVOIR SYSTEM AND LOWER RIVER

The Mainstem Reservoir System and Lower River consist of six dams and their associated lakes. The Missouri River Bank Stabilization and Navigation Project (BSNP) is the major feature on the Lower River. The entire mainstem system includes twelve Reservations and one area identified as Ponca Tribal Lands.

3.2.1 Fort Peck Project

Fort Peck Dam is located on the Missouri River at RM 1772 in northeastern Montana. The earth-filled dam, excluding the spillway, is 4 miles long and 220 feet high. Fort Peck Lake is 134 miles long and covers 246,000 acres when full. Its gross capacity is 18.7 million acre-feet (MAF). The powerplant annually produces approximately 1.2 billion kilowatt hours (kWh) of energy. Construction of the project was initiated in 1933, closure was made in 1937, and the project was placed in operation for purposes of navigation and flood control in 1940. The first hydroelectric unit went on line in 1943, the first hydroplant was completed with the installation of the third unit in 1951, and the second powerplant with two units was completed in 1961.

The Fort Peck Reservation is located directly downstream of Fort Peck Dam on the north bank of the river. Based on a survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Fort Peck Reservation indicated that prior to construction of the Missouri River dams, the river provided an important source for "travel, food and water" for the Assiniboine and Sioux Tribes. Today, Tribal land resources are predominantly agricultural, grazing, and forestry, with some industry. The Tribes indicated in the survey that water sources are extremely important to the Reservation. Based on the survey, Tribal water usage comes from the following sources: 80 percent from groundwater, 15 percent from the Missouri River, and the remaining 5 percent from the Poplar River and other streams. The Reservation indicated future objectives for an Municipal Rural and Industrial (MR&I) project from the Missouri River and additional irrigational projects.

3.2.2 Garrison Project

Garrison Dam is located at RM 1390 in central North Dakota. The earth-filled dam is 11,300 feet long and 180 feet high. Lake Sakakawea is 178 miles long and covers 380,000 acres when full. Its gross capacity is 23.8 MAF. The 5-unit powerplant annually produces 2.5 billion kWh of energy. Construction of the Garrison project started in 1946, closure occurred in 1953, and operation began in 1955. The first and last power-generating units were placed on line in 1956 and 1960, respectively.

Located on the upper part of Lake Sakakawea along both shorelines is the Fort Berthold Reservation. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Three Affiliated Tribes of the Fort Berthold Reservation indicated that, prior to the construction of the Missouri River dams, the river represented an "irrigated extension, trade system, food, water, soils, shelter from trees, grave sites on hills around, and buffalo that were located at the convergence of the Knife and Missouri Rivers." The construction of the dams split up the Tribes geographically, consequently resulting in a "general breakdown in Tribal culture." The trade system, drinking water quality, irrigation, buffalo, and tree shelters were greatly diminished.

Currently, the Reservation relies on water from Lake Sakakawea and the dominant aquifer. Future Tribal initiatives include aquifer preservation, implementing a water management plan, irrigation of lands near the lake, and irrigation permitting for non-Native Americans. For the most part, Tribal members indicated in the survey that the Lake's water level is about right, but indicated that the Corps should minimize the fluctuation. The Three Affiliated Tribes indicated that financial impact of the alternatives in the Preliminary Draft Environmental Impact Statement (PDEIS) would include the cost of modifying the existing intake system. The current land uses at the Fort Berthold Reservation are reported to be primarily agricultural and grazing with minor amounts of industry, recreation, and tourism.

3.2.3 Oahe Project

Oahe Dam is located at RM 1072 near Pierre, South Dakota. The earth-filled dam is 9,300 feet long, excluding the spillway, and 200 feet high. Lake Oahe is 231 miles long and covers 374,000 acres when full. Its gross capacity is 23.1 MAF. The 7-unit powerplant annually produces 2.9 billion kWh of energy. Construction began in 1948, closure occurred in 1958, and operation began in

1962. Power generating units came on line in 1962 and 1963.

Both the Standing Rock Reservation and the Cheyenne River Reservation are located on the west shoreline of the upper end of the lake. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Cheyenne River Reservation indicated that, prior to the construction of the Mainstem Reservoir System, the importance of the river was based on what it represented to the Sioux people: "subsistence." "Hunting, fishing, ceremonial burial sites, medicinal, firewood, and cultural" uses were all intertwined with the Sioux Tribe's existence. The lakes flooded the communities and dispersed the Tribe, creating a breakdown in the Tribe's cultural way of life.

Overall, the survey indicated that the Cheyenne River Reservation does not benefit from any flood control measures implemented by the Corps. High inflows to Lake Oahe have caused erosion on Reservation land while droughts have affected water supply intakes. Current land uses on the Cheyenne River Reservation were indicated to be predominantly agricultural, forestry, and hunting, with minor amounts of grazing and recreation. The Cheyenne River Sioux Tribe indicated that "solid waste-funding (State jurisdictional challenges), water, and air-funding (State jurisdictional challenges)" were the top three environmental challenges facing the Reservation.

Likewise, documentation from the Mni Sose Intertribal Water Rights Coalition Survey (February 1994) indicated that the Standing Rock Reservation did not complete a survey. Consultations with the Standing Rock Sioux Tribe on July 27 and 28, 1999, and the Tribe's July 7, 1993, comments on the PDEIS indicate that impacts of the Mainstem Reservoir System are similar to those on the Cheyenne River Reservation. The construction of the Mainstem Reservoir System destroyed a cultural way of life with little mitigation for the loss of trees, berries, land, etc. Low lake levels and flooding are both a concern to the Standing Rock Sioux Tribe as is water quality from non-point source runoff. Current land uses include agricultural and recreational uses. Future water uses indicated by the Standing Rock Sioux Tribe's comments include, but are not limited to, the following: Native American water rights with future economic development, such as recreation, municipal uses, water supply, irrigation, and hydropower.

3.2.4 Big Bend Project

Big Bend Dam is located at RM 987 in central South Dakota. The earth-filled dam is 10,570 feet long and 78 feet high. Lake Sharpe is 80 miles long and covers 61,000 acres when full. Its gross capacity is 1.9 MAF. The 8-unit powerplant produces 1.1 billion kWh per year. Construction began in 1959, closure occurred in 1963, and operation began in 1964. Power generating units came on line from 1964 to 1966. Big Bend tailwater elevation is affected by Fort Randall's reservoir most months of the year.

The Lower Brule Reservation along the west bank and the Crow Creek Reservation along the east bank are both located up and downstream from the Big Bend Dam. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Crow Creek Reservation attests that the Missouri River represented "total subsistence" to the Tribe prior to the construction of the Mainstem Reservoir System. The construction resulted in loss of "timber from the 16,000 now flooded acres" and loss of "medicinal purposes, food, fishing, hunting, ceremonial and burial grounds." Currently, the Tribe identifies the Missouri River and aquifer/well water as the Tribal water sources. For a Reservation that is located adjacent to Lake Sharpe and the Missouri River, water quality is a principal concern on the Crow Creek Reservation. Consequently, the Tribe identified "safe drinking water, a rural water system, and air quality" as the top three environmental challenges facing the Tribe. Currently, land use on the Reservation is identified as agricultural and grazing, with minor uses for industry, tourism, and residential. A survey was not completed for the Lower Brule Reservation.

3.2.5 Fort Randall Project

Fort Randall Dam is located at RM 880 in southeastern South Dakota. The earth-filled dam is 10,700 feet long and 140 feet high. Lake Francis Case is 107 miles long and covers 102,000 acres when full. Its gross capacity is 5.4 MAF. The Yankton Sioux Tribe's 8-unit powerplant produces 1.8 billion kWh per year. Construction began in 1946, closure occurred in 1952, and operation began in 1953. Power generating units came on line from 1954 to 1956.

The Yankton Reservation is located on the north shoreline upstream and downstream of Fort Randall Dam. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Yankton Reservation relied on the Missouri River for "sustenance, religious, and recreational purposes" prior to the construction of the Mainstem Reservoir System. The Yankton Sioux Tribe identified losses with regard to their cultural way of life with the construction of the dam and levees. The survey distinguished "solid waste, water resources planning/continued development, and pesticides" as the top three environmental challenges facing the Yankton Reservation.

3.2.6 Gavins Point Project

Gavins Point Dam is located at RM 811 on the Nebraska-South Dakota border near Yankton, South Dakota. The earth- and chalk-filled dam is 8,700 feet long and 45 feet high. Lewis and Clark Lake is 25 miles long and 31,000 acres in area when full. Its total capacity is 0.5 MAF. The 3-unit powerplant produces 0.7 billion kWh of energy per year. Construction began in 1952, and the project was operational in 1955. Power generating units came on line in 1956 and 1957.

The Ponca Tribal Lands and the Santee Reservation are located at the upper end of Lewis and Clark Lake on the south shoreline. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Ponca Tribe reported that prior to the construction of the Missouri Reservoir System, the river represented "salt, fishing, hunting, and ceremonial" purposes. The construction of the dams "changed their traditional way of life." The Ponca Tribe identified "starting an environmental program" as its biggest environmental challenge.

As for the Santee Reservation, the survey identified the Missouri River as source of "drinking/ household use, fishing, hunting, and navigation" prior to the construction of the dams. The dams created "more pollution, greater sedimentation in the water, and filled in the basin." The Santee Sioux Tribe feels that the "water should run freely." Currently, the Tribe identified "ponds, streams, and wells/aquifers" as the Tribal water sources. The Tribe also indicated that members feel that water levels in the adjacent lake/river fluctuate too much and that the Corps should minimize the fluctuations. Tribal members want to see an alternative that "keeps water levels high enough that people can access the lake for business/pleasure and to minimize sedimentation in boat basins." The survey indicates that the Santee Sioux Tribe feels that the alternatives previously evaluated in the PDEIS will create such large water fluctuations that the willows and vegetation used for sweat lodges will be affected. Currently, the Reservation is concerned about water quality and prioritizes "radon, underground tank storage, and drinking water" as its top three environmental challenges. The survey identified the current land uses on the Reservation as primarily agricultural, grazing, and forestry, with minor amounts of commercial, industrial, and residential uses.

3.2.7 Downstream Navigation and Bank Stabilization Project

The Lower River reach from Gavins Point downstream to St. Louis includes numerous authorized projects that provide bank stabilization and a navigation channel. In addition to the primary authorization to maintain a 9-foot-deep by 300-foot-wide navigation channel from Sioux City to the mouth, there are authorizations to stabilize the river banks.

This reach of the river has been modified over its entire length by an intricate system of dikes and revetments designed to provide a continuous navigation channel without the use of locks and dams. Authorized channel dimensions are achieved through supplementary releases from the large upstream reservoirs and occasional dredging and maintenance.

Downstream of Gavins Point are both the Winnebago and Omaha Reservations on the west bank south of Sioux City, Iowa, and the Iowa and Sac and Fox Reservations on the west bank north of St. Joseph, Missouri.

Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Winnebago Reservation feels that the Mainstem Reservoir System and levees "affected wetlands along the river, caused erosion, affected fishing and navigation, and caused willows to dry due to cranes." Prior to the construction of the dams and levees, the river was used for "navigation, fish, food and transportation, and willows along bank used to build wigwams, feeds, and baskets." Currently, the Tribal water sources identified in the survey are the Missouri River for agricultural uses and the aquifer/groundwater (Oglala) for domestic uses.

The Winnebago Tribe identified in the survey future water uses as "fisheries, recreation, and irrigation." Similar to the sentiments of the Santee Sioux Tribe, the Winnebago Tribe indicated in the survey that the water levels fluctuate too much and are too low. The Tribe identified "solid waste, water quality/groundwater contamination, and underground storage tanks" as its top three environmental challenges.

The Mni Sose Intertribal Water Rights Coalition survey indicated that, for the Omaha Reservation, the Missouri River represented "campsites, watering of livestock, fishing, watering gardens, recreation, drinking water, and trading with non-Indians" prior to the construction of the dams and levees. Construction of the dams and levees "dried Lawless Lake and Betsey Bottom Lake where cultural activities took place," caused "loss of individual allotments and Tribal lands," and moved the river, thus affecting the Tribe's sole sources of water. "Tribal ceremonies and religious activities ceased or changed," according to the survey.

Future water use concerns identified by the Omaha Tribe are water quality and quantity and Tribal water code by priority rights. Unlike the Winnebago Tribe, the Omaha Tribe feels that the water levels are about right and that the Reservation does benefit from the current flood control measures. Even so, the survey indicated that the Tribe feels that it would suffer a financial impact as a result of the loss of financial revenue from the alternatives previously evaluated in the PDEIS. The Omaha Tribe currently uses the Tribal Rural System (aquifer/wells system) for its water source. Additionally, the Tribe's top three environmental challenges were identified as "landfill closure, Tribal utility system, and water rights." Current land uses on the Omaha Reservation are identified as primarily agricultural, forestry, grazing, recreation, tourism, and residential, with minor amounts of commercial uses.

For Iowa Tribal members on the Iowa Reservation, the Missouri River was a source of "fish and fresh water" prior to the construction of the dams and levees. The survey completed by the Iowa Tribe indicated that the "fish population has declined dramatically" to "almost nonexistent" since construction of the dams and levees. Additionally, the Tribe feels that "dams and levees have caused flooding by trying to control and confine the river." The survey indicated that Tribal members feel that there is too much water level fluctuation and that the Corps should minimize the amount of fluctuation. Currently, the Tribe relies on well water as a Tribal water source and identifies recreation and irrigation as future water uses. "Solid waste, water pollution, and erosion" were identified as the top three environmental challenges facing the Iowa Tribe. Current land uses are identified as agricultural, grazing, and forestry.

The survey of the Sac and Fox Reservations indicated that, prior to the construction of the dams and levees, the Missouri River was a source for "navigation, hunting, and fishing." The construction of the dams "destroyed fish and wildlife habitat," "decreased navigation," and "lowered creeks, affecting fishing." The survey did not indicate any future water uses or environmental challenges for the Sac and Fox Reservation. The current identified land use on the Sac and Fox Reservation was identified primarily as agricultural.

3.2.8 Mainstem Reservoir System and Lower River Operation and Maintenance Costs

Operation and maintenance (O&M) costs are incurred annually to ensure that the Mainstem Reservoir System and the Lower River projects continue to provide benefits to various uses. The average annual total O&M costs over a recent 5-year period, 1993 through 1997, were $41.4 million. These costs have been allocated to six categories. The categories and their approximate average annual values are as follows: power production, $21.5 million (52 percent); flood control, $4.1 million (10 percent); navigation, $7.1 million (17 percent); recreation, $5.8 million (14 percent); special cultural resources, $0.4 million (1 percent); and bank stabilization, $2.5 million (6 percent).

3.2.9 Mississippi River from the mouth of the Missouri to the Gulf of Mexico – Channel Improvement Features

Channel improvement features on the Mississippi River consist of structural modifications for stabilizing the banks of the river in a desirable alignment and obtaining the most efficient flow characteristics for flood control and navigation by means of revetments, dikes, foreshore protection, and improvement dredging.

The Mississippi River, with a drainage area of about 1,245,000 square miles, has a wide range of flow, increasing from an approximate minimum of 90,000 cubic feet per second (cfs) (675,000 gallons per second) to a maximum of 2,345,000 cfs (17,587,000 gallons per second), which occurred in 1927 at the latitude of Red River Landing. The project flood is 3,030,000 cfs (22,500,000 gallons per second). Part of the tremendous energy of this volume of flowing water is directed toward a relentless attack on the banks of the river. This causes the unprotected banks to cave into the river. As these caving progresses, the attack becomes more direct, the bendway moves in toward the levee, and more sediment is placed in the river. The sediment is deposited downstream and creates a sandbar. This bar gradually builds out into the channel and deflects the river's attachment to the opposite bank. As the cycle is repeated, the river tends to meander and lengthen. Revetment is placed against the banks of the river at locations where mainline levees are being threatened with destruction, or where unsatisfactory alignment and channel conditions are developing. Revetment serves a threefold purpose because the river is prevented from encroaching on the main stem levees, the excess material is kept out of the stream, and a favorable channel alignment and depth are maintained. The objective is to preserve favorable alignments and efficient cross-sectional areas and to prevent the river from creating new meander patterns. In wide reaches of the river, dikes are used to contract the channel width to produce a single efficient channel for navigation and to ensure the flood carrying capacity of the river. Chutes and secondary channels are controlled for the same purpose. Improvement dredging is employed to assist the river in removing natural obstructions that deflect the current into undesirable patterns of flow and to assist in developing an efficient channel. Foreshore protection is utilized to preserve the integrity of the Mississippi River levees from attack by erosion of the batture. Erosion of the batture leads to steep slopes which, when undermined, result in considerable loss of batture and possible failure of the levee. Channel improvement features are designed using a low water reference plan developed based on established flow conditions consistent with Missouri River historical release patterns. Modification of the reservoir release and Missouri River flow patterns could require modification of the Mississippi River channel improvement features.

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3.3 WATER IN STORAGE AND RIVER FLOWS

The effects of operating the Mainstem Reservoir System under the CWCP result from changes in the amount of water in storage and river flows. These changes in reservoir elevations and release rates lead to differences in water quality, fish and wildlife habitat, wetlands, recreation, flood control, water supply, power production, and navigation.

3.3.1 General

Differing weather patterns and the resulting runoff in the basin are the primary factors governing the amount of water in storage and the release of water from the mainstem reservoirs. The broad range in latitude, longitude, and elevation of the Missouri River basin and its location near the geographical center of the North American continent result in a wide variation in climatic conditions. Average annual precipitation ranges from as little as 8 inches in the northern Great Plains to as much as 40 inches in the higher elevations of the Rocky Mountains and in the southeastern portion of the basin. Floods occur on the Missouri River and its tributaries most often in the late spring during the snowmelt season, but floods can also occur during occasional high summer or fall rainfall levels. The basin is also marked by periods of drought, most notably the nearly decade-long droughts of the 1930s and 1950s and the recent drought from 1987 to 1993.

Next to changes in precipitation, movements of water through the Mainstem Reservoir System and Lower River are controlled by demands on storage and depletions. Upper basin runoff is stored temporarily in the mainstem lakes and released throughout the year. The amount of water in storage usually peaks in July and then declines until late in winter, when the cycle begins again. Multi-year droughts cause smaller runoff volumes and gradually declining water levels in the lakes. Depletions in the form of diversions for water supply and irrigation have become a factor in basin runoff and will be more so in the future, especially as Native American Tribes in the Missouri River basin begin to exercise their Tribal water rights.

Flood control is typically accomplished by storing peak flows of the plains snowmelt and rainfall season from late February to April and the mountain snowmelt and rainfall period from May through July.

Regulation provided by the six mainstem lakes and by upper basin tributary reservoirs has nearly eliminated flood flows on the Missouri River from Fort Peck Dam downstream to the mouth of the Platte River below Omaha. Below the Platte River, flood flows still occur due to high local precipitation and runoff from downstream uncontrolled tributaries.

The greatest hydropower energy generation period extends from June through September, with peak load periods occurring in the winter heating season (December to mid-February) and the summer air-conditioning season (mid-June to early September). The normal 8-month commercial navigation season in the Lower River, which normally requires flow augmentation from Mainstem Reservoir System releases, extends from April through November. Releases for water supply intake requirements are maintained in portions of the river at certain times of the year.

Basin Hydrology

Total annual runoff varies considerably from year to year due to large variations in precipitation. Runoff, as measured at Sioux City with adjustments for depletions, has varied from a low of about 11 MAF per year to nearly 50 MAF per year over the period of record from 1898 to 1997 (Figure 3.3-1). The median runoff at Sioux City is 24.6 MAF. About 30 percent of the runoff enters above Fort Peck Dam, 45 percent enters between Fort Peck and Garrison Dams, about 9 percent enters between Garrison and Oahe Dams, 4 percent enters between Oahe and Fort Randall Dams, 6 percent enters between Fort Randall and Gavins Point Dams, and 6 percent enters between Gavins Point and Sioux City. Runoff from below Sioux City to St. Louis averages about 41 MAF (1898 through 1997), which accounts for 63 percent of the runoff in the basin. From August 1992 to July 1993, runoff above Sioux City was 31.1 MAF, while runoff below Sioux City was 85.8 MAF. The runoff below Sioux City was 209 percent of normal and reflected the beginning of the "Great Flood of 1993."

The most notable periods of drought are 1930 to 1941, 1954 to 1961, and 1987 to 1993 (Figure 3.3-1). The most recent of these droughts began when runoff fell below normal in the spring of 1987.

Relief for this recent drought came in the summer and fall of 1993 with the "Great Flood of 1993."

Annual runoff patterns have been affected by climate, upstream tributary depletions, and construction of reservoirs on the mainstem and tributaries. Depletions and evaporation from large reservoirs have reduced runoff from the basin. Depletions are likely to increase in the future, further reducing average annual basin runoff.

Total Water in System Storage

Total water in system storage gradually increased during the 1950s as the lakes filled, and reached the base of the system's annual flood control zone (57.1 MAF) for the first time in 1967. Since 1967, system water in storage has fallen below the base of this zone after dry years in 1977, 1980 to 1981, 1985, during the 1987 to 1993 drought (Figure 3.3-2), and in the current drought which began in 2000. The system has refilled in the subsequent spring of the dry year(s), except during multi-year droughts.

Future stored water levels under the CWCP are expected to remain between 55 and 65 MAF, except during multi-year droughts. Storage would fall to from 40 to 50 MAF in droughts such as those that occurred from 1954 to 1961 and from 1987 to 1993, and to as low as from 20 to 30 MAF in droughts such as the 1930 to 1941 drought. In 1990, during the 1987 to 1993 drought, storage fell to 41 MAF. Storage increased from 43 MAF to 57 MAF in 1993. Total water in system storage reached its largest volume, 72.1 MAF, in July 1975 and its second largest volume, 71.2 MAF, in 1997.

3.3.2 Fort Peck Lake

Inflow to Fort Peck Lake averages approximately 7 MAF per year. Since filling to the base of the annual flood control zone (elevation 2,234 feet and 15 MAF) in 1964, Fort Peck Lake filled into this zone each year until 1988. From 1988 through the summer of 1993, the lake was from 10 to 20 feet and 4 to 6 MAF below normal levels. Fort Peck Lake also fell below the base of the annual flood control zone during the current drought, which began in 2000. Under the CWCP, water in storage in the future during nondrought periods is expected to average from 15 to 17 MAF annually (elevation 2,230 to 2,242 feet). Storage levels would fall to 10 to 12 MAF (elevation 2,210 to 2,220 feet) in droughts like that from 1954 to 1961 and from 1987 to 1993 and to only 4 to 6 MAF (elevation 2,165 to 2,180 feet) in droughts like that from 1930 to 1941. During 1997, the lake level rose from elevation 2,235.3 to 2,250.3 feet, slightly above the top of the exclusive flood control zone.

3.3.3 Missouri River from Fort Peck Dam to Lake Sakakawea

Releases of water from Fort Peck Dam into the Missouri River average about 10 thousand cubic feet per second (kcfs) (7 MAF per year), with slightly more in wet years and slightly less in drought years. Channel capacity below Fort Peck Dam is approximately 35 kcfs.

Maximum Fort Peck Dam releases occur during the summer flood evacuation period or in the winter to support winter power demands. Daily winter release rates are generally 10 to 13 kcfs when water supply is near normal and about 7 to 8 kcfs during drought years. Maximum winter releases below Fort Peck Dam generally are not greater than those needed for full hydropower capacity, which is 15 kcfs. Releases are higher during large runoff years and lower during droughts.

Spring through fall releases are generally lower than winter releases, except during significant flood evacuation years such as 1975, when releases averaged 35 kcfs in July. During the 1987 to 1993 drought, releases in spring and early summer were in the 6- to 8-kcfs range, while late summer and fall releases varied between 3 and 10 kcfs. Releases during the tern and plover spring and summer nesting season are generally kept at below 9 kcfs.

Minimum hourly releases are generally about 4 kcfs to maintain trout habitat below the dam. When tributary inflows cause flooding in the reach, daily average releases are reduced to as low as 4 kcfs. Maximum hourly releases for power generation purposes (generally in winter) are 16 kcfs. The maximum release to evacuate the exclusive and annual flood control zones is near 35 kcfs, which is the channel capacity.

3.3.4 Lake Sakakawea

Since it was filled to the base of the annual flood control zone (elevation 1,837.5 feet and 18.1 MAF) in 1965, Lake Sakakawea has filled into this zone each year except 1981, during the 1987 to 1993 drought, and during the current drought, which began in 2000. From 1988 through June 1993, the lake was 10 to 20 feet (4 to 6 MAF) below the base of the annual flood control zone. In 1993, the water level rose from elevation 1,820 to 1,837 feet.

Under the CWCP, in future nondrought periods lake storage is expected to average 18 to 22 MAF (elevation 1,837 to 1,848 feet) annually. In droughts like that from 1954 to 1961 and from 1987 to 1993, storage will fall to 12 to 16 MAF (elevation 1,815 to 1,830 feet). In a drought like the 1930 to 1941 drought, storage will fall to only 6 to 8 MAF (elevation 1,780 to 1,795 feet). In 1997, the lake rose from elevation 1,838 to 1,854.4 feet, above the 1,854-foot top of the exclusive flood control zone. Under the CWCP, high and low lake elevations affect the Fort Berthold Reservation with shoreline erosion and erosion/exposure to known cultural sites.

3.3.5 Missouri River from Garrison Dam to Lake Oahe

Under the CWCP, releases from Garrison Dam are generally lowest in the spring and fall and highest in the winter and summer. Releases in non-flood periods may reach 40 kcfs, while minimum daily average releases may be as low as 9 to 10 kcfs. The channel capacity below Garrison Dam is approximately 60 kcfs.

In the winter nonnavigation season, monthly average releases from Garrison Dam, normally in the range of 18 to 22 kcfs in December, are usually increased to the 22- to 30-kcfs range in January and February to accommodate peak power demands and help balance the water in the system. Maximum daily winter releases from Garrison Dam necessary to limit downstream flooding are just over 30 kcfs. Winter releases are usually cut back to near 18 kcfs when the river first freezes in December. As freezing progresses, releases may be gradually increased. If the river ice recedes due to warmer weather, it is necessary to again limit releases during the refreeze period. Releases are normally reduced to about 20 kcfs by mid-March as the demand for power declines. In drought periods like the 1987 to 1993 drought, winter releases may be cut back in March and April to 10 to 15 kcfs to conserve water.

In the spring and fall, average monthly releases during droughts are also limited to 10 to 15 kcfs, the minimum level necessary to provide hydropower and to protect water supply intakes, water quality, irrigation needs, recreation, and fish and wildlife. During nondrought periods, spring and fall average monthly releases range from 20 to 30 kcfs or even higher during flood evacuation periods. To discourage terns and plovers from nesting too near the water during the mid-May through August nesting period, daily releases are usually fixed at a constant rate in the 19- to 26-kcfs range with hourly peaking limited to 6 hours a day near 30 kcfs. This release pattern restricts hydropower capacity to less than full powerplant capacity. During prolonged droughts, daily average releases for the birds may be in the 10- to 15-kcfs range with peaking restricted even further. During large system inflow years, large flood control evacuation release rates are necessary and nesting flow restrictions are lifted.

3.3.6 Lake Oahe

Lake Oahe filled to the bottom of the annual flood control zone (elevation 1,607.5 feet) for the first time in 1967. After 1967, the lake fluctuated within about 10 feet of the bottom of this zone until the end of 1988, when the lake dropped to nearly 20 feet (or 6 MAF) below the base of the zone. At the peak of the 1987 to 1993 drought, the lake dropped an additional 10 feet to elevation 1,581 feet. In 1993, the lake level rose from 1,590 feet to over the base of the annual flood control zone, cresting near 1,611.0 feet. In 1996 and 1997, the lake peaked at elevation 1,618 feet. Lake Oahe fell below 1,607.5 again in 2000 due to the current drought. Under the CWCP, these high elevations affect both the Standing Rock and Cheyenne River Reservations with community flooding and shoreline erosion. Known cultural sites are affected by erosion/exposure caused by fluctuating pool elevations.

3.3.7 Missouri River from Oahe Dam to Lake Sharpe

Oahe Dam water releases have a seasonal pattern. During the navigation season, water releases generally range from 22 to 34 kcfs to meet downstream demands for navigation, but flows may be higher or lower during floods or droughts. During the fall, releases from Oahe Dam are reduced to 22 to 30 kcfs to provide capacity in Lake Francis Case for winter releases from Oahe used to generate power. Hourly releases fluctuate from 0 to 58 kcfs for peaking power generation. Winter releases average 20 to 30 kcfs in nondrought years and 15 to 20 kcfs in drought years. There is no minimum release requirement from Oahe Dam, although weekend releases of 3 kcfs are provided during the daytime hours of the recreational fishing season. The channel capacity below Oahe Dam is approximately 60 kcfs for open-water conditions but may be as low as 25 kcfs under severe winter ice conditions.

3.3.8 Lake Sharpe

Generally, weekly flows from Oahe Dam are released at Big Bend Dam, and there is minimal fluctuation in Lake Sharpe water level. There are no minimum flow requirements below Big Bend Dam. Hourly releases at Big Bend Dam fluctuate from 0 to 110 kcfs for peaking power generation. Little fluctuation of water levels or average annual water in storage is expected in the future under the CWCP. Elevations usually fluctuate between 1,420 and 1,421 feet each week; however, the lake is allowed to drop as low as elevation 1,419 feet during high hydropower demand periods. Although there are comparatively minimal elevation fluctuations in Lake Sharpe under the CWCP, any fluctuations and wave action affect known cultural sites along the Lower Brule and Crow Creek Reservations. Lake Sharpe was lowered to 1,418.5 feet during the higher release years of 1996 and 1997 to help alleviate flood effects at Pierre, South Dakota.

3.3.9 Lake Francis Case

Lake Francis Case has filled into the annual flood control and multiple use zone (elevation 1,350 to 1,365 feet) each year since it was first filled in 1954. The water surface elevation normally varies with the year from about elevation 1,337.5 to 1,357 feet, while total storage varies from about 2.4 to 3.6 MAF. The greatest variability occurs during the fall drawdown period, which affects known cultural sites along the Crow Creek and Lower Brule Reservations by causing site exposures. The lake reached a record high elevation of 1,372.2 feet in May 1997.

During the fall, water releases from Fort Randall Dam are not replaced with Oahe and Big Bend releases of the same magnitude, thus resulting in the drawdown of Lake Francis Case by about 18 feet to elevation 1,337.5 feet. The vacated storage space is then refilled from upstream project releases during the winter season. The refilling allows higher winter releases from Oahe and Big Bend Dams to help meet peak hydropower demand; otherwise, releases from Oahe, Fort Randall, and Gavins Point Dams would be constrained by ice constricting the open river portion of the channel below the projects. This drawdown pattern occurs in drought and nondrought years.

The CWCP originally allowed for an annual evacuation of 2 MAF of storage and a drawdown of about 35 feet in Lake Francis Case. Such a drawdown of Lake Francis Case would provide an increase in winter energy generation of 300 million kWh; however, because of adverse impacts to Crow Creek and Yankton Reservations and other local residents, the drawdown has been limited to 0.9 MAF (18 feet) since 1972, which provides for an increase of 150 million kWh of winter energy generation. The drawdown to 1,337.5 feet msl is now the currently adopted water control plan.

3.3.10 Missouri River from Fort Randall Dam to Lewis and Clark Lake

Releases from Fort Randall Dam vary considerably during the year. Under the CWCP, this variability affects both the Yankton and Santee Reservations. The major concerns are that these fluctuations cause bank erosion and affect water intakes. Maximum hourly releases for hydropower generation are 45 kcfs. The minimum hourly release is zero kcfs, except during the spring game fish spawning season, when the desired minimum hourly release is 15 to 20 kcfs. In the navigation season, spring through fall monthly average releases are usually 20 to 36 kcfs to meet navigation targets downstream. During extended droughts, spring through fall monthly average releases may drop to as low as 3 to 15 kcfs, even in years when navigation is supported. Monthly average releases may also drop to 3 to 15 kcfs if there is too much water downstream, as occurs during flood years.

In winter, releases are generally kept in the 8- to 17-kcfs range to meet nonnavigation service levels downstream. At above-normal storage levels, winter releases are typically about 18 kcfs or even higher following large floods. During drought years, winter releases are generally 8 to 10 kcfs.

During the mid-May to mid-August nesting season of threatened and endangered birds, hourly releases are increased to 36 kcfs for 6 hours to encourage the birds to nest at higher island elevations where the nests are less vulnerable to inundation from late summer higher daily average navigation releases. This peak release permits average daily releases to be increased as needed to continue to meet the navigation requirements when the inflows from tributaries to the Lower River decrease. The 36-kcfs peak is less than powerplant capacity. During large system inflow years, large flood control evacuation rates are necessary and nesting flow restrictions are lifted. There is also a 15- to 20-kcfs hourly minimum flow to protect fish spawning from mid-April through June.

3.3.11 Lewis and Clark Lake

Lewis and Clark Lake water elevation and storage levels vary little within and between years. The water level is drawn down from elevation 1,207 feet toward the base of the annual flood control and multiple use zone (elevation 1,204.5 feet) each spring and the lake is allowed to fill before fall into the flood control and multiple use zone. The lake is operated at elevation 1,206 feet during the tern and plover nesting season, and it is allowed to rise to elevation 1,207 feet just before each fall. The Ponca and Santee Tribes are affected by delta formations. The recent change from the previous elevation of 1,208 feet was adopted to minimize shoreline erosion. No change in this pattern is anticipated in the future under the CWCP.

3.3.12 Missouri River from Gavins Point Dam to St. Louis (Lower River)

Releases from Gavins Point Dam follow the same pattern as those from Fort Randall Dam because there is little active storage in Lewis and Clark Lake. Releases from both dams are based on the amount of water in system storage, which governs how much water will be released to meet service demands in the portion of the Lower River from Sioux City to St. Louis. Constraints for flood control, threatened and endangered bird nesting, and fish spawning requirements also are factors governing releases.

Releases from Gavins Point Dam generally fall into three categories: navigation, flood evacuation, and nonnavigation releases. In the navigation season, which generally runs from April 1 through December 1 at the mouth, releases from Gavins Point Dam are generally 25 to 35 kcfs. In the winter, releases are in the 10- to 20-kcfs range. In wet years with above-normal upstream inflows, releases are higher to evacuate flood control storage space in upstream reservoirs. Maximum winter releases are generally kept below 24 kcfs to minimize downstream flooding problems caused by ice jams in the Lower River. During the 1987 to 1993 drought, nonnavigation releases were generally in the 8- to 9-kcfs range immediately following the end and preceding the start of the navigation season. During cold weather, releases were increased up to 15 kcfs, but generally averaged 12 kcfs over the 3-month winter period from December through February. In more recent years, winter releases have averaged from 25 kcfs to as high as 30 kcfs for flood storage evacuation.

Under the CWCP, navigation releases are provided through November if July 1 system storage is at least 41 MAF. In the 1987 to 1993 drought, navigation service was not provided for a full 8 months in some years even though water in storage exceeded 41 MAF. Navigation releases cease in mid-September if July 1 system storage is 25 MAF or lower.

Full-service navigation releases vary, depending on the demand for water at downstream navigation target points at Sioux City, Omaha, Nebraska City, and Kansas City. Operating experience since 1967 has demonstrated that flow rates of 31 kcfs at Sioux City and Omaha, 37 kcfs at Nebraska City, and 41 kcfs at Kansas City are sufficient to maintain the 9- by 300-foot navigation channel. Generally, an average navigation season release of 35 kcfs at Gavins Point Dam will provide downstream flows necessary for full service. If downstream tributary inflow above Kansas City is abnormally low, then additional water must be released from Gavins Point Dam to meet the 41-kcfs target at Kansas City. If downstream tributary inflows are high, then the flow target at Sioux City will determine the system release rate. When system storage is low, less than full service is provided by lowering target flows by up to 6 kcfs (minimum service). In extended droughts when navigation has ended or during floods, releases may be reduced to 9 kcfs or less.

Usually, navigation flow target requirements result in increasing summer releases to meet target flows as tributary inflows decline. Releases as high as 39 kcfs from Gavins Point Dam have been necessary to provide full service at Kansas City. Operation constraints dictate that releases from Gavins Point Dam not be increased between mid-May and mid-August because islands with nesting terns and plovers could be flooded. This constraint necessitates higher-than-needed late-spring and early-summer releases to anticipate the demand for late-summer navigation releases. The forecasted maximum late-summer navigation release requirement is established in mid-May, prior to nest initiation. This commitment dictates releases at least through early summer. To conserve water during the 1987 to 1993 drought, the summer release target was met only every third day until this maximum release was constantly needed for navigation. If conservation is not required, a constant day-to-day release target is set. If the release was set too low and a tributary inflow is lower than expected, navigation releases may not be adequate to maintain the desired navigation service. During the 1987 to 1993 drought, summer release restrictions at Gavins Point for the protection of terns and plovers resulted in not always meeting Nebraska City and Kansas City targets during August. A portion of the shortfall for the Kansas City target was met by water released from the Corps' Kansas River projects.

Conversely, when the system water supply is unusually large, as in 1996 and 1997, service levels for the orderly evacuation of stored flood waters take precedence over nesting birds. Consequently, release rates from Gavins Point may have to be increased to as much as 25 kcfs over and above full-service navigation flows during nesting.

During the 1987 to 1993 drought, minimum nonnavigation releases from Gavins Point Dam were set at 7.5 to 8 kcfs to protect downstream water supply intakes. During extreme cold spells, releases were increased up to a maximum of 17 kcfs to compensate for the loss of channel carrying capacity caused by ice bridges in the channel and ice-blocked water supply intakes. In early spring prior to the navigation season, releases were reduced to as low as 6 kcfs, depending on downstream tributary inflows, to conserve stored water.

In general terms under the CWCP, the Winnebago and Omaha Reservations near Sioux City, Iowa, and the Iowa and Sac and Fox Reservations near St. Joseph, Missouri, are affected in much the same way. Release fluctuations from Gavins Point may generate isolated erosion problems along Reservation shorelines. Water intake concerns could also be a potential problem.

3.3.13 Mississippi River from St. Louis to Mouth

The Mississippi River at St. Louis receives approximately 53 percent of its flow from the Upper Mississippi Basin and about 47 percent from the Missouri Basin. The average flow rate is approximately 198 kcfs. The maximum recorded flow rate was 1,300 kcfs in 1844. The minimum recorded flow rate was 18 kcfs in 1863. Peak flows typically occur in April or May, and minimum flows typically occur in December and January. Fluctuation in river stage may be as high as 40 feet during the year. The Mississippi River at the junction with the Ohio River receives about 45 percent of its flow from the Mississippi River and about 55 percent from the Ohio River.

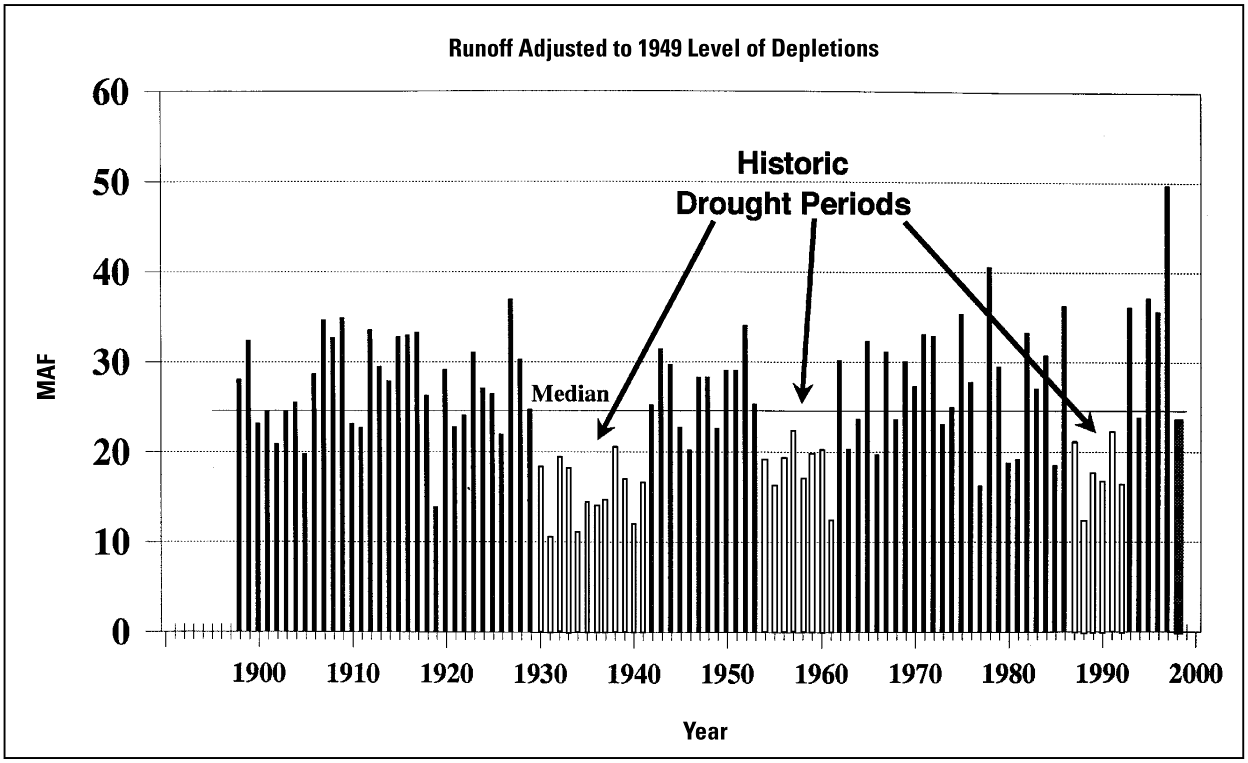

Figure 3.3-1. Annual runoff at Sioux City, Iowa.

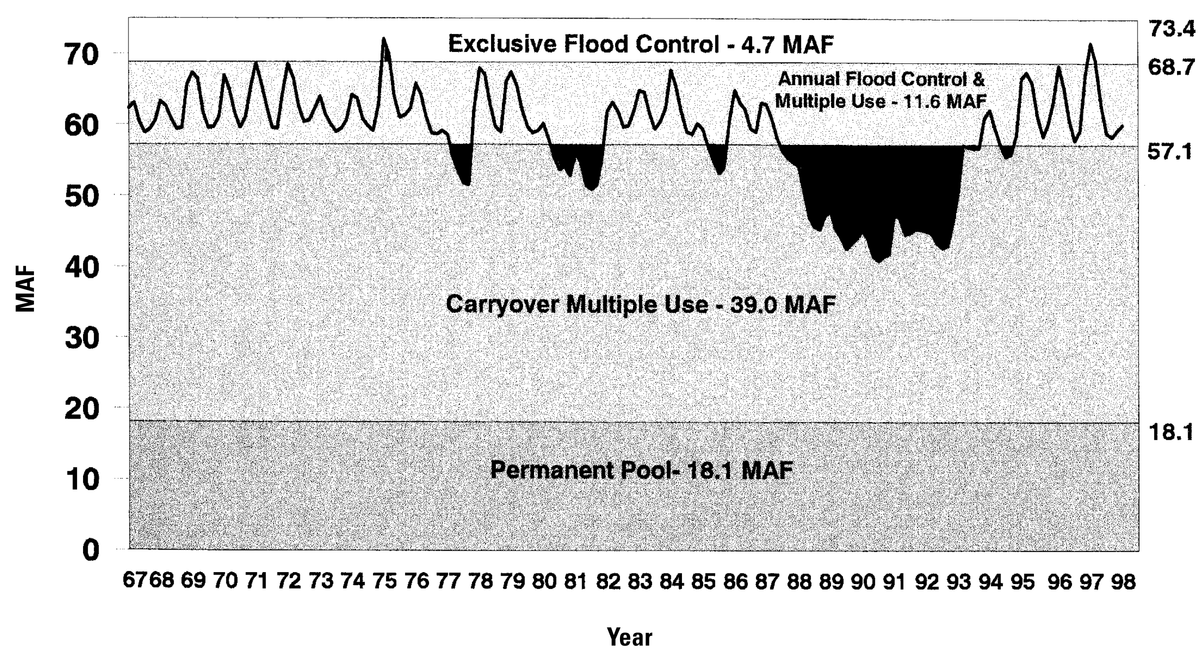

Figure 3.3-2. Total Mainstem Reservoir System end-of-month water in storage (MAF) from 1967 through 1998.

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3.4 SEDIMENTATION, EROSION, AND ICE PROCESSES

Changes in storage regimes and river flows could potentially lead to changes in sedimentation and erosion patterns, which in turn could affect storage and channel capacities, shoreline erosion, and flooding potential in affected areas. Agricultural and Reservation lands, cultural resources and historic properties, recreational areas, and fish and wildlife habitat are potentially affected by sedimentation and erosion in lakes and river reaches.

3.4.1 General

All six of the mainstem lakes are located in the Great Plains portion of the Missouri River basin, where the slope is generally gentle. Land surface is a mixture of glacial material, river sediments, and wind-blown sediment. Soils are a mixture of clay, silt, sands, and gravels. Bedrock is generally composed of shales and sandstones. Because of these soil features, shorelines and the bottoms of lakes and river reaches are highly erodible. Water action from waves, currents, and ice breakup and freezeup cause erosion.

River Channels

The Missouri River and its tributaries flow through the highly erodible sediments. Sediments from upstream and tributary sources are deposited in the upper ends of the lakes. As a result, the channels below the dams are subject to erosion as the clear water released from each dam picks up sediment and transports it downstream. This process results in a deepening and progressive armoring of the riverbed (Figure 3.4-1). Armoring is the gradual loss of finer particles from the sediment and the buildup of progressively larger sediment, such as gravel and cobbles. Unprotected riverbanks are also being eroded, but at a reduced rate in the absence of historic flood flows. Without overbank, sediment-laden flows, new high banks are not formed in the reaches immediately below the dams.

Fewer flood flows have led to less erosion of the banks and sandbars. Sediment deposits have built up below the mouths of larger tributaries because flows are no longer high enough to move the sediment downstream.

In general, downstream from Omaha, tributaries provide a sufficient level of coarse sediments to limit riverbed erosion, but degradation continues to be a problem in isolated locations. One of these locations is the Kansas City reach. Where degradation occurs, water levels decline, thus affecting resources, such as wetlands, along the river that depend on a water source from the river. Non-flood flows and degradation mean less formation of river-dependent water bodies, such as oxbow lakes. Erosion of the channel bed may also lead to additional bankline erosion in areas where the banks are unprotected. The mouths of tributaries are also susceptible to degradation where the main river's channel has been degraded.

Channel changes are expected to continue to occur in the future, although in many reaches the process is slowing because the armoring of the channel bed or the channel slope is reaching equilibrium. Erosion of the river channels will be confined primarily to periods of high flood-type flows, which are rare because of the large flood-storage capacity of the lakes. If left unprotected, islands and banks would continue to be eroded, thus leading to a wider channel and smaller and fewer islands. Some natural armoring of islands and shorelines will occur. Any changes to existing flow patterns will alter the present equilibrium, and if the changes are large enough, they could lead to further shifts in the channel.

From Sioux City to the Missouri River's mouth near St. Louis, the Corps has constructed river control structures to form a 9-foot-deep by 300-foot-wide navigation channel within a 600- to 1,100-foot-wide river. During the 1950s, there was intense construction of river training structures, with thousands of dikes and revetments installed. The channel was shortened, and its width was narrowed. Dredging of the channel is occasionally required in several reaches to maintain adequate navigation channel depths and widths.

River Ice

In winter, river flows below the dams may affect the formation and breakup of ice on the river. River ice formation is important primarily because it may play a role in causing floods by reducing the channel's water-carrying capacity and backing water upstream of ice bridges. The formation of river ice also reduces flow downstream, potentially affecting downstream resources dependent on river flow (e.g., water supply intakes). River ice is more prevalent in the northern portion of the river, but is also a factor in the Lower River. Mainstem dam releases in winter are adjusted to take into account ice conditions.

The potential for ice cover and resulting problems at any given location along the Missouri River is a function of cold weather intensity and flow discharge. Analysis of existing ice records, flow data, and air temperature records indicates that ice dynamics are related to the sequence of air temperatures, water surface elevations, and discharge rates that occur at particular locations.

Ice does not hinder river flow significantly as long as the ice is in motion; however, when ice begins to bridge or collect along the streambank, the ice cover makes a portion of the channel unavailable for flow, adds roughness to the channel, and can also cause stage increases with potential for flooding. These factors hinder flow of the river and temporarily reduce downstream flow rates. For these reasons, minimum releases from Gavins Point Dam are slightly higher during the winter (an average release of 12 kcfs compared to 9 kcfs during other seasons) to adequately serve water supply intakes downstream.

The Corps operates the Mainstem Reservoir System releases in winter to minimize problems with ice; however, sometimes problems cannot be averted. Ice jams can back up river flow, resulting in flooding upstream and the lack of adequate water downstream for water supply.

Sediment Deposition in Lakes

The mainstem reservoirs act as catchment basins for the tremendous load of sediment carried by the Missouri River. Approximately 20 to 25 thousand acre-feet (KAF) of sediment enters each of the four largest reservoirs each year. Approximately 100 KAF enters the mainstem reservoirs annually. The loss of storage capacity to date is about 5 percent of the total system capacity. Sediment is deposited slightly below the prevailing pool level. Most of the loss to the capacity of the permanent pools occurred during the filling period before 1965. Since then, the loss has been occurring primarily in the carryover multiple use zone. All six mainstem lakes have large deltas formed at their headwaters. These large sediment deposits continue to grow, although they are confined to the upper reaches of each reservoir or its tributary arms. Despite the high sediment loads, the useful life of the reservoirs is at least several hundred years due to their large volume.

These large growing deltas have posed problems at many of the mainstem lakes. With the channel capacity reduced by the sediment accumulation at the head of the reservoirs, flooding and high groundwater tables have caused problems at the upstream ends of Lake Sakakawea, Lake Oahe, and Lewis and Clark Lake. As deposits have grown in size and extended down into the lakes, they have blocked boat ramps and even cut off reservoir arms. Boat ramps are often concentrated in lake arms, as are fish spawning and rearing habitat.

Changes in lake levels also lead to changes in sediment patterns within the lakes. When lakes are lower, sediment is eroded from the deltas and is deposited farther downstream in the lake. With subsequent higher storage, sediment is again deposited nearer to the head of the lake.

Erosion of Lake Shorelines

In addition to sediment transported by the river, some sediment enters the mainstem lakes from shoreline erosion processes. Lake shorelines are highly erodible because the river valley slopes are terraced and the soils consist of sands, silts, clays, gravels, and shales. Over the centuries, the Missouri River has cut through layers of gravel, sand, silt, and clay. As the river cut through the various layers of sediment, major terraces were created because of the difference in erodibility of the layers. The uppermost layer near the top of the lakes tends to be silty wind-blown soils of the plains, which is highly erodible. Much of the shorelines of Lake Sakakawea and Lake Oahe cut into this type of terrace. Erosion of shorelines threatens recreation facilities and numerous historic and cultural properties. The thousands of miles of lake shorelines in the mainstem lakes remain largely unprotected because the costs of protection are high.

Because these shorelines consist of highly erodible soils, wave and ice action leads to accelerated erosion in the form of slumping cut-banks (Figure 3.4-2). The cut-banks are continually slumping into the lakes at rates as high as 20 feet per year. At such rates, there is not sufficient opportunity for protective vegetation to take root and protect the cut-banks from further erosion. Some cut-banks with high gravel or cobble content may become armored as rocks collect at the toe of the cut-bank, thus protecting it from further erosion. This occurrence is an exception, however, not a routine event. Erosion of the shorelines of the mainstem lakes is expected to continue to some extent throughout the life of the projects.

The slumping cut-bank material forms shelves of shallow water along the shorelines, with the water edge lapping at the toe of the cut-bank (Figure 3.4-2). The majority of eroded material usually remains immediately offshore, forming a very flat beach slope. As a result, the perimeters of the lakes are slowly becoming shallower and wider. In some cases, sediment moves along shore in the direction of the prevailing wind or current and collects in deeper channels of tributary arms. Some lake arms are filling and being cut off by these reservoir sediments and collapsing cut-banks.

Regulation of the mainstem lakes results in seasonal and annual water-level fluctuations that may aggravate or alleviate bank erosion in the lakes. High water levels and wave action cause erosion of unstabilized banks. Erosion is sporadic and particularly prevalent in years when excess runoff is stored in the flood control zones of the reservoirs. Steady water levels tend to erode a single cut-bank continuously. If the cut-bank contains less erodible material or armoring material such as gravel, shale, boulders, or cobbles, it may become stabilized and not erode. Lower water levels expose silt deposits, where subsequent drying causes hardened soils that do not revegetate. Lower water levels also allow waves to work on shorelines and terraces that were previously protected by overlying water. Erosion of the lower levels may further undermine cut-banks and possibly lead to larger slides or bank cavings.

3.4.2 Fort Peck Lake

Sediment deposition in Fort Peck Lake has averaged 18 KAF per year from 1938 to 1986, for a total deposition of about 5 percent of the original volume. There has been an 8 percent loss in the permanent pool and a 4 percent loss in the carryover multiple use zone. Most of the deposition has occurred upstream of the Musselshell Arm between RM 1866 and RM 1900, where the sediment depth is as great as 30 feet and the channel loss is about 50 percent.

The cut-banks along Fort Peck Lake are eroding at a rate of 4 feet or less per year. This is comparatively low because the shoreline is composed mostly of harder shale materials.

3.4.3 Missouri River from Fort Peck Dam to Lake Sakakawea

Although most of the bed degradation below Fort Peck Dam occurred before 1966, some degradation continues in the upper and center portions of the reach, causing some streambank erosion. Degradation below the dam (RM 1772) occurs at differing degrees to about RM 1650. On the north bank of this reach, the Fort Peck Reservation extends from RM 1766 to RM 1630.4. Below RM 1650, no significant degradation has occurred since 1966.

There has been little increase in the width of the river channel due to streambank erosion, except in isolated stretches between RM 1612 and RM 1746. Streambank erosion rates for the 204-mile reach were about 97 acres per year from 1975 to 1983. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Fort Peck Reservation identifies erosion as “moderate.”

Bed materials have become more coarse over time below Fort Peck Dam, with finer material deposited in the lower portion of the reach above Lake Sakakawea. Gravels and cobbles predominate below the dam. The finer materials have been washed downstream and not replaced.

Sediment is being deposited beginning at the mouth of the Yellowstone River, where a delta has formed because of a reduction in flood flows and the backwater effect of Lake Sakakawea. The associated increase in the elevation of the Yellowstone River channel has led to higher river water levels, local flooding, and higher water tables.

3.4.4 Lake Sakakawea

Sediment deposition has been predominantly confined to the upper end of Lake Sakakawea between RM 1510 and 1553. Little deposition has occurred in the lake below RM 1490. Deposition from 1956 to 1988 averaged about 26 KAF per year, for a total loss of approximately 4 percent of the gross storage capacity of the lake.

Deposition in Lake Sakakawea’s delta causes increases in flooding as a result of a loss of channel volume, which has reached nearly 50 percent near Williston (RM 1544). The Corps has built levees in the Williston area to protect property. High groundwater levels when the lake is full reduce crop yields in farmlands around the delta.

Along the shoreline, cut-banks are eroding at rates as high as 19 feet per year. There is little sign that erosion is decreasing, and there is visual indication that erosion increased during the high water years 1995 through 1997.

The Fort Berthold Reservation extends on both shorelines of Lake Sakakawea from RM 1483 to RM 1410. The Reservation represents 41 percent of Lake Sakakawea's total river miles. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Three Affiliated Tribes of Fort Berthold reported erosion as "extensive" on the Reservation.

3.4.5 Missouri River from Garrison Dam to Lake Oahe

Degradation of the riverbed below Garrison Dam (RM 1390) occurs primarily in the first 35 miles below the dam. Erosion was greatest before the beginning of power generation in 1956 and began to level off in about 1983. The channel below the dam degraded about 5 feet between 1950 and 1975. Further degradation is unlikely to occur, except during high-flow periods. Grain size has increased over the years in the 25 miles below Garrison Dam, thus indicating a gradual armoring of the channel. The riverbed 25 to 50 miles below the dam continues to degrade, but the rate of degradation became lower after 1975. Since 1960, erosion of the streambed in this area totals about 4 feet.

The channel widths for the first 20 miles below Garrison Dam have remained fairly constant. Only near the mouth of the Knife River (RM 1378) is the channel width decreasing. This decrease is due to a buildup of Knife River deposits resulting from a reduction in flood flow currents. Farther downstream, the channel is widening. Streambank erosion rates were 48 acres per year from 1978 to 1982 for the 87-mile reach.

Bank erosion continues in the reach, but has actually declined since dam closure in 1953, probably due to the reduction in high spring and early summer flows. Before 1953, bank erosion averaged 200 to 250 acres per year. Since 1953, the loss has been about 60 acres per year. The difference between pre- and post-1953 is that before 1953, bank erosion was accompanied by accretion during floods in other parts of the channel. In contrast, little or no new accretion has occurred after 1953 because flood peaks were eliminated or reduced by the flood control capacity of the upstream mainstem reservoirs. Some bank protection was constructed by the Corps in this reach in the 1980s, which has successfully limited the erosion in most subreaches.

3.4.6 Lake Oahe

Lake Oahe extends from RM 1303 to Oahe Dam at RM 1072. On the western shoreline of Lake Oahe, the Standing Rock Reservation extends from RM 1269.6 to RM 1194.0 and the Cheyenne River Reservation extends from RM 1194.0 to RM 1110.2. The Standing Rock and Cheyenne River Reservations represent 33 percent and 36 percent, respectively, of Lake Oahe's west-bank river miles.

Sediment deposition in Lake Oahe has been significant in the delta and at the mouths of four major tributaries: the Cheyenne, Moreau, Grand, and Cannonball Rivers. These tributaries affect the Reservations on the west shoreline of the lake. The Cannonball and Grand Rivers run along and through the Standing Rock Reservation. The Moreau River runs through the Cheyenne River Reservation, and the Cheyenne River runs along the south boundary of the Reservation. Average bed elevation of these tributaries has increased from 2 to 6 feet since 1958. Delta sediments originate from the Missouri River above the lake and the Knife and Heart Rivers, which enter the Missouri River below Garrison Dam. The loss of gross storage capacity, about 23 KAF per year, constitutes about 5 percent of the permanent pool and 3 percent of the carryover multiple use zone, resulting in a 1 percent water-level gain in the annual flood control and multiple use zone.

Cut-banks along the shoreline of Lake Oahe are eroding at rates as high as 23 feet per year. Visual inspection indicated that erosion increased in the high water years 1995 through 1997. Based on a survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the erosion along the Standing Rock and Cheyenne River Reservations is reported by the Tribes as "extensive" under the CWCP.

3.4.7 Missouri River from Oahe Dam to Lake Sharpe

The tailwater of Oahe Dam declined less than 1 foot in elevation through 1982. It has since been relatively stable. Bank erosion is not a problem because protective measures have been constructed.

3.4.8 Lake Sharpe

Lake Sharpe sediment deposition begins in the upper end of the lake at RM 1062, 10 miles below Oahe Dam and extends downstream to RM 1020, 37 miles above Big Bend Dam. The Lower Brule Reservation extends along the western shoreline of Lake Sharp from RM 1050 to below Big Bend Dam at RM 967. The Crow Creek Reservation on the eastern shoreline of Lake Sharp extends from RM 1041 to below Big Bend Dam at RM 967. The Lower Brule Reservation represents 89 percent of Lake Sharpe's river miles while the Crow Creek Reservation represents 77 percent of Lake Sharpe's river miles.

From 1963 to 1991, the elevation of the riverbed from RM 1037 to RM 1050 increased 10 to 18 feet. About 80 percent of the deposition occurred before 1976. The Bad River is the major source of sediment. Deposition is estimated to be about 4 KAF per year. Loss of capacity has been limited to about 8 percent of the permanent pool.

The cities of Pierre and Fort Pierre, South Dakota, located on opposite sides of the river near the mouth of the Bad River, are within the deposition reach. Both communities experience a high water table and risk flooding due to the decrease in the channel capacity. The primary impact of the deposition is the effect it has had on ice bridging and increased potential flooding during extremely cold winter periods. A 5-foot test drawdown of Lake Sharpe in combination with moderate Oahe Dam releases in the fall of 1995 indicated that sediment in the Pierre-Fort Pierre area can be flushed farther downstream into Lake Sharpe. The benefit of doing this is questionable due to impacts associated with the re-deposition of the sediment.

3.4.9 Lake Francis Case

Lake Francis Case extends from Fort Randall Dam at RM 880 upstream to Big Bend Dam at RM 987. Both the Lower Brule and Crow Creek Reservations extend from above Big Bend Dam to 20 miles downstream of the dam at RM 967 on both the western and eastern shorelines of Lake Francis Case. Both the Lower Brule and Crow Creek Reservations represent 19 percent of the river miles of Lake Francis Case.

At RM 970, up to 10 feet of deposition has occurred in the old channel. From RM 965 to the mouth of the White River (near RM 960), up to 25 feet of deposition has occurred in the old channel. From RM 940 to RM 950, sediment deposition ranges from 20 to 40 feet. Grain size gradually decreases from the mouth of the White River downstream to RM 930, reflecting the higher flow velocities at the mouth of the White River. Below RM 920, sediment deposition ranges from 5 to 15 feet. The loss in storage capacity of Lake Francis Case between 1953 and 1996 has been about 790 KAF (12.7 percent of the lake's gross storage capacity) or about 18 KAF per year.

The loss in storage capacity is predominantly due to White River sediment settling on the bottom of the lake. The sediment buildup has resulted in the formation of an upper lake that is 8 to 10 feet higher in elevation than the remainder of the lake during the fall drawdown.

3.4.10 Missouri River from Fort Randall Dam to Lewis and Clark Lake

The tailwater area of Fort Randall Dam from RM 880 to 860 has experienced up to 6 feet of degradation of the bed and widening of the channel from 1953 to 1986. The rate of erosion has decreased over this period. Streambank erosion since closure of the dam in 1953 has averaged about 40 acres per year compared to a pre-dam rate of 135 acres per year. The river has coarser bed material above than below RM 870, indicating some armoring of the channel below the dam. Downstream from the tailwater area, less erosion of the bed and streambanks occurs.

The Yankton Reservation is located on the northern banks of this reach, extending from approximately RM 880 at Fort Randall Dam to RM 845. The Yankton Reservation extends along approximately 80 percent of the northern banks of this reach. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Yankton Sioux Tribe reported "extensive" erosion problems on Reservation land.

At the mouth of the Niobrara River (RM 843.5), a delta of sediment has built up near Ponca Tribal Lands. The Ponca Tribal Lands is located at the confluence of the Niobrara River and the Missouri River. The delta has formed as a result of the lack of large flood flows to transport sediment downstream. Based on the survey performed by the

Mni Sose Intertribal Water Rights Coalition (February 1994), the Ponca Tribe reported erosion of Tribal land as "unknown."

3.4.11 Lewis and Clark Lake

Sediment is deposited in the Lewis and Clark Lake delta from the mouth of the Niobrara River downstream to RM 827. The Santee Reservation is located along the south shoreline in the affected region. The grain size of sediments decreases downstream of the Niobrara River. About 3 KAF of sediment is deposited each year. The bed elevation increased about 5 feet from 1954 to 1985. The loss of storage capacity is approximately 14 percent of the permanent pool and 11 percent of the carryover multiple use zone. Most of the sediment comes from the Niobrara River. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Santee Sioux Tribe reported erosion on the Santee Reservation as "marginal."

3.4.12 Missouri River from Gavins Point Dam to St. Louis

There has been a gradual erosion of the riverbed below Gavins Point Dam to Ponca, Nebraska, since 1955. The extent of erosion is highest (about 10 feet) in the reach immediately below the dam. The bed material in this reach has also become progressively more coarse than in the lower reach, thus indicating gradual armoring of the channel bed over time. The rate of riverbed erosion has diminished since 1980.

Streambank erosion has also occurred below Gavins Point Dam. The rate of erosion declined after 1955. Rates of erosion since closure in 1956 have averaged 157 acres per year between Gavins Point and Ponca State Park, compared to a pre-dam rate of 202 acres per year. Rates of erosion have declined somewhat since 1975.

Streambank erosion problems are generally confined to the river above Ponca because the banks are stabilized below Ponca. Coarse materials from the tributaries downstream from Omaha, except at Kansas City, keep most of the downstream reaches of the Missouri River from degrading.

In the Lower Missouri River below Gavins Point, the Winnebago and Omaha Reservations extend from RM 720 to RM 705 and RM 705 to RM 691, respectively. The Iowa and Sac and Fox Reservations are located at approximately RM 495. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Winnebago and Iowa Tribes reported "extensive" erosion at their respective Reservations. The Omaha Tribe reported "moderate" erosion of Reservation land, and the Sac and Fox Tribe reported the amount of erosion on Reservation land as "none."

Below Ponca, there are only a few sandbars and side channels. The channel from Ponca to the Missouri River mouth is 754 miles long. Floodplain levees along much of this reach have reduced overbank flooding, thereby decreasing water flows to old sloughs and chutes.

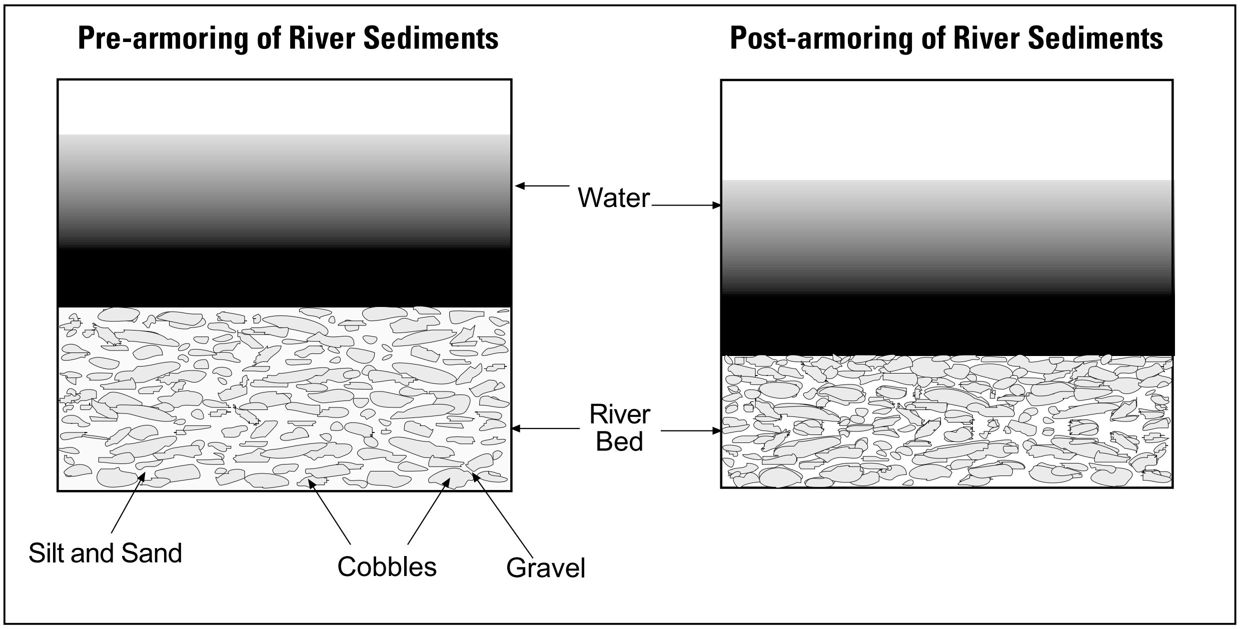

Figure 3.4-1. Armoring of riverbed.

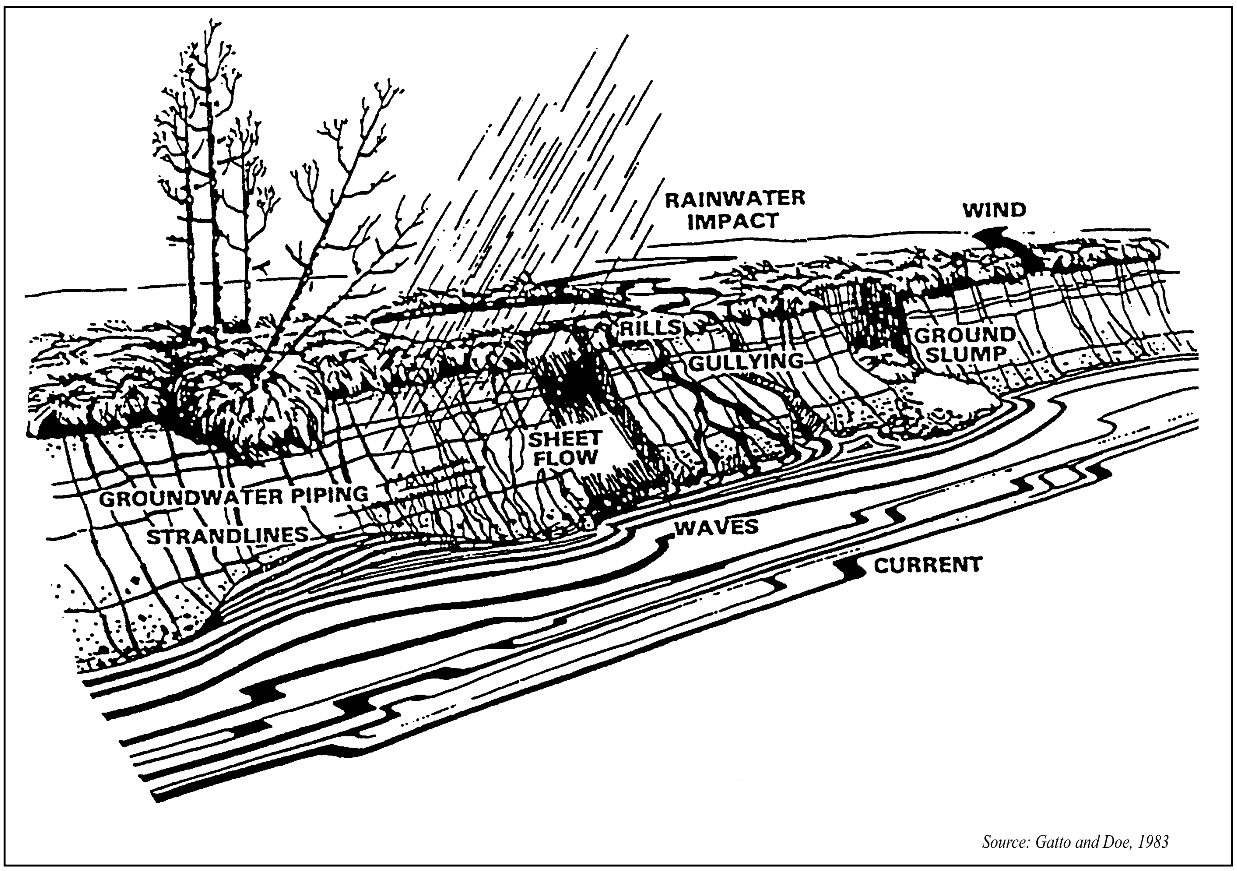

Figure 3.4-2. Bank erosion processes and bank characteristics contributing to erosion at northern lakes.

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3.5 WATER QUALITY

This section discusses the past and current water quality conditions of the Missouri River from Fort Peck Lake to the Mississippi River. The discussion provides a frame of reference to review and assess potential impacts of alternative water control plans on water quality issues. This section provides a discussion about the water quality during pre-dam conditions and the impacts to water quality under the Corps' current CWCP. It also addresses water quality regulations, water quality monitoring, National Pollutant Discharge Elimination System (NPDES) permitting, anti-degradation, and specific lake and river water quality issues.

The Missouri River Mainstem Reservoir System (Mainstem Reservoir System) provides an important water resource to millions of people. Not only is the Mainstem Reservoir System important for flood control, hydroelectric generation, and navigation but it provides drinking water, irrigation water, fish and wildlife habitat, and recreation to adjacent States. Managing this valuable water resource for water quality is critical to protect and maintain the various beneficial uses of the river (Missouri River Natural Resource Committee, 1996). For Native American Tribes within the Missouri River basin, water quality is equally important as Tribes choose to exercise Treaty water rights and manage water resources for their own beneficial uses. The U.S. Environmental Protection Agency (EPA) acts on behalf of Tribes without approved water quality standards, enforcing the standards through the Federal Clean Water Act (CWA) (Section 401 Water Quality Certification). None of the Tribes within the Missouri River basin have been authorized to administer the NPDES program; therefore, EPA also issues all NPDES permits for discharges to Tribal waters under Section 402. The Fort Peck Reservation (Assiniboine and Sioux Tribes) is the only Reservation on the Mainstem Reservoir System and Lower River with approved water quality standards.

Water quality along the Mainstem Reservoir System is managed by the EPA and the States of Montana, North Dakota, South Dakota, Iowa, Nebraska, Kansas, and Missouri for Tribes without authorization to administer the standards program. All of these States adopt water quality standards, and administer the Federal NPDES program. EPA is responsible for the implementation of water quality standards, and the issuance of NPDES permits. There are two EPA regions that oversee the State and Tribal water quality programs and water quality standards in the Missouri River basin, EPA Region 8 in Denver, Colorado (Montana, North Dakota, South Dakota) and Region 7 in Kansas City, Kansas (Nebraska, Iowa, Missouri, Kansas).

3.5.1 Water Quality Regulations

In accordance with the CWA, States and authorized Tribes or EPA are responsible for adopting water quality standards for their jurisdictions. The water quality standards are to identify and designate beneficial uses for all surface waters in their jurisdiction and to establish water quality criteria (numeric or narrative) to protect and maintain the identified designated uses. Table 3.5-1 is a listing of the designated uses for the Mainstem Reservoir System and Lower River. The designated uses include

1. coldwater aquatic life,
2. warmwater aquatic life,
3. domestic drinking water,
4. recreation,
5. agriculture,
6. industry,
7. livestock and wildlife watering, and
8. aesthetics (Nebraska only).

For waters with multiple-use designations, the water quality criteria for all the uses apply.

Numeric water quality criteria for metals (e.g., 10 micrograms per liter [µg/L] copper) are generally lowest for the aquatic life use designation. For organic contaminants and bioaccumulatives, the numeric critieria for human health use are usually the lowest concentration.

Water quality standards include narrative criteria that describe water quality conditions that must be attained, maintained, or avoided. The narrative criteria are generally similar for each of the states along the Missouri River. Examples of narrative criteria include the following:

1. Waters shall be free from substances that will settle to form sludge deposits.
2. Waters shall be free from floating debris, oil, grease, scum, and other floating materials in sufficient amounts.
3. Waters shall be free from substances in concentrations or combinations that are

Table 3.5-1. Missouri River State-designated uses. page 1 of 3

State	Water Body	Segment	Use Support							
			High Quality/State Resource Waters	**Coldwater Fishery**	**Warmwater Fishery**	**Drinking Water**	**Recreation**	**Agriculture**	**Industrial**	**Livestock & Wildlife Watering**
Montana	Fort Peck Lake	MT40E004_010		●		●	●	●	●	
	Missouri River	MT40S001_010 (Fort Peck Dam to Poplar River)		●	●	●	●	●	●	
	Missouri River	MT40S003_010 (Poplar River to ND State line)			●	●	●	●	●	
	Missouri River	MT40S003_010 (Poplar River to ND State line)			●	●	●	●	●	
Fort Peck Assiniboine-Sioux Reservation	Missouri River	Southern border of Reservation		●		●	●	●	●	
North Dakota	Missouri River	Entire length		●	●	●	●			
	Lake Sakakawea			●		●	●	●		●
South Dakota	Missouri River	Iowa border to Big Bend Dam			●	●	●		●	
	Missouri River	Big Bend Dam to North Dakota border		●		●	●		●	
	Lake Sharpe				●	●	●	●	●	
	Lake Oahe			●		●	●		●	
	Lake Francis Case				●	●	●		●	
	Lewis and Clark Lake				●	●	●		●	
Iowa	Missouri River	Iowa-Missouri State line to confluence with the Big Sioux River	●		●		●			

Table 3.5-1. Missouri River State-designated uses. page 2 of 3

State	Water Body	Segment	Use Support: High Quality/State Resource Waters	Coldwater Fishery	Warmwater Fishery	Drinking Water	Recreation	Agriculture	Industrial	Livestock & Wildlife Watering
	Missouri River	City of Council Bluffs Water Works intakes	●			●				
Missouri	Missouri River	Mouth to Gasconade River			●	●	●	●	●	●
	Missouri River	Gasconade River to Chariton River			●	●	●	●	●	●
	Missouri River	Chariton River to Kansas River			●	●	●	●	●	●
	Missouri River	Kansas River to State line			●	●	●	●	●	●
Nebraska*	Missouri River	NI1-10000 (Nebraska-South Dakota border to Niobrara River)	●		●		●	●		
	Missouri River	MT2-10000 (Niobrara River to Big Sioux River)	●		●	●	●	●		
	Missouri River	MTI-10000 (Big Sioux River to Platte River)			●	●	●	●	●	
	Missouri River	NE1-10000 (Platte River to Nebraska-Kansas border)			●	●	●	●	●	
Kansas	Missouri River	10240005-1			●	●	●	●	●	●
	Missouri River	10240005-2			●	●	●	●	●	●
	Missouri River	10240005-19			●	●	●	●	●	●
	Missouri River	10240005-20			●	●	●	●	●	●
	Missouri River	10240005-21			●	●	●	●	●	●
	Missouri River	10240011-1			●	●	●	●	●	●

Table 3.5-1. Missouri River State-designated uses. page 3 of 3

State	Water Body	Segment	Use Support							
			High Quality/State Resource Waters	Coldwater Fishery	Warmwater Fishery	Drinking Water	Recreation	Agriculture	Industrial	Livestock & Wildlife Watering
Kansas (cont.)	Missouri River	10240011-2			●	●	●	●	●	●
	Missouri River	10240011-4			●	●	●	●	●	●
	Missouri River	10240011-5			●	●	●	●	●	●
	Missouri River	10240011-7			●	●	●	●	●	●
	Missouri River	10240011-9			●	●	●	●	●	●
	Missouri River	10240011-11			●	●	●	●	●	●
	Missouri River	10240011-13			●	●	●	●	●	●
	Missouri River	10240011-15			●	●	●	●	●	●
	Missouri River	10240011-19			●	●	●	●	●	●

* All Nebraska segments have aesthetics as a designated use.

acutely toxic or harmful to human, animal, plant life, or aquatic biota.

4. Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor, or that prevent full maintenance of beneficial uses.

In addition to the designation of beneficial uses and the establishment of water quality criteria, the states' water quality standards must include an anti-degradation policy. The anti-degradation policy provides three tiers of protection:

1. Existing water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.
2. High quality waters shall be protected by minimizing impacts of new activities.
3. Designated high quality waters that constitute an outstanding State or National resource shall be maintained and protected.

The unchannelized Missouri River segments in Nebraska from the Nebraska-South Dakota border to the Niobrara River and from the Niobrara River to the Big Sioux River are designated as Outstanding State Resource Waters. These segments are also designated as a National Recreational River under the Federal Wild and Scenic Rivers Act (WSRA). The Missouri River along the western border of Iowa is also listed as a "water of exceptional State and National significance."

Water quality impacts to the Missouri River come from point and nonpoint sources of pollution which are affected by changing lake levels and river flow regimes. Point sources are those discharges that require an NPDES permit from a State or EPA. Point sources enter surface water systems from a discrete water conveyance system (e.g., pipes, culverts, trenches). Point sources include discharges from Publicly Owned Treatment Works (POTWs) and industrial facilities.

Nonpoint discharges are from diffuse sources that enter waterbodies in overland runoff or subsurface percolation. Nonpoint source pollution can arise from land use activities associated with agriculture, mining, urban areas, etc. The operation and management of the dam system that controls lake elevations and river flows can affect water quality. A reduction in stream flows can provide less dilution to pollutants entering the river from point and nonpoint sources, increasing pollutant concentrations. Discharges from dams can cause water quality and erosion problems downstream, that especially affect aquatic life. Dam discharges that impair water quality are identified under the CWA as a nonpoint source. Examples of water quality impacts to the Mainstem Reservoir System attributable to nonpoint sources include elevated water temperatures, depressed dissolved oxygen concentrations, high sediment loading and deposition, nutrient loading causing eutrophic conditions, bioaccumulation of metals, and pesticides contamination.

In accordance with Section 303(d) of the CWA, States and Tribes must identify surface waters (river segments, lakes, reservoirs, and wetlands) that do not meet EPA-approved water quality standards. The States are required to report these impaired water bodies to the EPA on a list called the 303(d) List of Impaired Waterbodies.

All impaired waterbodies identified on the 303(d) list must undergo development of a Total Maximum Daily Loading (TMDL) assessment by the States or EPA. The TMDL is a water quality management approach that

1. assesses the pollutant assimilation capacity of the impaired surface water;
2. determines mass loadings from point and nonpoint sources; and
3. develops mass allocations among point and nonpoint sources to obtain a mass loading below the assimilation capacity (with a margin of safety).

The TMDL approach is taken to reduce pollutant loading to an impaired stream in order to achieve and maintain State or Tribal water quality standards (EPA, 1991). Table 3.5-2 provides a summary of the impaired river segments and lakes on the Missouri River from Fort Peck Lake to the Mississippi River. The States of North Dakota and Kansas did not list any Missouri River segments on their 303(d) lists. Many of the TMDLs for the Missouri River segments and mainstem lakes have either not been started by the States or EPA or are in the very early stages of data collection and stakeholder coordination.

Fish consumption advisories are also developed by each State and authorized Tribes or EPA. These advisories inform those living in the State of possible health concerns associated with eating fish caught from identified waters. Section 3.5.7.3

Table 3.5-2. Impaired Missouri River segments reported on CWA Section 303(d) list. page 1 of 2

State	Water Body	Segment	Miles	Parameters	Sources	Severity	Remarks
Montana	Fort Peck Lake	MT40E004_010	134	Metals, lead, mercury, noxious aquatic plants	Agriculture, resource extraction, abandoned mining, atmospheric deposition, debris and bottom deposits	Moderate	TMDL
	Missouri River	MT40S001_010 (Fort Peck Dam to Poplar River)	87.6	Metals, thermal modification, flow alteration, other habitat alteration	Flow regulation/modification, hydromodification, upstream impoundment	High	303(d)/TMDL
	Missouri River	MT40S003_010 Poplar River to ND State line)	94.8	Thermal modification, flow alteration	Hydromodification, flow regulation/modification, upstream impoundment	Moderate	303(d)/TMDL
North Dakota							No stream or applicable reservoirs listed
South Dakota	Lake Sharpe		80	Accumulated sediment		High	Listed due to relationship and close proximity to Bad River Project (319 project)
Iowa	Missouri River	IA 06-WEM-0010-0 (Iowa-Missouri line to Platte River)		Unknown & siltation (Flow alterations leading to habitat alterations)	Hydrological modifications of Missouri River channel	High	Medium/Low on 303(d)/TMDL
	Missouri River	IA 06-WEM-0020-1 (Platte River to WS intake at Council Bluffs)		Unknown & siltation (Flow alterations leading to habitat alterations)	Hydrological modifications of Missouri River channel	High	Medium/Low on 303(d)/TMDL

Table 3.5-2. Impaired Missouri River segments reported on CWA Section 303(d) list. page 2 of 2

State	Water Body	Segment	Miles	Parameters	Sources	Severity	Remarks
	Missouri River	IA 06-WEM-0030-0 (Boyer River to L. Sioux River)		Unknown & siltation (Flow alterations leading to habitat alterations)	Hydrological modifications of Missouri River channel	High	Medium/Low on 303(d)/TMDL
	Missouri River	IA 06-WEM-0040-0 (L. Sioux River to Big Sioux River)		Unknown & siltation (Flow alterations leading to habitat alterations)	Hydrological modifications of Missouri River channel	High	Medium/Low on 303(d)/TMDL
Missouri	Missouri River	Mouth to Gasconade River		Habitat Loss	Channelization	Moderate	Schedule TBD
	Missouri River	Gasconade River to Chariton River		Habitat Loss	Channelization	Moderate	Schedule TBD
	Missouri River	Chariton River to Kansas River		Habitat Loss	Channelization	Moderate	Schedule TBD
	Missouri River	Kansas River to State line		Habitat Loss	Channelization	Moderate	Schedule TBD
Nebraska	Missouri River	MTI-10000 (Big Sioux River to Platte River)	139.8	Pathogens	Municipal point source, agriculture, urban runoff/storm sewers	Low	Not targeted for TMDL in the next 2 years
	Missouri River	MT2-10000 (Niobrara River to Big Sioux River)	109.2	Pathogens	Agriculture	Low	303(d)
	Missouri River	NE1-10000 (Platte River to Nebraska-Kansas border)	101.2	Pathogens	Agriculture, urban runoff/storm sewers	Low	Not targeted for TMDL in the next 2 years
Kansas							No Missouri River segments listed on 303(d)

TBD = to be determined

discusses the advisories for each of the States along the Missouri River.

3.5.2 Historic Water Quality Conditions

Prior to dam construction, the Missouri River was a dynamic, free-flowing, river. Continuous bank erosion, multiple channels, and numerous islands and sandbars characterized the original Missouri River. Annual flooding kept the Missouri River in a condition called dynamic equilibrium. This condition is characterized by the establishment and disappearance of side channels and islands as the river cuts a new course within the stream channel and floodplain. The dynamic nature of the river created braided, sinuous channels; sloughs; chutes; oxbows; gravel bars; sandbars; mud flats; snags; alluvial islands; deep pools; and marshlands. Aquatic and terrestrial habitats have adapted to the patterns of the Missouri River overtime. The construction of dams and the creation of the lakes interrupted the dynamics of the Missouri River and consequently affect the water quality of the river system (Missouri River Natural Resources Committee, 1996). The physical, chemical, and biological dynamics were altered due to the transition from a dynamic river (lotic) system to a controlled lake (lentic) system.

Natural background concentrations of arsenic, selenium, and mercury in the Mainstem Reservoir System are associated with the local geology, specifically the presence of Upper Cretaceous age Pierre Shale. Natural background levels of metals in the Mainstem Reservoir System are strongly influenced by the levels of those elements contained in the soils derived from the Pierre Shale and other Upper Cretaceous age rocks. Pierre Shale is the bedrock across which the Missouri River drainage system flows and from which the river and lakes receive runoff, tributary drainage, and groundwater seepage, all of which contribute both solid material and dissolved minerals and compounds (personal communication, K. Porter, Senior Research Geologist, Montana Bureau of Mines, July 10, 2001). Sedimentary shales contain as much as 5 to 13 parts per million (ppm) of arsenic, 0.18 to 0.40 ppm of mercury, and 0.6 ppm of selenium (Kabata-Pendias and Pendias, 1992).

3.5.3 Lake Dynamics

Dams were developed on the Missouri River for multiple purposes including, but not limited to, flood control, water supply, irrigation, navigation, recreation, and electrical power generation. Dam construction reduces the flow variability downstream and makes it effective for flood control. The lakes that were developed from the dam construction on the Missouri River are effective sediment traps. Sediment loads that are carried by the river and tributaries are deposited in the lakes due to a reduction in stream velocity. Lakes also act as sinks for pollutants such as metal and pesticides, which readily adsorb onto these transported sediment particles. Sediment transport and deposition over time influence the water storage of the lake. Sediment deposition at the inflow of the incoming river causes deltas. Sediment erosion and resuspension can occur within lakes undergoing extreme elevation fluctuations, which can expose sediments to powerful wave action.

When a dam is constructed, large amounts of land are flooded to create the lake, and the surrounding areas are affected. The flooding of the soils can change the water quality of the overlying water. Waterlogged soil becomes depleted of oxygen (anoxic), leading to oxygen stress and eventual elimination of the root system of plants along the original riverbanks. When flooded soils and vegetation decompose, the lower portions of the lake can become depleted of oxygen from the bacterial decomposition activity. In some cases, toxic methylmercury (which can bioaccumulate in predatory fish) may be formed by bacterial decomposition and mediation. The decomposition of flooded soils also releases nutrients like phosphorus and nitrogen, which may temporarily increase aquatic productivity of the lake (St. Louis, 2000).

The enrichment of surface waters through the excessive input of phosphorus and nitrogen can significantly increase the production rate of aquatic plants (i.e., algae and macrophytes). This enrichment of nutrients, called eutrophication, can lead to the impairment of designated uses, including recreation, drinking water supply, and aquatic life. Increased amounts of aquatic plants interfere with swimming, boating, and fishing. The odors produced by decaying plant matter also affect the aesthetic uses of the lake. Water treatment plant filters can become clogged by excess debris in the water, and the increased production and breakdown of plant matter can adversely affect the taste and odor of drinking water. Algae in the lake eventually die and settle to the bottom of the lake, encouraging microbial decomposition that requires oxygen. Oxygen can eventually be depleted, impacting aquatic habitats. The breakdown process can also produce ammonia. Reactions in fish because of the presence of ammonia range from reductions in growth rate and injury to liver and kidneys at low levels, to increased heart rate and death at extreme levels (EPA, 1999a).

As the seasons change, lakes undergo a process called thermal stratification and turnover. One characteristic of water is that as it cools it becomes denser, until it reaches its maximum density at 4°C. In the fall, as surface waters cool, the water becomes denser. When the temperature throughout the water column reaches 4°C, isothermal conditions are achieved and the water density is uniform. Isothermal conditions initiate the process called turnover. Isothermal conditions with wind action initiate a recirculation, or mixing of the upper and lower portions of the lake. The turnover of waters is an important process that releases and redistributes nutrients and organic matter throughout the water column of the lake. When the surface water falls below 4°C, the density becomes less than that of the deeper water, and it begins to freeze and form a layer of ice. The waters directly below the ice layer will remain cold throughout the winter, but the deepest water remains at 4°C. As the surface begins to warm in the spring, the ice melts, and the lake water column again reaches a uniform 4°C temperature and density. As the water temperature of the lake increases during the spring and summer months, stratification within the water column occurs. (Warmer water occurs at the surface and colder water at the bottom.) As spring turns into summer, waters at the surface of the lake stay warmer than those below due to sunlight, warm air temperatures, and reduced mixing owing to the difference in water densities.

The coolwaters near the bottom can experience oxygen depletion due to the decomposition of organic matter and the limited amount of mixing with the upper layers of water (Walker, 2001). Nutrients like phosphorus and nitrogen may become concentrated in the bottom water throughout the summer months, especially during anoxic conditions. Phosphorus enrichment can increase aquatic productivity; however, if enrichment is excessive it can lead to nuisance aquatic plant growth which can lead to the development of waters with little or no dissolved oxygen. Low dissolved oxygen encourages the generation of methane, sulfide, and ammonia from biological decomposition activity. Anoxic conditions can lead to the release of ferrous iron from sediments, thus allowing phosphorous to be liberated from the sediments and released into the water column (United Nations Environment Programme, 2000). Oxygen depletion can also occur during winter when the lake is covered with ice and accumulated organic matter decomposes. This situation can lead to a "winter kill" of fish.

Great quantities of sediment and organic matter flow into the Mainstem Reservoir System and are trapped behind dams. This reduces lake storage capacity and sediment transport below the dams. Dams block native fish migration to spawning grounds and modify the flow regime in the river system. Deltas are formed at lake inlets or headwaters from sediment mobilized in the inter-lake reaches and arriving from upstream tributaries. Deltas reduce lake storage and channel carrying capacity. Extensive wetlands can develop in these delta areas, providing excellent waterfowl and wildlife habitat and spawning areas for fish (Missouri River Natural Resource Committee, 1996).

3.5.4 Dam Releases

Water that is discharged from a dam on the Missouri River is either from a spillway or from an outlet in the bottom portion of the dam. The area immediately downstream of the dam that receives the discharge is referred to as the "tailwaters." Spillway releases occur when the capacity of the outlet is not adequate to make required releases from the dam. When spillway discharges occur they draw water from the warmer upper layer of the lake and discharge it downstream of the dam. Extreme aeration during spillway discharges may increase the total dissolved gas concentration of the receiving water. The bottom release dams draw water from the lower portion of the lake which is discharged through turbines to generate electrical power. The discharged water is generally cold, and contains low concentrations of suspended solids. Because of its low sediment load, bank and channel erosion downstream can result.

Tailwater erosion of riverbanks and channels near the discharge location can also be influenced by discharge velocity, channel morphology, and soil erosion potential. It scours the river bed, which affects benthic aquatic life, and lowers the elevation of the river bed. The lowering of the river bed elevation in turn lowers the local groundwater table, which affects vegetation and side channels. These cold water releases can cause thermal problems to aquatic life downstream that are adapted to warmer water temperatures. In the summer, these cold tailwaters begin to warm within a few miles of the dam. Water temperatures fall to near freezing in winter, except in the immediate tailwaters of the dam where water may be several degrees warmer (Corps, 1994).

3.5.5 Water Quality Monitoring

There are several water quality monitoring programs on the Mainstem Reservoir System and Lower River. The Corps performs water quality monitoring on selected stream reaches and lakes to generate annual and technical reports. The U.S. Geological Survey (USGS) also performs water quality monitoring at selected locations in the Missouri River basin (see Table 3.5-3). Between the USGS and the Corps there are 49 active monitoring locations on the Mainstem Reservoir System and Lower River, 25 are operated by the Corps, and 24 by the USGS. The States perform water quality monitoring, but the locations, status, and sampling frequency are not readily available. There is no comprehensive, integrated monitoring and reporting program for the entire Missouri River basin. The overall status of water quality for the entire Missouri River basin can only be determined through State 303(d) lists (Table 3.5-2) and 305(b) reports that are submitted to EPA.

3.5.6 NPDES Permitting

Municipal and industrial point sources are allowed to discharge effluent to the Missouri River if the discharge is permitted under the NPDES Program. The NPDES program establishes two methods for determining effluent limitations to be incorporated into permits. First, existing dischargers are required to meet technology-based effluent limitations that reflect the best controls available while considering economic impacts. New source dischargers must meet the best-demonstrated technology-based controls. Technology-based effluent limitations are defined by the EPA according to “industrial” category (e.g., sewage treatment plants, metal-plating, petroleum refineries, etc.). Second, where necessary, additional requirements are imposed to ensure attainment and maintenance of water quality standards. In establishing NPDES permit limits, it must be ensured that the limits will result in the attainment of water quality standards. Where violations of water quality standards are identified or projected, appropriate water quality-based effluent limits are to be developed for inclusion in any issued permits. Water quality-based permits are usually based on the capacity of the receiving water to assimilate the pollutant being discharged under a defined critical low flow. Water quality-based permit limits are more stringent than technology-based limits.

NPDES permits can contain thermal discharge limits. Temperature limits are typically required in permits for industrial operations that utilize cooling water and discharge it to a receiving water (e.g., powerplants, etc.). The States and EPA with NPDES permitting authority develop their own thermal requirements. As shown in Table 3.5-4, thermal water quality standards criteria for many States are based upon a maximum temperature and maximum change in temperature. The thermal criteria are based upon the use classification of the waterbody receiving the discharge.

Although not identified on 303(d) lists as a parameter that causes stream impairment on the Missouri River, the EPA and the States deem thermal issues important.

Low-flow conditions are critical in the development of water quality-based NPDES permit limits. Within their water quality standards, the states have defined critical low-flow conditions for application of their water quality standards. These “design flows” are used to define mixing zones and to determine the capacity of the receiving water to assimilate a discharged pollutant. The assimilative capacity of the receiving water represents the amount of a pollutant that a waterbody can receive and still meet water quality standards under the specified design conditions. Assimilative capacity is largely driven by the available “dilution” in the receiving water under the critical low flow conditions, and is determined for both acute and chronic toxicity concerns. The chronic design flow is typically defined as the 7-day, 10-year low flow (7Q10). The 7Q10 is the discharge at the 10-year recurrence interval determined from a frequency distribution of annual values of the lowest average discharge for seven consecutive days. Other chronic design flow conditions have been defined (i.e., 30Q5) depending on the pollutant involved.

Table 3.5-3. USGS water quality monitoring stations on the Missouri River. page 1 of 2

Agency	Location	Type
COE-OMAHA	Fort Peck Lake at Hell Creek	Ambient Lake
COE-OMAHA	Fort Peck Lake near Dam	Ambient Lake
COE-OMAHA	Fort Peck Lake Releases	Ambient Stream
COE-OMAHA	Lake Audubon at Snake Creek	Ambient Lake
COE-OMAHA	Lake Audubon Deepwater near Dam	Ambient Lake
COE-OMAHA	Lake Francis Case near Dam	Ambient Lake
COE-OMAHA	Lake Francis Case near Elm Creek	Ambient Lake
COE-OMAHA	Lake Francis Case Releases	Ambient Stream
COE-OMAHA	Lake Oahe near Dam	Ambient Lake
COE-OMAHA	Lake Oahe near Pollock, South Dakota	Ambient Lake
COE-OMAHA	Lake Oahe Releases	Ambient Lake
112WRD-USGS	Lake Sakakawea above Little Missouri River, ND	Ambient Lake
112WRD-USGS	Lake Sakakawea above Van Hook Arm, ND	Ambient Lake
112WRD-USGS	Lake Sakakawea at Beaver Creek Bay, ND	Ambient Lake
COE-OMAHA	Lake Sakakawea at Dam	Ambient Lake
112WRD-USGS	Lake Sakakawea at Douglas Creek Bay, ND	Ambient Lake
112WRD-USGS	Lake Sakakawea at Lewis and Clark Bay, ND	Ambient Lake
COE-OMAHA	Lake Sakakawea at Newtown, ND	Ambient Stream
112WRD-USGS	Lake Sakakawea at Riverdale, ND	Ambient Lake
112WRD-USGS	Lake Sakakawea at White Earth Bay, ND	Ambient Lake
112WRD-USGS	Lake Sakakawea near New Town, ND	Ambient Lake
COE-OMAHA	Lake Sharpe Releases	Ambient Stream
COE-OMAHA	Lake Sharpe near Dam	Ambient Lake
COE-OMAHA	Lewis and Clarke Lake near Dam	Ambient Lake
COE-OMAHA	Lewis and Clarke Lake near Springfield	Ambient Stream
COE-OMAHA	Lewis and Clarke Lake Releases	Ambient Stream
112WRD-USGS	Missouri River at Pierre, SD	Ambient Stream
112WRD-USGS	Missouri River at Yankton, SD	Ambient Stream
112WRD-USGS	Missouri River at Bismarck, ND	Ambient Stream
112WRD-USGS	Missouri River at Fort Benton, MT	Ambient Stream
112WRD-USGS	Missouri River at Garrison Dam, ND	Ambient Stream
112WRD-USGS	Missouri River near Williston, ND	Ambient Stream
112WRD-USGS	Missouri River at Toston, MT	Ambient Stream
112WRD-USGS	Missouri River at Virgelle, MT	Ambient Stream

Table 3.5-3. USGS water quality monitoring stations on the Missouri River. page 2 of 2

Agency	Location	Type
112WRD-USGS	Missouri River below Fort Peck Dam, MT	Ambient Stream
112WRD-USGS	Missouri River below Hauser Lake near Helena, MT	Ambient Stream
112WRD-USGS	Missouri River below Holter Dam near Wolf Creek, MT	Ambient Stream
112WRD-USGS	Missouri River near Culberston, MT	Ambient Stream
112WRD-USGS	Missouri River near Great Falls, MT	Ambient Stream
112WRD-USGS	Missouri River near Landusky, MT	Ambient Stream
112WRD-USGS	Missouri River near Ulm, MT	Ambient Stream
112WRD-USGS	Missouri River near Wolf Point, MT	Ambient Stream
COE-OMAHA	Monitor at Big Bend Power House	Ambient Lake
COE-OMAHA	Monitor at Fort Randall Power House	Ambient Lake
COE-OMAHA	Monitor at Garrison Power House	Ambient Lake
COE-OMAHA	Monitor at Gavins Point Power House	Ambient Lake
COE-OMAHA	Monitor at Oahe Power House	Ambient Lake
COE-OMAHA	Monitor at Fort Peck Power House	Ambient Lake
COE-OMAHA	Power House outfall at Pierre, SD	Ambient Lake
11NPSWRD-USGS	Yankton Raw Water Intake at Meridian Bridge	Ambient Stream

COE-OMAHA: Corps of Engineers – Omaha Monitoring Sites
112WRD: USGS Monitoring Sites
11NPSWD: USGS Monitoring Sites

Source: EPA, 2001 and Corps, 2000

Table 3.5-4. State thermal standards for the Missouri River. page 1 of 5

State	Water	Segment(s)	Use	Thermal Standard	Use Class Description	Exception(s)
Montana	Fort Peck Lake	MT40E004_010	B-2	0°C – 18.9°C: 0.5°C maximum increase above naturally occurring water temperature.	Waters classified as B-2 are suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.	NA
				18.9°C – 19.2°C: No discharge is allowed which will cause the water temperature to exceed 19.4°C.		
				19.2°C or greater: 0.3°C maximum increase above naturally occurring water temperature.		
				12.8°C or greater: 1.1°C-per-hour maximum decrease below naturally occurring water temperature.		
				12.8°C - 0°C: 1.1°C maximum decrease below naturally occurring water temperature.		
	Missouri River	MT40S001_010 (Fort Peck Dam to Poplar) MT40S003_010 (Poplar to ND State Line)	B-3	0°C - 25°C: 1.7°C maximum increase above naturally occurring water temperature.	Waters classified as B-3 are suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.	Mainstem of Yellowstone River from Billings water supply intake to water diversion at intake where:
				25°C – 26.4°C: No discharge is allowed which will cause the water temperature to exceed 26.7°C.		
				26.4°C or greater: 0.3°C maximum increase above naturally occurring water temperature.		0°C - 26°C: 1.70°C maximum increase 26.1°C – 27.5°C: No increase to exceed 27.8°C
				12.8°C or greater: 1.1°C-per-hour maximum decrease below naturally occurring water temperature.		27.5°C or greater: 0.3°C maximum increase
				12.8°C - 0°C: 1.1°C maximum decrease below naturally occurring water temperature.		Water diversion at intake to the ND State line where: 0°C – 27.8°C: 1.7°C maximum increase
						27.8°C – 29.2°C: No increase to exceed 29.4°C 29.2°C or greater: 0.3°C maximum increase

Table 3.5-4. State thermal standards for the Missouri River. page 2 of 5

State	Water	Segment(s)	Use Class	Thermal Standard	Use Class Description	Exception(s)
Fort Peck Assiniboine – Sioux Reservation	Missouri River	Southern border of Reservation	Class 1 Coolwater Aquatic Life	0°C – 18.9°C: 0.3°C maximum increase above naturally occurring water temperature. 18.9°C – 19.2°C: No discharge is allowed which will cause the water temperature to exceed 19.4°C. 19.2°C or greater: 0.3°C maximum increase above naturally occurring water temperature. 12.8°C or greater: 1.1°C-per-hour maximum decrease below naturally occurring water temperature. 12.8°C – 0°C: 1.1°C maximum decrease below naturally occurring water temperature.		NA
North Dakota	Missouri River Lake Sakakwea	Entire length	I	Maximum limit of 29.44°C. The maximum increase shall not be greater than 2.78°C above the natural background conditions.	The quality of waters in this class shall be suitable for the propagation or protection, or both, of resident fish species and other aquatic biota and for swimming, boating, and other water recreation. The quality of the waters shall be suitable for irrigation, stock watering, and wildlife without injurious effects. After treatment consisting of coagulation, settling, filtration, and chlorination, or equivalent treatment processes, the water quality shall meet the bacteriological, physical, and chemical requirements of the department for municipal or domestic use.	NA

Table 3.5-4. State thermal standards for the Missouri River. page 3 of 5

State	Water	Segment(s)	Use Class	Thermal Standard	Use Class Description	Exception(s)
South Dakota	Missouri River	Iowa border to Big Bend Dam	Warmwater Perm.	Less than or equal to 26.7°C. No discharge may affect the temperature by more than 2.2°C. Maximum incremental temperature may not exceed 1.1°C-per-hour. There may be no induced temperature change over spawning beds.	Surface waters of the State which support aquatic life and are suitable for the permanent propagation or maintenance, or both, of warmwater fish.	NA
	Missouri River	Big Bend Dam to North Dakota border	Coldwater Perm.	Less than or equal to 18.3°C. No discharge may affect the temperature by more than 2.2°C. Maximum incremental temperature may not exceed 1.1°C-per-hour. There may be no induced temperature change over spawning beds.	Surface waters of the State which are capable of supporting aquatic life and are suitable for supporting a permanent population of coldwater fish from natural reproduction or fingerling stocking. Warmwater fish may also be present.	NA
	Lake Sharpe		Warmwater Perm.	Less than or equal to 26.7°C. No discharge may affect the temperature by more than 2.2°C. Maximum incremental temperature may not exceed 1.1°C-per-hour. There may be no induced temperature change over spawning beds.	Surface waters of the State which support aquatic life and are suitable for the permanent propagation or maintenance, or both, of warmwater fish.	NA
	Lake Oahe		Coldwater Perm.	Less than or equal to 18.3°C. No discharge may affect the temperature by more than 2.2°C. Maximum incremental temperature may not exceed 1.1°C-per-hour. There may be no induced temperature change over spawning beds.	Surface waters of the State which are capable of supporting aquatic life and are suitable for supporting a permanent population of coldwater fish from natural reproduction or fingerling stocking. Warmwater fish may also be present.	NA
	Lake Francis Case		Warmwater Perm.	Less than or equal to 26.7°C. No discharge may affect the temperature by more than 2.2°C. Maximum incremental temperature may not exceed 1.1°C-per-hour. There may be no induced temperature change over spawning beds.	Surface waters of the State which support aquatic life and are suitable for the permanent propagation or maintenance, or both, of warmwater fish.	NA

Table 3.5-4. State thermal standards for the Missouri River. page 4 of 5

State	Water	Segment(s)	Use Class	Thermal Standard	Use Class Description	Exception(s)
South Dakota (continued)	Lewis and Clark Lake		Warmwater Perm.	Less than or equal to 26.7°C. No discharge may affect the temperature by more than 2.2°C. Maximum incremental temperature may not exceed 1.1°C-per-hour. There may be no induced temperature change over spawning beds.	Surface waters of the State which support aquatic life and are suitable for the permanent propagation or maintenance, or both, of warmwater fish.	NA
Iowa	Missouri River	Iowa-Missouri State line to confluence with the Big Sioux City of Council Bluffs Water Intakes	Missouri River	3°C maximum increase above naturally occurring water temperature. Rate shall not exceed 1°C-per-hour. No discharge is allowed which will cause the water temperature to exceed 32°C.		NA
Missouri	Missouri River	Mouth to Gasconade R. Gasconade R. to Charlton R. Charlton R. to Kansas R. Kansas R. to State Line	Warmwater Fishery	Maximum temperature limit: 32.2°C. Maximum allowable temperature change: 2.8°C.	Waters in which naturally occurring water quality and habitat conditions allow the maintenance of a wide variety of warmwater biota, including naturally reproducing populations of recreationally important fish species.	NA
Nebraska	Missouri River	MTI-10000 (Big Sioux to Platte R.) MT2-10000 (Niobrara R. to Big Sioux R.	Missouri River	Maximum temperature limit: 29°C. Maximum allowable temperature change: 2°C. Receiving water shall not be increased by a total of more than 3°C from natural outside the mixing zone.	NA	NA

Table 3.5-4. State thermal standards for the Missouri River. page 5 of 5

State	Water	Segment(s)	Use Class	Thermal Standard	Use Class Description	Exception(s)
Nebraska (continued)		NE1-10000 (Platte R. to Nebraska-Kansas border) NE1-10000 (Nebraska-South Dakota border to Niobrara R.				NA
Kansas	Missouri River	10240005-1 10240005-2 10240005-19 10240005-20 10240005-21 10240011-1 10240011-2 10240011-4 10240011-5 10240011-7 10240011-9 10240011-11 10240011-13 10240011-15 10240011-19	General	Discharge shall not elevate temperature of receiving water beyond the zone of initial dilution above 32°C. No increase beyond mixing zone greater than 3°C. No discharge shall lower the temperature beyond the mixing zone more than 3°C.	NA	NA

NA = not applicable

The acute design flow is typically defined as the 1Q10 flow. Any drastic changes to a stream flow regime can have impacts on downstream NPDES permits. Thermal conditions can also be affected by high ambient air temperatures, solar radiation, water depth, and thermal discharges from point sources.

3.5.7 Anti-degradation and Missouri River Water Quality

EPA's water quality standards regulations, according to the CWA, require states to adopt and implement an anti-degradation policy. The anti-degradation requirements declare that states must maintain and protect the quality and existing uses of the waters of the State. The intent of the policy is to limit discharges and other activities that will negatively affect water quality or impair beneficial uses of surface waters. The policy provides a baseline level of protection relative to established water quality criteria.

The anti-degradation provisions within water quality standards defines three tiers for maintaining and protecting water quality and beneficial uses:

1. Tier I provides a baseline protection for existing uses. Water quality must be preserved to protect and maintain those existing uses; activities that would cause water quality to be below the levels necessary to maintain existing uses are prohibited. EPA defines an existing use as "a use that is actually attained or attainable in a waterbody on or after November 28, 1975, whether or not it is included in the appropriate water quality standards."
2. Tier II protects high quality waters where water quality exceeds the criteria associated with the designated beneficial uses. Limited water quality degradation can occur if it is necessary to facilitate important and necessary economic or social development. Water quality must always be protective of designated beneficial uses.
3. Tier III provides special protection for waters which constitute an outstanding State or National resource such as those in National and State Parks, wildlife refuges, outstanding fisheries, and other waters with unique recreational or ecological value (40 CFR Part 131).

The States bordering the Missouri River have anti-degradation provisions in their water quality standards.

Missouri River Water Quality

From a historical perspective, water quality degradation has occurred in the Missouri River basin. Although the Missouri River has historically contained high sediment loading and naturally high concentrations of metals such as arsenic and selenium, the water quality characteristics of the Missouri River have changed within the past several decades. These water quality changes are a direct result of past and current changes in land use practices, increased urbanization, atmospheric deposition of pollutants, and dam construction and operations within the Missouri River basin. Examples of activities or occurrences that have contributed to the degradation of water quality include the following:

- Sediment erosion, nutrient, and pesticide runoff from agricultural practices;
- Historical mining practices that have increased sediment and metals loading;
- Stormwater discharges from growing urban areas with impervious areas;
- Increased wastewater and industrial plant discharges of nutrients, metals, and organic pollutants;
- Old or ineffective individual disposal septic systems leaching fecal coliform and nutrients; and
- Dam systems that are sediment and pollutant sinks and contain elevated concentrations of metals, organic pollutants, and nutrients.

There is limited information regarding how water quality has changed since the construction of the Mainstem Reservoir System on the Missouri River. There currently is not a monitoring program for the entire Missouri River that integrates and evaluates all the monitoring information collected by the Corps, States, USGS, and EPA. Due to this information limitation, it is not possible to evaluate temporal trends in water quality throughout the river system, nor is it possible to specify when water quality degradation started to occur. Degradation of water quality can be estimated by reviewing State 303(d) Lists of Impaired

Waterbodies and State 305(b) Reports submitted to EPA. These references provide an indication of existing water quality conditions and problems in the Missouri River basin. The areas of water quality degradation and concerns include the following:

- Thermal discharges (coldwater releases);
- Sediment erosion and deposition;
- Metal concentration from natural, point, and nonpoint sources along with aerial deposition (mercury, arsenic, selenium, etc.);
- Dissolved oxygen depletions in lakes;
- Nutrient loading (phosphorus, nitrate, nitrite, ammonia);
- Accumulated sediment;
- Pathogens (fecal coliform);
- Flow alterations leading to habitat changes;
- Pesticides;
- Bioaccumulation of toxic pollutants; and
- Protection of drinking water sources.

In regard to Tier III protection under the anti-degradation provisions, States within the Missouri River basin have designated high quality waters that constitute an outstanding State or National resource. These river segments include

1. the Missouri River in Nebraska from the Nebraska/South Dakota border to the Niobrara River,
2. the Missouri River in Nebraska from the Niobrara River to the Big Sioux River, and
3. the entire Missouri River reach adjacent to the State of Iowa.

Direct Water Quality Impacts from Corps Dam Operations

The majority of the water quality degradation that has occurred as a direct result of Corps dam operations occurs in the upper portion of the Missouri River basin. These direct water quality impacts include

1. thermal (coldwater) discharges from dams,
2. sediment erosion and bank cuts below dam releases,
3. alteration of habitat due to stream channel alternations of the river, and
4. coldwater fish habitat impacts due to reduced lake elevations.

These impacts are more physical in nature, involving the management of stream flow and water storage in the Mainstem Reservoir System.

Water temperature is recognized as an important water quality condition affecting the fishery population in the river reaches downstream of the dams. Discharges from Fort Peck Dam are much colder than historical natural conditions and have impaired the State-designated warmwater fisheries use downstream (Corps, 1994l). A TMDL analysis is currently being initiated in the river reach below Fort Peck to address the impacts the coldwater discharges have had on the warmwater fisheries.

Releases from Corps dams contain low concentrations of suspended solids. Water releases are discharged downstream at a high velocity. An area directly below the dam is scoured out due to the high velocity flows until an equilibrium condition is established with the river bed material. This process results in high channel and bank erosion in the river downstream of the dams. A TMDL analysis is currently being initiated in the river reach below Fort Peck to address this erosion issue.

Along the Lower River, habitat modifications occurred as a result of river channelization activities. Many river meanders and oxbow lakes were removed by the straightening of the river. It is estimated that 10 percent of the stream length was reduced by channelization. The width of the river was reduced in many sections and prevented the river from reaching its historical floodplain (Corps, 1994l).

A significant reduction in the level and volume of water in the lakes, especially during drought conditions, can have a significant impact on lake temperature and dissolved oxygen concentrations. These water quality parameters are critical for coldwater fish occupying the deeper portions of the lakes. To survive and thrive, coldwater fish require a habitat with water quality characteristics of low water temperatures and high dissolved oxygen concentrations. Established predator-prey relationships occur within these coldwater habitats. During drought conditions, lake levels may drop dramatically, especially in Fort Peck Lake and

Lakes Oahe and Sakakawea, reducing the overall volume of water in the lakes. This reduced level of the lakes reduces the size of the available coldwater habitat, affecting the viability of coldwater fish.

States bordering the Missouri River were solicited by EPA to provide comments on their water quality concerns associated with the CWCP. The State of Montana responded to the EPA and identified the following water quality issues:

- The portion of the Missouri River below Fort Peck Dam has been assessed to partially support some of its designated uses, and a TMDL is being performed to return the river to full support of its uses.
- Dam operation alternatives should improve conditions for riparian habitat, river bank stability, and erosion.
- Mercury contamination of fish tissue and drinking water remains a water quality issue.

Indirect Water Quality Impacts from Corps Dam Operations

Most water quality impairments in the Missouri River basin results from a combination of pollutant sources and hydrologic conditions throughout the watersheds. The Missouri River, lakes, and tributaries receive pollutant loading from point and nonpoint sources in the watersheds. The Corps is not the source of the pollutants that enter the Missouri River; however, it is responsible for managing the hydrologic regimes that store or transport pollutants downstream. Therefore, water quality impairments and problems may arise when the Corps is operating the dam system to meet the objectives of the CWCP. Brief descriptions of these indirect water quality issues are discussed below.

Water Temperature and Dissolved Oxygen For Lake Fish

Maintaining adequate lake levels and river flow is a factor in managing lake water quality within the Mainstem Reservoir System. Low lake levels in the summer generally lead to lower dissolved oxygen levels in the deeper, cooler portions of the three larger mainstem lakes. Low lake levels reduce the overall volume of water and available coldwater fish habitat. This volume reduction causes an increase in the overall temperature of the water in the lake and reduces the total amount of oxygen available to meet demands of sediment and decomposing organic material, such as decaying algae. There have been times when dissolved oxygen in the upper and lower portions of the Mainstem Reservoir System have not met State water quality standards.

Sediment Releases of Nutrients and Metals

Dissolved oxygen concentrations, especially in hypolimnetic waters, can be lowered through the decomposition of accumulated organic matter and the oxygen demand of sediments and reduced substances. The gradual buildup of oxygen-demanding sediments in the mainstem lakes increases the likelihood of low dissolved oxygen levels in deeper lake waters. Operational controls to alleviate this problem are limited because the dams were not constructed with multiple level outlets for releasing water. The absence of dissolved oxygen (anoxic conditions) during summer conditions may result in an influx of metals such as iron and manganese from the sediments into the water column. These concentrations may be 10 to 1,000 times higher than normal background concentrations and may result in detrimental effects to water users. Anoxic conditions, through the oxidation-reduction process, can also liberate nutrients such as phosphorus from the sediments. This can lead to nutrient enrichment and possible nuisance growth of algae.

There is very little detailed information on dissolved oxygen depletions within the deeper, cooler regions of the mainstem lakes. There have been reports stating the occurrence of low dissolved oxygen concentrations in some locations of Lake Oahe, Lake Sakakawea, and Fort Peck Lake. No vertical profile data were found showing the occurrence of depleted oxygen or anoxic conditions. It is believed that the occurrence of low dissolved oxygen concentrations varies spatially in the large lakes (personal communication, J. Schaufelberger, Colonel, Corps, 1993) and during drought conditions when lake elevations are lower (personal communication, F.J. Schwindt, Chief, Environmental Health Section, State of North Dakota, 1995).

Heavy Metals

Elevated heavy metal concentrations have been detected both in the water column and within the sediments of the Mainstem Reservoir System. The major metals of concern in the Mainstem Reservoir System are arsenic and mercury. Arsenic and mercury concentrations greater than State water quality criteria have been detected in several of the mainstem lakes.

Natural background concentrations of arsenic, selenium, and mercury in the Missouri River lakes are associated with the local geology, specifically the presence of Upper Cretaceous age Pierre Shale. Natural background levels of elements in the lakes are strongly influenced by the levels of those elements contained in the soils derived from the Pierre Shale and other Upper Cretaceous age rocks.

Arsenic is a water quality parameter that commonly exceeds water quality standards criteria in the Missouri River lakes (Corps, 1994t). Elevated arsenic concentrations are a localized occurrence associated with large storm events—storms that cause high sediment loading or wind action that results in resuspension of the lake sediments. Sediment elutriate studies have indicated that arsenic may be released into the water column from wind and wave erosion, causing sediment agitation (Corps, 1994f). Arsenic is a naturally occurring metal within the watershed and readily adsorbs onto fine soil particles as they are transported downstream and deposited in the lakes. The majority of arsenic entering the Mainstem Reservoir System is adsorbed onto sediment particles. The lakes prevent the transport of particulate arsenic from being transported and act as a "sediment-metal" sink.

The sources of mercury are naturally occurring soils, point source discharges, and sediments generated from historical mining practices that have been transported downstream into the mainstem lakes. Atmospheric deposition is another significant source of mercury (State of North Dakota, 2001). Through biological uptake and transformation, mercury can become toxic to fish and humans in the form of methylmercury.

Other metals that have been detected in elevated concentrations in the mainstem lakes are copper, lead, iron, and manganese.

Sediment Deposition

The Missouri River carries an enormous sediment load due to the highly erodible soils and stream channels in the large basin area. The Missouri River, except at the dam tailwater locations, can be very turbid. Tributaries to the Missouri River, such as the Bad River (Lake Sharpe), the White River (Francis Case Lake), and the Niobrara River (Lewis and Clark Lake) transport large amounts of sediment into the mainstem lakes. Deltas have formed at the upstream end of the mainstem lakes where water velocity decreases and suspended solids settle. Lake elevations, through their influence on velocities of river inflows, determine the location and pattern of sediment deposits (Corps, 1994o). These deposited sediments also carry adsorbed pollutants that can be released to the water column under certain physical and chemical conditions. Sediment has been identified as a source of impairment in several river segments (see Table 3.5-2).

Pesticides

Agricultural practices, both past and present, include the application of pesticides throughout much of the Missouri River basin. Pesticides detected include chlordane, atrazine, alachlor, diazinon, dacthal, benzene hexachloride, metolachlor, dieldrin, DDT, simazine, metribuzin, and propachlor (Corps, 1994f). Because of the widespread occurrence of pesticides, bioaccumulation of some pesticides in the tissue of aquatic organisms is a potential threat to all consumers of these organisms.

Nutrient Loading

Tributary waters exhibit significant nutrient loadings because of POTW effluent discharges, urban stormwater and agricultural runoff, and other nonpoint sources of pollution. High nutrient levels in the Missouri River and its tributaries can deliver nutrients to the mainstem lakes and lead to conditions which cause undesirable algae blooms. Some States along the Missouri River have adopted numeric water quality standards criteria for nutrients. Other States are currently developing nutrient criteria as per EPA requirements. Narrative water quality criteria associated with algal concentrations, turbidity, and aesthetics are applicable in all the States. The Missouri River basin contributes a significant source of nutrients and pollutants to the Mississippi River that are believed to contribute to the hypoxia problem in the northern Gulf of Mexico.

Biological Uptake of Contaminants

Bioaccumulation is the accumulation of contaminants in the tissue of organisms through any route, including respiration, ingestion, or direct contact with contaminated water or sediment. Bioavailable, for chemicals, is the state of being potentially available for biological uptake by an aquatic organism when that organism is processing or encountering a given environmental medium (e.g., the chemicals that can be extracted by the gills from the water as it passes through the respiratory cavity or the chemicals that are absorbed by internal membranes as the organism moves through or ingests sediment). In water, a chemical can exist in three different basic forms that affect availability to organisms: 1) dissolved, 2) sorbed to biotic or abiotic components and suspended in the water column or deposited on the bottom, and 3) incorporated (accumulated) into organisms. Bioconcentration is a process by which there is a net accumulation of a chemical directly from water into aquatic organisms resulting from simultaneous uptake (e.g., by gill or epithelial tissue) and elimination. Biomagnification is the result of the process of biocentration and bioaccumulation by which tissue concentrations of bioaccumulated chemicals increase as the chemical passes up through two or more trophic levels. The term implies an efficient transfer of a chemical from food to consumer, so that residue concentrations increase systematically from one trophic level to the next.

The degree of bioaccumulation also depends on the properties of a chemical. For organic chemicals (including many pesticides), the degree to which they are attracted to adipose or fat tissues (lipophilicity) provides an indication of how likely they are to bioaccumulate. Larger, long-lived individuals, with higher lipid (fat) content, or species with low rates of metabolism or excretion of a chemical will tend to bioaccumulate more than small, short-lived organisms. Thus, an older lake trout (a predator) may bioaccumulate much more than a young bluegill (an omnivore) in the same lake.

Mercury has a tendency to bioaccumulate in producers and biomagnify in consumers. Mercury can change forms from relatively low toxicity to very high toxicity through biological or other processes. In aquatic environments, mercury can by transformed to methylmercury, which is the most hazardous form of mercury due to its high stability, its lipid (fat) solubility, and its high ability to penetrate membranes in living organisms (Eisler, 1987). Methylmercury is produced through methylation of inorganic mercury by bacteria present in both freshwater and saltwater sediments. This transformation alters its chemical reactivity and its fate in the ecosystem.

Exposure to methylmercury at sufficient doses can cause neurotoxicity and neurological effects in humans. It is classified by EPA as a Group C carcinogen, meaning that there is inadequate data for humans and limited evidence from animal studies to fully evaluate its carcinogenic effects. The acute and chronic criteria for mercury for the protection of freshwater water aquatic life are 1.4 and 0.77 μg/L, respectively (EPA, 1999a). For human health, the criteria are 0.050 μg/L for consumption of water and organisms, and 0.051 for consumption of organisms only (EPA, 1999a). EPA has developed risk-based consumption limits for mercury in fish tissues. The limits are based on a sliding scale dependent on the amount of fish consumed per month. If four fish meals are consumed per month (assuming 8 ounces per meal), the recommended methylmercury concentration in fish tissue is 0.12 to 0.23 ppm (EPA, 2000).

Fish consumption advisories have been issued for fish caught in the Missouri River and the mainstem lakes in the States of Montana, North Dakota, Nebraska, and Missouri. Montana suggests limiting the consumption of walleye, northern pike, lake trout, and chinook salmon from Fort Peck Lake to one meal a week for those who eat sport-caught fish regularly for 3 or more months of the year due to elevated levels of mercury. In North Dakota, all species and size of fish tested were found to contain mercury. The State recommends that only small fish be eaten, and that consumption of larger fish be limited to only one to four meals per month. In Nebraska, the State found elevated levels of polychlorinated biphenyls and dieldrin in channel catfish taken from the Missouri River near Omaha, Plattsmouth, and Rulo, Nebraska. Sturgeon from the river in Missouri have been found to have combinations of PCBs and chlordane at levels of health concern (EPA, 2001).

3.5.8 Specific Lake and River Reach Water Quality

Water quality summary information on specific Missouri River reaches and lakes is provided in this section. The general information provided includes the following:

- Domestic water users,
- Water quality parameters of interest, and
- Water quality impairment status.

Table 3.5-5 summarizes other water quality issues based upon information provided in the States 305(b) reports that are biennially submitted to EPA. As previously mentioned, the 305(b) report summarizes the current water quality conditions within that particular State. Water quality issues beyond those detailed in the 305(b) are summarized in the table. In addition, the table describes water quality issues for Tribal lands located along the Missouri River.

There are concerns about the protection of domestic drinking water uses of the Missouri River and the mainstem lakes. A listing of domestic water intakes is located in Section 3.4.

Table 3.5-6 summarizes the water quality conditions of the lakes (inflows, lake, and outflows locations). This table provides information on the length, surface area, volume, and daily inflow rate.

Fort Peck Lake

Fort Peck Lake is located in eastern Montana about 18 miles from Glasgow, Montana. The lake is located behind Fort Peck Dam at RM 1771 of the Missouri River. The lake and dam are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, wildlife, and recreation (Corps, 2000). The major tributaries to Fort Peck Lake are the Musselshell River and Little Dry Creek.

Fort Peck Lake is used as a water supply by Fort Peck and Glasgow, Montana and for numerous individual cabins in the area. Full body contact recreation is allowed at the lake (Corps, 2000).

The State of Montana has placed Fort Peck Lake on the 303(d) List of Impaired Waterbodies owing to lead, mercury, and other metals, and noxious aquatic plants. The identified sources of these pollutants and conditions are agriculture, abandoned mining, and atmospheric deposition.

Inflows and waters within Fort Peck Lake have a low pH and elevated levels of arsenic, phosphorus, mercury, manganese, beryllium, and iron.

The Montana Department of Public Health and Human Services has published a “Meal Advisory” for the consumption of certain species and size of fish caught in Fort Peck Lake, due to mercury in the tissues of walleye, northern pike, lake trout, and chinook salmon (EPA, 2001).

Dissolved oxygen levels in the deeper waters of the lake and in dam releases are at times below saturation, indicating the possible presence of oxygen-demanding materials in sediments or excessive algal blooms. The die-off of algal blooms and subsequent settling of organic matter contribute to the oxygen demand of the deeper isolated waters of the lake. Toxins associated with algal blooms have been detected in isolated areas of the lake. As water levels drop during extended droughts, algal blooms have a greater impact on dissolved oxygen conditions.

Missouri River from Fort Peck Dam to Lake Sakakawea

There are two Missouri River segments downstream of Fort Peck Dam that are on the State of Montana’s 303(d) List of Impaired Waterbodies, segment MT40S001_010 from Fort Peck Dam to the Poplar River, and segment MT40S003_010 from the Poplar River to the North Dakota border. These segments are affected by metals and habitat alteration resulting from the modified stream flows. Fort Peck Lake alters the temperature in the Missouri River, and the effects of these temperature shifts can be observed throughout this reach. Abnormally coldwater temperatures and extreme water clarity from Fort Peck Dam have significantly altered the river environment and have impacted the downstream warmwater fishery. This river reach also contains stream banks that are eroded and a streambed that is degraded because of the low sediment load of the river (Corps, 1994l). Stream segment MT40S001_010 is rated as a high “severity” on the 303(d) list and a TMDL study has already been initiated by the State of Montana.

Table 3.5-5. 305(b) report summaries of water quality. page 1 of 4

State	Water Body	Segment	State/Tribal	Water Quality Issues	303(D) Listed
Montana	Fort Peck Lake	MT40E004_010	State/Tribal: Fort Peck Reservation	Metals, lead, mercury, noxious aquatic plants	Y
	Missouri River	MT40S001_010 (Fort Peck Dam to Poplar River)	State/Tribal: Fort Peck Reservation	Metals, thermal modification, flow alteration, other habitat alteration	Y
	Missouri River	MT40S003_010 Poplar River to ND State line)		Thermal modification, flow alteration	Y
North Dakota	Missouri River	ND State border to confluence of Yellowstone and Missouri Rivers Confluence of Yellowstone and Missouri Rivers to Lake Sakakawea	State	Flow alteration, habitat alteration	N
	Lake Sakakawea		State/Tribal: Fort Berthold Reservation	Metals, nutrient loading, flow alteration, stream habitat degradation	N
	Missouri River	Garrison Dam to Lake Oahe	State	Stream habitat degradation, excessive nutrient loading, siltation, sediment disposition	N
	Lake Oahe		State/Tribal: Standing Rock Sioux Tribe, Cheyenne River Sioux Tribe	Metals, excessive nutrient loading, siltation, stream habitat degradation	N
South Dakota	Missouri River	ND border to Big Bend Dam	State/Tribal: Standing Rock Sioux Tribe, Cheyenne River Sioux Tribe, Lower Brule Reservation, Crow Creek Reservation	Metals, stream habitat degradation, ammonia, bacteria, dissolved oxygen, nutrient loading, accumulated sediment	N
	Lake Sharpe		State/Tribal: Lower Brule Sioux Tribe, Cow Creek Sioux Tribe	Accumulated sediment	Y
	Missouri River	Big Bend Dam to Iowa border	State/Tribal: Yankton Sioux Tribe	Ammonia, bacteria, dissolved oxygen, nutrients, accumulated sediment	N

Table 3.5-5. 305(b) report summaries of water quality. page 2 of 4

State	Water Body	Segment	State/Tribal	Water Quality Issues	303(D) Listed
South Dakota (cont.)	Lake Francis Case		State/Tribal: Yankton Sioux Tribe	Thermal modification, flow alteration, elevated pH, accumulated sediment, nutrient loading, siltation	N
	Lewis and Clark Lake		State/Tribal: Santee Sioux Tribe, Ponca Tribe of Nebraska	Thermal modification, flow alteration, elevated pH, accumulated sediment, nutrient loading, siltation	N
Iowa	Missouri River	IA 06-WEM-0010-0 (Iowa-Missouri line to Platte River) IA 06-WEM-0020-1 (Platte River to WS intake at Council Bluffs) IA 06-WEM-0030-0 (Boyer River to L. Sioux River)	State	Unknown & siltation (flow alterations leading to habitat alterations)	Y
	Missouri River	IA 06-WEM-0040-0 (L. Sioux River to Big Sioux River)	State/Tribal: Winnebago Reservation, Omaha Reservation	Unknown & siltation (flow alterations leading to habitat alterations)	Y
Missouri	Missouri River	Mouth to Gasconade River Gasconade River to Chariton River Chariton River to Kansas River Kansas River to State line	State	Habitat loss	Schedule TBA
Nebraska	Missouri River	MTI-10000 (Big Sioux River to Platte River)	State/Tribal: Winnebago Reservation, Omaha Reservation	Pathogens	Y; Not targeted for TMDL in next 2 years
	Missouri River	MT2-10000 (Niobrara River to Big Sioux River)	State/Tribal: Santee Reservation, Ponca Tribe of Nebraska	Pathogens	Y
	Missouri River	NE1-10000 (Platte River to Nebraska-Kansas border)	State/Tribal: Iowa Reservation, Sac and Fox Reservation	Pathogens	Y; Not targeted for TMDL in next 2 years

Table 3.5-5. 305(b) report summaries of water quality.

State	Water Body	Segment	State/Tribal	Water Quality Issues	303(D) Listed
Kansas	Missouri River	10240005-1 (Nodaway River to Mission Creek) 10240005-2 (Mission Creek to Mill Creek) 10240005-19 (Squaw Creek to Nebraska Border) 10240005-20 (Mill Creek to Cedar Creek) 10240005-21 (Cedar Creek to Squaw Creek) 10240011-1 (Jersey Creek to Fivemile Creek) 10240011-2 (Fivemile Creek to Bear Creek) 10240011-4 (Bear Creek to North of Harpst Chute) 10240011-5 (North of Harpst Chute to Owl Creek) 10240011-7 (Owl Creek to Walnut Creek) 10240011-9 (Walnut Creek to Sugar Creek)	State/Tribal: Iowa Reservation, Sac and Fox Reservation, Kickapoo Reservation, Potawatomi Reservation	Nutrient loading, habitat modification, fecal coliform	N

Table 3.5-5. 305(b) report summaries of water quality. page 4 of 4

State	Water Body	Segment	State/Tribal	Water Quality Issues	303(D) Listed
Kansas (cont.)		10240011-11 (Sugar Creek to Independence Creek) 10240011-13 (Independence Creek to Walnut Creek) 10240011-15 (Walnut Creek to Mace Creek) 10240011-19 (Mace Creek to Nodaway River)			

Table 3.5-6. Lake water quality and physical description summary.

Project	Potential Problem Areas	State Standard Concerns		Length (miles)	Surface Area (acres)	Gross Volume (acre-feet)	Mean Daily Inflow (kcfs)
Fort Peck, Mt Missouri River Mainstem	Coal and oil, development, algal blooms	Inflows: Lake: Releases:	None identified Arsenic, mercury, dissolved oxygen Arsenic	134	240,000	18,688,000	10.8
Lake Sakakawea, Nd Missouri River Mainstem	Oil dripping, strip mining, algal blooms, metribuzin	Inflows: Lake: Releases: Impoundment:	None identified Arsenic, mercury, dissolved oxygen None identified Arsenic, mercury, total phosphorus, dissolved oxygen, sulfate	178	364,000	23,821,000	24.0
Lake Oahe, Sd Missouri River Mainstem	Ag runoff, mercury, bioaccumulation, metribuzin	Inflows: Lake: Releases:	None identified Mercury, total phosphorus, iron, sulfate Arsenic, mercury, sulfate, total phosphorus	231	360,000	23,137,000	26.7
Lake Sharpe, Sd Missouri River Mainstem	Ag runoff, atrazine	Impoundment: Inflows: Lake: Releases:	Arsenic, iron, total phosphorus, sulfate None identified Mercury, sulfate, dissolved oxygen Sulfate	80	60,000	1,859,000	25.8
Lake Francis Case, Sd Missouri River Mainstem	Intrusion of the white river delta, metribuzin, atrazine	Inflows: Lake: Releases:	None identified Mercury, sulfate, dissolved oxygen, total phosphorus, arsenic Sulfate, mercury	107	95,000	5,418,000	26.8
Lewis And Clark Lake, Sd Missouri River Mainstem	Emergent aquatic vegetation, atrazine, cyanazine	Inflows: Lake: Releases:	Sulfate, mercury Mercury, sulfate, dissolved oxygen, arsenic Sulfate, total phosphorus, arsenic	25	28,000	470,000	29.3

Notes: Ag = Agriculture; Nd = North Dakota; Mt = Montana; Sd = South Dakota

Length, surface area, and gross volume are at full pool levels. Mean daily inflow is for the period 1967 to 2000.

Source: Corps, 2000

Under the 303(d) listing process, mercury has also been mentioned as a parameter of concern that is directly related to dam operations (personal communication, N. Mackin, TMDL Coordinator, Montana Department of Environmental Quality, July 17, 2001). There is concern that dissolved mercury concentrations increase in dam tailwaters in comparison to concentrations within the lake. Studies to determine the fate and transport of mercury have not been performed by the State of Montana.

Dissolved oxygen in the releases from Fort Peck Dam at times is slightly below saturation levels. The Milk and Yellowstone Rivers are the major tributaries to this river reach. The Yellowstone River is on the State of North Dakota's 303(d) List of Impaired Waterbodies due to metals and pathogens.

The Assiniboine and Sioux Tribes of the Fort Peck Reservation exercise water rights downstream from Fort Peck Dam. These Tribes are in the process of using the Missouri River for domestic water. In cooperation with EPA, the Tribes are developing a treatment system based upon existing water quality conditions in the river.

Lake Sakakawea

Lake Sakakawea is located in central North Dakota 75 miles northwest of Bismarck, North Dakota. The lake is located behind Garrison Dam at RM 1389 of the Missouri River. The lake and dam are used primarily for flood control, irrigation, navigation, hydropower, domestic and sanitary use, wildlife, and recreation. Lake Sakakawea is the largest lake in the Mainstem Reservoir System. The major tributaries are the Little Missouri River, the Yellowstone River, and the Milk River (Corps, 1994k). Major tributaries of the lake are sampled by the USGS, and Corps personnel collect lake and release samples six times per year.

The lake is used as a water supply by some individual cabins and by the cities of Riverdale, Pick City, Twin Buttes, Mandaree, Four Bears, Williston, Parshall, and Trenton, North Dakota (Corps, 2000).

Lake Sakakawea is not on the State of North Dakota's 303(d) List of Impaired Waterbodies.

Algal blooms occur at times in the lake during low lake conditions. A toxic algal bloom occurred in the lake in 1990 when the lake was near its lowest level (elevation 1,815 feet) during a drought. Organic materials, such as decaying algae and imported organic matter, contribute to the in-lake oxygen demand and result in reduced dissolved oxygen levels in the deeper, cooler portion of the lake.

Dissolved oxygen and arsenic concentrations at times exceed the State of North Dakota's water quality standards criteria. Dissolved oxygen concentrations fall below 5 mg/l in the deeper, cooler portion of the lake, and coldwater habitats can be significantly reduced during drought conditions.

Elevated concentrations of arsenic, mercury, copper, iron, lead, and pesticides have been detected in Lake Sakakawea (personal communication, F.J. Schwindt, Chief, Environment Health Section, State of North Dakota, 1995). Observed arsenic and mercury levels are below EPA recommended drinking water standards. Atrazine was also detected in Lake Sakakawea; however, State criteria have not yet been developed for this pesticide. Lake level, especially during drought conditions, has a significant influence on water quality.

The North Dakota Department of Health and Consolidated Laboratories (NDDHCL) has issued an advisory on consumption of fish caught in some streams and lakes in North Dakota. A study conducted by the NDDHCL concluded that walleye, sauger, and chinook salmon populations all demonstrated elevated levels of mercury (EPA, 2001).

Missouri River from Garrison Dam to Lake Oahe

This reach of the Missouri River has remained in a near-natural state, except for some bank stabilization programs. The river below Garrison Dam flows through forested bottomland typical of the land before impoundment.

The reach is dominated by cold, clear water releases from Lake Sakakawea that can support trout and salmon year round (Corps, 1994l). There are, however, fish consumption advisories within this river reach.

Lake Oahe

Lake Oahe is located in central South Dakota north of Pierre, South Dakota. It is located behind Oahe Dam at RM 1072 of the Missouri River. The lake and dam are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, wildlife, and recreation. Lake Oahe is the second largest lake in the Mainstem Reservoir System. The Missouri River enters Lake Oahe just downstream of Bismarck, North Dakota. The Cheyenne River is the major tributary entering the lake. The major tributaries to Lake Oahe are sampled by the USGS and area Corps personnel collect lake and release samples six times per year.

Lake Oahe is used as a water supply by Fort Yates, North Dakota, and Mobridge, Wakpala, Gettysburg, Eagle Butte, Swiftbird, Blackfoot, Promise, White Horse, Green Grass, Bear Creek, LaPlante, Dupree, Iron Lightning, Faith, Bridger, Cherry Creek, Red Schaffold, Thunder Butte, Red Elm, and Lantry, South Dakota, as well as some individual cabins (Corps, 2000).

Low dissolved oxygen levels occur, especially at low lake levels in deeper portions of the lake in the summer or in shallow bays during the winter. Winterkills of fish sometimes occur in these bays. Low storage levels during drought conditions reduce dissolved oxygen concentrations in the bottom waters because of the increased water temperature and sediment oxygen demand.

Lake Oahe is not on South Dakota’s the 303(d) List of Impaired Waterbodies.

Elevated concentrations of arsenic, manganese, iron, and beryllium have been monitored in Lake Oahe and its inflows. Elevated levels of mercury have also been found at times and in certain locations. The elevated concentration of mercury is primarily isolated to the Cheyenne River and Cheyenne Arm of Lake Oahe, which runs along the southern boundary of the Cheyenne River Reservation. While a past point source of the mercury is now controlled, sediments in the river and lake remain contaminated and continue to be deposited in Lake Oahe (Corps, 1994f). The water quality parameters of concern within the lake are arsenic, dissolved oxygen, pH, iron, lead, manganese, and copper. The major source of pollutants is agricultural runoff.

The Cheyenne River Sioux Tribe and the South Dakota Game, Fish and Parks have collected fish tissue samples in the Cheyenne River, Grand River, and Moreau River arms in Lake Oahe. The tissue samples contained sufficient levels of mercury to warrant a consumption advisory on fish caught in areas adjacent to Tribal lands. Extended studies are currently being performed by the State of South Dakota regarding this issue (Corps, 2000).

Missouri River from Oahe Dam to Lake Sharpe

This reach of the Missouri River is only 5 miles long and is strongly influenced by water releases from Oahe Dam. The reach is dominated by cool, clear release waters with no large tributary inputs (Corps, 1994l). The Bad River enters near the downstream end of this reach. A large amount of sediment enters the river from this tributary. An EPA-funded Section 319 project in the Bad River basin has reduced this sediment load in recent years.

The State of South Dakota has not listed this reach of the Missouri River on its 303(d) List of Impaired Waterbodies.

Lake Sharpe

Lake Sharpe, located behind Big Bend Dam (RM 987), is located in central South Dakota. The dam and lake are used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, wildlife, and recreation. Lake Sharpe is used as a water supply by Pierre, Fort Pierre, Fort Thompson, and Lower Brule, South Dakota. Full body contact recreation is allowed at the lake (Corps, 2000). The pool elevation remains fairly constant, even during drought conditions (Corps, 1994o). Corps personnel sample Lake Sharpe water quality six times per year.

Lake Sharpe is on the State of South Dakota’s 303(d) List of Impaired Waterbodies due to accumulated sediment in its close proximity to the Bad River Section 319 Nonpoint Source Management Project.

Lake Sharpe experiences dissolved oxygen depletion in its deeper, cooler waters during summer conditions. Water quality parameters of concern are dissolved oxygen, sulfate, and arsenic. Lake Sharpe receives agricultural runoff containing pesticides and nutrients. Elevated levels of PCBs and pesticides have been monitored in the lake. Lake Sharpe receives very little sediment inflow from the mainstem of the Missouri River due to the close proximity of the Oahe Dam; however, a delta formed by sediment deposition from the Bad River is extensive.

Lake Francis Case

Lake Francis Case is located in southern South Dakota behind Fort Randall Dam (RM 888). The dam and lake are primarily used for flood control, irrigation, navigation, hydropower, domestic and sanitary use, wildlife, and recreation. The White River is the main tributary to the lake. Major tributaries to Lake Francis Case are sampled by the USGS, and Corps area Corps personnel collect lake and release samples six times per year.

Lake Francis Case is used as a water supply by the communities of Wagner, Ravinia, Lake Andes, Geddes, Platte, Chamberlain, Oacoma, Pukwana, Kimball, White Lake, Reliance, Marty, Greenwood, Dante, and Pickstown, South Dakota. Full body contact recreation is allowed at the lake (Corps, 2000).

Lake Francis Case is not on the 303(d) Listing of Impaired Waterbodies in South Dakota.

The White River delta has had a significant impact on Lake Francis Case. Sediment from the river has formed a plume, which occupies at least 30 miles of the lake. The diffuse nature of this sediment resists consolidation and makes it very susceptible to wind mixing. Numerous metals that are associated with the sediment directly influence lake water quality, and increased turbidity influences many aspects of the lake biota. The long-term effects of the sediment include increased metals in the water column and destruction of benthic habitat. The White River's huge sediment load remains in Lake Francis Case and also adds to total suspended sediments in the tailwaters of Fort Randall Dam.

Parameters that have been found to exceed water quality standards' criteria for Francis Case Lake are dissolved oxygen, arsenic, phosphorus, and mercury. The Corps' Annual 2000 Report (Corps, 2000) mentioned that the observed concentrations may restrict the propagation of sensitive species. Although EPA's recommended drinking water standards criteria for arsenic and mercury were not exceeded, the Corps recommended that local municipalities monitor raw water intakes. Elevated concentrations of arsenic, pesticides, lead, mercury, cadmium, and zinc have also been measured in the Lake.

Missouri River from Fort Randall Dam to Lewis and Clark Lake

The State of South Dakota has not listed this reach of the Missouri River on the 303(d) List of Impaired Waterbodies. The water quality parameters of concern include ammonia, pathogens, dissolved oxygen, nutrients, and accumulated sediment.

This 47-mile-long unchannelized reach is a wide, meandering channel. Warmwater dominates this reach because Lake Sharpe and Lake Francis Case rarely stratify in the summer and cooler, deeper water is absent in the tailwaters. Tailwaters are turbid due to the sediment accumulation in the upstream lakes.

Lewis and Clark Lake

Lewis and Clark Lake, the smallest of the mainstem lakes, is located on the Nebraska-South Dakota border. It is located behind Gavins Point Dam at RM 811 of the Missouri River. The dam and lake are used for flood control, irrigation, navigation, hydropower, domestic and sanitary water use, wildlife, and recreation. The Niobrara River and Bazille Creek are the major tributaries into the lake. Major tributaries to Lewis and Clark Lake are sampled by the USGS. Corps area personnel collect lake and release samples six times per year.

Lewis and Clark Lake is used as a water supply by Yankton, Bon Homme, Springfield, and Cedar, South Dakota.

Lewis and Clark Lake is not on the 303(d) Listing of Impaired Waters in Nebraska or South Dakota. However, dissolved oxygen levels are at times depressed in the lake during summer stratification. Arsenic, iron, mercury, manganese, and lead concentrations are at times elevated and exceed State water quality standards' criteria. The Corps' Annual 2000 Report (Corps, 2000) mentioned that these elevated concentrations may restrict the propagation of sensitive species. Although the EPA's recommended drinking water standards criteria for arsenic and mercury were not exceeded, the Corps recommended that local municipalities monitor raw water intakes.

Pesticides and mercury have been detected in fish tissue samples taken from the lake. The Nebraska Department of Environmental Control collected fish tissue samples from Lewis and Clark Lake in 1988. The tissue samples contained cadmium, mercury, and DDT.

Missouri River from Gavins Point Dam to St. Louis

Water quality management from Gavins Point Dam to St. Louis, Missouri is under the jurisdiction of five States (South Dakota, Nebraska, Iowa, Kansas, and Missouri). Three of these States, Nebraska, Iowa, and Missouri, have placed the Missouri River on the 303(d) List of Impaired Waterbodies (See Table 5.5-2). The main reasons listed for water quality impairment are flow alternations leading to habitat impacts, habitat loss, siltation, and pathogens. The listed sources of the pathogens are municipal point sources, agriculture, and urban stormwater runoff.

The quality of the water released from Gavins Point Dam gradually deteriorates downstream due to inflows from tributaries and point and nonpoint sources. At the Gavins Point Dam, the summer water temperature is 24 to 26°C, with saturated levels of dissolved oxygen and low nutrient and sediment levels. With increasing distance from the dam, the water temperature, nutrient levels, and biological oxygen-demanding materials increase, peaking at about Kansas City.

Nutrient concentrations that increase significantly downstream include organic nitrogen, nitrate, total phosphorus, and ortho-phosphorus. Sewage treatment plant effluents, although contributing only a small flow (less than 0.1 kcfs each), have high concentrations of nutrients and oxygen-demanding materials. Tributaries provide warm, turbid water with elevated levels of nutrients and other oxygen-demanding materials.

Powerplants that use the river for cooling water (21 plants) circulate up to 2.2 kcfs through their cooling condensers. This heats the water 10º to 15ºC above the river's ambient temperature before discharging back to the river. In some reaches, the thermal discharges from power plants raise the average river temperature 1º to 2ºC. Downstream from Sioux City, water quality standards' criteria for water temperature are a maximum of 32ºC and no more than a 3ºC rise above the ambient river temperature in the mixing zone. The criteria for dissolved oxygen is a minimum concentration of 5 mg/l.

The EPA is performing a thermal mixing zone study in the lower portions of the Missouri River. Thermal modeling studies will be performed under various flow regimes in the Missouri River. Model results will be verified by using direct in-stream measurements or using remote satellite sensing (personal communication, J. Dunn, EPA, Kansas City, Missouri, July 25, 2001). The study started in the summer of 2001 and is estimated to finish in 2002.

Mississippi River from St. Louis to Gulf of Mexico

The primary water quality concern in the Middle Mississippi River (mouth of the Missouri to the mouth of the Ohio) is low dissolved oxygen levels in side channels. Many of the side channels or chutes have been blocked to divert flow to the main channel to maintain navigation traffic. Once isolated or partially isolated, the side channels begin to resemble eutrophic lakes with water stratification and fluctuations in dissolved oxygen levels from top to bottom. As the side channels stratify, they experience anoxic (low oxygen) conditions at the substrate level, killing most of the invertebrate fauna. These low oxygen conditions have been documented in many of the Middle Mississippi River side channels (personal communication, B. Hrabik, Missouri Department of Conservation, Long Term Resource Monitoring Program, Open River Field Station, July 2001).

The primary water quality concern on the Lower Mississippi River (Ohio River to the Mouth) is saltwater intrusion. During low-flow periods, saltwater from the Gulf of Mexico intrudes up the Mississippi River channel, causing problems for water intakes and wells. Since the saltwater is heavier than the freshwater, it remains closer to the channel bottom. At the upstream edge of the intrusion, the saltwater lies in a thin layer at the bottom of the channel. Closer to the mouth, the saltwater layer is thicker and is referred to as a wedge. The saltwater wedge position is basically a function of discharge, rate of change of discharge, discharge duration, and whether or not the discharge is increasing or decreasing. A natural barrier, known as "Kenner Hump," normally prevents the saltwater wedge from advancing upstream. Under certain conditions, however, particularly during low-flow conditions of long duration, the wedge can and has advanced upstream of that point. If the toe of the wedge advances beyond the Kenner Hump and the low-water condition persists allowing saltwater at higher elevations to advance, water supply for the city of New Orleans, Louisiana would be threatened and the economic impact of the saltwater intrusion could be great. As was done in 1988, a sill would be constructed in case of a severe low-water event to prevent such an occurrence.

Gulf of Mexico

The northern portion of the Gulf of Mexico experiences extreme water quality impacts due to large inputs of nutrients, oxygen-demanding substances, pesticides, and other toxic pollutants. It is estimated that 25 percent of the nutrient and pesticide loading comes from nonpoint sources from the Missouri River basin. The Corps has several stream restoration and wetland projects that will help alleviate the nutrient loading into the Missouri River. There are also numerous State- and EPA-funded pollution projects, such as Section 319 Projects, that are focused on managing nonpoint sources of pollution, especially from agricultural operations.

Nitrogen from the Mississippi River basin has been implicated as one of the principle causes for the expanding hypoxic zone that develops most years on the Louisiana-Texas continental shelf in the Gulf of Mexico. Hypoxia, or oxygen depletion, in bottom waters below a concentration of 2 mg/L can cause stress or death to bottom-dwelling organisms over thousands of square kilometers of the Gulf. Nitrate concentrations have increased significantly during the past 100 years in streams draining some parts of the Mississippi River basin.

Within the Missouri River basin, average annual nitrate concentrations have more than doubled between the period of 1905-1907 to 1980-1996 (as measured in the Lower Missouri River). It has been demonstrated that fluxes of nitrate will be low in dry years and high in wet years. Accordingly, any modification of the annual discharge hydrograph for the Missouri and Mississippi Rivers may have ramifications on the size and persistence of the hypoxic zone in the Gulf. As a result of concerns over the severity of the problem of the Gulf hypoxic zone, an Action Plan for reducing, mitigating, and controlling hypoxia in the Northern Gulf of Mexico has been prepared by a high level Task Force of Federal and State agencies.

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3.6 WETLAND AND RIPARIAN VEGETATION

Water levels and flows affect abundance, distribution, and species composition of wetland and riparian vegetation. Because the alternative water control plans will affect water levels and flows, this section focuses on describing the riparian vegetation and wetlands along the Missouri River.

3.6.1 General

The Missouri River floodplain currently supports significant stands of riparian forest and includes numerous old channels that have been cut off from the river, forming oxbow lakes. Within the active channel of some reaches, the process of erosion and deposition still creates islands, sandbars, chutes, and backwaters that support a variety of wetlands. Deltas have developed in the lakes associated with the six mainstem dams, supporting additional extensive wetland complexes. The wetlands along the river and in deltas serve many important functions: wildlife habitat (waterfowl, big game, furbearers, etc.), fish breeding and foraging habitat, nutrient/sediment trapping, flood control, and recreation. Riparian forests serve as important wildlife habitat, timber sources, wind shelters for residences, and locations for recreational activities.

The terms "wetland" and "riparian" mean different things to different people. For this document, wetlands and open water areas of the Missouri River are classified according to the USFWS's system of definitions for the National Wetlands Inventory (NWI), commonly referred to as the Cowardin System (Cowardin et al., 1979). According to the Cowardin system (1979), all wetlands exhibit three characteristics: (1) the presence of hydrophytic (water-loving) plants; (2) predominantly undrained hydric soils; and (3) a substrate that is saturated with water or covered by shallow water for at least some portion of the growing season (Cowardin et al., 1979). Open water or deepwater habitats are defined as "permanently flooded lands lying below the deepwater boundary of wetlands" (Cowardin et al., 1979) and include the reservoirs and river. The wetland classes along the Missouri River fall into four major groups, based on dominant vegetation structure:

1. emergent—dominated by perennial or persistent herbaceous plants;
2. scrub-shrub—dominated by woody vegetation less than 20 feet tall;
3. forested—dominated by woody vegetation greater than 20 feet tall; and
4. exposed shore—less than 30 percent cover of trees, shrubs, or persistent emergents and associated with rivers, reservoirs, or lakes.

For this document, the term "wetland" is used to refer to emergent, scrub-shrub, and forested classes. The term "exposed shore" refers to shoreline wetlands, both vegetated and unvegetated.

"Riparian" applies specifically to the upland, or non-wetland, component of the Missouri River floodplain. Typically occurring at higher elevations than wetlands, riparian communities are characterized by relatively dry, sandy soil and occasional intermittent flooding. Intermittent flooding is defined as inundation or saturation for less than 2 percent of the growing season for 1 to 10 years out of every 100 years (Mitsch and Gosselink, 1986). Dominance of hydrophytic vegetation is used to distinguish wetland and riparian habitats. The vegetation in riparian areas may be transitional, including plants found in both upland and wetland communities. Three riparian vegetation classes were identified along the Missouri River, each defined by dominant vegetation structure: (1) grassland, (2) shrub, and (3) forest.

Floodplain and aquatic habitat includes three classes of wetlands, three classes of riparian vegetation, and river, reservoir, and exposed shoreline categories, as presented in Table 3.6-1. The different classes of wetland and riparian vegetation tend to occur in distinct elevational bands that parallel the river, reflecting a soil moisture gradient of increasing dryness with increasing distance from the river.

Field and mapping efforts inventoried approximately 112,600 acres of wetlands and 60,500 acres of exposed shore in the deltas and reaches along the 1,900 miles of the Missouri River from the Fort Peck Lake delta in Montana to St. Louis (Table 3.6-1; Corps, 1994d). This area also contains about 192,500 acres of non-wetland riparian vegetation in the floodplain and 719,000 acres of agricultural lands (Table 3.6-1; Corps, 1994d). Field mapping efforts were focused on the major deltas and riverine reaches where a hydrological connection (surface or subsurface) to the Missouri River could be demonstrated; therefore, not all wetlands and riparian areas are included in the inventory.

Table 3.6-1. Acreages of floodplain and aquatic resources mapped in deltas and riverine reaches along the Missouri River in 1991[a/]. Page 1 of 3

Missouri River Segments	Emergent Wetlands	Scrub-Shrub Wetlands	Forested Wetlands	Wetland Subtotal	Riparian Forest	Riparian Shrub	Riparian Grass[b/]	Riparian Subtotal	Rivers[c/d/]	Reservoirs[e/]	Surface Water Subtotal	Exposed Shoreline[f/]	TOTAL
Upper River													
Sevenmile Creek	689	2,927	692	4,308	112	25	1	138	803	41	844	230	5,520
C.K. Creek	1,543	2,172	234	3,949	0	0	4	4	0	2,092	2,092	1,103	7,148
Mussellshell River	2,301	1,737	89	4,127	12	227	29	268	0	4,803	4,803	1,504	10,702
Fort Peck Lake Delta	**4,533**	**6,836**	**1,015**	**12,384**	**124**	**252**	**34**	**410**	**803**	**6,936**	**7,739**	**2,837**	**23,370**
Wolf Point/ Skinner's Island	4,211	2,916	457	7,584	8,641	1,995	1,668	12,304	8,552	252	8,804	1,213	29,905
Snowden	2,553	1,772	41	4,366	4,804	758	2,799	8,361	6,197	65	6,262	479	19,468
Fort Peck Dam to Lake Sakakawea Delta	**6,764**	**4,688**	**498**	**11,950**	**13,445**	**2,753**	**4,467**	**20,665**	**14,749**	**317**	**15,066**	**1,692**	**49,373**
Trenton Bottoms	715	1,646	1,375	3,736	592	53	1,091	1,736	1,079	1,191	2,270	428	8,170
Lewis and Clark	3,649	2,129	537	6,315	208	17	1,358	1,583	0	1,784	1,784	4,421	14,103
Williston Lagoon	4,195	5,403	1,226	10,824	6	1	27	34	0	3,002	3,002	3,423	17,283
Lake Sakakawea Delta	**8,559**	**9,178**	**3,138**	**20,875**	**806**	**71**	**2,476**	**3,353**	**1,079**	**5,977**	**7,056**	**8,272**	**39,556**
Stanton	431	130	202	763	5,640	0	2,770	8,410	2,425	543	2,968	1,482	13,623
Washburn	752	253	49	1,054	3,293	272	2,325	5,890	2,990	96	3,086	1,797	11,827
Square Butte	660	201	47	908	137	244	1,309	1,690	2,869	31	2,900	1,755	7,253
I-94	300	129	18	447	669	37	569	1,275	1,369	52	1,421	674	3,817
Garrison Dam to Lake Oahe Delta	**2,143**	**713**	**316**	**3,172**	**9,739**	**553**	**6,973**	**17,265**	**9,653**	**722**	**10,375**	**5,708**	**36,520**
Sibley Park	2,314	129	17	2,460	3,438	30	209	3,677	1,170	10	1,180	611	7,928
Kimball/ Graner/ McLean	3,982	657	324	4,963	4,638	68	920	5,626	744	811	1,555	875	13,019
Glencoe/ Carlson	2,234	1,358	50	3,642	1,614	205	321	2,140	0	2,117	2,117	7,150	15,049

Table 3.6-1. Acreages of floodplain and aquatic resources mapped in deltas and riverine reaches along the Missouri River in 1991[a]. Page 2 of 3

Missouri River Segments	Emergent Wetlands	Scrub-Shrub Wetlands	Forested Wetlands	Wetland Subtotal	Riparian Forest	Riparian Shrub	Riparian Grass[b]	Riparian Subtotal	Rivers[c/d]	Reservoirs[e]	Surface Water Subtotal	Exposed Shoreline[f]	TOTAL
Cannonball River	958	1,110	40	2,108	117	1	1,857	1,975	1,838	11,402	13,240	18,218	35,541
Moreau River	366	1,963	104	2,433	60	0	161	221	106	9,003	9,109	3,984	15,747
Cheyenne River	90	1,632	381	2,103	0	0	5	5	213	1,620	1,833	3,224	7,165
Lake Oahe Deltas	**9,944**	**6,849**	**916**	**17,709**	**9,867**	**304**	**3,473**	**13,644**	**4,071**	**24,963**	**29,034**	**34,062**	**94,449**
Greenwood	929	144	802	1,875	3,854	15	545	4,414	5,380	39	5,419	131	11,839
Verdel/ Choteau	753	310	87	1,150	682	181	19	882	2,029	7	2,036	166	4,234
Fort Randall Dam to Lewis & Clark Lake Delta	**1,682**	**454**	**889**	**3,025**	**4,536**	**196**	**564**	**5,296**	**7,409**	**46**	**7,455**	**297**	**16,073**
Niobrara	1,521	391	201	2,113	165	3	111	279	0	2,747	2,747	39	5,178
Bazille Creek	5,260	671	120	6,051	1,262	130	338	1,730	0	5,280	5,280	843	13,904
Lewis & Clark Lake Delta	**6,781**	**1,062**	**321**	**8,164**	**1,427**	**133**	**449**	**2,009**	**0**	**8,027**	**8,027**	**882**	**19,082**
Myron Grove	935	782	91	1,808	2,202	448	1,288	3,938	7,286	216	7,502	338	13,586
Mulberry Point	1,053	915	93	2,061	1,082	27	123	1,232	4,775	46	4,821	138	8,252
Elk Point	473	820	3	1,296	665	399	184	1,248	3,096	52	3,148	69	5,761
Gavins Point Dam to Ponca	**2,461**	**2,517**	**187**	**5,165**	**3,949**	**874**	**1,595**	**6,418**	**15,157**	**314**	**15,471**	**545**	**27,599**
Upper River Subtotal	**42,867**	**32,297**	**7,280**	**82,444**	**43,893**	**5,136**	**20,031**	**69,060**	**52,921**	**47,302**	**100,223**	**54,295**	**306,022**
Lower River													
Winnebago	1,860	1,539	116	3,515	4,812	532	1,169	6,513	3,404	309	3,713	187	13,928
Tieville Lake	553	435	32	1,020	1,653	179	252	2,084	1,017	122	1,139	59	4,302
Louisville	613	483	36	1,133	1,864	200	271	2,335	1,261	133	1,394	84	4,946
Bullard Bend	604	445	36	1,084	2,248	234	280	2,762	1,281	120	1,401	134	5,381
California	1,789	1,178	126	3,093	8,967	898	11,929	21,794	4,878	406	5,284	522	30,692
Ponca to Omaha	**5,420**	**4,080**	**346**	**9,845**	**19,544**	**2,042**	**13,901**	**35,487**	**11,841**	**1,090**	**12,931**	**986**	**59,250**
Otoe-Hamburg	1,212	875	96	2,182	5,741	577	11,452	17,770	4,281	266	4,547	296	24,795
Lincoln Bend	1,189	715	54	1,958	4,171	424	370	4,965	4,143	238	4,381	402	11,706
Worthwine Island	1,744	953	76	2,773	6,421	637	601	7,659	8,385	353	8,738	812	19,982

Table 3.6-1. Acreages of floodplain and aquatic resources mapped in deltas and riverine reaches along the Missouri River in 1991[a/]. Page 3 of 3

Missouri River Segments	Emergent Wetlands	Scrub-Shrub Wetlands	Forested Wetlands	Wetland Subtotal	Riparian Forest	Riparian Shrub	Riparian Grass[b/]	Riparian Subtotal	Rivers[c/d/]	Reservoirs[e/]	Surface Water Subtotal	Exposed Shoreline[f/]	TOTAL
Omaha to St. Joseph	**4,145**	**2,543**	**225**	**6,913**	**16,333**	**1,638**	**12,423**	**30,394**	**16,809**	**857**	**17,666**	**1,510**	**56,483**
Jackass Bend	1,393	361	2,876	4,630	13,240	21	1,009	14,270	14,984	738	15,722	651	35,272
Overton Bottoms	1,030	329	2,234	3,592	12,488	20	1,060	13,568	12,730	529	13,259	975	31,395
Eagle Bluff	87	55	391	534	2,362	4	144	2,510	4,932	21	4,953	435	8,433
Morrison Bend	141	88	585	813	5,203	9	273	5,485	6,696	33	6,729	539	13,566
Berger Bend	163	98	672	933	4,945	8	219	5,172	6,086	46	6,132	312	12,549
Howell Island	676	280	1,935	2,890	15,487	25	1,090	16,602	11,626	277	11,903	830	32,225
St. Joseph to St. Louis	**3,490**	**1,211**	**8,693**	**13,393**	**53,725**	**87**	**3,795**	**57,607**	**57,054**	**1,644**	**58,698**	**3,742**	**133,440**
Lower River Subtotal	**13,055**	**7,833**	**9,263**	**30,151**	**89,602**	**3,767**	**30,119**	**123,488**	**85,704**	**3,592**	**89,296**	**6,238**	**249,173**
TOTAL	**55,922**	**40,130**	**16,543**	**112,595**	**133,495**	**8,903**	**50,150**	**192,548**	**138,625**	**50,894**	**189,519**	**60,533**	**555,195**

a/ See text for definitions of wetland and riparian types and study area boundary. This table does not include Lake Sharpe or Lake Francis Case because their deltas are not expected to be affected by the water control plan alternatives. In addition, the short (5 mile) riverine reach between Oahe Dam and Lake Sharpe is not included because this area supports few wetlands. Acreages are not comprehensive. Field and mapping efforts focused on major deltas and river reaches. See Section 3.6 for definitions of wetland and riparian types.

b/ Includes small amounts of agricultural lands.

c/ Rivers include river surface area.

d/ River acres in delta segments represent the portion of the segment that is above the mean reservoir pool elevation and, therefore, exhibits more riverine characteristics.

e/ Reservoirs include the reservoir surface area in deltas only, as well as aquatic bed wetlands and oxbow lakes along the river and in deltas.

f/ Exposed shoreline includes bare and vegetated unconsolidated shore.

To facilitate analyzing the impacts of alternative water control plans in this document, the Missouri River has been divided into upper and lower sections based on climate and physiography. The following sections present a general description of the Upper and Lower River sections.

Upper River

For the wetland and riparian vegetation analyses, the Upper River extends from the Fort Peck Lake delta (RM 1893) to Ponca (RM 754), just upstream of Sioux City. Mainstem Reservations included in the Upper River are as follows: Fort Peck Reservation, Fort Berthold Reservation, Standing Rock Reservation, Cheyenne River Reservation, Lower Brule Reservation, Crow Creek Reservation, Yankton Reservation, Ponca Tribal Lands, and the Santee Reservation. This reach encompasses the ponderosa pine, prairie, and plains grassland ecosystems defined by the U.S. Department of Agriculture (USDA) Forest Service (1977). Natural upland vegetation consists primarily of grasslands. The climate along the Upper River is characterized by cold winters with variable amounts of snowfall (30 to 50 inches) and hot, dry summers (Corps, 1991a). The growing season is relatively short, extending from late May to early September in the northern reaches and from late April/early May to late September near Sioux City (National Oceanic and Atmospheric Administration, 1990).

The 1,139-mile Upper River encompasses all six of the Corps' mainstem reservoirs and four riverine reaches, including Fort Peck Dam to Lake Sakakawea delta; Garrison Dam to Lake Oahe delta; Fort Randall Dam to Lewis and Clark Lake delta; and Gavins Point Dam to Ponca. About 55 percent of the total acreage of aquatic habitat exists along the Upper River (555,195 acres total). It includes about 74 percent of the mapped wetlands, much of which (53 percent) occurs in the four major deltas (Figure 3.6-1). The density of wetlands, expressed as acres per mile of river length, is therefore much greater in the Upper River. In particular, the major reaches and deltas of the Upper River support much greater densities of emergent marsh, scrub-shrub, and exposed shore habitat compared to the Lower River (Figure 3.6-2). Conversely, non-wetland riparian vegetation along the Upper River represents only 36 percent of the amount in the Missouri River floodplain (Figure 3.6-1).

Reservoir Deltas

The four principal mainstem deltas, associated with Fort Peck Lake, Lake Sakakawea, Lake Oahe, and Lewis and Clark Lake, supported over 59,000 acres of wetlands in 1991, near the end of the recent drought. At that time, this acreage represented more than one-half of all the wetland acreage along the entire river (Table 3.6-1) and about 72 percent of that occurring along the Upper River (Figure 3.6-2). Delta wetlands generally expand during drought periods, encroaching on sediments exposed by receding water levels. When the lake levels return to normal operating conditions, which they approached or achieved in 1993 as a result of the "Great Flood of 1993," wetland plants drown and a significant portion of the wetland acreage reverts to open water. Missouri River deltas typically support less diverse wetland complexes compared to riverine reaches because fluctuating water levels preclude the establishment of trees and other species that are intolerant of long periods of inundation. The same process similarly limits development of riparian vegetation in the deltas, which currently support only 10 percent of the riparian vegetation along the entire river (Table 3.6-1).

Riverine Reaches

The Upper River includes four riverine reaches considered in the wetland inventory and analyses, one each below Fort Peck (some of Fort Peck Reservation boundary included in this reach), Garrison, Fort Randall (some of Yankton Reservation boundary included in this reach), and Gavins Point Dams. A short riverine reach extends approximately 5 miles below Oahe Dam, but was not field investigated because its wetlands will be essentially unaffected by proposed changes in mainstem operations.

Riverine reaches in the Upper River are relatively sinuous and semi-braided, and have retained many of the islands, backwaters, and side channels characteristic of pre-dam geomorphology. There is little overbank flooding and sediment deposition in the reaches, resulting in channel degradation and greatly reduced rates of island and sandbar creation. The regeneration of cottonwood forests is restricted because this species requires a moist, bare substrate for establishment (Johnson et al., 1976; Reily and Johnson, 1982). Cottonwood forest regeneration along the Upper River currently appears largely restricted to narrow shoreline zones or the upstream end of deltas. The decreased frequency of overbank flooding, perhaps compounded by lowered water tables, is probably causing the reduced cottonwood vigor, branch loss, and high mortality observed in mature riparian forests along the Upper River. Moisture conditions resulting from the reduced frequency of spring flooding and lowered water table are likely contributing to stress already occurring as a consequence of the advanced age of most cottonwood stands.

The four Upper River reaches contain about 130,000 acres of aquatic and floodplain habitat, including about 23,300 acres of wetland and 49,650 acres of riparian vegetation. The Upper River reaches support about 21 and 28 percent of the wetlands along the entire river and Upper River, respectively. Conversely, Upper River reaches support 72 percent of the riparian vegetation along the Upper River, but only 26 percent of that along the entire Missouri River (Figures 3.6-1 and 3.6-3).

Lower River

For the wetland and riparian vegetation analyses, the Lower River extends from Ponca (RM 754) to St. Louis (RM 0) and lies within the plains grasslands and oak-hickory forest ecosystems. The mainstem Reservations along the Lower River include the Winnebago Reservation, the Omaha Reservation, the Sac and Fox Reservation, and the Iowa Reservation. The northern portion of the Lower River is characterized by grasslands (USDA Forest Service, 1977). Beginning at St. Joseph, Missouri, and continuing to the mouth of the river, rolling hills forested with oak, hickory, and maple predominate. The climate along the Lower River is more mild and humid, and the growing season extends from early April to late October (National Oceanic and Atmospheric Administration, 1990).

The entire reach below Sioux City is the authorized BSNP. Construction of dikes and levees provides a narrow, sinuous channel (Hallberg et al., 1979; Kallemeyn and Novotny, 1977), with few islands, backwaters, or side channels. As a consequence of channel work and bed degradation, drainage has improved on the floodplain and accreted lands have been reclaimed for agricultural purposes. Only a few oxbow lakes and isolated backwaters remain, passively maintained by groundwater seepage or surface inflow, or actively maintained by pumping of groundwater or surface water. Although still important resources, the separation of these isolated oxbows and backwaters from the river channel has reduced their functional value as habitat.

The 754-mile Lower River is divided into three river reaches: Ponca to Omaha (Winnebago and Omaha Reservation boundaries included in this reach); Omaha to St. Joseph (Iowa and Sac and Fox Reservation boundaries included in this reach); and St. Joseph to St. Louis. Together, these three reaches contain about 249,200 acres of floodplain and aquatic habitat. Although the Lower River encompasses about the same acreage of floodplain and aquatic habitat as the Upper River, its composition differs markedly (Figure 3.6-1). The Lower River is characterized by a much greater density of riparian forest (119 acres/river mile) compared to the Upper River (39 acres/river mile), and supports much lower densities of emergent marsh, scrub-shrub, and exposed shore habitat (Figure 3.6-2). The Lower River floodplain also includes a much greater acreage of agricultural land (generally not considered wetland or riparian habitat) compared to the Upper River floodplain.

3.6.2 Fort Peck Lake Delta

The Fort Peck Lake delta extends 26 miles from just upstream of Sevenmile Creek (RM 1893) to the confluence of the Musselshell River (RM 1867). In 1991, the Fort Peck Lake delta was about 53 percent wetland, 33 percent water, 12 percent exposed shore, and 2 percent riparian vegetation (Table 3.6-1). The Fort Peck Lake delta supported about 11 percent of the wetland acreage along the entire river and only a negligible portion of the riparian vegetation (Figure 3.6-4).

Fort Peck Lake delta wetlands were dominated by scrub-shrub classes (55 percent). Forested and emergent classes constituted about 8 and 37 percent, respectively (Table 3.6-1). Delta scrub-shrub wetlands were characterized by dense thickets of young sandbar willow (*Salix interior*) with virtually no understory. Sandbar willow quickly colonizes exposed mudflats that retain sufficient moisture for germination, but remain unflooded for the remainder of the first growing season (Barnes, 1985; Noble, 1979; Wilson, 1970). Many of the areas supporting scrub-shrub wetlands in 1991 were inundated in 1993 when Fort Peck Lake returned to full pool. Emergent wetlands in the Fort Peck Lake delta support a variety of perennial grasses and forbs, primarily western wheatgrass (*Agropyron smithii*) and Canada thistle (*Cirsium arvense*). A few stands of river bulrush (*Scirpus fluviatilis*), spike-rushes (*Eleocharis* spp.), and rushes (*Juncus* spp.) are found in the lower portion of the delta, near Musselshell River. The few forested wetlands consist primarily of large sandbar willow and/or peachleaf willow (*Salix amygaloides*) and plains cottonwood (*Populus deltoides*).

During 1991 field investigations, Fort Peck Lake was approximately 14 feet below the normal operating level (2,234 feet). Consequently, large areas of exposed shore were common, particularly in lower portions of the delta near the Musselshell River. These areas generally support a mixture of weedy, mesic species, including cocklebur (*Xanthium strumarium*), kochia (*Kochia scoparia*), horseweed (*Conyza canadensis*), barnyard grass (*Echinochloa* sp.), witchgrass (*Panicum capillare*), and foxtail barley (*Hordeum jubatum*). The most recently exposed shores are usually unvegetated and consist of expanses of viscous silty clay, locally known as "gumbo."

Riparian vegetation is generally restricted to the extreme upper portion of the Fort Peck Lake delta, where the floodplain widens and is less frequently subjected to prolonged periods of inundation. Over 60 percent of the riparian areas in the Fort Peck Lake delta consist of riparian shrublands dominated by plains cottonwood and lower densities of peachleaf willow. These stands appear to be an extension of the riparian forests and shrublands that cover nearly half of the floodplain adjacent to the river upstream of the delta.

3.6.3 Missouri River from Fort Peck Dam to Lake Sakakawea

The Fort Peck reach for the wetlands and riparian vegetation analyses extends from Fort Peck Dam (RM 1771) 198 miles downstream to the Lake Sakakawea delta near Trenton Bottoms (RM 1573). The Fort Peck Reservation boundaries, which extend along the northern banks from RM 1766.0 to RM 1630.4, represent approximately 69 percent of the reach. This river reach includes many sandbars, islands, and side channels. Abandoned channels and several oxbow lakes remain in the floodplain. Upstream of Brockton, Montana (RM 1660), the floodplain is about 4 miles wide and is bordered by rolling grasslands, dryland crops, and rangelands. Downstream from this point, the floodplain narrows to a 1-mile-wide valley surrounded by badlands. Major tributaries include the Milk, Poplar, and Yellowstone Rivers, although the latter enters the Missouri River just upstream of the Lake Sakakawea delta and influences only a short segment of the Fort Peck reach.

Three study sites were chosen for detailed field investigation in this reach. Sites were chosen irrespective of political boundaries and were based on physical characteristics. The best representative sites were selected. Of the three study sites chosen as representative sites, both the Wolf Point and Skinner's Island study sites are located on or adjacent to the Fort Peck Reservation. The Wolf Point study site is located about 63 miles downstream of the Fort Peck Dam in an old channel that became dissociated from the main channel. The Skinner's Island study site is located just downstream from the confluence of the Poplar River, about 100 miles from Fort Peck Dam. Collected field data on wetland/riparian resources from all three sites are representative of the Fort Peck reach.

Riparian vegetation comprises about 42 percent of the area covered by the river and floodplain in the Fort Peck reach, water about 31 percent, wetlands about 24 percent, and exposed shoreline about 3 percent (Table 3.6-1). The Fort Peck reach is more than double the length of any other Upper River reach, supporting about 11 percent of the wetland acreage along the entire river and approximately 30 percent of the riparian vegetation along the 1,139-mile Upper River (Figures 3.6-3 and 3.6-4). More than one-half (56 percent) of the wetlands in the Fort Peck reach are emergent wetlands; most of the remainder (39 percent) are scrub-shrub wetlands, characterized by mixed stands of cottonwood and willow. Most emergent wetlands consist of extensive stands of reed canarygrass (*Phalaris arundincea*) and common reed (*Phragmites australis*). Drier emergent wetlands include western wheatgrass, common reed, and Canada thistle. Cattails are generally restricted to old oxbows or along islands, side channels, and backwaters. Scrub-shrub wetlands consist primarily of thin bands of sandbar willow along the shorelines.

Exposed shores are uncommon in the Fort Peck reach. When present, they mostly occur on the edges of islands and bars in the main channel, although some bare shorelines appear during periods of falling river stage.

Riparian vegetation occurs along the entire Fort Peck reach. Over one-half of the riparian vegetation is riparian forest, which commonly lines both shores. Cottonwood currently dominates the riparian forests, but green ash (*Fraxinus pennsylvanicus*) is considered the climax species in this area. Most of the original floodplain vegetation has been cleared, particularly from lands more removed from the river banks. Consequently, the density of riparian forest along the Fort Peck reach is lower than along any other Upper River reach (67 acres/mile). Riparian shrublands generally include cottonwood, snowberry (*Symphoricarpos* sp.), rose (*Rosa* spp.), and dogwood (*Cornus* spp.). Smooth brome (*Bromus inermis*) typically dominates riparian grasslands.

3.6.4 Lake Sakakawea Delta

The Lake Sakakawea delta extends approximately 38 miles, from the Trenton Bottoms area (RM 1573) downstream to just past Raum's Landing (RM 1535). The Fort Berthold Reservation boundaries along the Lake Sakakawea shorelines extend from RM 1483 to RM 1410, which is approximately 52 miles downstream of this delta. A Federal levee system protects portions of the town of Williston, located on the north shore of the delta, from rising water associated with delta formation. Large areas of cropland are converting to wetlands as a result of aggradation (Corps, 1989).

Three study sites were chosen for detailed field investigation in the Sakakawea delta. The sites were chosen irrespective of political boundaries and were based on physical characteristics. The best representative sites were selected. None of the study sites chosen as representative sites were located on the Fort Berthold Reservation. The study site closest to the Reservation is the Lewis and Clark study site, approximately 70 miles upstream of the Reservation. Collected field data on wetland/riparian resources from these sites are considered representative of the Sakakawea Delta.

Wetlands constituted 53 percent of the Lake Sakakawea delta in 1991, exposed shoreline about 21 percent, water 18 percent, and riparian vegetation about 9 percent (Table 3.6-1). Lake Sakakawea is the largest of the mainstem reservoirs, and its delta supports more wetland acreage than any other delta or reach, consisting of about 19 percent of the amount along the entire river in 1991 (Figure 3.6-4). Conversely, riparian vegetation in the delta represented only 2 percent of the amount along the river (Figure 3.6-4). In 1991, most of the wetland acreage in the Lake Sakakawea delta consisted of the scrub-shrub type (44 percent), followed by the emergent type (41 percent). Forested wetlands accounted for 15 percent of the delta wetland area (Table 3.6-1). Scrub-shrub wetlands in the Lake Sakakawea delta were similar to those in the Fort Peck Lake delta: dense stands of sandbar willow that colonized the mudflats exposed by the 1987 to 1993 drought. A marked abundance of common reed, slough sedge (*Carex atherodes*), and reed canarygrass distinguished the drier emergent wetlands of the Lake Sakakawea delta from similar classes in the Fort Peck delta. Wetter emergent classes in the Lake Sakakawea delta were characterized by monocultures of cattail (*Typha* spp.) occurring in old backwaters, ponds, and side channels that had been cut off from the main channel. Forested wetlands consisted primarily of sandbar and peachleaf willow, but included some cottonwood.

During the 1991 field investigations, the pool elevation of Lake Sakakawea was 1,829 feet, approximately 9 feet below the normal operating level (1,837.5 feet). The reservoir had also been at 1,829 feet or lower during the drought years of 1989 and 1990 (Corps, 1991a). Large, nearly monotypic stands of scrub-shrub wetlands were observed from Raum's Landing downstream for 8 miles, with some admixed stands of cattail and annual weedy species. More recently exposed shores occurred in the lower portions of the delta, over 8 miles downstream of Raum's Landing. These areas typically supported a mixture of weedy mesic species similar to those found in the Fort Peck Lake delta.

Riparian vegetation occurs throughout the Lake Sakakawea delta, generally on small ridges of higher ground that are surrounded by wetlands. Most riparian areas consist primarily of grasslands dominated by Kentucky blue grass (*Poa pratensis*), quackgrass (*Agropyron repens*), crested wheatgrass (*A. cristatum*), and smooth brome. Cottonwoods and rough-leaf dogwood, respectively, dominate the tree canopy and understory of riparian forest stands. The largest stands occur at the Lewis and Clark and Trenton Bottoms wildlife refuges.

3.6.5 Missouri River from Garrison Dam to Lake Oahe

The river between Garrison Dam (RM 1390) and the Lake Oahe delta (RM 1306) is about 84 miles long and is referred to as the Garrison reach. Within the floodplain, terraces form a complex of different low-lying landforms, many at an elevation within 3 feet above the river. The river is restricted to one main channel with very few side channels, old channels, or oxbow lakes. Significant tributaries include the Knife River near Stanton, North Dakota, and the Heart River just upstream of the Lake Oahe delta and downstream of Mandan, North Dakota.

Riparian vegetation constitutes about 47 percent of the Garrison reach floodplain, water about 28 percent, exposed shore about 16 percent, and wetlands about 9 percent (Table 3.6-1). The Garrison reach is less than one-half as long as the Fort Peck reach but supports about 25 percent of the riparian vegetation along the Upper River (Figure 3.6-3).

Emergent wetlands constitute about 68 percent of the wetland acreage in the Garrison reach; most of the remainder is scrub-shrub wetland (22 percent). Emergent wetlands generally support a mix of hydric and mesic species, including quackgrass, bluegrass, and mints (*Mentha* spp.). Reed canarygrass dominates some areas and slough sedge forms extensive stands, particularly near Bismarck. Cottonwood, indigo bush, and peachleaf willow characterize most of the scrub-shrub wetlands.

The Garrison reach supports a much lower density of wetlands (38 acres/mile) than the other Upper River reaches. The large diurnal and seasonal variations in river flow for the peaking operation of Garrison Dam probably impede wetland establishment and survival, favoring instead greater amounts of exposed shore. The large islands and bars, particularly those close to the dam, are periodically scoured and support little, if any, perennial vegetation.

Riparian forest constitutes just over half of the riparian vegetation in this reach, commonly lining both shores. Cottonwood, slippery elm (*Ulmus fulva*), green ash, and box elder (*Acer negundo*) are the most common tree species on the floodplain (Johnson et al., 1976). Sandbar willow, peachleaf willow, and cottonwood occur along the river sandbars. The acreage of riparian forest in this reach has been drastically reduced since settlement.

3.6.6 Lake Oahe Deltas

The mainstem Lake Oahe delta extends 64 miles from just downstream of Bismarck (RM 1306) to Fort Yates (RM 1242), North Dakota, near the North Dakota-South Dakota border. Approximately 28 miles of the Standing Rock Reservation shoreline, from RM 1269.6 to RM 1242, is included in the main Lake Oahe delta. Four separate Lake Oahe deltas are grouped together for analysis: the main delta formed by the Missouri River and the three deltas formed by inflows from the Cannonball (RM 1270), Moreau (RM 1175), and Cheyenne (RM 1110) Rivers. The Cannonball delta connects with Standing Rock Reservation shorelines while both the Moreau and Cheyenne River deltas correlate with the Cheyenne River Reservation shorelines.

Six study sites were chosen for detailed field investigation in the Lake Oahe delta. The best representative sites were selected based on physical characteristics. Three of the study sites chosen as representative sites are located on Reservation land. One study site, the Cannonball River study site, is located on the Standing Rock Reservation near the town of Cannonball, North Dakota. The other two sites, the Moreau River study site and the Cheyenne River study site, are located on the Cheyenne River Reservation. The Moreau River study site is found in the Moreau River delta (RM 29.7) near Promise, South Dakota. The other study site is located at Cheyenne (RM 26.4), near the Sunshine Ranch in the Cheyenne River Reservation, South Dakota. The remaining three study sites are located between Bismarck, North Dakota, and the northern boundary of the Standing Rock Reservation. Collected field data on wetland/riparian resources from these sites are considered representative of the Lake Oahe delta.

Lake Oahe is the second largest of the mainstem reservoirs, and its deltas supported about 17,700 acres of wetlands in 1991, second only to the Lake Sakakawea delta. Lake Oahe delta wetlands represented about 16 percent of the amount along the entire river (Figure 3.6-4). About two-thirds of the Lake Oahe delta areas was either open water (31 percent) or exposed shore (36 percent); 19 percent was wetland, and 14 percent riparian vegetation (Table 3.6-1). The smaller proportion of area supporting wetlands at Lake Oahe compared to the other principal Missouri River deltas is attributable to the large area of open water and exposed shoreline habitats associated with the four Lake Oahe deltas. Riparian vegetation constitutes about 14 percent of the Lake Oahe deltas, representing 20 percent of the amount along the Upper River deltas, and 7 percent of the amount along the entire river (Figures 3.6-3 and 3.6-4).

Like other deltas, wetlands at Oahe consisted almost entirely of scrub-shrub (39 percent) or emergent classes (56 percent). The greatest concentration of wetlands occurred in the upper portion of the mainstem delta from Schmidt Bottom (RM 1301) to Carlson Bottom (RM 1282). The wide, meandering river channel in this portion of the delta has created numerous old oxbows, such as Carlson (RM 1283) and Wilde (RM 1278) Lakes. These areas are typically flooded by the Missouri River about once every 5 years, which helps maintain extensive wetland complexes. Emergent wetlands commonly include prairie cordgrass (*Spartina pectinata*), quackgrass, sedge (*Carex* sp.), Canada thistle, and redtop (*Agrostis alba*). Many of the emergent wetlands contain remnant stands of more hydric species, such as cattails, but appear to be drying out and shifting to more mesic flora. Areas of cattail, river bulrush, soft-stem bulrush (*Scirpus validus*), spike-rushes, and smartweeds (*Polygonum* spp.) occur throughout the upper portion of the mainstem delta, generally confined to the margins of old backwater channels and Carlson and Wilde Lakes. Scrub-shrub wetlands in the Lake Oahe deltas include dense stands of sandbar willow, but indigo bush (*Amorpha fruticosa*) and peachleaf willow are also common. As at Fort Peck Lake and Lake Sakakawea, many of the scrub-shrub wetlands in the Lake Oahe deltas colonized the mudflats that were exposed by the lower water levels caused by the 1987 to 1993 drought.

The Lake Oahe pool elevation during the 1991 field investigations was approximately 1,591 feet, approximately 16 feet below the normal operating level (1,607.5 feet). Consequently, areas of exposed shoreline dominated large expanses of the deltas, particularly the lower portions that are usually inundated. Between Fort Rice (RM 1275) and Fort Yates, North Dakota, these areas were characterized by weedy annuals, including sweet clover (*Melilotus* spp.), cocklebur, sow thistle (*Sonchus arvensis*), prickly lettuce (*Lactuca serriola*), beggar's tick (*Bidens* spp.), dock (*Rumex* sp.), and sunflower (*Helianthus* spp.). With the return to a full pool in 1993, most of these areas and most of the scrub-shrub wetlands have probably been inundated and reverted to open-water habitat.

Riparian vegetation occurs throughout the mainstem Lake Oahe delta, but is less abundant on the tributary deltas. Nearly three-fourths of the riparian vegetation is riparian forest, and much of this type occurs in the upper mainstem delta from Sibley Park (RM 1307) to Carlson Bottoms. Many of these areas support stands of mature cottonwood trees, which are on ridges and higher ground at the margins of the mainstem delta.

3.6.7 Missouri River from Oahe Dam to Lake Sharpe

This short reach extends from Oahe Dam (RM 1072) 5 miles downstream to Lake Sharpe (RM 1067) near the city of Pierre. This reach is relatively straight, confined to one channel, and bordered by narrow bands of riparian forest and grasslands. Small amounts of wetland are associated with backwaters created by channel structures (Corps, 1989). This reach was not mapped and is not included in the totals in Table 3.6-1.

3.6.8 Lake Sharpe

Because Lake Sharpe is so close to Oahe Dam, it receives very little sediment inflow from the mainstem of the Missouri River. However, a delta formed by sediment from the Bad River, a major right-bank tributary, extends from Pierre (RM 1067) to the DeGray area (RM 1037). Both the Lower Brule Reservation and Crow Creek Reservation shorelines are impacted by sedimentation of this particular delta. In addition, there are smaller deltas associated with several tributary creeks. Lake Sharpe remains at a nearly constant pool elevation, even in drought periods.

There were no study sites chosen for detailed field investigation in this reach/delta; therefore, there were no study sites located on either the Lower Brule or the Crow Creek Reservation lands.

The majority of the delta is shallow open water or seasonally flooded mudflats (Corps, 1989). Palustrine emergent wetlands are limited to large islands in the Bad River delta and tributary deltas. About 430 acres of emergent wetlands occur on the two largest islands and are dominated by dense stands of common reed, cattail, and reed canarygrass (Corps, 1989). The few scrub-shrub wetlands are largely confined to portions of these islands.

The Lake Sharpe delta was not mapped and is not included in the totals in Table 3.6-1.

3.6.9 Lake Francis Case

Because of the proximity of Big Bend Dam immediately upstream, Lake Francis Case receives very little sediment inflow from the mainstem of the Missouri River. However, a delta formed by sediment from the White River (RM 956), a major right-bank tributary, extends approximately 15 miles up the White River valley from its confluence with Lake Francis Case. The Lower Brule and Crow Creek Reservations are approximately 11 miles upstream of this confluence. The Yankton Reservation is located another 76 miles downstream from the Missouri River/White River delta.

There were no study sites chosen for detailed field investigation in this reach or delta; therefore, there were no study sites located on either the Lower Brule Reservation, the Crow Creek Reservation, or the Yankton Reservation lands.

Lake Francis Case is typically drawn down every autumn to provide storage space for high winter hydropower releases from Lake Oahe and Lake Sharpe. Although appreciable amounts of wetland and riparian vegetation occur in the White River delta, this resource is not likely to be affected differently by other alternative water control plans and was therefore not inventoried. The White River delta consists primarily of emergent and scrub-shrub wetlands dominated by species typically occurring in these classes along other portions of the Upper River (Corps, 1989). Large areas of forested wetlands and riparian forests also occur within the delta.

The Lake Francis Case delta was not mapped and is not included in the totals in Table 3.6-1.

3.6.10 Missouri River from Fort Randall Dam to Lewis and Clark Lake

The 36 miles of river from Fort Randall Dam (RM 880) to the Lewis and Clark Lake delta (RM 844) is referred to as the Fort Randall reach and is designated a National Recreational River under the WSRA. The banks along this reach tend to restrict flow to one main channel; there are only a few side channels and backwaters, except at the lower end in the Lewis and Clark Lake delta. Yankton Reservation banks are included within this reach beginning at RM 880 downstream to RM 845. The Fort Randall reach receives no significant inflow from tributaries.

Two study sites were chosen for detailed field investigation in the Fort Randall river reach. The best representative sites were selected based on physical characteristics. None of the study sites chosen as representative sites were located on Yankton Reservation lands. Both study sites, the Greenwood study site and the Verdel/Choteau study site, are located on the right banks of the Missouri River, directly across the river from the Yankton Reservation. Collected field data on wetland/riparian resources from these sites are considered representative of the Fort Randall reach.

Riparian vegetation constitutes about 33 percent of the Fort Randall reach, water about 46 percent, wetlands about 19 percent, and exposed shore less than 1 percent (Table 3.6-1). The Fort Randall reach is the second shortest riverine reach and supports only 3 percent of both the wetland and non-wetland riparian vegetation acreage along the entire river (Figure 3.6-4).

Nearly 30 percent of wetland acreage in the Fort Randall reach is forested; most of the remainder is emergent (56 percent). The forested wetlands are characterized by a mix of peachleaf willow and cottonwood, with some sandbar willow. Emergent wetlands generally support the typical mix of reed canary grass and common reed. Expansive areas of cattail, often mixed with softstem bulrush, have developed in old channels and backwaters. In the upper reaches, some of these areas were dry during the 1991 field observation. Based on examination, the residual vegetation appeared substantially less productive than in previous years, probably as a result of channel degradation and lowered water levels. Extensive areas of exposed shore are limited to a few sandbars, islands, and eroded banks.

Nearly all of the riparian vegetation in the Fort Randall reach is forested, dominated by cottonwood mixed with green ash, Russian olive (*Elaeagnus angustifolia*), slippery elm, and box elder. The sparse understory typical of mature stands contains Kentucky bluegrass, smooth brome, scouring rush, eastern redcedar (*Juniperus virginiana*), and rough-leaf dogwood. Open areas are usually grazed or farmed.

3.6.11 Lewis and Clark Lake Delta

The Missouri and Niobrara Rivers annually contribute sediment to Lewis and Clark Lake, creating a delta that currently extends from near Verdel, Nebraska (RM 844), to about 3 miles downstream of Springfield, South Dakota (RM 833). The Yankton Reservation shoreline ends at RM 845, one mile upstream of the Missouri/Niobrara delta. Sedimentation from this delta could affect both Ponca Tribal Lands, which is located on the Niobrara River at the confluence with the Missouri River, and the Santee Reservation, which extends from RM 841.4 to RM 820 directly downstream of the Missouri/Niobrara delta. The Niobrara River is responsible for approximately 60 percent of the sediment input. Upstream of Springfield, which includes deltas associated with the Niobrara River and Bazille Creek, wetlands establish on sediments exposed by fluctuations controlled primarily by river stage. However, from Springfield downstream, wetlands establish on sediments where water levels fluctuate due to changes in pool elevation (Corps, 1989). Lewis and Clark Lake levels typically fluctuate only about 2 feet on an annual basis, even in drought periods.

Two study sites were chosen for detailed field investigation in the Lewis and Clark Lake delta. The best representative sites, the Niobrara study site and the Bazille Creek study site, were selected based on physical characteristics. The first site, the Niobrara study site, is not located on either the Santee Reservation nor Ponca Tribal Lands. The site is located at the confluence of the Missouri and the Niobrara rivers near Niobrara, Nebraska. Both the Santee Reservation and the Ponca Tribal Lands are located in the proximity of the Niobrara study site. The Bazille Creek study site is located on the right bank of the Missouri River at the confluence of Bazille Creek at RM 837, immediately adjacent to the Santee Reservation boundaries. Collected field data on wetland /riparian resources from these two sites are considered representative of the Lewis and Clark Lake delta.

Wetlands constitute approximately 43 percent of the Lewis and Clark Lake delta, open water 42 percent, riparian vegetation about 11 percent, and exposed shore about 5 percent (Table 3.6-1). The smallest of the four principal mainstem reservoir deltas, the Lewis and Clark Lake delta, contains about 7 percent of the wetlands and 1 percent of the riparian vegetation along the entire river. In contrast to the other major mainstem deltas, numerous backwaters, ponds, and chutes occur in the Lewis and Clark Lake delta, supporting extensive emergent wetlands (83 percent of the wetland acreage). A reconnaissance survey in 1988 indicated that about one-half of these emergent wetlands are infested with purple loosestrife (*Lythrum salicaria*), a plant that readily invades freshwater wetlands, excluding other species and degrading habitat. Emergent wetlands not infested with purple loosestrife are dominated by reed canarygrass and common reed. Cattails occupy shallow waters associated with islands, backwaters, and side channels. Because cattails can germinate in several inches of water (Bedish, 1967), the current operating regime, involving spring drawdown and higher pool levels in July, has favored the establishment of near monotypic stands of this species (Corps, 1989). This operating regime, however, probably precludes establishment of scrub-shrub wetlands in many areas of the delta because sandbar willow requires recently deposited sediments that remain unflooded for the duration of the summer.

Relatively small annual drawdowns expose only limited amounts of shore substrate, although several large new islands are forming at the mouth of the Niobrara River. Studies of these islands and sediment deposition indicate that extensive aggradation has occurred in the Lewis and Clark Lake delta (Corps, 1989). Dead cottonwood trees on several islands between the mouth of the Niobrara River and Bazille Creek, and their replacement by stands of cattail and bulrush (*Scirpus* spp.) provide additional evidence of recent aggradation.

Riparian vegetation occurs throughout the upper portion of the delta. Over half of the riparian vegetation is forest, occurring on large islands near the mouth of Bazille Creek, Niobrara River, and Choteau Creek. Cottonwood dominates these stands, with green ash, dogwood, and snowberry typically constituting a shrub understory in mature stands. Scouring rush (*Equisetum* sp.) frequently forms a ground cover, particularly in stands growing on sandy soils.

3.6.12 Missouri River from Gavins Point Dam to Ponca

The 58-mile stretch of river between Gavins Point Dam (RM 810) and Ponca (RM 752) is known as the Gavins Point reach. This reach is also designated a National Recreational River under the WSRA. It is also the only river segment downstream of Gavins Point Dam that has not been channelized by dikes and revetments. A wide, braided channel and numerous islands, chutes, and backwaters favor a variety of wetlands. The Gavins Point reach resembles the natural river more than any other reach, and, compared to the other reaches, displays the greatest density of wetlands, approximately 90 acres per mile. Wetland acreage, however, has undoubtedly declined as a result of channel degradation. Major tributaries in the Gavins Point reach are the James and Vermillion Rivers.

Riverine habitat constitutes about 56 percent of the Gavins Point reach, riparian vegetation about 23 percent, wetlands about 19 percent, and exposed shore about 2 percent (Table 3.6-1). This reach is the second shortest riverine reach and supports only 5 percent of the wetland acreage along the entire river and 3 percent of the riparian vegetation (Figure 3.6-4).

Wetlands in the Gavins Point reach are composed of an even mix of emergent (48 percent) and scrub-shrub (49 percent) classes. Scrub-shrub wetlands typically occur as dense stands of young sandbar willow, but less frequently inundated areas also include peachleaf willow and cottonwood. Most emergent wetlands consist of reed canarygrass or a mix of hydric and mesic species. Cattails occur in old channels, backwaters, and near islands. Areas of exposed shore are not common but occur along the entire Gavins Point reach and are associated with sandbars, eroding banks, developing islands, and areas exposed as a result of degradation of the riverbed.

Riparian vegetation has been severely reduced by clearing for agriculture. Over one-half of that remaining is forested and is dominated by cottonwood with lower densities of green ash, slippery elm, red cedar, Russian olive, mulberry (*Morus* spp.), and box elder. The typically sparse herbaceous stratum beneath mature cottonwood consists mostly of scouring rush, Kentucky bluegrass, smooth brome, and switchgrass (*Panicum virgatum*). Riparian grasslands along the National Recreational River reach are dominated by Kentucky bluegrass, smooth brome, and other invasive grasses and weeds.

3.6.13 Missouri River from Ponca to Omaha

The 142-mile Ponca (RM 752) to Omaha (RM 610) reach is composed of about 60 percent riparian vegetation, 22 percent deepwater habitat, 17 percent wetlands, and 2 percent exposed shore (Table 3.6-1). The Winnebago Reservation's western bank extends from RM 720 to RM 705, and the Omaha Reservation's western bank extends from RM 705 to RM 691. This reach is the shortest of the three Lower River reaches and supports 33 percent of the wetland acreage mapped along the Lower River and 29 percent of the riparian vegetation (Figure 3.6-5). Major tributaries include the Big Sioux, Little Sioux, and Floyd Rivers.

Five study sites were chosen for detailed field investigation in this Lower River reach from Ponca to Omaha. The best representative sites were selected based on physical characteristics. None of the study sites chosen as representative sites were located on either Winnebago or Omaha Reservations lands. The nearest study sites to the Reservations are the Winnebago Bend study site and the Tieville Lake study site. The Winnebago Bend study site is found on the left bank of the Missouri River (Iowa), directly across the river from the Winnebago Reservation and approximately 9 miles upstream of Macy, Nebraska. The other site, the Tievill Lake study site, is located on the right bank of the Missouri River directly adjacent to the Omaha Reservation boundaries and just outside Decatur, Nebraska, at the Highway 75 bridge. Collected field data on wetland/riparian resources from these five study sites are considered representative of the Ponca to Omaha Lower River reach.

Over one-half (55 percent) of the wetland acreage in the Ponca to Omaha reach is emergent, dominated by reed canarygrass or, less frequently, common reed. Scrub-shrub wetlands are also abundant (41 percent) and are characterized by peachleaf willow and cottonwood, with some sandbar willow. Most of the wetlands in the Ponca to Omaha reach are associated with the old bends and oxbows that have been cut off from the river by bank stabilization structures or levees, but are hydrologically maintained by groundwater seepage, surface inflows, or groundwater or surface water pumping. The largest and most diverse wetland/riparian complexes occur at the wildlife areas managed by the Iowa Department of Natural Resources at Tieville Lake (RM 692), Snyder/Winnebago (RM 709), Louisville (RM 683), and California (RM 650) Bends. Desoto National Wildlife Refuge (NWR) (RM 643), owned and managed by the USFWS, also includes large wetland and riparian complexes. Boyer Chute (RM 633.5 to RM 637.7), an area restored by the Corps, is also in this reach. Areas of exposed shore are uncommon in this reach, limited mainly to a few sandbars and shorelines associated with dikes. Many Federal and State areas adjacent to the river have been acquired in recent years.

Much of the riparian habitat in the Ponca to Omaha reach has developed in areas that were originally part of the river channel but have been filled due to channelization. Approximately 40 percent of the riparian vegetation is classified as riparian grassland; 55 percent is currently forested. The largest forest stands occur with wetland complexes in State and Federal wildlife management areas (WMAs) and, less extensively, as thin bands along the river. Riparian forests are characterized by even-aged stands of cottonwood. This species reaches maturity in about 45 years and rapidly declines after 70 years (Harlow et al., 1979), opening up the stands to invasion by other species such as elm, green ash, Russian olive, box elder, red cedar, and mulberry (Wilson, 1970).

3.6.14 Missouri River from Omaha to St. Joseph

The 164-mile Omaha (RM 610) to St. Joseph (RM 446) reach is composed of about 54 percent riparian vegetation, 31 percent water, 12 percent wetlands, and 3 percent exposed shore (Table 3.6-1). The Iowa and Sac and Fox Reservation banks are located at RM 495. Although longer than the Ponca to Omaha reach, the Omaha to St. Joseph reach supports only 23 percent (versus 33 percent) of the wetland acreage mapped along the Lower River (Figure 3.6-5). The Platte River is the largest tributary of this reach.

Three study sites were chosen for detailed field investigation in this Lower River reach from Omaha to St. Joseph. The best representative sites were selected based on physical characteristics. None of the study sites chosen as representative sites were located on the Iowa or the Sac and Fox Reservations. The nearest study site is the Lincoln Bend study site, approximately 25 miles upstream of both Reservations at RM 519.9. Collected field data on wetland/riparian resources from these three study sites are considered representative of the Omaha to St. Joseph reach.

Emergent and scrub-shrub wetlands constitute 60 and 37 percent, respectively, of the total wetland area in the reach. Reed canarygrass dominates emergent wetlands, but sedges, rushes, and rice cutgrass (*Leersia oryzoides*) are also common in this type. Scrub-shrub wetlands typically support a mix of black willow (*Salix nigra*), young cottonwood, and some sandbar willow. Most of the wetlands in the Omaha to St. Joseph reach are associated with the old bends and oxbows that have been cut off from the river by levees but remain wet because of pumping, groundwater seepage under levees, or surface inflows.

About 41 percent of the riparian vegetation is classified as riparian grassland; 54 percent of the riparian vegetation is currently forested. The largest stands of riparian forest occur in association with wetland complexes, but substantial acreage occurs as linear bands along the river banks. Forest stands are dominated by cottonwood, but green ash, sycamore (*Platanus* sp. *occidentalis*), mulberry, elm, and box elder are also common.

3.6.15 Missouri River from St. Joseph to St. Louis

The 446-mile St. Joseph (RM 446) to St. Louis (RM 0) reach is composed of 43 percent riparian vegetation, 44 percent open water, 10 percent wetlands, and 3 percent exposed shoreline (Table 3.6-1). The St. Joseph to St. Louis reach is more than twice as long as any other riverine reach. It encompasses nearly one-quarter of the floodplain and aquatic acreage along the entire Missouri River, but supports a relatively low density of wetlands (30 acres/mile) representing only 12 percent of the wetland acreage along the entire river (Figure 3.6-4). Conversely, nearly 30 percent of the riparian vegetation along the entire river is found along the St. Joseph to St. Louis reach, far more than any other reach or delta area (Figure 3.6-4). Major tributaries include the Kansas, Grand, Osage, and Gasconade Rivers.

Differing markedly from other reaches, almost two-thirds of the wetland acreage in the St. Joseph to St. Louis reach is forested (Table 3.6-1). Emergent wetlands make up about 25 percent of the wetland acreage. Forested wetlands in this reach are dominated by black willow mixed with lower densities of silver maple (*Acer saccharinum*) and sycamore. Emergent wetlands, which tend to occupy shallow waters in ponds located between the river and levees, are characterized by flatsedges (*Cyperus* spp.), smartweeds, and, less commonly, cattails. Other emergent wetlands in this reach support rice cutgrass, green bulrush (*Scirpus atrovirens*), skullcap (*Scutellaria* sp.), and smartweeds. Most of the wetlands in the St. Joseph to St. Louis reach are associated with islands or old bends and oxbows that have been cut off from the river by levees but remain wet. Many of these wetland complexes are managed by the Missouri Department of Conservation as wildlife or natural areas. Channel structures in the Lower River have been undergoing modifications since 1974 to restore side channels or backwater habitats.

Nearly all of the riparian vegetation (93 percent) is classified as riparian forest characterized by a mix of cottonwood, silver maple, box elder, dogwood, and mulberry (Table 3.6-1). The understory typically includes vines such as wild grape (*Vitis* sp.) and clematis (*Clematis* sp.). One of the largest, most diverse, and undisturbed areas of riparian forest along the Lower River occurs at Fort Leavenworth, Kansas. This area includes many species that are now rarely seen along the Lower Missouri River, including pecan (*Carya illinoensis*), pawpaw (*Carica papaya*), Kentucky coffeetree (*Gymnocladus dioica*), American elm (*Ulmus americana*), and swamp chestnut oak (*Quercus michauxii*).

3.6.16 Mississippi River from St. Louis to Mouth

The leveed floodplain along the Lower Mississippi River varies in width from about 1 to 15 miles and consists of about 1.7 million acres of lands, exclusive of rivers, lakes, and other waterbodies. These lands function as the natural overflow system of the river and contain a diversity of habitats. Floodplain lands are composed of approximately 1.1 million acres of forests, palustrine wetlands, and marshes; 420,000 acres of croplands; 60,000 acres of pastures and old fields; and 70,000 acres of urban areas, sandbars, and other nonvegetated lands.

Bottomland hardwood forests are made up of 21 major forest classes. Hackberry/American elm/green ash and sycamore/sweetgum (*Liquidambar styraciflua*) /American elm (*Ulmus americana*) forest classes are predominant in the bottomlands, constituting about 40 percent of the total forested area.

There are approximately 127,000 acres of lakes, tributaries, pen water marshes, and wetland habitat on the Lower Mississippi River floodplain. Of this complex, there are 543 floodplain lakes. Point bar and meander loop cutoffs have created oxbow and abandoned channel lakes, several of which exceed 900 acres in surface area. Numerous small scour channel lakes occupy pointbar swales. Floodplain depression lakes formed by uneven sedimentation, crevasse lakes, and batture lakes are also present.

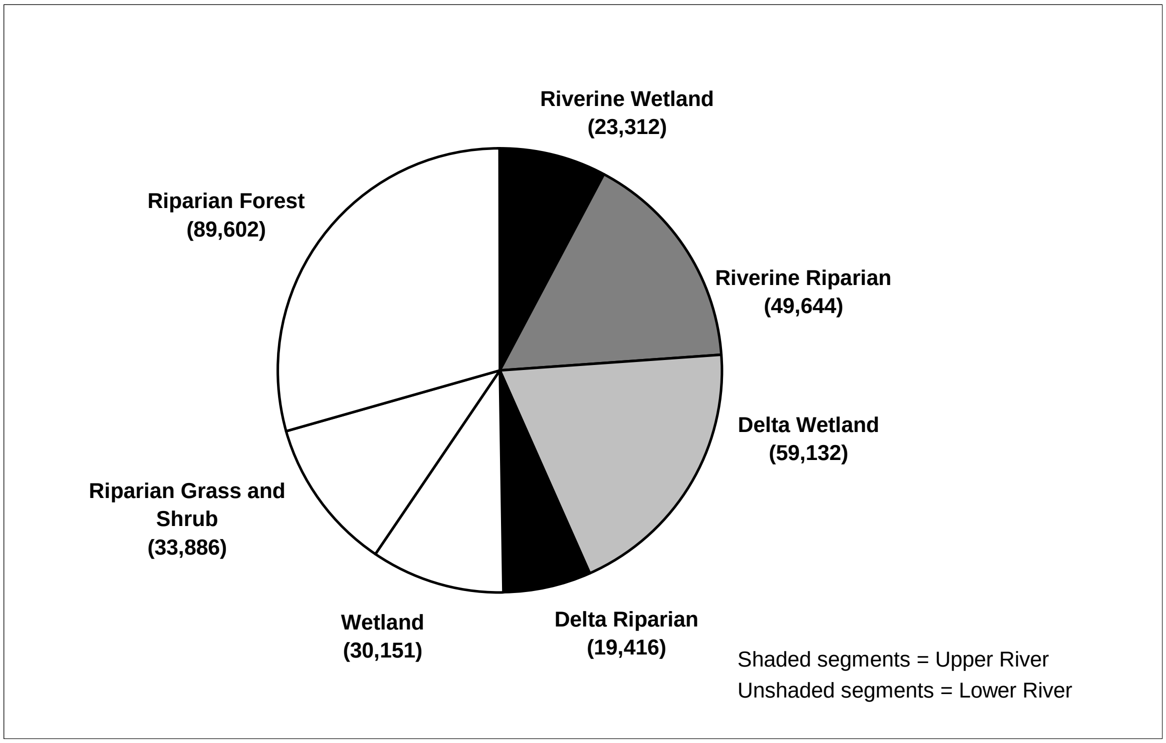

Figure 3.6-1. Distribution (acres) of wetlands and riparian vegetation along the entire river in 1991.

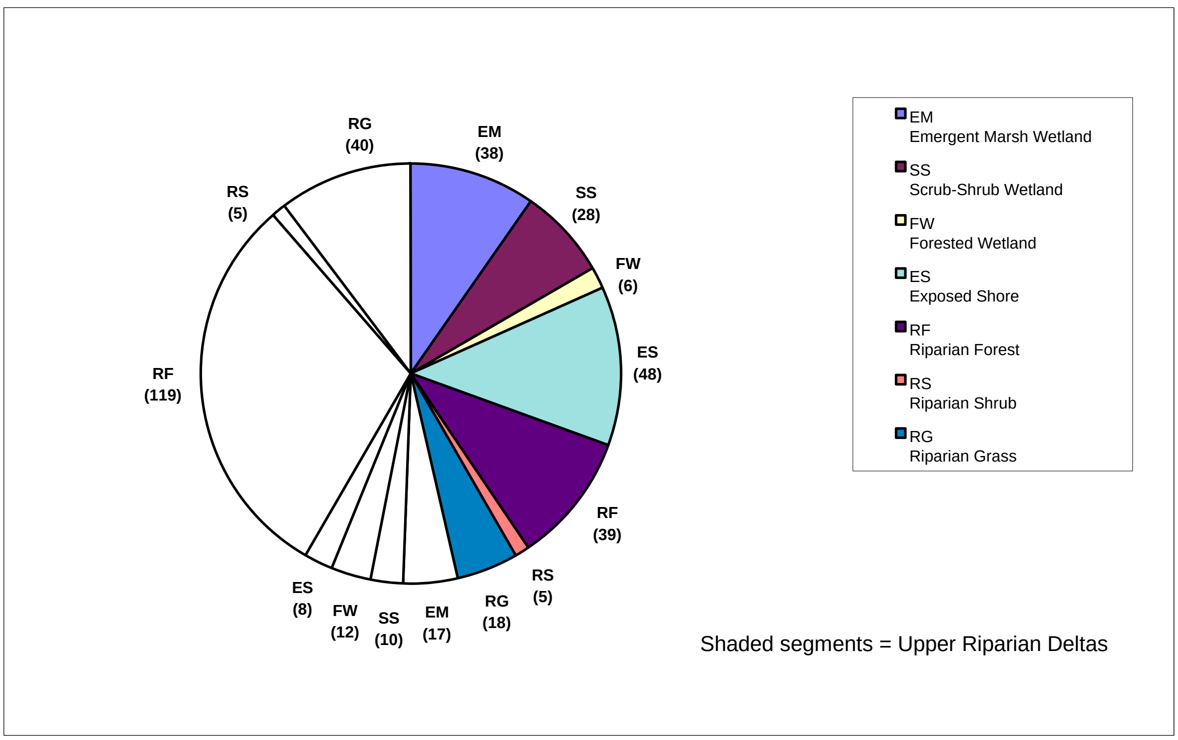

Figure 3.6-2. Density (acres/river mile) of wetland and riparian vegetation along the entire river in 1991.

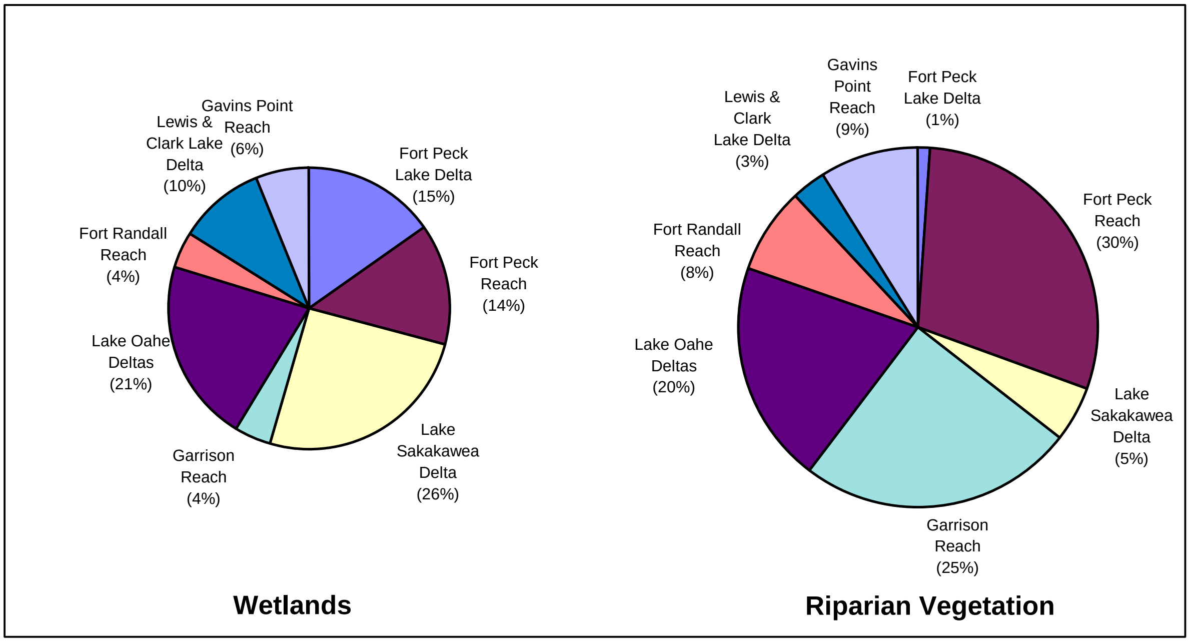

Figure 3.6-3. Distribution of wetlands and riparian vegetation by reach and delta along the Upper River in 1991.

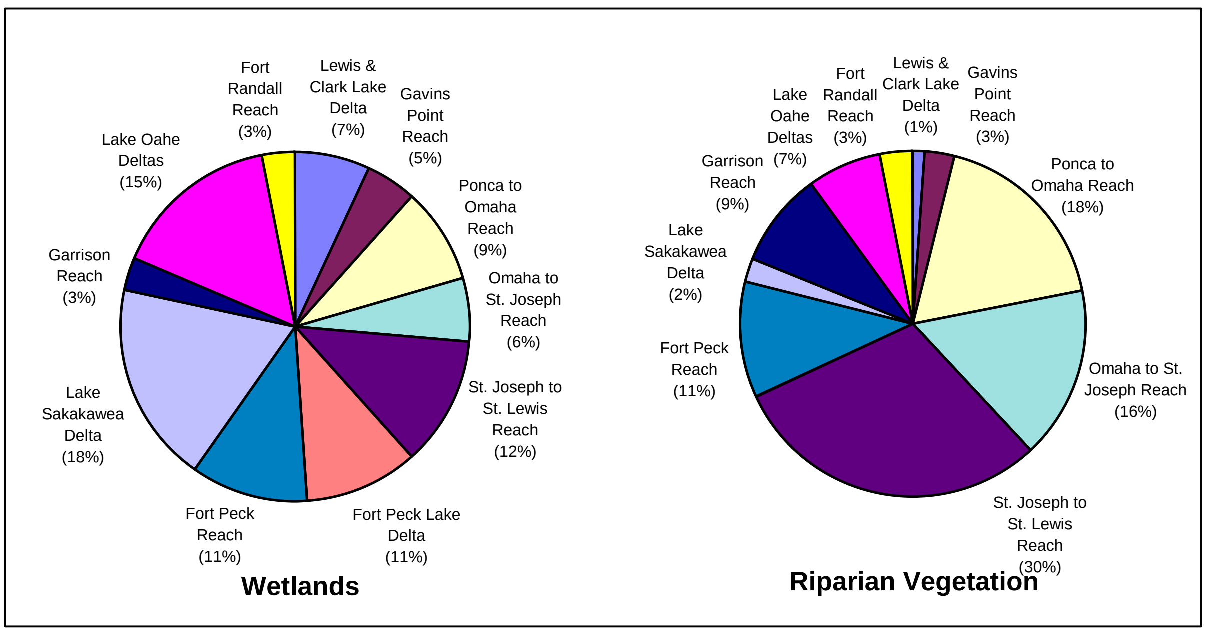

Figure 3.6-4. Distribution of wetlands and riparian vegetation by reach and delta along the entire river in 1991.

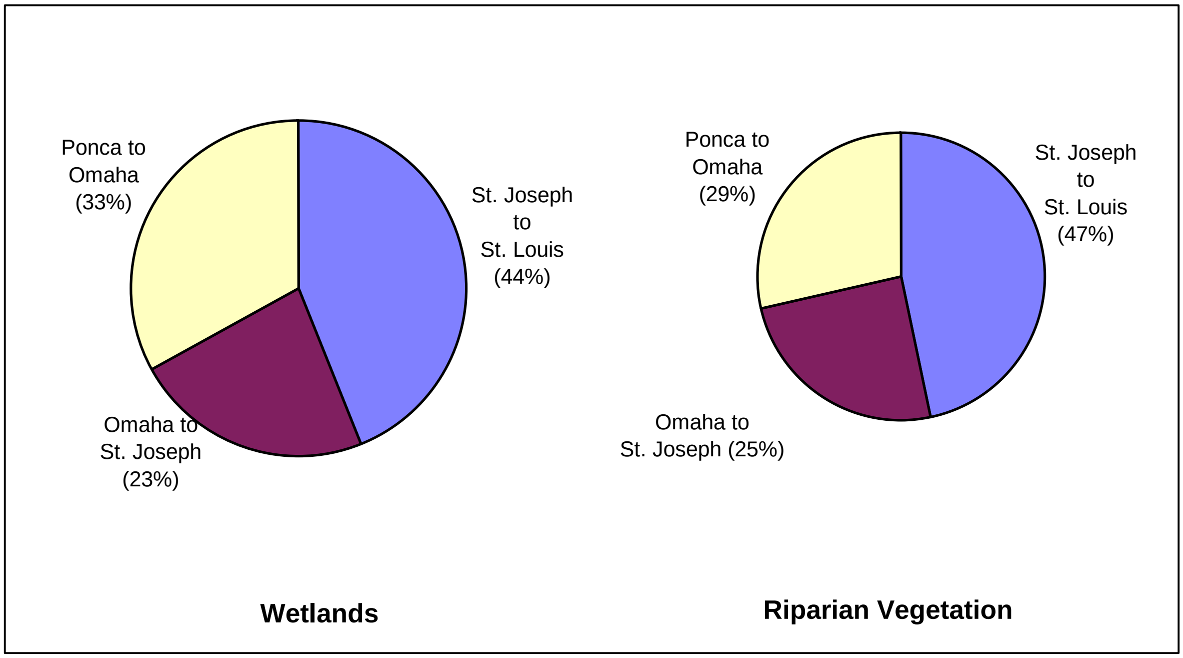

Figure 3.6-5. Distribution of wetlands and riparian vegetation by reach along the Lower River in 1991.

3.7 WILDLIFE RESOURCES

3.7.1 General

The Missouri River creates and maintains important forest and wetland habitat for a wide diversity of wildlife, including at least 60 species of mammals, 301 species of birds, and 52 species of reptiles and amphibians (Dunlap and Kruse, undated; Lynk and Harrell, undated; USFWS, 1979). Of these, six bird and two bat species occurring in the river valley are Federally listed as threatened or endangered. Because much of the river's course traverses the arid Great Plains, where less than 5 percent of the land supports trees, the densities and distributions of many of these wildlife species depend on the forests and wetlands associated with the river.

The diversity and abundance of wildlife reflect the diverse mix of habitat classes occurring in the Missouri River valley: riverine; lakes and ponds; emergent, scrub-shrub, and forested wetlands; riparian forests; grasslands; and croplands. The combination of open water, wetlands, and riparian vegetation is particularly important for the large number of waterfowl that stop along the Missouri River during spring and fall migration.

The river hydrology and morphology influence the composition and distribution of vegetation on the floodplain, causing habitat changes on a daily, seasonal, annual, and long-term basis. Erosion and sediment transport play an important role in the creation and degradation of sandbar habitat, scouring or elimination of vegetated lands, and creation of suitable substrate for plant germination and the initiation of early-successional plant communities. Seasonal flow patterns dictate the frequency and duration of wetland flooding and maintain oxbow lakes that are important for breeding and foraging wildlife. Lake storage levels determine the water depths in wetlands located along the six mainstem lakes and the extent of exposed lake shoreline.

The on-going reduction of wetland and riparian habitat that results from erosion and degradation of the river channel, lack of cottonwood regeneration, and agricultural conversion reduces the productivity and diversity of wildlife in the Missouri River basin. Degradation of the river channel lowers water levels and alters moisture conditions in adjacent wetlands and riparian communities. Shoreline erosion reduces riparian habitat, including cottonwood forests. Regeneration of cottonwood forests has been adversely affected by reductions in overbank flooding, which creates suitable conditions for germination and survival of cottonwood seedlings. The lack of high flows in the river restricts creation of sandbars and wide expanses of unvegetated shorelines needed by some species of wildlife for nesting and foraging.

The Upper River, extending from the headwaters of Fort Peck Lake to Ponca (for wetland and riparian vegetation analyses), contains a relatively diverse mix of wetlands, riparian habitats, riverine open water, and open water associated with the six mainstem lakes (Section 3.5). The highly variable water levels of the lakes can produce extensive zones of wetland or weedy herbaceous wildlife habitat that establishes on exposed shoreline sediments. The large wetland/riparian complexes that have developed at the upstream end of each lake also provide productive habitat and are actively managed for wildlife.

Productive habitat in the Lower River, downstream of Ponca (for wetland and riparian vegetation analyses), is largely restricted to the old oxbows and chutes that were partially or entirely cut off from the river by dikes and revetments. For this reason, many of the larger river bends in Nebraska, Iowa, Missouri, and Kansas are managed as State wildlife management areas (WMAs).

Wildlife of the Missouri River can be grouped into the following categories: waterfowl; shorebirds, wading birds, and waterbirds; upland game birds; big game; raptors; furbearers; and other species, including bats and other small mammals, songbirds, reptiles, and amphibians. The dependence of each of these groups of species on habitats and changes in lake level and river flow is discussed in the following sections.

Waterfowl

The Mainstem Reservoir System and Lower River are located within the North American central flyway for the migration and breeding of waterfowl. The Mainstem Reservoir System and Lower River and their associated lakes and wetlands provide important migration stopover habitat and, in times of drought when habitat in the North and South Dakota prairie pothole region is limited, important breeding habitat.

Seventeen species of ducks, three species of geese, and one swan species occur along the Missouri

River Mainstem Reservoir System and Lower River (Bellrose, 1976; Johnsgard, 1980; USFWS, 1979). Ten of these species are relatively common. Most of the waterfowl use occurs during spring (March through April) and fall (September through November), when millions of birds reside for varying periods of time along the river while migrating between breeding and wintering areas. During migration stops, dabbling ducks and geese rest on islands and sandbars and forage in grain fields, whereas diving ducks use large open water areas such as lakes and reservoirs for loafing and foraging. Most of the use during spring and fall migration occurs on the mainstem lakes and unfrozen sections of river downstream of each of the dams in the Upper River, while oxbows and old chutes are heavily used in the Lower River. Waterfowl may remain on the river until it freezes, which in the Upper River can occur as early as November; however, even during very cold years, some open water persists downstream of each of the dams, providing some winter habitat.

Within the Upper River reaches, the most common species of nesting waterfowl include Canada geese (*Branta canadensis*), mallards (*Anas platyrhynchos*), gadwall (*Anas strepera*), and blue-winged teal (*Anas discors*). Canada geese nest among forbs and shrubs on islands located in the riverine reaches and mainstem reservoirs. Geese also nest in cottonwood trees and on cliffs on occasion. Mallards, gadwall, and blue-winged teal nest in cattail or bulrush emergent wetlands and in riparian areas with dense herbaceous vegetation. Wood ducks (*Aix sponsa*) and common mergansers (*Mergus merganser*), two locally common cavity-nesters, nest in wetland and riparian forests. Diving ducks, including canvasbacks (*Aythya valisineria*), redheads (*Aythya americana*), and lesser scaup (*Aythya affinis*), nest in dense emergent wetlands and forage in the lakes, diving for mollusks and aquatic insects (Bellrose, 1976).

Nesting and migration-resting habitat have been reduced by past and on-going conversion of riparian and wetland areas to agricultural uses. The availability of remaining habitat is controlled largely by river flow patterns, which maintain favorable vegetation and water depths. Although low flows in March, April, and May in the upper river reaches tend to expose more island substrate for nesting and loafing (Canada geese, mallards, and gadwall), flows must be sufficiently high to prevent land bridging and predator access. During migration, flows high enough to keep islands separated from the mainland, but low enough to create abundant sandbars, are especially important for geese. Flow patterns also affect waterfowl nesting success and productivity by flooding nests or eliminating suitable wetland foraging or brood-rearing areas.

Scattered along the river are State and Federal WMAs, most of which are managed for waterfowl. Many thousand acres of wetland and riparian land in the Lake Sakakawea, Lake Oahe, and Lewis and Clark Lake deltas are used by migratory and breeding waterfowl. Numerous WMAs along the Lower River in Kansas and Missouri, some of which receive water pumped from the Missouri River, support a large number of migrating waterfowl from October through December as well as some breeding populations during spring and summer.

Shorebirds, Wading Birds, and Waterbirds

The Missouri River and its associated wetlands support approximately 61 species of shorebirds, wading birds, and waterbirds (Johnsgard, 1980; USFWS, 1979). Common shorebirds and wading birds that rely on shallow water and emergent wetland habitat include great blue heron (*Ardea herodias*), killdeer (*Charadrius vociferus*), sora (*Porzana carolina*), rails (*Rallidae* sp.), various species of sandpipers (*Scolopacidae*), piping plovers (*Charadrius melodus*), and mountain plovers (*Charadrius montanus*). The great blue heron is a colonial tree-nester that selects riparian forests for nest sites and forages on frogs and small fish in shallow water and emergent wetlands common in backwaters and chutes (Ogden, 1978). All of the shorebirds and wading birds are dependent upon Missouri River hydrology for supplying sandbars, shorelines, and shallow water zones that meet nesting and foraging needs.

Waterbirds found along the Missouri River that require large areas of open water for foraging include common loon (*Gavia immer*); five species of grebes (*Podiceps* sp.); American white pelican (*Pelecanus erythrorhynchos*); double-crested cormorant (*Phalacrocorax auritus*); common terns (*Sterna hirundo*), Forster's terns (*Sterna forsteri*), and least terns (*Sterna antillarum*); and several species of gulls (*Larus* sp.). These species require either sandbars or dense emergent wetland vegetation for nesting and open water for foraging.

Other Wildlife

A variety of other wildlife, including upland game birds, furbearers, big game, raptors, bats, songbirds, cavity-nesting birds, reptiles, and amphibians, rely on Missouri River habitats that are tied to Missouri River hydrology. Aquatic furbearers, such as mink (*Mustela vison*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*), den near the shoreline, where flood events or sudden changes in water level can destroy dens or leave them vulnerable to predation. Upland game birds are especially dependent on emergent wetlands and riparian forests. They also heavily use dense, weedy, herbaceous vegetation that establishes on exposed shoreline sediments in the three upper reservoirs when water levels are drawn down.

The principal big game species are white-tailed deer (*Odocoileus virginianus*), which occur along the entire river, and mule deer (*Odocoileus hemionus*), which occur primarily in Montana, North Dakota, and South Dakota (Mackie et al., 1982; Hesselton and Hesselton, 1982). Both species forage, fawn, and seek winter cover in riparian and wetland vegetation. During drought years, deer feed on the vegetation established on sediments exposed by lowered lake levels. Bighorn sheep and elk occur on the Charles M. Russell NWR near the upstream end of Fort Peck Lake. Although primarily an upland species, pronghorns (*Antilocapra americana*) occasionally extend into the Montana and Dakota portions of the Missouri River floodplain.

The Missouri River supports at least 17 species of hawks, falcons, eagles, osprey (*Pandion haliaetus*), and turkey vultures (*Cathartes aura*), as well as 8 species of owls. Most of these species are dependent on wetland and riparian habitat for nesting and/or foraging habitat.

Approximately 54 species of reptiles and amphibians are found in wetland and riparian areas.

Threatened and Endangered Species

The Missouri River provides breeding habitat for the endangered interior least tern and the threatened bald eagle (*Haliaeetus leucocephalus*) and piping plover (*Charadrius melodus*). It also provides migration and wintering habitat for the endangered peregrine falcon (*Falco peregrinus*) and whooping crane (*Grus americana*). The river valley potentially provides habitat for the endangered Eskimo curlew (*Numenius borealis*), gray bat (*Myotis grisescenses*), and Indiana bat (*Myotis sodalis*).

Bald Eagle

The bald eagle is Federally listed as threatened in all Missouri River basin States. Breeding populations were historically common along the Missouri River but declined during the 19th and 20th centuries. Bald eagle numbers, as well as nests and nest success, have increased dramatically during the past decade (USFWS, 2000). For example, Iowa has one of the most rapidly expanding areas of eagle nesting, with a ten-fold increase in nesting sites since 1991 (USFWS, 2000). Delisting goals established in the 1983 Northern States Bald Eagle Recovery Plan were met in 1991 for that region, which includes most of the project area. With the exception of goals along the Missouri River (recovery zone 47), delisting goals have also been met in Montana since 1991. Montana is part of the Pacific Region bald eagle recovery zone.

Bald eagles winter in various areas throughout the United States, but in greatest numbers along large rivers in the West and Midwest. Of the approximately 12,000 bald eagles counted during the 1988 nationwide midwinter survey of the lower 48 States, about 600 were identified in the Missouri River basin (USFWS, 1990a).

Bald eagles nest in large trees with specific size and structural characteristics (Stalmaster, 1987). Proximity to shorelines of lakes, rivers, or seacoasts and sufficient distance from human activity also influence their selection of nesting sites. Bald eagles usually nest in the same territories each year, often using the nests repeatedly (Stalmaster, 1987). Although trees of sufficient size grow along most of the flowing reaches of the Missouri River, only limited areas in Montana and North Dakota have provided relatively successful nesting habitat (USFWS, 1990a). The decline in North American nesting populations is attributed primarily to the loss of habitat as natural areas were developed for human occupation. Trapping and shooting, human disturbance, and poisoning by organochlorine insecticides (mid-1900s) also contributed to the decline in population.

Wintering bald eagles require night roosts located in sheltered timber stands near an abundant, readily available food supply such as fish, waterfowl, or carrion (Stalmaster, 1987; USFWS, 1990a). Eagles concentrate below the Missouri River mainstem dams to feed on fish that are killed or crippled while passing through the turbines and waterfowl attracted to the open water. In the northern States, where natural lakes and smaller rivers freeze during winter, the Missouri River provides the only open water for wintering birds. During the past decade, wintering populations have been increasing in the continental United States, including the Missouri River; however, perching, roosting, and nesting habitats continue to decline due to the loss of mature cottonwoods along the river. As cottonwoods succumb to age, other tree species such as ash invade the stands. Conversion of riparian and wetland habitat to agricultural uses is also affecting eagle habitat.

Whooping Crane

The endangered whooping crane is one of the rarest North American birds. Never common in recent times, whooping cranes numbered approximately 1,300 to 1,400 birds in the mid-1800s (Allen, 1952). By 1941 the population had declined to 16 individuals. Since then, the population has rebounded to just under 365 birds, including captive individuals. An all time record of 30 whooping crane chicks arrived at the wintering grounds in the fall of 1997. They are a part of the only wild breeding population, the Wood Buffalo-Aransas flock, which totaled 182 birds in the spring of 1998. A new nonmigratory flock has been established in central coastal Florida (personal communication, W. Jobman, Wildlife Biologist, USFWS, Grand Island, Nebraska, May 5, 1998). The remaining birds consist of the nonbreeding experimental Grays Lake (Idaho)-New Mexico flock and various captive flocks.

The Wood Buffalo-Aransas flock winters along the Texas gulf coast and breeds in Wood Buffalo National Park in the Northwest Territories, Canada. The 80-to-120-mile-wide primary migration corridor passes approximately 15 degrees west of north from Aransas NWR until reaching the Missouri River near the confluence with the Niobrara River in north-central Nebraska. The migration corridor then follows the Missouri River into North Dakota, bending slightly to the west as it leaves the Missouri River near Garrison, North Dakota. From Garrison, the corridor continues 30 degrees west of north and broadens in the Canadian portion of the flyway as it approaches Wood Buffalo National Park (Johnson and Temple, 1980).

Migrating whooping cranes interrupt their journey with brief, usually 2-day, overnight stopovers, during which time the birds feed and rest. Stopover roosting sites typically exhibit the following features: (1) surface water, either natural or artificially created and/or maintained (from less than one acre to thousands of acres); (2) horizontal and overhead visibility; (3) proximity to feeding sites; and (4) reasonable isolation from human developments and/or disturbances (Howe, 1989; Johnson and Temple, 1980). Omnivorous and opportunistic, cranes feed in various habitats including cropland, wet meadows, palustrine wetlands, and native grasslands (Howe, 1989; Platte River Management Joint Study, 1990). The typical diet of migratory whooping cranes includes emerging winter wheat, barley, wheat, felled corn, waste milo, and various native plant and/or animal food items such as frog and toad egg masses, beetles and other insects, small fish, snakes, crayfish, and possibly snails and bivalve mollusks (Johnson and Temple, 1980). The abundance of wet meadows, which provide suitable foraging habitat for stopovers and native food species, is dependent on river hydrology, particularly patterns of flows, as discussed in Section 3.6, Wetland and Riparian Vegetation.

Within the potential migration corridor of the whooping crane, Montana, North Dakota, and South Dakota received reports of migratory stopovers (personal communication, Arnold Dodd, Wildlife Biologist, Montana Department of Fish, Wildlife, and Parks, Bozeman, Montana, November 9, 1992; personal communication, Ron Stromstad, Wildlife Biologist, North Dakota Game and Fish Department, Bismarck, North Dakota, November 4, 1992; personal communication, Doug Backlund, Wildlife Biologist, South Dakota Game, Fish, and Parks Department, Pierre, South Dakota, November 5, 1992). The most critical migration stopover areas are along or near the Platte River in central Nebraska. However, at least 21 sightings have been made of cranes roosting on Missouri River sandbars in eastern Montana, North Dakota, and South Dakota. The highest number of observations have occurred in the reach downstream of Garrison Dam, but mudflats in the drawdown zones of Lake Sakakawea, Lake Audubon, and Lake Oahe are also important roosting areas (personal communication, W. Jobman, Wildlife Biologist, USFWS, Grand Island, Nebraska, May 5, 1998).

Eskimo Curlew

Historically, the endangered Eskimo curlew was an abundant spring migrant in the Great Plains region, but is now rare. Thousands of curlews formerly visited the Plains States between early April and late May on their 8,000-mile journey between wintering grounds on the pampas grasslands of southern South America and nesting grounds on the arctic tundra of the MacKenzie Territory (Currier et al., 1985). Current estimates place the population at approximately 50 individuals, but little is known regarding the current distribution of these birds (Gollop, 1988). The population decline is attributed to extensive hunting of the species during the late 1800s (Gollop, 1988), although habitat changes and other human-related perturbations may have been contributing factors (Banks, 1977).

Curlews stop over in tall grass prairie habitat that occurs along their spring migration route, but prefer wet meadows along rivers (Swenk, 1915; Bent, 1929). They feed on grubs, cutworms, grasshoppers, grasshopper eggs in tilled croplands, pastures, and meadows (Swenk, 1915). Eskimo curlews were sighted in only four locales in North America during 1987: (1) near Grand Island, Nebraska; (2) near the Texas-Louisiana border; (3) at Aransas NWR in Texas; and (4) near Lac Rendezvous, Northwest Territories, Canada (personal communication, John Dinan, Wildlife Biologist, Nebraska Games and Parks Commission, Omaha, Nebraska, November 6, 1992). Curlews were last reported in Kansas in 1902 (personal communication, Ken Burnson, Non-game Program Coordinator, Kansas Department of Wildlife and Parks, Pratt, Kansas, November 4, 1992). The level of use of the Missouri River corridor is unknown, but is probably limited to rare visits of short duration during spring migration. Fall migration follows the Atlantic coastline and completely avoids the Missouri River basin (USFWS, 1980).

Indiana Bat and Gray Bat

The endangered Indiana and gray bats have experienced serious population declines due to habitat loss and human disturbance. Their historical abundance and distribution are unknown because, although distinct species, these bats are similar to other, more common, bat species in the genus *Myotis*.

The current range of the migratory Indiana bat extends from Oklahoma, Iowa, and Wisconsin east to Vermont and south to northwestern Florida (Barbour and Davis, 1969). The winter range is associated with regions of well-developed limestone caverns. Major populations of hibernating Indiana bats occur in Missouri, Kentucky, and Indiana. Smaller hibernating populations also occur in most of the remaining eastern States. Although the winter range is large, the species is restricted to about 135 hibernacula caves (Brady et al., 1983). The gray bat has been reported in Missouri, Illinois, Indiana, Kentucky, Kansas, Tennessee, and Alabama. About 95 percent of all gray bats appear to hibernate in only nine identified caves (Tuttle, 1979). Both species are known to occur in Boone County in central Missouri and use Missouri River bluff caves for hibernation (personal communication, Ken Brunson, Non-game Program Coordinator, Kansas Department of Wildlife and Parks, Pratt, Kansas, November 4, 1992; personal communication, Dennis Figg, Wildlife Biologist, Missouri Department of Conservation, Columbia, Missouri, November 6, 1992).

When coexisting, the gray bat appears to out-compete the Indiana bat and force it out of the riparian corridor and into upland areas to forage (personal communication, Mike LeValley, Wildlife Biologist, USFWS, Columbus, Missouri, December 15, 1992). The abundance of insects preyed upon by both species of bats may be partially dependent on the abundance and composition of wetland and riparian communities. In Kansas, the bats occur only in the southeast corner of the State and probably not in the vicinity of the Missouri River (personal communication, Ken Brunson, Non-game Program Coordinator, Kansas Department of Wildlife and Parks, Pratt, Kansas, November 4, 1992).

Peregrine Falcon

The endangered peregrine falcon historically nested throughout North America. Its decline has been attributed to human expansion and the use of chlorinated hydrocarbon pesticides. Though considered extinct east of the Rocky Mountains in 1964 (Recovery Team, 1982), 17 nesting pairs of the *anatum* subspecies were identified in the eastern United States in 1983 (Craig, 1986). In addition, release programs have produced 38 to 40 nesting pairs of non-*anatum* peregrine falcons (Craig, 1986).

Peregrine falcons almost always nest on steep cliffs greater than 150 feet in height that are close to water (Recovery Team, 1982). Peregrine falcons occasionally nest on building ledges in North American cities (Craig, 1986). Common characteristics of natural falcon nest sites include: (1) large cliffs with a small cave or overhanging ledge large enough to contain three or four full-grown nestlings; (2) proximity to water; and (3) nearby foraging areas. Peregrine falcons feed almost exclusively on birds captured in flight (Kirven, 1978; Monk, 1981) in areas such as woodlands, marshes, open grasslands, coastal strands, and bodies of water with a diversity of prey that cannot easily escape (Recovery Team, 1982; Seattle City Light, 1989).

The wintering habitat of the peregrine falcon is poorly documented. Some adults remain near the nest cliff year round; others move from their northern-most breeding grounds during the winter to forage further south, usually in wetlands (Recovery Team, 1982).

The historic range of the *anatum* subspecies included the Missouri River corridor in Montana, Missouri, and small areas of Iowa, South Dakota, and Nebraska. Recent peregrine falcon nesting has been documented at hacking (artificial release) sites in Omaha (personal communication, J. Fleckstein, Wildlife Biologist, Iowa Department of Natural Resources, Des Moines, Iowa, November 16, 1992) and Kansas City (personal communication, Ken Brunson, Non-game Program Coordinator, Kansas Department of Wildlife and Parks, Pratt, Kansas, November 4, 1992). Although suitable natural habitat occurs throughout the Missouri River corridor, no nesting or wintering activity has been documented in recent times. Migrating peregrine falcons have been reported from all States along the river, including several sightings near Kansas City (personal communication, Ken Brunson, Non-game Program Coordinator, Kansas Department of Wildlife and Parks, Pratt, Kansas, November 4, 1992).

Interior Least Tern and Piping Plover

The interior least tern and piping plover were listed as endangered and threatened species, respectively, in 1985 (USFWS, 1990a). Historically, the least tern commonly bred on the Missouri River and many of its tributaries from Montana to St. Louis (USFWS, 1990a). Lewis and Clark frequently observed the tern along the river (Burroughs, 1961). In the early 1900s, naturalists described the plover as common. Since the early 1980s, however, there has been a substantial decrease in the populations of these two species. Both of these species winter near the Gulf of Mexico (USFWS, 1990a; Haig and Oring, 1985; Nichols, 1989).

Least terns and piping plovers typically nest in colonies on riverine sandbars isolated by water (Faanes, 1983). Their nesting habitat requirements are similar, usually consisting of river sandbars, islands, and lakeshore peninsulas, where access by mammalian predators is minimized and foraging habitat (shallow water for terns and shorelines for plovers) is nearby (Faanes, 1983). Both species nest in shallow, inconspicuous depressions in dry, open, sandy areas with less than 30 percent vegetative cover and plant heights less than 1 foot (USFWS, 1990b; USFWS, 1990c).

The significant decline in tern and plover populations is attributed to loss of habitat and human disturbance (Cairns and McLaren, 1980; Russell, 1983; USFWS, 1990b). Nesting habitat was historically created by high flows that scoured vegetation from islands and redeposited sediments to create new sandbars. In the past half century, dams and storage reservoirs have reduced peak flows and sediment loadings, allowing vegetation to encroach on islands and reducing the creation of new sandbars. Current low productivity reflects the effects of predation, weather, human disturbance, erosion and flooding of nests, and nest abandonment (Sidle et al., 1992). Although periodic high water levels are needed to maintain good nesting habitat, timing of high inflows and releases can preclude nesting (Sidle et al., 1992). For example, the large inflow years of 1993, 1995, 1996, and 1997 inundated habitat, causing greater than normal loss of nests and, in some of these years, reduced the number of nesting birds. Fluctuating water levels can also erode sandbars, destroying nests and eliminating nesting habitat.

From 1986 to 1997, piping plover numbers on the Missouri River averaged 402 adult birds. The adult census numbers ranged from a high of 618 piping plovers in 1991 to a low of 117 piping plovers in 1997. Over the same time period, the least tern census on the Missouri averaged 589 adult birds. The adult census numbers ranged from a high of 763 least terns in 1994 to a low of 442 least terns in 1996.

Nesting commences between April and June each year, depending on the weather and water levels (USFWS, 1990a; Faanes, 1983). The USFWS identifies the following sections of the Missouri River as least tern breeding habitat: Fort Peck Dam to Lake Sakakawea, Garrison Dam to Lake Oahe, Fort Randall Dam to the Niobrara River, and Gavins Point Dam to Ponca. Identified breeding habitat also includes the Yellowstone River, the Cheyenne River, and the Platte River (USFWS, 1990b). About 59 percent (4,201 of 7,064) of the least tern population on the Missouri River nests on the river below Garrison Dam and Gavins Point Dam. Around 16 percent (1,158 of 7,064) of the least terns nest on Lake Oahe and 11 percent (810 of 7,064) nest on the Missouri River below Fort Peck River Dam. The remaining 14 percent (896 of 6,992) nest on Fort Peck Lake, Lake Sakakawea, the Missouri River below Fort Randall Dam, and on Lewis and Clark Lake.

About 56 percent (2,725 of 4,824) of the piping plover population on the Missouri River nests on the river below Garrison and Gavins Point Dams. Around 16 percent (758 of 4,824) of the piping plovers nest on Lake Oahe and 15 percent (735 of 4,824) nest on Lake Sakakawea. The remaining 13 percent (606 of 4,824) nest on Fort Peck Lake, the Missouri below Fort Peck Dam, the Missouri River below Fort Randall Dam, and on Lewis and Clark Lake.

The least tern and piping plover recovery plans identify population recovery goals of 2,100 adult least terns and 970 adult plovers (USFWS, 1990a; USFWS, 1990b). During the past several years, the USFWS and the Corps have created additional nesting habitat on several reaches of the Missouri River by removing vegetation from islands and by installing fences in shallow water to trap sediment. The Corps has also initiated programs in recent years to benefit bird reproduction, while maintaining flows to serve authorized purposes. Project discharges are increased from Fort Peck, Garrison, Fort Randall, and Gavins Point Dams when birds begin to nest in May. The releases in August also are increased, but allow full service to authorized purposes. Daily peaking power limits, less than full powerplant capacity, are also initiated at this time and held through the nesting season. Depending on water conditions, releases at Fort Peck and Garrison Dams may be reduced slightly in July and August to provide a nest free-board cushion should rainfall runoff materialize. During large system inflow years, large flood control evacuation rates are necessary and nesting flow restrictions are lifted. In high water years 1995, 1996, and 1997, eggs were collected and nests moved to higher elevations to prevent inundation.

American Burying Beetle

The American burying beetle (*Nicrophorus americanus*) is listed as an endangered species due to its precipitous population decline (Ratcliffe and Jameson, 1992). Historically, this species ranged throughout the eastern United States west to Nebraska and South Dakota. Today, it is known to occur in only a few locations. The riparian and wetland forest and grasslands along the Missouri River in South Dakota, Nebraska, and Iowa potentially support isolated populations of American burying beetles; however, no observations of the beetles have been made on the Missouri River to date (personal communication, B.C. Ratcliffe, Curator, University of Nebraska State Museum, March 24, 1993). The habitat requirements are not well understood, but the beetles apparently occur wherever small mammal or bird size carrion is available and suitable substrate for burying the carrion is present in forest or grassland habitats (Anderson, 1982; Ratcliffe and Jameson, 1992; personal communication, B.C. Ratcliffe, Curator, University of Nebraska State Museum, March 24, 1993).

3.7.2 Fort Peck Lake

Fort Peck Lake and the surrounding Charles M. Russell NWR provide a mix of open water, wetland, and upland habitat that supports a diversity of wildlife. Mule deer, white-tailed deer, elk (*Cervus elaphus*), and pronghorn are the most important mammalian wildlife species in the Fort Peck Lake area. The delta upstream of the mouth of the Musselshell River is especially important for deer and elk that congregate in the willow thickets and emergent wetlands during fall and winter. The extensive emergent and scrub-shrub wetlands and the riparian/wetland forests associated with the lake delta provide habitat uncommon in the region and important for songbirds such as yellow warblers (*Dendroica petechia*), yellow-headed (*Xanthocephalus xanthocephalus*) and red-winged blackbirds (*Agelaius phoeniceus*), and kingbirds (*Tyrannus* sp.). Canada geese nest on islands in the river upstream of the delta and form large flocks on the lake during molting and migration periods. Flocks of American white pelicans and double-crested cormorants breed and forage on the lake during the spring to fall period.

Twenty-five pairs of bald eagles nested along the Missouri River upstream of Fort Peck Lake in 1997 (personal communication, D. Flath, USFWS, Montana, 1998), but no successful nesting near Fort Peck Lake itself has been reported. Between 50 and 200 bald eagles winter upstream of Fort Peck Lake, while 50 individuals were observed wintering near the lake in 1998 (personal communication, D. Flath, USFWS, Montana, 1998). The level of use in the area is likely tied to the presence of wetland and riparian forests along the river. Peregrine falcons occasionally migrate through the area (USFWS, 1979).

From 1988 through 2000, an average of 12 adult piping plovers were observed on Fort Peck Lake. A high of 30 plovers were observed in 1993, with a low of zero reported for the high-reservoir years 1996, 1997, and 2000. An average of three adult least terns were observed on the lake during the same time period. A high of 10 terns were observed in 1991, but no terns were observed on the lake in 1992, 1996, 1997, 1999, or 2000 (Mackey and Spence, 1990; USFWS, 1990a). Nests are usually located on shorelines, most commonly on peninsulas along the Big Dry Arm. The number of nesting pairs is, in part, dependent on the availability of suitable nesting sandbars and can vary markedly from year to year. Receding water levels during drought years, such as the period 1987 through 1992, expose increased acreage of suitable habitat along reservoir shorelines and result in increased nesting success.

3.7.3 Missouri River from Fort Peck Dam to Lake Sakakawea

Wildlife habitat in this 204-mile reach comprises emergent, scrub-shrub, and forested wetlands situated in oxbow lakes, chutes, and the inner banks of river bends. Most of the floodplain consists of croplands, pastures, and hayfields in private ownership or in the Fort Peck Reservation. The wetland and riparian forests provide habitat for white-tailed and mule deer, waterfowl, bald eagles, aquatic furbearers, and other wildlife. White-tailed deer typically congregate in densely vegetated scrub-shrub and emergent wetlands and riparian forests on islands and the floodplain (USFWS, 1990a). The wood duck and common merganser nest in wetland/riparian forested areas, while Canada geese rely on vegetated islands for nest sites. Other species of waterfowl such as mallard, blue-winged teal, and gadwall nest in uplands in proximity to water or in emergent wetlands. Islands and sandbars provide numerous waterfowl with secure loafing and roosting areas during spring and fall migration. During spring migration, normal flows near 10 kcfs yield about 300 acres of suitable sandbar roosting/resting habitat; there is slightly less of this habitat during fall migration due to higher discharges (Corps, 1994e). The acreage of sandbar habitat varies from 85 acres at 15 kcfs to 635 acres at 6 kcfs.

Between 25 and 50 bald eagles wintered (November to February) along the ice-free reach between Fort Peck Dam and Lake Sakakawea in 1998 (personal communication, D. Flath, USFWS, Montana, 1998). These birds foraged primarily on mutilated fish [primarily cisco (*Coregonus* sp.)] in the 2 to 3 miles immediately downstream of the dam within the Charles M. Russell NWR. Peregrine falcons and whooping cranes occasionally also occur along this reach during spring and fall migration.

Terns and plovers are found on the Missouri River below Fort Peck Dam from RM 1725 down to the confluence with the Yellowstone River at RM 1581. The Fort Peck Reservation banks are included within this identified reach for terns and plovers. Piping plovers are not plentiful on this part of the Missouri River, averaging just 11 adults annually. The adult numbers range from a high of 24 plovers in 1996 to zero in 1992. Least terns are more abundant compared to the plovers along this reach, particularly during years when habitat on the other reaches is inundated or in otherwise poor condition. Below Fort Peck Dam, tern adult numbers average 68 birds annually. The adult numbers range from a high of 162 terns in 1997 to 13 in 2000.

Flooding, predation, and severe rainstorms cause nest failure and chick mortality for both terns and plovers. The frequency of nest flooding is directly related to flows during the nesting season and the amount of habitat available. Subsequent to the high summer flows of 1997, hundreds of acres of sandbar habitat with several vertical feet of elevation above the water was available for the birds in 1998. The lack of scouring flows allows riparian vegetation to encroach on bare sandy shorelines, rendering them unsuitable for tern and plover nesting. With nesting habitat consequently becoming restricted, nests would tend to be located closer to the water’s edge, where flooding is more likely.

River flow also affects predation. Restricting terns and plovers to small areas for nesting concentrates the birds, increasing their vulnerability to a catastrophic predation event. High flows will tend to inundate land bridges, including nesting habitat. Nesting flows of approximately 6 to 13 kcfs, depending upon previous years' flows, usually maintain sufficient habitat. Fluctuations of 0.5 kcfs or more, however, can flood nests. Early spring flows greater than winter flows would likely scour more vegetation from islands. Even though Fort Peck releases are reduced, high flows from the Milk River can contribute to nest flooding in much of the reach.

3.7.4 Lake Sakakawea

Extensive wetland and riparian areas located in the Lake Sakakawea delta are managed for wildlife by the North Dakota Game and Fish Department. The reservoir-wetland-riparian forest complex supports white-tailed and mule deer, migrating waterfowl, mink, beaver, and other species. The extreme upstream end of the delta is an important nesting area for Canada geese, with higher pools generally creating better habitat.

No nesting bald eagles have been observed along Lake Sakakawea. Fewer than a dozen eagles winter in the delta near Williston, North Dakota (USFWS, 1990a).

Piping plovers are found widely in the Lake Sakakawea area, which includes the Fort Berthold Reservation. Prime nesting areas include shoreline beaches southeast of Independence Point, islands in the Van Hook Arm, the shoreline beaches west of the Little Egypt Recreation Area, and Steinke Bay and West Totten areas. Over the past 13 years, 1988 to 2000, adult censuses have been conducted on Lake Sakakawea. In this time, piping plover numbers have averaged 94 birds. The adult numbers range from a high of 277 plovers in 2000 to just 3 adults seen in high water year 1997. Least terns are sporadic nesters on the reservoir and not as abundant on the lake compared to the plovers, averaging just 15 adult birds each year over the past 13 years. The adult numbers range from a high of 35 terns in 1994 to 2 adults in 1997.

3.7.5 Missouri River from Garrison Dam to Lake Oahe

The 90-mile reach between Garrison Dam and Lake Oahe lies at the transition zone of eastern and western bird species and therefore supports a very diverse bird community. More than 50 species of breeding birds depend on the wetland riparian habitat in the corridor, along with 17 species of reptiles and amphibians. The extensive riparian cottonwood forests that historically bordered the river have diminished since dam closure, largely as a result of the conversion of land for agricultural uses. In addition to land use impacts, cottonwood acreage will continue to diminish as mature stands age and convert to stands of mixed species.

Canada geese (more than 2 pairs per mile of river) rely on stable flows in this reach during mid-March to mid-May for successful nesting. From late-October to December, several hundred thousand migrating waterfowl, including over 180,000 Canada geese, use sandbars, wetlands, and croplands (personal communication, M. Olson, Wildlife Biologist, USFWS, Bismarck, North Dakota, May 5, 1998). Waterfowl often remain in the area until the river freezes (between November and December), and some continue to inhabit the river area below the dam all winter. Sandbar habitat for migratory waterfowl varies from 18 acres at 30 kcfs to 3,237 acres at 10.3 kcfs, with flows in most years producing between 135 and 765 acres (Corps, 1994e). Shallow water areas provide night roosting for as many as 30,000 migrating sandhill cranes during September and October.

There were eight bald eagle nests between Garrison Dam and Upper Lake Oahe in 1998 (personal communication, M. Olson, Wildlife Biologist, USFWS, Bismarck, North Dakota, May 5, 1998). The current nests are located in a stand of riparian cottonwoods that is 12 to 20 feet above the normal river level. Bald eagles also winter along this reach, with total populations exceeding 100 birds (personal communication, D. Flath, USFWS, Montana, 1998).

The Missouri River below Garrison Dam is an important area for both piping plovers and least terns. From 1988 through 2000, 23 percent (1,339 of 5,899) of the piping plovers and 25 percent (1,973 of 7,867) of the least terns observed on the Missouri River and reservoirs were found here. Piping plover numbers on this part of the river have averaged 103 adult birds annually from 1988 to 2000. The adult bird numbers have ranged from a high of 261 plovers in 1995 to a low of 6 plovers observed in 1997. Least tern numbers have averaged 152 adult birds. The number of adult birds has ranged from a high of 284 terns in 1995 to a low of 41 in 1997. The continual shifting of sandbars and the dynamic nature of the vegetation on the sandbars forces the birds to relocate to new nest sites from year to year. Some of these birds have nested within the headwaters of Lake Oahe during low water periods. Predation and sandbar use by boaters and recreationists near Bismarck have been reducing tern and plover nesting success.

Migrating whooping cranes have been observed to roost in this section of the river in recent years (Howe, 1989; personal communication, W. Jobman, Wildlife Biologist, USFWS, Grand Island, Nebraska, February 19, 1993).

3.7.6 Lake Oahe

Extensive wetland and riparian habitat extends from Bismarck, North Dakota, downstream to the South Dakota border. Additional extensive bottomlands also adjoin the Cannonball, Moreau, and Cheyenne Rivers. Included in this area, which also includes the Standing Rock and Cheyenne River Reservations, are about 34,000 acres of vegetated shorelines. These shorelines were exposed by drawdown during the 1987 to 1998 drought and were converted to open water due to reservoir levels rising. Even during full pool conditions, the meandering river between Bismarck (RM 1310) and Fort Rice (RM 1273) provides important wildlife habitat, some of which has been incorporated into WMAs by the North Dakota Game and Fish Department. Water control structures were constructed by Ducks Unlimited in the Glencoe/Carlson, Kimball, and Sugarloaf Bottoms (RM 1277 to RM 1296) to maintain wetlands and ponds for migrating waterfowl. Hundreds of thousands of waterfowl use this habitat during migration, as do other wildlife throughout the year. Wetlands and croplands near Lake Oahe, especially in South Dakota, are important for as many as 30,000 migrating sandhill cranes (USFWS, 1990d).

The endangered bald eagle and least tern and the threatened piping plover occur in the Lake Oahe vicinity. Between 75 and 150 bald eagles wintered in the area in 1988, perching and roosting in trees within shoreline riparian forests (USFWS, 1990a). Lake Oahe has harbored important concentrations of both piping plovers and least terns in the 13 years between 1988 and 2000. Over this period, piping plover numbers averaged 79 adult birds. The adult numbers ranged from a high of 143 plovers in 1992 to a low of 21 plovers in 1996. Least tern numbers on Lake Oahe averaged 103 adult birds. The adult numbers ranged from a high of 160 terns in 1994 to a low of 57 terns in 1999. Peregrine falcons and whooping cranes may migrate through this area, but their occurrence is rare (USFWS, 1990a).

3.7.7 Missouri River from Oahe Dam to Lake Sharpe

Large numbers of waterfowl, especially Canada geese, congregate on the river downstream of Lake Oahe and on Lake Sharpe near Pierre, profiting from the mix of open river and riparian and cropland cover that characterizes the reach and adjacent lands between the two reservoirs. Much of the wetland and riparian vegetation of this reach occurs in the tailwaters of Oahe Dam in a stretch of the river that is usually ice-free in the winter. This area downstream of the dam is an important feeding area for wintering bald eagles, which prey on waterfowl attracted to the open water and shoreline cover. The Missouri River in South Dakota supports as many as 400 wintering bald eagles (personal communication, J. Peterson, Wildlife Biologist, USFWS, Lake Andes, South Dakota, May 5, 1998). However, numbers have declined in recent years, possibly due to reduced perching and roosting habitat along the river in this reach. No tern or plover nesting on this reach has been reported, but peregrine falcons and whooping cranes may briefly stop over in wetlands during their migration.

3.7.8 Lake Sharpe

Wildlife resources of Lake Sharpe are similar to those of the riverine reach immediately upstream. Unlike other mainstem lakes, water levels in Lake Sharpe remain relatively stable throughout the year. Wetland and riparian areas provide habitat for waterfowl and aquatic furbearers, mostly at the upstream end of the lake. South Dakota Department of Game, Fish and Parks manages one game management area for waterfowl and upland game birds, including pheasants. Additionally, the Lower Brule and Crow Creek Reservations have staff that manage sites for wildlife. Few bald eagles overwinter around Lake Sharpe because of a lack of perch sites. No least tern or piping plover nesting along the shorelines has been reported.

3.7.9 Lake Francis Case

Hundreds of thousands of waterfowl migrate through Lake Francis Case each fall, constituting an important waterfowl hunting area (USFWS, 1990d).

These waterfowl are dependent upon wetlands and sandbars during these visits. Several sizable tributaries and embayments contain forested and wetland habitat. The 8 miles immediately downstream of Big Bend Dam support extensive forest, emergent, and scrub-shrub wetland habitat for cavity-nesting waterfowl and woodpeckers, songbirds, and aquatic furbearers. The White River, a major tributary, contains the only significant bottomland forests in the immediate area and supports deer, turkey, and beaver.

No least tern or piping plover nesting has been documented on Lake Francis Case, although least terns occasionally have been observed near the mouth of the White River.

3.7.10 Missouri River from Fort Randall Dam to Lewis and Clark Lake

This reach supports migrating and breeding waterfowl and contains two great-blue heron and double-crested cormorant rookeries. Of particular importance for migratory waterfowl are the 10 to 70 acres of sandbar habitat exposed by flows between 35 and 18 kcfs (Corps, 1994e).

This reach, which includes both Yankton and Santee Reservation lands and Ponca Tribal Lands, is an active wintering area for bald eagles, particularly within the Karl Mundt NWR, where from 1995 to 1997, between 150 and 200 bald eagles wintered in the 3-mile stretch below Fort Randall Dam (USFWS, 1998). The mature riparian forests, high waterfowl population, and abundance of fish provide high-quality bald eagle habitat. Six active nests were found along the river between Fort Randall Dam and Sioux City, Iowa.

This 45-mile stretch of the Missouri River did not see large numbers of either piping plovers or least terns until 1998. From 1988 through 2000, this part of the river averaged just 17 adult piping plovers. The adult numbers ranged from a high of 62 plovers in 2000 to zero plovers in 1988, 1989, 1995, and 1997. Least tern numbers on the Missouri below Fort Randall Dam averaged 33 adult birds annually. The adult numbers ranged from a high of 124 terns in 1999 to zero terns in 1988 and 1997. The long-term reduction of water-borne sediments has reduced sandbar habitat for tern and plover nesting. Cold hypolimnic water may also reduce tern and plover use of this reach by affecting forage. Whooping cranes have also been observed foraging in adjacent wetlands in this river corridor (Howe, 1989).

3.7.11 Lewis and Clark Lake

This reach extends from the Niobrara River to just downstream of Springfield, and it includes extensive emergent wetland and riparian forest. Purple loosestrife has infested most of the emergent wetland. This has reduced wetland productivity as wildlife breeding habitat, but still provides shelter for migratory waterfowl. The Bazille Creek WMA in the lake's delta and over 3,000 acres in the Springfield and Running Water Bottoms (approximately RM 840) are managed for waterfowl. The open-water areas of the lake provide resting habitat for Canada geese and ducks, especially diving ducks.

The least tern and piping plover nest on sandbars in the delta just downstream of the Niobrara River confluence and just upstream of the Santee Reservation banks. Lewis and Clark Lake typically supports a minimal number of both terns and plovers during the nesting season, although populations of both species spiked up in 1998 and 1999 following the high water year in 1997. In the 13 years of adult censuses between 1988 and 2000 on the lake, an average of 29 piping plovers has been observed annually. The adult numbers have ranged from a high of 84 plovers in 1998 to a low of 4 plovers seen in 1995. Least tern numbers on the lake have averaged 53 adult birds. The adult numbers have ranged from a high of 120 terns in 1998 to 16 terns in 1995. Bald eagles also winter in the delta, feeding on waterfowl.

3.7.12 Missouri River from Gavins Point Dam to Ponca

In this reach, the emergent, scrub-shrub, and forested wetlands and riparian forest support a wide variety of waterfowl, furbearers, upland game birds, raptors, big game, threatened and endangered species, and other wildlife. Agricultural conversion of wetlands and riparian forest has eliminated over 60 percent of these habitats within 0.6 mile of the river (Clapp, 1977). Vegetation encroachment limits the use of numerous sandbars and islands by shorebirds and waterfowl. In most years, between 70 and 300 acres of sandbar are exposed during the fall migration at flows of 20 kcfs and 35 kcfs, respectively (Corps, 1994e).

There were at least two active bald eagle nests in Nebraska in 1998. There are 19 areas in this reach that provide habitat for wintering bald eagles, especially areas downstream of Gavins Point Dam and near the mouth of the James River. These areas have large stands of riparian forests and are near waterfowl concentration sites along the river. From Gavins Point Dam to Rulo, Nebraska, over 200 bald eagles were observed wintering in 1997, many of which were in this reach (USFWS, 1998).

The Missouri River below Gavins Point Dam contains the highest number of piping plovers and least terns found during the 13 years (1988 to 2000) that adult censuses have been conducted on the river. This part of the river accounted for 24 percent (1,414 of 5,899) of all plovers and 28 percent (2,240 of 7,867) of all terns found on the river from 1988 to 2000. During this time period, an annual average of 109 adult piping plovers has been observed. The adult numbers ranged from a high of 212 plovers in 1988 to a low of 22 plovers seen in 1996 and 1997. Least tern numbers on this part of the river have averaged 172 adult birds annually. The adult numbers ranged from a high of 272 terns in 1993 to a low of 82 terns in 1996. Flat releases (equivalent to anticipated mid-August discharges) are made from Gavins Point Dam during the nesting season to ensure that terns and plovers do not nest at low elevations on sandbars that would likely be flooded between nesting initiation and late August, when young birds have fledged. High flows from rainstorms and erosion also destroy a small percentage of the nests each year. Predation, however, is the largest cause of nest losses in this reach. Rain storms and recreational use of the river during the summer also limit tern and plover productivity. Record runoff from 1995 to 1997 greatly increased the amount of suitable sandbar habitat in this reach.

The American burying beetle may occur on the older, wooded islands in the reach, but none have been confirmed. The beetles appear to require forested islands with an accumulation of humus sufficient to bury carrion.

In accordance with its November 2000 Missouri River BiOp, the USFWS recommends flow modification by 2003 at Gavins Point to provide an ecologically improved hydrograph for the Lower Missouri River. Flow modifications at Gavins Point will restore and serve to maintain sandbars and shallow water areas that serve as nesting and foraging habitat for least terns and piping plover, provide nursery habitat for pallid sturgeon and other native fishes, trigger spawning activity in fishes, and reconnect potential riverine and floodplain habitat by inundating side channels needed as spawning areas for fish. The USFWS mandated the spring rise to be run at 17.5 kcfs every three years between May 1 and June 15 as runoff conditions permit. Summer flows are to be decreased every year from June 21 until September 1. A period of three weeks before and after the summer flow will be needed to adjust the river to implement the new summer-flow regime.

3.7.13 Missouri River from Ponca to St. Louis (Channelized Reach)

The most productive wildlife habitat in this channelized reach occurs in oxbow lakes and chutes that have been cut off from the river by the dikes but still receive surface or groundwater. Many of the larger river bends have been incorporated into State-managed WMAs and Corps mitigation and environmental restoration sites (Section 3.8.1), affording protection from development in a floodplain where 95 percent of the land has already been converted to cropland. In particular, the DeSoto NWR, Squaw Creek NWR, and Plattsmouth WMA provide critical habitat for migratory waterfowl. Wetland habitat in several of the WMAs is maintained by pumping water from the river into the cut off oxbow or chute. Others are maintained through overbank or groundwater flow. The bottomland forests in Nebraska, Iowa, and Missouri, including Winnebago, Omaha, Iowa, and Sac and Fox Reservation lands, provide good to excellent cover and browse for deer. The extent and species composition of these forests depend, in part, on the frequency of flooding and soil saturation (Section 3.6).

Bald eagles nest and overwinter along the Lower River. No nesting bald eagles had been reported in Kansas or Missouri in areas adjacent to the Missouri River until recent years. In 1973, eagles constructed a nest along the Nebraska/Iowa border but later abandoned it.

Many eagles overwinter along the Missouri River. More than 200 bald eagles have wintered along the Nebraska/Iowa reach of the Missouri River (USFWS, 1998). In 1990, approximately 1,500 eagles wintered along the Missouri River and its major tributaries, including the Kansas, Grand, and

Osage Rivers. Approximately one-third of these bald eagles wintered along the Missouri River.

Cold winters and lack of ice-free open water upstream often force the eagles to overwinter along the Lower River.

No least tern or piping plover nesting has been recorded along the portion of Lower River from Ponca to the mouth of the Missouri River in recent times.

3.7.14 Mississippi River from St. Louis to Mouth

The least tern also nests on nonvegetated portions of sandbars in the Mississippi River downstream from St. Louis from about May to September. The most recent published least tern survey for the Mississippi River identified a total of 5,920 least terns and 65 nesting colonies below the mouth of the Missouri River (Jones, 2000).

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3.8 FISH

3.8.1 General

Over 156 fish species have been documented in the Missouri River. These species include a wide variety of native species and numerous species that have been introduced into the mainstem lakes and riverine stretches of the river. The habitat classes available and, correspondingly, the species composition of the Missouri River differ considerably between the riverine and lake segments. The large mainstem reservoirs formed by the six dams on the river greatly changed the character of the river water and thus fish habitat. Even the river reaches below the dams have changed, particularly in terms of water temperature, clarity, chemical composition, and bottom configuration and substrate. The diversity of habitat has led to a greater diversity in the fish community. Because of the differences in species composition as well as the physical characteristics between the riverine reaches and the lakes, the mechanisms affecting fish production are also very different.

Riverine Fish Community

The most important sportfish in the riverine stretches are walleye (*Stizostedion vitreum*), sauger (*Stizostedion canadense*), white bass (*Morone chrysops*), yellow perch (*Perca flavescens*), channel catfish (*Ictalurus punctatus*), paddlefish (*Polyodon spathula*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), and northern pike (*Esox lucius*). Trout and salmon (*Salmonidae*) and smallmouth bass (*Micropterus dolomieui*) are also targeted in many of the tailrace fisheries below the dams. Until recently, channel catfish, bigmouth buffalo (*Ictiobus cyprinellus*), smallmouth buffalo (*Ictiobus bubalus*), flathead catfish (*Phylodictis olivaris*), goldeye (*Hiodon alosoides*), and suckers (*Catostomidae*) were exploited commercially in some areas.

The native river fishes, including the catfish, sturgeon, sauger, suckers, and paddlefish, have declined as a result of migration blockage, loss of habitat, change in habitat, and competition from new species that have taken advantage of the changes. The pallid sturgeon (*Scaphirhynchus albus*) has been listed as an endangered species. Paddlefish populations have declined sharply and are being considered for threatened or endangered status. Currently, a moratorium on the commercial harvest of catfish is in effect in the Lower River. Dams, channelization, river channel degradation, farmland reclamation, and flood flow control have contributed to the loss of important fish habitat in the Missouri River. Other common species in the river include carp, river carpsucker (*Carpoides carpio*), shorthead redhorse (*Moxostoma macrolepidotum*), freshwater drum (*Aplodinotus grunniens*), and goldeye. Shortnose gar (*Lepisosteus platostomus*), gizzard shad (*Dorosoma cepedianum*), flathead chub (*Hybopsis gracilis*), blue sucker (*Cycleptus elongatus*), and several shiners are also common in some parts of the river.

Natural seasonal flow patterns to which many of the native fishes have adapted have changed. Many species have adapted to take advantage of increased backwater and overbank areas that naturally occur during high flow periods in the spring. These areas provide high quality spawning, incubation, and rearing habitat. The spring overbank flows also contribute nutrients and organic material to the river system. Spawning of several species is triggered by increasing spring flows. High spring flows have been nearly eliminated on some sections of the river and reduced on others.

Most riverine fish depend on the remaining low-velocity, shallow-water habitat at some point in their life history. Several species spawn in such habitat, and the juveniles of most species rear in low-velocity regions until they are large enough to maintain themselves and avoid predation in the higher velocity flows of the river's main channel. Many species spend their entire lifetime in the low-velocity areas of the river. Backwaters, side channels, and other low-velocity habitat are limited in the remaining river reaches.

Other factors that have affected the availability of shallow, low-velocity habitat include channelization, bed degradation, and lower sediment loads. With lower bed elevations, higher flows are required to inundate the side channels and backwaters along the river margins. Hence, many of these potential habitat areas are frequently not available. Channelization of the river through construction of dikes and revetments has also reduced the availability of backwaters and other low-velocity habitats. The reduced sediment load in the river has affected the habitats available not only through degradation of the riverbed, but also through reduction of the number of sandbars in the river channel. Deeper pools with low velocities often develop on the downstream side of sandbars; hence, a secondary effect of reduced sediment loads is the loss of deep pool habitat. The reduction in sediment loads and turbidity has also tended to favor sight feeders over those native species that are specially adapted to feeding in high turbidity waters.

Since 1992, additional aquatic habitat has been constructed on the Missouri River under Corps mitigation and environmental restoration programs, in cooperation with State and local entities. Construction to date has been in the form of "chutes" (reconnected river meanders with upstream and downstream river connections) or "backwaters" (generally water with little or no velocity, an abundance of wetland plants, and usually with one seasonally active river connection).

Chute construction includes Boyer Chute in Nebraska, which has an average depth of 5 feet and flow velocities slower than the Missouri River. This chute opened in 1993, creating about 50 acres of flowing water. Shovelnose sturgeon, channel catfish, and other native species have been captured in Boyer Chute.

New side-channel aquatic habitat was constructed at Hamburg Bend (54 acres), Overton Bottoms (35 acres), California Bend (35 acres) and Tobacco Island (64 acres). Juvenile paddlefish were documented using the Overton Bottoms chute immediately after initial construction. Construction at Winnebago Bend and Louisville Bend has preserved 487 and 71 acres, respectively, of wetlands. Deroin Bend in Missouri will add an additional 85 acres of side channel habitat when construction is completed in 2001.

Backwater construction includes Hidden Lake (built in 1996), which has an average depth between 5 and 6 feet and is approximately 25 acres in size. Fish studies at this site are in progress. Benedictine Bottoms (Kansas) was constructed in 1994 and restored 132 aquatic acres by notching adjacent river structures. Overton Bottoms and Lower Hamburg (Missouri) reattached approximately 5,000 acres of previously levee-protected floodplain to the Missouri River through abandoned and breached levees. A combination chute/backwater project at Langdon Bend created 48 aquatic acres. A combination of backwater, chute, and main channel border habitat was created at the Grand Pass Conservation Area (Missouri). Grand Pass was constructed in 1992 and restored 193 aquatic acres by notching two existing closure structures and an old side channel with 4 hard points and 10 brush piles for habitat.

Many other chute and backwater projects are under design or are being constructed. A 400-acre backwater fish nursery area is under construction at the Eagles Bluff Conservation Area (Missouri), and a 70-acre chute/backwater area and a 30-acre chute are planned for Lower Hamburg (Missouri) and Worthwine Island Conservation Area (Missouri), respectively.

In addition to constructed habitat, new aquatic habitat was created during the high flows and flood events of 1993 and 1995. One example is Lisbon Bottoms, a 2-mile chute created by these high flows within the Big Muddy Fish and Wildlife Refuge in Missouri. The first known reproduction of the pallid sturgeon in the Lower Missouri River in at least the last 50 years was documented near Lisbon Bottoms when several larval pallid sturgeon were collected during the summers of 1998 and 1999. Numerous scour lakes were also created on the Lower Missouri River during 1993 and several remain connected to the Lower River, providing habitat for fish larvae and 36 taxa of juvenile and adult small fishes (Tibbs and Galat, 1997). In addition to restoring aquatic habitat, the floods of 1993 and 1995 temporarily reconnected previously isolated wetlands, thus augmenting the value of those wetlands to include Missouri River fishery benefits. Floodplain connections of wetlands benefit fish when water temperatures are appropriate for spawning and larval development (Galat et al., 1998). It is estimated that the 1993 flood created about 1,170 acres of connected scour lakes and wetlands and 2,052 acres of unconnected scour lakes and wetlands (USFWS, 2000). The Kansas City District has created more than 2,000 dike notches (USFWS, 2000).

Tailwaters differ from the natural river habitat in temperature, turbidity, substrate, current and flow patterns, and food supply and the ensuing difference in species assemblages. Because of the low sediment load of the river below the dams, tailwaters frequently exhibit bed degradation, deep pools, coarse bed materials, and high biotic diversity. The cool or coldwater releases from the dams support coolwater and coldwater fish assemblages. Trout, salmon, walleye, sauger, northern pike, smallmouth bass, and many other species use the cooler waters below the dams. Most of these populations are self-sustaining, although some, especially trout and salmon, are supported or enhanced by stocking.

The quantity of coldwater habitat available downstream of the dams is a function of the quantity of water released from the dams during the summer months and the temperature of that water. When mainstem lake levels are low, water releases from the dams may be warmer and provide less coldwater habitat downstream.

A native fish of primary concern is the endangered pallid sturgeon. The historic range of pallid sturgeon, as described by Bailey and Cross (1954), encompassed the middle and Lower Mississippi River, the Missouri River, and the lower reaches of the Platte, Kansas, and Yellowstone Rivers. Because the pallid was not recognized as a distinct species until 1905, little is known about its abundance and distribution prior to this date. Forbes and Richardson (1905) and Bailey and Cross (1954) indicated that the species was always uncommon. At the time of their original descriptions, pallid sturgeon were reported to comprise 1 in 500 river sturgeon captured by commercial fishermen in the Mississippi River at Grafton, Illinois. It was also reported that pallids were more abundant in the Lower River near West Alton, Missouri, where they constituted one-fifth of the river sturgeon captured (Forbes and Richardson, 1905). Hybrids of the shovelnose and pallid sturgeon have been collected and may be common in the Lower River.

Surveys suggest a probable decline in the abundance of pallid sturgeon from former levels. According to the Pallid Sturgeon Recovery Plan, modification of the natural hydrograph, habitat loss, migration blockage, pollution, hybridization, and overharvesting are probably all responsible for this decline (USFWS, 1993).

According to the November 2000 Missouri River Biological Opinion (BiOp), the USFWS recommends flow modifications by 2003 for at least one third of the years below Fort Peck Dam. This will provide higher spring flows and warmer water temperatures during the open water period to improve conditions for the endangered and threatened species. The higher and warmer flows, to be run over the Fort Peck Dam spillway at up to 19 kcfs for 3 days, and the warm water for at least 30 days, will provide the hydrologic cue for pallid sturgeon and other native fish to spawn. This warm water will be run after the forage fish spawn period (mid-April to mid-May).

The present distribution and abundance of pallid sturgeon are difficult to quantify because of different levels of sampling effort throughout its range. Carlson and Pflieger (1981) state that the pallid sturgeon is rare, but widely distributed, in the Missouri River and the Mississippi River downstream from the mouth of the Missouri River. Since 1980, most frequent sitings occur on the Missouri River between the Marias River and Fort Peck Lake, between Fort Peck Dam and Lake Sakakawea, within the lower 70 miles of the Yellowstone River, in the headwaters of Lake Sharpe, and in the Missouri River near the Platte River mouth. Areas of most recent and frequent occurrence on the Mississippi River are near Chester, Illinois, and Caruthersville, Missouri, and at the confluence of the Mississippi River and Atchafalaya River near the old river control structure (USFWS, 1993).

Forbes and Richardson (1905), Schmulbach et al. (1975), Kallemeyn (1983), and Gilbraith et al. (1988) describe pallid sturgeon as being well adapted to life on the bottom of swift, large, turbid, free-flowing rivers. Pallid sturgeon are adapted to the diverse, sometimes harsh ecosystem of the pre-regulated Missouri and Mississippi Rivers. Characteristics of this ecosystem, consisting of seasonal flooding and high flows of warm muddy water, represent conditions necessary for the continued health of native fish populations, including the pallid sturgeon.

Studies of pallid sturgeon from the Missouri River above Lake Sakakawea found pallid sturgeon in deep pools at the downstream ends of chutes and sandbars and in slower currents of near-shore areas (USFWS, 1993). Ultrasonic transmitter studies in the Missouri River in the State of Missouri indicate that pallid sturgeon are found in high-velocity water (0.5 to 1.5 meters per second) at the main channel border macrohabitat of the river, near sand islands, and off the ends of wing deflector structures, usually over a sand substrate. Depths at these locations measured from less than 1 meter to 9 meters (Dryer, 1997). Habitat use in the middle Mississippi River is similar, but more pallid sturgeon use the main channel in the Mississippi (46 to 67 percent of the time), followed by main channel border areas (Hurley et al., 1997).

Reproductive biology of pallid sturgeon has not been extensively studied due to their rarity; however, inferences can be made from studies completed on the closely related shovelnose sturgeon. Shovelnose spawn over substrates of rock, rubble, or gravel in the main channel and major tributaries or on wing dams in larger rivers (Christiansen, 1975; Elser et al., 1977; Moos, 1978; Helms, 1974). In the unchannelized Missouri River near Vermillion, South Dakota, shovelnose sturgeon spawn in late May through June with water temperatures near 18.5°C to 19.5°C (Moos, 1978). Shovelnose spawning also has been documented in the lower Tongue River near Miles City, Montana, from early June until mid-July at temperatures of 17.0°C to 21.6°C (Elser et al., 1977). Initiation of sturgeon spawning migrations has been associated with seasonal flow differences (Peterman, 1977; Zakharyan, 1972).

The Blind Pony State Fish Hatchery (Missouri Department of Conservation) was the first hatchery to successfully spawn, rear, and stock pallid sturgeon. About 8,000 young pallids have been stocked so far in the Lower Missouri River, the Mississippi River, and the lower Platte River near Louisville, Nebraska (Omaha World Herald, 1998). In 2001, the facility has successfully spawned two female pallid sturgeon. Stocking plans are currently being revised to allow for increased stocking numbers (up to 10,000 progeny). All stocked fish will be identified by a Passive Integrated Transponder-type tag.

In 1997, successful spawning of pallid sturgeon at the Gavins Point National Fish Hatchery (NFH) was achieved. In 1998, pallid sturgeon were spawned successfully at both the Garrison Dam and Gavins Point NFHs. Successful spawning activities have continued in each successive year through 2001 at one or more of the primary facilities involved in producing pallid sturgeon (Gavins Point NFH, Garrison Dam NFH, Nachtitoches NFH, and Blind Pony State Fish Hatchery). Hatchery-propagated captive broodstocks are being held at the Gavins Point NFH and represent all genetic crosses of the "wild" fish spawned at the facility. These captive broodstock help to ensure the preservation of the genetic material of the species while habitat improvement plans are being implemented on the Missouri River and significant tributaries. The first hatchery-produced fish were reintroduced into the upper Missouri River in Recovery Priority Management Areas 1 and 2 in August 1998. Additional fish have been stocked in Recovery Priority Management Areas 2 and 3 in 2000.

Consistent stocking schedules and efforts have been hampered by what is now referred to as the "Missouri River Iridovirus." Stringent fish health sampling efforts of hatchery-produced and wild pallid and shovelnose sturgeon have been established to learn more about this virus. Future stocking of pallid sturgeon hinges on identifying whether the virus is endemic to the Missouri River system. In 1993, an Upper Basin Pallid Sturgeon Workgroup was established to determine and implement priorities for management and stocking in the upper Missouri River. In 2001, additional workgroups were established to represent the middle and lower basins to better allow the partnering agencies to determine and implement priorities for these reaches and unify recovery efforts.

The Pallid Sturgeon Recovery Plan also identifies some management goals toward recovery of the pallid sturgeon. Goals that pertain to the CWCP follow:

1. Restore habitats and functions of the Missouri and Mississippi River ecosystem, while minimizing impacts on other uses of the rivers. Restoration of the natural habitat involves restoring (1) the natural hydrograph (e.g., high spring and low late summer and fall flows); (2) the natural temperature regime; (3) large woody debris; (4) the dynamic equilibrium of sediment transport; and (5) free movement of pallid sturgeon.

2. Protect pallid sturgeon and their habitat and minimize threats from existing and proposed man-caused activities. Protection objectives include remediating sources of environmental contaminants, protecting important habitat areas, and maintaining the needs of the pallid sturgeon.

Aquatic invertebrates (principally the immature stages of insects) comprise most of the diet of adult shovelnose, while adult pallid sturgeons and hybrids consume a greater proportion of fish (mostly minnows) (Carlson et al., 1985; Cross, 1967; Held, 1969). Although pallids consume larger numbers of fish than shovelnose, most fish-eating Missouri River species eat large quantities of aquatic insect larvae in early life and even as adults. Modde and Schmulbach (1973) observed that factors affecting shovelnose prey (insect larvae) availability within the unchannelized Missouri River include temperature, seasonal prey recruitment, and changes in prey density, which have been influenced by the timing and discharge rates from Gavins Point Dam. They hypothesized that reduced rations in shovelnose may be due to reduced vulnerability of prey species caused by high discharges from Gavins Point Dam. In order to determine if there was a relationship between discharges and food availability, sturgeon diet weight and the weight of benthic and drifting invertebrates was compared between years and among discharges below Gavins Point Dam during 1993 and 1994. The study concluded that there was no difference in diet weight of shovelnose sturgeon among years of low, medium, and high flow; however, existing data support the hypothesis that lower flows allowed the benthic biomass to increase (Berry, 1996). Results comparing drifting invertebrates and flow showed a weak negative relationship between discharge and drift biomass in 1993 but not in 1994 (Berry, 1996).

Shovelnose sturgeon in the channelized Missouri River near Omaha were found to be restricted to tributary mouth habitat during the navigation season and widely distributed in all river habitats during the nonnavigation season. The habitat use pattern was thought to be related to the availability of sandbar and pool habitat (Latka, 1994). The majority of shovelnose sturgeon captured during the 1996 and 1997 field seasons of the benthic fish study (Missouri River from Montana to St. Louis) were from inside bends, connected side channels, and channel crossovers (Dieterman et al., 1996; Young et al., 1998).

The Pallid Sturgeon Recovery Plan (USFWS, 1993) identified six recovery-priority management areas that will receive priority for implementation of appropriate recovery tasks: (1) the Missouri River from the mouth of the Marias River downstream to the headwaters of Fort Peck Lake; (2) the Missouri River from Fort Peck Dam downstream to the headwaters of Lake Sakakawea, including the entire southern Fort Peck Reservation banks and the Yellowstone River upstream to the mouth of the Tongue River; (3) the Missouri River from Fort Randall Dam down to the mouth of the Niobrara River, which includes the Yankton Reservation banks; (4) the Missouri River below Gavins Point Dam to its confluence with the Mississippi River, most importantly within 20 miles upstream and downstream of major tributary mouths including the Platte, Kansas, and Osage Rivers; (5) the Mississippi River from its confluence with the Missouri River to the Gulf of Mexico, most importantly within 20 miles upstream and downstream of major tributary mouths, including the St. Francis, Arkansas, and Yazoo Rivers; and (6) the Atchafalaya River distributary system to the Gulf of Mexico.

The paddlefish, another large native species, is a candidate species for threatened or endangered status under the ESA. Blockage of migrations, overharvest, and loss of deep pool habitat are among the key factors affecting their populations. Recent studies indicate a positive relationship between larval paddlefish abundance below Fort Randall Dam and the volume of discharge from Fort Randall Dam (USFWS, 1993).

Other native fish species are also declining. The sturgeon chub (*Macrhybopsis gelida*) and sicklefin chub (*Macrhybopsis meeki*) are candidate species for listing under the ESA. Several other species have been classified as species of special concern by the various States along the river (Corps, 1994f). Little is known about the biology or specific habitat requirements of many of these species, although several recent studies are shedding some light on habitat use.

Thirteen historic Missouri River collection sites between the Iowa-Missouri border and St. Louis were sampled during 1994. Sicklefin chubs (163 total) were found at all collection sites, and sturgeon chubs (112 total) were found at 11 of the 13 sites. These numbers suggest that these species have not declined in distribution or abundance in this part of the Missouri River when compared with earlier studies (Gelwicks et al., 1996). Collection sites were around channel sandbars and connected sandbars. Sicklefin chubs were collected most frequently (72 percent) on the channel side of these sandbars, while sturgeon chub were collected most frequently (60 percent) on the chute side of sandbars (Gelwick et al., 1996). Both were collected most frequently over sand or gravel substrates, with silt and flooded vegetation as lesser habitat. Sampling sites with velocities between 0.30 to 0.35 meters per second (m/s) produced sicklefin chubs and sturgeon chubs 100 percent of the time in this study while other flows produced the chubs at lesser frequencies (Gelwick et al., 1996). The 1996 and 1997 field data from the benthic fish study (Missouri River from Montana to St. Louis) indicated that sturgeon chub were distributed fairly evenly among channel crossovers, outside bends, inside bends, and connected secondary channels (Dieterman et al., 1996; Young et al., 1997). Sicklefin chub data indicate that few were found in inter-reservoir areas or in macrohabitats that generally contain stationary water, such as backwaters (Dieterman et al., 1996; Young et al., 1997).

Factors that might affect the continued existence of the sturgeon chub and sicklefin chub within their normal range include the availability of high spring flows to trigger spawning, availability of low-velocity shallow-water habitat, food availability, hindrances to migrations, changes in turbidity and siltation patterns, and access to tributary spawning habitats. Each of these factors except migration blockage can be related directly to flows in the river.

Mainstem Lake Fisheries

The six mainstem lakes of the Missouri River contain a diverse community of coldwater, coolwater, and warmwater fishes. The upper three lakes have been stocked with coldwater game and forage fish species to take advantage of the coldwater habitat that is retained through the summer and fall in the lower depths of the lakes. These species include chinook salmon (*Oncorhynchus tshawytscha*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), lake trout (*Coregonus artedi*) (Fort Peck Lake only), cisco (forage in Fort Peck Lake), and rainbow smelt (*Osmerus mordax*) (Corps, 1994h). Species in the lower three lakes and in the warmer waters of the upper three lakes include native and non-native species that have adapted to lacustrine conditions. Some of the most common of these species are walleye, sauger, goldeye, carp, channel catfish, river carpsucker, crappie (*Pomoxis* sp.), gizzard shad (*Dorosoma cepedianum*), and emerald shiner (*Notropis atherinoides*). Smallmouth bass have also been stocked in several of the lakes. White bass and northern pike are common in several lakes. Many of the species present in the lakes support sports fisheries.

Natural reproduction of the fish populations of the six mainstem lakes is limited by the availability of spawning and young-of-year rearing habitat. The coldwater species generally lack spawning habitat and, thus, are primarily supported by hatcheries. An exception is the lake trout of Fort Peck Lake, which spawn naturally in the rock riprap along the dam face. Most of the warmwater and coolwater species spawn in shallow habitat of the lake margins, in the river above the lakes, or in tributary streams. Walleye, and to a lesser degree, sauger, require clean rock in moderately shallow water. Northern pike and several other warmwater species spawn in submerged vegetation.

The effect that the availability of spawning habitat has on the production of fish was evident when the lakes were first filled. Rising waters inundated vast areas of terrestrial vegetation. The populations of northern pike and other species requiring vegetated spawning and rearing habitat increased dramatically. These species also prospered from an abundance of small forage fish. Upon the eventual decay of submerged vegetation, the lakes declined in productivity and many species began to decline. Other factors that affected the production of fish include the gradual decline of shallow-water habitat as embayments fill with sediment and shorelines are smoothed.

Coincident with the decline in these populations, walleye abundance increased as a result of stocking and improved spawning habitat. In some of the lakes, the increase in walleye populations was related to an increasing abundance of wave-washed rocks along the shores of the reservoirs, which provided spawning habitat.

During the 1987 to 1993 drought, the upper three lakes were drawn down about 20 to 25 feet below the base of the annual flood control level, draining much of the shallow habitat normally found in embayments, exposing available clean rock, and limiting the availability of submerged vegetation to support spawning and rearing. Concern arose regarding the Mainstem Reservoir System's ability to maintain the productivity of the important game and forage fishes. Stocking was increased to maintain populations of game fish.

High productivity in the upper lakes was a result of the filling of reservoirs following the drought. During the extended drawdown period, vegetation developed along the normally inundated shorelines, which now provides new spawning and rearing habitat.

Coldwater habitat available to support the popular trout and salmon fisheries is decreased during periods of drought. The amount of well-oxygenated coldwater retained through the summer and fall is directly related to the water level in the upper three lakes (Corps, 1994g).

Habitat in the lower three mainstem lakes has been affected very little by drought because operations are largely unchanged by drought conditions. Little coldwater habitat is retained through the summer and fall in these lakes due to their smaller size and the high level of warmwater flowing through the lakes.

Flow through the lower three lakes varies considerably from year to year, with higher flow-through rates generally detrimental to fish production (Corps, 1994f). High flows may reduce primary and secondary productivity, reduce spawning success, and flush fish from the lakes. High flows are caused by evacuation of storage for flood control. Low flows occur in Lower River floods (e.g., 1993) and during droughts when navigation service is reduced to conserve storage water.

In addition to mandating the release of warmwater over the Fort Peck Dam spillway and the Gavins Point Dam spring rise and summer low flow, the USFWS mandated other requirements. In its November 2000 Missouri River BiOp, the USFWS mandated unbalancing the three upper lakes beginning this year on a three-year cycle by lowering one of the lakes by three feet, holding the second lake constant, and raising the third lake by three feet. This unbalancing would increase the growth of habitat around the perimeter of the lakes. Secondly, a plan is under development this year to provide additional habitat. The habitat mandated is 19,565 acres by 2020 of submerged shallow water habitat (less than five feet deep) in August; minimum emergent interchannel sandbar habitat (60% dry sand and 20-80 acres per mile) downstream of Garrison Dam, Fort Randall Dam, Lewis and Clark Lake, and Gavins Point Dam; and all potential reservoir beach and island habitat for the upper three lakes by 2020. If the habitat goals are not met, supplemental sandbar habitat will be artificially or mechanically created downstream of Fort Peck Dam, Garrison Dam, Fort Randall Dam, Gavins Point Dam, and Lewis and Clark Lake. Studies will be made starting in 2003 on the lack of sediment transport and impacts on habitat regeneration and turbidity. Tern and plover nesting habitat will be checked once every three years.

3.8.2 Fort Peck Lake

Fort Peck Lake is particularly noted for its walleye fishery. Spawning habitat for walleye is generally very sparse because of the nature of the shoreline and the general lack of rocky substrates. Because the spawning habitat is not adequate, supplemental stocking is necessary to support the fishery. Low water levels during the 1987 to 1993 drought reduced walleye access to many traditional spawning areas, including shallow embayments normally used for spawning and rearing. Refilling of these areas during the high flows of the early 1990s resulted in good spawning habitat and habitat for young-of-year fish.

The lake also has a significant coldwater fishery for lake trout and chinook salmon. Chinook salmon do not reproduce naturally and are stocked annually. The coldwater habitat used by chinook salmon is normally found in the downstream two-thirds of the lake. Lake trout also have been introduced; however, they now spawn naturally on riprap on the face of the dam and stocking is not normally necessary to maintain population levels. Both salmon and lake trout populations appear to benefit from higher lake levels and do poorly at low lake levels such as occurred during the drought. The reductions in water surface elevation have also reduced the upstream extent of coldwater habitat and the availability of spawning area for lake trout on the face of the dam.

Other important game species in Fort Peck Lake include smallmouth bass, northern pike, crappie, and yellow perch. The lack of vegetation around the reservoir, caused by erosion associated with wave action and water level fluctuations, severely limits spawning and rearing habitat for many of these species.

Pallid sturgeon and paddlefish have also been found in the lake. They migrate seasonally upstream into the Missouri River above the lake. Little is known of their habitat requirements in the Lake.

3.8.3 Missouri River from Fort Peck Dam to Lake Sakakawea

Although river flows are regulated in the 204-mile-long river reach from Fort Peck Dam along the Fort Peck Reservation banks to the headwaters of Lake Sakakawea, the reach remains in a seminatural state, partly because of the influence of unregulated tributaries. Backwaters, oxbows, and side channels are abundant, except in the 10-mile section below Fort Peck Dam, where the banks are excessively eroded and the streambed is degraded.

The river immediately below Fort Peck Dam is cold and clear and has little cover. The low sediment load in this section contributes to the presence of the gravel substrate throughout the area. The tailrace area supports a large population of shovelnose sturgeon in the winter. Pallid sturgeon have also been documented in the tailrace in the winter. In the tailrace area, a 2-mile-long side channel developed during dam construction provides good spawning and rearing habitat for rainbow trout. The quality of the spawning habitat has been enhanced by the placement of gravel in this side channel. Two dredge cuts in the same area provide 860 acres of lake-like habitat that is used by paddlefish and numerous other species as refuge from the main currents of the river.

Downstream of the tailrace area, the river becomes gradually warmer and more turbid and the characteristics of the river approach more natural conditions. The inflow of the Milk and Yellowstone Rivers and other large tributary streams contributes to these changes. Pallid sturgeon are present but rare in this stretch of the river, and blue suckers are relatively common. Some of the largest paddlefish and sauger populations left in the Missouri River are also present in this reach. Paddlefish migrate out of Lake Sakakawea in spring to spawn in the Milk and Yellowstone Rivers. Pallid sturgeon also migrate from Lake Sakakawea to spawn in the Yellowstone River.

3.8.4 Lake Sakakawea

Lake Sakakawea is managed primarily for walleye, sauger, and chinook salmon and, to a lesser extent, northern pike, trout, and smallmouth bass. The walleye fishery relies heavily upon stocking programs to maintain the population at desired levels during drought, and the chinook salmon population is entirely dependent upon the stocking program. Trout, northern pike, and paddlefish populations are also enhanced on a limited basis through stocking.

The walleye fishery is renowned as one of the foremost trophy-sized walleye fisheries in North America. Most of the natural reproduction of the species occurs in the upstream portions of the lake, north of Fort Berthold Reservation, and, to some extent, in the riverine sections above the lake.

During the 1987 to 1993 drought, low water levels were detrimental to fish habitat. Much of the rocky habitat normally used by walleye for spawning was exposed. The drawdown also substantially reduced the volume of coldwater habitat, potentially reducing the survival and production of coldwater forage and game fish. The numerous embayments that normally provide shallow-water habitat and most of the vegetated habitat in the reservoir were largely drained, eliminating spawning habitat for vegetation-dependent species and rearing and feeding habitat for many coolwater and warmwater fish.

The return of high water in the 1990s flooded vegetation that became established during the 1987 to 1993 drought. The submerged vegetation provided improved spawning substrate for northern pike, white crappie (*Pomoxis annularis*), yellow perch, and forage fishes.

The delta area in the upper portion of the reservoir also serves as a nursery area for paddlefish, pallid sturgeon, and other river species. Little is known about the specific habitat requirements of these fish or the effects of lake-level changes on their populations.

3.8.5 Missouri River from Garrison Dam to Lake Oahe

The Missouri River channel downstream of Garrison Dam has remained in a near-natural state, except for some bank stabilization. Backwater and side channel habitat is common, and numerous sand bars and deep pools are present.

The reach is dominated by releases of cold, clearwater releases from Garrison Dam. In the tailwaters, water temperatures are cold enough to support populations of trout and salmon. Walleye, sauger, white bass, and channel catfish are also common in the tailrace. Temperature and turbidity increase downstream as a result of local runoff and bank erosion. In the downstream sections of the reach, carp, white bass, yellow perch, and river carpsucker dominate the species composition. The lower portion of the reach also supports substantial populations of shovelnose sturgeon, blue sucker, sauger, walleye, shorthead redhorse, and channel catfish. Pallid sturgeon may occur in this reach.

3.8.6 Lake Oahe

Walleye, northern pike, and, to a lesser degree, salmon represent the primary target species of sport fishermen in Lake Oahe. Walleye are by far the most popular of these species. Walleye spawning habitat is generally abundant throughout the lake at normal water levels. Natural reproduction of walleye was limited during the 1987 to 1993 drought because of low water levels, resulting in walleye being stocked to supplement natural production.

As in most of the mainstem lakes, flooded vegetation became scarce after the lake was first filled. This loss of cover vegetation, combined with the gradual filling of embayments, has reduced the spawning and rearing habitat of the numerous warmwater species common in the lake. Since the lake was filled, spawning and rearing habitat for carp, northern pike, and other shallow-water spawning species has largely been limited to that which develops during the annual drawdown. During the drought years, little or no inundation of annual vegetation occurred. The return of high water in the 1990s allowed vegetation established during the drought to become flooded, recreating spawning and young-of-year habitat. Approximately half of the vegetated shoreline affected by high water is along the Standing Rock and Cheyenne River Reservations.

3.8.7 Missouri River from Oahe Dam to Lake Sharpe

The 5-mile-long reach between Oahe Dam and Lake Sharpe is dominated by coldwater releases from the dam. These releases vary hourly and cause wide fluctuations in water surface elevations. The reach supports a strong and very popular sport fishery. Rainbow trout have been stocked annually in the Oahe Dam tailwaters since 1981, providing a popular fishery (Johnson et al., 1998). Primary species include sauger, walleye, white bass, and channel catfish. Paddlefish were once a popular target species; however, that fishery has been closed to protect the remnant population. Management objectives are largely oriented toward enhancing the coolwater sport fisheries and protecting endangered species. A population of pallid sturgeon also exists in this reach. They are in poor condition, and the potential for reproduction appears limited.

3.8.8 Lake Sharpe

Lake Sharpe, which includes the Lower Brule and Crow Creek Reservation shorelines, retains very little coldwater habitat through the summer and fall and thus supports primarily coolwater and warmwater fish. Walleye, white bass, largemouth bass (*Micropterus salmoides*), and smallmouth bass are commonly caught in the upper reaches of the lake. In the middle and lower portions of the lake, the dominant game species include walleye, smallmouth bass, northern pike, sauger, and yellow perch. Reproduction in Lake Sharpe is generally good because the lake level is steady. Wind-wave action along shallow mudflats limit the establishment of vegetation in the shallows. Fish production appears to be negatively related to the rate of summer water flow through the lake. Pallid sturgeon have been captured throughout Lake Sharpe, especially in proximity to tributary creeks (USFWS, 1998).

3.8.9 Lake Francis Case

Walleye dominate the sportfishery in Lake Francis Case; however, smallmouth bass, northern pike, white bass, and channel catfish also are harvested. Walleye, goldeye, and channel catfish constitute almost 80 percent of the total biomass of non-forage species in the lake. Game fish production appears to be positively related to spring inflow to the lake.

Paddlefish collected in the White River, a tributary to the lake, are used to provide brood stock for hatchery programs. Young paddlefish are restocked regularly into the lake to enhance populations and maintain the brood stock population.

Lake Francis Case is normally drawn down 17 feet in the fall, affecting some of the shoreline along the Lower Brule, Crow Creek, and Yankton Reservations. The upper part of the lake behind the White River delta draws down only about 7 feet through the winter. This drawdown exposes aquatic plants and benthos, but occurs too late in the season to allow the establishment of terrestrial vegetation; therefore, vegetated habitat of either terrestrial or aquatic source is normally scarce. A drop in water surface elevation and its negative affect on reproduction has been identified as the major factor limiting fish production in the lake.

Another factor affecting the lake is continued siltation, which is rapidly changing the habitat classes available. As embayments and the lake fill with sediment, rocks are buried and solid substrate is reduced. Over time, species that do not rely on rocks or firm substrates would be favored over those that require such habitat.

3.8.10 Missouri River from Fort Randall Dam to Lewis and Clark Lake

Fish habitat in the 39-mile-long reach between Fort Randall Dam and Lewis and Clark Lake is more similar to natural river conditions than reaches downstream. This reach is designated as a Recreational River under the Wild and Scenic Rivers System (WSRS). The channel, including banks of the Yankton Reservation, is wide and meandering and contains numerous shifting sandbars and side channels. Because neither Lake Sharpe nor Lake Francis Case stratify strongly, release water temperatures do not support coldwater species and the reach is dominated by coolwater and warmwater species. The reach is subject to considerable bank erosion because of variable flows released from the dams and the natural meandering of the river. Native fish populations in the area are relatively productive. A naturally reproducing population of paddlefish occurs in the reach. This reach is one of the recovery-priority areas for the pallid sturgeon. Little is known about the specific habitat requirements of fish in the reach or how their populations respond to changes in the flow regime of the river. The principal tributary in this river reach is the Niobrara River.

3.8.11 Lewis and Clark Lake

Sauger are the most sought after sport species in Lewis and Clark Lake. Walleye, freshwater drum, and channel catfish are also common in catches, and smallmouth bass are becoming more common. Smallmouth bass were stocked below Fort Randall Dam and have since become established in Lewis and Clark Lake. A small population of adult paddlefish is also present in the lake and is believed to be spawning naturally upstream of the lake near the Santee Reservation banks. High water levels during the spring spawning period increase the reproductive potential of most fish species in the lake. As in Lake Sharpe, fish production appears negatively related to the rate of water flow through the lake.

3.8.12 Missouri River from Gavins Point Dam to St. Louis

Downstream of Gavins Point Dam, the Missouri River flows unimpounded to its mouth. The character of the river, however, changes dramatically about 20 miles upstream from Sioux City. The 57- to 59-mile section of the unchannelized river downstream of Gavins Point Dam is designated as a Recreational River under the WSRS. This portion of the river is a meandering channel with many chutes, backwater marshes, sandbars, islands, and variable current velocities. Snags and deep pools are also common. Although this portion of the river includes bank stabilization structures, the river remains fairly wide.

Because river sediment is captured above Gavins Point Dam, extensive bed degradation has occurred in the river below the dam. Gradual armoring of the riverbed has reduced the rate of channel degradation. Approximately 27 percent of the banks have been stabilized to curtail erosion. Channel degradation and siltation of shallow areas have contributed to the loss of marshes, backwaters, and chute habitats.

Downstream of Sioux City, the river has been extensively modified by the construction of dikes and revetments and is channelized. The lowest velocities are found in eddies that form behind dikes, occasionally in front of the next downstream dike, and along channel margins, particularly on the inside of bends in the river.

Principal fish species are similar in the unchannelized and channelized portions of the river and include emerald shiner, river carpsucker, channel catfish, gizzard shad, red shiner (*Notropis lutrensis*), shorthead redhorse, carp, and goldeye. Pallid and shovelnose sturgeon and paddlefish are also found in the Lower River and its major tributaries. Studies of the benthic fishes within the Missouri River were conducted between 1995 and 1999. Results from the 1996 and 1997 field seasons indicate that the overall diversity of species in the unchannelized reaches is increasing, which reflects the greater number of microhabitats and available niches. The largest number of species (40) was collected in the segment downstream from Gavins Point Dam and the smallest number (16) in the segment downstream from Fort Peck Dam (Dieterman et al., 1996). In general, depth and velocity parameters for most taxa were generally skewed to shallow depths (<2 m) and slower velocities (<0.6 m/s). Species requiring deeper water (2 to 6 m) and faster velocity (0.6 to 1.2 m/s) included shovelnose sturgeon, sturgeon chub, sicklefin chub, blue sucker, blue catfish, and stonecat (Dieterman et al., 1996). Fish use all habitats in the unchannelized river, but are most abundant in connected backwater areas. In the channelized reaches downstream of Sioux City, fish are associated with revetments and dikes. Side channels yield the greatest species richness and greatest numbers of fish; however, very few side channels remain. Little is known about what controls fish production under current conditions in this reach of the river. It also should be noted that more natural flows occur in this stretch of the river as one moves toward the mouth because the river has more unregulated tributary inflow.

3.8.13 Mississippi River from St. Louis to Mouth

The aquatic habitats of the Mississippi River consist of the main channel, secondary channels, sandbars, and natural steep banks. Each of these habitats may be modified by the presence of large stone dikes constructed to achieve a self-maintaining, properly aligned navigation channel. Much of the natural bank habitat has been stabilized with articulated concrete mattress revetment to protect levees and maintain the desired channel alignment. At a bank-full river stage, there is about 480,000 acres of aquatic habitat between the top banks of the river channel in the Lower Mississippi River. The most frequent aquatic habitats in the middle Mississippi River (from about 100 miles upriver of the Missouri River confluence to the confluence of the Ohio) consist of approximately 40,000 acres of main channel, 21,000 acres of main channel sandbar habitat, 28,000 acres of wooded sandbars, 5,500 acres of diked main channel, 14,000 acres of diked main channel sandbars, 6,900 acres of diked temporary secondary channel sandbars, 6,300 acres of floodplain lands, and smaller acreages of other habitat classes (personal communication, Steve Cobb, Lower Mississippi Valley Division, Corps, 1998).

The surface area of aquatic habitat in the lower Mississippi River varies directly with river stage and discharge. The surface area of total aquatic habitat in the channel environment increases linearly as river stages rise above the top of the banks. Aquatic habitats in the channel also undergo pronounced changes in water depth, volume, and hydrodynamics during the year as a result of river stage fluctuations. For instance, in diked secondary channels, lentic pools are typically created at low discharges, while rigorous lotic conditions prevail at high discharge. During periods of overflow discharge, expansive areas of floodplain forests, swamps, and farmlands are inundated, providing ecologically important aquatic habitat.

The Mississippi River below St. Louis provides important and diverse habitats for a large number of riverine fish species including the Federally listed endangered specie Pallid Sturgeon.

The Lower Mississippi River aquatic ecosystem may support as many as 91 species of freshwater species that are potentially maintaining reproducing populations in the river (Baker et al., 1991).

Larval and juvenile pallid sturgeons have recently been collected from the Mississippi River (Hrabik 2001, personal communication). In 1989, the Missouri Department of Conservation (MDOC) collected a young-of-the-year pallid sturgeon at approximate river mile 49.5(L) south of Cape Girardeau in the Middle Mississippi River. In 2000, three pallid sturgeons, four probably pallid sturgeons, and seventeen specimens believed to be pallid x shovelnose sturgeon hybrids were collected between May 31 and June 8 by the MDOC. Larval pallid sturgeon and hybrids were captured from three general locations: the Grand Tower/Cottonwood Island complex near Grand Tower, Illinois, and the Greenfield Bend near Cairo, Illinois, in the Middle Mississippi River, and the Wolf Island complex near Columbus, Kentucky, in the Lower Mississippi River.

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3.9 FLOOD CONTROL

3.9.1 General

The Missouri River basin contains approximately 100 multipurpose reservoirs and over 1,200 single-purpose reservoirs, either completed or under construction. In the aggregate, these reservoirs provide over 106 MAF of multipurpose storage capacity. The six mainstem reservoirs contain 73.4 MAF of multipurpose storage capacity. Purposes served by individual multipurpose reservoirs may include any combination of the following: flood control, municipal and industrial water supply, water quality control, irrigation, navigation, hydropower, fish and wildlife habitat, and recreation. In no way do these purposes attempt to define, regulate, or quantify any treaty water rights to which any sovereign Tribe within the Missouri River basin is entitled. Exercising treaty water rights is an individual decision of each individual Tribal Government. In contrast, the function of most single-purpose reservoirs is either flood control or water supply. The Corps is responsible for flood control regulation of all Federally financed reservoirs with allocated flood control space.

The objective of Mainstem Reservoir System flood control is to regulate the mainstem lakes to prevent Missouri River flows from contributing to flood damage in the reaches downstream from dams. Regulation of individual lakes is coordinated to prevent damaging releases from a particular lake.

The usual lake operation is to store flood inflows, which generally extend from March through July, and to release them during the remainder of the year. Most of these releases are made before December. Winter releases are restricted due to the formation of ice bridges and the associated higher river stages. The objective is to have lake levels lowered to the bottom of the annual flood control and multiple use zone by March 1 of each year. Operations during the winter require special consideration because ice bridges restrict channel capacity. Upstream from Gavins Point, releases from Fort Peck, Garrison, Oahe, and Fort Randall Dams are reduced during periods of ice formation until an ice cover is formed, after which releases can be gradually increased. No ice problems exist directly downstream from Big Bend Dam due to its proximity to Lake Francis Case.

Operation of the mainstem lakes for flood control must take into account highly variable flows from numerous tributaries. During any flood season, the existence of upstream tributary storage reduces mainstem flood volumes to some extent. Normally, the natural crest flows on the mainstem reservoirs will also be reduced by the existence of tributary reservoir storage, provided significant runoff contributing to the crest flows originates above the tributary projects.

In addition to lake storage and release, flood control on the Missouri River also includes an extensive levee system. Federal agricultural levee construction in accordance with the 1941 and 1944 Flood Control Acts began in 1947. These levees are designed to function together with mainstem lakes and tributary reservoirs. Neither the mainstem lakes nor the levees alone provide the desired degree of protection; together they protect against most floods. Most existing Federal levees are in the reach located between Omaha and Kansas City. These Federal levees are designed to hold discharges in the range of 250 kcfs at Omaha, 295 kcfs at Nebraska City, 325 kcfs at St. Joseph, and 425 kcfs at Kansas City, and up to 620 kcfs at Hermann, Missouri, near the mouth of the Missouri River.

Levee projects for the protection of large urban areas along the Missouri River have been constructed at Omaha, Council Bluffs, and Kansas City. These projects are designed to operate in conjunction with the mainstem lakes and tributary reservoirs to prevent flooding of these localities during the most severe flood events of record. Between Sioux City and the mouth of the Missouri River, local interests have built many miles of levees, consisting of about 500 non-Federal levee units through this reach of the river. Most of these levees are inadequate to withstand major floods, but generally protect against floods smaller than a 20-year magnitude.

The three primary resources directly affected by the Mainstem Reservoir System's ability to control floods are agricultural resources, nonagricultural resources, and navigation.

Approximately 1.4 million acres of agricultural land is subject to flooding along the Mainstem Reservoir System. Ninety percent of these acres are located downstream of Gavins Point. Corn is the primary crop cultivated, followed by soybeans and wheat. The acres and crop distribution for agricultural resources potentially affected by flood control measures are presented in Table 3.9-1. This table includes agricultural resources of the Tribes adjacent to these reaches. Table 3.9-2 presents these resources by Tribe. In total, approximately 42,800 acres of Tribal lands are subject to flooding. Most of the acres are on the Fort Peck Reservation. Grassland is not included in the acreage figures.

Nonagricultural resources include residential and nonresidential structures located in areas along the Mainstem Reservoir System that are subject to flooding. There are 30,395 residential buildings worth approximately $1.9 billion located within identified flood hazard areas (Corps, 1998e). There are 5,345 nonresidential buildings subject to flooding, with a total value of approximately $15.7 billion. Residential development is characterized according to 10 general classes of residential buildings. Farmsteads are included in the residential building category. For nonresidential structures, over 100 building categories were used for the initial classification. The value of each structure is based upon the size, condition, and construction type and includes the value of the building's contents. Data regarding the number and value of structures subject to flooding are presented in Table 3.9-3. The table includes development on Tribal lands adjacent to the Missouri River. Table 3.9-4 reflects the nonagricultural resources of the Tribes. About 475 buildings worth an estimated $62 million are located in the floodplain. Approximately 96 percent of this estimated value is located on Fort Peck Reservation.

Flood flows greater than a 25-year flood event have the potential to adversely affect navigation on the Missouri River. Navigation losses result from interrupted service. The duration of the interruption depends on the length of river affected and the magnitude of the flood. Losses are based on daily barge and towboat costs and the average daily tonnage moved during the month in which a flood occurs. The flood of 1993 interrupted navigation service for 7 weeks. Due to the relatively small benefits to navigation in comparison to total benefits of flood control, these benefits are not presented in this document.

The area immediately adjacent to each of the lakes is Federal land containing water supply intakes and recreation areas. During periods when the system is operated for flood control, these areas may be adversely affected. The flood control benefits to these sites were not evaluated for the RDEIS using daily reservoir elevations; however, in the 1994 DEIS, these benefits were found to be relatively small and insensitive to alternative operation plans using monthly data. Reservoir operations can affect tributary areas along the river and the reservoir reaches. High water can result in poor drainage, higher groundwater, blocked access, and associated damage and inconvenience. Benefits from reducing the damages on tributaries from dam operation have not been quantified for the RDEIS.

Although there may be flood damage from flooding on tributaries to the Missouri River and the lakes, those damages are not considered in this study. The Corps has authority to address flood control in these problem areas as separate individual studies.

Flood control provided by the mainstem reservoirs during the flood of 1993 prevented an estimated $4.4 billion in damages. This compares to total flood damages of $12 billion on the Missouri and Mississippi Rivers. Damages prevented by flood control of mainstem lakes since 1937 (1937 to 2000) total $18.0 billion. Peak flows in July 1993 were approximately 75 kcfs at Sioux City (includes Winnebago and Omaha Reservations), 200 kcfs at Nebraska City, and 335 kcfs at St. Joseph (includes Iowa and Sac and Fox Reservations). Without the mainstem flood control projects, flows would have been 140, 270, and 410 kcfs, respectively.

3.9.2 Missouri River from Fort Peck Dam to Garrison Dam

The reach extending from Fort Peck Dam to Lake Sakakawea contains 100,600 acres of agricultural land subject to flooding. For flood damage purposes, the value of wheat was assigned to this land. There are 1,544 residential buildings subject to flooding along this reach, with a total building and contents value of $196 million. There are only two nonresidential buildings, with a total value of $10 million. Flood control benefits to recreation areas, including access roads, and water supply intakes on land adjacent to Lake Sakakawea were not evaluated for the RDEIS.

For the Fort Peck Reservation, which is located on the northern bank of the Missouri River, there are 446 residential buildings and 1 nonresidential building subject to flooding. The estimated value of these buildings is $59.5 million. Furthermore, the Fort

Table 3.9-1. Agricultural acres, crop distribution, and damageable value potentially subject to flooding.

Reach	Acres	Crop Distribution (%) Corn	Soybeans	Wheat	Damageable Value ($millions)	Discharge at which Damages Begin (kcfs)
Fort Peck	100,600	0	0	100	9.1	30
Garrison	34,600	0	0	100	3.1	50
Oahe	0	0	0	0	0	57
Big Bend	0	0	0	0	0	NA
Fort Randall	2,200	28	17	55	0.4	60
Gavins Point	1,900	28	17	55	0.4	55
Sioux City	359,700	50	50	0	112.3	76
Omaha	54,200	50	50	0	16.9	98
Nebraska City	208,500	50	50	0	65.1	75
St. Joseph	151,700	50	50	0	47.4	88
Kansas City	250,100	50	50	0	78.1	160
Boonville	102,500	50	50	0	32.0	150
Hermann	119,200	50	50	0	37.2	280
Total	**1,385,200**				**402.0**	

Source: Corps, 1998e.

Table 3.9-2. Agricultural acres, crop distribution, and damageable value potentially subject to flooding by Tribe.

Reservation	Acres	Crop Distribution (%) Corn	Soybeans	Wheat	Damageable Value ($millions)	Discharge at which Damages Begin (kcfs)
Fort Peck	29,037	0	0	100	2.6	30
Yankton	375	28	17	55	0.1	60
Winnebago	6,404	50	50	0	2.0	76
Omaha	5,978	50	50	0	1.9	76
Iowa	1,002	50	50	0	0.3	88
Total	**42,796**				**6.9**	

Peck Reservation has approximately 29,000 acres of cropland located in the Missouri River floodplain. The damageable value of the crops is estimated at $2.6 million. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Fort Peck Tribes indicated that they do feel that the towns and villages of the Reservation benefit from flood control measures. The only impacts on Reservation land identified in the survey from the 1993 flooding were “some domestic damage from tributary flooding.”

The Fort Berthold Reservation is located adjacent to Lake Sakakawea on both sides of the lake. Fifteen recreation areas and 79 water intakes are located on Corps land within the exterior boundaries of the Reservation. Flood damage to these facilities was not evaluated for the RDEIS.

The area most subject to flooding problems is near Williston, North Dakota. Aggradation of the river channel and Lake Sakakawea delta has caused a backwater effect between the lake and the mouth of the Yellowstone River. This backwater effect does not have an impact on the Fort Peck Reservation. The Corps has built levees in this reach to protect Williston and nearby agricultural lands. The Corps has also purchased land that can no longer be effectively farmed due to a high water table and has built drains to lower the water table.

Table 3.9-3. Number and value of buildings potentially subject to flooding.

Reach	Residential		Non-Residential		Total		Discharge at which Damages Begin (kcfs)
	Number	Value ($millions)	Number	Value ($millions)	Number	Value ($millions)	
Fort Peck	1,544	196	2	10	1,546	206	30
Garrison	3,500	312	260	580	3,760	892	50
Oahe	271	24	9	3	280	27	57
Big Bend	40	4	13	2	53	6	100
Fort Randall	62	6	4	1	66	7	60
Gavins Point	3,705	254	343	131	4,048	385	80
Sioux City	8,563	533	1,561	1,633	10,124	2,166	76
Omaha	7,724	416	700	2,872	8,424	3,288	98
Nebraska City	1,480	73	321	1,055	1,801	1,128	75
St. Joseph	688	22	165	496	853	518	88
Kansas City	2,068	66	1,144	5,875	3,212	5,941	160
Boonville	259	8	248	86	507	94	150
Hermann	491	16	575	2,956	1,066	2,972	400
Total	**30,395**	**1,930**	**5,345**	**15,700**	**35,740**	**17,630**	

Source: Corps, 1998e.

Table 3.9-4. Number and value of Reservation buildings potentially subject to flooding.

Reservation	Residential		Non-Residential		Total		Discharge at which Damages Begin (kcfs)
	Number	Value ($millions)	Number	Value ($millions)	Number	Value ($millions)	
Fort Peck	446	56.6	1	2.9	447	59.5	30
Yankton	11	1.0	1	0.2	12	1.2	60
Omaha	12	1.0	0	0.0	12	1.0	76
Iowa	4	0.4	0	0.0	4	0.4	88
Total	**473**	**59.0**	**2**	**3.1**	**475**	**62.1**	

3.9.3 Missouri River from Garrison Dam to Oahe Dam

The reach extending from Garrison Dam to Lake Oahe Dam contains 34,600 acres of agricultural land subject to flooding. For flood damage purposes, the value of wheat was assigned to this land. There are 3,500 residential buildings subject to flooding along this reach, with a total building and contents value of $312 million. There are 260 nonresidential buildings with a total value of $580 million.

The area most subject to flooding is near Bismarck, North Dakota. Housing developments in bottomlands along the river are subject to flooding during the winter freeze-in periods.

Flood control benefits to recreation areas, including access roads and water supply intakes on land adjacent to Lake Oahe, were not evaluated for the RDEIS.

The Cheyenne River Reservation is located adjacent to Lake Oahe on the right bank of the lake. Two recreation areas and nine water intakes are located on Corps land just outside the boundaries of the Reservation. Flood damage to these facilities was not evaluated for the RDEIS.

Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Cheyenne River Sioux Tribe indicated that it does not feel that the Tribe benefits from flood control measures. Impacts such as flooded "fishing access roads" and "murky water through intakes" were identified in the 1993 flooding. Additionally, the survey indicated that the 1993 flooding caused increased erosion to Reservation land and adverse impacts to grazing.

The Standing Rock Reservation is located adjacent to Lake Oahe on the right bank of the lake. Four recreation areas and 14 water intakes are located on Corps land just outside the boundaries of the Reservation. Fort Yates is located next to Lake Oahe. Development is located on ground above the top of the exclusive flood control pool elevation of 1,620 feet. There are some structures at elevations where high groundwater and poor drainage would adversely affect them when lake levels are high. Wakpala is located in the Oak Creek floodplain. Oak Creek is tributary to Lake Oahe. The buildings are located above 1,620 feet. Approximately four buildings are on ground less than 1,630 feet. Prolonged high pool elevations, intense rainfall, and/or Oak Creek flooding will cause problems for buildings on low ground. Flood damage to these facilities and buildings was not evaluated for the RDEIS.

The survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994) was not completed by the Standing Rock Sioux Tribe. Sentiments expressed in consultation meetings conducted on July 27, July 28, and August 24, 1999, and in PDEIS comments dated July 7, 1993, indicated impacts similar in nature to those of the Cheyenne River Reservation. More specifically, erosion of land and roads, "Wakpala and Fort Yates flooding," and "flooding due to ice jams at Grand River" are all flood control issues identified by the Standing Rock Sioux Tribe as impacts on Reservation lands.

3.9.4 Missouri River from Oahe Dam to Big Bend Dam

The reach extending from Oahe Dam to Big Bend Dam does not contain any agricultural land subject to flooding. There are 271 residential buildings subject to flooding along this reach, with a total building and contents value of $24 million. There are nine nonresidential buildings with a total value of $3 million.

The areas most likely to flood are Pierre and Fort Pierre, South Dakota. High releases from Oahe Dam, coupled with river ice formation, have caused water to back up into storm sewer outlets, which in turn has caused residential street flooding. Releases are reduced during such events to help prevent flooding.

Big Bend Dam is normally operated on a weekly cycle in which the pool elevation reaches its maximum of 1,421 feet on Sunday and its minimum of 1,420 feet on Friday. Pool elevations fluctuate in a narrow range between 1,419 feet and 1,421.7 feet for all alternatives. Flood control benefits to recreation areas, including access roads and water supply intakes on land adjacent to Lake Sharpe, were not evaluated for the RDEIS.

The Crow Creek Reservation is located adjacent to Lake Sharpe on the left bank of the lake. Seven recreation areas and 55 water intakes are located on Corps land just outside the boundaries of the Reservation. Flood damage to these facilities was not evaluated for the RDEIS.

The Lower Brule Reservation is located adjacent to Lake Sharpe on the right bank of the lake. Ten recreation areas and 22 water intakes are located on Corps land just outside the boundaries of the Reservation. Flood damage to these facilities was not evaluated for the RDEIS.

Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Crow Creek Sioux Tribe did not indicate whether or not it feels the Reservation benefits from flood control measures. Additionally, flooding impacts were not identified nor addressed in the survey. The Lower Brule Sioux Tribe did not complete a survey for the Lower Brule Reservation.

3.9.5 Missouri River from Big Bend Dam to Fort Randall Dam

The reach extending from Big Bend Dam to Fort Randall Dam does not contain any agricultural land subject to flooding. There are 40 residential buildings subject to flooding along this reach, with a total building and contents value of $4 million. There are 13 nonresidential buildings with a total value of $2 million. Because this reach is small and showed essentially no sensitivity to the range of alternatives in the DEIS, it was not included in this analysis.

3.9.6 Missouri River from Fort Randall Dam to Gavins Point Dam

The reach extending from Fort Randall Dam to Gavins Point Dam contains 2,200 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 62 residential buildings subject to flooding along this reach, with a total building and contents value of $6 million. There are four nonresidential buildings with a total value of $1 million. These figures include the Tribal resources located adjacent to the Missouri River.

Pool elevations at Lewis and Clark Lake fluctuate in a narrow range between 1,209 feet and 1,204 feet for all alternatives. Flood control benefits to recreation areas, including access roads and water supply intakes on land adjacent to the lake, were not evaluated for the RDEIS.

For the Yankton Reservation, located on the northern side of the Missouri River, about 375 acres of cropland is located in the floodplain. It has $100,000 of damageable crop value subject to flooding. Eleven residential buildings valued at $1 million and one nonresidential building worth $200,000 are also located in the floodplain. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Yankton Sioux Tribe did not indicate whether or not it feels that the Reservation benefits from flood control measures. Additionally, flooding impacts were not identified or addressed in the survey.

Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Northern Ponca Tribe did not indicate whether or not it feels that its Tribal lands benefit from flood control measures. The Tribe did indicate that additional flood control protection is “needed” for protection of Tribal land. Flooding impacts were not identified or addressed in the survey.

The survey completed by the Santee Sioux Tribe indicated that the Tribe did not feel that the Reservation benefited from current flood control measures. Flooding impacts were not identified or addressed in the survey. The Santee Reservation is located adjacent to Lewis and Clark Lake on the right bank of the lake. Two recreation areas (Santee Creek and part of Bazile Creek) and seven water intakes are located on Corps land just outside the boundaries of the Reservation. Even though the lake elevation fluctuation is narrow, all or part of the recreation sites may be adversely affected when the pools are high. Flood damage to these facilities was not evaluated for the RDEIS.

The area most likely to flood stretches from the mouth of the Niobrara River downstream to the outskirts of Springfield, South Dakota. Ponca Tribal Land, which is located at the confluence of the Niobrara River and the Missouri River, is included in this region. Sediment deposits from the Niobrara River have caused backwaters and high water tables.

3.9.7 Missouri River from Gavins Point Dam to Sioux City

The reach extending downstream from Gavins Point Dam to Sioux City contains 1,900 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 3,705 residential buildings subject to flooding along this reach, with a total building and contents value of $254 million. There are 343 nonresidential buildings with a total value of $131 million.

The operation of the mainstem projects provides the most flood protection to this reach of the Lower River because of the lack of tributary inflow. During the flood of 1993, the highest water level reached only 27.3 feet, nearly 3 feet below flood stage. The water level would have reached 36 feet in the absence of the Mainstem Reservoir System.

3.9.8 Missouri River from Sioux City to Blair

The Sioux City reach contains 359,700 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 8,563 residential buildings subject to flooding along this reach, with a total building and contents value of $533 million. There are 1,561 nonresidential buildings with a total value of $1,633 million. These numbers include Tribal resources of the Winnebago and Omaha Reservations. The area most subject to flooding is near Omaha, Nebraska.

The Winnebago Reservation, located along the western banks of this reach, has about 6,400 acres of cropland subject to flooding from the Missouri River. The damageable value of the crops is $2 million. There are no buildings located in floodplain. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Winnebago Tribe of Nebraska indicated that the Tribe did not feel that the Reservation benefits from current flood control measures. Flooding impacts were not identified nor addressed in the survey.

Directly south of the Winnebago Reservation, the Omaha Reservation has approximately 5,980 acres of cropland with a damageable value of $1.9 million. Twelve residential buildings are located in the floodplain. The estimated value of these buildings is $1 million. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Omaha Tribe indicated that it feels that towns and villages on the Reservation benefit from current flood control measures. Additionally, flooding impacts that were identified as a result of the 1993 flooding were "loss of gravel roads, plugged culverts, and erosion to bridge foundation." The Omaha Tribe indicated that additional "maintenance/repairs" were still needed to "adequately" protect Reservation lands from flooding.

3.9.9 Missouri River from Blair to Platte River

The Blair reach near Omaha contains 54,200 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 7,724 residential buildings subject to flooding along this reach with a total building and contents value of $416 million. There are 700 nonresidential buildings with a total value of approximately $2.8 billion.

Like the flood control protection near Sioux City, the mainstem projects provide a large degree of flood control protection to the Omaha area. In 1993, the flood stage was exceeded by only 1.2 feet compared to the predicted 7.0 feet without the projects.

3.9.10 Missouri River from Platte River to Rulo

The Platte River to Rulo reach contains 208,500 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 1,480 residential buildings subject to flooding along this reach, with a total building and contents value of $73 million. There are 321 nonresidential buildings with a total value of $1 billion.

Below the Platte River, flood control protection from the mainstem projects declines because of increased tributary inflow. In 1993, the stage at Nebraska City reached 9.2 feet above flood stage compared to the 12.2 feet above flood stage it would have reached without the projects.

3.9.11 Missouri River from Rulo to Kansas City (St. Joseph Reach)

The St. Joseph reach contains 151,700 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 688 residential buildings subject to flooding along this reach, with a total building and contents value of $22 million. There are 165 nonresidential buildings with a total value of $496 million. These numbers include the resources of the Iowa and Sac and Fox Reservations.

For the Iowa and Sac and Fox Reservations, about 1,000 acres are located in the Missouri River floodplain. The value of the crops that could be damaged is $300,000. Four residential buildings are located in the floodplain and subject to flooding. Their value is estimated to be $400,000. Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Iowa Tribe of Kansas and Nebraska indicated that the Tribe did not feel that its Reservation benefits from current flood control measures. The Tribe additionally indicated that no additional flood control benefits were needed to protect Reservation land. "Silt" was the only impact to Reservation land identified from the 1993 flooding.

Based on the survey performed by the Mni Sose Intertribal Water Rights Coalition (February 1994), the Sac and Fox Tribe of Missouri did not indicate whether or not it feels the Reservation benefits from flood control measures. Additionally, no flooding impacts were identified as a result of the 1993 flooding. The Tribe did not address the question of needing additional flood control benefits to protect Reservation land in its survey.

In 1993, the water reached 15.1 feet above flood stage at St. Joseph compared to the 17.2 feet it would have reached without the projects.

3.9.12 Missouri River from Kansas City to the Crooked River (Kansas City Reach)

The Kansas City reach contains 250,100 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 2,068 residential buildings subject to flooding along this reach, with a total building and contents value of $66 million. There are 1,144 nonresidential buildings with a total value of $5,875 million.

In 1993, flood waters reached 16.9 feet above flood stage at Kansas City compared to the 20.2 feet it would have reached without the projects.

3.9.13 Missouri River from the Crooked River to the Osage River (Boonville Reach)

The Boonville River reach contains 102,500 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land.

There are 259 residential buildings subject to flooding along this reach, with a total building and contents value of $8 million. There are 248 nonresidential buildings with a total value of $86 million.

In 1993, the maximum water level reached 16.1 feet above flood stage at Boonville compared to the 19.6 feet it would have reached without the projects.

3.9.14 Missouri River from the Osage River to Mouth (Hermann Reach)

The Hermann reach of the river contains 119,200 acres of agricultural land subject to flooding. Corn and soybeans are the primary crops grown on this land. There are 491 residential buildings subject to flooding along this reach, with a total building and contents value of $16 million. There are 575 nonresidential buildings with a total value of $2,956 million.

In 1993, the water level reached 16.0 feet above flood stage compared to the 18.9 feet it would have reached without the projects. At the peak of the flood, Gavins Point releases amounted to less than 1 percent of the 750-kcfs flow at Hermann.

3.9.15 Mississippi River from St. Louis to Mouth

A total of 1,526 miles of levees has been constructed along the Mississippi River, confining flood flows to a floodplain having an average width of 5 miles. These levees extend uninterrupted along both sides of the river from just south of Cape Girardeau, Missouri, almost to the Gulf of Mexico, except where major tributaries enter or where high ground makes levees unnecessary. Another 669 miles of levees extend upstream for short distances along the banks of major tributaries and along four floodways designed to carry water in excess of the safe capacity of the channel. These levees provide various levels of protection.

In 1993, flooding along the Mississippi River would have been worse without the mainstem projects. The Mainstem Reservoir System prevented the overtopping of several urban levees in the Kansas City and St. Louis areas.

3.10 WATER SUPPLY

3.10.1 General

Water is withdrawn from the Missouri River and its mainstem lakes for cooling purposes in the production of electricity, municipal water supply, and commercial, industrial, irrigation, domestic, and public uses. More than 1,600 intakes and intake facilities have been identified on the lakes and river reaches of the Mainstem Reservoir System (Table 3.10-1). Of these, 302 intakes and intake facilities are identified for Native American Tribes.

Access to the water rather than quantity of water available is the main concern of the intake operators. In periods of average or above-average rainfall, few problems are experienced because water levels are sufficiently high for all intakes. During below average rainfall or drought periods, low reservoir levels and low river flows have resulted in water availability problems at some intakes, causing intake owners extreme difficulties related to pumping the water. Low flows and low pool levels also alter sediment deposition and sandbar formation, which may further restrict the flow of water to the intakes. During the winter, ice formation can further complicate water availability, particularly in the Lower River reaches. During floods, dam releases are minimized, which may cause local water access problems downstream.

In addition to water access problems, water quality is a concern. Low flows directly affect the ability of thermal powerplants to meet NPDES permit standards for discharging cooling water back into the river. Low lake and river levels may increase the sediment content in water supplies. Establishment of TMDL standards, pursuant to recent EPA regulations, may also be affected by low flows.

Changes in river flows and reservoir pool elevations affect the cost of operating intake facilities. Low water levels may increase day-to-day operating costs, or, in extreme cases, lead to capital costs for intake modification or location of an alternative water source, or even shutdowns. Low pool levels and below-normal project releases during the recent drought forced many intake owners to modify operations and intake structures.

Dependence on the Mainstem Reservoir System as a source for water supply is continually increasing. Increases in use of the water normally result in decreases in the amount of water that is available for use by those downstream from the new users. These depletions of river flow are estimated by the Bureau of Reclamation (BOR). The BOR also makes estimates of future levels of depletion based on projections of increased water users along the Mainstem Reservoir System. Based on the current (1990) estimates of depletion, the existing levels are expected to continue over the next decade.

Certain Missouri River basin Native American Tribes are entitled to water rights in streams running through and along their Reservations under the Winters Doctrine. This doctrine refers to the 1908 U.S. Supreme Court decision in the case of *Winters v. U.S.* (207 U.S. 564 1908). These reserved water rights are not forfeited by non-use. The basin's Native American Tribes are in various stages of exercising their water rights. Currently, Tribal Reservation-reserved water rights have not been quantified in an appropriate legal forum or by compact, except for four instances. These are the rights embodied in the Compacts between Montana and the Tribes of the Fort Peck Reservation (awaiting congressional approval), between Montana and the Tribes of Rocky Boys Reservation, between Montana and the Tribes of the Northern Cheyenne Reservation, and the Wyoming settlement within the Wind River Reservation. The current standard for quantification of reserved water rights where Reservations were intended for agricultural purposes is the measure of practicable irrigable acreage. There may be other standards for quantifying Tribal water rights, e.g., where a Reservation was intended to maintain viable fisheries. The standard for quantification of Tribal water rights is still evolving, however, and is not under the legal authority of the Corps.

The Fort Peck Compact proposal now awaiting Congressional approval would entitle the Assiniboine and Sioux Tribes of the Fort Peck Reservation to an annual diversion of 1 MAF with an annual consumptive use of 0.55 MAF. A Wyoming Supreme Court decision held that the United States, as trustee for the Shoshone and Arapahoe Tribes, was entitled to annually divert approximately 0.48 MAF of water. The Wyoming Supreme Court decision was affirmed, without opinion, by a divided United States Supreme Court. The Northern Cheyenne Indian Reserved Water Rights Settlement Act (P.L. 102-374), was passed by Congress and signed by the President.

Table 3.10-1. Number of intakes by location.

Reach	Lower Boundary	Intakes						Total Intakes
		Power	Municipal	Industrial	Irrigation	Domestic	Public	
Fort Peck Lake	1,771.60		1		5	101	2	109
Fort Peck	1,547.10		5 (1)	4	283 (94)	162 (14)	1	455 (109)
Lake Sakakawea	1,389.90	1	10 (5)	6 (1)	44 (10)	228 (63)	11	300 (79)
Garrison	1,317.40	6	3	6	77	28	3	123
Lake Oahe	1,072.30		8 (3)	2	179 (12)	21 (6)	8 (2)	218 (23)
Oahe	1,072.20							0
Lake Sharpe	987.40		3 (2)		91 (71)	19 (4)	2	115 (77)
Big Bend	987.30							0
Lake Francis Case	841.80		6		72	4	3	85
Fort Randall	836.10				8 (4)			8 (4)
Lewis and Clark Lake	811.10		2		27 (5)	6	2 (2)	37 (7)
Gavins Point	734.20		1		33	7	1	42
Sioux City	648.00	2	2	1	42 (3)		2	49 (3)
Omaha	597.20	3	2	1	8	2	5	21
Nebraska City	497.40	2			22	1		25
St. Joseph	374.00	3	4				2	9
Kansas City	249.90	5	4				1	10
Boonville	129.90		3				1	4
Hermann	0.00	3	3					6
Total		**25**	**57 (11)**	**20 (1)**	**891 (199)**	**579 (87)**	**44 (4)**	**1,616 (302)**
Above Gavins Point		7	38 (11)	18 (1)	786 (196)	569 (87)	32 (4)	
Below Gavins Point		18	19	2	105 (3)	10	12	

Source: Corps, 1994g.
( ) Denotes intakes located on Reservation land.

This Compact allows the annual use or disposition by the Tribe of 0.03 MAF of stored water in Big Horn Reservoir in Montana, as measured at the outlet works of the dam or at the diversion point from the reservoir, for any purpose. Before the DEIS was published, the Compact between Montana and Tribes of the Rocky Boys Reservation generally provided for withdrawal of 10,000 acre-feet from the tributaries of the Milk River and 10,000 acre-feet from the Tiber River. The Standing Rock Sioux Tribe has indicated in correspondence to the Corps that it believes its water rights should be quantified at 1.2 MAF.

The Study considered only existing consumptive uses and depletions. Potential Tribal water rights associated with these uses and depletions were not addressed. Native American reserved water rights are rights to divert water from a stream for beneficial use. When a Tribe exercises its water rights, these consumptive uses will then be incorporated as an existing depletion. Unless specifically provided for by law, these rights do not entail an allocation of storage. Accordingly, water must actually be diverted to have an impact on the operation of the Mainstem Reservoir System. Further modifications to system operation, in accordance with pertinent legal requirements, will be considered as Tribal water rights are exercised in accordance with applicable law. Thus, while existing depletions are being considered, the Study process does not prejudice any reserved Native American water rights of the Missouri River basin Tribes. Potential future depletions are examined in the impact analysis in Chapter 7.

Additional information submitted by the Missouri River basin Tribes and their representatives is provided in the Tribal Appendix (Appendix A).

Powerplants

Twenty-five electric generating stations, including coal- and nuclear-fired powerplants, are located on the Mainstem Reservoir System and Lower River, from which they draw cooling water for their steam-electric generating processes. The powerplants have a gross electric generating capacity of 15,084 megawatts (MW). Seventy-four percent of this capacity is produced by powerplants in the river reaches below Gavins Point Dam (Table 3.10-2). While most of the major powerplants are coal-fired, there are three nuclear powerplants located in the Omaha, Nebraska City, and Hermann reaches. The nuclear powerplants have a combined generating capacity of 2,556 MW. Of the 25 powerplants, four powerplants, including one nuclear plant (combined generating capacity of 3,634 MW), use cooling towers. The remainder use once-through cooling, which demands much more river water per unit of generating capacity.

Some powerplants have had problems with water access and thermal water quality standards compliance. Powerplants that use once-through heat rejection systems are required by law to meet NPDES permit requirements for discharging cooling water back into rivers. The Federal water

Table 3.10-2. Thermal powerplant gross electric-generating capacity by reach.

Reach/Lake	Powerplant Gross Capacity (MW)	Share of Total (%)
Fort Peck Lake	0	0
Fort Peck	0	0
Lake Sakakawea	879	6
Garrison	3,147	21
Lake Oahe	0	0
Lake Sharpe	0	0
Lake Francis Case	0	0
Lewis and Clark Lake	0	0
Gavins Point	0	0
Sioux City	1,560	10
Omaha	2,028	13
Nebraska City	1,424	9
St. Joseph	1,026	7
Kansas City	1,309	9
Boonville	0	0
Hermann	3,711	25
Total	**15,084**	**100**
Above Gavins Point	4,026	27
Below Gavins Point	11,058	73

Source: Corps, 1994i.

quality standards require that a plant not increase the river temperature by more than 3°C or increase the total river temperature to more than a specified temperature within a specified mixing zone (some portion of the river). The flow in the river and ambient water temperature affect a plant's ability to operate within standards. If requirements cannot be met, operations may be curtailed or powerplants may be shut down. The corresponding State issues NPDES permits for each powerplant, and the permits reflect the State's interpretation of the standards and the site-specific conditions. Therefore, permit requirements vary from State to State and facility to facility.

Even when standards can be met, variable costs may be incurred when mainstem lake or river levels fall below the elevation required for normal intake operation. These costs include O&M, pumping, personnel, and emergency operations costs. In extreme cases, plants could be required to install cooling towers to meet thermal water quality standards. In addition to the cost of cooling towers, powerplant efficiency and capacity could be reduced because a portion of the plant's energy output and capacity must be used to power the closed-cycle cooling system. Loss of capacity could force utilities to construct additional facilities or purchase outside energy to replace the decreased capability. In some cases, cooling towers are not viable, and replacement generating capacity would need to be constructed if thermal discharge requirements would significantly curtail power generating capability.

Municipal and Industrial Supply

Missouri River water is also used for municipal and industrial uses. Municipal use is for Tribal and public supply of water to Reservations, residents of cities and towns, and rural water districts or associations. Industrial use is for manufacturing or processing purposes other than powerplant use.

Approximately 3 million people are served by municipal water supply facilities that withdraw water from the Mainstem Reservoir System and the Lower River (Table 3.10-3). Tribal, public, and private water supply facilities provide treated water to households and commercial and industrial establishments. Most of the smaller municipal water supply facilities are located on the lakes and upper reaches and serve about 190,000 persons. The large municipal water supply facilities are located in the Lower River reaches and serve the major urban areas of the lower basin. The municipal facilities below Gavins Point Dam serve nearly 2.9 million persons. The larger downstream municipal intakes on the river were in place before construction of the Mainstem Reservoir System.

Some were in place before the turn of the century. Some of the smaller municipal or rural water supply intakes are situated at a relatively high elevation in mainstem lakes. One owner had to lower its intakes during the recent drought. Some intakes are located in shallow basins off the main body of the lake, which made it necessary for one owner to take special precautions to ensure that its intake would be operable during the winter of 1991 to 1992.

In addition to the cost of extending intakes, costs may be incurred due to additional strain on equipment, increased sedimentation problems, and the necessity for more frequent and thorough cleaning of intake screens. Other costs include increased pumping costs, costs for additional personnel, and increases in water treatment costs to eliminate taste and odor problems that could occur from heavier algae growth at lower reservoir levels.

Most municipalities located on the river or mainstem lakes have no alternative sources of water. Some have wells that serve as backup systems only. Even with strict conservation measures in place, most facilities have only about one to two days supply available in storage. To increase the amount of water available, some municipalities have had to drill new wells as an alternative water source or to increase pumping capacity at existing wells.

Irrigation Intakes

Numerous private irrigators withdraw water from the mainstem lakes and the river to increase crop yields or to grow crops that otherwise could not be grown in the area. Most are located in the upper basin where the annual rainfall is less and the growing season is shorter than in the lower basin. The majority of irrigation intakes are portable and are placed to access water at a low cost; however, adjusting intakes to changing water surface elevations requires costs in time and efficiency.

As pool elevation falls below the level needed for normal intake operation, irrigators incur increased O&M and pumping costs, losses in net income because of a decrease in acres irrigated, and intake extension costs. In the river reaches below the

Table 3.10-3. Population served by municipal facilities by reach.

Reach/Lake	Municipal Water Supply Population Served	Share of Total (%)
Fort Peck Lake	580	<1
Fort Peck	28,020 (200)	1
Lake Sakakawea	21,950 (2,562)	1
Garrison	69,960	2
Lake Oahe	48,050 (11,550)	1
Oahe	0	0
Lake Sharpe	2,390 (600)	<1
Big Bend	0	0
Lake Francis Case	12,100	<1
Fort Randall	0	0
Lewis and Clark Lake	4,380	<1
Gavins Point	15,000	<1
Sioux City	88,800	3
Omaha	530,000	17
Nebraska City	0	0
St. Joseph	418,000	14
Kansas City	845,500	27
Boonville	46,740	1
Hermann	940,000	31
Total	**3,071,470 (14,912)**	**100**
Above Gavins Point	187,430 (14,912)	6
Below Gavins Point	2,884,040 (0)	94

Source: Corps, 1994g.
( ) Denotes Reservation population served by municipal intakes.

mainstem lakes, most irrigators can extend intakes and continue to pump water for irrigation at any stage in the river; however, they require prior warning of extreme fluctuations in water surface elevations so that their pumps can be reset.

Domestic Intakes

Rural domestic use includes lawn, tree, and small garden irrigation, stock watering, agricultural spraying, or other small agricultural uses in connection with domestic needs, and other domestic uses, excluding drinking water. Most domestic intakes serve one household, and many may be used only on a seasonal basis. The majority of the domestic intakes are portable and are located on the upper two lakes (Fort Peck Lake and Lake Sakakawea) and in the river reach below Fort Peck Dam. Many of the portable domestic intakes access water at a low cost because they are placed high in the lakes compared to the minimum operating pool. When the water surface elevation falls below that required for normal operation of the intake, owners have to move their pumps or extend their pipeline to continue intake operation.

Tribal and Public Intakes

Tribal and public intakes provide water for parks, golf courses, other recreational purposes, and fish and wildlife uses. Most of these intakes are located along the mainstem lakes and river reaches above Gavins Point Dam. The operating season varies from intake to intake, but generally occurs either year-round or from April through November. Insufficient water surface elevation may result in increased O&M and pumping costs. Additional costs related to intakes for fish and wildlife could include increases in disease treatment costs, decreases in units of production, and decreases in acres irrigated. Capital costs could include intake extension, modification, or location of an alternative source. Some fish hatcheries could be forced to shut down during periods of low water levels.

3.10.2 Fort Peck Lake

There are 109 water supply intakes and intake facilities located on Fort Peck Lake. These include 1 municipal water supply facility, 5 irrigation intakes, 101 domestic intakes, and 2 public intakes. The municipal water supply facility serves a population of approximately 580 persons. The majority of the domestic intakes are used by cabin owners for general use in watering lawns, washing cars, and other domestic uses, including fire protection. Domestic intakes along this reach are not generally used to provide drinking water, which is obtained in neighboring towns.

3.10.3 Missouri River from Fort Peck Dam to Lake Sakakawea

There are 455 water supply intakes and intake facilities located on the Missouri River in this reach from Wolf Point to Williston. These include 5 municipal water supply facilities, 4 industrial intakes, 283 irrigation intakes, 162 domestic intakes, and 1 public intake. The municipal water supply facilities serve a population of approximately 28,020 persons, 80 percent of whom live in the Williston area.

Of the total 455 water supply intakes and intake facilities, there are 109 water supply intakes and intake facilities located on the Missouri River serving the Fort Peck Reservation. These include 1 municipal water supply facility, 94 irrigation intakes, and 14 domestic intakes. The municipal water supply facilities serve a population of approximately 200 persons.

3.10.4 Lake Sakakawea

There are 300 water supply intakes and intake facilities that draw water from Lake Sakakawea. These include 1 powerplant, 10 municipal water supply facilities, 6 industrial intakes, 44 irrigation intakes, 228 domestic intakes, and 11 public intakes. The powerplant has a gross generating capacity of 879 MW. The municipal water supply facilities serve a population of approximately 21,950 persons.

Of the 300 water supply intakes and intake facilities, there are 79 water supply intakes and intake facilities that serve the Fort Berthold Reservation. These include 5 municipal water supply facilities, 1 industrial intake, 10 irrigation intakes, and 63 domestic intakes. The municipal water supply facilities serve a population of approximately 2,562 persons.

3.10.5 Missouri River from Garrison Dam to Lake Oahe

There are 123 water supply intakes located downstream of Garrison Dam to Lake Oahe. These include 6 powerplants, 3 municipal water supply facilities, 6 industrial intakes, 77 irrigation intakes, 28 domestic intakes, and 3 public intakes. The 6 powerplants have a gross generating capacity of 3,147 MW. The municipal water supply facilities serve a population of approximately 70,000 persons.

3.10.6 Lake Oahe

There are 218 water supply intakes located on Lake Oahe. These include 8 municipal intakes, 2 industrial intakes, 179 irrigation intakes, 21 domestic intakes, and 8 public intakes. The municipal water supply facilities serve a population of approximately 48,050 persons.

Of the 218 water supply intakes, 14 water supply intakes service the Standing Rock Reservation. These include two municipal intakes, nine irrigation intakes, one domestic intake, and two public intakes. The municipal water supply facilities serve a population of approximately 1,550 persons.

Likewise, nine water supply intakes service the Cheyenne River Reservation. These include one municipal intake, three irrigation intakes, and five domestic intakes. The municipal water supply facilities serve a population of approximately 10,000 persons.

3.10.7 Lake Sharpe

There are 115 water supply intakes located on Lake Sharpe. These include 3 municipal intake facilities, 91 irrigation intakes, 19 domestic intakes, and 2 public intakes. The municipal water supply facilities serve a population of approximately 2,390 persons.

Of the 115 water supply intakes, there are 22 water supply intakes serving the Lower Brule Reservation. These include a single municipal intake facility, 20 irrigation intakes, and one domestic intake. The municipal water supply facility serves a population of approximately 300 persons.

Additionally, there are 55 water supply intakes serving the Crow Creek Reservation. These include a municipal intake facility, 51 irrigation intakes, and three domestic intakes. The municipal water supply facility serves a population of approximately 300 persons.

3.10.8 Lake Francis Case and Missouri River from Fort Randall Dam to Lewis and Clark Lake

There are 85 water supply intakes located on Lake Francis Case. These include 6 municipal water supply facilities, 72 irrigation intakes, 4 domestic intakes, and 3 public intakes. The municipal water supply facilities serve a population of approximately 12,100 persons. In addition, there are eight irrigation intakes located on the river reach downstream of Fort Randall Dam. Of these eight irrigation intakes located on the river reach downstream of Fort Randall Dam, four irrigation intakes are located on the Yankton Reservation.

3.10.9 Lewis and Clark Lake

There are 37 water supply intakes located on Lewis and Clark Lake. These include 2 municipal water supply facilities, 27 irrigation intakes, 6 domestic intakes, and 2 public intakes. The municipal water supply facilities serve a population of approximately 4,380 persons.

Of the 37 water supply intakes, there are seven water supply intakes located on Lewis and Clark Lake serving the Santee Reservation. These include five irrigation intakes and two public intakes.

3.10.10 Missouri River from Gavins Point Dam to Sioux City (Yankton Reach)

There are 42 water supply intakes located on the Missouri River in this reach. These include 1 municipal water supply facility, 33 irrigation intakes, 7 domestic intakes, and 1 public intake. The municipal water supply facility serves a population of approximately 15,000 persons.

3.10.11 Missouri River from Sioux City to Blair (Sioux City Reach)

There are 49 water supply intakes located on the Missouri River in the Sioux City reach. These include 2 powerplants, 2 municipal water supply facilities, 1 industrial intake, 42 irrigation intakes, and 2 public intakes. The two powerplants have a gross generating capacity of 1,535 MW. The municipal water supply facilities serve a population of approximately 88,800 persons.

Of the 49 water supply intakes located on the Missouri River in the Sioux City reach, there is one irrigation intake on the Winnebago Reservation and two irrigation intakes on the Omaha Reservation.

3.10.12 Missouri River from Blair to Bellevue (Omaha Reach)

There are 21 water supply intakes located on the Missouri River in the Omaha reach. These include three powerplants (one nuclear), two municipal water supply facilities, one industrial intake, eight irrigation intakes, two domestic intakes, and five public intakes. The three powerplants have a gross generating capacity of 1,975 MW. The municipal water supply facilities serve a population of approximately 530,000 persons.

3.10.13 Missouri River from Bellevue to Rulo (Nebraska City Reach)

There are 25 water supply intakes located on the Missouri River in the Nebraska City reach. These include two powerplants (one nuclear), 22 irrigation intakes, and one domestic intake. The two powerplants have a gross generating capacity of 1,424 MW.

3.10.14 Missouri River from Rulo to Kansas City (St. Joseph Reach)

There are nine water supply intakes located on the Missouri River in the St. Joseph reach. These include three powerplants, four municipal water supply facilities, and two public intakes. The three powerplants have a gross generating capacity of 1,026 MW. The municipal water supply facilities serve a population of approximately 418,000 persons.

None of nine water supply intakes located on the St. Joseph reach of the Missouri River are on the Iowa Reservation or the Sac and Fox Reservation.

3.10.15 Missouri River from Kansas City to the Grand River (Kansas City Reach)

There are 10 water supply intakes located on the Missouri River in the Kansas City reach. These include five powerplants, four municipal water supply facilities, and one public intake. The five powerplants have a gross generating capacity of 1,309 MW. The municipal water supply facilities serve a population of approximately 845,500 persons.

3.10.16 Missouri River from the Grand River to the Osage River (Boonville Reach)

There are four water supply intakes located on the Missouri River in the Boonville reach. These include three municipal water supply intakes and one public intake. The municipal water supply intakes serve a population of approximately 46,740 persons.

3.10.17 Missouri River from the Osage River to St. Louis (Hermann Reach)

There are six water supply intakes located on the Missouri River in the Hermann reach. These include three powerplants (one nuclear) and three municipal water supply facilities. The three powerplants have a gross generating capacity of 3,711 MW. The municipal water supply facilities serve a population of approximately 940,000 persons.

3.10.18 Mississippi River from St. Louis to Mouth

Water supply intakes on the Mississippi River are generally constructed to accommodate the large fluctuations in water level common to the river. Interviews with 58 Mississippi River water intake operators were conducted to determine the impacts of low water levels. All but one indicated that low water situations were manageable. Historically, low Mississippi River stages resulted in inconveniences at only five sites.

3.11 HYDROPOWER

3.11.1 General

Hydroelectric power plays an important role in meeting the electricity demands of our nation. It is a renewable energy source that helps conserve our nonrenewable fossil and nuclear fuels. It helps meet the upper Midwest's needs at an affordable price in an environmentally safe way.

At the six mainstem dams, there are 36 hydropower units with a combined capacity of 2,435 MW (Table 3.11-1). These units have provided an average of 10.2 million megawatt hours (MWh) per year, or about 9 percent of the energy used in the Mid-continent Area Power Pool (MAPP) region. The MAPP region includes all of Iowa, Minnesota, Nebraska, and North Dakota; most of South Dakota; and portions of Illinois, Montana, and Wisconsin (Figure 3.11-1). Power generated at the Missouri River mainstem dams is marketed within the MAPP and Western Systems Coordinating Council (WSCC) regions by the Western Area Power Administration (Western) of the U.S. Department of Energy.

The Corps constructed these hydroelectric facilities as part of a larger effort to develop multipurpose water projects that have functions other than power generation, including flood control, irrigation, navigation, and recreation. The projects must be operated in a way that balances their authorized purposes; in many instances, power is not the primary use.

Nearly all of the water that flows into the Missouri River passes through hydropower turbines. On average, March through July runoff supplies 70 percent of the water used for annual hydropower generation. Only during larger magnitude inflow years is storage evacuation passed through the flood control tunnels or over spillways, thus bypassing powerhouses. This occurs most often at the Gavins Point Dam, where water releases exceed the discharge capacity of the powerhouse about 25 percent of the time.

Big Bend and Oahe Dams are used primarily to follow daily load patterns. In the summer cooling season (Figure 3.11-2), Big Bend and Oahe generation is patterned to meet peak electricity demands, which generally occur around 6 p.m. In the winter heating season (Figure 3.11-3), their generation is patterned to meet morning and evening peak demands. Fort Randall, Garrison, and Fort Peck Dams are also used for peaking, but to a lesser degree. The relative role of each plant in meeting required peaking patterns varies with relative water supply available to each plant and other operational factors. The peaking patterns vary through time, primarily in response to such factors as the demand for power and the average release rate through the system. At individual dams, daily power releases are normally adjusted for other project purposes, taking into account flood control, conservation, and environmental objectives and constraints, and other factors.

The mainstem dams provide three principal hydropower benefits. First, by providing dependable capacity to meet annual peak power demands, mainstem hydropower helps ensure the reliability of the electrical power system in the MAPP. This reduces the need for additional coal, gas, oil, or nuclear generating capacity. Second, the six powerplants provide a large amount of energy at a very small cost relative to thermal electric generating stations, reducing the overall cost of electricity. Hydropower facilities reduce the burning of fossil fuels, thereby reducing air pollution, acid rain, and the greenhouse effect. Finally, hydropower has several valuable operating characteristics that improve the reliability and efficiency of the electric power supply system, including efficient peaking, rapid rate of unit unloading, and rapid power availability for emergencies on the power grid.

The hydropower generating capacity that is available from the mainstem dams at any time varies with the water-surface elevations of the lakes ("head" on the units). As the lake elevations fall during long-term droughts, the generating capacity (capability) of the system is decreased. During the 1987 to 1993 drought, power production fell sharply. In 1992, lower lake levels and reduced releases resulted in power production at 65 percent of normal. Power production in 1993 was even lower due to reductions in system releases for flood control.

The dependable capacity, as currently marketed by Western, is based on the potential reoccurrence of the 1954 to 1961 drought conditions. At the time this criterion was established, it was determined that the mainstem dams could provide this amount of capacity or more about 85 percent of the time. Based on conditions that were estimated to exist in 1961 following 8 years of drought and 1990 depletion levels, about 2,070 MW and 2,010 MW of dependable capacity are available during summer

Table 3.11-1. Overview of the mainstem dam hydropower supply.

Dam	Generator Capacity (MW)	Energy (billion KWh)	Average Annual Energy Plant Factor (%)	Units	Average Gross Head (feet)	Average Flow (kcfs)	Normal Powerhouse** Capacity (kcfs)	Average Annual Flow Plant Factor (%)	Type
Fort Peck	185	1.2	74	5	200	10.1	16.0	63	Semi-Peaking
Garrison	518	2.5	55	5	173	22.8	38.0	60	Semi-Peaking
Oahe	786	2.9	42	7	181	25.4	55	46	Peaking
Big Bend	494	1.1	25	8	68	25.4	103.0	25	Peaking
Fort Randall	320	1.8	64	8	118	26.7	44.5	60	Semi-Peaking
Gavins Point	132	0.7	61	3	48	29.0	35.0	83	Baseload
Total	**2,435**	**10.2**		**36**	**788**				

** Normal powerhouse capacity is based on average reservoir elevation.

Note: Flow plant factors are calculated based on average flows versus powerhouse flow capacities. These differ from energy-based plant factors to the extent that actual plant head is less than maximum gross head.

Source: Corps, 1967-1997 actual data.

and winter seasons, respectively. Western will select an updated dependable capacity from the revised Master Manual when data become available.

The two major components of hydropower value are capacity and energy values. For hydropower, maximum value is achieved when the capacity and energy outputs are maximized. The capacity value reflects the ability of the hydropower units to provide capacity when needed, especially during summer and winter peak demand periods. With reduced dependable capacity during these time periods, alternative generation facilities would need to be constructed beyond those currently planned over the next decade or two to avoid potential brownouts or blackouts.

The value of power produced at a particular plant is greatest when the available capacity is maximum. This occurs when the available head is maximum. For most plants, this condition occurs when the lake is at its maximum elevation. As the pool elevation drops, the head decreases, and the capacity and value drop proportionally. Because sufficient water must be released to make the capacity available through the peak demand period, capacity benefits are also a function of lake release. For each month evaluated, the amount of water released must be sufficient to generate electricity 4 hours per day for 5 consecutive days each week. If flows are insufficient, the capacity value is reduced accordingly.

The value of the energy produced varies from season to season, depending on water conditions and the power demand. The higher the demand, the greater the value of hydropower. Because demand is greatest in summer and winter, energy produced during these seasons is of greater overall value than energy produced in the spring and fall. In general, the energy value represents the value of hydropower that minimizes the cost of operating all available plants (hydropower plus thermal) to meet day-to-day power demand. This value is greatest when the hydropower units have sufficient water to produce a maximum amount of energy.

The value of the energy produced by a particular plant during a month is generally maximized when the plant produces as much energy as possible. Because hydropower units burn no fuel, the cost of production is very low, about 1 mill per kWh. A mill is one-tenth of a cent. When hydropower is available, generation from more expensive coal- or oil-burning plants can be reduced. The savings hydropower provides depends on the value of the thermal energy it displaces and the amount of hydropower produced. Hence, the energy value is the per-unit cost of the thermal energy displaced.

The plant factor is the ratio of the actual monthly energy generation by the hydropower plant to the maximum possible monthly generation. The plant factor is 100 percent when the hydropower plant is making full releases 100 percent of the time. This would occur during full lake conditions, when as much water is being released through the hydropower units as possible on a 24-hours-per-day basis. Under these conditions, the hydropower displaces more efficient baseload thermal power generation. These more efficient thermal plants have low production costs so the unit value is much less than if the hydropower can displace more expensive coal or oil facilities. However, the hydropower system operates under these conditions only a very small percentage of the time. Under normal water-supply conditions, hydropower operates at a lower plant factor than 100 percent and its unit value is greater because it is displacing generation from more expensive and less efficient coal or oil units.

Power generation at the six mainstem dams generally must follow the seasonal pattern of water movement through the system. However, adjustments have been made to the extent possible to provide maximum power production during the summer and winter months when demand is high. Oahe and Big Bend power generation is relatively high during the winter. Since system release in the winter is low, the winter Oahe and Big Bend powerplant releases must be stored in Lake Francis Case. To allow for this, Lake Francis Case is drawn down during the fall of each year.

3.11.2 Fort Peck Dam

There are five units operating at Fort Peck, with a generating capacity of 185 MW. The powerhouse capacity is 16 kcfs and the average flow is 10.1 kcfs, resulting in an average annual plant factor of 63 percent. The powerplant produces an average of approximately 1.2 billion kWh of energy per year. The first hydroelectric unit went on line in 1943, and the first hydroplant was completed with the installation of the third unit in 1951. The second powerplant with two units was completed in 1961. Fort Peck Dam is a semi-peaking plant.

3.11.3 Garrison Dam

There are five units operating at Garrison, with a generating capacity of 518 MW. The normal powerhouse capacity is 38 kcfs and the average flow is 22.8 kcfs, resulting in an average annual plant factor of 60 percent. The powerplant produces an average of 2.5 billion kWh of energy annually. The first and last power generating units were placed on line in 1956 and 1960, respectively. Garrison Dam is primarily a semi-peaking plant.

3.11.4 Oahe Dam

There are seven units operating at Oahe, with a combined generating capacity of 786 MW. The normal powerhouse capacity is 55 kcfs. When the average flow is 25.4 kcfs, the average annual plant factor is 46 percent. The powerplant annually produces 2.9 billion kWh of energy. The power generating units came on line in 1962 and 1963. Oahe Dam is used to meet peaking demand patterns. It is usually the plant whose electrical output is scheduled to follow the fluctuation in system load demand.

3.11.5 Big Bend Dam

There are eight units operating at Big Bend, with a generating capacity of 468 MW. At this rating, the powerhouse capacity is 103 kcfs. When the average flow is 25.4 kcfs, the average annual plant factor is 25 percent—the lowest of the six mainstem dams. The powerplant produces 1.1 billion kWh per year. Power generating units came on line from 1964 through 1966. Big Bend Dam is primarily a peaking powerplant.

3.11.6 Fort Randall Dam

There are eight units operating at Fort Randall, with a generating capacity of 320 MW. Normal powerhouse capacity is 44.5 kcfs, and average flow is 26.7 kcfs. The average annual plant factor is 60 percent. The powerplant produces 1.8 billion kWh per year. Power generating units came on line between 1954 and 1956. Fort Randall is a semi-peaking plant.

3.11.7 Gavins Point Dam

There are three units operating at Gavins Point, with a generating capacity of 132 MW. These power generating units came on line in 1956 and 1957. The powerhouse capacity is 35 kcfs, and the average flow is 29 kcfs. The average annual plant factor is 83 percent—the highest of the six mainstem dams. The powerplant produces 0.7 billion kWh of energy per year. Gavins Point is the only dam that is not operated to provide peaking power. Generally, daily releases from Gavins Point are constant to allow for stable downstream navigation and other project purposes. The constant release rate prevents a peaking-type operation of the Gavins Point generating units.

3.11.8 Old River Hydropower Plant – Mississippi River

The Sidney A. Murray, Jr. Hydroelectric Station is located on the western bank of the Mississippi River about 40 miles south of Vidalia, LA and Natchez, MS. It is located immediately upstream of the Old River Control Complex, which has been operated by the Corps since 1963. The Old River Control Complex regulates the daily flow between the Mississippi, Red, and Atchafalaya Rivers to prevent the Mississippi River from changing course and flowing down the Atchafalaya River. A portion of the daily flow from the Mississippi River to the Atchafalaya River is allocated by the Corps to the hydroelectric station for power generation. The privately owned station, which was completed in 1990, consists of eight turbines, each capable of generating up to 24 MW for a total station capability of 192 MW. The station is the largest low-head (maximum 25 feet) run-of-the-river hydro plant in the world.

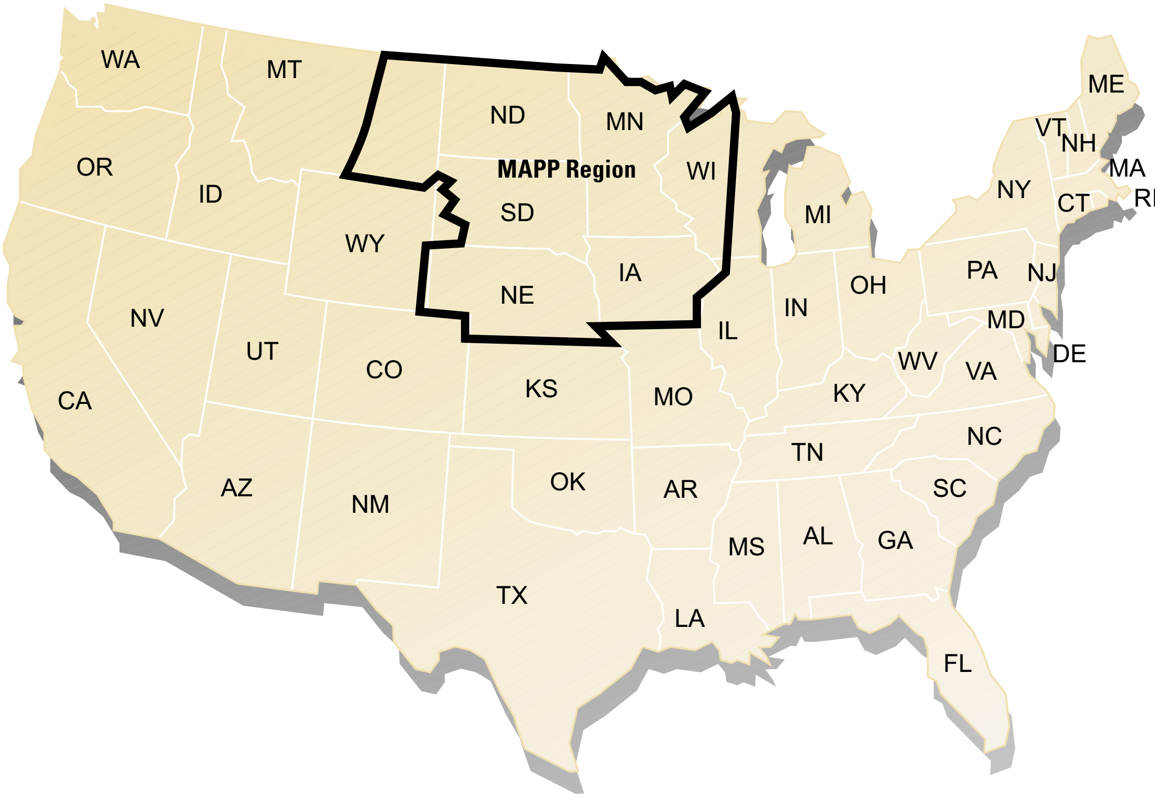

Figure 3.11-1. Mid-continent Area Power Pool (MAPP) (U.S. portion).

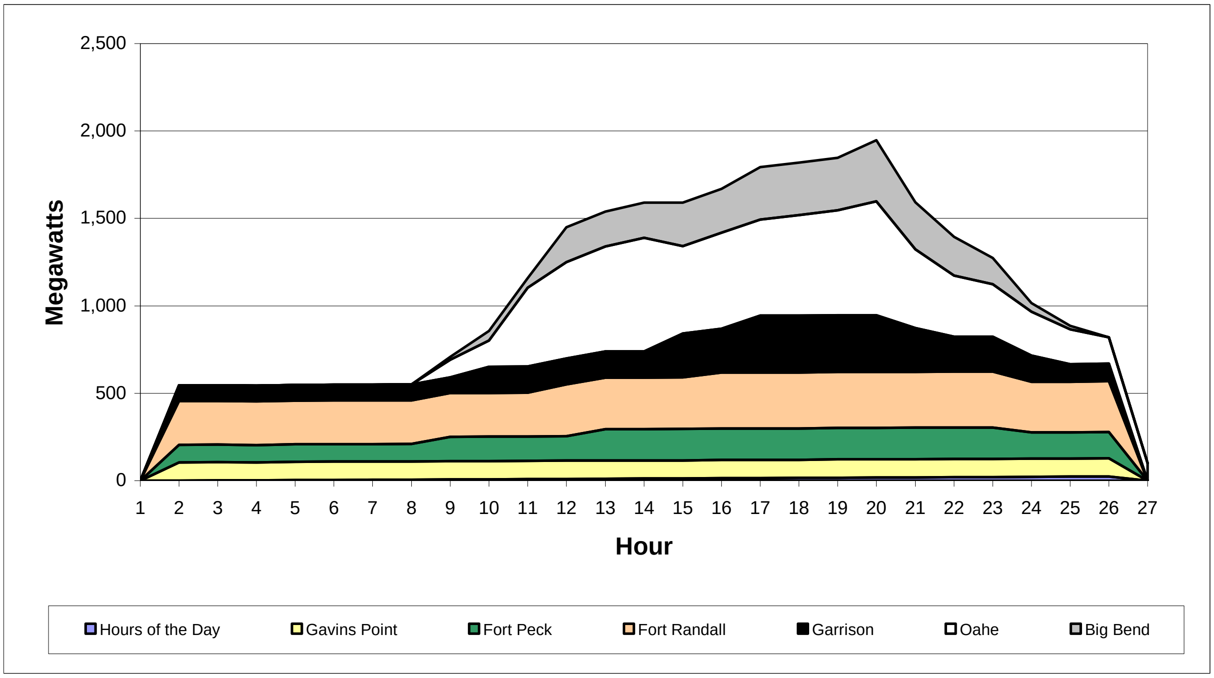

Figure 3.11-2. Typical summer load pattern (reservoirs full, normal releases).

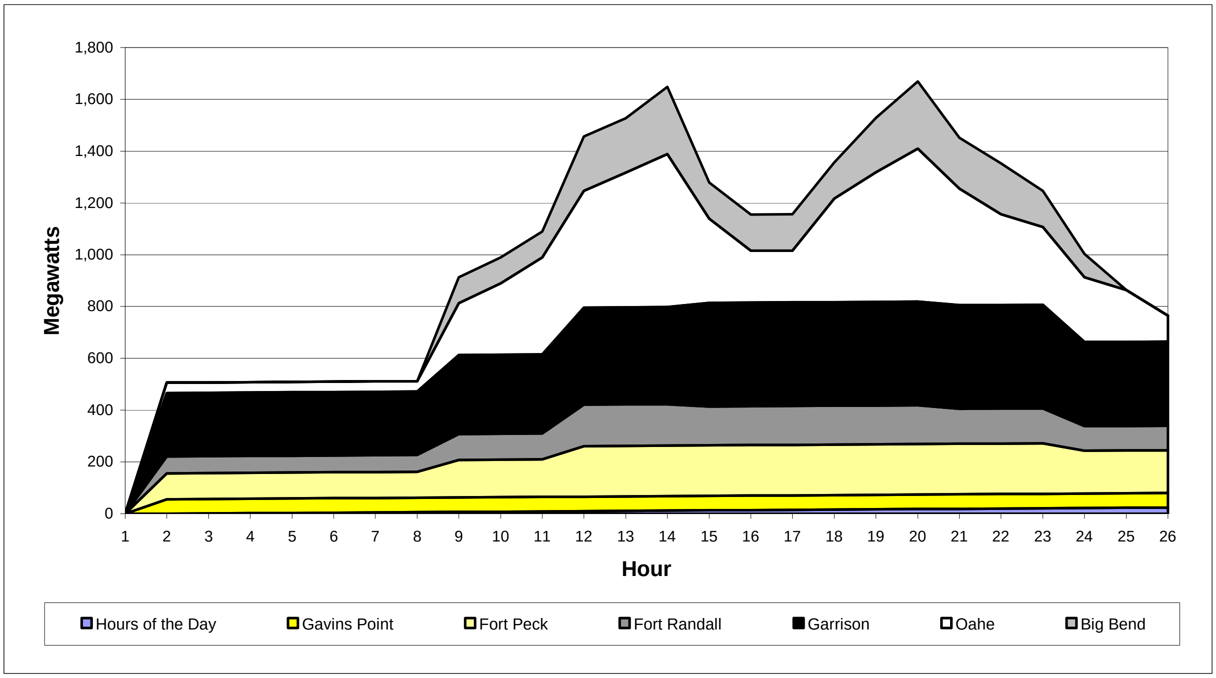

Figure 3.11-3. Typical winter load pattern (reservoirs full, normal releases).

3.12 RECREATION

3.12.1 General

The six large lakes of the Mainstem Reservoir System and the reaches between and below these lakes provide recreation opportunities to residents of the States through which the river flows, as well as neighboring States. Recreational activity is a source of income for businesses catering to boating, hunting, fishing, camping, and other recreational pursuits, as well as service establishments located near the river.

There are a variety of recreational opportunities on the Mainstem Reservoir System and the Lower River. Water-based recreation includes boating, boating-related activities, and swimming. Sport fishing is a primary component of recreation along the entire system. The wetlands along the river corridor provide waterfowl habitat, and waterfowl hunting is popular. Hunting for small and large game such as pheasant, grouse, rabbit, and deer occurs on land along the lakes and river. The aesthetically pleasing character of the lakes and river reaches attract sightseers. Camping facilities vary from fully developed to primitive.

Factors that affect recreation along the Mainstem Reservoir System include the health of the economy, fishing success, trends in vacation and recreational activity, the price of gasoline, the character and condition of the recreation and access areas, local celebrations that increase the general population base for a brief period, promotional activities, and information provided by public and private sources.

More than two-thirds of the recreational opportunities are associated with the six mainstem lakes. There are over 80,000 acres of recreational lands along nearly 6,000 miles of lake shoreline. Table 3.12-1 provides data on the recreation facilities of the mainstem lakes. Of this 80,000 acres of recreational lands, 6,457 acres are existing recreational areas located on Reservation lands along the mainstem Missouri River with another 925 acres identified as future recreational areas. Table 3.12-2 shows recreational acres on Reservation lands per Reservation.

Water levels are a key factor in use of the lakes and river. At low lake levels, some boat ramps are unusable. River flow levels affect the ability of boats to maneuver. For aesthetic reasons, some visitors are less likely to frequent lakes or streams that have noticeably low water levels. Certain kinds of fishing and hunting are dependent upon lake levels and stream flows.

The lakes created by the mainstem dams provide opportunities for recreation. With time, recreational facilities became more developed and opportunities for recreation have increased. The introduction of additional fish species attracted greater numbers of fishermen to the lakes. Road improvements made the lakes and river reaches more accessible. Recently, the national trend towards outdoor recreation and the number of recreationists willing to travel longer distances have added to recreational visitation along the Mainstem Reservoir System.

During the last two decades, recreational use and the distribution of activity along the system have been affected by drought. Only the upper three lakes, Fort Peck Lake, Lake Sakakawea and Lake Oahe, are affected by drought, leading to a reduction in access and a shift in recreational use to those areas with water access. Fishing, a major attraction for lake recreationists, has been affected by drawdowns that decreased volumes of warmwater and coldwater habitat in the upper lakes. In reaction to the 1987 to 1993 drought, boat ramps have been relocated or extended. A total of 94 boat ramps were extended at a Federal cost of $3.9 million. An additional $0.6 million was incurred by State and private entities. Ramp extensions/ relocations on Reservation lands are shown in Table 3.12-3; total Federal costs amounted to $145,200 and other agency total costs amounted to $161,500. In areas where use has increased, facilities have been improved to minimize the adverse effects of overcrowding.

Under a recently enacted Title VI Program included in the Water Resource Development Act (WRDA 99), the government has begun a lengthy process to transfer lands including Corps recreational sites to the State of South Dakota, and the Cheyenne River Sioux and Lower Brule Tribes. For the interim, 23 recreational sites have been leased to the State of South Dakota.

River recreation, like lake recreation, is predominantly water based. Boating is a major activity, with fishing activity high in tailwater reaches below the dams. Boating, and to some extent fishing, are affected by river flows and releases from the mainstem dams. Low flows may limit river activity and access to the river from marinas and boat launches.

Table 3.12-1. Recreation facilities on the mainstem lakes.

Reach	Number of NRMS Reporting Areas[a/]	Number of Marinas		Number of Camping Sites	Number of Swimming Areas
		Open	Closed[b/]		
Fort Peck Lake	26	3	1	231	3
Lake Sakakawea	45	9	4	1,111	4
Lake Oahe	52	4	0	995	5
Lake Sharpe	31	1	0	371	7
Lake Francis Case	31	3	0	578	6
Lewis and Clark Lake	28	2	0	1,022	7
Total	**213**	**22**	**5**	**4,308**	**32**

a/ The Natural Resource Management System (NRMS) reporting areas include sites where visitor use occurs and may include visitor centers, powerplant exhibit areas, cabin sites, fishing access areas, campgrounds, multiple use areas, and day use facilities. These areas are located both upstream and immediately downstream of the dam within the project boundary.

b/ In 1993, the upper three lakes returned to near normal water levels, and all marinas were reopened.

Source: Corps, 1991b.

Table 3.12-2. Recreational lands on Reservation land.

Reservation	Existing Recreational Land		Acres
Fort Peck Reservation	N/A		0
Fort Berthold Reservation	Beaver Creek Bay		65
	Indian Hills		62
	Deepwater		17
	Parshall Bay		172
	Van Hook		46
	Pouch Point		50
	Newtown		174
	McKenzie Bay		383
	Charging Eagle		960
	Twin Buttes		900
	Four Bears		10
	Skunk Creek		302
	Reunion Bay		50
		Total:	**1,508**
Standing Rock Reservation	Indian Memorial		247
	Grand River		19
	Fort Yates		210
	Walker Bottom		117
	Four Mile Bay*		305
		Total:	**898**

Table 3.12-2. Recreational lands on Reservation land (continued).

Reservation	Existing Recreational Land	Acres
Cheyenne River Reservation	Forest City	75
	Rousseau Area	448
	Old Agency Park*	190
	Aeber Creek*	145
	Blackfoot Area*	192
	Bender Bay*	73
	Total:	**1,123**
Lower Brule Reservation	Left Tailrace	66
	Right Tailrace	148
	Good Soldier	17
	Counselor Creek	375
	Lower Brule Area	52
	Lower Brule Ramp	6
	Narrows Area	1,100
	Iron Nation North	146
	Iron Nation South	459
	Cedar Creek	250
	Jiggs Area*	20
	Total:	**2,639**
Crow Creek Reservation	Spillway	115
	Old Ft. Thompson	170
	North Shore	340
	North Bend	161
	West Bend	173
	Joe Creek	141
	Crow Creek Area	4
	Total:	**1,104**
Yankton Reservation	N/A	0
Ponca Reservation	N/A	0
Santee Reservation	Santee Area	109
	Bazile Creek Area	1
	Total:	**110**
Winnebago Reservation	N/A	0
Omaha Reservation	N/A	0
Iowa Reservation	N/A	0
Sac & Fox Reservation	N/A	0
	Total Recreational Area on Reservation Lands:	**7,382**

* Denotes Future Recreational Area.

Table 3.12-3. Ramp extensions/relocations on Reservation lands.

Reservation	Ramp
Fort Peck Reservation	N/A
Fort Berthold Reservation	**Beaver Bay** - Low water ramp constructed in 1989 by North Dakota Game and Fish Department (NDG&F) ($4,500). Permanent ramp replace in 1990 by NDG&F and Zap Park Board ($14,000). Low water ramp constructed in 1990 by Corps as relocated Little Missouri Bay ramp ($36,300). **Deepwater Creek** - (Cabin Site) low water ramp constructed in 1988/89 by NDG&F (3,500). Low water ramp constructed in 1989/90 by Corps ($55,300). **Four Bears Park** - Low water ramp constructed in 1989 by Corps ($32,700). **Indian Hills** - Low water ramp constructed in 1988 and extended in 1991 by NDG&F ($4,500). Main ramp extended in 1989 by NDG&F ($63,500). **McKenzie Bay** - Low water ramp constructed in 1988 by NDG&F ($3,500). Main ramp extended in 1988/89 by NDG&F and McKenzie Marine Club ($5,600). Low water ramp relocated in 1989 and extended in 1990, 1991, and 1992 ($10,600). **Newtown Marina** - Ramp extended in 1988, 1989, and 1990 by NDG&F and Newtown Marine Club ($6,100). **Parshall Bay** - Low water ramp constructed in 1988, extended in 1989, 1990, and 1991 by NDG&F and Mountrail County ($12,200). Main ramp extended in 1988 and 1989 ($8,200). **Pouch Point** - Low water ramp constructed in 1989 by concessionaire and TAT ($3, 500). Low water ramp relocated in 1990 ($2,000). **Reunion Bay** - Low water ramp installed in 1991 by NDF&F ($8,800). **Van Hook** - Low water ramp constructed in 1988, reworked in 1991 by NDG&F ($6,000). Low water ramp relocated in 1992 ($5,000).
Standing Rock Reservation	**Walker Bottom** - Low water ramp constructed in 1989 as relocation for Ft. Yates by Corps ($20,900).
Cheyenne River Reservation	N/A
Lower Brule Reservation	N/A
Crow Creek Reservation	N/A
Yankton Reservation	N/A
Ponca Reservation	N/A
Santee Reservation	N/A
Winnebago Reservation	N/A
Omaha Reservation	N/A
Iowa Reservation	N/A
Sac & Fox Reservation	N/A
Total Federal Costs: $145,200	
Other Agency Costs: $161,500	

Portions of the river above Fort Peck Lake and below Fort Randall and Gavins Point Dams are designated components of the National WSRS under the WSRA. The two lower sections are designated as Missouri National Recreational Rivers under the WSRA. These two sections are the 39-mile reach below Fort Randall Dam (including along the river bank of the Yankton Reservation) and the 58-mile reach below Gavins Point Dam.

3.12.2 Fort Peck Lake

Fort Peck Lake is located in northeastern Montana (Figure 3.12-1). The lake typically ranges from 2 to 5 miles wide for most of its length, but a section near the dam extending into the Big Dry Arm is 15 miles wide. Fort Peck Lake contains 1,520 miles of shoreline, and 7,862 acres are designated for recreational use. This lake is unique among the other mainstem lakes because it is surrounded by the Charles M. Russell NWR.

Fort Peck Lake is primarily attractive to recreationists for its abundant and varied fishing opportunities. Visitor Estimation and Reporting System data indicate that visitor recreation days totaled 315,000 days in 1993 (Table 3.12-4). The lake offers a wide variety of sportfish. Walleye, sauger, and lake trout have long been the staple species of the fishery; however, catfish, chinook salmon, and smallmouth bass have been introduced in recent years to develop additional sport fishing opportunities. Besides fishing, the lake offers other water-based activities, including waterskiing, sailing, pleasure boating, canoeing, and jetskiing.

Land-based activities include hunting, camping, hiking, sightseeing, and picnicking. Lands around Fort Peck Lake are noted for upland game hunting. The lake's surroundings offer opportunities to observe diverse wildlife, habitat, and scenic vistas.

Fort Peck Lake is less accessible than the other lakes due to the management objectives of the surrounding NWR, limited road network, remoteness, and rugged terrain. A limited number of recreation sites have been developed around the lake, and in recent years, road improvements have been made to access these sites. Visitors have also increased the distances that they travel in pursuit of recreation and leisure.

Boat ramps were extended in the early stages of the 1987 to 1993 drought, allowing boaters to continue to access the lake (Table 3.12-5). These improvements offset the negative impacts of the 1987 to 1993 drought to some extent. Access to the southwest segment of the lake, however, was affected. Both the boat ramp at the Crooked Creek Recreation Area and the marina facility were closed in 1988. A ramp in the upper reaches of the Big Dry Arm area was also unusable. In late summer 1993 (August), boat ramps at Crooked Creek and Nelson Creek once again became operational while the marina became operational in time for the 1994 season. The boat ramps were again affected by drought in 1997.

The Montana Department of Fish and Game has increased its efforts to stock the lake with sport fish. Fish management efforts were hampered, however, during the drought. Use of spawning stations necessary for propagation of fish for stocking was curtailed by the low lake levels. Drawdowns during the drought reduced coldwater habitat. It is not known whether this reduction affected the coldwater fish population.

Fort Peck Lake is enjoyed for its aesthetics, remote characteristics, and excellent coldwater fishing. Increases in visitation are expected to continue; however, the lake's relative inaccessibility and distance from major population centers are expected to limit growth.

3.12.3 Missouri River from Fort Peck Dam to Lake Sakakawea

The river reach from Fort Peck Dam to Lake Sakakawea is a 204-mile stretch of river that extends from northeastern Montana and continues to the northwestern portion of North Dakota (Figure 3.12-2). The Fort Peck Reservation is located adjacent to the river on the northern side for much of the reach.

This reach is popular for boating, including canoeing and floating; fishing; and deer hunting. In 1993, total recreation days were 55,000 (Table 3.12-4). A trout fishery, located within the first 6 miles below Fort Peck Dam, is a popular attraction. Bank fishing is popular 10 miles downstream from Fort Peck Dam to the delta of Lake Sakakawea. There are only three boat ramps along this reach. Of these three boat ramps, one ramp is located on the Fort Peck Reservation. There are no recreational areas identified on the Fort Peck Reservation (Table 3.12-2).

Use of boat ramps below the dam is contingent upon dam releases. A minimum 4-kcfs release from Fort Peck Dam is required to ensure that one ramp is usable. All of the ramps are usable when the release reaches 8 kcfs.

The 1987 to 1993 drought and repairs to one of the two powerhouses at Fort Peck Dam affected flows in this river reach. In general, the effect was beneficial as the lower and steady flows reduced erosion in this reach. This improved reach aesthetics and waterfowl hunting. These changes also affected the location and number of fish found in this portion of the river.

3.12.4 Lake Sakakawea

Lake Sakakawea is located in North Dakota, beginning at Garrison Dam (RM 1390). The lake extends 178 miles in a northwesterly direction, averages 3 miles in width, and includes 1,340 shoreline miles (Figure 3.12-3). The lake is characterized by steep banks and surrounded by large expanses of prairie. A major portion of the lake is within the Fort Berthold Reservation. There are 45 developed recreation sites located on Lake

Table 3.12-4. 1993 recreation days, 1995 visitor hours, and 2000 visitor hours for the Missouri River.

Reach	1993 Recreation Days	1995 Visitor Hours	2000 Visitor Hours
Fort Peck Lake	315,000	4,200,000	6,073,500
Downstream of Fort Peck Dam	55,000		
Lake Sakakawea	1,152,000	11,600,000	16,485,900
Downstream of Garrison Dam	216,000		
Lake Oahe	1,815,000	16,000,000	14,175,800
Lake Sharpe	852,000	3,500,000	5,204,000
Lake Francis Case	1,266,000	10,100,000	9,489,300
Downstream of Fort Randall Dam	130,000		
Lewis and Clark Lake	1,249,000	8,300,000	8,290,500
Subtotal Upper River Lakes and Reaches	**7,050,000**	**53,700,000**	**59,719,000**
Gavins Point Dam Downstream to Sioux City	744,000		
Sioux City to Kansas City	1,945,000		
Kansas City to Missouri River Mouth	451,000		
Subtotal Lower River Reaches	**3,140,000**		
Total	**10,190,000**		

Note: The activities used in determining recreation days are wide ranging, including soccer, tennis, and other non-water-based recreational pursuits. These activities are more prevalent on the reaches located below Lewis and Clark Lake; therefore, not all recreation days on that portion of the river depend on pool elevations and river flows.

Source: Corps, 1994h.

Table 3.12-5. Effects of lake elevation on access to three upper mainstem lakes.[a/]

	Number of Areas on Lake with Boat Ramps[b/]	Average Pool Elevation, July 1992 (feet)	Number of Ramps Usable at Pool Elevation, July 1992	Lowest Pool Elevation, 1987-1993 Drought Cycle (feet)	Number of Ramps Usable, 1987-1993 Drought Cycle
Fort Peck Lake	12	2,212.9	9	2,208.7	8
Lake Sakakawea	37	1,824.6	31	1,815.0	20
Lake Oahe	40	1,589.7	30	1,580.7	23
Total	**89**		**70**		**51**

a/ The pool levels in Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake have remained fairly constant and, therefore, boat access has not been affected by the recent drought.

b/ The total number of ramps in a given area varies, depending on the water level. Many areas have multiple ramps, such as a low and/or high water ramp.

Note: Corps statistics from 1967 to 1987 (a “normal” period) of the average daily pool elevation range from April 1 to October 30: Fort Peck 2,237.3 – 2,242.7 (feet); Lake Sakakawea 1,839.0 – 1,846.0 (feet); Lake Oahe 1,604.7 – 1,610.8 (feet).

Source: Corps, 1994h.

Sakakawea (Table 3.12-1). Of these 45 recreational sites, 13 are located on Fort Berthold Reservation for a total of 1,508 acres (Table 3.12-2). These recreational sites include two cabin developments, the McKenzie Marine Club and the Newtown Marine Club. Lake Sakakawea has three State parks: Lake Sakakawea State Park, Fort Stevenson State Park, and Lewis and Clark State Park. These areas offer well-developed recreational facilities; camping, swimming, and picnicking are popular activities.

Other popular activities include hunting, sightseeing, hiking, boating, and fishing. A Federal fish hatchery capable of producing coldwater, coolwater, and warmwater species is located below Garrison Dam, and it contributes to the diversity of fish available. The lake fishery is managed primarily for walleye, sauger, and chinook salmon. Upland game hunting opportunities include pheasant, deer, and waterfowl.

On Lake Sakakawea, recreation days totaled 1,152,000 in 1993 (Table 3.12-4). Boat ramp access to the lake is affected by water level declines (Table 3.12-5). Boat ramps were extended or relocated throughout the 1987 to 1993 drought period to maintain access to the lake. The upper one-third of the lake was most affected by the drought, with only a few areas remaining accessible. A total of 10 boat ramps were either extended or relocated, as identified in Table 3.12-3, on the Fort Berthold Reservation. Lake-wide, 54 percent of the ramps were accessible, even at the lowest lake level, and visitation shifted toward those sites. Declining water surface elevations during the 1987 to 1993 drought reduced natural reproduction of walleye; however, increased stocking maintained a good population. Implementation of more stringent harvest limits during the drought also helped maintain the population. The declining water levels also reduced coldwater habitat in the upper lake reaches, and coldwater fishing opportunities shifted to the lower portions of the lake.

The 1987 to 1993 drought also affected camping, swimming, boating, sightseeing, and hiking. Recreationists have had to alter their array of choices in terms of locations available to them.

Hunting along the banks of Lake Sakakawea improved during the 1987 to 1993 drought. Vegetation grew in areas normally covered by water, thereby providing habitat for wetland and other species.

The 1987 to 1993 drought had both positive and negative effects on the aesthetic character of the lake. In certain areas, shoreline that became visible added to the beauty of the lake. In more shallow arms connected to the lake, some areas are unattractive because they have no water and are not used by recreationists.

Services such as marine fuel sales and slip rentals were reduced or eliminated at some concessionaires where the drawdown significantly affected business.

3.12.5 Missouri River from Garrison Dam to Lake Oahe

The river reach from Garrison Dam to Lake Oahe is an 87-mile unchannelized river stretch. Population centers of Bismarck and Mandan, North Dakota, are located near the downstream end (Figure 3.12-4). Proximity to these cities and the river's aesthetic values contribute to the popularity of this river reach for recreation. Recreation use is estimated at 216,000 recreation days on this river reach (Table 3.12-4).

Along the reach, parks and recreational sites provide visitors with a variety of recreational opportunities. There are 15 sites found on the reach. Cross Ranch State Park is located approximately 36 miles from Bismarck near Hensler, North Dakota. Just outside of the Bismarck City limits is Sibley Park, a county park that has boat launches and islands along the shoreline that can be reached by swimmers. South of Mandan, Fort Lincoln State Park provides easily accessible recreational opportunities. Camping, boating, hiking, swimming, and picnicking are popular activities in these areas.

Fishing and hunting are also popular in this reach. A popular fishery has developed below Garrison Dam. At the upper end of the reach, water temperatures are cool enough to support trout and salmon year round. Other species along the reach include channel catfish, walleye, sauger, and white bass. White tailed deer is the most harvested game species.

The 1987 to 1993 drought affected this reach minimally. In some cases, the effect was positive because there were more islands and sandbars available for recreation under reduced flows. On the negative side, boaters had to remove their large boats from the water earlier in the fall under lower flows. Because of lower Lake Oahe levels and the change from a lake environment to a river-like environment downstream from Bismarck, river fishermen adjusted their fishing patterns by moving farther downstream into the upper reaches of Lake Oahe.

3.12.6 Lake Oahe

Lake Oahe extends for 231 miles from approximately 5 miles below Bismarck to approximately 4 miles north of Pierre (Figure 3.12-5). The lake has 2,250 miles of shoreline with 52 developed recreational sites ranging from well developed to primitive (Table 3.12-1). The most intense recreational development exists at the two ends of the lake and at the town of Mobridge, South Dakota. The Standing Rock and Cheyenne River Reservations are located along the west side of the lake. Of the 52 developed recreational sites, Standing Rock Reservation has four existing recreational sites and one future recreational site for a total of 898 acres, while the Cheyenne River Reservation has two existing recreational sites and four future recreational sites for a total of 1,123 acres (Table 3.12-2).

Boating, fishing, hunting, nature walks, camping, picnicking, and sightseeing are popular recreational activities on Lake Oahe. Total recreation days were 1,815,000 for 1993 (Table 3.12-4). Lake Oahe attracts visitors because of its high-quality fishing. Sport fish species include walleye, chinook salmon, channel catfish, northern pike, white bass, sauger, trout, blue gill (*Lepomis macrochirus*), and crappie. Waterfowl and upland and big game hunting opportunities exist. Commonly sought species include sharptail grouse, Canada goose, and various ducks.

The 1987 to 1993 drought adversely affected Lake Oahe recreation. As with Fort Peck Lake and Lake Sakakawea, several boat ramps had to be extended or relocated to provide continued access to the lake. Only one low-water ramp was constructed as a relocation ramp for Fort Yates in 1989 on the Standing Rock Reservation (Table 3.12-3). At the lowest pool level during the drought, 40 percent of the ramps were not accessible. Access on the west side of the lake was particularly limited. Much of the upper half of the lake receded to river conditions, which affected usage of several major recreation areas.

Because of the drought, fish habitat declined, decreasing forage and gamefish populations in the lake. However, emerald shiner and yellow perch populations increased, making up for some of the loss in forage fish. Declining water-surface elevations reduced reproduction of walleye, the principal sportfish, during the 1987 to 1993 drought; however, increased stocking maintained a good population. Walleye numbers have gradually increased since 1990 as lake levels have risen from lows in 1989 and 1990. A sharp increase in northern pike reproduction was apparent in 1993 that was also attributable to the rising water levels. These and other changes provide for an optimistic prognosis for the coming years.

Bottomland habitat for most game species increased during the 1987 to 1993 drought, and hunting conditions improved. Vegetation growth in shallow areas that at one time were submerged decreased erosion along shorelines. When the water rose, fish spawning and rearing habitat improved as shoreline vegetation was again flooded.

3.12.7 Missouri River from Oahe Dam to Lake Sharpe

The river reach located below Oahe Dam to the headwaters of Lake Sharpe is about 5 miles long. Pierre and Fort Pierre are located along this reach (Figure 3.12-6). This is a major population center that has extensive river development, including the Pierre waterfront, a nature trail, a biking trail, a dock, and an amphitheater. Other activities include fishing, waterskiing, pleasure boating, and windsurfing.

Fishing is excellent and popular below Oahe Dam, and there is a major Corps recreation area downstream from the dam. Recreational activities in this reach are dependent on river levels that are primarily influenced by Lake Sharpe water levels. System operations normally do not affect recreation in this river reach because Lake Sharpe levels are always relatively constant. Because fishing is curtailed when daily flows fall to zero in the daily peaking cycle, the Corps maintains weekend releases to support fishing.

3.12.8 Lake Sharpe

Lake Sharpe extends 80 miles north from Big Bend Dam (RM 987) (Figure 3.12-4). The lake is bordered on the east side by the Crow Creek Reservation and on the west side by the Lower

Brule Reservation. There are 31 recreational facilities, ranging from primitive to well developed. Of these 31 recreational facilities, 10 are located on the Lower Brule Reservation, with one site identified as a future recreational area, and seven are located on the Crow Creek Reservation. The Lower Brule Reservation and the Crow Creek Reservation have a total recreational acreage of 2,639 acres and 1,104 acres, respectively (Table 3.12-2). The condition of these facilities can be classified as ranging from primitive development to fully developed campgrounds with waterborne facilities and electric hookups. In 1993, recreation days totaled 852,000 (Table 3.12-4).

Fishing is the most popular activity at Lake Sharpe because stable lake levels and good water quality provide good spawning and rearing habitat for fish. Walleye, smallmouth bass, northern pike, sauger, and yellow perch are commonly caught species. Walleye fishing has been excellent during the recent drought.

Sightseeing, swimming, hiking, camping, picnicking, powerboating, and hunting are popular recreational activities on the lake and along its shoreline.

Lake Sharpe pool levels are maintained at about 1,420 feet at all times. Consequently, recreation on the lake was not affected as a result of the 1987 to 1993 drought.

3.12.9 Lake Francis Case

Lake Francis Case, located in south-central South Dakota, extends for 107 miles from Big Bend Dam to Fort Randall Dam (RM 880) at Pickstown, South Dakota, near the Nebraska State line (Figure 3.12-7). The Yankton Reservation extends from RM 880 along the north shoreline at Fort Randall Dam to RM 845 along the north shoreline downstream of Fort Randall Dam.

There are 31 recreational facilities along the lake that range from full-service development to primitive lake access. Of these 31 recreational facilities, four of the sites are located along the former Yankton Reservation shoreline (Table 3.12-2). Recreational activities pursued within the Lake Francis Case region include hunting, fishing, sightseeing, camping, picnicking, boating, sailing, and swimming. Recreation days in 1993 totaled 1,266,000 days (Table 3.12-4).

Walleye dominate the sport fish harvest, representing 70 to 90 percent of the total sport harvest. Smallmouth bass, northern pike, white bass, and channel catfish are also harvested.

Lake Francis Case has consistent operations whether the system is experiencing normal inflow periods or drought. The annual fall drawdown of Lake Francis Case, which negatively affects recreational activities, continued through the 1987 to 1993 drought. Fishing remained popular despite reduced harvest and minimum size limits on walleye that were initiated by South Dakota in 1990. Attendance at fishing tournaments on the lake increased. The abundance of sport fish has increased since 1990, except in the lower portion of the lake.

Current development along Lake Francis Case includes Cedar Shores Resort near Chamberlain, South Dakota. This is a major resort with a motel, camping facilities, and a large marina.

3.12.10 Missouri River from Fort Randall Dam to Lewis and Clark Lake

The river reach from Fort Randall Dam to Lewis and Clark Lake is a 44-mile unchannelized reach that has been designated a National Recreational River under the WSRA (Figure 3.12-8). This reach extends from approximately Pickstown to Niobrara State Park in Nebraska. The Yankton Reservation borders a portion of this stretch on the north bank. Ponca Tribal Land is located south of the Yankton Reservation at the confluence of the Niobrara River and the Missouri River.

The upper 39 miles are collectively designated as the 39-mile Missouri National Recreational River (MNRR). This section is managed by the National Park Service (NPS) as a primitive recreational area to protect its wildlife habitat, natural landscapes of the Lewis and Clark National Historical Trail, and cultural resources. It also provides a primitive recreational experience.

There are approximately six public boat access sites located along the reach. Some boat ramps are located downstream of Fort Randall Dam and are designed to operate under the fluctuating dam releases for power production and navigation. Currently, none of the sites located downstream of Fort Randall Dam are located on either the Yankton Reservation or the Ponca Tribal Land

(Table 3.12-2). Some cabin developments attract visitors from distant population centers.

Boating, waterfowl hunting, and fishing are popular water-based activities enjoyed on the reach. Sandbars are popular for volleyball, picnicking, and other leisure activities. Canoeing and float trips originating at Fort Randall Dam and ending at Niobrara State Park are popular.

The effect of the 1987 to 1993 drought on recreation was minimal. Visitation is estimated at 130,000 recreation days (Table 3.12-4). Low flows during the "Great Flood of 1993" brought poor conditions for recreation and reduced visitation.

3.12.11 Lewis and Clark Lake

Lewis and Clark Lake, impounded by Gavins Point Dam (RM 811), is located on the Nebraska and South Dakota State line. There are 90 shoreline miles with 28 recreational sites (Figure 3.12-9). In 1993, recreation days totaled 1,249,000 on Lewis and Clark Lake (Table 3.12-4). Recreational areas along the lake are easily accessible by highway systems. The Santee Reservation is located on the south side in the upper reaches of the lake. Of the 28 recreational areas on Lewis and Clark Lake, only two recreational areas are located on the Santee Reservation shoreline, for a total of 110 acres (Table 3.12-2).

Recreational opportunities include land and water-based activities. Power boating, sailing, canoeing, water-skiing, fishing, and swimming are primary water activities. Land-based activities include camping, picnicking, hiking, golf, horseback riding, bicycling, archery, and hunting. Popular winter activities include cross-country skiing, snow mobiling, ice skating, ice fishing, ice sailing, and sledding.

The lake has unique fishing opportunities. Sauger is the most sought after fish species, while walleye, channel catfish, and smallmouth bass are also harvested. Thousands of visitors are attracted to the tailwaters of the dam for the annual paddlefish season.

Lewis and Clark Lake operations are basically the same every year. The 1987 to 1993 drought had little effect on recreational activity on the lake.

3.12.12 Missouri River from Gavins Point Dam to Sioux City

The 58-mile segment of the Lower River from below Gavins Point Dam, located on the Nebraska and South Dakota State line, to Ponca State Park (RM 810-752) in Nebraska is a component of the National WSRS and has been designated a National Recreation River (Figure 3.12-10) under WSRA. The Kenslers Bend Bank Stabilization Project extends from Ponca State Park to Sioux City. This river reach is very scenic, with hilly, rolling terrain extending to the horizon.

Recreational use of the area is similar to that associated with other river stretches of the Missouri River Mainstem Reservoir System. The recreation activity on this reach of the river is estimated at 744,000 recreation days (Table 3.12-4). Boating, jetskiing, water-skiing, canoeing, fishing, sightseeing, and swimming are popular activities. Waterfowl hunting is also popular. This reach provides important recreational opportunities for the population centers of Omaha and Sioux City. Cabin development is extensive, and well-developed camping facilities are available along this reach.

Most boat ramps are inaccessible during nonnavigation season (generally November 21 through March 20) along the upper unchannelized portion of this river reach above Ponca. There are approximately three boat ramps that are usable by small fishing boats during the winter.

Recreation was relatively unaffected by the 1987 to 1993 drought because the navigation season flows were maintained during most of the spring through fall seasons. Access was severely limited in 1993 due to very low releases from Gavins Point Dam as a consequence of the "Great Flood of 1993."

3.12.13 Missouri River from Sioux City to Omaha

The Lower River is channelized for navigation from Sioux City to Omaha (Figure 3.12-11). This reach is 118 miles long with 17 developed recreation sites. A small portion of this reach is abutted by both the Winnebago and Omaha Reservations. Of the 17 developed recreational sites, none of the sites is located on the Winnebago Reservation banks or the Omaha Reservation banks (Table 3.12-2).

The reach is popular for boating and has seven marinas. In addition, Ponca State Park and Wilson Island State Park offer diverse recreational opportunities. Oxbow lakes near the river, including Lake Manawa, Snyder Lake, and Brown's Lake, account for a significant amount of this activity. The DeSoto Bend NWR, Boyer Chute, and other wildlife refuges are located along the river.

The 1987 to 1993 drought resulted in a shorter navigation season in some years; thus, lower flows were released earlier from upstream lakes. During nonnavigation periods, lower flows made river access more difficult, and all marinas closed. In some cases, boat ramps reached the river, but flows were not sufficient for boats to navigate. Small fishing boats usually do not experience difficulties during the low-flow period.

Numerous oxbow lakes were formed along this reach and downstream reaches of the river during major floods or during the construction of the BSNP. Many of these lakes have recreational development, and they are heavily used by those seeking opportunities to boat, fish, swim, picnic, hike, and camp.

3.12.14 Missouri River from Omaha to Kansas City

The Lower River reach from Omaha to Kansas City is channelized to support navigation (Figure 3.12-11). This reach is 250 miles long and has 22 developed recreation areas. A small portion of the reach is abutted by the Iowa and Sac and Fox Reservations. Of the 22 developed recreational areas, none are located on the Iowa and Sac and Fox Reservations (Table 3.12-2).

This reach offers wildlife areas, State parks with fully developed recreational areas, and city parks providing a wide range of recreational opportunities. Dodge Park in Omaha and Riverview Park in Nebraska City are examples of popular city parks. Boating, fishing, swimming, hunting, hiking, camping, and nature study are popular recreational pursuits along this reach. The primary sportfish species are channel catfish and carp.

As is the case with the Sioux City to Omaha reach, reduced levels of service to navigation affect recreational opportunities. Boat ramp access is not maintained during periods of nonnavigation. This limits the ability of boaters to use the river for recreational pursuits.

Visitation for the channelized river reach extending from Sioux City to Kansas City totaled 1,945,000 recreation days (Table 3.12-4).

3.12.15 Missouri River from Kansas City to St. Louis

This is a channelized reach that is 312 miles long and has 32 developed recreation sites (Figure 3.12-12). Proximity to the population centers of Kansas City and St. Louis and smaller towns in between make this a popular reach for recreation.

Similar to the upper portion of the channelized river, this reach offers diverse recreational opportunities from developed recreation sites to city parks with soccer fields, tennis courts, and ballfield complexes. Popular recreation activities include boating, fishing, hunting, hiking, camping, and nature study. Sportfish species include channel catfish, carp, flathead catfish, crappie, sturgeon, largemouth bass, and paddlefish.

During the 1987 to 1993 drought, a number of shortened navigation seasons occurred. This affected boaters' ability to access the water and to navigate. Some boat ramps are inaccessible during nonnavigation periods.

Visitation for the channelized reach from Kansas City to St. Louis totaled 451,000 recreation days (Table 3.12-4).

3.12.16 Mississippi River from St. Louis to Mouth

This reach of the Mississippi River offers abundant opportunities for outdoor recreation not requiring developed sites. Access is somewhat limited due to lack of boat launching ramps. Where launch sites are available, many individuals participate in activities such as fishing, hunting, and boating.

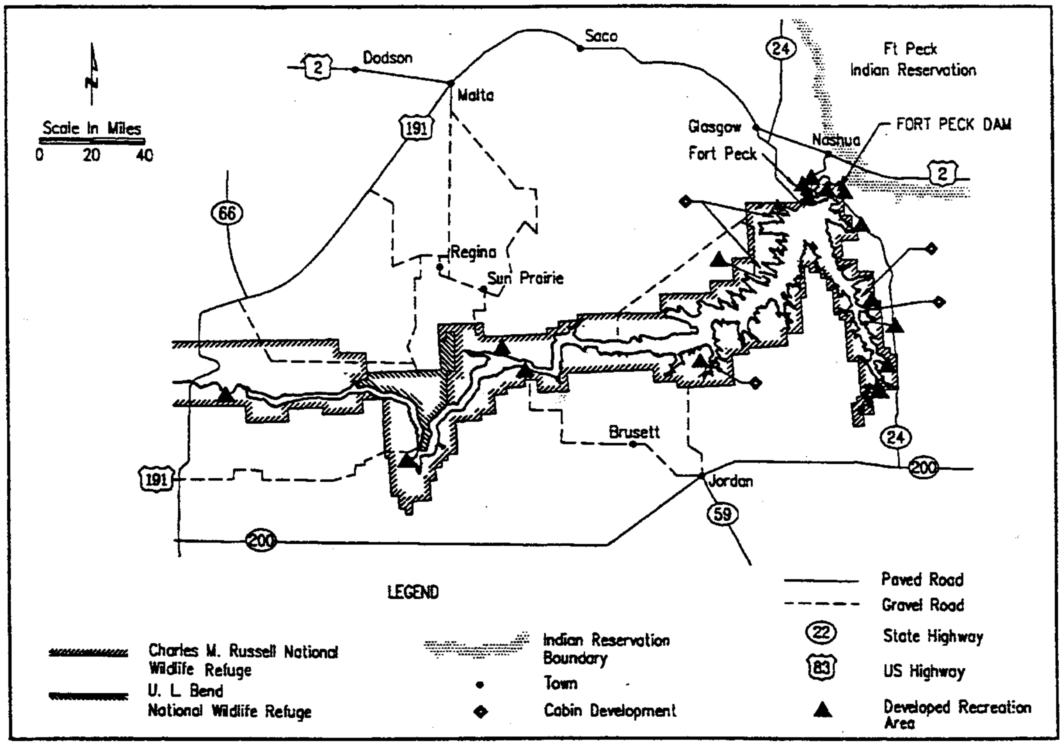

Figure 3.12-1. Fort Peck Lake, Montana.

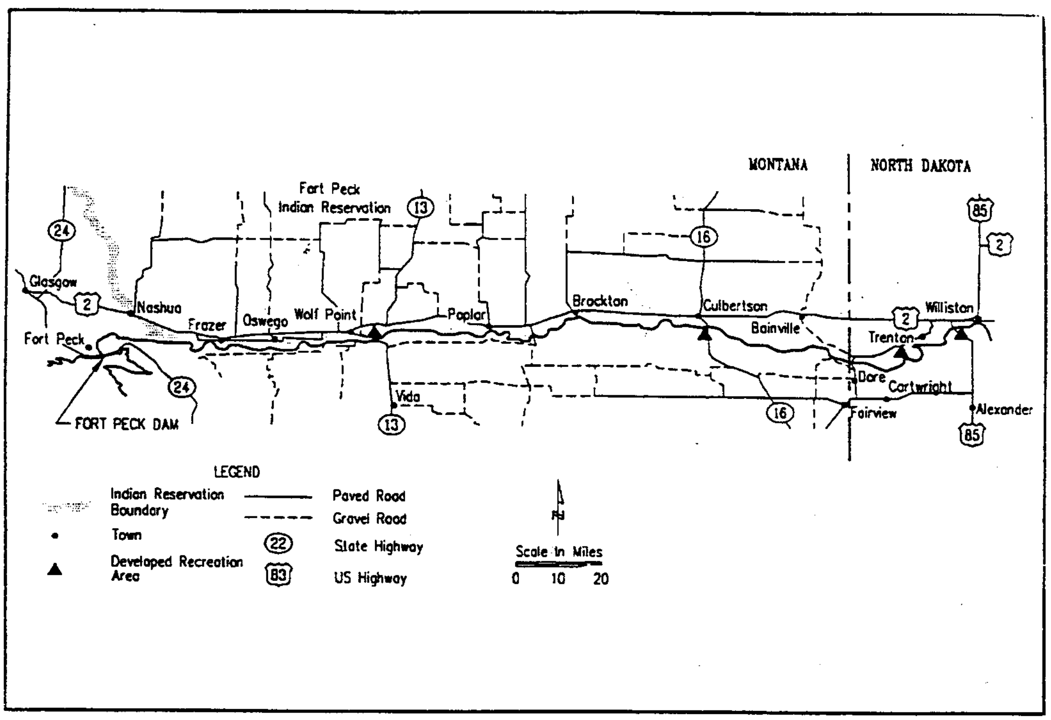

Figure 3.12-2. River reach from Fort Peck Lake, Montana, to Lake Sakakawea, North Dakota.

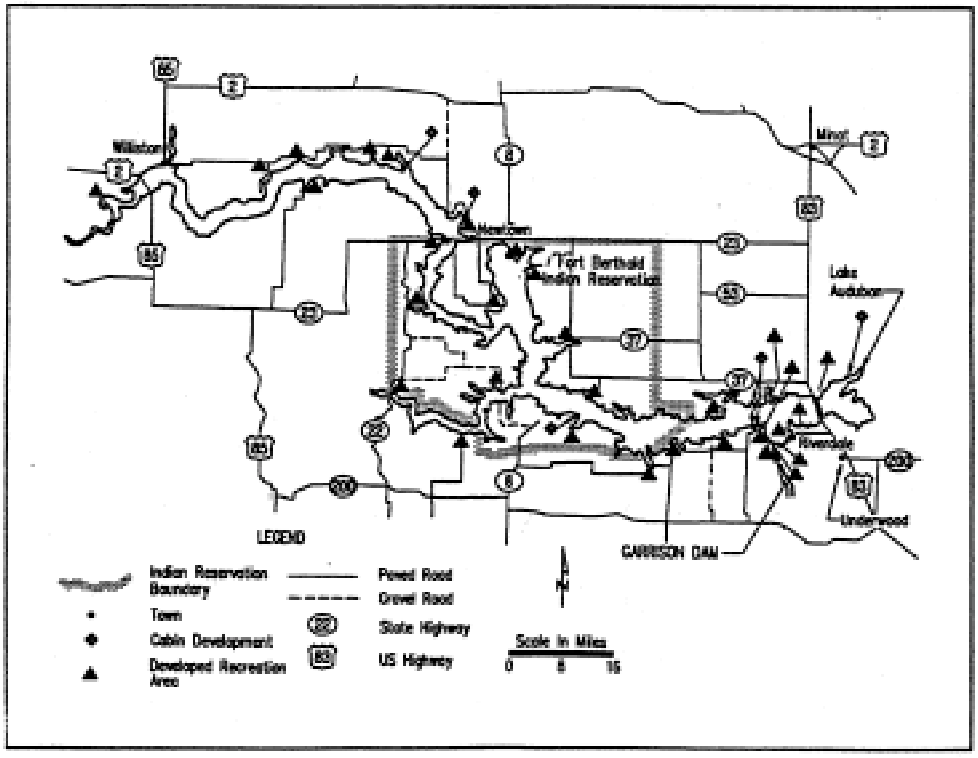

Figure 3.12-3. Lake Sakakawea, North Dakota.

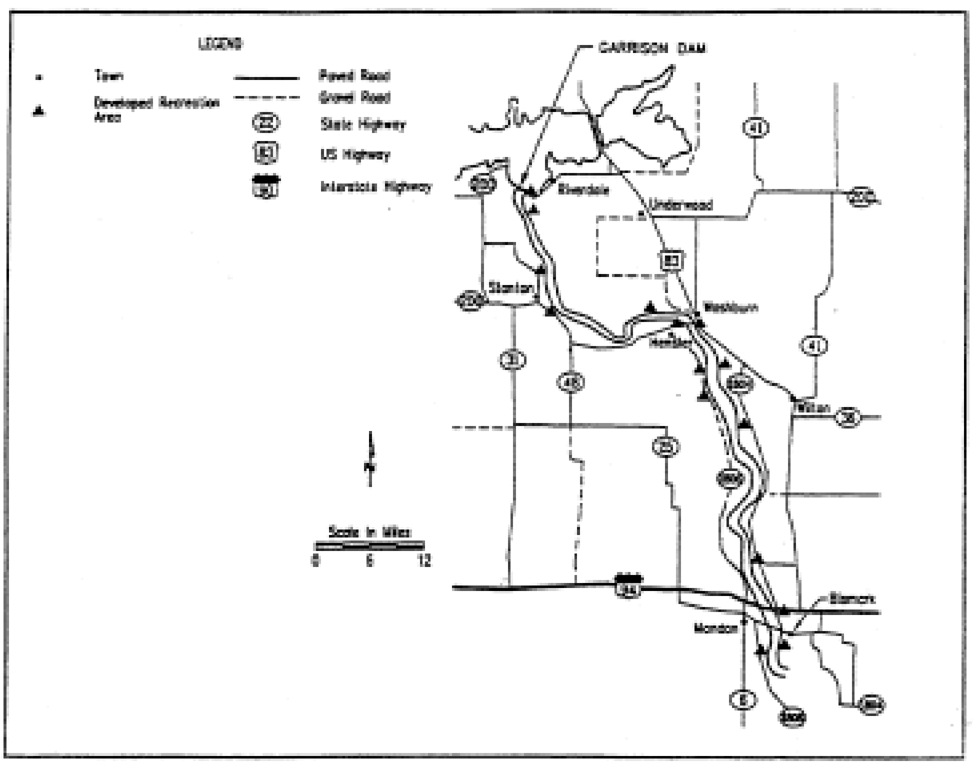

Figure 3.12-4. River reach from Lake Sakakawea to Lake Oahe, North Dakota.

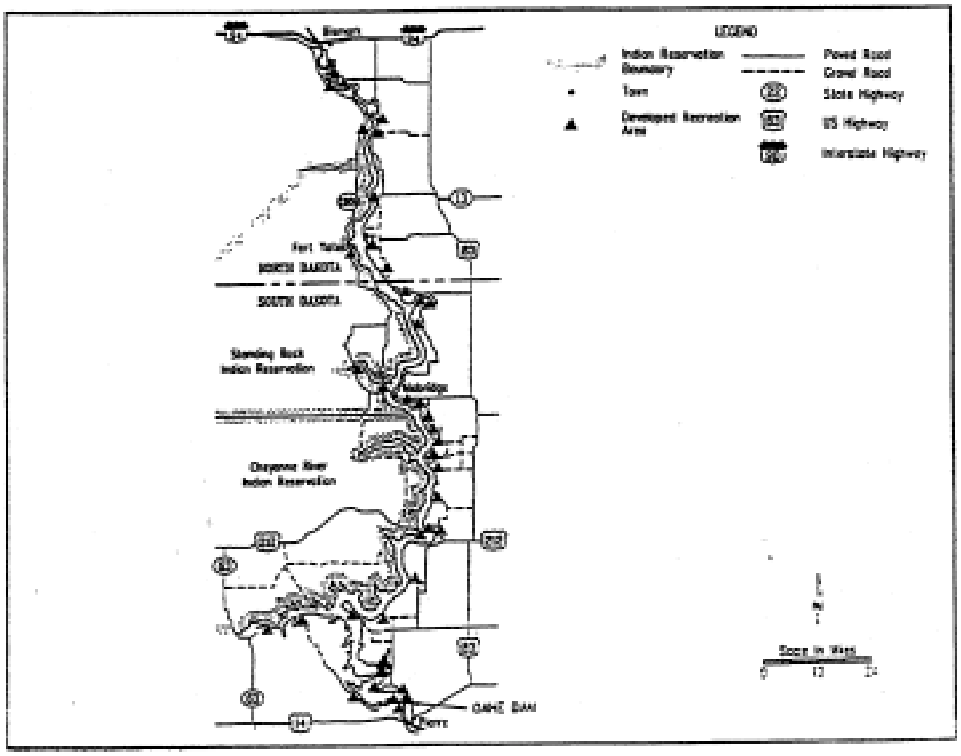

Figure 3.12-5. Lake Oahe, North Dakota and South Dakota.

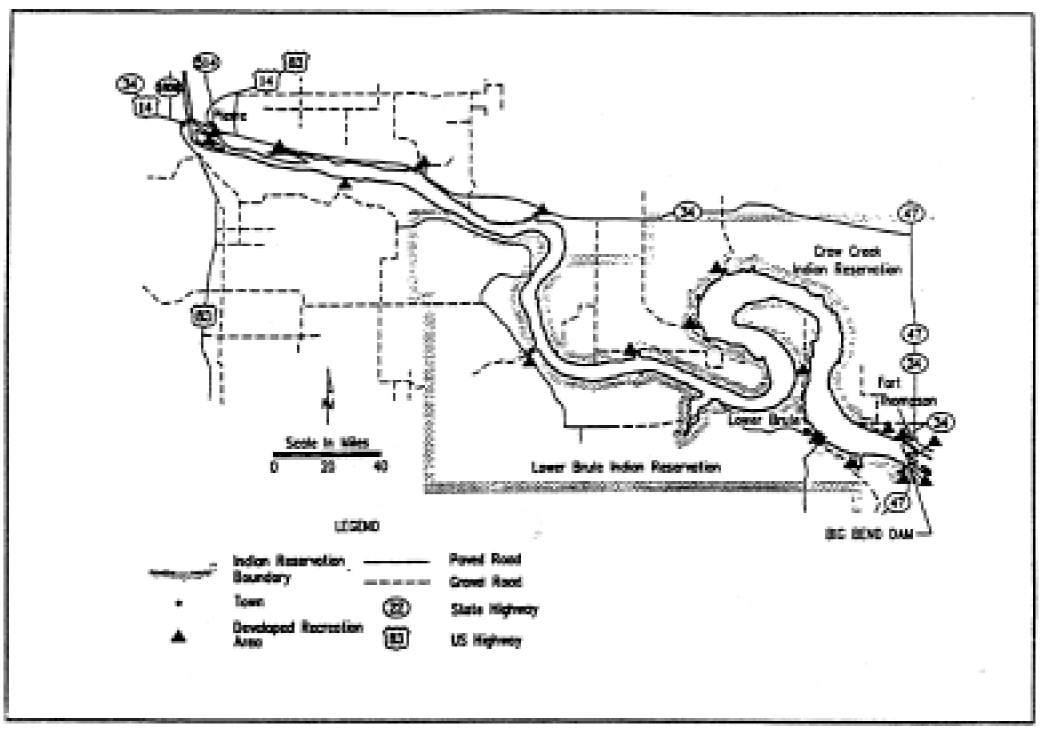

Figure 3.12-6. River reach from Lake Oahe to Lake Sharpe and Lake Sharpe, South Dakota.

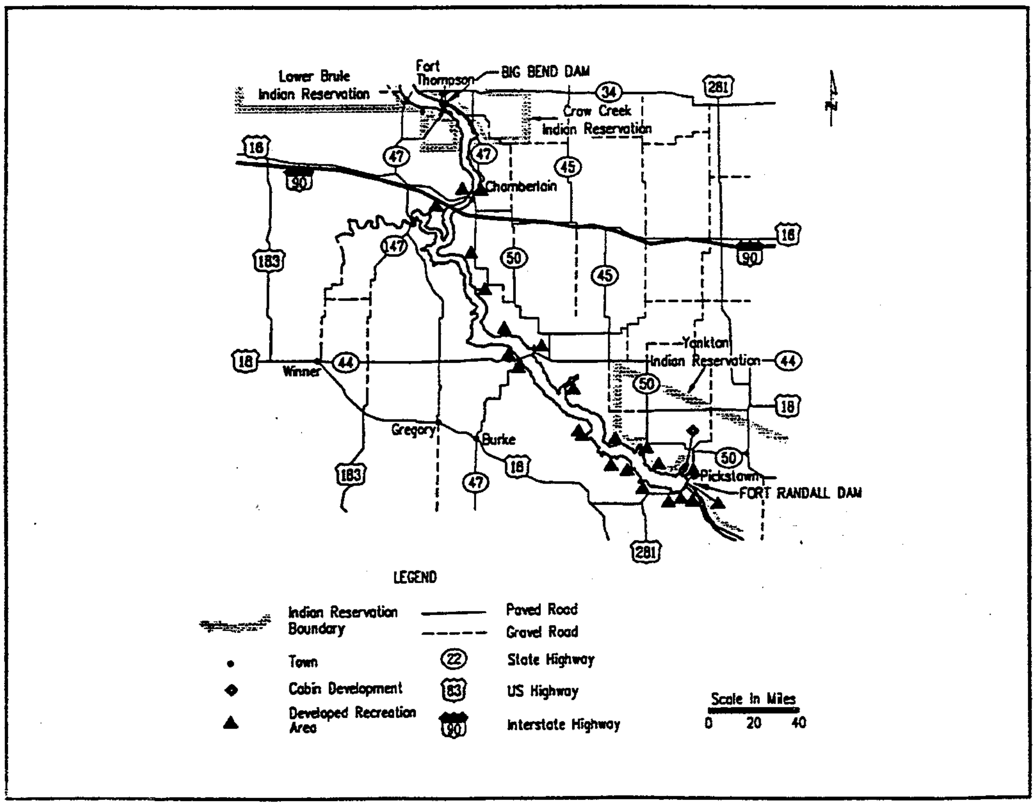

Figure 3.12-7. Lake Francis Case, South Dakota.

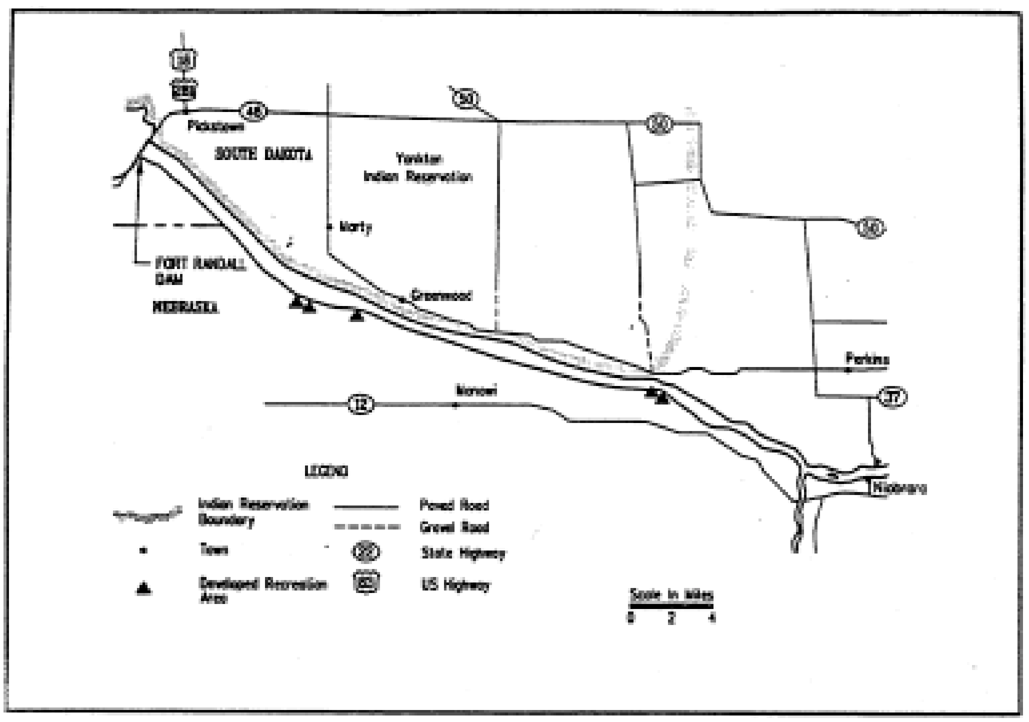

Figure 3.12-8. River reach from Fort Randall Dam to Lewis and Clark Lake, South Dakota.

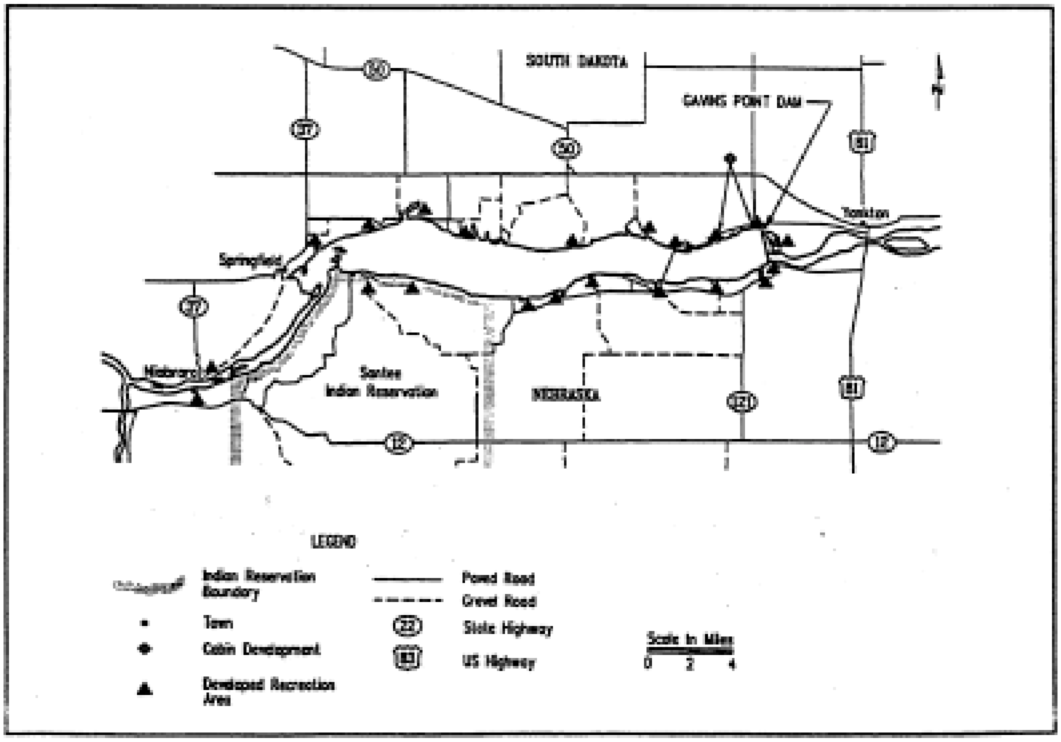

Figure 3.12-9. Lewis and Clark Lake, South Dakota.

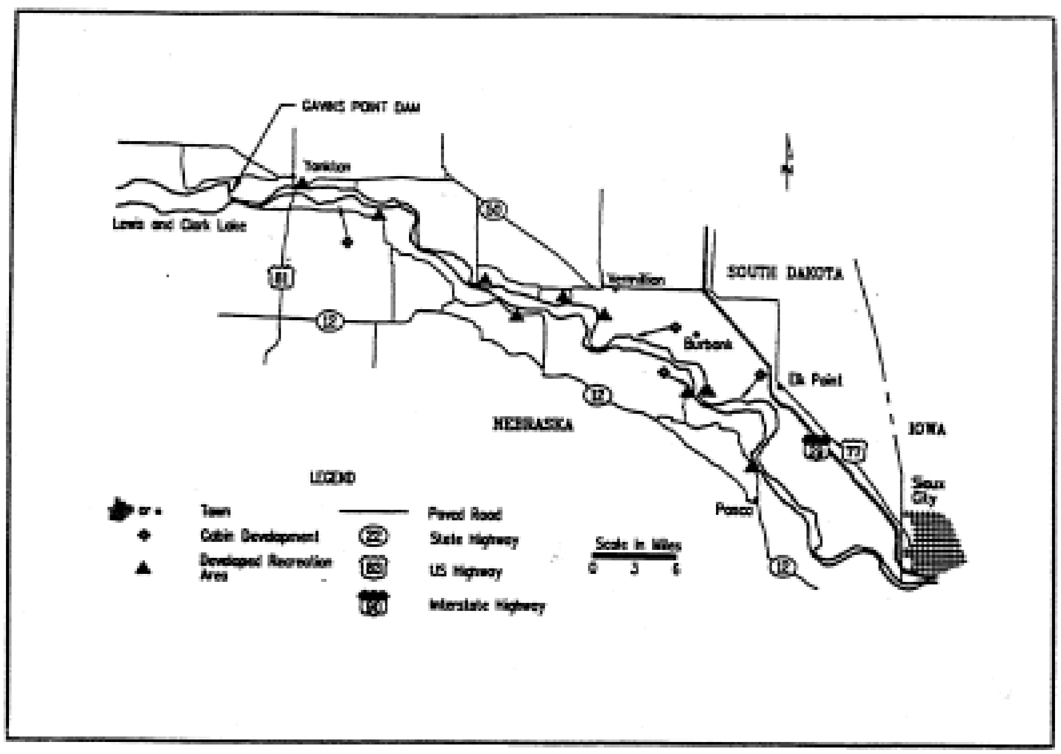

Figure 3.12-10. River reach from Gavins Point Dam, Nebraska, to Sioux City, Iowa.

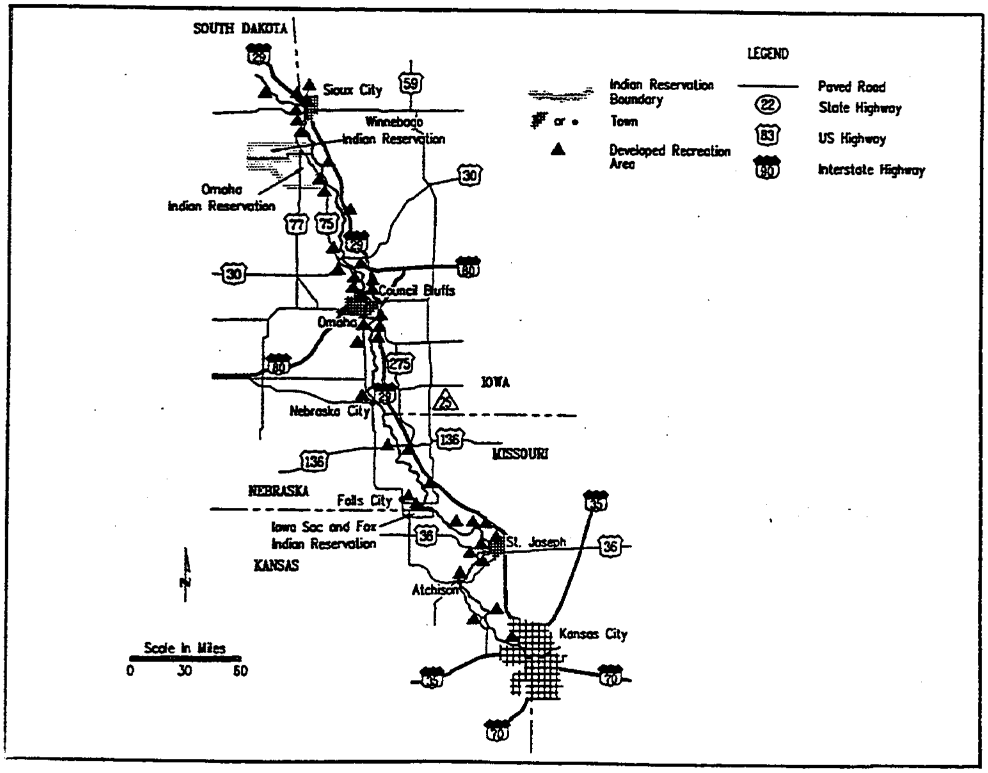

Figure 3.12-11. River reach from Sioux City, Iowa, to Omaha, Nebraska, and from Omaha to Kansas City, Missouri.

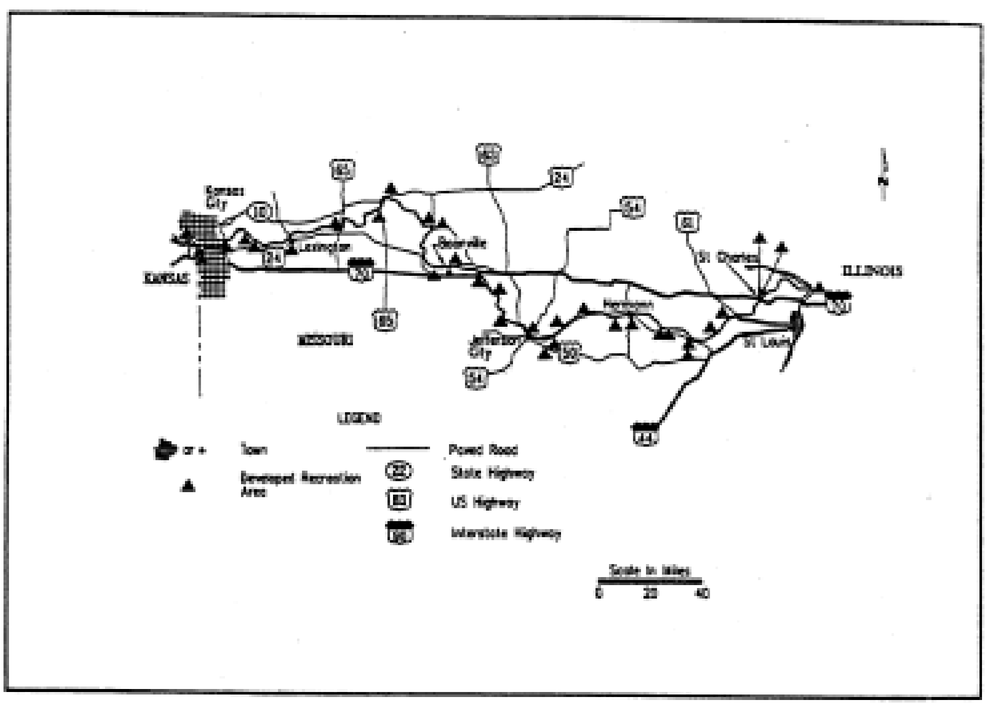

Figure 3.12-12. River reach from Kansas City, Missouri, to St. Louis, Missouri.

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3.13 NAVIGATION

The Missouri River BSNP was designed to prevent bank erosion and meandering and to provide reliable navigation. This project, authorized by Congress in the Rivers and Harbors Act of 1945, provides for a 9-foot-deep channel a minimum of 300 feet wide from Sioux City to the mouth of the river near St. Louis, a distance of 735 miles. Construction of the navigation works was declared complete in September 1981, although corrective work will be required as the river continues to form its channel in response to changing flow conditions.

Navigation on the Missouri River is limited to the normal ice-free season, with a full-length flow support season of 8 months. At Sioux City, the full-length flow support season extends from March 23 to November 22. At St. Louis, the full-length flow support season extends from April 1 to December 1. When water supplies are above normal, a 10-day season extension is provided.

3.13.1 Missouri River Freight Traffic

Major commodities transported on the Missouri River include agricultural products (farm and food products), chemicals including fertilizers, petroleum products including asphalt, manufactured goods including building products such as cement, and crude materials such as sand, gravel, and materials used to maintain the Missouri River BSNP (Table 3.13-1 and Table 3.13-2). Commercial tonnage, which excludes sand and gravel and waterway materials, peaked in 1977 at 3.3 million tons and has generally declined since then. During 1994, total tonnage transported via Missouri River navigation was 8.5 million tons (a Missouri River record high) and commercial tonnage was 1.8 million tons. The only year between 1988 and 1996 that the navigation season on the Missouri River was not interrupted or shortened by drought or flood was 1994.

Commercial tonnage moves throughout the navigation season, but tends to peak in the spring and fall (Figure 3.13-1). Based on the survey by the Mni Sose Intertribal Water Rights Coalition (February 1994), none of the Tribes within the Missouri River basin indicated navigation use for shipping or receiving goods, and the Tribes, therefore, do not have impacts associated with navigation service. The State of Missouri is typically an origin or destination for over half of Missouri River commercial tonnage. The Port of Kansas City serves as an origin or destination for about one-third to as much as one-half of Missouri River commercial tonnage. Upbound movements of commercial products have recently exceeded downbound movements by as much as two to one in some years. This is a reversal of the predominant direction of product movement from earlier decades of Missouri River navigation, when grain movements were more dominant. Approximately 90 percent of Missouri River commercial tonnage is also moved on the Mississippi River.

About 120 docks and terminals are located on the Lower River. Approximately one-half of these are located near and downstream of Kansas City, about 26 percent near Nebraska City and downstream to Kansas City, about 11 percent near Omaha and downstream to Nebraska City, and about 10 percent upstream of Omaha, including Sioux City.

3.13.2 Navigation Service

Navigation service on the Lower River between Sioux City and St. Louis is provided by the release of water necessary to maintain 8 to 9 feet of water depth in the navigation channel. The level of navigation service (full, reduced, or minimum) depends on the level of system releases, which are based on the quantity of water in storage. Releases from Gavins Point Dam provide most of the water at Sioux City, because there is little inflow to the river between the dam and Sioux City. In 1992, a low-storage drought year, Gavins Point August releases of 21 to 23 kcfs were needed to maintain minimum service (25 kcfs) at Sioux City. At Kansas City, system flows are greatly augmented by major tributaries, including the Platte and Kansas Rivers. Because of this added inflow, navigation demands on system storage water are often set by Sioux City. During low-tributary-flow summers, releases at Gavins Point Dam are sometimes increased to meet target flows for Nebraska City, Omaha, and Kansas City.

Operating experience has demonstrated that the flows for full-service navigation are 31 kcfs at Sioux City and Omaha, 37 kcfs at Nebraska City, and 41 kcfs at Kansas City. These full-service flows generally provide the authorized 9-foot navigation channel, and they allow the capability to load barges to an 8.5-foot draft. Flows 6 kcfs lower are provided for the designated minimum service. These flows generally provide a minimum 8-foot

Table 3.13-1. Missouri River navigation freight traffic (thousands of short tons).[a/]

	Year						
Commodity	**1940[b/]**	**1950[b/]**	**1960**	**1970**	**1980**	**1990**	**2000[d/]**
Farm Products	53.2	79.9	1,061.3	1,059.0	1,099.8	371.0	487.2
Corn			59.5	143.8	87.8	32.0	197.7
Wheat			649.1	669.0	835.2	171.0	21.2
Soybeans			104.9	208.8	164.1	40.0	153.1
Nonmetallic Minerals	330.0	282.9	1,495.3	2,869.5	2,855.4	4,268.0	7,253.0
Sand/Gravel	330.0	282.9	1,462.1	2,677.5	2,715.2	4,240.0	7,225.3
Food and Kindred			135.5	370.3	570.8	61.0	42.5
Pulp and Paper			0.0	16.7	3.6	6.0	0
Chemicals	0.5	0.8	21.3	526.2	501.8	345.0	289.1
Fertilizer			11.3	460.2	455.9	312.0	279.8
Petroleum	46.5	3.5	17.2	50.4	315.6	345.0	256.3
Stone/Clay/Glass			0.0	157.7	146.7	154.0	163.4
Primary Metals	6.3	58.5	164.8	57.8	95.4	11.0	37.4
Waterway Materials	844.8	1129.5	4,045.8	2,377.2	290.3	272.0	164.4
Other	15.2	54.4	7.7	34.4	35.4	8.0	40.0
Total	**1,296.5**	**1,609.5**	**6,948.9**	**7,519.2**	**5,914.8**	**5,841.0**	**8,733.3**
Total Commercial[c/]	121.7	197.1	1,441.0	2,464.5	2,909.3	1,329.0	1,343.6

a/ Annual freight traffic data for 1935 through 1990 are included in the technical appendix.
b/ Commodity category definition is slightly different before 1960.
c/ Commercial excludes sand and gravel and waterway materials.
d/ Preliminary data subject to change.
Source: Navigation Economics Technical Report (Corps, 1998c).

Table 3.13-2. Missouri River commodity tonnage by month and reach.

		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Sioux City - Mouth														
Farm products		873,297	769,845	560,472	676,104	697,029	759,009	371,000	678,000	401,000	486,000	488,000	373,000	452,000
Food products		480,373	369,465	350,206	291,177	177,576	144,734	61,000	91,000	138,000	77,000	64,000	69,000	51,000
Chemicals		713,237	688,354	693,425	664,166	568,812	410,710	345,000	334,000	407,000	495,000	600,000	452,000	551,000
Building products		150,043	236,714	238,537	273,160	268,002	303,559	154,000	168,000	188,000	209,000	230,000	219,000	214,000
Petroleum products		283,799	362,470	333,239	317,018	325,906	192,667	345,000	201,000	213,000	241,000	349,000	277,000	236,000
Other Commercial*		377,971	179,613	168,020	183,587	119,062	95,829	53,000	92,000	56,000	62,000	69,000	47,000	44,000
	Subtotal	2,878,720	2,606,461	2,343,899	2,405,212	2,156,387	1,906,508	1,329,000	1,564,000	1,403,000	1,570,000	1,800,000	1,439,000	1,547,000
Sand and gravel		3,185,022	3,392,572	4,161,906	4,080,342	4,421,016	3,357,645	4,240,000	4,043,000	4,121,000	3,867,000	6,144,000	5,222,000	6,278,000
Waterway material		322,463	472,385	484,973	250,414	103,475	88,129	272,000	122,000	259,000	194,000	557,000	224,000	341,000
	TOTAL	**6,386,205**	**6,471,418**	**6,990,778**	**6,736,868**	**6,683,178**	**5,352,282**	**5,841,000**	**5,729,000**	**5,783,000**	**5,631,000**	**8,501,000**	**6,884,000**	**8,165,000**
Kansas City - Mouth														
Farm products		873,297	769,132	560,472	676,104	697,029	759,009	371,000	678,000	401,000	486,000	487,000	372,000	452,000
Food products		480,373	369,465	345,908	266,864	170,892	136,853	56,000	91,000	138,000	77,000	64,000	69,000	51,000
Chemicals		651,882	629,510	654,130	617,688	533,129	373,858	313,000	309,000	383,000	461,000	547,000	417,000	514,000
Building products		150,043	236,714	238,537	273,160	268,002	303,559	154,000	168,000	188,000	209,000	230,000	219,000	214,000
Petroleum products		283,799	362,470	333,239	317,018	321,130	192,667	345,000	201,000	213,000	220,000	349,000	277,000	236,000
Other commercial*		376,571	179,613	163,372	183,587	119,062	95,829	51,000	88,000	52,000	60,000	69,000	47,000	44,000
	Subtotal	2,815,965	2,546,904	2,295,658	2,334,421	2,109,244	1,861,775	1,290,000	1,535,000	1,375,000	1,513,000	1,746,000	1,402,000	1,511,000
Sand and gravel		2,939,862	3,124,212	3,963,266	3,789,792	4,126,956	3,145,025	3,831,000	3,775,000	3,853,000	3,596,000	5,765,000	4,975,000	5,914,000
Waterway material		230,305	292,146	298,917	191,725	85,291	63,132	261,000	77,000	229,000	176,000	428,000	217,000	316,000
	TOTAL	**5,986,132**	**5,963,262**	**6,557,841**	**6,315,938**	**6,321,491**	**5,069,932**	**5,382,000**	**5,387,000**	**5,457,000**	**5,285,000**	**7,939,000**	**6,594,000**	**7,740,000**
Omaha City - Kansas City														
Farm products		627,087	397,490	243,840	284,319	437,159	349,343	192,000	317,000	171,000	239,000	293,000	216,000	308,000
Food products		430,184	353,405	318,155	280,190	160,434	132,905	46,000	56,000	107,000	62,000	53,000	53,000	41,000
Chemicals		489,823	446,840	387,057	366,652	334,239	243,018	203,000	174,000	217,000	261,000	291,000	233,000	304,000
Building products		108,956	98,210	106,239	151,163	112,883	167,456	80,000	137,000	103,000	111,000	99,000	94,000	85,000
Petroleum products		46,836	86,177	48,332	101,488	65,804	20,972	9,000	24,000	5,000	46,000	125,000	90,000	52,000
Other commercial*		126,426	99,303	85,180	44,141	48,274	47,810	44,000	68,000	50,000	43,000	43,000	35,000	33,000
	Subtotal	1,829,312	1,481,425	1,188,803	1,227,953	1,158,793	961,504	574,000	776,000	653,000	762,000	904,000	722,000	823,000
Sand and gravel		254,763	271,251	198,640	290,550	294,273	212,620	409,000	268,000	267,000	272,000	379,000	247,000	364,000
Waterway material		73,766	168,619	132,606	46,189	20,621	27,621	0	30,000	12,000	7,000	142,000	2,000	23,000
	TOTAL	**2,157,841**	**1,921,295**	**1,520,049**	**1,564,692**	**1,473,687**	**1,201,745**	**983,000**	**1,074,000**	**932,000**	**1,041,000**	**1,425,000**	**970,000**	**1,210,000**
Sioux City - Omaha City														
Farm products		18,433	30,943	5,454	2,154	4,118	2,449	21,000	20,000	10,000	26,000	30,000	34,000	74,000
Food products		263,019	212,462	193,779	204,776	105,073	76,560	28,000	39,000	96,000	51,000	44,000	50,000	36,000
Chemicals		156,761	130,016	147,373	146,574	165,687	121,361	101,000	85,000	84,000	117,000	99,000	58,000	120,000
Building products		0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum products		37,688	49,658	17,951	49,736	4,776	0	0	24,000	0	15,000	11,000	6,000	0
Other commercial*		51,142	43,775	21,369	10,982	8,304	14,535	10,000	16,000	8,000	5,000	11,000	1,000	1,000
	Subtotal	527,043	466,854	385,926	414,222	287,958	214,905	160,000	184,000	198,000	214,000	195,000	149,000	231,000
Sand and gravel		0	0	0	0	3,700	0	0	0	2,000	0	0	0	0
Waterway material		24,500	17,750	50,750	15,250	1,950	6,600	11,000	18,000	18,000	17,000	68,000	7,000	25,000
	TOTAL	**551,543**	**484,604**	**436,676**	**429,472**	**293,608**	**221,505**	**171,000**	**202,000**	**218,000**	**231,000**	**263,000**	**156,000**	**257,000**

* Excluding sand and gravel

channel, and barges can be loaded to a 7.5-foot draft. Commercial navigation declines precipitously below the minimum service level of 8 feet. There is generally little traffic when the channel is below 7 feet. Although these flows are generally adequate to provide the indicated drafts, considerable time has been lost due to bumpings and groundings.

The level of navigation service to be provided is determined by the amount of water in storage on March 15 and July 1 of each year. If there is more than 54.5 MAF in total mainstem storage on March 15, full service is provided. If there is 46 MAF or less, then only minimum service is provided. On July 1, full service is provided if there is 59 MAF or more water in storage and minimum service is provided if there is less than 50.5 MAF. When the quantity of water in storage is in between these amounts, navigation service flows are reduced proportionally.

The level of service to navigation can also be affected by release restrictions at Gavins Point Dam for the least tern and piping plover nesting season. These restrictions were first implemented in 1986. At times, navigation target flows cannot be met by system releases during this period, because tributary flows are declining in July and August and flows cannot be augmented by increased releases from Gavins Point Dam beyond the maximum release established prior to least tern and piping plover nesting. Generally, restrictions to protect the birds are lifted in mid-August.

Beginning in 1995, releases from Gavins Point Dam were adjusted in early May, when the terns and plovers began to initiate nesting. The release rate was based on an assessment of flows needed to support navigation in July and August. The resulting release prevented inundation of nests and chicks due to increased navigation support flows in late summer.

High flows can also disrupt navigation. The river is generally closed to navigation when stages become so high that towboat prop wash and waves from the tow can damage the levees. In the flood of 1993, service was interrupted for 7 weeks by high flows between Kansas City and St. Louis and low flows near Sioux City. During the 1987 to 1993 drought, navigators experienced hardships and lost revenues due to both reduced project releases and shortened navigation seasons. Minimum service was often provided, which resulted in reduced cargoes and higher transportation costs. Tonnage fell from 2.3 million in 1986 to 1.33 million in 1990.

3.13.3 Missouri River from Sioux City to Omaha

In 1994, 11 percent of the commercial tonnage moved on the Missouri River was transported in this reach. Eleven docks and terminals are located in the Sioux City reach. Four are located in Washington County, Nebraska; one in Monona County, Iowa; and six in Woodbury County, Iowa. Agricultural products and chemicals are the primary products moved in this reach.

3.13.4 Missouri River from Omaha to Kansas City

In 1994, approximately 50 percent of commercial tonnage moved on the Missouri River was in this reach. This reach was an origin or destination for about 40 percent of Missouri River commercial tonnage. Forty-four docks and terminals are located in this reach. Sixteen are located in Nebraska, 4 are located in Iowa, 17 in Kansas, and 7 in Missouri.

3.13.5 Missouri River from Kansas City to St. Louis

Agricultural products, petroleum products, chemicals, and cement account for the majority of commercial tonnage transported in this reach. This reach also accounts for most of the sand and gravel moved on the Missouri River. Typically, over 95 percent of commercial tonnage transported on the Missouri River passes through at least a portion of this reach. In addition, this reach serves as an origin or destination for over 50 percent of commercial tonnage shipped or received on the Missouri River. Sixty-four docks and terminals are located in the Kansas City reach, including the Port of Kansas City and extending to the mouth at St. Louis. All but four docks and terminals are situated in Missouri; the remainder are in Kansas.

3.13.6 Mississippi River from St. Louis to Mouth

A 9-foot-deep channel 300 feet wide is maintained on the Mississippi River downstream of the Missouri River. Waterborne commerce on the Mississippi River has risen from 30 million tons in

1940 to approximately 520 million tons in 1996. This heavy commercial traffic includes grains, coal and coke, iron and steel, petroleum products, sand and gravel, salt, sulfur, and chemicals. About 113 million tons of cargo were carried on the Mississippi River in 1996 between St. Louis and the mouth of the Ohio River.

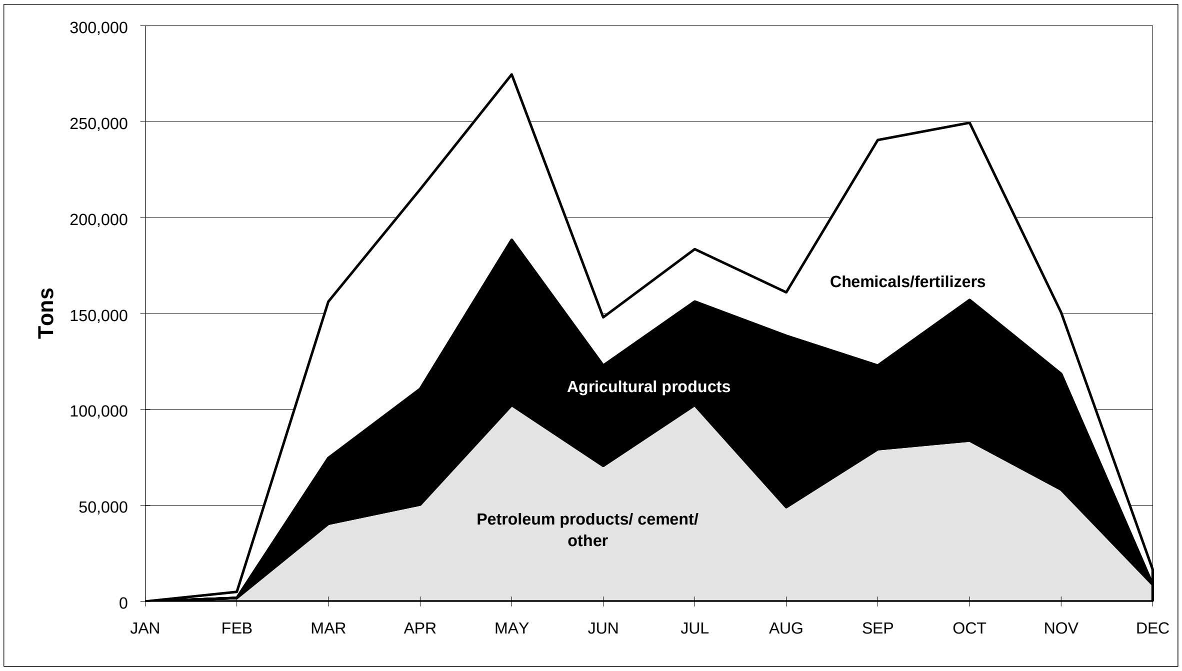

Figure 3.13-1. Missouri River commercial tonnage by month (1994).

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3.14 SOCIOECONOMICS

3.14.1 General

Seven States border the mainstem Missouri River from Fort Peck Lake to its confluence with the Mississippi River and benefit directly from the presence of the river. The bordering States are Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri. For the 13 Reservations that also border the mainstem Missouri River, economic benefits to the individual Tribes is yet be determined due to the limited available data concerning the Reservations. Consequently, the socioeconomic data presented in this section are based on regional data and are not specific to any Reservation. The mainstem Reservations are Fort Peck Reservation, Fort Berthold Reservation, Standing Rock Reservation, Cheyenne River Reservation, Lower Brule Reservation, Crow Creek Reservation, Yankton Reservation, Ponca Tribal Land, Santee Reservation, Omaha Reservation, Winnebago Reservation, Iowa Reservation, and Sac and Fox Reservation. The Mainstem Reservoir System is a valuable source of jobs, recreation, hydropower, transportation of goods, and water supply for powerplants and domestic, agricultural, and industrial uses. In addition, operation of the mainstem reservoirs affects flows in the Mississippi River and, therefore, could affect transportation and the economies of Illinois, Kentucky, Tennessee, Mississippi, Arkansas, and Louisiana.

Missouri River States

The States along the Missouri River have had low levels of population growth or have experienced population declines in the past 20 years (Table 3.14-1). Montana, South Dakota, and Nebraska have had declining population growth rates since 1970. Kansas and Missouri have had steady population levels over the past 20 years. North Dakota and Iowa had slight growth from 1970 through 1980, but then experienced population declines through 1990. In comparison, the United States experienced a 9 percent growth from 1970 to 1980 and a 10 percent growth from 1980 to 1990.

Lack of population growth has been accompanied by an increase in the average age of the populations in many of these States. The 1990 median age of residents ranged from a low of 32.4 years in North Dakota to a high of 34.0 years in Iowa. The United States had a 1990 median age of 32.9 years.

The average household size ranges from 2.52 people/household in Iowa to 2.59 in South Dakota. The average household size in the United States is 2.64 people/household.

The primary 1990 employment sectors in the Missouri River States included 30 percent employed in wholesale and retail trade; 24 percent in professional services; 18 percent in government; and 16 percent in manufacturing (see Table 3.14-2). Overall, the States had a 4.8 percent unemployment rate. The first-tier counties (that is, those adjacent to the river) surrounding the Missouri River had a slightly smaller proportion employed in wholesale and retail trade (24 percent) and government (10 percent) than the Missouri River states as a whole, but similar proportions employed in services (26 percent) and manufacturing (16 percent).

Mississippi River States

Operation of the Mainstem Reservoir System could affect navigation and transportation of commodities in other States, which in turn would affect their economies. Thus, a general discussion of their demographic and economic characteristics is required to evaluate the potential impacts. Other States that might be affected by the mainstem reservoir operation include Illinois and the downstream Mississippi River States of Kentucky, Tennessee, Mississippi, Arkansas, and Louisiana.

These Mississippi River States had a 1990 population of 29,137,000, with Illinois having the largest population (11.4 million); the remainder of the State populations ranged from 2.3 to 4.9 million.

Median ages ranged from 31.0 to 33.8 years, and average household size ranged from 2.56 to 2.75 people/household. Both of these ranges are similar to the overall compositions of the Missouri River States.

First-tier Counties

The following sections describe the demographic and employment characteristics of the counties bordering the reservoirs and river reaches composing the Mainstem Reservoir System and the Lower River. These counties are hereafter referred to as the first-tier counties and are identified for each reservoir and river reach. Where counties border both a reservoir

Table 3.14-1. State and first-tier county demographic characteristics.

Area	1970 (population)	1980 (population)	1970-80% change	1990 (population)	1980-90% change	Median Age (years)	Average Household Size (persons)
United States	207,976,452	226,545,805	9	248,709,873	10	32.9	2.64
Missouri River States							
Montana	694,409	786,690	13	799,065	2	33.8	2.53
First-tier	55,016	56,416	3	51,584	-9		
Rest-of-State	639,393	730,274	14	747,481	2		
North Dakota	617,761	652,717	6	638,800	-2	32.4	2.55
First-tier	130,364	155,442	19	153,606	-1		
Rest-of-State	487,397	497,275	2	485,194	-2		
South Dakota	665,507	690,768	4	696,004	1	32.5	2.59
First-tier	122,842	122,539	0	116,603	-5		
Rest-of-State	542,665	568,229	5	579,401	2		
Nebraska	1,483,493	1,569,825	6	1,578,385	1	33.0	2.54
First-tier	585,812	619,595	6	649,310	5		
Rest-of-State	897,681	950,230	6	929,075	-2		
Iowa	2,824,376	2,913,808	3	2,776,775	-5	34.0	2.52
First-tier	239,240	238,292	0	227,096	-5		
Rest-of-State	2,585,136	2,675,516	3	2,549,679	-5		
Kansas	2,246,578	2,363,679	5	2,477,574	5	32.9	2.53
First-tier	497,804	537,033	8	617,612	15		
Rest-of-State	1,748,774	1,826,646	4	1,859,962	2		
Missouri	4,676,501	4,916,686	5	5,117,073	4	33.5	2.54
First-tier	2,309,608	2,495,451	8	2,641,750	6		
Rest-of-State	2,366,893	2,421,235	2	2,475,323	2		
Total First-tier	3,940,686	4,224,768	7	4,457,561	6		
Total Rest-of-State	9,267,939	9,669,405	4	9,626,115	0		
Total Missouri States	13,208,625	13,894,173	5	14,083,676	1		
Mississippi River States							
Illinois				11,430,602		32.8	2.65
Kentucky				3,685,296		33.0	2.60
Tennessee				4,877,185		33.6	2.56
Mississippi				2,573,216		31.2	2.75
Arkansas				2,350,725		33.8	2.57
Louisiana				4,219,973		31.0	2.74
Total Mississippi States				**29,136,997**			

[a/] First-tier counties are those counties adjacent to the river.
Source: U.S. Bureau of the Census, 1992.

Table 3.14-2. State and first-tier county 1990 employment characteristics (rounded to nearest 5). Page 1 of 2

Area	Manu-facturing	Total Jobs (%)	Construction & Mining	Total Jobs (%)	Transportation Comm. & Utilities	Total Jobs (%)	Wholesale & Retail	Total Jobs (%)
Missouri River States								
Montana	22,225	8	16,645	6	16,630	6	78,370	27
First-tier	1,180	8	1,380	9	740	5	3,565	24
Rest-of-state	21,045	8	15,265	6	15,890	6	74,805	28
North Dakota	17,350	7	14,400	5	17,100	6	70,150	26
First-tier	2,700	4	5,050	8	5,400	9	15,290	25
Rest-of-state	14,645	7	9,350	5	11,700	6	54,860	27
South Dakota	25,900	11	13,610	6	12,270	5	65,215	29
First-tier	4,645	11	1,200	3	1,895	4	10,590	24
Rest-of-state	21,255	12	12,410	7	10,375	6	54,625	30
Nebraska	98,360	13	28,760	4	45,825	6	186,760	26
First-tier	43,565	13	13,240	4	22,595	7	80,925	24
Rest-of-state	54,795	14	15,515	4	23,230	6	105,835	27
Iowa	235,800	19	46,900	4	55,900	5	540,200	44
First-tier	16,070	17	3,610	4	5,520	6	26,250	27
Rest-of-state	219,730	19	43,290	4	50,380	4	513,950	46
Kansas[c/]	—	—	—	—	—	—	—	—
First-tier	—	—	—	—	—	—	—	—
Rest-of-state	—	—	—	—	—	—	—	—
Missouri[c/]	438,100	19	102,200	4	190,300	8	562,100	24
First-tier	346,750	17	93,575	5	4,460	0	502,543	24
Rest-of-state	91,350	32	8,625	3	185,840	66	59,555	21
Total First-Tier	**417,880**	**16**	**118,230**	**4**	**41,010**	**2**	**642,260**	**24**
Total Rest-of-State	**422,825**	**17**	**104,460**	**4**	**297,410**	**12**	**863,630**	**35**
Total Missouri States	**837,740**	**16**	**222,515**	**4**	**338,025**	**7**	**1,502,790**	**30**

Table 3.14-2. State and first-tier county 1990 employment characteristics (rounded to nearest 5). Page 2 of 2

Area	Finance, Ins. Real Est.	Total Jobs (%)	Services	Total Jobs (%)	Government	Total Jobs (%)	Total Employed	Total Unemployment Total	Unemployment Rate
Missouri River States									
Montana	13,085	5	71,980	25	64,045	22	378,975	23,025	5.7
First-tier	586	4	3,450	23	4,090	27	23,685	1,550	6.1
Rest-of-state	12,500	5	68,530	25	59,960	22	355,290	21,475	5.7
North Dakota	12,450	5	68,650	26	65,500	25	311,995	13,000	4.0
First-tier	2,270	4	15,975	26	13,000	21	75,535	3,520	4.4
Rest-of-state	10,180	5	52,675	26	52,500	26	236,460	9,475	3.9
South Dakota	11,070	5	45,340	20	51,130	23	347,000	13,000	3.6
First-tier	1,520	3	10,215	23	13,740	31	56,505	2,155	3.7
Rest-of-state	9,550	5	35,125	19	37,390	21	290,495	10,845	3.6
Nebraska	48,415	7	178,720	24	144,270	20	821,000	18,000	2.1
First-tier	28,910	9	95,960	28	51,420	15	339,580	8,100	2.3
Rest-of-state	19,505	5	82,760	21	92,850	24	481,420	9,900	2.0
Iowa	69,300	6	288,600	24	219,600	18	—	—	—
First-tier	4,300	4	26,220	27	15,170	16	—	—	—
Rest-of-state	65,000	6	262,380	23	204,430	18	—	—	—
Kansas[c/]	—	—	—	—	—	—	—	—	—
First-tier	—	—	—	—	—	—	—	—	—
Rest-of-state	—	—	—	—	—	—	—	—	—
Missouri[c/]	—	—	578,700	25	369,700	16	2,483,000	151,000	5.7
First-tier	—	—	536,625	26	150,509	7	1,373,608	70,426	4.9
Rest-of-state	—	—	42,075	15	219,191	77	1,109,392	80,574	6.8
Total First-Tier	**178,265**	**7**	**690,920**	**26**	**250,625**	**10**	**2,329,965**	**107,105**	**4.4**
Total Rest-of-State	**116,082**	**5**	**543,545**	**22**	**666,320**	**27**	**2,473,060**	**132,270**	**5.1**
Total Missouri States	**293,720**	**6**	**1,231,990**	**24**	**914,245**	**18**	**4,341,970**	**218,025**	**4.8**

a/ First-tier counties are those located adjacent to the river.
b/ Rounded to nearest 5.
c/ Data are not available or are inconsistent and should be used only for illustrative purposes.
Source: U.S. Bureau of the Census, 1992.

and river reach, populations were apportioned to each county based upon the amount of the county's land area lying along the reach/reservoir, location of State parks, and the accessibility afforded by highways and roads.

These first-tier counties have the following percentages of 1990 total State populations: 6.5 percent of Montana; 24 percent of North Dakota; 16.8 percent of South Dakota; 41.1 percent of Nebraska; 8.2 percent of Iowa; 24.9 percent of Kansas; and 51.6 percent of Missouri. In total, the first-tier counties account for 31.7 percent of the total 1990 population of the Missouri River States. Overall, the first-tier counties accounted for 50 percent of the total manufacturing employment in the Missouri River States; 53 percent of construction and mining; 12 percent of transportation, communications, and utilities; 43 percent of wholesale and retail trade; 61 percent of finance, insurance, and real estate; 56 percent of services; and 27 percent of government employment. Altogether, the first-tier counties accounted for 27 percent of the total employment in the Missouri River States. These data include census data relative to the portion of Reservation populations within the respective county boundaries. Many Missouri River basin Tribes are concerned that the census data are inaccurate with respect to the Reservations. Consequently, the regional socioeconomic data presented may not be reflective of Reservation life.

Reservations

Population data were available from the 1990 decennial census for Native American Reservations (U.S. Bureau of the Census, 1992). Employment data specific to the Reservations were obtained from The Characteristics of American Indians by Tribe and Language, Employed Persons 16 Years and Over, from the 1990 Census of Population and Housing published by the U.S. Bureau of the Census.

3.14.2 Fort Peck Lake

First-tier Counties

Fort Peck Lake is bordered by Fergus, Garfield, Petroleum, Phillips, Valley, and one-half of McCone Counties in northeastern Montana. It includes RM 1906 through 1772. Glasgow, in Valley County, is the largest city near the reservoir and is located on U.S. Highway 2.

The first-tier counties surrounding Fort Peck Lake have had a declining population since 1970. A 3 percent decline occurred from 1970 to 1980 (33,377 to 32,355) and an additional 11 percent decline occurred from 1980 to 1990.

The populations of these counties have a higher median age than the overall Missouri River States and the United States. The median age of the counties ranges from 34 to 38 years, compared to the Montana median age of 33.8 years and the United States median age of 32.9 years (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for Fort Peck Lake were government (29 percent), wholesale and retail trade (25 percent), and services (23 percent). Construction employment (10 percent) was slightly higher than for other reaches and reservoirs. The unemployment rate was 5.1 percent, slightly less than the 5.5 for the United States and slightly more than the 4.8 percent for the Missouri River States.

The residents' dependence on the Missouri River is exemplified by the amount of farming, recreation, and water supply intakes that occur around Fort Peck Lake. A total of 942,400 acres of cropland are farmed in the first-tier counties surrounding the lake, 88,000 acres (9.3 percent) of which are irrigated. An estimated 315,000 recreation days occurred in 1993; the lakeshore includes 9,500 acres of managed recreational use areas. The recreational facilities were affected the most by the 1987 to 1993 drought and its decreased lake levels, resulting in $0.6 million in boat ramp modifications from 1988 through 1991. In addition, 109 water supply intakes exist on the lake, providing water for irrigation (5), municipal (1 intake serving 580 people), domestic (101), and public (2) uses. Fort Peck Dam, with a capacity of 185 MW, also provides energy to the region.

The Fort Peck project, its supporting facilities, and the local recreation industry supported by the lake provide employment opportunities for many local residents. Profits from the project and recreation benefit the local economy and contribute to the local tax base. Recreational facilities draw permanent and part-time residents to the area.

Fort Peck Reservation

The Fort Peck Reservation is located downstream of Fort Peck Dam on the northern bank of the Missouri

River from RM 1760.0 to RM 1547.1. The Reservation, in northeastern Montana, is included in Daniels, Sheridan, Roosevelt, and Valley Counties. The latter two counties are within the first-tier counties of analysis. The Reservation had a 1990 population of 10,595. The ethnic distribution of the residents was approximately 55 percent Native American, 45 percent Caucasian, and less than 1 percent of other ethnic heritage. The median age was 28.6 years, with an average of 3.04 people/household (U.S. Bureau of the Census, 1992).

The Reservation encompasses approximately three-fourths of Roosevelt County and about one-third of Valley County. Roosevelt County had the highest 1990 unemployment rate (9.5 percent) of the first-tier counties in Montana, and Valley County was among the lowest (4.7 percent). In comparison, the 1990 State average unemployment rate was 5.7 percent.

The primary 1990 employment sectors were government (23 percent), services (24 percent), and manufacturing (13 percent). The transportation and communication (11 percent) and wholesale and retail trade (11 percent) sectors were slightly lower. The agriculture, construction, financial, insurance, and real estate sectors combined accounted for the remaining 18 percent.

The residents' socioeconomic dependence on the Missouri River is embodied in a single boat ramp, farming, and 109 water supply intakes. There are 29,000 acres and 447 buildings located in the floodplain. The water supply intakes are municipal, domestic, and irrigation intakes.

Mainstem Reservoir System operations may currently have a minor socioeconomic effect on the livelihood and quality of life of Reservation residents, but future economic development is being contemplated by Tribes on the Fort Peck Reservation. Some residents are employed directly or indirectly because of the project. Tourism contributes to the local economy. The project lands and waters provide hunting and fishing opportunities.

3.14.3 Missouri River from Fort Peck Dam to Lake Sakakawea

The 204-mile Fort Peck Dam to Lake Sakakawea reach is bordered by Richland, Roosevelt, and one-half of McCone Counties in northeastern Montana. It includes RM 1772 through 1568. The largest communities in the reach are Wolf Point in Roosevelt County and Sidney in Richland County. Wolf Point is located on U.S. Highway 2, and Sidney is at the intersection of State Routes 16 and 200.

First-tier counties below Fort Peck Dam have had a varying population trend since 1970. A moderate 11 percent increase occurred from 1970 to 1980 (21,640 to 24,061) but a slight 5 percent decline occurred from 1980 to 1990. The 1990 median age of Richland and Roosevelt Counties was 33.0 and 29.8 years, respectively, both of which are less than the State average. However, McCone County’s median age of 36 years is significantly higher than the State’s median age (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for this reach were government (25 percent), services (23 percent), and wholesale and retail trade (22 percent). The manufacturing (12 percent) and construction and mining employment (8 percent) sectors were slightly higher, proportionally, than other reaches and reservoirs. The unemployment rate was 7.6 percent, the highest of the reaches and reservoirs, and significantly more than the 5.5 percent for the United States and the 4.8 percent for the Missouri River States.

The residents’ dependence on the Missouri River is exemplified in the amount of recreation, farming, water intakes, and flood control that occur along the reach. A total of 739,000 acres of cropland exist in the first-tier counties surrounding Fort Peck Lake, 46,100 acres (6.2 percent) of which are irrigated. An estimated 73,000 recreation visitor days occurred in 1992. In addition, 455 water supply intakes exist on the reach, providing water for irrigation (283), municipal (5 intakes serving 28,020 people), domestic (162), industrial (4), and public (1) uses. Flood control on this reach of the Mainstem Reservoir System benefits 100,600 acres of farmland, 1,544 residential buildings worth $174.9 million, and two nonresidential buildings worth $9.4 million.

Residents hunt, fish, boat, or generally recreate along the river. Access to the river is at times affected by low water.

3.14.4 Lake Sakakawea

First-tier Counties

Dunn, McKenzie, Mountrail, Williams, three-fourths of McLean, and one-half of Mercer Counties border Lake Sakakawea in west-central North Dakota. The lake encompasses RM 1568 through 1390. The larger cities in the first-tier counties include Williston, New Town, Parshall, Killdeer, and Garrison. U.S. Highway 83 runs north-south through the eastern portion of the area, and State Route 200 is a major east-west route.

Counties surrounding Lake Sakakawea had a population increase in the 1970s, followed by a decline in the 1980s. A moderate 11 percent increase occurred from 1970 to 1980 (50,286 to 55,664); an 8 percent decline occurred from 1980 to 1990. The 1990 median age ranged from 32.4 years in Mercer County to 37.3 years in McLean County (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for Lake Sakakawea were wholesale and retail trade (24 percent), services (22 percent), and government (20 percent). Construction and mining (16 percent) and transportation, communications, and utilities (10 percent) employed greater proportions of the population than most of the other reach and reservoir first-tier counties. The 1990 unemployment rate was 4.6 percent, which is less than the rates for the United States and the Missouri River States.

The Lake Sakakawea vicinity has a total of 1,777,300 acres of cropland in the first-tier counties surrounding the lake, 35,500 acres (2.0 percent) of which are irrigated. An estimated 1,152,000 recreation visitor days occurred in 1993; the lakeshore includes 4,766 acres of managed recreational use areas. An estimated $1.6 million in boat ramp modifications occurred from 1988 through 1991 as a result of the drought and decreased water levels. In addition, 300 water supply intakes exist on the lake, providing water for irrigation (44), municipal (10 intakes serving 21,950 people), industrial (6), domestic (228), and public (11) uses. Garrison Dam, with a capacity of 518 MW, provides energy to the region. A thermal powerplant on Lake Sakakawea has a capacity of 879 MW.

Some residents of the counties around Lake Sakakawea are closely tied to the lake via employment, the economy, and recreational opportunities. Tourism and permanent and part-time residences on the lake bring dollars that contribute significantly to the local economy and also bring employment to area residents. Nearly one-half of the population depends on water from the lake for water supply. Some residents use the lake for recreation.

Water level reductions in the reservoir during the 1987 to 1993 drought hurt tourism. The decline in the number of visitors affected the local economy and reduced employment opportunities. Lower water levels in the lake affected the upper lake residents and recreationists the most. During years of higher water level, flooding has been a problem at the upper end of the lake. Farm lands have been saturated and basements flooded from high water tables.

Fort Berthold Reservation

The Fort Berthold Reservation is located in west-central North Dakota, lying within Dunn, McKenzie, McLean, Mercer, Mountrail, and Ward Counties. It surrounds both shores of central Lake Sakakawea, including Van Hook Arm, from about Sanish and New Town in the north down to a line south of White Shield. The Reservation had a 1990 population of 5,395. The ethnic distribution of the residents was approximately 56 percent Native American, 44 percent Caucasian, and less than 1 percent of other ethnic heritage. The median age was 30.0 years, with an average of 3.00 people/household (U.S. Bureau of the Census, 1992).

The Reservation encompasses about one-third of Mountrail County, less than one-fourth of Dunn and McLean Counties, and a small portion of McKenzie and Mercer Counties. Mountrail County had the second highest 1990 unemployment rate (6.1 percent) of the first-tier counties in North Dakota, and Dunn and McLean Counties had 5.7 and 5.6 percent unemployment rates, respectively. These counties all had moderately higher unemployment rates than the 1990 North Dakota average unemployment rate of 4 percent.

The primary 1990 employment sectors were services (51 percent), transportation, communication (11 percent), mining (9 percent), and government (9 percent). Wholesale and retail trade was also about 9 percent. The agriculture, manufacturing, and construction sectors combined accounted for the remaining 11 percent of the employment.

The residents' socioeconomic dependence on the Missouri River is embodied in the 15 recreation areas, farming, and 79 water supply intakes. The water supply intakes are municipal, domestic, industrial, and irrigation intakes.

The livelihood and quality of life of Reservation residents is affected directly and indirectly by the Mainstem Reservoir System operations. Tourism contributes to the local economy. The project lands and waters provide hunting and fishing opportunities.

3.14.5 Missouri River from Garrison Dam to Lake Oahe

Burleigh, Morton, Oliver, one-fourth of McLean, and one-half of Mercer Counties border the Garrison Dam to Lake Oahe reach of the Missouri River. The reach includes RM 1390 through RM 1303. Some of the largest cities included in this area are Underwood, Washburn, Stanton, Hazen, Beulah, Wilton, Bismarck, Mandan, and New Salem, North Dakota. Interstate 94 provides major access to the southern portion of the reach, as does U.S. Highway 83.

Counties comprising the Garrison Dam to Lake Oahe reach have had a population increase since 1970, the only portion of the upper Missouri River are to do so. A significant 30 percent increase from 1970 to 1980 (69,246 to 90,281) was followed by a 4 percent increase from 1980 to 1990. The median age ranges from 32.0 years in Burleigh County to 37.3 years in McLean County.

The primary 1990 employment sectors in the first-tier counties for this reach were services (28 percent), wholesale and retail trade (26 percent), and government (21 percent). Transportation, communications, and utilities (9 percent) employed a greater proportion of the population than most of the other reach and reservoir first-tier counties. The unemployment rate was 4 percent, less than that of the United States and the Missouri River States.

A total of 1,020,900 acres of cropland exist in the first-tier counties along this reach, of which 10,900 acres (1.1 percent) are irrigated. An estimated 216,000 recreation days occurred in 1992. There are 123 water supply intakes in the reach, providing water for irrigation (77), municipal (3 intakes serving 69,960 people), domestic (28), industrial (6), and public (3) uses. Land use in this reach consists of 34,600 acres of farmland, 6,123 residential buildings worth $332.7 million, and 333 nonresidential buildings worth $158.3 million. This reach also has six thermal powerplants with a combined capacity of 3,147 MW.

River flows from Garrison Dam releases affect recreation, water supply intakes, and flood potential. Low flows affect water intakes, boating access, and other recreational opportunities.

3.14.6 Lake Oahe

First-tier Counties

Emmons and Sioux Counties in south-central North Dakota, and Campbell, Corson, Dewey, Potter, Sully, Walworth, and one-half of Stanley Counties in north-central South Dakota surround Lake Oahe. The reservoir lies between RM 1303 and RM 1072. Larger cities within these first-tier counties include Strasburg on Interstate 83, Fort Yates, Mobridge, McLaughlin, Selby, Gettysburg, and Onida. U.S. Highway 83 continues southward through Emmons County, providing access to Lake Oahe.

Counties surrounding Lake Oahe have had a declining population since 1970. A 9 percent decline occurred from 1970 to 1980 (39,744 to 36,244) and an additional 11 percent decline occurred from 1980 to 1990. The median age for counties surrounding the reservoir include some of the lowest and the highest for the entire Missouri River Mainstem Reservoir System. The median age ranges from 22.8 years in Sioux County on the western shore of the Missouri and including part of the Standing Rock Reservation to 40.4 years in Emmons County on the opposite shore of the Missouri River (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for Lake Oahe were government (35 percent), services (24 percent), and wholesale and retail trade (24 percent). This area had one of the highest governmental employment sectors of all of the reaches. Transportation, communications, and utilities (9 percent) employed a greater proportion of the population than most of the other reach and reservoir first-tier counties. The unemployment rate was 4 percent, less than that of the United States and the Missouri River States.

Lake Oahe has a total of 1,746,600 acres of cropland in the first-tier counties surrounding the lake, 31,700 acres (1.8 percent) of which are irrigated. An estimated 1,815,000 recreation days occurred in 1993; the area has 6,451 acres of managed recreational use areas. An estimated $1.6 million in boat ramp modifications occurred from 1988 through 1991 as a result of the drought and decreased water levels. In addition, there are 218 water supply intakes on the lake, providing water for irrigation (179), municipal (8 intakes serving 48,050 people), industrial (2), domestic (21), and public (8) uses. Oahe Dam, with a capacity of 786 MW, provides energy to the region.

With the high annual visitor use at the lake, tourism is a very important aspect of the local economy. The tourism industry around the lake provides many jobs. Many permanent and part-time residents are drawn to the lake for its recreational opportunities. Out-of-state visitors are important to North and South Dakota. The quality of life for area residents is thus closely tied to the lake.

Low water levels during the 1987 to 1993 drought had an effect on tourism. Much of the visitor use remained, but some shifted to the lower portion of the lake, where facilities likely became crowded. Those residents that depend on the upper portion of the lake suffered the most. The economies of the counties were affected by reduced tourism and development. Employment opportunities were lost or shifted location. County and township fiscal conditions were similarly affected. The State and Federal governments have had to expend additional funds to upgrade facilities and stock additional fish to continue to attract visitors to the area and provide a high-quality experience.

Standing Rock Reservation

The Standing Rock Reservation is located on the western shore of Lake Oahe in south-central North Dakota and north-central South Dakota. A small portion lies in Sioux County, North Dakota, and a majority of the Reservation (estimated to be 75 percent or more) lies in Corson County, South Dakota. The Reservation had a 1990 population of 7,956, consisting of 3,761 in the North Dakota portion of the Reservation and 4,195 in the South Dakota portion. The ethnic distribution of the residents was approximately 61 percent Native American, 38 percent Caucasian, and 1 percent of other ethnic heritage. The median age was 22.8 years for the North Dakota portion of the Reservation and 27.9 years for the South Dakota portion. The average number of people/household was 3.68 for the North Dakota portion and 3.22 for the South Dakota portion (U.S. Bureau of the Census, 1992).

The Reservation encompasses all of Sioux and Corson Counties; thus, Reservation unemployment data are reflected in the county statistics. Sioux County had the highest 1990 unemployment rate (17.6 percent) of the first-tier counties in North Dakota, and Corson County had the highest in South Dakota (13.3 percent). These rates were significantly higher than the 1990 State average unemployment rates of 4 percent for North Dakota and 3.6 percent for South Dakota.

The primary 1990 employment sectors were services (44 percent), and government (26 percent). Wholesale and retail trade was about 11 percent. The agriculture, manufacturing, forestry and fisheries, construction, transportation, communication, financial, insurance, and real estate sectors combined accounted for the remaining 19 percent. Employment in forestry and fisheries and mining accounted for less than 1 percent.

Residents depend, in part, on the tourism-based economy of the lake for some of their employment and income. The residents' socioeconomic dependence on the Missouri River is represented in the four recreation areas, farming, and 14 water supply intakes. The water supply intakes are for irrigation, municipal, domestic, and public uses. Some residents use the lake and adjacent lands for hunting and fishing.

Cheyenne River Reservation

The Cheyenne River Reservation is located directly south of and adjacent to the Standing Rock Reservation on the western shore of Lake Oahe in north-central South Dakota. It lies within Dewey and Ziebach Counties and had a 1990 population of 7,743. The ethnic distribution of the residents was approximately 66 percent Native American, 34 percent Caucasian, and less than 1 percent of other ethnic heritage. The median age was 25.4 years, with an average of 3.29 people/household (U.S. Bureau of the Census, 1992).

The Reservation encompasses all of Dewey and Ziebach Counties. Dewey County borders Lake Oahe and had the second highest 1990 unemployment rate (9.7 percent) of the first-tier counties in South Dakota. This rate was significantly higher than the 1990 South Dakota State average unemployment rate of 3.6 percent.

The primary 1990 employment sectors were services (35 percent) and government (20 percent). Employment in wholesale and retail trade and construction were about 10 percent each. Agriculture employed about 8 percent of the employed people over the age of 16. The manufacturing, forestry and fisheries, transportation, communication, financial, insurance, and real estate sectors combined accounted for the remaining 17 percent. Employment in forestry and fisheries and mining accounted for less than 1 percent.

Similar to residents of the Standing Rock Reservation, Cheyenne River Reservation residents depend, in part, on the tourism-based economy of the lake for some of their employment and income. The residents' socioeconomic dependence on the Missouri River is represented in the two recreational sites, farming, and nine water supply intakes. The water supply intakes are for municipal, irrigation, and domestic uses. Some residents use the lake and adjacent lands for hunting and fishing.

3.14.7 Lake Sharpe

First-tier Counties

One-half of Stanley, Buffalo, and Lyman Counties and all of Hughes and Hyde Counties surround Lake Sharpe in central South Dakota. RM 1072 through RM 987 delineate Lake Sharpe. Pierre, Fort Pierre, Highmore, Fort Thompson, and Lower Brule are the larger cities in these first-tier counties. U.S. Highway 14 and Interstate 90 are major east-west routes through the area.

Counties surrounding Lake Sharpe had a population increase after 1970, but the increase has subsequently leveled off. A 12 percent increase occurred from 1970 to 1980 (18,275 to 20,385), while there was no significant increase from 1980 to 1990. Buffalo County has the lowest 1990 median age with 22.1 years and Hyde County has the highest with 39.4 years; the remaining counties have relatively average median ages (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for Lake Sharpe were government (39 percent), services (25 percent), and wholesale and retail trade (23 percent). This area had the highest percentage of governmental employment of the reaches and reservoirs. The unemployment rate was 2.8 percent, among the lowest of the river reaches and reservoirs, and significantly less than that of the United States and the Missouri River States.

Lake Sharpe has a total of 349,700 acres of cropland in the first-tier counties surrounding the lake, 19,100 acres (5.4 percent) of which are irrigated. An estimated 852,000 recreation days occurred in 1993; the lakeshore includes 5,795 acres of managed recreational use areas. Because water levels are fairly constant in the lake, no boat ramp modifications occurred from 1988 through 1991. There are 115 water supply intakes on the lake, providing water for irrigation (91), municipal (3 intakes serving 2,390 people), domestic (19), and public (2) uses.

During the 1987 to 1993 drought, water levels in the lake were unaffected. The area may have benefited from a shift in visitors from the affected lakes to Lake Sharpe, which in turn benefited the local economies of the counties along the lake. Releases from Lake Oahe affect fishing and boating in the upper end of Lake Sharpe.

Lower Brule Reservation

The Lower Brule Reservation is primarily located on the western shore of Lake Sharpe with a small part of the Reservation on the western shore of the upper reaches of Lake Francis Case in central South Dakota. The Reservation lies primarily within Lyman County, and a small portion lies in Stanley County. It had a 1990 population of 1,123. The ethnic distribution of the residents was approximately 89 percent Native American, 11 percent Caucasian, and less than 1 percent of other ethnic heritage. The median age was 19.7 years, and there was an average of 3.98 people/household (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors were services (35 percent) and government (23 percent). Wholesale and retail trade and construction were about 10 percent each. Agriculture employed about 7 percent of the employed people over the age of 16. Transportation and communication also employed about 7 percent in 1990. The manufacturing, forestry and fisheries, financial, insurance, and real estate sectors combined accounted for the remaining 8 percent.

Employment in forestry and fisheries and mining accounted for less than 1 percent.

The Reservation comprises less than one-fourth of Lyman County and only a small portion of the southeast corner of Stanley County. Lyman County had a moderately higher 1990 unemployment rate (4.7 percent) and Stanley County had a slightly higher unemployment rate (4.2 percent) than the first-tier counties in South Dakota. In comparison, the 1990 State average unemployment rate was 3.6 percent. The residents' socioeconomic dependence on the Missouri River is reflected in the 10 recreation areas, farming, and 22 water supply intakes. The water supply intakes are for municipal, irrigation, and domestic uses.

Crow Creek Reservation

The Crow Creek Reservation is located across the lake from the Lower Brule Reservation on the eastern shore of Lake Sharpe, with a small part of the Reservation on the eastern shore of the upper reaches of Lake Francis Case. It lies within Buffalo, Hughes, and Hyde Counties in South Dakota. It had a 1990 population of 1,756. The ethnic distribution of the residents was approximately 87 percent Native American, 13 percent Caucasian, and less than 1 percent of other ethnic heritage. The median age was 21.1 years, and there was an average of 3.98 people/household (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors were services (39 percent) and government (25 percent). Wholesale and retail trade was about 16 percent. Construction employed about 10 percent of the employed people over the age of 16. The agricultural, manufacturing, forestry and fisheries, mining, transportation, communication, financial, insurance, and real estate sectors combined accounted for the remaining 10 percent of the employed people. No Native Americans over the age of 16 were employed in forestry and fisheries or mining in 1990.

The Reservation comprises less than one-half of Buffalo County and a small portion of the southern parts of Hughes and Hyde Counties. Buffalo County had a significantly higher 1990 unemployment rate (8.9 percent) compared to the first-tier counties in South Dakota. Hughes County had a significantly lower unemployment rate (2.4 percent), as did Hyde County (2.6 percent). In comparison, the 1990 State average unemployment rate was 3.6 percent. The residents' socioeconomic dependence on the Missouri River is illustrated in the seven recreation areas, farming, and 55 water supply intakes. The water supply intakes are for municipal, irrigation, and domestic uses.

3.14.8 Lake Francis Case

One-half of Buffalo, Charles Mix, and Lyman Counties and all of Brule and Gregory Counties constitute the first-tier counties around Lake Francis Case in southeastern South Dakota. Lake Francis Case includes RM 987 through RM 880. The primary access routes are Interstate 90 and U.S. Highways 18 and 183. Chamberlain, Kimball, Platte, Gregory, and Burke are the largest towns in the area.

Counties surrounding Lake Francis Case have had a declining population since 1970. An 8 percent decline occurred from 1970 to 1980 (20,477 to 18,930), and an additional 4 percent decline occurred from 1980 to 1990. Buffalo County had the lowest 1990 median age at 22.1 years and Gregory County had the highest at 38.1 years, but the remaining counties had relatively average median ages (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for Lake Francis Case were 29 percent each for government, services, and wholesale and retail trade. The unemployment rate was 3 percent, among the lowest of the reaches and reservoirs, and significantly less than that of the United States and Missouri River States.

Lake Francis Case has a total of 663,800 acres of cropland in the first-tier counties surrounding the lake, of which 17,500 acres (2.6 percent) are irrigated and 646,300 acres are non-irrigated. An estimated 1,266,000 recreation days occurred in 1993; the lakeshore includes 6,800 acres of managed recreational use areas. There are 85 intakes on the lake, providing water for irrigation (72), municipal (6 intakes serving 12,100 people), domestic (4), and public (3) uses. Fort Randall Dam, with a capacity of 320 MW, provides energy to the region.

Like Lake Sharpe, normal water levels were not affected in the 1987 to 1993 drought, because relatively little of the lake volume is used for storage. The fall drawdown regime, described in Section 2, remains a constant hindrance to tourists and lake residents.

3.14.9 Missouri River from Fort Randall Dam to Lewis and Clark Lake

First-tier Counties

Below Fort Randall Dam, the Missouri River extends from RM 880 to RM 836 at Lewis and Clark Lake delta. One-half of Charles Mix County, South Dakota, and all of Boyd County, Nebraska, border this reach. Wagner, South Dakota, is the largest town in the reach.

As with Lake Francis Case, counties below Fort Randall Dam have had a declining population since 1970. A 7 percent decline occurred from 1970 to 1980 (8,749 to 8,171), and an additional 9 percent decline occurred from 1980 to 1990. Although Charles Mix has an average 1990 median age of 32.9, Boyd County had a very high median age at 41.1 years (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for this reach were government (38 percent), wholesale and retail trade (24 percent), and professional services (23 percent). This area had one of the highest levels of governmental employment of the reaches and reservoirs. The unemployment rate was 2.9 percent, among the lowest of the reaches and reservoirs, and significantly less than that of the United States and the Missouri River States.

A total of 244,800 acres of cropland exists in the first-tier counties along this reach, of which 8,500 acres (3.5 percent) are irrigated. An estimated 130,000 recreation days occurred in 1992. Eight irrigation intakes exist on the reach. Flood control on this reach benefits 2,200 acres of farmland, 62 residential buildings worth $6.4 million, and 4 nonresidential buildings worth $0.6 million.

Water releases from Fort Randall Dam affect fishing and boating opportunities in the river and, to some extent, visitor use patterns.

A new Missouri River bridge below Niobrara opened in summer 1998. It furnishes a much-needed tie between Nebraska and South Dakota.

Yankton Reservation

The Yankton Reservation is located on the northeastern shore of the Missouri River in Charles Mix County in southeastern South Dakota. It had a 1990 population of 6,269. Its ethnic distribution was approximately 32 percent Native American, 68 percent Caucasian, and less than 1 percent other ethnic heritage. The median age was 32.6 years, and there was an average of 2.83 people/household (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors were services (50 percent), manufacturing (13 percent), and government (12 percent). Employment in wholesale and retail trade was about 7 percent. Transportation and communication sectors accounted for about 7 percent. Construction employed about 6 percent of the employed people over the age of 16. The agricultural, forestry and fisheries, mining, financial, insurance, and real estate sectors combined accounted for the remaining 5 percent of the employed people. No Native Americans over the age of 16 were employed in forestry and fisheries or mining in 1990.

The Reservation constitutes about one-half of Charles Mix County, which had a 1990 unemployment rate of 3.7 percent. The 1990 State average unemployment rate was 3.6 percent. The residents' socioeconomic dependence on the Missouri River is represented in the farming activities and four irrigation water supply intakes. About 375 acres of farmland and 12 buildings are located in the floodplain.

3.14.10 Lewis and Clark Lake

First-tier Counties

Bon Homme County and one-half of Yankton County, South Dakota, and all of Knox County, Nebraska make up the first-tier counties for Lewis and Clark Lake. The lake includes RM 836 through RM 811. Major cities in the area include Tyndall, Springfield, and Yankton, South Dakota. U.S. Highway 81 and Interstate 29 provide major access to the lake.

Counties surrounding Lewis and Clark Lake have had a declining population since 1970. A 3 percent decline occurred from 1970 to 1980 (29,820 to 28,992), and an additional 9 percent decline occurred from 1980 to 1990. Bon Homme and Knox Counties had higher median-age populations, 37.6 and 40.6 years, respectively, but Yankton had a typical median age (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for Lewis and Clark Lake were 26 percent each for government and wholesale and retail trade and 22 percent for services. This area had higher manufacturing employment (16 percent) than some of the other reaches and lakes. The unemployment rate was 2.1 percent, the lowest of the reaches and lakes, and significantly less than that of the United States and the Missouri River States.

Lewis and Clark Lake has a total of 520,600 acres of cropland in the first-tier counties surrounding the lake, of which 37,500 acres (7.2 percent) are irrigated. An estimated 1,249,000 recreation days occurred in 1993; the lakeshore includes 2,860 acres of managed recreational use areas. There are 37 intakes on the lake, providing water for irrigation (27), municipal (2 intakes serving 4,380 people), domestic (6), and public (2) uses.

Since the water level of the lake is generally unaffected by Mainstem Reservoir System operation, local tourism and visitation remain stable.

Santee Reservation

The Santee Reservation is located in northeastern Nebraska in Knox County, along the southern shore of Lewis and Clark Lake. It had a 1990 population of 758. The ethnic distribution of the residents was approximately 56 percent Native American, 43 percent Caucasian, and 1 percent other ethnic heritage. The median age was 29.5 years, with an average of 2.83 people/household (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors were services (37 percent), manufacturing (11 percent), and government (19 percent). Wholesale and retail trade was about 12 percent. Transportation and communication sectors accounted for about 7 percent. The agricultural and financial and the insurance and real estate sectors accounted for 7 percent and 8 percent, respectively. No Native Americans over the age of 16 were employed in forestry and fisheries, construction, or mining in 1990.

The Reservation comprises less than one-fourth of Knox County. The county had a 1990 unemployment rate of 2.3 percent, compared to the State's average unemployment rate of 2.1 percent. The residents' socioeconomic dependence on the Missouri River is illustrated in the 2 recreation areas, farming, and 7 water supply intakes. The water supply intakes serve irrigation and public needs.

Ponca Tribe of Nebraska (Ponca Tribal Lands)

The Ponca Tribal Lands are located in portions of three counties located in the eastern third of the State of Nebraska. The counties are Knox and Madison, situated in the northeastern section of the State, Douglas and Lancaster, located in southeastern Nebraska, and Charles Mix in south central South Dakota. The Tribal headquarters is located in Niobrara with satellite offices in Lincoln, Omaha, and Norfolk Nebraska. The Ponca Tribe has approximately 1300 enrolled members with a Reservation population of 30. Tribal owned land consists of 159 acres. The Ponca Tribe of Nebraska was terminated in 1962 by an act of Congress. In October 1990, the Ponca Restoration Act was signed and the Ponca have once again become a Federally recognized Tribe.

The primary 1990 employment sectors for the Ponca's Tribal Land were services (48 percent), wholesale and retail trade (16 percent), manufacturing (15 percent), and construction (14 percent). Transportation and communication sectors accounted for about 7 percent. No Native Americans over the age of 16 were employed in the other sectors in 1990.

3.14.11 Missouri River from Gavins Point Dam to Sioux City

The first-tier counties in the reach from Gavins Point Dam to Sioux City (RM 811 to RM 717) include Clay and Union Counties in southeastern South Dakota and Cedar, Dixon, and one-half of Dakota Counties in northeastern Nebraska. Primary access into the area is via U.S. Highway 20 and Interstate 29. Vermillion, South Dakota; Hartington and South Sioux City, Nebraska; and Sioux City, Iowa, are the largest cities in the area.

Counties below Gavins Point Dam have had a varying population trend since 1970. A 4 percent increase occurred from 1970 to 1980 (58,299 to 60,902) but a slight 5 percent decline occurred from 1980 to 1990. Clay County had the lowest 1990 median age at 24 years, and Dixon County had the highest at 36.9 years (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for this reach were manufacturing (30 percent), government (26 percent), wholesale and retail trade (19 percent), and services (15 percent). This reach had the highest proportion of manufacturing employment of all the first-tier counties along the Mainstem Reservoir System and Lower River. The unemployment rate was 3.2 percent, among the lowest of the reaches and lakes, and significantly less than that of the United States and the Missouri River States.

A total of 802,200 acres of cropland exist in the first-tier counties along this reach, of which 98,600 acres (12.3 percent) are irrigated. An estimated 744,000 recreation days occurred in 1993. Eight irrigation intakes exist in the reach. In addition, there are 91 water supply intakes providing water for irrigation (75), municipal (3 intakes serving 103,800 people), industrial (1), domestic (7), and public (3) uses. Flood control on this reach benefits 1,900 acres of farmland, 39 residential buildings worth $2.9 million, and seven nonresidential buildings worth $5.2 million. There are two thermal powerplants with a total capacity of 1,535 MW.

The social well being of the county residents along this reach, which has been designated as a National Recreational River, is moderately tied to the river, because of the high visitor use.

3.14.12 Missouri River from Sioux City to Omaha

First-tier Counties

The first-tier counties of the Sioux City to Omaha reach include one-half of Dakota County and all of Burt, Douglas, Thurston, and Washington Counties in Nebraska and Harrison, Monona, Pottawattamie, and Woodbury Counties in Iowa. The reach includes RM 717 through RM 597.

Counties in the Sioux City to Omaha reach have had an insignificant but steady population increase since 1970. A 1 percent increase occurred from 1970 to 1980 (643,875 to 652,317), and an additional 1 percent increase occurred from 1980 to 1990 (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors in the first-tier counties for this reach were services (30 percent), wholesale and retail trade (25 percent), government (13 percent), and manufacturing (13 percent). This area had the highest proportion of services employment of the reaches and lakes. The unemployment rate was 2.9 percent, among the lowest of the reaches and lakes, and significantly less than that of the United States and the Missouri River States.

This reach differs from the previous reaches described above because the transportation of goods and materials via barge is an important additional contribution to the area economy. The twelve barge and terminal companies located on this reach, moved 403,332 tons in 1999. This available shipping is important to the farmers on the 1,711,900 acres of cropland that exist in the first-tier counties along this reach. Of the total, 97,600 acres (5.7 percent) are irrigated. Eight irrigation intakes exist on the reach. In addition, there are 21 water supply intakes providing water for irrigation (8), municipal (2 intakes serving 530,000 people), industrial (1), domestic (2), and public (5) uses. An estimated 1,238 recreation days occurred in 1993. Flood control on this reach benefits 134,900 acres of farmland, 1,736 residential buildings worth $115.0 million, and 425 nonresidential buildings worth $950.6 million. There are three thermal powerplants with a total capacity of 1,975 MW; one of these is a nuclear powerplant with a capacity of 500 MW.

Although the river provides some recreational benefit to the local economy and social well being of the residents, its primary social value is as a working river. Various water users are dependent on the releases of water stored upstream in project reservoirs and on the flood water storage capacity of the reservoirs. The 1987 to 1993 drought reduced the amount of water available for navigation flows. Area farmers suffered from less available shipping and the higher cost of shipping. Residents, towns, and cities dependent on the barge transportation industry were also affected.

Winnebago Reservation

The Winnebago Reservation is located in northeastern Nebraska along the western shore of the Missouri River in Dixon and Thurston Counties. It had a 1990 population of 2,341. The ethnic distribution of the residents was approximately 49 percent Native American, 50 percent Caucasian, and 1 percent other ethnic heritage. The median age was 28.6 years, with an average of 3.08 people/household (U.S. Bureau of the Census, 1992).

The Reservation constitutes about one-half of northern Thurston County and a very small portion of the southeast corner of Dixon County. The Omaha Reservation, described below, constitutes the remaining southern one-half of Thurston County. Thurston County had the highest 1990 unemployment rate (5.1 percent) of the first-tier counties in Nebraska. In comparison, the 1990 State average unemployment rate was 2.1 percent.

The primary 1990 employment sectors were services (38 percent), government (22 percent), wholesale and retail trade (13 percent), and construction (11 percent). Transportation and communication accounted for about 6 percent. The remainder of the employed Native Americans over 16 were employed in the agricultural, forestry and fisheries, manufacturing, and financial, insurance, and real estate sectors. No Native Americans over the age of 16 were employed in mining in 1990.

Like the other residents of the counties along the river, residents of the Reservation are dependent, in part, on the river. Currently, there are no developed recreational areas located on the Winnebago Reservation banks. There is one water supply intake which supplies irrigation water. About 6,400 acres of farm land is located in the floodplain.

Omaha Reservation

The Omaha Reservation is located in Monona County in western Iowa and Burt, Cuming, and Thurston Counties in northeastern Nebraska. It had a 1990 population of 5,227, all residing in the Nebraska portion of the Reservation. The ethnic distribution of the residents was approximately 37 percent Native American, 63 percent Caucasian, and less than 1 percent other ethnic heritage. The median age was 30.6 years, with an average of 2.95 people/household (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors were services (41 percent), government (11 percent), wholesale and retail trade (25 percent), and manufacturing (10 percent). The remainder of the employed Native Americans over 16 years (13 percent) were employed in the agricultural, construction, transportation, communication, and financial, insurance, and real estate sectors. No Native Americans over the age of 16 were employed in forestry and fisheries or mining in 1990.

The Reservation constitutes the southern one-half of Thurston County and small portions of the remaining counties. As noted above, Thurston County had a 1990 unemployment rate of 5.1 percent. The residents' socioeconomic dependence on the Missouri River is reflected in its farming activities and water supply intakes, which serve irrigation needs. About 5,980 acres of farm land and 12 buildings are located in the Missouri River floodplain.

3.14.13 Missouri River from Omaha to St. Louis

First-tier Counties

The Omaha to St. Louis reach includes RM 597 through RM 0. It comprises five counties in eastern Nebraska, two counties in southwestern Iowa, six counties in northeastern Kansas, and 25 counties in central Missouri.

The Omaha to St. Louis reach has had an 8-percent increase in population each decade since 1970. The population increased from 2.95 to 3.2 million from 1970 to 1980 and to 4.46 million in 1990 (U.S. Bureau of the Census, 1992). The primary 1990 employment sectors in the first-tier counties for this reach were services (26 percent), wholesale and retail trade (24 percent), and manufacturing (17 percent). The unemployment rate was 4.7 percent.

Like the Sioux City to Omaha reach, this reach is also important for transporting goods and materials via barge. An estimated 130 barge and terminal companies located on this reach moved 8,859,492 tons in 1999. Its total of 1,042,300 acres of cropland in the first-tier counties is also unique to the lower river reaches. Of these, only 14,600 acres (1.4 percent) are irrigated. In addition, 51 water supply intakes exist on the reach, providing water for irrigation (22), municipal (14 intakes serving 2,250,200 people), domestic (1), and public (4) uses. An estimated 1,158,000 recreation days occurred in 1992. Flood control on this reach benefits 834,700 acres of farmland, 8,973 residential buildings worth $477.8 million, and 856 nonresidential buildings worth $1,103.1 million. There are 13 thermal powerplants with a total capacity of 7,936 MW, making this the most energy-productive segment of the Mainstem Reservoir System and Lower River. Two of these are nuclear powerplants with a total capacity of 2,040 MW. Associated with this energy production is the need for reliable, high-quality cooling water.

The social value of the river includes its transportation, water supply, and recreational uses. Each use has a high inherent value, and, when combined, make the river an important factor in the local and regional economies. The mainstem dams contribute to this value with water releases in support of navigation and flood control capacity.

Iowa and Sac and Fox Reservations

The U.S. Bureau of the Census provides information separately for the Iowa and Sac and Fox Reservations. The Census indicates that the Iowa Reservation, located on the western shore of the Missouri River, is split evenly between southeastern Nebraska and northeastern Kansas. It lies in Richardson County, Nebraska, and Brown and Doniphan Counties, Kansas. It had a 1990 population of 172, with 157 in Kansas and 15 in Nebraska. The ethnic distribution of the residents was approximately 48 percent Native American and 52 percent Caucasian. The median age was 27.6 years in the Kansas portion of the Reservation and 17.5 in the Nebraska portion. There was an average of 2.85 people/household in Kansas and 3.75 in Nebraska (U.S. Bureau of the Census, 1992).

The primary 1990 employment sectors were services (35 percent), wholesale and retail trade (14 percent), transportation and communication (13 percent), construction (11 percent), manufacturing (10 percent), and government (7 percent). The remainder of the employed Native Americans over 16 years (17 percent) were employed in the agricultural, government, and financial, insurance, and real estate sectors. No Native Americans over the age of 16 were employed in forestry and fisheries or mining in 1990.

The Iowa Reservation residents' socioeconomic dependence on the Missouri River is reflected in farming. There are about 1,000 acres of farm land and four buildings located in the floodplain.

The Sac and Fox Reservation lies within Tama County, Iowa; Richardson County, Nebraska; and Brown County, Kansas. It had a 1990 population of 787, with 577 in Iowa, 127 in Nebraska, and 83 in Kansas. The ethnic distribution of the residents was approximately 78 percent Native American, 21 percent Caucasian, and 1 percent other ethnic heritage. The median age was 22.9 years in the Iowa portion of the Reservation, 33.8 in the Nebraska portion, and 25.4 in Kansas. There was an average of 4.14 people/household in the Iowa portion of the Reservation, 2.76 in the Nebraska portion, and 3.32 in the Kansas portion (U.S. Bureau of the Census, 1992).

The Reservation constitutes a small portion of Richardson and Brown Counties. Richardson County had a 1990 unemployment rate of 2.8 percent, and Brown County had a 4.1 percent unemployment rate. The primary 1990 employment sectors were services (38 percent), wholesale and retail trade (20 percent), construction (15 percent), manufacturing (14 percent), and government (8 percent). The remainder of the employed Native Americans over 16 years (5 percent) were employed in the transportation and communication and the financial, insurance, and real estate sectors. No Native Americans over the age of 16 were employed in agriculture, forestry and fisheries, or mining in 1990.

3.15 HISTORIC PROPERTIES

Historic properties include historic and prehistoric archaeological sites, historic architectural and engineering features and structures, and resources having traditional cultural or heritage significance to Native Americans and other social or cultural groups. Paleontological resources are fossils of prehistoric plants and animals. The National Historic Preservation Act (NHPA) and its implementing regulations (36 CFR 800) define responsibilities for managing cultural resources when a Federal agency considers an undertaking. Any undertaking that would affect sites, structures, or objects eligible for nomination to the National Register of Historic Places according to the criteria set forth in 36 CFR 800 merits an analysis of the significance of the effect and potential avoidance or mitigation measures under the NHPA. The Antiquities Act of 1906 mandates that the Federal government protect significant fossil discoveries.

Although "Historic Properties" is a legal definition pertaining to a specific field of science, in terms of Native American Cultural Resources, it is not a reflective term from the Native American viewpoint and is quite often a point of disagreement. In general, Native Americans view cultural resources from a spiritual viewpoint and disagree with the premise adopted by field of archaeology.

3.15.1 Historic and Archaeological Resources

Historic and archaeological resources are the physical remains of human occupation and activity that extend back in time for approximately 11,500 years in North America. Written historical records tell the story of the past 200 years. Archaeologists have reconstructed the general trends of prehistory from analyses of archaeological remains. The significance of historic and archaeological resources lies in their heritage and scientific value. Important historical sites or historic architectural or engineering structures embody our technological and historical heritage. Archaeological sites are the raw material from which specific events and general trends of prehistory and generalizations about human social and cultural evolution can be constructed.

3.15.2 Prehistory

The Mainstem Reservoir System spans two subregions of the Great Plains region. These are the Northwest Plains and the Middle Missouri subregions. Fort Peck Lake is located within the Northwest Plains subregion, and the remaining mainstem facilities are located within the Middle Missouri subregion. Prehistoric and historic trends in these two subregions are parallel and similar, but also exhibit major differences, particularly after A.D. 1. Figure 3-17 (Gregg, 1986) compares and contrasts the chronological sequences for the Northwestern Plains subarea and the Middle Missouri subarea.

Prehistory begins in both subregions with a Paleoindian period, followed by the Archaic period. The final prehistoric period is called Late Prehistoric in the Northwest Plains. The Middle Missouri subregion, in contrast, adopts horticultural economic practices and diverges in cultural development from the Northwest Plains subregion. The final two prehistoric temporal periods in this region are called Plains Woodland and Plains Village.

The Paleoindian period in both subregions extends between 9,500 and 6,500 B.C. (Frison, 1991). Paleoindian is generally thought to represent the remains of the earliest human occupants of North America, who entered the continent by crossing the Beringian land bridge between Asia and North America. Paleoindian remains are sometimes associated with bones of extinct large game species such as mammoth, mastodon, camel, horse, and giant bison.

The Plains Archaic period extended from 6,500 B.C. to A.D. 500 in the Northwest Plains and until A.D. 1 in the Middle Missouri. This period is generally divided into Early, Middle, and Late subperiods. The beginning of this period is marked by a change from the lance-shaped projectile points of the Paleoindian period to smaller points with basal "ears" or large notches on their sides near the base, used to assist in tying them to a lance or spear. It is also possible that there was a shift at this time from the use of lance weapons to the atl-atl, or spear thrower. Other significant innovations first appeared during this period, including pit houses, stone tipi rings, and the beginnings of bone boiling and bone grease extraction, which was significant in the later development of pemmican food storage technology (Reeves, 1990). An increase in grinding stones and platforms points to more efficient plant food processing, possibly to make use of a wider variety of food sources.

After 1,000 B.C., the number and complexity of communal bison kill sites detected in the archaeological record increased dramatically in the northern Plains. Possibly, a new form of socio-political organization, the pan-tribal society, developed during this period, influenced by the economic surpluses derived from the preparation of pemmican on a large scale (Reeves, 1990). Pemmican, a mixture of dried meat, berries, fat, and liquid bone grease, was compact, highly nutritious, and preserved well, allowing the Plains people to store a secure winter food supply.

After A.D. 1, a cultural pattern began to develop in the Middle Missouri subregion that emphasized exploitation of food resources in river valleys and wooded bottomlands and showed many cultural affinities with archaeological cultures of the eastern United States at this time (Lehmer, 1971). This manifestation is called Plains Woodland. As in the Mississippi and Illinois river valleys and elsewhere, Woodland peoples on the Plains may have begun experimenting with small-scale horticulture through the husbanding of native seed crops such as lamb’s quarter, goosefoot, and sumpweed and imported plants such as maize, beans, and squash. Horticultural foods did not make up a significant percentage of the diet until much later, however. This period also marks the advent of pottery making on the Plains.

The Late Prehistoric period began in the Northwest Plains subregion with the advent of the bow and arrow, sometime after A.D. 500. With its greater range, accuracy, and rapid-fire capability, this weapon enabled more efficient bison procurement. This may have led to increasing population densities and more complex forms of social organization.

In the Middle Missouri subregion, the Plains Woodland culture gave way to the Plains Village culture with the advent of full-scale maize horticulture by around A.D. 1000. Two major traditions, the Middle Missouri and the Coalescent, and the influence of numerous other groups made up the Middle Missouri subregion of the Plains Village Tradition. Plains Village is marked by continued exploitation of bison resources from large and permanent earth lodge villages located mostly on the mainstem and by the intensification of a horticultural subsistence subsystem based on maize, beans, and squash. Maize horticulture did not penetrate upstream of the Yellowstone River mouth.

3.15.3 History

At the time of the earliest European American contact in the early 18th century, the horticultural Mandan, Hidatsa, and Arikara Tribes occupied earth lodge villages along the Middle Missouri, and semi-nomadic bison hunting tribes such as the Blackfoot, Crow, and Assiniboine occupied the Northwest Plains. The introduction of horses, guns, and diseases dramatically altered Tribal economies as well as political relationships between the Tribes. Woodland Tribes such as the Dakota and Cheyenne moved onto the Plains and took up bison hunting. Waves of epidemic diseases such as smallpox dramatically reduced the strength of the Plains Village Tribes, who began a process of consolidation and aggregation.

The earliest recorded European American penetration of the Middle Missouri region was the 1738 trading expedition of Pierre Gualtier de Varennes, Sieur de la Verendrye to the Mandan villages (Lehmer, 1971). French traders entered and resided in the area intermittently for the remainder of the century.

After America gained control of the region from the Louisiana Purchase in 1803, organized trading parties and established trading posts became more common on the Middle Missouri and beyond. Lewis and Clark explored the region between 1804 and 1806, and the Missouri River Fur Company, based in St. Louis, established several trading posts under the direction of Manuel Lisa until the company’s demise in 1814 (Oglesby, 1963). The period between 1820 and 1860, however, was the most important for the fur trade, and numerous trading forts were constructed on the Missouri during that period.

The period between 1850 and 1880 was marked by the establishment of United States military forts, principally to protect navigation on the river. The Treaty of Fort Laramie in 1868 established several Reservations, but most forts were in operation until the 1880s. Farmers increasingly arrived in the Great Plains to settle after the completion of the earliest railroads in the 1880s. The railroad was completed to Bismarck in 1873 and to Pierre in 1880.

3.15.4 Paleontology

Significant paleontological resources along the Mainstem Reservoir System are found in the Fort Peck region. Downstream of Fort Peck, the river flows through thick deposits of glacial till and loess and does not cut through the deeper fossiliferous bedrock. Cretaceous and Tertiary sedimentary deposits, including the fossiliferous Hell Creek formation, are exposed in the Fort Peck region, representing some of the most important fossil-find locations in the United States. These have produced well-preserved skeletons of dinosaurs and other orders, as recent widely publicized discoveries of *Tyranosaurus Rex* skeletons attest.

3.15.5 Archaeological Resources

The lakes, shoreline zones, and adjacent uplands of the Mainstem Reservoir System contain a variety of archaeological site classes, including prehistoric sites of all periods and historic-era forts and homesteads. Although the reservoirs were constructed before the passage of the NHPA, considerable archaeological research was conducted in the impoundment zones of the North and South Dakota projects under the auspices of the Smithsonian Institution's River Basin Surveys program (Lehmer, 1971). This work resulted in the discovery and recording of over 800 archaeological sites and excavation at more than 200 sites. Since Fort Peck Lake was constructed before the River Basin Surveys program, little archaeological work was done there until recently, and little was known about its archaeological resources until the Corps sponsored a sample survey of 4,000 acres located along the shorelines of Fort Peck Lake (Ebasco Environmental, 1992).

The Fort Peck survey recorded 49 archaeological sites, including 12 historic and 37 prehistoric sites. These sites ranged from historic-era homesteads to scatters of stone tool waste, tipi rings, and rock cairn sites to a large communal bison kill and processing site. The survey represented approximately 2.3 percent of the lake perimeter and immediately adjacent backlands. By extrapolation, about 2,000 sites may occur in this perimeter zone at Fort Peck. Other recorded sites at Fort Peck number 110, for a total of 159 recorded sites. Only four of these sites have been recorded within the lakes.

Archaeological surveys have resulted in the discovery of 1,402 archaeological sites in and adjacent to Lake Sakakawea. These include 85 historic sites and 1,317 prehistoric sites. The historic sites include 60 homesteads and cabins, 7 towns, 2 trading posts, and others. The prehistoric sites include 7 earthlodge villages, 2 Plains Woodland burial mounds, 225 rock alignment sites (rock cairns and tipi rings), 200 scatters of stone tool waste, 27 eagle trapping pits, and hearth, cache pit, and bison jump sites. Only 120 of these sites are located in the reservoir pool.

Surveys at Lake Oahe recorded 1,114 archaeological sites, including 241 historic and 874 prehistoric sites. The historic sites include 84 homesteads, 7 farms, 17 towns, 9 missions, 2 trading posts, 2 Indian agencies, 6 military posts, a riverboat wreck, and other sites. The prehistoric sites include 230 earthlodge villages, 9 Plains Woodland mounds, 87 stone alignment sites (tipi rings, rock cairns), 342 scatters of stone tool waste, and 1 bison jump. Only 314 of these sites are located in the reservoir pool, including 12 of the towns and many of the other historic sites.

Archaeological surveys have recorded 165 other archaeological sites, including 19 fortified villages at Lake Sharpe, 78 sites at Lake Francis Case, and 26 sites at Lewis and Clark Lake.

The natural and human forces affecting the archaeological and historic sites in the project area differ widely, according to their location either within the lake or above it on adjacent terraces and on bluff tops in the backshore operating zone. Sites located deep in the pool, below the shoreline fluctuation zone, are to some extent protected by siltation and inaccessibility; however, these sites also suffer increasing degradation due to water saturation and soil chemical change (Lenihan et al., 1981). In addition, they are largely rendered inaccessible because they are covered with water. Sites located within the zone of lake fluctuation suffer inundation effects and, in addition, are eroded by wave action (Lenihan et al., 1981). Materials such as pottery and bone deteriorate rapidly in this zone because of the repeated wetting and drying.

Sites located on terraces and bluff tops adjacent to the reservoir are subject to at least three major sources of degradation. First, normal erosive forces caused by vegetation, stream cutting, and runoff affect these sites to varying degrees. Second, the sites are subject to vandalism and unauthorized artifact collecting. Such effects may increase after dam construction due to the recreational attractiveness of the lake shoreline. Third, these sites are subject to deposit loss stemming from headward erosion of bluff banks due to wave and frost action. A recent study of 12 archaeological sites on bluff tops adjacent to Lake Sakakawea, Lake Oahe, Lake Francis Case, and Lewis and Clark Lake measured bank recession over a period of 50 years using historical aerial photos (Ebert et al., 1989). This study found a steady rate of erosion averaging 8.2 horizontal feet per year at these sites. In some areas, 25 percent or more of this shoreline recession may be directly attributable to frost action. Extreme high water or storm events can also cause sudden and dramatic shoreline slumping. The average annual erosion at all the Mainstem Reservoir System lakes is estimated at between 1 and 2 square miles, resulting in the loss of 40 to 80 sites per year.

The lengths of 142 recorded earthlodge and burial mound sites exposed to bank erosion have been measured at five of the mainstem lakes (Corps, undated). The site totals were 275 yards at Lake Sakakawea, 44,237 at Lake Oahe, 10,322 at Lake Sharpe, 8,492 at Lake Francis Case, and 463 at Lewis and Clark Lake, totaling 63,789 yards, or 36.24 linear miles. Although earthlodge village and burial mound sites are generally larger than other site classes, they represent only the residential and ceremonial sites dating after A.D. 1.

Of 380 Plains Village earthlodge villages (post-A.D. 1000) identified along the Missouri River in South Dakota, 215 are inundated or otherwise inaccessible; 43 are immediately threatened with destruction due to lake action or other causes; 91 are suffering some lake erosion or agricultural impact; and 31 are in good or excellent condition (Winham et al., 1992).

Sites located on banks above the lake pool contain relatively intact deposits and have greater scientific and interpretive value. Lacking artificial bank stabilization or establishment of a natural state of erosional equilibrium, however, some of these sites will be completely destroyed within a few decades.

3.15.6 Bank Stabilization for Protection of Archaeological Sites

The Corps, through the O&M appropriations, has made some progress in bank stabilization efforts for the protection of archaeological sites. Table 3.15-1 summarizes these efforts by fiscal year. The Corps will consult with Native American Tribes, Tribal Historic Preservation Offices, and State Historic Preservation Offices to determine priority sites where bank stabilization efforts should be focused. Site-stabilization work is contingent upon available funds. Additional sites will be protected as funding becomes available. (See Section 3.5 for discussion of lake shoreline erosion.)

3.15.7 Native American Graves Protection and Repatriation Act

On November 16, 1990, the Native American Graves Protection and Repatriation Act (NAGPRA) was signed into law. NAGPRA addresses the recovery, treatment, and repatriation of Native American and Native Hawaiian cultural items by Federal agencies and museums. NAGPRA also addresses the inadvertent discovery of Native American or Native Hawaiian cultural items. As defined by the Act, cultural items are human remains, associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony.

It is the policy of the Corps, Omaha District, to repatriate the remains of Native Americans in accordance with NAGPRA that are inadvertently uncovered by erosion or any other means. Remains are repatriated to the appropriate Tribe with cultural affiliations. Within the State of North Dakota, the remains of Native Americans are repatriated to the North Dakota Intertribal Reinternment Committee. A NAGPRA-based Memorandum of Agreement was signed in 1993 between the Devil’s Lake Sioux Tribe, Standing Rock Sioux Tribe, Three Affiliated Tribes, and Turtle Mountain Band of Chippewa, as represented by the North Dakota Intertribial Reinternment Committee, and the Corps, Omaha District, concerning the protection, preservation, and disposition of unmarked human burials, burial mounds, and cemeteries.

Table 3.15-1. Bank stabilization efforts for the protection of archaeological sites.

Site Name	Fiscal Year	Expenditures ($thousands)
Crow Creek	1978	384
Walth Bay	1979	25
Travis 2	1980	15
DeGrey	1987	15
Havens	1989	97
Whistling Elk	1989	99
Iron Nation (vegetative)	1996	15[a/]
South Iron Nation	1997	60
Iron Shooter	1997	30
Additional/South Iron Nation	1998	42[b/]
Additional/Iron Shooter	1998	45 [b/]
Stony Point	1998	53 [b/]
Demery (vegetative)	1998	15 [a/]
Rorgo/Walth Bays	1998	74[b/]
Crow Creek	1998	277[b/]
Kenel	1998	45
Vanderbilt	1999	278
Molstad	1999	94
Mobridge	2000	96
Lake Whitebull	2001	Ongoing
Leavenworth	2001	Ongoing

a/ Estimated value of volunteer service.

b/ Planned expenditures for fiscal year 1998.

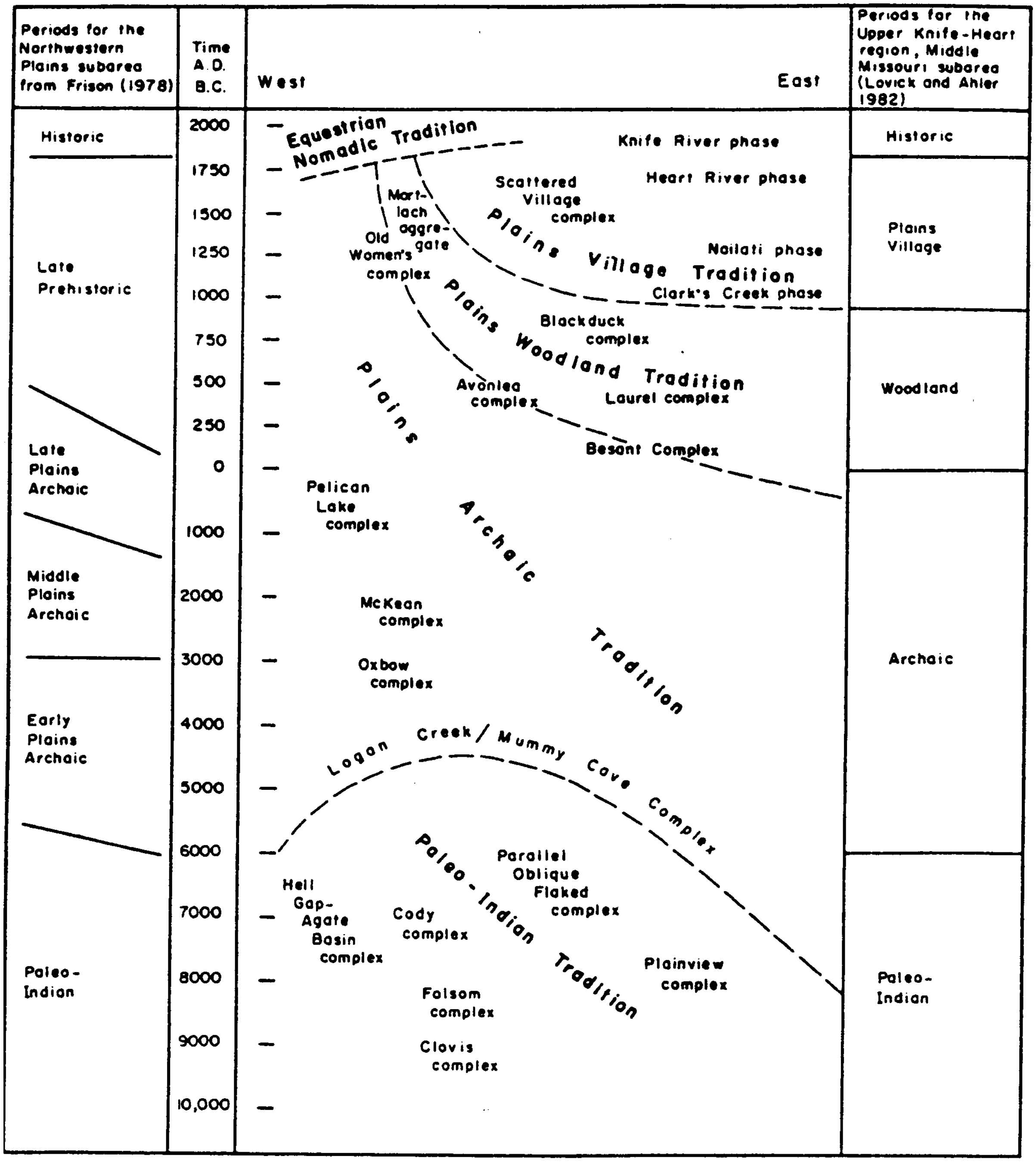

Figure 3.15-1. Chronological model for the Northern Plains, depicting named archaeological units with components known or anticipated in western and central North Dakota.