DEC 4 1998

Reservoir Control Center

Mr. Ralph Morgenweck
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U.S. Fish and Wildlife Service
P.O. Box 25486
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Denver, Colorado 80225-0486

Mr. William Hartwig
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U.S. Fish and Wildlife Service
Bishop Henry Whipple Federal Building
1 Federal Drive
Fort Snelling, Minnesota 55111-4056

Dear Messrs. Morgenweck and Hartwig:

Pursuant to our recent discussions, enclosed is our biological assessment of the effects of the operation of the Missouri River Main Stem Reservoir System on listed species under the current Water Control Plan. This assessment covers Federally listed species and, for purposes of further discussion, the sicklefin chub and sturgeon chub, two candidate species for Federal listing. We have also included an assessment of the effects of certain Kansas River Reservoir System projects as they relate to the operation of the Missouri River Main Stem Reservoir System.

The biological assessment concludes the operation of the Missouri River Main Stem Reservoir System under the current Water Control Plan is likely to adversely affect the pallid sturgeon, piping plover, and interior least tern. The two candidate species will also be affected. In addition, some of the combined operations of the Kansas River and Missouri River Main Stem Reservoir Systems are also likely to adversely affect the Federally listed species. The candidate species will also be affected. Therefore, I am requesting Section 7 consultation under the Endangered Species Act to address whether the operation of the Missouri River Main Stem System and the related operation of the Kansas River Reservoir System will likely jeopardize the continued existence of these listed species.

As we enter consultation, I look forward to working with you and your staff in our continuing discussions of the listed species on the Missouri and Kansas Rivers. Messrs. Doug Latka (402-697-2477) and David Ponganis (503-803-3828) will be our points of contact for this consultation.

If I can be of further assistance, please do not hesitate to contact me.

Sincerely,

Robert H. Griffin
Brigadier General, U.S. Army
Division Engineer

Enclosure

Copy Furnished:
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CENWO-ED-HA (Tim Temeyer)
CENWK-PE-PC (Richard Oldham)
CENWD-MR-ET-R (Admin Record)

Latka/Ponganis/alw/2477

Cieslik/CENWD-MR-ET-R

Goyal/CENWD-MR-ET-C

Crews/CENWD-ET

Ransom/CENWD-OC

Meuleners/CENWD-MR-DD

Griffin/CENWD-DE

MFR: Transmits the biological assessment on Missouri River operations.
Doug Latka/Dave Ponganis 3 Dec 98

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BIOLOGICAL ASSESSMENT

EFFECTS OF MISSOURI RIVER MAIN STEM SYSTEM OPERATIONS ON THE:

PALLID STURGEON

PIPING PLOVER

INTERIOR LEAST TERN

BALD EAGLE

PREPARED BY
NORTHWESTERN DIVISION
CORPS OF ENGINEERS
DECEMBER 1998

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Introduction

The northern Great Plains and Atlantic coast populations of the piping plover (*Charadrius melodus*) were listed as Threatened under the Endangered Species Act of 1973, as amended (ESA) on 11 December 1985. The interior population of the least tern (*Sterna antillarum*) was listed as Endangered under the ESA on 27 June 1985. The pallid sturgeon (*Scaphirhynchus albus*) was listed as Endangered under the ESA on 6 September 1990.

On 8 April 1986 the, U.S. Army Corps of Engineers (the Corps), determined that operation of the Missouri River main stem dam and lake system had the potential to adversely affect the northern Great Plains population of piping plover and the interior population of the least tern. Accordingly, the Corps initiated consultation with the U.S. Fish and Wildlife Service (Service) regarding Missouri River Mainstem System operations, as required under section 7(a)(2) of the ESA. The Corps prepared its Biological Assessment (BA) in October 1987.

The Service issued its Biological Opinion (BO) on 14 November 1990, concluding that the current operations of the Missouri River system would likely jeopardize the continued existence of the northern Great Plains population of piping plover and the interior population of the least tern (the pallid sturgeon was not included in this consultation). The BO contained Reasonable and Prudent Alternatives to avoid jeopardizing the birds, Conservation Actions to assist in the recovery of the birds, and Reasonable and Prudent Measures to minimize or avoid the "taking" of terns, plovers, or their habitat. The BO contains provisions for the ongoing creation and reclamation of habitat suitable for tern and plover nesting, chick-rearing, and foraging. The Corps began implementing provisions of the BO in 1992. Reasonable and Prudent Alternatives 1b and 1c are the primary tasks which guide present habitat development.

Since issuance of the Final Biological Opinion in 1990, the pallid sturgeon has been Federally listed as an endangered species. In addition, extensive data on interior least terns and piping plovers has been gathered. This Biological Assessment summarizes this information and will determine whether operating the Missouri River Reservoir system according to the current Master Water Control Manual will likely adversely affect the listed and candidate species.

This first part of the Biological Assessment summarizes information on the natural history of the pallid sturgeon, northern Great Plains population of the piping plover, interior population of the least tern and two candidates for Federal listing, the sicklefin chub and the sturgeon chub within the Missouri River system. The second part of the Biological Assessment describes the operation of the Missouri River Reservoir system as prescribed in the current Master Water Control Manual. The third part of the Biological Assessment describes the determination of whether or not the current operation is likely to affect the listed species and provides a rationale for the determination.

The bald eagle (Haliaeetus leucocephalus), a threatened species that utilizes the riparian corridor along the Missouri River and below the mainstem dams, is not discussed in detail in the enclosed Biological Assessment. The Corps has made a "no effect" determination for the bald eagle which is consistent with the original 1987 Biological Assessment on the ongoing operation of the

Missouri River main stem system. The U.S. Fish and Wildlife Service noted this "no effect" determination in their 1990 Biological Opinion. The bald eagle was downlisted from Endangered to Threatened in 1995.

I. NATURAL HISTORY

1. Pallid Sturgeon

1.1 General Description

The pallid sturgeon is one of eight North American species of sturgeon (Acipenseridae), and one of three North American *Scaphirhynchus*, the other species being shovelnose sturgeon (*Scaphirhynchus platorynchus* Rafinesque) and Alabama sturgeon (*Scaphirhynchus suttkus* Williams) recently described from the Mobile Basin in Alabama and Mississippi (Williams and Clemmer 1991 USFWS 1993). The pallid sturgeon was first described by S.A. Forbes and R.E. Richardson in 1905 from nine specimens collected from the Mississippi River near Grafton, Illinois, in June 1904 (Forbes and Richardson 1905). Pallid sturgeons have a flattened, shovel-shaped snout; long, slender, and completely armored caudal peduncle; and lack a spiracle (Smith 1979). As with other sturgeon, the mouth is toothless, protrusible, and ventrally positioned under the snout (USFWS 1993). The skeletal structure is primarily cartilaginous (Gilbraith et al. 1988).

Pallid sturgeons are similar in appearance to the more common, darker shovelnose sturgeon (USFWS 1993). Pflieger (1975) reports the principal features distinguishing pallid sturgeon from shovelnose sturgeon are the paucity of dermal ossifications on the belly, 24 or more anal fin rays, and 37 or more dorsal fin rays. Electrophoretic analysis of the two *Scaphirhynchus* species have suggested a very close genetic relationship (USFWS 1993) and mitochondrial DNA studies could not detect significant differences between the two species (Genetic Analyses Inc. 1994). One study concluded that the close genetic similarity of pallid sturgeon and shovelnose sturgeon was due to recent or incomplete reproductive isolation (Phelps and Allendorf 1983). However, Campton et al. (1995) recently concluded that the pallid sturgeon and shovelnose sturgeon are reproductively isolated in North Dakota and Montana

The pallid sturgeon is one of the largest fish species in the Missouri/Mississippi River drainage (USFWS 1993). Adult pallid sturgeon collected from the upper Missouri River are generally larger than adults collected from the middle Missouri River and Mississippi River (USFWS 1993). The maximum recorded weight of a pallid sturgeon collected from the Missouri River in Montana and North Dakota is approximately 39 kg (86 lbs) (Gilbraith et al. 1988), while the maximum recorded weight from the Missouri River in South Dakota and Nebraska is approximately 21 kg (46 lbs), and the maximum recorded weight in the Mississippi River is approximately 12 kg (26 lbs) (USFWS 1993).

1.2 Distribution

1.2.1 Historical

The historical range of pallid sturgeon (Figure 1-1), 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 (USFWS 1993). Keenlyne (1989) reported pre-1980 catch records for the pallid sturgeon as follows: (1) in the Mississippi River from its mouth upstream to its confluence with the Missouri River, a length of 1,857 kilometers (km) (1,154 miles (mi)); (2) in the lower 56 km (35 mi) of the Yazoo/Big Sunflower and St. Francis Rivers (tributaries to the Mississippi); (3) in the Missouri River from its mouth to Fort Benton, Montana, a length of 3,323 km (2,065 mi); (4) in the lower 64 km (40 mi) of the Kansas River; (5) in the lower 34 km (21 mi) of the Platte River; and (6) in the lower 322 km (200 mi) of the Yellowstone River (tributaries to the Missouri River). The total length of the species' range is approximately 5,656 km (3,515 mi) of river.

1.2.2 Present

The present distribution and abundance of pallid sturgeon is difficult to quantify because of different levels of sampling effort throughout its range. Carlson and Pflieger (1981) stated that pallid sturgeon are rare, but widely distributed in the Missouri River and in the Mississippi River downstream from the mouth of the Missouri River. Since 1980, reports of most frequent occurrence are from the Missouri River: (1) between the Marias River and Fort Peck Lake in Montana; (2) between Fort Peck Dam and Lake Sakakawea (near Williston, North Dakota); (3) within the lower 113 km (70 mi) of the Yellowstone River to downstream of Fallon, Montana; (4) in the headwaters of Lake Sharpe in South Dakota; and (5) from the Missouri River near the mouth of the Platte River near Plattsmouth, Nebraska (USFWS 1993) (Figure 1-2). Areas of most recent and frequent occurrence on the Mississippi River are: (1) near Chester, Illinois; (2) Caruthersville, Missouri; and (3) in both the Mississippi and Atchafalaya Rivers in Louisiana at the Old River Control where the Atchafalaya diverges from the Mississippi River (USFWS 1993) (Figure 1-2). Figure 1-2 describes present distribution and areas of frequent occurrence.

1.3 Abundance

1.3.1 Historical

The pallid sturgeon was not recognized as a species until 1905. Therefore little is known concerning its early abundance and distribution (Pflieger 1975). Forbes and Richardson (1905) and Bailey and Cross (1954) indicated that the species was always uncommon. When the pallid sturgeon was first described in 1905, it comprised only about 0.2 percent of the river sturgeon captured in the Mississippi River at Grafton, Illinois (Forbes and Richardson 1905). It was more abundant in the lower Missouri River near West Alton, Missouri, where it comprised about 20 percent of the river sturgeon captured (Forbes and Richardson 1905). Bailey and Cross (1954) provided additional information on the proportions of pallid sturgeon in the total commercial catch of river sturgeon from various parts of the species' range as follows: Kansas River at Lawrence, Kansas (8 percent); Missouri River in South Dakota (5 percent); and Mississippi River at New Orleans (75 percent). Fisher (1962) recorded 4 of 13 river sturgeons (31 percent) from the Missouri River in Missouri as pallid sturgeon. Comparable commercial catch records are not available for the upper Missouri River reaches where commercial fishing was light or nonexistent (USFWS 1993).

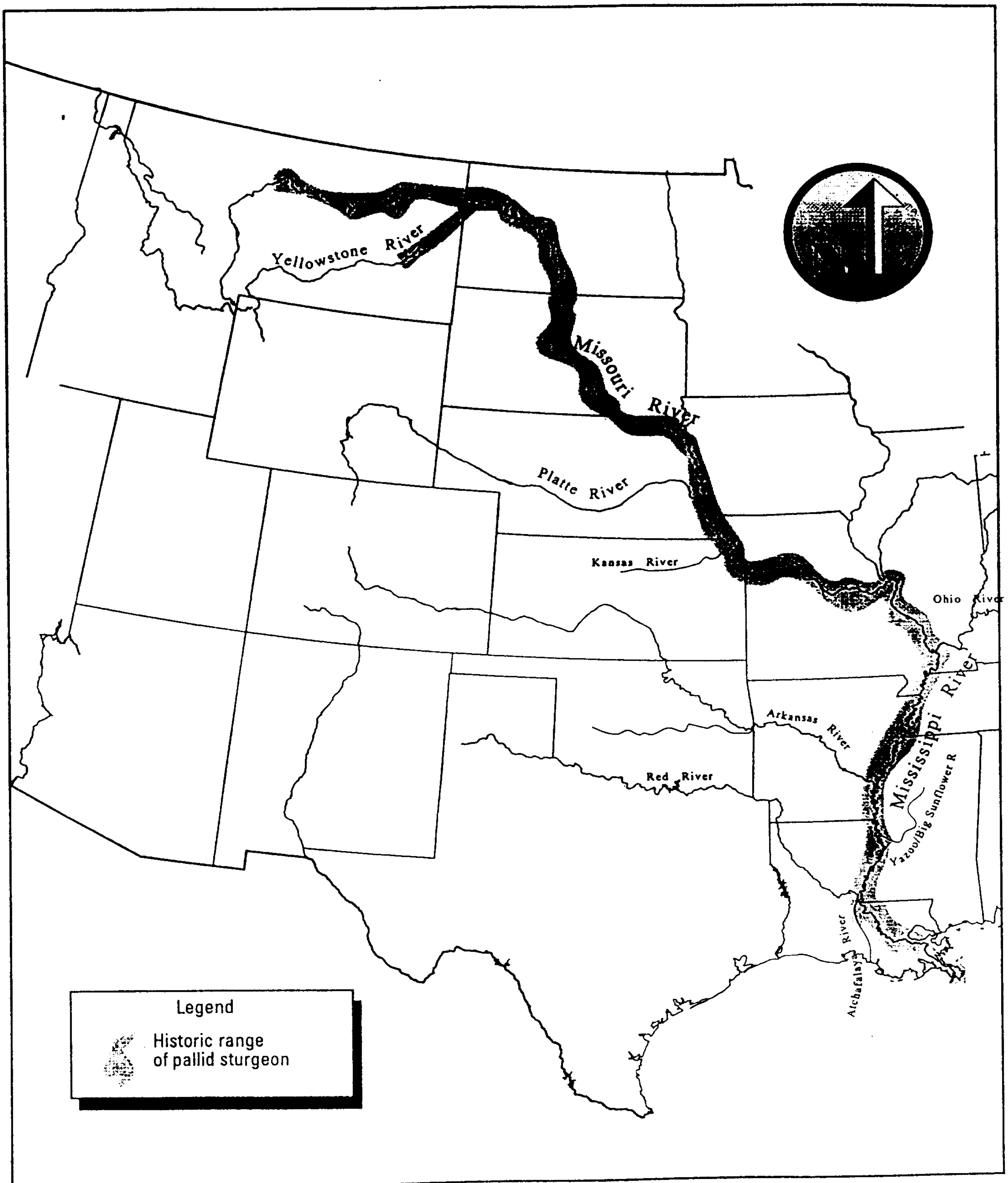

Figure 1-1.
Historic range of pallid sturgeon

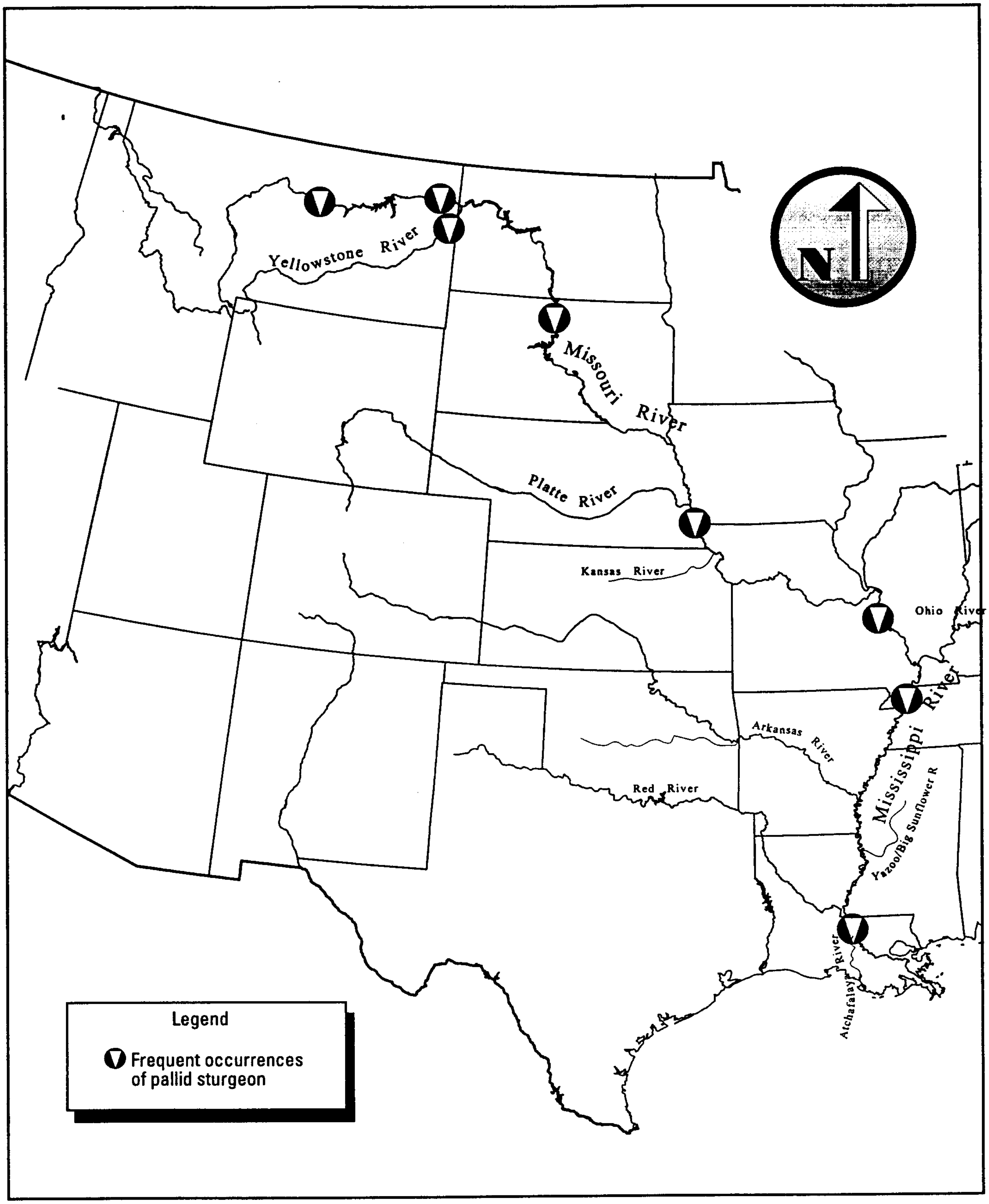

Figure 1-2.
Frequent occurrences of pallid sturgeon

1.3.2 Present

The pallid sturgeon remains one of the rarest fish of the Missouri and Mississippi River basins (USFWS 1993). Carlson and Pflieger (1981) stated that pallid sturgeon are rare, but widely distributed in the Missouri River and in the Mississippi River downstream from the mouth of the Missouri River.

Recent surveys suggest a probable decline in the abundance of pallid sturgeon from former levels. Since 1988, pallid sturgeon researchers have collaborated on studies to gather information about the species, including estimates of distribution and abundance [Keenlyne1995; Upper Basin Pallid Sturgeon Workgroup Stocking Team (UBPSWST) 1997]. This collaboration has allowed workers to identify where populations still remain and to obtain rough estimates of present abundance of the species.

Based on mark and recapture studies, an estimated 50 to 100 pallid sturgeon remain in the Missouri River above the Fort Peck Dam in Montana, and an estimated 200 to 300 remain between the Garrison Dam in North Dakota and Fort Peck Dam, which also includes the lower Yellowstone River (UBPSWST 1997). One to five pallid sturgeon sitings per year have been made between the headwaters of Oahe Reservoir South Dakota and Garrison Dam, North Dakota and between the headwaters of Lewis & Clark Lake and Fort Randall Dam, both in North Dakota and South Dakota. These observations indicate that perhaps as many as 25 to 50 sturgeons may remain in each of these areas (UBPSWST 1997). A small population – perhaps 50 to 100 fish – also remains in the riverine section between Oahe Dam and the Big Bend Dam on the Missouri River in South Dakota (UBPSWST 1997). No evidence of reproduction has been obtained for any of these upper Missouri River system populations; only large individuals are being reported (Keenlyne 1989).

Sampling high-velocity river reaches is difficult, inhibiting accurate abundance estimates in the channelized Missouri River from Sioux City, Iowa to its juncture with the Mississippi River, and in the Mississippi River downstream from the mouth of the Missouri River (UBPSWST 1997). In general, more pallid sturgeon sitings occur in the more turbid lower Missouri River than the Mississippi River (UBPSWST 1997). Pallid sturgeon are still captured in the Mississippi River between the mouth of the Missouri River and the mouth of the Ohio River, but fewer sitings occur downriver due to the diluting effect of the relatively cleaner Ohio River (Keenlyne 1989).

The current best estimate of the total, range-wide population of pallid sturgeon is 6,000 to 21,000 genetically pure individuals (UBPSWST 1997).

Figure 1-3 illustrates the six recovery-priority management areas (RPMAs) that were established in the Pallid Sturgeon Recovery Plan (USFWS 1993) (Figure 1-3). These areas were selected based upon the most recent records of pallid sturgeon occurrence and the higher probability that these areas still provide suitable habitat for restoration and recovery of the species. The six RPMAs are: (1) the Missouri River from the mouth of the Marias River to the headwaters of Ft. Peck Reservoir; (2) the Missouri River from Ft. Peck Dam to the headwaters of Lake Sakakawea, including the Yellowstone River upstream to the mouth of the Tongue River; (3) the Missouri River from 20 miles upstream of the mouth of the Niobrara River to Lewis and Clark

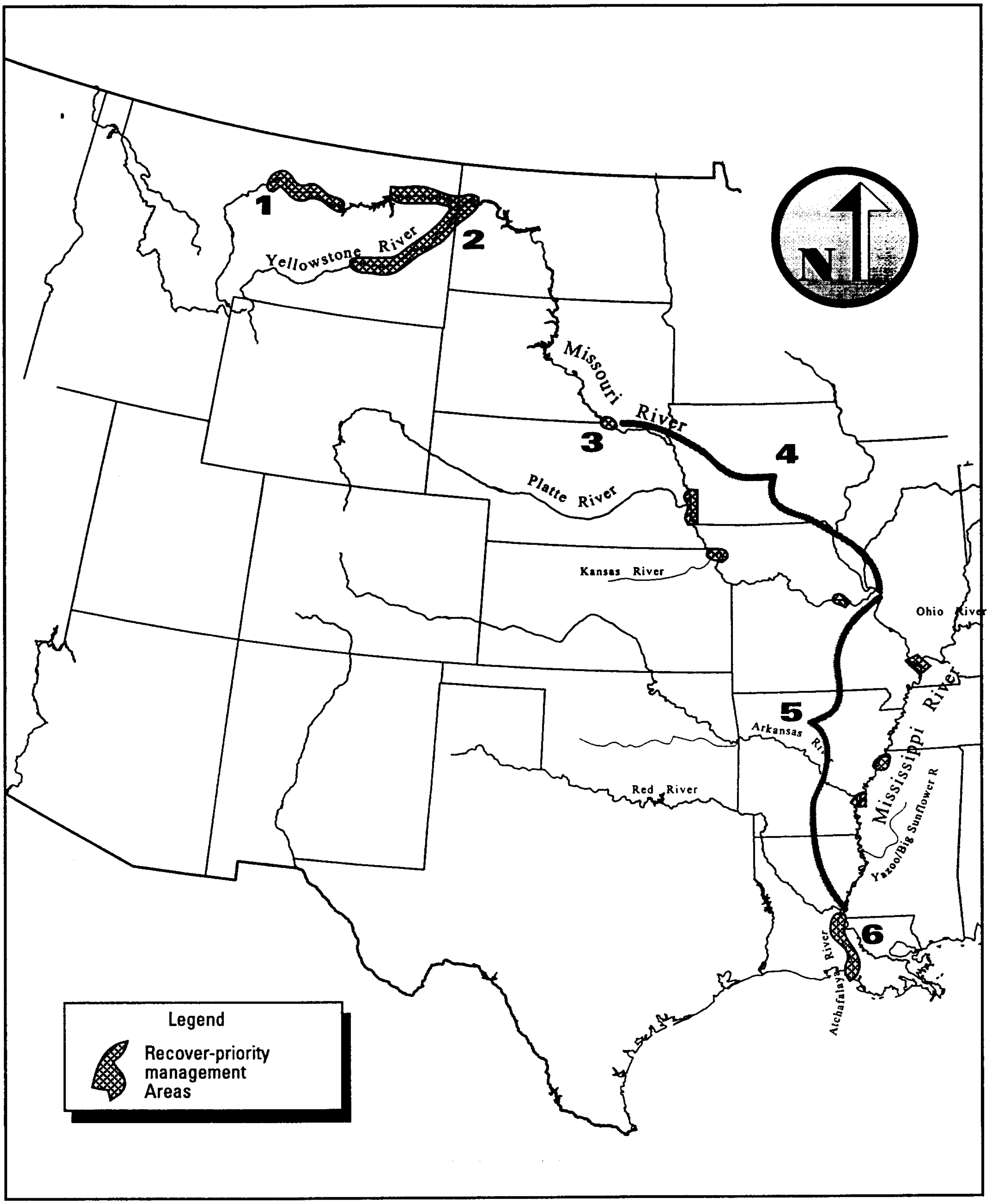

Figure 1-3.
Recovery-priority management areas

Lake; (4) the Missouri River below Gavins Point Dam to its confluence with the Mississippi River; (5) the Mississippi River from its confluence with the Missouri River to the Gulf of Mexico; and (6) the Atchafalaya River distributary system to the Gulf of Mexico.

1.4 Reproduction

1.4.1 General Breeding Biology

Little is known about reproductive activities of pallid sturgeon in the wild (USFWS 1993). Even basic parameters such as spawning locations, substrate preference, water temperature, and time of year have not been well documented (USFWS 1993). And, because pallid sturgeon larvae cannot be distinguished from shovelnose sturgeon larvae at present, it has not been possible to document pallid sturgeon reproduction through the collection of larval pallid sturgeon (USFWS 1993). Spawning reportedly occurs between June and August (Forbes and Richardson 1905). Females collected in June and July from Lake Sharpe, a reservoir on the Missouri River in South Dakota, contained mature ova and presumably was ready to spawn. However, there has been no evidence of successful reproduction during 10 years of sampling for young-of-the-year fish in Lake Sharpe (Kallemeyn 1983). Pallid sturgeon aggregations in the late spring and early summer indicate that spawning may occur in the lower 13 km of the Yellowstone River (Bramblett 1996).

Pallid sturgeons do not become sexually mature until several years of age (UBPSWST 1997). Males reach sexual maturity between 533 to 584 millimeters (mm) total length (Fogle 1961) or between 5 to 7 years of age, while females do not become sexually mature until reading a length of at least 850 mm (fork length) and an age of 15 years (Keenlyne and Jenkins 1993). Pallid sturgeon may spawn from April, in the lower portion of their range, to early June in the extreme northern portion of their range (UBPSWST 1997). Pallid sturgeons have mature reproductive products (eggs and sperm) at times, which coincide with natural high river flows in the respective portions of their range (Keenlyne and Jenkins 1993).

In the wild, males do not spawn every year and females may take up to 10 years between spawning depending on the quality and quantity of food in their natural habitat (Keenlyne and Jenkins 1993). Fecundity of a female may vary considerably with an individual female spawning only a few times during their normal life span. Keenlyne et al. (1992) report that a 17.11 kg pallid sturgeon female, 41 years old, contained 1,952 gm of eggs (11.4 percent of her total weight) numbering 170,000 eggs (UBPSWST 1997).

Because of the lack of information on pallid sturgeon reproduction, inferences are made from what is known of natural reproduction of the closely related shovelnose sturgeon. Shovelnose sturgeon spawn over rock, rubble, or gravel substrates 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°Centigrade (C) to 19.5°C (Moos 1978). Shovelnose spawning has also 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 increased spring flows (Peterman 1977, Zakharyan 1972).

Collections of young-of-year (<120 mm) *Scaphirhynchus* (probably shovelnose sturgeon, based on preliminary identification) made during the 1996 and 1997 field seasons of the Benthic Fish Study provide documentation of ongoing shovelnose sturgeon reproduction and recruitment in the following segments of the Missouri River: (1) between the mouth of the Yellowstone River and the headwaters of Lake Sakakawea (1 fish); (2) in the channelized Missouri River from Rulo, Nebraska to Glasgow, Missouri (15 fish); and (3) from Glasgow to the Mississippi River confluence (4 fish) (pers. comm. between ACOE staff and members of the Benthic Fish Consortium, 1998). Although the same collection technique (benthic trawl) was used in six other river segments, no young-of-year sturgeons were captured in those segments during the two field seasons.

Because of recent successful spawning of pallid sturgeon in a hatchery environment, a federal plan has been developed to increase the species. This includes using three hatcheries to produce young for stocking (ACOE 1998). The UBPSWST prepared a 1997 agency draft for stocking of pallid sturgeon in RPMA 1 and RPMA 2 in Montana and North Dakota (UBPSWST 1997). Beginning in the spring of 1998, approximately 1,500 juvenile pallid sturgeons were to be released back into the wild, including the Missouri River (UBPSWST 1997). About 8,000 young pallid sturgeons 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).

1.4.2 Age and Growth

Little is known about age and growth of pallid sturgeon (USFWS 1993). The lifespan of pallid sturgeon has been estimated to be greater than 40 years (USFWS 1993). Fogle (1963) estimated that pallid sturgeon from Lake Oahe in South Dakota grew relatively rapidly during the first 4 years, but more slowly between ages 5 and 10. Pallid sturgeon in the Missouri and Mississippi Rivers in Missouri showed slightly slower growth than pallid sturgeon in South Dakota (Carlson and Pflieger 1981).

1.5 Habitat Characteristics and Food Habits

1.5.1 Macro Habitats

Pallid sturgeons are well adapted to life on the bottom in swift waters of large, turbid, free-flowing rivers (Forbes and Richardson (1905), Schmulbach et al. (1975), Kallemeyn (1983), and Gilbraith et al. (1988)). Pallid sturgeons prefer turbid, flowing riverine habitat with rocky or sandy substrate (Erickson 1992). Carlson et al. (1985) captured pallid sturgeon in the main channels of the Missouri River along sandbars at the inside of river bends, and behind wing dikes with deeply scoured trenches. Pallid sturgeon collected in the Missouri River have been primarily upstream of reservoirs, with a preference for riverine-like conditions (Kallemeyn 1983). Pallid sturgeon are reported to inhabit areas of swifter water than the closely related but smaller shovelnose sturgeon (Forbes and Richardson 1905; Carlson et al. 1985), although in some reaches of the Missouri River, pallid and shovelnose sturgeon have been collected in the same trammel net set. For example, one small pallid sturgeon and two shovelnose sturgeon were collected in the same trammel net drift in the Missouri River in Missouri in August 1998 (pers. comm. with Dr. Christopher Guy, Kansas State University). However, in the Yellowstone and upper Missouri Rivers, where reproductive isolation still occurs (Campton et al. 1995), there are substantial differences in habitat use and movements between adult pallid and shovelnose sturgeon. Thus, shovelnose sturgeons have limited utility as a model for the pallid sturgeon in this part of the Missouri River system (Bramblett 1996). There is not enough information on young-of-year and juvenile pallid and shovelnose sturgeon to know whether they utilize similar macrohabitats in the Missouri River.

Pallid sturgeon evolved in the diverse environments of the Missouri and Mississippi Rivers (USFWS 1993). Floodplains, backwaters, chutes, sloughs, islands, sandbars, and main channel waters formed the large-river ecosystem that provided macrohabitat requirements for pallid sturgeon and other native large-river fish, such as paddlefish and other sturgeon (USFWS 1993). These habitats were historically in a constant state of change (USFWS 1993). Today many of these habitats have been profoundly altered or eliminated by human developments.

The historic floodplain habitat of the Missouri River provided important functions for the native large-river fish (USFWS 1993). Floodplains were the major source of organic matter, sediments, and woody debris for the main stem river when floodflows crested the river's banks. The transition zone between the vegetated floodplain and the main channel included habitats with varied depths described as chutes, sloughs, or side channels (USFWS 1993). The chutes or sloughs between the islands and shore were shallower and had less current than the main channel. These areas provided diversity to the fish habitat and probably served as nursery and feeding areas for many aquatic species (Funk and Robinson 1974). Still waters in this transition zone allowed organic matter accumulations, important to the production of macroinvertebrates. Both shovelnose sturgeon and pallid sturgeon have a high incidence of aquatic invertebrates in their diet (Gardner and Stewart 1987 Berry, 1996;). Floodflows connected these habitats and allowed fish from the main channel to use these areas and their food sources (USFWS 1993).

Floodflows also stimulated spawning migrations (USFWS 1993). Prior to impoundment, the Missouri River had two periods of peak discharge – one in April resulting from spring runoff and snowmelt on the Great Plains, and a second higher peak in late May to early June resulting from mountain snowmelt. Both shovelnose sturgeon and paddlefish spawning migrations occur in response to increased flows in June (Berg 1981). Studies on the Yellowstone and upper Missouri Rivers suggest that discharge and photoperiod may be important environmental cues for movements of both species (Bramblett 1996).

1.5.2 Micro-Habitat Characteristics

Studies of microhabitat use by pallid sturgeon have only recently been undertaken (USFWS 1993). Because micro-habitat use by pallid sturgeon has been measured primarily in highly-altered river systems, research results may only indicate use of habitat that is currently available, not use of habitat that is optimum (USFWS 1993).

1.5.2.1 Water Velocity. Pallid sturgeons have most frequently been found to use moderately swift waters. In a Montana study, pallid sturgeon were most frequently associated with water velocities ranging from 0.40 to 0.90 meters/second (m/s) [1.3 to 2.9 feet/second (ft/s)] (pers. comm. with P. Clancey, Montana Dept. of Fish, Wildlife, and Parks, 1992 cited in USFWS 1993). Pallid and shovelnose sturgeon in the Yellowstone and upper Missouri Rivers used bottom velocities ranging from 0 to 1.37 m/s (in the Yellowstone) and 0.02 to 1.51 m/s (in the Missouri) (Bramblett 1996). Pallid sturgeon in the Missouri River above Garrison Reservoir in North Dakota during spring and fall seasons were found in the slower currents of near-shore areas (pers comm. with A. Sandvol, U.S. Fish and Wildlife Service, pers. comm. 1992 cited in USFWS 1993). In the Missouri River in South Dakota pallid sturgeon most frequently occupied river bottoms where water velocity ranged from 0.10 to 0.30 m/s (0.33 to 0.98 ft/s), (pers. comm. with J. Erickson, South Dakota State University, 1992 cited in USFWS 1993). Ultrasonic transmitter studies in the Missouri River in the State of Missouri found pallid sturgeon in water velocities of 0.5 to 1.5 m/s at the edge of the main river channel, near sand islands, and off the ends of wing deflector structures (UBPSWST 1997).

1.5.2.2 Turbidity. Pallid sturgeon have historically occupied turbid river systems (USFWS 1993). Turbidity levels where pallid sturgeon were found in South Dakota ranged from 31.3 Nephelometric Turbidity Units (NTU) to 137.6 NTU (pers. comm. with J. Erickson, 1992 cited in USFWS 1993).

1.5.2.3 Water Depth. Pallid sturgeons have most frequently been found in the deeper portions of a river, or on the edge of deep regions. In Montana, pallid sturgeon were captured at depths ranging from 1.2 to 3.7 m (3.9 to 12.1 ft) in the summer, but were captured in deeper waters during winter (pers. comm. with P. Clancey, 1992 cited in USFWS 1993). One pallid sturgeon collected on the Yellowstone River in July 1991 was captured at a depth of 1 to 2 m (3.3 to 6.6 ft) (Watson and Stewart 1991). Pallid and shovelnose sturgeon in the Yellowstone and upper Missouri Rivers were captured at depths ranging from 0.6 to 14.5 m (in the Yellowstone) and 0.9 to 10.1 m (in the Missouri) (Bramblett 1996). During late summer in North Dakota, pallid sturgeon were captured at depths that ranged from 2.1 to 7.6 m (6.9 to 24.9 ft), often in deep pools at the downstream end of chutes and sandbars (pers. comm. with A. Sandvol, 1992 cited in USFWS 1993). Pallid sturgeon were frequently found at water depths ranging from 2 to 6 m (7 to 20 ft) in South Dakota (pers. comm. with J. Erickson, 1992 cited in USFWS 1993). One pallid sturgeon was captured in the lower Platte River in May 1989 at a depth of 1.5 m (4.9 ft) (pers. comm. with M. Harberg, U.S. Army Corps of Engineers, 1992 cited in USFWS 1993). Habitat use studies on the middle Mississippi River (sonar telemetry) revealed that pallid sturgeon most frequently use the deeper main river channel (46 to 67 percent of the time), followed by main channel border areas (Hurley et al. 1997).

1.5.2.4 Substrate. Pallid sturgeon are most frequently caught over a sand bottom, the predominant bottom substrate within the species' range on the Missouri and Mississippi Rivers (USFWS 1993). A pallid sturgeon collected on the Yellowstone River in July 1991 by Watson and Stewart (1991) was over a bottom of mainly gravel and rock, which is the predominant substrate at that capture site. Pallid sturgeon in the Yellowstone and upper Missouri Rivers preferred sand substrates, while shovelnose sturgeon preferred gravel or cobble substrates (Bramblett 1996).

1.5.2.5 Water Temperature. Water temperature preference or the effects of water temperature on the pallid sturgeon is unknown (USFWS 1993). Pallid sturgeons inhabit areas where the water temperatures range from 0^0 C to 30^0 C, the range of water temperature on the Missouri and Mississippi Rivers (USFWS 1993). Curtis (1990) found no relation between surface water temperatures and depth used by shovelnose sturgeon on the Mississippi River, and no indication that shovelnose sturgeon were moving into deeper, cooler water (if available) as water temperature increased.

1.5.3 Feeding Habits

The diet of adult shovelnose sturgeon is comprised primarily of aquatic invertebrates (principally the immature stages of insects in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies) and Diptera (flies and midges) (Megargle and White 1997)). Some fish are also consumed. Adult pallid sturgeon and hybrids consume a greater proportion of fish (mostly minnows) than do shovelnose sturgeon (Carlson et al. 1985, Cross 1967, Held 1969), but it is assumed that aquatic insect larvae also form an important component of the pallid sturgeon diet, especially for juvenile fish.

Modde and Schmulbach (1973 and 1977) observed that several factors affect shovelnose sturgeon prey (insect larvae) availability within the unchannelized Missouri River, including temperature, seasonal prey recruitment, and changes in prey density (which was influenced by the timing and discharge rates from Gavins Point Dam). They hypothesized that reduced numbers of shovelnose sturgeon may be due to reduced prey availability caused by high discharges from Gavins Point Dam. Berry (1996) examined the relationship between dam discharges and food availability for shovelnose sturgeon by comparing sturgeon diet weight and the weight of benthic and drifting invertebrates among years and discharges below Gavins Point Dam. No difference in diet weight of shovelnose sturgeon among years of low, medium, and high flow was found (Berry 1996). However, results supported 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).

Adult, wild-captured pallid sturgeon kept in captivity in hatcheries or aquaria feed exclusively on minnows, goldfish, or small trout (pers. comm. with Darrell Feit, Jerry Hamilton, and Herb Bollig, cited in UBPSWST 1997). Young hatchery-raised fish, as well as older stock, are fed commercial diet (pers. comm. with Mark Drobish, Gavins Point National Fish Hatchery).

1.6 Reasons for Decline

1.6.1 Habitat Loss

Habitat alteration and loss are major factors in the decline of the pallid sturgeon (Williams et al. 1989). Over the past 75 years, habitat of the pallid sturgeon has been lost and dramatically altered (UBPSWST 1997). The most obvious change is the series of impoundments on the upper Missouri River main stem system, and channelization of the lower Missouri and Mississippi Rivers (UBPSWST 1997). Approximately 51 percent of the range of the pallid sturgeon has been channelized, 28 percent impounded, and the remaining 21 percent affected by upstream impoundments that alter flow regimes and modify both turbidity and water temperatures (Keenlyne 1989).

The upper Missouri River dams have created physical barriers that block normal migration patterns, altered habitat characteristics, and restricted riverine fish to the limited reaches of flowing river (Hesse et al. 1989). Damming of the upper Missouri River has altered river features such as channel morphology, current velocity, seasonal flows, sediment load, turbidity, temperature and nutrient supply and food chain paths (Russell 1986, Unkenholz 1986, Hesse 1987). Moreover, these large impoundments have replaced large segments of riverine habitat with lentic conditions.

Channelization of the middle and lower Missouri River has reduced water surface area by half, doubled current velocity, and decreased sediment load (Funk and Robinson 1974). These modifications adversely affect the pallid sturgeon by blocking movements to spawning or feeding areas, destroying spawning areas, altering conditions or flows of potential remaining spawning areas, reducing food sources or the ability to obtain food (Keenlyne 1989).

The Missouri River habitat between and downstream of mainstem dams has been altered by removal of snags, reductions in sediment and organic matter transport/deposition, channel degradation, flow modification, hypolimnetic water releases, and narrowing of the river through channelization (USFWS 1993). These activities have adversely affected natural river dynamics by reducing the diversity of bottom contours and substrate, slowing accumulation of organic matter, reducing overbank flooding, changing seasonal flow patterns, severing flows to backwater areas, and reducing turbidity and water temperature (USFWS 1993).

1.6.2 Commercial Harvest

Historically, pallid, shovelnose, and lake sturgeon were commercially harvested on the Missouri and Mississippi Rivers (Helms 1974). The larger lake and pallid sturgeon were sought for their eggs, which were sold as caviar; shovelnose sturgeons were discarded as bycatch (USFWS 1993). Commercial harvest of all sturgeon has declined substantially since record keeping began in the late 1800s (USFWS 1993). Most commercial catch records for sturgeon have not differentiated between species. Combined annual harvests as high as 195,450 kg (430,889 lbs) were recorded in the Mississippi River in the early 1890s, but had declined to less than 9,100 kg (20,062 lbs) by 1950 (Carlander 1954). Lower harvests reflected a decline in shovelnose sturgeon abundance since the early 1900s (Pflieger 1975).

Today, mortality of pallid sturgeon occurs from both sport and commercial fishing (USFWS 1993). In 1990, the head of a pallid sturgeon was found at a sport-fish cleaning station in South Dakota, and in 1992 a pallid sturgeon was found dead in a commercial fisherman's hoop net in Louisiana (USFWS 1993).

The States of North Dakota, South Dakota, and Louisiana require the release of all sturgeon whether taken commercially or for sport (USFWS 1993). Neither Montana nor Kansas allow commercial harvest of sturgeon (USFWS 1993). Sturgeon continue to be harvested as a bycatch of commercial fishing operations in Nebraska, Iowa, Missouri, Illinois, Kentucky, Tennessee, Arkansas, and Mississippi (USFWS 1993).

1.6.3 Pollution/Contaminants

Although more information is needed, pollution is a likely threat to the pallid sturgeon over much of its range (USFWS 1993). The prolonged egg maturation cycle of the pallid sturgeon (Conte et al. 1988), combined with an inclination for certain contaminants to be concentrated in eggs (Ohlendorf et al. 1981), could make contaminants a likely agent adversely affecting developing eggs, development of embryos, or survival of fry, and thereby reduce reproductive success (Ruelle and Keenlyne 1991).

Pollution of the Missouri River by organic wastes from towns, packing houses, and stockyards was evident by the early 1900s and continued to increase as populations grew and additional industries were established along the river (Whitley and Campbell 1974). Polychlorinated biphenyls (PCB's), cadmium, mercury, and selenium have been detected at elevated concentrations in tissue of three pallid sturgeons collected from the Missouri River in North Dakota and Nebraska. Detectable concentrations of chlordane, DDE, DDT, and dieldrin also were found (Ruelle and Keenlyne 1991). Selenium ingested by fish in the diet is readily transmitted to developing eggs from the parent where it can cause fish teratogenic deformity and embryo mortality (Lemly 1995). Complete reproductive failure can occur with no observable toxic effects on adult fish (Lemly 1995).

Abandoned landfills, mines, sewage treatment plants, and industries have a high potential to contaminate pallid sturgeon habitats in several states (USFWS 1993). Due to the identified presence of a variety of pollutants, numerous fish-harvest and consumption advisories have been issued over the last two decades from Kansas City, Missouri, to the mouth of the Mississippi River (USFWS 1993). This region represents about 45 percent of the pallid sturgeon's range.

1.6.4 Hybridization

Hybridization of pallid sturgeon with shovelnose sturgeon has been reported (Carlson et al. 1985, Keenlyne et al. 1993). Three genetic studies were unable to separate the species genetically. These results suggest that the pallid sturgeon could be a rare morphotype of the shovelnose, that hybridization was occurring, or those testing methods were inadequate (Phelps and Allendorf 1983, Genetic Analyses Inc. 1994). However, a recent genetic study found that pallid and shovelnose sturgeons are reproductively isolated in the Yellowstone and Missouri River confluence area of North Dakota and Montana (Campton et al. 1995 cited in UBPSWST 1997).

The Campton et al. (1995) data support the hypothesis that these species are reproductively isolated in less-altered habitats. However, hybridization may occur in heavily altered habitats such as the lower Missouri River and Mississippi River systems (USFWS 1993). Presumably, the loss of habitat diversity caused by human-induced environmental changes inhibits naturally occurring reproductive isolating mechanisms. Also, the loss of spawning habitat forces similar species to share suitable habitat areas, resulting in increased hybridization. Pallid-shovelnose hybrids are apparently fertile, as evidenced by the capture of ripe female hybrids, and by the wide range of morphometric and meristic variations seen in hybrids that are likely F2 or greater crosses (hybrid x pallid, hybrid x shovelnose, hybrid x hybrid) (Henry and Ruelle 1992).

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2. Piping Plover

2.1 General Description

The piping plover is a migratory shorebird of the family Charadriidae. Adult piping plovers have an average body length of 17 cm (Palmer 1967) and generally weigh from 46 to 64 gm (Wilcox 1959). Throughout the year, adults have a sand-colored upper body, white undersides, and orange legs. During the breeding season, adults develop orange bills and single black bands on the forehead and breast. In general, males have more complete bands than females, and inland birds have more complete bands than Atlantic coast birds (Prater et al. 1977, Haig and Oring 1988). Breeding birds lose the orange bill and bands after the breeding season, but are easily distinguished from related plover species by their slightly larger size and orange legs (Haig and Oring 1987). Juvenile plumage is similar to adult nonbreeding plumage (USFWS 1988). Juveniles acquire adult plumage the spring after they fledge (Prater et al. 1977).

2.2 Distribution

2.2.1 Historical

Piping plovers bred historically in three areas of North America: (1) the Atlantic Coast region from Newfoundland to South Carolina; (2) beaches of the Great Lakes; and (3) the northern Great Plains/Prairie region from the provinces of Alberta, Saskatchewan, Manitoba, and Ontario, to the northern Great Plains states of Montana, North Dakota, South Dakota, and Nebraska (USFWS 1988).

Plovers wintered historically along the southern Atlantic Coast and the Gulf of Mexico—on coastal beaches in Texas, Louisiana, Mississippi, Alabama, and Florida (USFWS 1988). Wintering grounds received much less attention than breeding grounds in the past, so many possible wintering areas were not surveyed (USFWS 1988).

2.2.2 Present

Piping plovers still nest within all three areas of their historic breeding range in North America: (1) the Atlantic Coast region from Newfoundland to South Carolina; (2) Great Lakes beaches; and (3) the northern Great Plains/Prairie region. However, breeding along Great Lakes beaches is currently limited to parts of northern Michigan (USFWS 1994).

The complete winter distribution of piping plovers remains to be determined, but specific sites along the Gulf of Mexico and southern Atlantic coastal states are coming to be recognized as important wintering areas for plovers (USFWS 1988). Band returns indicate that most piping plovers winter along the Gulf of Mexico, on coastal beaches in Texas, Louisiana, Mississippi, and Florida (USFWS 1988).

2.2.3 Distribution on the Missouri River Mainstem System

Piping plovers occur along the Missouri River and its tributaries from central Montana to northern Iowa and Nebraska. In recent years, about 56 percent of the piping plover population on the mainstem Missouri River have nested on river reaches below the Garrison Dam and Gavins Point Dam, around 16 percent have nested on Lake Oahe, and 15 percent on Lake Sakakawea (RDEIS August 1998). Nesting plovers have been documented on a number of Missouri River tributaries, including the Niobrara River, Loup Rivers, and Platte River, and in recent years on the Kansas River.

2.3 Abundance

2.3.1 Historical

There are no estimates of historic piping plover population sizes (i.e., populations prior to the initiation of surveys in the early 1980s) (USFWS 1988).

2.3.2 Present

Breeding surveys in the early 1980s reported 2,137-2,684 adult plovers in the Northern Great Plains/Prairie region, 28 adults in the Great Lakes region, and 1,370-1,435 adults along the Atlantic Coast (Haig and Oring 1985). Surveys on the wintering grounds during the same time period recorded only 25 percent of the population counted on the breeding grounds. No explanation was offered for the difference between wintering and breeding population sizes, but it seems apparent that one or more wintering areas was undiscovered at the time.

In 1991, the first International Piping Plover Census was conducted by the Great Lakes & Northern Great Plains and the Atlantic Coast Piping Plover Recovery Teams (U.S.) and the Prairie Canada Piping Plover Recovery Team (Canada) (Haig and Plissner 1993). This was an important step for surveying piping plovers on breeding and wintering grounds, because census methods and timing were similar in all areas. Results of the 1991 breeding ground surveys were: 1,975 adults in the Atlantic Coast region, 40 adults in the Great Lakes region, and 3,467 adults in the northern Great Plains/Prairie region (Haig and Plissner 1993). On the wintering grounds 3,451 plovers were recorded, with the majority observed in Texas (Haig and Plissner 1993). The 1991 International Piping Plover Census reported major piping plover breeding sites in Montana, North Dakota, South Dakota, and Nebraska (Haig and Plissner 1993).

A second International Census took place in 1996. Results of the 1996 breeding ground surveys were: 2,581 adults in the Atlantic Coast region, 48 adults in the Great Lakes region, and 3,284 adults in the northern Great Plains region (Plissner and Haig 1997). On the wintering grounds, 2,515 plovers were counted (Plissner and Haig 1997).

2.3.3 Abundance on the Missouri River Mainstem System

An Annual census of the adult piping plover population on the Missouri River mainstem system, from Fort Peck Lake, Montana to Ponca, Nebraska, has been conducted from 1988 to the present (ACOE 1993, 1994, 1995, 1996, 1997). For census purposes, the Missouri River system has been divided into eight reaches: (1) Fort Peck Lake; (2) Fort Peck to Lake Sakakawea; (3) Lake Sakakawea; (4) Garrison to Lake Oahe; (5) Lake Oahe; (6) Fort Randall to Niobrara; (7) Lewis and Clark Lake; and (8) Gavins Point to Ponca. Prior to 1993, the Service conducted all census activities on the Missouri River System. Since 1993, the Corps has conducted census activities on all of the system, except for Fort Peck Lake where the Service continues to conduct the census.

Census results for the adult piping plover population on the Missouri River system for 1988 through 1997 are presented in Table 2-1 and shown graphically in Figure 2-1. The adult population has fluctuated from a high of 618 in 1991 to a low of 117 in 1997. For the years 1988 through 1991, the piping plover population fluctuated around an approximate average of 535 adults. However, starting in 1992, the population began a rather steady decline (with the exception of 1995) to its nadir in 1997. Table 2-1 also shows annual plover census results by individual reach within the Missouri River system. Four reaches have been the most important for piping plover: (1) Lake Sakakawea; (2) Garrison to Lake Oahe; (3) Lake Oahe; and (4) Gavins Point to Ponca. These reaches typically have the highest number of adults censured each year, but also show the greatest year-to-year fluctuation in plover numbers.

The 1991 adult plover census counted 618 birds, the highest total in the twelve years of census on the Missouri River system. This total was considerably higher than the 516 birds counted in 1990 and the 446 birds counted in 1989. Most adults were counted on the Lake Sakakawea, Garrison to Lake Oahe, and Gavins Point to Ponca reaches. The greatest increase in numbers, from 71 adults in 1990 to 121 adults in 1991, occurred on the Garrison to Lake Oahe reach. Other reaches had slight increases or remained relatively unchanged from 1990 to 1991.

The 1992 adult plover census counted 478 birds, a 23 percent decrease from the 618 adults counted in 1991, but similar to the numbers counted in 1990 (516 adults) and 1989 (446 adults). Most adults were counted on the Lake Sakakawea, Lake Oahe, and Gavins Point to Ponca reaches. The Fort Peck to Lake Sakakawea, Lake Sakakawea, Garrison to Lake Oahe, Fort Randall to Niobrara, Lewis and Clark Lake, and Gavins Point to Ponca reach all experienced declines from 1991 to 1992. Only Lake Oahe had an increase in numbers from 1991 to 1992.

The 1993 adult plover census counted 381 birds, a 20 percent decrease from the 478 adults counted in 1992, and a 38 percent decrease from the 618 adults counted in 1991. Most adults were counted on the Garrison to Lake Oahe and Gavins Point to Ponca reaches. The greatest decline in numbers were on Lake Sakakawea, which fell from 108 adults in 1992 to only 5 in 1993, and on Lake Oahe, which fell from 143 adults in 1992 to 77 in 1993. Both reservoirs had very high water levels at census time, resulting in little habitat availability. In contrast, Lewis and Clark Lake and Garrison to Lake Oahe experienced substantial increases from 1992 to 1993. Numbers counted on the other reaches remained relatively unchanged between years.

The 1994 adult plover census showed a slight decrease from 1993. The adult census count of 352 represents an 8 percent decrease from the 381 birds counted in 1993, and a 43 percent decrease from the peak year of 1991. Most plovers were counted on the Garrison to Lake Oahe and Lake Oahe reaches. The decline in plover numbers was most severe in the Lewis and Clark

Table 2-1.
Piping Plover Population Survey Data
Missouri River Mainstem System, 1988-98

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Fort Peck Lake											
Adults	10	12	22	25	26	30	4	5	0	0	4
Fledglings/Pair	-	1.50	-	1.90	1.30	0.60	1.50	1.2	0	0	0
Fort Peck to Lake Sakakawea											
Adults	5	11	17	13	0	2	9	20	24	23	4
Fledglings/Pair	-	-	0	0	{}	0+	0	3.50	1.0	0.89	1
Lake Sakakawea											
Adults	143	57	132	150	108	5	46	24	70	3	112
Fledglings/Pair	-	-	-	-	1.50	0.88+	1.22	0	0.57	0.67	1.50
Garrison to Lake Oahe											
Adults	113	86	71	121	77	125	118	261	45	6	68
Fledglings/Pair	1.0+	0.26+	1.05+	1.06+	1.06+	0.88+	0.97	0.93	0.09		1.79
Lake Oahe											
Adults	55	140	88	87	143	66+	84	30	21	31	91
Fledglings/Pair	0.90	-	-	-	0.96+	0.21	0.10	0.93	0.29	1.29	1.10
Fort Randall to Niobrara											
Adult	31	0	31	45	12	12	17	0	3	0	31
Fledglings/Pair	0.07	0	0.69*	0.21	0.50	0	0	0	0.0	0	1.29
Lake Lewis and Clark											
Adult	0	18	11	12	1	32	12	4	6	32	84
Fledglings/Pair	-	0.56	0.69+	0	0	0.06	0.33	0	0.0	1.25	2.45
Gavins Point to Ponca											
Adults	212	122	144	165	111	109	62	63	22	22	49
Fledglings/Pair	0.62	0.21	0.41+	0.35	0.35	1.05	0.61	0.16	0	0	2.12
Total Adults	**569**	**446**	**516**	**618**	**478**	**381**	**352**	**407**	**191**	**117**	**443**
Fledglings/Pair	**0.82**	**0.35**	**0.62**	**0.64**	**0.96**	**0.84**	**0.64**	**0.88**	**0.39**	**0.87**	**1.68**

- Data Not Collected
*** Partial Survey Results**
{} No Birds Found
+ Subsampling of Selected Nesting Areas

Lake and Gavins Point to Ponca reaches. Conversely, Lake Sakakawea experienced a substantial increase in plover numbers from 1993 to 1994.

The 1995 adult plover census showed an increase in numbers for the first time in four years. The adult census count of 407 represents a 16 percent increase over 1994, when 352 plovers were counted, but a 34 percent decrease from the peak year of 1991, when 618 plovers were counted. The overall numbers, however, do not reflect the dynamic changes that occurred within the system in 1995. The majority of plovers (284 or 70 percent) were found on one reach, Garrison to Lake Oahe. This high count, a record for the Garrison to Lake Oahe reach, was most likely a result of low releases from Garrison Dam during the summer. The low releases exposed large areas of sandbar and beach habitat on the river. In addition, high water levels on Lake Sakakawea and Lake Oahe that virtually eliminated habitat on those reaches may have moved birds to the Garrison to Lake Oahe reach.

The 1996 adult plover census showed a precipitous decline in numbers from 1995. The adult census count of 191 plovers represents a 53 percent decline from 1995, when 407 plovers were counted, and a 69 percent decline from the peak year of 1991, when 618 plovers were counted. The decline in plover numbers between 1995 and 1996 was most acute on three reaches (Garrison to Lake Oahe, Lake Oahe, and Gavins Point to Ponca), while numbers actually increased on two reaches (Fort Peck to Lake Sakakawea and Lake Sakakawea). Numbers were virtually unchanged between 1995 and 1996 on the remaining reaches. The overall drop in plover numbers likely was the result of high water levels in the reservoirs and high releases from the dams, both of which substantially reduced the availability of nesting habitat. The fall of numbers on the Garrison to Lake Oahe reach was related to water releases from Garrison Dam, while decreased numbers on the Gavins Point to Ponca reach was related to releases from Gavins Point Dam. Low plover numbers on Lake Oahe were related to high water levels.

The 1997 adult plover census showed a continued decline from 1996. Overall, the census count of 117 adult plovers was the lowest ever in the 12 years that censuses have been conducted on the Missouri River, and represents a 36 percent decline from 1996. The decline in plover numbers between 1996 and 1997 was greatest on the Lake Sakakawea and Garrison to Lake Oahe reaches. In 1996, 66 plovers were counted on Lake Sakakawea whereas only three were found in 1997. In 1996, 41 plovers were counted on the Garrison to Lake Oahe reach. The sharp decline in numbers on both reaches can be attributed directly to the lack of habitat in 1997. When the census was conducted in late June 1997, the level of Lake Sakakawea was already in its exclusive flood zone above 1850 ft msl. Releases from Garrison Dam were at 50,000 cfs, more than twice the normal average. In contrast to these declines, Lake Oahe experienced a slight gain in adult plovers, from 20 in 1996 to 31 in 1997. In addition, Lewis and Clark Lake saw an increase in adults between years, from six in 1996 to 32 in 1997. This increase was due to the inclusion of census numbers from the Niobrara River mouth in 1997; this area was not surveyed in 1996. Census results for the Fort Peck to Lake Sakakawea and Gavins Point to Ponca reaches changed little between 1996 and 1997. No plovers were counted on Fort Peck Lake in 1996 or 1997.

The adult plover census showed a significant increase from the previous two years. The adult census count of 443 adult plovers represents a 379 per cent increase from 1997, when 117 were counted, and was the highest number counted since 1992 when 478 plovers were censured. Substantial increases in the number of plovers occurred on all traditional nesting reaches from Lake Sakakawea down through Gavins Point to Ponca. For 1998, most of the adults were found on Lake Sakakawea, Garrison to Lake Oahe, Lake Lewis and Clark (a large number from Niobrara to the headwaters of Lewis and Clark Lake) and Gavins Point to Ponca reaches. The large increase in the plover numbers was due to the large increase in viable sandbar habitat caused by the high releases and reservoir elevations of 1995, 1996, and 1997. The record flows of 1997 were followed by 1998 releases and reservoir elevation increases, which were only about one-half as great as those experienced in 1997.

2.4 Reproduction

2.4.1 General Breeding Biology

Piping plovers arrive at breeding areas on the Missouri River system in April and May (ACOE 1993, 1994, 1995, 1996, 1997). Adults may return to the same nest areas in succeeding years, as has been documented in other studies (Wilcox 1959, Cairns 1982, Haig and Oring 1988, Wiens and Cuthbert 1988). Piping plovers exhibit a predominantly monogamous mating system, although mate switching may occur during the breeding season (Haig and Oring 1988a) or between years (Wilcox 1959, Wiens 1986, Haig and Oring 1988a).

Nest initiation on the Missouri River system may begin as early as late April or as late as early July (ACOE 1993, 1994, 1995, 1996, 1997). Finished nest scrapes or bowls are shallow depressions approximately 2 cm deep and 6 cm in diameter, frequently lined with small pebbles or shell fragments (USFWS 1988). Both adults actively defend nesting territories. Females lay an egg every other day until a 4-egg clutch is complete. Both sexes share incubation, which can last for 25-31 days (Wilcox 1956, Cairns 1977, Prindiville 1986, Wiens 1986, Haig and Oring 1988a). In Manitoba, incubation began with the laying of the first egg (Haig 1987a), while in Nova Scotia, incubation did not begin until the third egg was laid (Cairns 1977).

On the Missouri River system, eggs begin to hatch from late May to mid-June (ACOE 1993, 1994, 1995, 1996, 1997). Clutches hatch within one-half to one day, and chicks are precocial, being able to feed themselves within hours (USFWS 1988). As chicks leave the nest soon after hatching, little is known about their survival (Prindiville Gaines and Ryan 1988). Males and females share brooding duties, although females in Manitoba deserted broods as early as the first week after hatch (Haig 1987a). Broods generally remain on nesting territories but may expand their movements as they mature or are disturbed. Fledging time varies from 21 days in Manitoba (Haig and Oring 1988a) and North Dakota (Prindiville 1986) to 30-35 days on Long Island, New York (Wilcox 1959). On average, pairs fledge 0.3-2.1 chicks per year (Haig and Oring 1985). Little is known about piping plovers once they have fledged (Niver no date).

By July and August, piping plovers flock on undefended feeding areas and begin migration (Cairns 1982, Prindiville Gaines and Ryan 1988). Breeding adults in Minnesota were observed departing the nesting grounds as early as mid-July and the majority had left by early August (Wiens 1986). Juveniles departed a few weeks later and had largely disappeared by late August (Wiens 1986). Adult males in Manitoba were observed to remain with broods until after fledging and were frequently seen moving into nonbreeding flocks with their chicks (Haig 1987a).

During a single year, most adults raise only one brood of up to 4 chicks, although 1 pair in Nebraska raised 2 broods (Lingle, 1990). When nests are destroyed, adults may renest up to 4 times (Dyer et al. 1987). Young plovers are able to breed the year after fledging, but there is little evidence indicating reproduction by first year birds on the Great Plains (pers. comm. with C. Kruse, U.S. Army Corps of Engineers, September 1998).

Breeding site fidelity for piping plovers ranges from 15 percent in Nova Scotia (Cairns 1977) to 92.3 percent in Minnesota (Haig and Oring 1987b). Return patterns do not differ significantly between males and females (Haig and Oring 1988a). Furthermore, return patterns to specific breeding sites do not seem influenced by previous reproductive success (Wiens 1986, Haig and Oring 1988a). In Manitoba, adults exhibited 2 patterns: (1) those that hatched chicks the year before returned to the same breeding site but changed territories; (2) adults that experienced nest failure the year before generally changed sites (Haig and Oring 1988a). Adults have been known to use breeding sites as far as 546 km apart in consecutive years (Haig 1987a).

The percentage of chicks returning to fledging sites ranges from 4.7 percent in New York to 20.2 percent in Minnesota (Wilcox 1959, Wiens 1986). In Manitoba, first year males and females return in equal numbers (Haig 1987a). Chick dispersal is difficult to characterize, although long-range dispersal distances have been documented.

Current estimates of piping plover survival rates are limited. Root et al. (1992) estimated a mean annual survival rate of 0.664 for adults in the Great Plains population from 1984-1990 using recapture and re-sighting data from plovers in North Dakota. Most plover mortality has been thought to occur during migration or on wintering grounds (Root et al. 1992), but recent studies indicate that overwinter survival can be very high (pers. comm. with C. Kruse, U.S. Army Corps of Engineers, September 1998).

Modeling results have suggested that an annual fledging rate of 1.15-1.44 chicks/breeding pair is essential to stabilize the northern Great Plains piping plover population (Prindiville Gaines and Ryan 1988). Unfortunately, accurate juvenile survival data were unavailable to use in this model, so juvenile survival rates had to be estimated as a percentage of known adult survival. This calls into question both the accuracy and reliability of model results. Ryan et al. (1993) constructed a population model for piping plovers in the Great Plains, again using estimates of juvenile survival rates based on adult survival. Values used were 0.86 for fledge rates, 0.66 for adult survival rates, and 0.60 for immature survival rates. They suggested that fledge rates of 1.13 chicks/breeding pair, adult survival rates of 0.72, and immature survival rates of 0.65 were necessary to keep the population stable. Evidence indicates that the Great Plains piping plover population is declining, and model projections estimate that population extirpation will occur in approximately 80 years (Ryan et al. 1993).

2.4.2 Productivity on the Missouri River Mainstem System

Annual productivity monitoring of the piping plover population on the Missouri River mainstem system, from Fort Peck Lake, Montana to Ponca, Nebraska, began in the 1988 nesting season and has continued each year to the present (ACOE 1993, 1994, 1995, 1996, 1997). Prior to 1993, the Service conducted all census and monitoring activities on the Missouri River System. Since 1993, the Corps has conducted census and monitoring activities on all of the system except

Fort Peck Lake, where the Service continues to conduct the monitoring. Data are collected on the following parameters related to productivity: (1) total number of adults; (2) nests initiated; (3) nests hatched; (4) cause of nest loss; (5) clutch size; (6) eggs hatched; and (7) chicks fledged.

Productivity of the piping plover population on the Missouri River mainstem system for 1988 through 1997 is presented in Tables 2-2 through 2-6. Detailed productivity information (e.g., number of nests, number of nests hatched, number of eggs, number of eggs hatched, total chicks fledged) for 1993 through 1997 is presented in Tables 2 through 6. Productivity has fluctuated from an estimated high of 230 fledged chicks in 1992 to an estimated low of 37 fledged chicks in 1996. Tables 2-2 through 2-6 also show annual productivity by individual reaches within the Missouri River system. As with adult population numbers, four reaches have been the most important for piping plover productivity over the last 12 years: (1) Lake Sakakawea; (2) Garrison to Lake Oahe; (3) Lake Oahe; and (4) Gavins Point to Ponca.

In 1991, productivity was monitored on only six of eight Missouri River system reaches (Lake Sakakawea and Lake Oahe were not monitored). On these six reaches, the overall fledge ratio was calculated to be 0.64. Using this ratio, 198 chicks were estimated to have fledged on the Missouri River system in 1991. Most fledged chicks (64) were produced on the Garrison to Lake Oahe reach.

In 1992, 230 piping plover chicks were estimated to have fledged on the Missouri River system, an overall fledge ratio of 0.96. This is the highest estimated production of piping plovers during the 1988-97 period. Most fledged chicks were produced on the Lake Sakakawea (81), Garrison to Lake Oahe (41), and Lake Oahe (69) reaches. Although a large number of adults (111) was counted on the Gavins Point to Ponca reach, the fledge ratio there was a low 0.35, resulting in the fledging of only 19 chicks. Lake Sakakawea and Fort Peck Lake had especially high fledge ratios of 1.50 and 1.30 respectively.

In 1993, piping plover productivity declined from 1992 levels. One hundred sixty-eight (168) chicks were estimated to have fledged in 1993, down from an estimated 230 in 1992. The 1993 fledge ratio was 0.84, also down from the estimated 0.96 fledge ratio in 1992. Most fledged chicks were produced on the Lake Sakakawea/Garrison to Lake Oahe and Gavins Point to Ponca reaches.

Piping plover productivity also declined in 1994 from 1993 levels. One hundred thirteen (113) chicks were estimated to have fledged in 1993, down from the 168 in 1993. Likewise, the 1994 fledge ratio of 0.64 was down considerably from the 1993 fledge ratio of 0.84. Only three reaches fledged substantial numbers of chicks in 1994 – Lake Sakakawea, Garrison to Lake Oahe, and Gavins Point to Ponca. On Lake Sakakawea, a large amount of nesting habitat became available as the lake level rose to a peak of 1845.4-ft msl.

Table 2-2. PIPING PLOVER PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1993.

REACH	RIVER MILES	NESTS	EGGS	NEST HAT.	NEST SUCC.	EGGS HAT.	FATE DESTROYED					FATE UNKN.	ABAN.	AVG. CLUTCH	ADULT PAIRS a	CHICKS FLEDGE	FLEDGE RATIO
							FLOOD	PRED.	H. DIST.	WTHR.	UNKN.						
Ft. Peck Lk.	14.0	15	55	6	40.0	20	8	0	0	0	1	0	0	3.7	15	9	0.60
Ft. Peck to √ Lk. Sakakawea	39.5	1	4	0	0.0	0	1	0	0	0	0	0	0	4.0	1	0	0.00
Lk. Sakakawea	86.8	11	38_o	3	27.3	11_o	6	0	0	0	0	2	0	3.5	2	34	/
GARRRIV	40.0	69	58	22	31.9	33	11	12	2	2	11	6	2	3.4	43	23	1.07
LONDRES	20.0	41	105_o	6	14.6	18	24	4	0	0	6	0	1	2.6	14	6	
LOSDRES	61.7	7	7	4	57.1	11	1	1	0	0	0	1	0	3.5	7	1	0.14
FTRLRIV	35.0	4	12	2	50.0	8	1	0	0	0	1	0	0	3.0	6	0	0.00
LECLRES	34.0	16	51	5	31.2	16	0	5	0	0	5	1	0	3.2	16	1	0.06
GAPTRIV	61.0	54	195	37	68.5	130	4	1	1	3	7	1	0	3.6	55	58	1.05
TOTAL	378.0	218	525	85	39.0	247	56	23	3	5	31	11	3	3.2	157	132	0.84

a Rounded up to represent complete pairs.
√ Subsampled reaches
o Incomplete reporting
/ Composite fledge ratio due to movement of birds within reaches prior to adult census.

Table 2-3. PIPING PLOVER PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1994.

REACH	NESTS	NEST HAT.	NEST SUCC.	EGGS	EGGS HAT	FATE DESTROYED							FATE UNKN	ABAN	ADULT CENSUS	CHICKS FLEDGE
						FLOOD	PRED	HUMAN DIST.	BANK EROS.	WTHR	LIVE STOCK	UNKN				
Ft. Peck Lk.	11	5	45.5	39	19	0	0	0	0	2	0	2	0	2	4	3
Ft. Peck to Lk. Sakakawea	1	0	0.0	3	0	0	0	0	0	0	0	0	1	0	9	0
Lk. Sakakawea	17	13	76.5	63	43	3	0	0	0	0	0	0	1	0	46	28
Garrison to Lk. Oahe	51	35	68.6	179	126	0	2	0	1	3	0	4	2	4	118	57
Lk. Oahe	33	18	55.0	124	61	3	0	0	0	0	1	0	9	2	84	4
Ft. Randall to Niobrara	6	4	66.7	21	13	0	0	0	0	1	0	1	0	0	17	0
Lewis & Clark Lk.	10	1	10.0	33	4	1	6	1	0	0	0	0	0	1	12	2
Gavins Pt. to Ponca	52	23	44.2	177	80	0	15	0	1	2	0	7	2	2	62	19
TOTAL	**181**	**99**	**54.7**	**639**	**346**	**7**	**23**	**1**	**2**	**8**	**1**	**14**	**15**	**11**	**352**	**113**

Table 2-4. PIPING PLOVER PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1995.

REACH	NESTS	NEST HAT.	NEST COLL.	HAT. & COLL.	NEST SUCC.	EGGS	EGGS HAT.	EGGS COLL.	COLL. HAT.	CHICK COLL	FATE DESTROYED							FATE	FATE	ADULT	CHICK	COLL.
											FLOOD	PRED.	HUMAN DIST.	BANK EROS.	WTHR	LIVE STOCK	UNKN.	UNKN.	ABAN.	CENSUS	FLEDGE	CHICK FLEDGE
Ft. Peck Lk.	10	2	0	0	20.0	31	7	0	0	0	6	1	0	0	0	0	1	0	0	5	3	0
Ft. Peck to Lk. Sakakawea	3	3	0	0	100.	11	8	0	0	0	0	0	0	0	0	0	0	0	0	20	7	0
Lk. Sakakawea	42	5	14	0	11.9	145	14	51	47	0	14	1	6	0	0	1	0	0	1	24	0	44
Garrison to Lk. Oahe	136	81	10	4	82.5	500	292	40	33	9	4	8	0	0	3	0	11	10	5	261	122	33
Lk. Oahe	21	7	3	0	33.3	70	21	8	6	0	3	1	0	0	2	0	4	1	0	30	14	4
Ft. Randall to Niobrara	7	0	0	0	0	9	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
Lewis & Clark Lk.	3	0	2	0	0	6	0	5	4	0	0	1	0	0	0	0	0	0	0	4	0	4
Gavins Pt. to Ponca	56	9	28	0	16.1	189	29	93	78	7	3	12	1	0	0	0	1	1	1	63	5	76
TOTAL	**278**	**1070**	**57**	**44**	**39.9**	**961**	**371**	**197**	**168**	**16**	**37**	**24**	**7**	**0**	**5**	**1**	**17**	**12**	**7**	**407**	**151**	**161**

Table 2-5. PIPING PLOVER PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1996.

REACH	NESTS	NEST	NEST	HAT. &	NEST	EGGS	EGGS	EGGS	COLL.	CHICK	FATE DESTROYED						DEST.	FATE		ADULT	CHICK	COLL
		HAT.	COLL.	COLL.	SUCC.		HAT.	COLL.	HAT.	COLL.	FLOOD	PRED.	HUMAN DIST.	BANK EROS.	WTHR	LIVE STOCK	UNKN.	UNKN.	ABAN.	CENSUS	FLEDGE	CHICK RELEASE
Ft. Peck Lk.	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ft. Peck to Lk. Sakakawea	6	3	0	0	50.0	23	8	0	0	0	0	2	0	1	0	0	0	0	0	24	5	0
Lk. Sakakawea	43	17	16	0	39.5	159	56	61	48	0	5	1	0	0	2	1	0	0	1	70	20	43
Garrison to Lk. Oahe	26	1	9	0	3.8	59	2	21	18	0	1	1	1	0	8	0	0	3	2	45	2	15
Lk. Oahe	18	2	0	0	11.1	45	6	0	0	0	4	4	0	0	5	0	0	2	1	21	3	0
Ft. Randall to Niobrara	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Lewis & Clark Lk.	18	0	17	0	0.0	39	0	38	31	0	0	0	0	0	0	0	1	0	0	6	0	29
Gavins Pt. to Ponca	17	0	8	0	0.0	46	0	20	18	0	0	3	0	0	0	0	1	4	1	22	0	15
TOTAL	**128**	**23**	**50**	**0**	**18.0**	**371**	**72**	**140**	**115**	**0**	**10**	**11**	**1**	**1**	**15**	**1**	**2**	**9**	**5**	**191**	**30**	**102**

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Table 2-6. PIPING PLOVER PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1997.

REACH	NESTS	NEST	NEST	NEST	EGGS	EGGS	EGGS	COLL.	FATE DESTROYED						DEST.	FATE		NON	ADULT	CHICKS	COLL.
		HAT.	COLL.	SUCC.		HAT.	COLL.	HAT.	FLOOD	PRED.	HUMAN DIST.	BANK EROS.	WTHR	LIVE STOCK	UNKN.	UNKN.	ABAN.	VIABLE	CENSUS	FLEDGE	CHICK RELEASED
Ft. Peck Lk.	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ft. Peck to Lk. Sakakawea	6	2	0	33.3	23	8	0	0	1	0	0	0	0	0	2	0	1	0	23	10	0
Lk. Sakakawea	13	1	8	7.7	52	4	31	26	4	0	0	0	0	0	0	0	0	0	3	1	24
Garrison to Lk. Oahe	1	0	1	0.0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	6	0	0
Lk. Oahe	19	11	0	57.9	70	41	0	0	1	0	1	0	1	0	1	3	1	0	31	20	0
Ft. Randall to Niobrara	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lewis & Clark Lk.	17	11	0	64.7	66	40	0	0	0	0	0	0	0	0	3	3	0	0	32	20	0
Gavins Pt. to Ponca	14	7	0	50.0	50	23	0	0	1	1	1	1	0	0	1	1	1	0	22	0	0
TOTAL	**70**	**32**	**9**	**45.7**	**265**	**116**	**33**	**26**	**7**	**1**	**2**	**1**	**1**	**0**	**7**	**7**	**3**	**0**	**117**	**51**	**24**

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Overall productivity of piping plovers was good in 1995, but productivity varied dramatically from reach to reach within the system. One hundred seventy-nine (179) chicks were estimated to have fledged from uncollected nests in 1995, for a fledge ratio of 0.88 for uncollected nests. This represents a substantial increase over 1994. High water levels on Fort Peck Lake, Lake Sakakawea, Lake Oahe, and Lewis and Clark Lake eliminated most nesting habitat for plovers on these reaches. Likewise, high releases from Fort Randall Dam and Gavins Point Dam had the same effect on river reaches below the two dams. In contrast, the low releases from Garrison Dam resulted in abundant nesting habitat in the Garrison to Lake Oahe reach, leading to a boom in productivity; 122 of the 179 chicks that fledged in 1995 came from the Garrison to Lake Oahe reach. Rising water conditions in 1995 forced the collection of 197 plover eggs for captive rearing. Their fate is discussed in section 2.7.2.1 of this report.

Productivity throughout the Missouri River system was poor for piping plovers in 1996. The lack of nesting habitat caused by high water levels throughout the system resulted in concentration of nesting efforts. This led to increased predator efficiency and compounded the catastrophic losses to weather events. Overall, only 37 chicks were estimated to have fledged in 1996, for a fledge ratio of 0.39. This ratio was about 55 percent lower than the 1995 fledge ratio of 0.88. Only four reaches fledged any plovers at all (Fort Peck to Lake Sakakawea, Lake Sakakawea, Garrison to Lake Oahe and Lake Oahe). Lake Sakakawea produced most of these. Water conditions in 1996 forced the collection of 140 plover eggs for captive rearing. Their fate is discussed in section 2.7.2.1 of this report.

Productivity throughout the Missouri River system rebounded for piping plovers in 1997 compared to 1996. Plover productivity more than doubled, from 0.39 fledglings per pair in 1996 to 0.87 fledglings per pair in 1997. The fledge ratio was the highest since 1993. Although these results are encouraging, they must be tempered by the fact that the actual number of breeding pairs recorded in 1997 was very low, meaning that overall productivity was also low. Only 51 chicks were estimated to have fledged in 1997. Although an increase from 1996, when only 37 chicks fledged, this is a still a substantial decrease from previous years (e.g., 179 chicks fledged in 1995). In addition, production was concentrated at limited locations in 1997; 50 of the 51 fledglings came from only three reaches – Fort Peck to Lake Sakakawea, Lake Oahe, and Lewis and Clark Lake (mouth of the Niobrara River). Water conditions in 1997 forced the collection of only 33 plover eggs for captive rearing. Their fate is discussed in section 2.7.2.1 of this report.

Productivity for the Missouri River system in 1998 was the highest estimated production of piping plovers during the 1988 to 1998 period. Plover productivity doubled, from 0.87 fledglings per pair in 1997 to 1.68 fledglings per pair in 1998. Chicks estimated to have fledged in 1997 were 372. A record number of chicks was estimated to have been produced on the Lake Sakakawea, Fort Randall to Niobrara, and Lake Lewis and Clark reaches.

2.5 Nesting Habitat

2.5.1 General

Throughout its range, the piping plover nests on wide beaches with little vegetation (Prindiville Gaines and Ryan 1988). Plovers nest on sparsely vegetated sandbars, sand and gravel shorelines of rivers, and alkali wetlands.

The 1991 International Piping Plover Census reported major piping plover breeding sites in Montana, North Dakota, South Dakota, and Nebraska (Haig and Plissner 1993). Montana plovers breed on sandflats, shorelines of the Missouri Rivers, and saline wetlands. Approximately 15 percent of North Dakota plovers nest along the Missouri River while 85 percent nest in alkali wetlands on the Missouri Coteau (USFWS 1994). In South Dakota, most breeding occurs on sandbars along the Missouri River. Nebraska plovers breed along the Missouri, Niobrara, and lower Platte Rivers. Haig and Plissner (1993) reported 59.6 percent of northern Great Plains/Prairie plovers used alkaline lake habitat, 18.2 percent used reservoir beaches, and 19.9 percent used river islands and sandpits.

Surveys in the 1996 International Census found fewer plovers along reservoirs (7 percent) and river islands (8 percent) and an increase of plovers along alkaline lake habitat (75 percent) (Plissner and Haig 1997). This change may be attributed to decreased habitat availability along the Missouri River as a result of increased flows during these surveys.

2.5.2 Missouri River Mainstem System

Nesting habitats on the Platte, Niobrara, and Missouri Rivers typically are dry sandbars with less than 25 percent vegetation cover located midstream in wide, open channel beds (Faanes 1983, Schwalbach 1988, Ziewitz et al. 1992). On the Missouri River, nests are typically placed in the highest suitable habitat at the time of nest initiation (pers. comm. with C. Kruse, U.S. Army Corps of Engineers, September 1998). These conditions are thought to provide protection from terrestrial predators, isolation from disturbance (especially human disturbance), and protection from slight natural rises in river levels. On the Niobrara River, nesting piping plovers were found to utilize islands where at least 1.3 percent of the total island area was high sand, and greater than 9 percent of the total island area was low sand (Adolf 1998).

2.6 Food and Feeding Habits

Little is known about the diet of piping plovers or their foraging behavior during any phase of the annual cycle (breeding, migration, wintering), largely because the species' status and sensitivity to disturbance have precluded the collection of birds for stomach contents analysis. Along the Platte River in central Nebraska, piping plovers prey primarily on beetles and small soft-bodied invertebrates from dry substrates and from along the waterline (Lingle 1988).

2.7 Reasons for Decline on the Missouri River Mainstem System

2.7.1 Historical

The Missouri River has a drainage basin of over 529,000 square miles (ACOE 1996). Historically, Missouri River flows would rise in early spring from snowmelts on the plains and peak again in June due to snowmelt from the Rockies. Flows would then decline through the summer and fall (ACOE 1996). Flooding was a natural occurrence and was not considered a "problem" until towns grew up along the river. In 1944 the Flood Control Act became law and authorized the construction of dams on the Missouri River and its tributaries (ACOE 1996). Six main dams were constructed along the stretch of the Missouri River from Yankton, South Dakota to Glasgow, Montana. The stretch from Sioux City, Iowa to St. Louis, Missouri was channelized and dredged (ACOE 1996).

2.7.1.1 Habitat Loss. Undoubtedly, the loss of riverine breeding habitat on the Missouri and Platte Rivers has been a major factor in the decline of the northern Great Plains population of the piping plover. The damming, channelization, and withdrawal of water from the Missouri River and its tributaries have eliminated nesting sandbar habitat along hundreds of kilometers of river (USFWS 1988). Seventy-six (76) percent of the Missouri River within the piping plover's nesting range is either fully channelized or impounded by dams, thereby eliminating mid-channel sandbar nesting habitat. These losses have been only partially offset by shoreline habitat created by the reservoirs. Ongoing operation of the reservoir system has contributed to habitat loss in the remaining free-flowing segments of the Missouri River. Riverbed degradation and trapping of sediments at reservoirs has decreased sandbar habitat formation. When river system management does not allow regular scouring of the river, vegetation encroachment is likely to occur on higher islands.

2.7.1.2 Habitat Creation, Reclamation, and Maintenance, 1987-98. To combat historical losses of plover and tern habitat, the Corps embarked on a program of habitat creation, reclamation, and maintenance in 1987. The following section summarizes habitat work by year, and provides more-detailed information by reach. Although this information is included in the piping plover section, it is also applicable to the interior least tern.

The habitat work is presented in two levels of detail. First, a summary table has been prepared of all work, by year and by reach, with abbreviated information on habitat methods (Table 2-7). The summary table also includes information on inflow by year, since the amount of water in the system affects the amount of habitat work that can be done in a given year. Second, habitat work has been summarized by reach, across the years. This section provides more detail on habitat work completed, methodology, and problems encountered. Documents used in the preparation of this section include ACOE (1987, 1991, 1992, 1992a, 1992b, 1993, 1993a, 1993b, 1994, 1994a, 1995, 1996, 1997, 1998, 1998a), Kruse (1993, 1993a), Latka and Nebel (1993), NGPC (1985), and USFWS (1990).

Many factors enter into the planning process for habitat work in a given reach or area. These include historic use by terns and plovers, the proximity to human recreation areas, the proximity to known predator habitat, the availability of foraging habitat, the availability of alternate habitat, the elevation of the habitat, anticipated water surface elevations for that year, etc. Habitat Development Criteria were developed in 1992 for initial use in "screening" potential habitat creation or reclamation areas. The purpose of the criteria was to avoid habitat development in areas where the birds would likely not survive until fledging due to predation, human disturbance, or other factors.

Table 2-7

Corps' Habitat Manipulation on the Missouri River Mainstem System, by Reach

YEAR	Gavins Reach	L&C Lake	Ft. Randall Reach	Lake Oahe	Garrison Reach	Lake Sakakawea	Ft. Peck Reach	Ft. Peck Reservoir
1987	m1	--	--	--	--	--	--	--
1988=	m1, m2, c2	--	--	--	--	--	--	--
1989-	c1	--	m1, c1	--	--	--	--	--
1990	m1, m2, c1	--	m1, m3, c1	--	--	--	--	--
1991-	m5, c2	--	m5	--	p1	--	--	--
1992-	m3, c2, m5, b, p4	m4, c2, p4	m2, c2, m3	--	p1, p2, b, c2	--	--	b
1993*	m1, m3, p4, b	p3	--	--	p1, p2, c2	--	p3	b
1994	m1, m2, m3, c2, p4	--	--	m1, m2, c2, b	m4, c2, p2	--	p2, p3	--
1995*	--	--	--	m2, m3	--	--	m2	--
1996*	--	--	--	c2	--	m3, p2	--	--
1997*	--	--	--	--	c2	m3, p2, c2	c2	--
1998	--	--	--	e	--	m2, c2	--	--

Table Key

Inflow

-	years of less than lower quartile inflows (drought potential)
=	years of less than lower decile inflows (severe drought potential)
*	years of greater than upper decile inflows (severe flood potential)

Mechanical Manipulation

m1	-	mowing or disking vegetation
m2	-	tree removal by bulldozing, cutting, etc
m3	-	"pushing up" low sand to higher elevations.
m4	-	dredging sand for island/sandbars
m5	-	hand-pulling vegetation

Burning

b	-	burning vegetation

Passive / Manufactured

p1	-	sand fences
p2	-	oyster shell / gravel
p3	-	floating islands
p4	-	sandbag / SEAbag

Chemical Manipulation

c1	-	pre-emergent herbicide (Norosac 10-G)
c2	-	contact herbicide (Rodeo)

Explosives

e	-	removal of vegetation using explosives

Initial habitat efforts, prior to receipt of the BO in 1990, were experimental and small-scale, with the objective of determining which methods would work. Implementation of the BO and associated habitat tasks began in 1992. Due to the differing habitat problems associated with drought and flood situations, yearly habitat efforts have a different focus, based on the anticipated inflows and existing habitat conditions for that year (Table 2-7). For example, during prolonged low inflows, vegetation removal was the main focus of habitat efforts, whereas when high flows were anticipated, creation (or reclamation) of high-elevation habitat was the main focus. In recent years of record inflows, even high-elevation habitat was at risk or inundated, prompting alternative actions such as the collection of eggs, which initiated the Corps' chick-rearing program. As these high flows receded, however, high elevation, low vegetation habitat was exposed. These replenished sandbars have resulted in record fledging success rates and low predation during 1998 (U.S. Army Corps of Engineers, 1998 unpublished data).

2.7.1.2.1 Gavins Point to Ponca. The Gavins Point to Ponca reach has had more habitat improvement activity than any other reach in the Missouri River mainstem system, both in the number of years habitat work has occurred, and in the number of acres that have been created, reclaimed, or maintained. As early as 1982, a Nebraska Game and Parks Commission's (NGPC) survey report indicated that the sandbar complex at RM 801 had potential for mechanical manipulation of vegetation to create additional "low vegetation" habitat. In 1985, the NGPC presented a habitat management proposal to the Corps which included a suggestion to artificially maintain nesting habitat by clearing vegetation on islands that were high enough that they were not subject to flooding.

In October, **1987**, approximately four acres of vegetation on a low sandbar on the south side of the complex at RM 801was tilled with a 5-foot tiller pulled by a small tractor. The site contained young trees easily removed with a tiller. The elevation of the sandbar was such that river fluctuations of 1 to 2 feet would not affect nesting habitat. The tilling initially created suitable nesting substrate, but revegetation was becoming widespread by the summer of 1988, creating unsuitable nesting conditions. Resprouting willows, cottonwoods, and annual vegetation covered the entire tilled area.

In **1988**, habitat work continued on RM 801. Habitat work was also expanded to include RM 797, which had been abandoned by the birds in 1986, presumably due to overvegetation. In August, Rodeo herbicide was aerial sprayed over both islands. (Rodeo herbicide is safe for aquatic use, and is a contact herbicide that is absorbed by the foliage of actively growing plants, killing the entire plant. Rodeo is not effective on dormant plants or seeds.) At RM 801, low sandbars at the north and south ends of the complex were sprayed, as well as a high sandbar extending down the middle of the complex. The high sandbar had cottonwood trees up to 15 feet tall (5 to 8 years old). About 30 acres of cottonwood and willow trees were sprayed at RM 797. Within two weeks of spraying, a total kill of sprayed vegetation was documented. Although burning the dead vegetation was attempted, it was unsuccessful due to the sparse distribution of vegetation.

In September, heavy equipment was transported to the islands with the help of the South Dakota Army National Guard's (SDNG) 200th Engineer Battalion. At RM 801, vegetation was knocked down on the high bar using a front-end loader, a bulldozer, and a tractor with mower. The vegetation was piled for burning, but too much sand was included in the piles for successful burning. Vegetation on the low bars was mowed to prevent the formation of a seedbed. At RM 797, approximately 20 acres were mowed, and then half of the mowed area was also disked in anticipation of a 1989 application of pre-emergent herbicide.

Habitat work continued in **1989**, with the spring aerial application of Norosac 10-G (a pre-emergent herbicide) in test strips on the sandbar complex at RM 801. Norosac was also aerially applied to about ten acres on RM 797. Norosac was effective in preventing germination in the sandy soils. Follow-up visits to the islands indicated that there was no apparent difference in the two different application rates used, since both controlled new vegetative growth. In June, 11 least tern nests and 2 piping plover nests were established on the low sandbar on the north side of RM 801. A predator, probably a mink, subsequently destroyed all nests.

During April, **1990**, 13 acres of RM 801 were mowed, disked, and treated with Norosac. Brush piles from the 1989 efforts were piled into a depression and buried, in case they were providing habitat for predators. Much plover courtship activity occurred at RM 801, but only 3 plover nests were established, and no young fledged. At RM 797, 13 acres were disked and treated with Norosac. This island provided habitat for 2 plover nests, but fledged no young. Budget constraints prevented expansion of the habitat program this year.

Budget constraints were again a factor in **1991**, and Operation Desert Storm limited the availability of the SDNG, so only small-scale activities were pursued. Due to concerns expressed about the use of Norosac, the focus for chemical control of vegetation was turned to Rodeo herbicide. Prior to full-scale use of Rodeo, however, the Service requested that the Corps complete a literature review on toxic effects of Rodeo. Additionally, a two-year patterned vegetative removal study was initiated at several islands below Gavins Point Dam. South Dakota State University (SDSU) was contracted to determine the effectiveness of hand-pulling or hand-cutting vegetation for small plot vegetation control, as well as the "preferred" patterns of vegetation removal for nesting habitat. It was thought that terns and plovers, especially chicks, may need some vegetation for shade and cover from avian predators. Fall hand-clearing was done at RM 803.7, 790.5, 781.4, and 759.0.

1992 was the first year of major habitat activities directly implementing the BO. A basin-wide plan was developed, and additional funding was requested and received. Coordination efforts with other agencies increased, and a Tern and Plover subcommittee was formed under the Missouri River Natural Resources Committee. The Corps, SDSU, and volunteers continued hand-pulling and hand-cutting vegetation for the patterned vegetation study. Small plots (less than 5 acres total) were cleared on 10 islands. Both terns and plovers used the cleared areas for nesting during 1992. The study found that the greatest impact (hand pulling vs. hand cutting; spring vs. fall) on vegetative regrowth (stems per square meter) could be obtained by hand-pulling 3- to 6-year-old vegetation during the fall, but this method was time consuming. Hand-cutting vegetation during the fall was almost as successful with much less time commitment.

Rodeo was used to clear 10 acres of island habitat in the Gavins Point to Ponca reach during September. During October, the SDNG assisted in transporting equipment to "push up" 2 low-elevation islands to higher elevations. The newly created areas were protected from erosion by sandbags and SEAbags. Fall vegetation burning was done at RM 759. Habitat modifications were made at the following RMs: 804.5, 804, 803.8, 803.7, 801, 799.1, 798.5, 797, 790.6, 790.5, 790.4, 781.6, 781.4, 781.3, 775.9, 775.0, 772.5, 770.1, 770.0, 761.7, 759.2, 759.0, 757.4, 757.3.

Beginning in **1993**, islands at the above-listed river miles were considered "habitat maintenance areas," that is, islands where the Corps had already done habitat creation/restoration work, and would continue to maintain habitat. Habitat "maintenance" included the following: (1) using Rodeo herbicide to control vegetation; (2) burning of dead vegetation; (3) armoring islands with sandbags or SEAbags; (4) installation and removal of sand fences; placement of oyster shell or gravel; (5) removal of large driftwood and other non-living potential predator habitat; (6) minor sand-dune reshaping using hand tools or equivalent; (7) mowing of vegetation; and (8) hand-cutting of woody saplings (less than 4 inches, dbh). Maintenance activities were scheduled prior to the birds' arrival, after the birds' departure, or on islands not being used by birds that year.

Habitat creation and maintenance included late October efforts, with assistance from the 200th and 854th Units of the SDNG, inmates from the Yankton Federal Prison Camp, as well as Corps' staff. Nine sites at 6 island locations were created, totaling about 4 acres at RM 804.5-804.6, 803.8, 802.7, 801.5, 801, and 799.2. Sites were pushed up to an average of 46 inches above existing elevations using heavy equipment. In addition, approximately 18 acres of habitat were mowed, with 7 of these acres available for 1994 nesting. The remaining acres needed spring herbicide treatment prior to the nesting season. SEA bags were placed on the upstream ends of RM 803.8 and 801.5. Residual vegetation remaining after mowing at RM 801 was burned.

In April **1994**, approximately 120 acres of habitat were cleared on 9 sites using chainsaws and brush hogs. The SDNG and a private contractor were used to shuttle equipment to the islands. After clearing, the sites were "capped" with unconsolidated sediments using bulldozers and tractors pulling discs. SEA bags and sandbags were used to stabilize upstream and channel sides of some of the sites. The project was very successful, with over 250 nests being initiated on these sites and the sites created during the fall of 1993. In late July and August, 110 acres of habitat were maintained with Rodeo to prepare the nesting areas for the 1995 nesting season.

Upper decile inflows in **1995, 1996,** and **1997** precluded habitat development below Gavins Point Dam. The receding high flows and the median inflows during **1998** resulted in hundreds of acres of newly-created vegetation-free sandbar habitat, resulting in record high fledge ratios in this reach as well as low predation rates (See Table 2-8). No habitat maintenance or creation was needed in this reach during 1998.

Table 2 - 8

Sandbar acreage for three years from Gavins Point Dam to Ponca, NE.

year	discharge cfs	very good(1)	good(2)	fair(3)	total acres
1992*	32,000	nd	nd	nd	69
1996**	45,000	77	621	271	968
1998**	32,000	1937	448	779	3164

1 very good = sandbars with no vegetation
2 good = sandbars with less than 10% vegetative cover
3 fair = sandbars with 10% to 25% vegetative cover
* acreage determined from aerial videography
** acreage determined from digital ortho photography
nd = not determined

2.7.1.2.2 Lewis and Clark Lake. Habitat efforts in this reach began during April **1992**, with the creation of 5 small dredge islands in the extreme upper end of Lewis and Clark Lake near Springfield, South Dakota. Small islands (about 1/26 acre each) were created at RM 832.0, 832.8, 833.0, 833.2, and 833.8 using a crane-on-barge method of dredging bottom sediments onto existing low-elevation sandbar islands. Water erosion of the newly created islands was a problem within weeks. Two of the new islands were completely lost, 1 needed to be sandbagged in July, and the remaining 2 were sandbagged in September. The island that was sandbagged in July (RM 833.0) supported a colony of 22 adult least terns during 1992. The initial fledge effort from this island was lost due to owl predation, but a strobe system was installed, and the island ended up fledging 23 tern chicks. During September, these dredge islands were treated with Rodeo to kill vegetation, and heavy equipment was used to increase their size by pushing up adjacent low sandbars to higher elevations, and armoring the new areas with sandbags and SEAbags.

One floating island made up of 14 modular "Schwimmenkampen" units was installed in the extreme upper end of Lewis and Clark Lake in April **1993**. The floating island was partially assembled on land, then towed out into the lake and anchored. The modular units were topped with gravel for use as tern nesting habitat. Driftwood and shade boxes provided shade, since the gravel could get extremely hot. To avoid being a navigation hazard anchored buoys with the nautical "hazard" symbol and solar-controlled blinking strobe lights were also installed in the vicinity of the island. There was vandalism to the island early in the year, and terns and plovers did not use it.

No habitat improvement work was done during **1994, 1995, 1996, 1997,** or **1998** on Lewis and Clark Lake.

2.7.1.2.3. Fort Randall to Niobrara. Experimental vegetation control that was begun in the Gavins Point to Ponca reach was expanded to RM 869 in the Fort Randall to Niobrara reach during 1989. The island at RM 869 was a 10-acre, vegetated (with grasses, sedges, and 3- to 6-foot cottonwoods and willows), high sandbar with no reports of past tern or plover use. Vegetation removal on RM 869 provided an opportunity to attract nesting birds to an island previously not used. In April, 5 acres of the island were mowed with a tractor-mounted mower. Three 400-foot-long test strips ranging from 25 to 75 feet in width were also tilled in the targeted area using a tractor-mounted tiller. Tilling successfully uprooted 75% of the young trees. Norosac was applied to the 5 acres using a tractor-mounted seeder to control new germination. In September, the island was also aerially sprayed with Rodeo to control willows and cottonwoods that had survived the April mowing. An analysis was made of the different combinations of Norosac and mechanical treatments, consisting of stem counts and determinations of percent vegetative cover during June, July, and August. There was no difference in vegetation control between differing rates of Norosac used, but there was a difference between mechanical removal methods. Tilling, in combination with Norosac, was the most effective method for vegetative removal.

During **1990**, 10 acres at RM 869 were mowed, and 8.5 acres treated with Norosac. A bulldozer was used to move sand from dunes into low areas. This island had 7 tern and 3 plover nests in the area where dune sands had been moved. Eight of the 10 nests hatched young. At least 6 terns fledged, and an undetermined number of plovers fledged. During **1991**, selected islands in this reach were included in the SDSU patterned vegetation removal study (see discussion under Gavins Point to Ponca reach) using hand-pulling and hand-cutting of vegetation.

During April, **1992**, heavy equipment was used to mechanically scrape newly formed vegetation and to reshape islands in 3 locations below Fort Randall Dam. The SDNG assisted with equipment transport to the islands. At RM 869, dunes were leveled into flat mesa areas using bulldozers, scraping off existing vegetation in the process. At RM 866.7, bulldozers pushed exposed low-elevation sand to higher elevations. The targeted elevation was 18 inches above the water surface elevations during peak summer flows. At RM 853.8, dunes were leveled in a similar manner to those at RM 869, in addition to scraping vegetation from adjacent areas. A line of young willows from 3 to 5 feet tall was left standing on the upwind (and upstream) end of the island to create a "snow fence" effect and build up new dunes. These willows were sprayed with Rodeo in the fall, as was all vegetation on RM 869, 866.7, and 853.8.

Planned **1993** habitat work at RM 875 was curtailed due to unresolved conflicts over ownership of the island between the State of South Dakota and the Yankton Sioux Tribe. No habitat work was done during **1994, 1995, 1996, 1997,** or **1998.**

2.7.1.2.4 Lake Oahe. Habitat improvement projects were completed at Lake Oahe beginning in **1994**. At RM 1293, 6 acres of vegetation were treated with Rodeo herbicide in July. During August, the dead vegetation was cut and burned, then the island was disked. At RM 1270, about 100 cottonwood trees were cleared from Dredge Island. The Blue Blanket area of Lake Oahe, a high-use area of less than 1 acre, was sprayed with Rodeo and cleared of trees. Additional areas were sprayed with Rodeo during September: Okobojo Creek Island (4 acres), Plum Creek and Dry Creek shoreline (2 acres), Agency Creek shoreline (1 acre), and the Mission Creek peninsula (8 acres).

In April **1995**, the chemically treated sites at Mission Island, Mission Creek Peninsula, Okobojo Creek Island, Plum Creek, and Dry Creek were dragged and leveled. In the fall of **1996**, Dredge Island was treated with Rodeo to reduce vegetation on the island. Approximately 75 to 80 percent of the island's vegetation were eliminated by the treatment. No habitat work was done during **1997** due to high reservoir levels. During September **1998**, the south side of a peninsula at Little Bend (RM 1109) was removed as part of a training exercise for the SDNG.

2.7.1.2.5 Garrison to Lake Oahe. During August **1991**, 4 sets of sand fences were set up on 3 sandbar areas below Garrison Dam. Sand dunes up to 3 feet high formed in only a few months, primarily behind the first rows of fencing (farthest upwind). One set of fences was knocked down and buried by a high water release from Garrison Dam. All fences were removed during the month of November so as not to be dislodged by ice over winter.

During the winter of **1992**, the dunes created by the snow fences were being eroded by the wind. In April, oyster shell was spread on the remaining portions of some sand dunes to determine if the shell could slow wind erosion. The oyster shell succeeded in reducing erosion. The Corps and the Service cut down approximately 2 acres of vegetation on RM 1351.2 during August. Vegetation removal using Rodeo herbicide was done during the fall at RM 1351.2, 1352.8, and 1353.7, totaling approximately 4 acres. Burning of vegetation at RM 1353 - 1354 was attempted but was very labor-intensive and not very successful. Sand fences were set up at RM 1374.3, 1374.5, 1374.6, and 1351.2 (new site this year).

During the fall of **1993**, islands at RM 1351 and 1368 had sand fences installed for sand dune creation. Oyster shell was placed on the newly formed dunes to prevent wind erosion. Islands at RM 1371.1 (2.8 acres) and 1373.5 (6.4 acres) had Rodeo treatment to remove vegetation.

Three habitat improvement projects were conducted during **1994**. Rodeo herbicide was used on portions of 4 islands to reduce vegetation; RM 1371.5 (6 acres), RM 1369 (1 acre), RM 1300.9 (3 acres), RM 1299.5 (1.5 acres). Oyster shells were spread over 1 acre of sand dune habitat on RM 1354.5. Dredge spoil material from a private action during the fall was placed on an island at 1362.4 as a condition of the Corps' section 404 permit. The spoil material was used to build the island up to a higher elevation (3 to 5 feet above previous elevation).

No habitat work was done during **1995** or **1996** due to high water. During the fall of **1997**, 8 acres of Rereg Island (RM 1380) were treated with Rodeo herbicide to curtail an invasion of willows. No habitat work was done during **1998** due to the vast amount of new, high-elevation sand habitat resulting from high flows from previous years.

2.7.1.2.6 Lake Sakakawea. During the fall of **1996**, construction of a 1.4-acre nesting site was begun adjacent to Steinke Bay on the DeTrobirand Wildlife Management Area. Vegetation was bladed off the site and the ground was scarified. 700 cubic yards of gravel were placed on the site. The site is protected from public access by a fence and a gate. The Steinke Bay habitat development project was completed in April **1997**. A pair of piping plovers, during the 1997 nesting season, used the site. It was treated with Rodeo herbicide to reduce vegetation encroachment during the fall.

During **1998**, cottonwood and willow trees in upper Lake Sakakawea (RM 1580.5) were removed by spraying, then using a brush hog and mower. An additional 40 acres of young cottonwoods and willows were sprayed with Rodeo herbicide at RM 1562.5 - 1580.5.

2.7.1.2.7 Fort Peck to Lake Sakakawea. In April **1993**, 3 sets of paired "Schwimmenkampen" floating modular units were installed at 3 locations downstream from Fort Peck Dam. Island units were assembled, topped with local sand, and placed on existing low-elevation islands in the river. Sand was "mounded" up along the island units, simulating natural contours. As the highest points on the islands, it was hoped that these islands would provide a floating surface to combat flooding caused by tributary inflow in this river reach. The islands were successful in floating when the remaining island habitat was inundated by tributary inflow, but were not used by the birds. Islands were removed in the fall to avoid ice damage. In **1994**, floating islands were again installed, covered with local sand, and anchored into the island. Islands were placed at river mile (RM) 1700, 1688, and 1682.8. The island and anchor at RM 1700 were washed out as flows eroded the island. No tern or plover use was documented. However, Canada geese used islands at RM 1688 and 1682.8 as resting areas.

During September **1995**, about one acre of willows was cleared from a high-elevation area on the west side of an island at RM 1578.5. No habitat work was done during **1996** due to high flows. Rodeo herbicide was used to clear vegetation near the Yellowstone River confluence during the fall of **1997**. No habitat work was done in this reach during **1998**.

2.7.1.2.8 Fort Peck Lake. In April **1992**, the Corps assisted the Service in burning vegetated portions of exposed reservoir shoreline. About 30 acres of dense grass were cleared in this manner, and there was no vegetative regrowth in July. The Corps again assisted the Service in burning vegetation on Fort Peck Lake during **1993**. No habitat work was done on the reservoir during **1994, 1995, 1996, 1997,** or **1998** due to high reservoir levels some years, and adequate habitat conditions in others.

2.7.2 Present Status

Recent investigations into the reproductive ecology of the threatened Great Plains population of piping plover and interior least tern have identified several factors that continue to limit plover and tern productivity along the Missouri River mainstem system (Kruse 1993). These factors include: (1) fluctuating water levels (Schwalbach 1988, Mayer and Dryer 1989, Dirks 1990, USFWS 1991, Kirsch 1992); (2) human disturbances of nesting areas during recreational use (Dryer and Dryer 1985, Haig 1986, Schwalbach 1988, Dirks 1990); (3) predation (Whyte 1985, Haig and Oring 1988, Prindiville-Gaines and Ryan 1988, Dirks 1990, Lingle 1990, Mayer and Ryan 1991, Kruse 1993, ACOE all years, USFWS 1991, 1992); and (4) weather events (rain, hail, high wind, etc.).

Kruse (1993) studied the influence of predation on piping plover reproductive success along the Fort Randall and Gavins Point reaches of the Missouri River in southeastern South Dakota in 1991 and 1992. His report presents data on the fate of piping plover nests along this stretch of river from 1988-92. In addition, Corps biologists have monitored piping plover nests along all eight reaches of the Missouri River mainstem system since 1993 (ACOE 1993, 1994, 1995, 1996, 1997). Tables 2-2 through 2-6 include information on the fate of monitored plover nests from 1993 through 1997.

2.7.2.1 Fluctuating Water Levels. Fluctuating water levels have been clearly documented to impact piping plover nesting on the Missouri River mainstem system (ACOE 1993, 1994, 1995, 1996, 1997). Unavoidable flooding has destroyed plover nests every year since monitoring began, but especially during flood years (Tables 2-2 through 2-6). From 1988-1992, an average of 5.6 nests (4.6 percent) were lost to flooding per year along the Fort Randall and Gavins Point reaches of the Missouri River (Kruse 1993). Fifteen nests were lost to flooding in 1991 (Kruse 1993). In the years 1993 through 1997, from 7 to 56 monitored nests were lost each year to flooding along the eight reaches of the Missouri River mainstem system (Tables 2-2 through 2-6). Greatest losses occurred in the flood years of 1993 (56 nests) and 1995 (37 nests).

The Corps attempts to manage water level fluctuations to maintain the best possible conditions for threatened and endangered species (see Section II for a detailed discussion of water level management for threatened and endangered species). However, this is not always possible, especially during flood years. To address this problem, the Corps has a policy of relocating nests and/or chicks to higher ground when feasible (Gordon and Kruse 1998). In 1993, 9 piping plover nests were relocated (ACOE 1993), and, in 1994, one nest was relocated (ACOE 1994). In 1995, 26 plover nests and 21 plover chicks were relocated (ACOE 1995). Most relocated nests (19 of 23 nests or 83 percent) were successful. All relocated chicks apparently fledged. In 1996, eight nests were relocated; only two of these nests hatched successfully and another two were collected (ACOE 1996). In 1997, eight nests were relocated; four were subsequently lost to flooding, one was lost to human disturbance, and three were collected (ACOE 1997).

In addition, the Corps initiated a salvage program in 1995 to prevent the complete loss of nests during uncontrolled flood operations (ACOE 1995). The program consists of: (1) salvaging eggs that would be lost due to natural flooding events of the Missouri River; (2) incubating the eggs and raising the chicks until fledging at a Corps captive rearing facility at Gavins Point; and (3) releasing chicks back to the wild after fledging. In 1995, egg incubation, rearing of chicks, and release of fledged juveniles was conducted in accordance with a pre-approved plan "Incubation, Propagation, and Release of Least Tern and Piping Plover Eggs Collected During the 1995 Missouri River Flood Control Operation Plan" (ACOE 1995). During the 1995 salvage effort, 20.6 percent of the plover eggs (197 of 956) located on the Missouri River were collected. Hatching success for plover eggs was 70.0 percent (138 of 197 eggs), and 96 percent of the hatched chicks eventually fledged and were released back to the wild. Fledged plovers were released on secure habitats once they had shown the ability to procure their own food. Release sites were on the Missouri River below Garrison Dam and below Gavins Point Dam, on Lewis and Clark Lake, and along the lower 10 miles of the Niobrara River in north central Nebraska.

In 1996, egg collections, incubation, rearing, and release were conducted according to approved protocols (see Captive Rearing Protocol in the Corps' "Least Tern and Piping Plover Management Plan, 1996 Missouri River Operations") (ACOE 1996). During the 1996 salvage effort, 38 percent of the plover eggs (140 of 361) located on the Missouri River were collected. Hatching success for plover eggs was 82 percent (115 of 140 eggs), and 89 percent of the hatched chicks eventually fledged and were released back to the wild. Release sites were below Gavins Point Dam, on Lewis and Clark Lake, and the lowest 10 miles of the Niobrara River in north central Nebraska.

In 1997, egg collections, incubation, rearing, and release were conducted according to approved protocols (see Captive Rearing Protocol in the Corps' "Least Tern and Piping Plover Management Plan, 1997 Missouri River Operations") (ACOE 1997). During the 1997 salvage effort, only 12 percent of the plover eggs (33 of 265) located on the Missouri River were collected. Hatching success for plover eggs was 79 percent (26 of 33 eggs), and 100 percent of the hatched chicks eventually fledged and were released back to the wild. Release sites were on the Niobrara River near Niobrara, Nebraska and the Bowdoin National Wildlife Refuge about 50 miles west of Glasgow, Montana.

2.7.2.2 Predation. Avian and mammalian predators are a major threat to piping plover productivity throughout the species' breeding range (Sidle et al. 1991). Predator exclosures and electric fences have been used with some success in decreasing this problem (Rimmer and Deblinger 1990, Mayer and Ryan 1991, Melvin et al. 1992). The following mammalian and avian species have been implicated as predators of piping plover eggs and chicks during other studies in the upper Missouri River Basin (Montana, North Dakota, South Dakota, Iowa, and Nebraska) and in Canada (Kruse 1993):

1) ring-billed gulls (*Larus delawarensis*) and California gulls (*L. californicus*) (McCracken et al. 1981, Whyte 1985, Prindiville-Gaines and Ryan 1988, Mayer 1991)
2) northern harriers (*Circus cyaneus*) (Whyte 1985)
3) striped skunks (*Mephitis mephitis*) and red fox (*Vulpes vulpes*) (Haig and Oring 1988)
4) great horned owls (*Bubo virginianus*) (Dirks 1990, Lingle 1990)
5) mink (*Mustela vison*) and raccoons (*Procyon lotor*) (Dirks 1990)
6) American kestrel (*Falco sparverius*) (Kruse 1993).

From 1988-1992, an average of 25.2 nests (20.7 percent) were lost to predation per year along the Fort Randall and Gavins Point reaches of the Missouri River (Kruse 1993). Predation was the principal cause of nest loss on these river reaches during Kruse's study (Kruse 1993). Forty-four nests were lost to predators in 1991; this was 42 percent of known nests. In the years 1993 through 1997, from 1 to 24 monitored nests were lost each year to predators along the eight reaches of the Missouri River mainstem system (Tables 2 through 6). Greatest losses occurred in 1993 (23 nests), 1994 (23 nests), and 1995 (24 nests).

To address this problem, the Corps has had a predator aversion program since 1993. In addition, predator removal is occasionally undertaken to address specific problems. This is accomplished in full cooperation with all relevant authorities. Starting in 1993 predator exclosure cages were used to increase survival of piping plover nests. In 1993, 82 plover nests were caged; 49 hatched successfully (60 percent) (ACOE 1993). Strobe light systems were used on an experimental basis in 1993 to deter nocturnal, vision-dependent predators. In 1994, 87 nests were caged (ACOE 1994). Caged nests had a slightly higher nest success than uncaged nests (59 percent versus 52 nests). Strobe light systems were again used in 1994 to deter predators. Overall, plover nests on the 5 sites equipped with strobe light systems had a 73 percent nest hatching success. One fox was removed from a site on Lake Sakakawea.

In 1995, 114 nests were caged (ACOE 1995). Caged nests had a substantially higher nest success than uncaged nests (58 percent versus 42 percent). Strobe light systems were not used in 1995, nor were predator removal measures undertaken for either piping plover or least tern. In 1996, 42 plover nests were caged (ACOE 1996). Survival was again higher for caged nests than uncaged nests (30 percent versus 12 percent). Strobe lights were not used in 1996 nor were any predator control activities undertaken. In 1997, 53 piping plover nests were caged (ACOE 1997). Once again, caged nests had greater hatching success than uncaged nests (59 percent versus 35 percent). In an attempt to reduce the incidence of predation, 5 great horned owls were removed from Dredge Island in Lake Oahe.

2.7.2.3 Human Disturbance. Human disturbances have been documented in Atlantic Coast plovers (Haig and Plissner 1991, USFWS 1996) and in the Great Plains region, sandbars are often used for recreational purposes during the nesting season (Sidle et al. 1991). From 1988-1992, an average of 2.2 plover nests per year were lost to human disturbance along the Fort Randall and Gavins Point reaches of the Missouri River in southeastern South Dakota (Kruse 1993). In the years 1993 through 1997, from 1 to 7 monitored nests were lost each year to human disturbance along the eight reaches of the Missouri River mainstem system (Tables 2-2 through 2-6). Greatest losses occurred in 1995 (7 nests).

To address this problem, the Corps has posted and/or fenced specific nesting areas since at least 1993. In 1993, islands with more than 4 active nests and in jeopardy of human disturbance were signed and roped off (ACOE 1993). No information on 1994 activities is included in ACOE (1994). In 1995, nest sites close to or within recreation areas or areas with the high potential for human disturbance were posted with restriction signs and/or roped off with orange twine (ACOE 1995). Nesting sites in approximately 14 different locations were thus posted. In 1996, nest sites in 5 different locations were posted with signs or restrictive fencing (ACOE 1996). In 1997, nest sites in 9 locations were posted with signs or restrictive fencing (ACOE 1997). In addition to signing and restrictive fencing, the Corps has conducted a public awareness campaign regarding piping plovers and least terns since at least 1992.

2.7.2.4 Weather. Heavy rains and winds, as well as hailstorms have been observed to cause mortality in plover adults and chicks. From 1988-1992, an average of 0.6 nests per year were lost to human disturbance along the Fort Randall and Gavins Point reaches of the Missouri River in southeastern South Dakota (Kruse 1993). In the years 1993 through 1997, from 1 to 15 monitored nests were lost each year to weather along the eight reaches of the Missouri River mainstem system (Tables 2-2 through 2-6). Greatest losses occurred in 1996 (15 nests), when rain storms accompanied by hail swept through the Garrison to Lake Oahe reach on several occasions during the nesting season, destroying a number of piping plover and interior least tern nests. Weather also destroyed plover nests along the shore of Lake Oahe.

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3. Interior Least Tern

3.1 General Description

The migratory least tern (all currently recognized subspecies and populations) is the smallest member of the subfamily Sterninae of the family Laridae. Adults measure approximately 21-24 cm in length, with a 51 cm wingspan (USFWS 1990). Least terns are characterized by a black-capped crown, white forehead, grayish back and dorsal wing surfaces, and snowy white undersurfaces. Sexes generally look alike, except for leg and bill color (USFWS 1990). Immature birds have darker plumage than adults, a dark bill, and darkeye stripes on their white foreheads (USFWS 1990).

3.2 Distribution

3.2.1 Historical

The interior least tern historically bred along the Mississippi, Rio Grande, Red, Arkansas, Platte, Niobrara, and Missouri Rivers and tributaries such as the Loup rivers in Nebraska, and the Cimarron and Canadian Rivers in Oklahoma (USFWS 1990). The breeding range extended from Texas to Montana, and from eastern Colorado and New Mexico to southern Indiana (USFWS 1990). Incidental occurrences of least terns have been reported from Michigan, Minnesota, Wisconsin, Ohio, and Arizona (USFWS 1990). Historical wintering areas for the least tern are unknown (USFWS 1990).

3.2.2 Present

The interior least tern continues to breed in most of its historic breeding range, although its distribution is generally restricted to less-altered river segments (USFWS 1990). It breeds along the lower Mississippi River from approximately Cairo, Illinois south to Vicksburg, Mississippi (USFWS 1990). In the Great Plains, it breeds along: (1) the Missouri River and many of its major tributaries in Montana, North Dakota, South Dakota, and Nebraska; (2) the Arkansas River in Oklahoma and Arkansas; (3) the Cimarron and Canadian Rivers in Oklahoma and Texas; and (4) the Red River and Rio Grande River in Texas (USFWS 1990).

Current wintering areas of the interior least tern remain unknown (USFWS 1990). Least terns of unknown populations/subspecies are found during the winter along the Central American coast and the northern coast of South America from Venezuela to northeastern Brazil (USFWS 1990). One banded interior least tern was captured in El Salvador two years after banding (USFWS 1990).

3.2.3 Distribution on the Missouri River Mainstem System

The interior least tern still breeds along the Missouri River and its tributaries in Montana, North Dakota, South Dakota, and Nebraska (USFWS 1990). Major tributaries include the Yellowstone River in Montana and North Dakota, the Cheyenne River in South Dakota, the lower Niobrara

River in Nebraska (from Keya Paha and Rock Counties to the Missouri River), Elkhorn River in Nebraska, Loup River in Nebraska (most commonly between Saint Paul and the confluence with the Platte River), and the Platte River in Nebraska (from the Missouri River to North Platte, and along the South Platte River as far west as Ogallala, Nebraska) and recently Kansas River (USFWS 1990).

3.3 Abundance

3.3.1 Historical

There are no comprehensive historic population figures for the interior least tern (USFWS 1990). Early qualitative descriptions suggest that that the interior least tern was rather common (Burroughs 1961, Hardy 1957).

3.3.2 Present

The total population of interior least terns in 1987 was estimated to be 4,800 individuals (USFWS 1990).

3.3.3 Abundance on the Missouri River Mainstem System

An Annual census of the adult interior least tern population on the Missouri River mainstem system, from Fort Peck Lake, Montana to Ponca, Nebraska, has been conducted from 1988 to the present. For census purposes, the Missouri River system has been divided into eight reaches: (1) Fort Peck Lake; (2) Fort Peck to Lake Sakakawea; (3) Lake Sakakawea; (4) Garrison to Lake Oahe; (5) Lake Oahe; (6) Fort Randall to Niobrara; (7) Lewis and Clark Lake; and (8) Gavins Point to Ponca. Prior to 1993, the Service conducted all census activities on the Missouri River System. Since 1993, the Corps has conducted census activities on all of the system, except for Fort Peck Lake where the Service continues to conduct the census.

Census results for the adult interior least tern population on the Missouri River system for 1988 through 1997 are presented in Table 3-1 and shown graphically in Figure 3-1. The adult population has fluctuated from a high of 772 in 1994 to a low of 446 in 1997. For the years 1988 through 1994, the interior least tern population grew rather steadily each year to its maximum of 772. In 1995 and 1996 the population declined rather precipitously, but it rebounded slightly in 1997. Table 3-1 also shows annual least tern census results by individual reach within the Missouri River system. Five reaches have been the most important for interior least tern numbers: (1) Fort Peck to Lake Sakakawea; (2) Garrison to Lake Oahe; (3) Lake Oahe; (4) Lewis and Clark Lake; and (5) Gavins Point to Ponca. These reaches typically have the highest number of adult least terns censured each year, but also show the greatest year-to-year fluctuation in least tern numbers.

Table 3-1.
Interior Least Tern Population Survey Data
Missouri River Mainstem System, 1988-98

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Fort Peck Lake											
Adults	3	4	6	10	0	7	9	2	0	0	4
Fledglings/Pair	-	-	-	0.50	{}	0	0.44	0	0	0	0
Fort Peck to Lake Sakakawea											
Adults	18	51	92	66	110	1	58	95	128	162	26
Fledglings/Pair	1.66+	1.62+	0.20+	0.70+	0.62+	0.43	0.67+	0.98	0.34	0.53	1.73
Lake Sakakawea											
Adults	7	15	6*	8	29+	14	35	7	27	2	22
Fledglings/Pair	-	-	-	-	0.50+	0.17	0	0	0.15	0	1.27
Garrison to Lake Oahe											
Adults	142	122	174	195	198	135	212	284	105	41	123
Fledglings/Pair	0.93+	0.42+	0.44+	0.65	0.48	0.17	0.57	0.89	0.08	0.39	1.35
Lake Oahe											
Adults	82	97	100	143	124	123	160	84	74	101	90
Fledglings/Pair	-	-	-	-	0.42	0	0.06	0	0.24	0.16	1.49
Fort Randall to Niobrara											
Adult	45	4	67	62	20	38	43	10	2	0	64
Fledglings/Pair	0.14	0	0.34+	0.23	0.30	0	0	0	0.0	0	0.94
Lake Lewis and Clark											
Adult	0	29	21	25	22	76	44	16	28	60	120
Fledglings/Pair	-	0.64	0.34+	0	2.09	0.97	0	0	0.0	1.57	2.50
Gavins Point to Ponca											
Adults	252	210	166	193	186	272	211	93	82	115	144
Fledglings/Pair	0.49	0.55	0.45+	0.26	0.22	0.83	0.4	0.49	0.27	0.90	2.33
Total Adults	**549**	**532**	**632**	**702**	**689**	**696**	**772**	**591**	**446**	**481**	**593**
Fledglings/Pair	**0.64**	**0.70**	**0.40**	**0.44**	**0.47**	**0.57**	**0.43**	**0.66**	**0.21**	**0.66**	**1.80**

- Data Not Collected
*** Partial Survey Results**
{} No Birds Found
+ Subsampling of Selected Nesting Areas

Figure 3-1.

The 1991 adult least tern census counted 702 birds, a substantial increase over the 632 counted in 1990 and the 532 counted in 1989. The Garrison to Lake Oahe, Lake Oahe, and Gavins Point to Ponca reaches recorded the most least terns in 1991. The Lake Oahe reach experienced a substantial increase in 1992 over 1991 (143 birds in 1992 versus 100 birds in 1991). Conversely, the Fort Peck to Lake Sakakawea reach experienced a substantial decline between years (66 birds in 1992 versus 92 birds in 1991). All other reaches changed little between the two years.

The 1992 adult least tern census tallied 689 birds, a very slight decrease from the 1991 total of 702 birds. The Fort Peck to Lake Sakakawea, Garrison to Lake Oahe, Lake Oahe, and Gavins Point to Ponca reaches recorded the most least terns in 1992. The Fort Peck to Lake Sakakawea reach experienced a substantial increase in 1992 over 1991 (110 birds in 1992 versus 66 birds in 1991). Conversely, the Fort Randall to Niobrara reach experienced a substantial decline between years (20 birds in 1992 versus 62 birds in 1991). All other reaches changed little between the two years.

The 1993 adult least tern census counted 696 birds, a very slight increase over the 1992 total of 689 birds. The Garrison to Lake Oahe and Gavins Point to Ponca reaches recorded the highest counts. The 272 adult least terns counted on the Gavins Point to Ponca reach and 76 adults on the Lewis and Clark Lake reach were record highs for those reaches. This was perhaps due to the fact that nesting conditions further south, on the Platte and Mississippi Rivers, were quite poor in 1993. The low numbers counted on Lake Sakakawea were likely due to rising water levels on the reservoir, which reduced the amount of available habitat. Both the Fort Peck to Lake Sakakawea and Garrison to Lake Oahe reaches also experienced declines in numbers from 1992 to 1993.

The 1994 adult least tern census counted 772 birds, the highest total in the 12 years of census on the Missouri River system, and an 11 percent increase over the 1993 total of 696. The Garrison to Lake Oahe, Lake Oahe, and Gavins Point to Ponca reaches recorded the highest counts. Ample nesting habitat was available in all three of these reaches. Six of eight reaches recorded increases from 1993 to 1994. Only the Lewis and Clark Lake and Gavins Point to Ponca reaches had decreases from 1993 (1993 was a record high year for both these reaches, perhaps because nesting conditions further south were poor).

The 1995 adult least tern census showed a substantial decline in numbers from 1994. The adult census count of 591 was 23 percent lower than the total of 772 least terns counted in the peak year of 1994. The overall numbers do not reflect the dynamic changes that occurred within the system in 1995. Nearly half the least terns (284 of 591) were found within one reach, the Garrison to Lake Oahe reach. This was a record total for the reach. The high numbers were most likely the result of low water releases from Garrison Dam during the summer, which exposed large areas of sandbar and beach nesting habitat. In addition, high water levels on Lake Sakakawea and Lake Oahe eliminated most habitat on those reaches and may have forced birds to move to the Garrison to Lake Oahe reach.

The 1996 adult least tern census showed a precipitous decline in numbers from 1995. The adult census count of 446 was a 25 percent decline in numbers from the 1995 total of 591. Most least terns were counted in the Fort Peck to Lake Sakakawea, Garrison to Lake Oahe, and Gavins

Point to Ponca reaches. Least tern numbers were much reduced on the Garrison to Lake Oahe reach in 1996 as compared to 1995. This is likely a result of the substantial changes in habitat availability that took place in the reach between 1995 and 1996. In 1995, habitat was quite abundant due to low water releases from Garrison Dam, but in 1996, habitat was greatly reduced because of high water releases from the Dam. Least tern numbers on the Gavins Point to Ponca reach were depressed in 1996 by high water releases from Gavins Point Dam, just as they were in 1995. Conversely, the Fort Peck to Lake Sakakawea reach experienced an increase in numbers in 1996, as it also experienced in 1994 and 1995.

The 1997 adult least tern census showed a slight increase from 1996. Although the adult census count of 481 was an 8 percent increase over 1996's total of 446, the total was still 38 percent lower than the peak year of 1994, when 772 least terns were counted. Most least terns were counted in the Fort Peck to Lake Sakakawea and Gavins Point to Ponca reaches. Four of the eight reaches saw an increase in adult least tern numbers in 1997 compared to 1996. Lewis and Clark Lake had the greatest increase, from 28 to 60 birds (114 percent). This was due to the presence of a large tern colony at the mouth of the Niobrara River; this area was not surveyed in 1996. The Gavins Point to Ponca reach experienced a 44 percent increase, from 80 to 115 birds. Though well below the average of 211 least terns per year for 1986-1994, the 115 terns was unexpected considering the high releases from Gavins Point dam (60,000 cfs) at the time of the census. The Fort Peck to Lake Sakakawea and Lake Oahe reaches also saw increases in adult least tern numbers. There was a decrease in tern numbers on the Lake Sakakawea and Garrison to Lake Oahe reaches, because little habitat was available for least terns on these two reaches. No terns were found on the Fort Peck Lake or the Fort Randall to Niobrara reaches.

The 1998 adult least tern census showed a moderate increase in the number of adults compared to the numbers of 1996 and 1997. The adult census count of 593 was a 23 percent increase in numbers from the 1997 total of 481. Five of the eight reaches had increases in adult tern numbers in 1998 compared to 1997. For 1998 the most least terns were censused in the Garrison to Lake Oahe, Lake Oahe, Lake Lewis and Clark, and Gavins Point to Ponca reaches. The increase in the tern numbers was due to the large increase in viable sandbar habitat caused by the high releases and reservoir elevations of 1995, 1996, and 1997. The record flows of 1997 were followed by 1998 releases and reservoir elevation increases which were only about one-half as great as those experienced in 1997.

3.4 Reproduction

3.4.1 General Breeding Biology

Interior least terns tend to arrive at breeding areas on the Missouri River system from mid-May to early June (ACOE 1993, 1994, 1995, 1996, 1997). Nest initiation on the Missouri River system may begin as early as the second week of May or as late as the third week of July (ACOE 1993, 1994, 1995, 1996, 1997). Most nests are initiated during the first two weeks of June, but nest initiation during the last week of May or third week of June is not uncommon, depending on the year (ACOE, 1993, 1994, 1995, 1996, 1997). The nest is a shallow depression in an open, sandy area, gravelly patch, or exposed flat (USFWS 1990). Small stones, twigs, pieces of wood, and debris usually lie near the nest (USFWS 1990). Least terns nest in colonies. Nests can be as close as just a few meters apart or up to hundreds of meters apart (Ducey 1988, Anderson 1983, Hardy 1957, Kirsch 1990, Smith and Renken 1990, Stiles 1939). The benefit of semi-colonial nesting in least terns may be related to anti-predator behavior and social facilitation (Burger 1988).

Least terns usually lay 2 or 3 eggs (Anderson 1983, Faanes 1983, Hardy 1957, Kirsch 1987-89, Sweet 1985, Smith 1985). The average clutch size for interior least terns nesting on the Mississippi River during 1986-1989 was 2.4 eggs (Smith and Renken 1990). Both sexes share incubation, which generally lasts 20 to 25 days but has ranged from 17 to 28 days (Faanes 1983, Hardy 1957, Moser 1940, Schwalbach 1988).

On the Missouri River system, eggs begin to hatch from late June to early July (ACOE 1993, 1994, 1995, 1996, 1997). Interior least tern chicks are precocial. They hatch within one day of each other, are brooded for about one week, and usually remain within the nesting territory when very young but wander further as they mature (USFWS 1990). Fledging occurs after 3 weeks, although parental attention continues until migration (Hardy 1957, Massey 1972, 1974, Tomkins 1959). Departure from colonies by both adults and fledglings varies but is usually complete by early September (Bent 1921, Hardy 1957, Stiles 1939).

Coastal and California least terns exhibit very high breeding site fidelity (Atwood et al. 1984, Burger 1984). A variety of observational evidence summarized in USFWS (1990) (e.g., Mayer and Dryer 1990, Smith and Renken 1990) suggests that the same may also be true for interior least terns.

The interior least tern's home range during the breeding season usually is limited to a reach of river near the sandbar-nesting site (USFWS 1990). Nesting territories are defended against intruders (USFWS 1990). Birds defend any nest in the colony, not just their own (USFWS 1990). In defending the territory, the intruding bird will fly up and give an obvious alarm call followed by repeated dives at the intruder (Hardy 1957). The strong defense of territories facilitates locating colonies during population surveys (USFWS 1990).

Fledging rates (expressed as fledglings per pair) documented in previous studies have varied from 0.21 to 1.09 (USFWS 1990). These studies indicate that fledging rates can vary widely from year to year along the same stretch of river, no doubt a result of yearly differences in habitat conditions, predation rates, and weather effects.

3.4.2 Productivity on the Missouri River Mainstem System

Annual productivity monitoring of the interior least tern population on the Missouri River mainstem system, from Fort Peck Lake, Montana to Ponca, Nebraska, began in the 1988 nesting season and has continued each year to the present. For census and monitoring purposes, the Missouri River system has been divided into eight reaches: (1) Fort Peck Lake; (2) Fort Peck to Lake Sakakawea; (3) Lake Sakakawea; (4) Garrison to Lake Oahe; (5) Lake Oahe; (6) Fort Randall to Niobrara; (7) Lewis and Clark Lake; and (8) Gavins Point to Ponca. Prior to 1993, the Service conducted all census and monitoring activities on the Missouri River System. Since 1993, the Corps has conducted census and monitoring activities on most of the system, while the Service has conducted census and monitoring on the remainder. Data are collected on the following parameters related to productivity: (1) total number of adults; (2) nests initiated; (3) nests hatched; (4) cause of nest loss; (5) clutch size; (6) eggs hatched; and (7) chicks fledged.

Productivity of the interior least tern population on the Missouri River mainstem system for 1988 through 1997 are presented in Table 3-1. Detailed productivity information (e.g., number of nests, number of nests hatched, number of eggs, number of eggs hatched, total chicks fledged) for 1993 through 1997 is presented in Tables 3-2 through 3-6. Productivity has fluctuated from an estimated high of 196 fledged chicks in 1995 to an estimated low of 47 fledged chicks in

1996. Table 3-1 also shows annual productivity by individual reaches within the Missouri River system. Three reaches have been the most important for interior least tern productivity over the last 12 years: (1) Fort Peck to Lake Sakakawea; (2) Garrison to Lake Oahe; and (3) Gavins Point to Ponca.

In 1991, productivity was monitored on only six of eight Missouri River system reaches (Lake Sakakawea and Lake Oahe were not monitored). On these six reaches, the overall fledge ratio was calculated to be 0.44. Using this ratio, 154 chicks were estimated to have fledged on the Missouri River system in 1991. Most fledged chicks (63) were produced on the Garrison to Lake Oahe reach.

In 1992, 162 least tern chicks were estimated to have fledged on the Missouri River system, an overall fledge ratio of 0.47. Most fledged chicks were produced on the Fort Peck to Lake Sakakawea (34), Garrison to Lake Oahe (48), and Lake Oahe (26) reaches. Although a large number of adults (186) was counted on the Gavins Point to Ponca reach, the fledge ratio there was a low 0.22, resulting in the fledging of only 20 chicks.

In 1993, least tern productivity increased from 1992 levels. One hundred seventy-nine (179) chicks were estimated to have fledged in 1993, up down from an estimated 162 in 1992. The 1993 fledge ratio was 0.57, also up from the estimated 0.47 fledge ratio in 1992. By far the most fledged chicks were produced on the Gavins Point to Ponca reach (113), but Lewis and Clark Lake and the Garrison to Lake Oahe reaches also produced some chicks. No chicks were fledged on the Fort Peck Lake, Lake Oahe, or Fort Randall to Niobrara reaches.

Least tern productivity declined in 1994 from 1993 levels. One hundred sixty-five (165) chicks were estimated to have fledged in 1994, down from the 179 in 1993. Likewise, the 1994 fledge ratio of 0.43 was down considerably from the 1993 fledge ratio of 0.57. Only three reaches fledged substantial numbers of chicks in 1994 – Fort Peck to Lake Sakakawea, Garrison to Lake Oahe, and Gavins Point to Ponca. No chicks at all were fledged on the Lake Sakakawea, Fort Randall to Niobrara, or Lewis and Clark Lake reaches.

Overall productivity of least terns was good in 1995, although productivity varied from reach to reach within the system. One hundred ninety-six (196) chicks were estimated to have fledged in 1995, for a ratio of 0.66. This represents a substantial increase, both in total chicks fledged and in fledge ratio, over 1994. High water levels on Fort Peck Lake, Lake Sakakawea, Lake Oahe, and Lewis and Clark Lake eliminated most of the nesting habitat for least terns. Consequently, no chicks were fledged from any of these reaches. Likewise, high water releases from garrison

Dam and Gavins Point Dam decreased the availability of nesting habitat downstream, thus lowering least tern productivity in these areas as well. Conversely, low water releases out of Garrison Dam for most of the summer resulted in high availability of nesting habitat and concomitant high productivity by the least terns in this reach. Water conditions in 1995 forced the collection of 160 least tern eggs for captive rearing. Their fate is discussed in section 3.7.2.1 of this report.

Table 3-2.

INTERIOR LEAST TERN PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1993.

REACH	RIVER MILES	NESTS	EGGS	NEST HATC	NEST SUCC	EGGS HATC	FATE DESTROYED					FATE UNKN	ABAN	AVG. CLUTCH	ADULT PAIRS a	CHICKS FLEDGE	FLEDGE RATIO
							FLOOD	PRED	HUMAN DIST	WTHR	UNKN						
Ft. Peck Lk.	14.0	3	7	0	0.0	0	3	0	0	0	0	0	0	2.3	4	0	0.00
Ft. Peck to Lk. Sakakawea √	39.5	14	37	8	57.1	20	0	0	0	0	0	6	0	2.6	7	3	0.43
Lk. Sakakawea √	86.8	10	15[o]	2	20.0	3[o]	4	2	0	1	0	1	0	1.5	5	1	
Garrison to Lk. Oahe √	40.0	66	52	24	36.4	20	15	7	0	6	8	4	2	1.9	40	12	0.19 /
Lk. Oahe N. √	20.0	65	119[o]	3	4.8	3	52	1	0	3	5	0	1	1.8	25	0	
Lk. Oahe S. √	61.7	13	13	5	38.4	8	6	0	0	1	0	1	0	1.9	19	0	0.00
Ft. Randall to Niobrara	35.0	15	31	6	40.0	12	0	0	0	1	0	8	0	2.1	19	0	0.00
Lewis & Clark Lk.	34.0	54	107	20	37.0	41	9	13	0	0	10	11	0	2.0	38	37	0.97
Gavins Pt. to Ponca	61.0	182	430	85	46.7	216	29	1	0	3	28	32	4	2.4	136	113	0.83
TOTAL	378.0	422	811	153	36.3	323	118	24	0	15	51	63	7	2.2	291	166	0.57

a Rounded up to represent complete pairs.
√ Subsampled reaches
o Incomplete reporting
/ Composite fledge ratio due to movement of birds within reaches prior to adult census.

EXHIBIT 952 040175

Table 3-3.

INTERIOR LEAST TERN PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1994.

REACH	NESTS	NEST HATCH	NEST SUCC.	EGGS	EGGS HATCH	FATE DESTROYED							FATE UNKN	ABAN	ADULT CENSUS	CHICKS FLEDGE
						FLOOD	PRED	HUMAN DIST.	BANK EROS.	WTHR	LIVE STOCK	UNKN				
Ft. Peck Lk.	8	3	37.5	14	6	1	0	0	0	0	0	1	3	0	9	2
Ft. Peck to Lk. Sakakawea	23	14	60.9	46	31	0	0	0	0	0	0	2	3	4	58	19
Lk. Sakakawea	18	3	16.7	41	4	0	1	1	0	1	0	11	0	1	35	0
Garrison to Lk. Oahe	132	60	45.5	270	131	1	3	1	3	10	0	6	45	3	212	66
Lk. Oahe	71	14	19.7	173	32	5	4	0	0	2	5	2	35	4	160	5
Ft. Randall to Niobrara	27	15	55.6	63	37	4	0	1	0	5	0	1	1	0	43	0
Lewis & Clark Lk.	21	0	0.0	32	0	11	10	0	0	0	0	0	0	0	44	0
Gavins Pt. to Ponca	218	75	34.4	514	179	13	69	0	5	11	0	14	21	10	211	51
TOTAL	**518**	**184**	**35.5**	**1153**	**420**	**35**	**87**	**3**	**8**	**29**	**5**	**37**	**108**	**22**	**772**	**143**

EXHIBIT 952

040176

Table 3-4.

INTERIOR LEAST TERN PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1995.

REACH	NESTS	NEST HAT.	NEST COLL.	HAT. & COLL.	NEST SUCC.	EGGS	EGGS HAT.	EGGS COLL.	COLL. HAT.	CHICK COLL.	FATE DESTROYED							FATE	FATE	ADULT	CHICK	COLL.
											FLOOD	PRED.	HUMAN DIST.	BANK EROS.	WTHR	LIVE STOCK	UNKN.	UNKN.	ABAN.	CENSUS	FLEDGE	CHICK FLEDGE
Ft. Peck Lk.	5	0	0	0	0.0	6	0	0	0	0	5	0	0	0	0	0	0	0	0	2	0	0
Ft. Peck to Lk. Sakakawea	31	20	0	0	84.5	76	51	0	0	0	2	2	0	0	7	0	0	0	0	95	21	0
Lk. Sakakawea	2	0	0	0	0.0	5	0	0	0	0	2	0	0	0	0	0	0	0	0	7	0	0
Garrison to Lk. Oahe	159	72	15	0	45.3	403	193	28	16	0	5	4	0	0	6	0	19	38	0	284	126	13
Lk. Oahe	35	13	0	0	37.1	78	27	0	0	0	0	7	0	0	2	0	1	5	7	84	0	0
Ft. Randall to Niobrara	26	0	11	0	0.0	32	0	17	10	0	11	4	0	0	0	0	0	0	0	10	0	9
Lewis & Clark Lk.	17	0	12	0	0.0	31	0	23	14	0	5	0	0	0	0	0	0	0	0	16	0	6
Gavins Pt. To Ponca	118	26	42	0	22.0	253	55	92	72	0	5	31	1	1	0	0	1	10	1	93	23	50
TOTAL	**393**	**131**	**80**	**0**	**33.3**	**884**	**326**	**160**	**112**	**0**	**35**	**48**	**1**	**1**	**15**	**0**	**21**	**53**	**8**	**591**	**170**	**78**

EXHIBIT 952

040177

Table 3-5.

INTERIOR LEAST TERN PRODUCTIVITY MONITORING, MISSOURI RIVER MAINSTEM SYSTEM, 1996.

REACH	NESTS	NEST HAT.	NEST COLL.	COLL & HAT	NEST SUCC.	EGGS	EGGS HAT.	EGGS COLL.	COLL. HAT	FATE DESTROYED							FATE UNKN.	FATE ABAN.	ADULT CENSUS	CHICK FLEDGE	COLL. CHICK FLEDGE
										FLOOD	PRED.	HUMAN DIST.	BANK EROS.	WTHR	LIVE STOCK	UNKN.					
Ft. Peck Lk.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ft. Peck to Lk. Sakakawea	28	11	0	0	39.3	62	25	0	0	0	2	0	1	0	0	0	6	2	128	7	0
Lk. Sakakawea	19	4	9	0	21.1	39	8	23	0	5	0	0	0	0	0	1	0	0	27	2	21
Garrison to Lk. Oahe	88	8	30	0	9.1	155	14	57	0	9	0	1	0	32	0	0	6	2	105	4	51
Lk. Oahe	43	10	0	0	23.3	93	22	0	0	1	0	0	0	8	0	0	19	5	74	9	0
Ft. Randall to Niobrara	1	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0
Lewis & Clark Lk.	7	0	7	0	0	16	0	16	0	0	0	0	0	0	0	0	0	0	28	0	13
Gavins Pt. to Ponca	96	4	56	2	8.3	179	9	108	0	0	2	0	0	0	0	13	15	4	82	11	91
TOTAL	**282**	**37**	**102**	**2**	**13.8**	**546**	**78**	**204**	**0**	**16**	**4**	**1**	**1**	**40**	**0**	**14**	**46**	**13**	**446**	**33**	**176**

Table 3-6.

INTERIOR LEAST TERN PRODUCTIVITY MONITORING, MAINSTEM MISSOURI RIVER SYSTEM, 1997.

REACH	NESTS	NEST HAT.	NEST COLL.	NEST SUCC.	EGGS	EGGS HAT.	EGGS COLL.	COLL. HAT.	FATE DESTROYED						DEST. UNKN.	FATE UNKN.	FATE ABAN.	NON VIABLE	ADULT CENSUS	CHICK FLEDGE	COLL. CHICK RELEASE
									FLOOD	PRED.	HUMAN DIST.	BANK EROS..	WTHR	LIVE STOCK							
Ft. Peck Lk.	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ft. Peck to Lk. Sakakawea	17	11	0	64.7	41	26	0	0	0	0	0	0	2	0	1	2	1	0	162	8	0
Lk. Sakakawea	14	6	5	42.9	27	12	10	9	0	0	1	0	0	0	0	0	0	2	2	0	7
Garrison to Lk. Oahe	26	14	7	53.8	53	27	14	10	0	3	1	0	1	0	0	0	0	0	41	8	9
Lk. Oahe	83	35	0	42.2	193	82	0	0	4	1	0	0	13	1	3	17	5	4	101	8	0
Ft. Randall to Niobrara	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lewis & Clark Lk.	34	25	0	73.5	91	65	0	0	1	1	0	0	0	0	0	5	2	0	60	47	0
Gavins Pt. to Ponca	106	49	0	46.2	266	132	0	0	9	7	0	4	2	0	17	7	10	1	115	52	0
TOTAL	**280**	**140**	**12**	**50.0**	**671**	**344**	**24**	**19**	**14**	**12**	**2**	**4**	**18**	**1**	**21**	**31**	**18**	**7**	**481**	**123**	**16**

Productivity throughout the Missouri River system was extremely poor for least terns in 1996. The fledge ratio of 0.21 was the lowest recorded in the 12 years of productivity monitoring on the Missouri River, and was only one-third the ratio recorded in 1995 (0.66). Only 47 chicks were estimated to have fledged in 1996, down from the estimated 1995 total of 196 chicks fledged. High water levels throughout the Missouri River system drastically reduced the amount of habitat available for nesting. This, in turn, led to increased predator efficiency and also compounded catastrophic losses to weather-related events. Nearly 40 percent of all least tern eggs laid during 1996 were salvaged from rising water conditions and reared in captivity. Only four reaches fledged any chicks at all: Fort Peck to Lake Sakakawea, Lake Sakakawea, Garrison to Lake Oahe, and Lake Oahe. Of these, only the Fort Peck to Lake Sakakawea and Lake Sakakawea reaches produced more than 10 fledglings each. Water conditions in 1996 forced the collection of 204 least tern eggs for captive rearing. Their fate is discussed in section 3.7.2.1 of this report.

Productivity throughout the Missouri River system rebounded for least terns in 1997 compared to 1996. The fledge ratio for least terns more than tripled, from 0.21 in 1996 to 0.66 in 1997. The 0.66 fledge ratio was the third highest in the 12 years that productivity has been monitored on the Missouri River. One hundred fifty-eight (158) chicks were estimated to have fledged in 1997, a dramatic increase over the 47 that were estimated to have fledged in 1996. Very good least tern production was observed along the Fort Peck to Lake Sakakawea and Gavins Point to Ponca reaches, and from the mouth of the Niobrara River (Lewis and Clark Lake reach). There was limited least tern production from the Garrison to Lake Oahe and Lake Oahe reaches. No least tern production was recorded from the Fort Peck Lake, Lake Sakakawea, and Fort Randall to Niobrara reaches. Water conditions in 1997 forced the collection of only 24 least tern eggs for captive rearing. Their fate is discussed in section 3.7.2.1 of this report.

Productivity for least terns on the Missouri River system in 1998 was the highest estimate in the 12 years that productivity has been monitored. The fledge ration for least terns nearly tripled from 0.66 in 1997 to 1.80 in 1998. Good tern reproduction was observed on the Fort Peck to Lake Sakakawea. Lake Sakakawea, Garrison to Lake Oahe, and Lake Oahe reaches. Outstanding reproduction was observed on the Lake Lewis and Clark and Gavins Point to Ponca reaches. There was production of the Fort Randall to Niobrara reach but no reproduction on Fort Peck Lake.

3.5 Nesting Habitat

3.5.1 General

Interior least terns nest on sand and gravel bars in rivers, and on sand spits or salt flat along lake shorelines. Riverine nesting areas are sparsely vegetated sand and gravel bars within a wide unobstructed river channel. Nest sites are usually at the highest spots on the sandbar or island and away from the water's edge because nesting usually starts when the river flows are high and only the higher elevations are exposed. On the Niobrara River, nesting least terns were found to utilize islands where at least 1.3 percent of the total island area was high sand, and greater than 7 percent of the total island area was low sand (Adolf 1998). The size of nesting areas depends on water levels and the extent of associated sandbars.

The interior least tern nests on dike fields along the Mississippi River (Smith and Stuckey 1988, Smith and Renken 1990), at sand and gravel pits (Kirsch 1987-89), ash disposal areas of power plants (Dinsmore and Dinsmore 1988, Johnson 1987, Wilson 1984), along the shores of reservoirs (Boyd 1987, Chase and Loeffler 1978, Neck and Riskind 1981, Schwalbach 1988), and at other manmade sites (Shomo 1988). It is unknown to what extent sand and gravel pits, dike fields, reservoir shorelines and other artificial habitats have replaced natural habitat.

3.5.2 Missouri River Mainstem System

An examination of interior least tern nesting on the Missouri River in South Dakota (Schwalbach 1988) determined that most tern colonies occurred on sandbars on river reaches below dams (specifically, Gavins Point and Fort Randall Dams), but some sand and gravel beaches, points or parking lots were used along Lake Oahe, and some sand and gravel beaches were used along the Cheyenne River. All tern colony sites were characteristically barren or with short (< 10 cm), sparse (< 10 percent) vegetative cover. Average nest elevation varied from 0.63 feet to 2.41 feet above the waterline.

3.6 Food and Feeding Habits

The interior least tern is piscivorous, feeding on small fish in shallow waters of rivers, streams, and lakes (USFWS 1990). Important prey genera include *Fundulus*, *Notropis*, *Campostoma*, *Pimephales*, *Gambusia*, *Blonesox*, *Morone*, *Dorosoma*, *Lepomis*, and *Carpiodes* (Grover 1979, Hardy 1957, Rumancik 1988, 1989, Schulenberg et al. 1980, Smith and Renken 1990, Wilson et al. 1989).

3.7 Reasons for Decline on the Missouri River Mainstem System

3.7.1 Historical

Undoubtedly, the loss of riverine breeding habitat on the Missouri, Arkansas, and Red Rivers and their tributaries (e.g., the Platte and Niobrara Rivers for the Missouri, and the Cimarron and Canadian Rivers for the Arkansas) has been a major factor in the decline of the interior population of the least tern. The Missouri River has a drainage basin of over 529,000 square miles (ACOE 1996). Historically, Missouri River flows would rise in early spring from snowmelts on the plains and peak again in June due to snowmelt from the Rockies. Flows would then decline through the summer and fall (ACOE 1996). Flooding was a natural occurrence and was not considered a "problem" until towns grew up along the river. In 1944 the Flood Control Act became law and authorized the construction of dams on the Missouri River and its tributaries (ACOE 1996). Six main dams were constructed along the stretch of the Missouri River from Yankton, South Dakota to Glasgow, Montana. The stretch from Sioux City, Iowa to St. Louis, Missouri was channelized and dredged (ACOE 1996).

3.7.1.1 Habitat Loss. The damming, channelization, and withdrawal of water from the Missouri River and its tributaries have eliminated nesting sandbar habitat along hundreds of kilometers of river (USFWS 1988). Seventy-six (76) percent of the Missouri River within the interior least tern's nesting range is either fully channelized or impounded by dams, thereby eliminating mid-channel sandbar nesting habitat. These losses have been only partially offset by shoreline habitat created by the reservoirs. Ongoing operation of the reservoir system has contributed to habitat loss in the remaining free-flowing segments of the Missouri River. Riverbed degradation and trapping of sediments at reservoirs has decreased sandbar habitat formation. When river system management does not allow regular scouring of the river, vegetation encroachment is likely to occur on higher islands.

3.7.1.2 Habitat Creation, Reclamation, and Maintenance, 1987-98. To combat historical losses of plover and tern habitat, the Corps embarked on a program of habitat creation, reclamation, and maintenance in 1987. A summary of habitat work by year and by reach is included in Section 2.7.1.2. Although this information is included in the piping plover section, it is also applicable to the interior least tern. Documents used in the preparation of this section include ACOE (1987, 1991, 1992, 1992a, 1992b, 1993, 1993a, 1993b, 1994, 1994a, 1995, 1996, 1997, 1998, 1998a), Kruse (1993, 1993a), Latka and Nebel (1993), NGPC (1985), and USFWS (1990a).

3.7.2 Present

Recent investigations into the reproductive ecology of the interior least tern and piping plover populations have identified several factors that continue to limit tern and plover productivity along the Missouri River mainstem system (Kruse 1993). These factors include: (1) fluctuating water levels (Schwalbach 1988, Mayer and Dryer 1989, Dirks 1990, USFWS 1991, Kirsch 1990); (2) human disturbances of nesting areas during recreational use (Dryer and Dryer 1985, Schwalbach 1988, Dirks 1990); (3) predation (Dirks 1990, Lingle 1990, USFWS 1991, USFWS 1992); and (4) weather events (rain, hail, high wind, etc.).

Kruse (1993) studied the influence of predation on interior least tern reproductive success along the Fort Randall and Gavins Point reaches of the Missouri River in southeastern South Dakota in 1991 and 1992. His report presents data on the fate of interior least tern nests along this stretch of river from 1988-92. In addition, Corps biologists have monitored interior least tern nests along all eight reaches of the Missouri River mainstem system since 1993. Tables 2 through 6 present information on the fate of monitored least tern nests from 1993 through 1997.

3.7.2.1 Fluctuating Water Levels. Fluctuating water levels have been clearly documented to impact interior least tern nesting on the Missouri River mainstem system (ACOE 1993, ACOE 1994, ACOE 1995, ACOE 1996). Unavoidable Flooding has destroyed least tern nests every year since monitoring began, but especially during flood years (Tables 3-2 through 3-6). From 1988-1992, an average of 12 nests (5.8 percent) were lost to flooding per year along the Fort Randall and Gavins Point reaches of the Missouri River (Kruse 1993). Twenty-one nests were lost to flooding in 1991 (Kruse 1993). In the years 1993 through 1997, from 14 to 118 monitored nests were lost each year to flooding along the eight reaches of the Missouri River mainstem system (Tables 3-2 through 3-6). Greatest losses occurred in the flood year of 1993 (118 nests).

The Corps attempts to manage water level fluctuations to maintain the best possible conditions for threatened and endangered species (see Section II for a detailed discussion of water level management for threatened and endangered species). However, this is not always possible, especially during flood years. To address this problem, the Corps has a policy of relocating nests and/or chicks to higher ground when feasible. In 1993, 2 least tern nests were relocated (ACOE 1993), but no nests were relocated in 1994 (ACOE 1994). In 1995, 3 least tern nests were relocated, but all three nests were later lost to flooding (ACOE 1995). No least tern chicks were relocated in 1995. In 1996, only 2 least tern nests were relocated, but both were still lost to flooding (ACOE 1996). One least tern nest was relocated in 1997; three eggs subsequently hatched from the nest (ACOE 1997).

In addition to nest relocation, the Corps initiated a salvage program in 1995 to prevent the complete loss of nests during uncontrolled flood operations (ACOE 1995). The program consists of: (1) salvaging eggs that would be lost due to natural flooding events of the Missouri River; (2) incubating the eggs and raising the chicks until fledging at a Corps captive rearing facility at Gavins Point; and (3) releasing chicks back to the wild after fledging. In 1995, egg incubation, rearing of chicks, and release of fledged juveniles was conducted in accordance with a pre-approved plan "Incubation, Propagation, and Release of Least Tern and Piping Plover Eggs Collected During the 1995 Missouri River Flood Control Operation Plan" (ACOE 1995). During the 1995 salvage effort, 18 percent of the least tern eggs (160 of 888) located on the Missouri River were collected. Hatching success for least tern eggs was 70 percent (112 of 160 eggs), and 70 percent of the hatched chicks eventually fledged and were released back to the wild. Fledged least terns were released on secure habitats once they had shown the ability to procure their own food. Release sites were on the Missouri River below Gavins Point Dam, on Lewis and Clark Lake, and along the lower 10 miles of the Niobrara River in north central Nebraska.

In 1996, egg collections, incubation, rearing, and release were conducted according to approved protocols (see Captive Rearing Protocol in the Corps' "Least Tern and Piping Plover Management Plan, 1996 Missouri River Operations") (ACOE 1996). During the 1996 salvage effort, 37.5 percent of the least tern eggs (204 of 544) located on the Missouri River were collected. Hatching success for least tern eggs was 90 percent (184 of 204 eggs), and 96 percent of the hatched chicks eventually fledged and 24 were released back to the wild. Release sites were below Gavins Point Dam, on Lewis and Clark Lake, and the lowest 10 miles of the Niobrara River in north central Nebraska.

In 1997, egg collections, incubation, rearing, and release were conducted according to approved protocols (see Captive Rearing Protocol in the Corps' "Least Tern and Piping Plover Management Plan, 1997 Missouri River Operations") (ACOE 1997). During the 1997 salvage effort, only four percent of the least tern eggs (26 of 671) located on the Missouri River were collected. Hatching success for least tern eggs was 73 percent (19 of 26 eggs), and 84 percent of the hatched chicks eventually fledged and 16 were released back to the wild on the Niobrara River near Niobrara, Nebraska.

3.7.2.2 Predation. Avian and mammalian predators are a major threat to interior least tern productivity throughout the species' breeding range. Predator exclosures and electric fences have been used with some success in decreasing this problem. The following mammalian and avian species have been implicated as predators of interior least tern eggs and chicks during other studies in the upper Missouri River Basin (Montana, North Dakota, South Dakota, Iowa, and Nebraska) and in Canada (Kruse 1993):

1) great horned owl (Dirks 1990, Lingle 1990)
2) mink (Dirks 1990)
3) raccoon (Dirks 1990)
4) American kestrel (Kruse 1993).

From 1988-1992, an average of 33 nests (15.9 percent) were lost to predation per year along the Fort Randall and Gavins Point reaches of the Missouri River (Kruse 1993). Predation was the principal cause of nest loss on these river reaches during Kruse's study (Kruse 1993). Fifty-seven (57) nests were lost to predators in 1992; this was 35 percent of known nests. In the years 1993 through 1997, from 4 to 87 monitored nests were lost each year to predators along the eight reaches of the Missouri River mainstem system (Tables 2 through 6). Greatest losses occurred in 1994 (87 nests), and 1995 (48 nests).

To address this problem, the Corps has had a predator aversion program since 1993. In addition, predator removal is occasionally undertaken to address specific problems. This is accomplished in full cooperation with all relevant authorities. In 1993 predator exclosure cages were first used to increase survival of piping plover nests, but not least tern nests (ACOE 1993). Strobe light systems were used on an experimental basis in 1993 to deter nocturnal, vision-dependent predators. Strobe light systems were again used in 1994 to deter predators (ACOE 1994). Overall, least tern nests on the 5 sites equipped with strobe light systems had a 48 percent nest hatching success. One fox was removed from a site on Lake Sakakawea.

In 1995, no predator aversion measures were undertaken specifically for least terns (ACOE 1996). Likewise, no predator aversion measures were undertaken specifically for least terns in 1996 (ACOE 1996). In an attempt to reduce the incidence of predation, 5 great horned owls were removed from Dredge Island in Lake Oahe in 1997 (ACOE 1997).

3.7.2.3 Human Disturbance. Some minor levels of human disturbance of interior least tern nests has been documented in the Great Plains region, where river sandbars are often used for recreational purposes during the nesting season. From 1988-1992, an average of 1.2 least tern nests per year were lost to human disturbance along the Fort Randall to Niobrara and Gavins Point to Ponca reaches of the Missouri River in southeastern South Dakota (Kruse 1993). In the years 1993 through 1997, from 0 to 3 monitored nests were lost each year to human disturbance along the eight reaches of the Missouri River mainstem system (Tables 3-2 through 3-6).

To address this problem, the Corps has posted and/or fenced specific nesting areas since at least 1993. In 1993, islands with more than 4 active nests and in jeopardy of human disturbance were signed and roped off (ACOE 1993). No information on 1994 activities is included in ACOE (1994). In 1995, nest sites close to or within recreation areas or areas with the high potential for human disturbance were posted with restriction signs and/or roped off with orange twine. Nesting sites in approximately 14 different locations were thus posted (ACOE 1995). One area was fenced off and signed to protect a tern nest in 1996 (ACOE 1996). In 1997, nest sites in 9 locations were posted with signs or restrictive fencing (ACOE 1997). In addition to signing and restrictive fencing, the Corps has conducted a public awareness campaign regarding piping plovers and least terns since at least 1992.

3.7.2.4 Weather. Heavy rains and winds, as well as hailstorms have been observed to cause mortality in interior least tern adults and chicks. From 1988-1992, an average of 2.4 nests (1.2 percent) per year were lost to human disturbance along the Fort Randall to Niobrara and Gavins Point to Ponca reaches of the Missouri River in southeastern South Dakota (Kruse 1993). In the years 1993 through 1997, from 15 to 40 monitored nests were lost each year to weather along the eight reaches of the Missouri River mainstem system (Tables 3-2 through 3-6). Greatest losses occurred in 1996 (40 nests), when rain storms accompanied by hail swept through the Garrison to Lake Oahe reach on several occasions during the nesting season, destroying a number of piping plover and interior least tern nests.

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4.1 Sturgeon Chub (*Macrhybopsis gelida*)

The sturgeon chub historically occurred along most of the Missouri River and larger western tributaries including the Platte River (Hesse et al 1993, Lee et al. 1980). It has experienced serious decline within its range and is a candidate for ESA listing (USFWS 1993a).

The sturgeon chub is rare or absent in Nebraska streams, as shown by collection efforts at 350 sites across Nebraska (Hesse et al. 1993). Only one was captured in the Platte River by Peters et al. (1989) in two years of sampling. During four years of intensive sampling in the Big Bend Reach of the Platte, Chadwick & Associates (1994) did not capture any sturgeon chub.

In the Missouri and Yellowstone Rivers Benthic Fish Study in 1996, 344 sturgeon chub were captured (by bag seines and benthic trawls only) in all segments sampled except the four inter-reservoir segments: Fort Peck Dam to Milk River (Montana), Garrison Dam to Lake Oahe headwaters (North Dakota), Fort Randall Dam to Lewis and Clark Lake headwaters (South Dakota and Nebraska), and Gavins Point Dam to Ponca (South Dakota and Nebraska) (Dieterman et al. 1996). Eighty percent of sturgeon chubs were collected in two least-impacted segments: Sturgeon Island to Beauchamp Coulee (Montana) and Intake Diversion Dam to Missouri River confluence (lower Yellowstone River in Montana). These two segments comprise 12 percent of the river miles sampled. Fourteen percent were collected in inter-reservoir segments: Wolf Point to Yellowstone River (Montana and North Dakota) and Yellowstone River to Lake Sakakawea headwaters (North Dakota). They were not captured in other inter-reservoir segments, but 17 individuals (6 percent) were found in channelized segments, although these segments make up 51 percent of the river miles sampled (Dieterman et al. 1996).

In the Benthic Fish Study in 1997, 546 sturgeon chub were captured 10 in 15 segments sampled (Young et al. 1997). As in 1996, most chubs (82 percent) were captured in two least-impacted: Sturgeon Island to Beauchamp Coulee (30 percent) and Intake Diversion Dam to Missouri River confluence on the lower Yellowstone River (52 percent) (Young et al. 1997).

In the Benthic Fish Study in 1996, sturgeon chub were captured in all macrohabitats except tributary mouths and non-connected secondary channels (Dieterman et al. 1996). In order of greatest frequency of occurrence, sturgeon chub were captured by bag seining in: (1) connected, shallow, secondary channels; (2) inside bend-sand bars; (3) connected, deep, secondary channels, and by benthic trawling in: (1) inside bend-channel borders; (2) outside bends; (3) channel cross-overs; and (4) connected, deep, secondary channels (Dieterman et al. 1996). In 1997, chubs were captured primarily in main channel habitats and were not found in tributary mouths or in non-connected secondary channels (Young et al. 1997).

Sturgeon chub are highly adapted to turbid conditions. Their eyes are relatively small and taste buds externalized (Pflieger 1975). Typical habitat for this species includes very shallow areas of large, open, silty rivers over shifting sand bottom or fine gravel (Tabor 1993, Pflieger 1975). Highest abundance usually occurs in gravel riffles (USFWS 1993a). Four fish were collected in 1991 near the mouth of the Platte River (USFWS 1993a).

In the Benthic Fish Study in 1996, sturgeon chubs were captured at water depths from 0 to 9 m (Dieterman et al. 1996). Most (55 percent) were captured at depths between 2 and 3 m. This may be partly due to the fact that most sturgeon chubs were collected in the benthic trawl, which is used in depths generally greater than 1.2 m. Few sturgeon chubs were in depths greater than 4 m. Most chubs (50 percent) were collected in water velocities between 0.6 and 1.0 m/s (Dieterman et al. 1996). About 5 percent were collected in 3.6 to 3.8 m/s. All other sturgeon chubs were captured in water velocities less than 2.0 m/s. Almost all sturgeon chubs (about 95 percent) were collected in 10 to 100 NTU turbidities and 20 to 26 degree C water temperatures. In 1997, most chubs were collected in water depths from 0 to 3m; very few were collected at depths greater than 4 m (Young et al. 1997). Most (greater than 65 percent) were captured in water velocities ranging from 0.2 to 0.8 m/s, and turbidity of 10 to 50 NTUs. Water temperature varied from 12 to 26 degrees C. Most (about 63 percent) were captured in temperatures ranging from 14 to 20 degrees.

In the Benthic Fish Study in 1996, sturgeon chub ranged in size from 17 to 121 mm, with most being less than 100 mm (Dieterman et al. 1996). Only in one segment (Milk River to Hwy. 13 bridge in Montana) did sturgeon chub exceed 100 mm, with 55 percent of the catch exceeding that figure. Two segment (Arrow Creek to Birch Creek in Montana and Wolf Point to Yellowstone River in Montana and North Dakota) had higher frequencies of sturgeon chub less than 50 mm. In 1997, Most chubs captured were less than 150 mm total length (Young et al. 1997). Captured fish were predominantly in smaller size classes, evidence that recruitment has been successful (Young et al. 1997).

Decline of the sturgeon chub may be caused by major habitat alterations and destruction resulting from mainstem and tributary impoundment, intensive agricultural cultivation, stream channelization, soil conservation practices, streamflow diversion, and irrigation groundwater withdrawal (Tabor 1993). Hesse et al. (1993) stated that a variety of changes in the Missouri River may have affected this species, including (1) snag loss and removal; (2) reduced food supply; (3) altered habitat structure and reduced rearing habitat; (4) loss of floodplain connectivity; (5) altered hydrograph and reduced peak flows; (6) loss of sediment transport; (7) altered temperature regimes; and (8) elimination of fish passage at Missouri River dams.

4.2 Sicklefin Chub (*Macrhybopsis meeki*)

The sicklefin chub historically occurred exclusively in the mainstem Missouri River (except in Kansas) and lower Mississippi River (Lee et al. 1980). This species is declining markedly and is now a candidate for ESA listing (USFWS 1993b).

Only one specimen was collected in the Nebraska portion of the Missouri River from 1986 to 1990 (Hesse et al. 1993). No confirmed collections have been made in the Platte River (Lee et al. 1980, Peters et al. 1989, Hesse et al. 1993, Chadwick & Associates, Inc. 1994, USFWS 1993b).

In the Missouri and Yellowstone Rivers Benthic Fish Study in 1996, 83 sicklefin chub were captured, almost exclusively by benthic trawl (all but one individual were captured with this gear) (Dieterman et al. 1996). Numbers of sicklefin chubs collected were nearly equally split among least-impacted (33 percent), inter-reservoir (42 percent), and channelized (25 percent) segments. However, most of the inter-reservoir individuals (80 percent) were captured between the Yellowstone River mouth and Lake Sakakawea headwaters in North Dakota (Dieterman et al. 1996). Only one sicklefin chub was collected in a segment immediately downstream of an impoundment. In 1997, 212 sicklefin chub were captured in 8 of 15 segments sampled (Young et al. 1997). By far the most chubs (109 or 51 percent) were captured in one segment – Sturgeon Island to Beauchamp Coulee in Montana.

In the Benthic Fish Study in 1996, sicklefin chubs were captured in the following macrohabitats: (1) channel cross-overs (in least-impacted and inter-reservoir segments only); (2) outside bends (in least-impacted and inter-reservoir segments only); (3) inside bend-channel borders; (4) inside bend-sand bars; and (5) connected, deep secondary channels (Dieterman et al. 1996). They were not captured in tributary mouths or non-connected secondary channels.

The sicklefin chub has habitat and adaptive characteristics similar to those of the sturgeon chub. It occurs in large, turbid rivers with shifting sand or fine gravel bottom, and has reduced eyes partly covered with skin (Tabor 1993, Pflieger 1975, USFWS 1993b).

In the Benthic Fish Study in 1996, most sicklefin chubs were collected at water depths ranging from 1 to 5 m (67 percent), and water velocities greater than 0.4 m/s (83 percent) (Dieterman et al. 1996). Most (about 90 percent) were collected in turbidities between 10 and 100 NTUs and water temperatures greater than 18 degrees C. In 1997, most sicklefin chubs were captured at water depths ranging from 1 to 4 m (about 85 percent), and water velocities between 0.2 and 1.2 m/s (about 90 percent) (Young et al. 1997). Most (about 80 percent) were collected in turbidities between 10 and 100 NTUs. Chubs were captured in a wide range of water temperatures in 1997, from 14 to 28 degrees C.

In the Benthic Fish Study in 1996, collected sicklefin chub ranged from 25 to 128 mm total length (Dieterman et al. 1996). In general, larger size classes were apparent in two segments: the Missouri River below Fort Peck Dam and the Yellowstone River. In 1997, most sicklefin chubs were in the 0 to 50 mm, and 50 to 100 mm size classes (Young et al. 1997).

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II. OPERATION OF THE MISSOURI RIVER MAIN STEM SYSTEM

5.1 Operational Objectives

5.1.1 History

After closure of Fort Peck dam on the Missouri River in 1937, extensive plans for further control of the river were developed by several federal agencies. Two of the most comprehensive were the proposals of the Corps of Engineers (Corps), oriented toward flood control and navigation, and that of the Bureau of Reclamation (USBR), emphasizing irrigation and hydropower generation. The two plans were merged during joint meetings in October 1944, and their major features incorporated by the Flood Control Act of 1944, enacted in December that year. More than 100 reservoirs throughout the Missouri Basin were authorized by this Act, called the Pick-Sloan Plan. The paramount feature of the plan was the integrated operation of the six Missouri River main stem dams shown on **Figure 5-1**.

A reconciliation of project purposes for this Pick-Sloan Plan (Senate Document 247) by the Corps and the USBR in December 1944 focused on the construction of the main stem reservoirs as multiple purpose with a unified plan for the total development of the Missouri River basin including "maximum benefits for flood control, irrigation, navigation, power, domestic and sanitary purposes, wildlife and recreation".

In 1954 a Corps of Engineer's Reservoir Control Center (RCC) was established within the Division Office to plan, regulate and coordinate the operation of the Missouri River Main Stem Reservoirs System (System) as well as provide oversight on the regulation of the Corps tributary reservoirs and Bureau of Reclamation projects. The RCC prepares both short-term and long-term operating plans, coordinates these plans with affected interests, and specifies how the projects shall be regulated on a day-by-day basis.

5.1.2 Guidelines

Corps guidelines for operating the main stem reservoirs are contained in a Corps document referred to as the Missouri River Master Water Control Manual (Master Manual). The current Master Manual (revised 1979) recognizes the legislated project purposes. Paragraph 1-2 states, "The Missouri River Main Stem System (System) of reservoirs consists of six reservoirs, ...constructed by the Corps of Engineers on the main stem of the Missouri River for flood control, navigation, irrigation, power, water supply, water quality control, recreation, and fish and wildlife." In order to help serve these project purposes, the original water control plan for the Master Manual was selected ensuring: 1. that adequate space (system storage near the base of flood control) in the system be reserved by March 1st to store large flows originating in the upper basin, and 2. that the system would not be drawn down below permanent pool level throughout another drought similar to the one experienced in the 1930's

Master Manual guidelines are followed each year, as the Corps Annual Operating Plan (AOP) for the System is prepared. The AOP identifies the operating plan for the upcoming year. In real time, regulating the System involves reserving water for water supply, recreation, irrigation, fish and wildlife and other in-reservoir benefits, and releasing water to generate hydropower and benefit downstream uses including navigation, fish and wildlife, water quality, water supply, and recreation.

Missouri River Basin

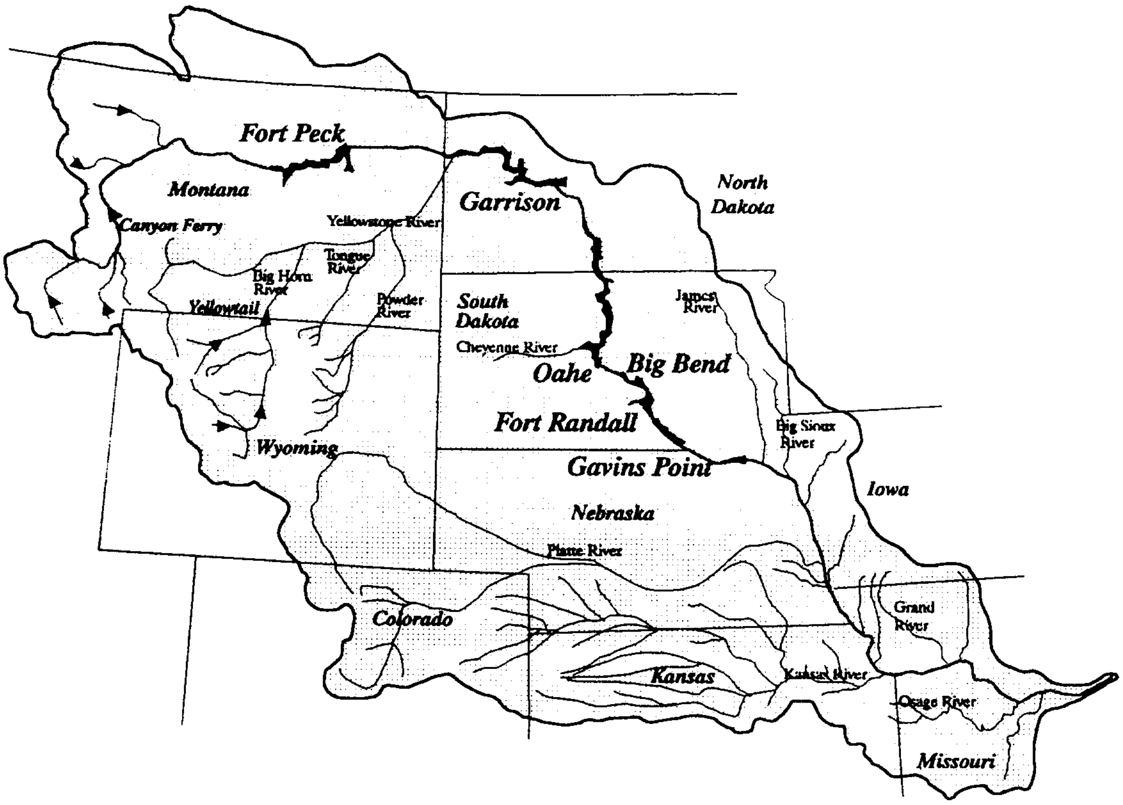
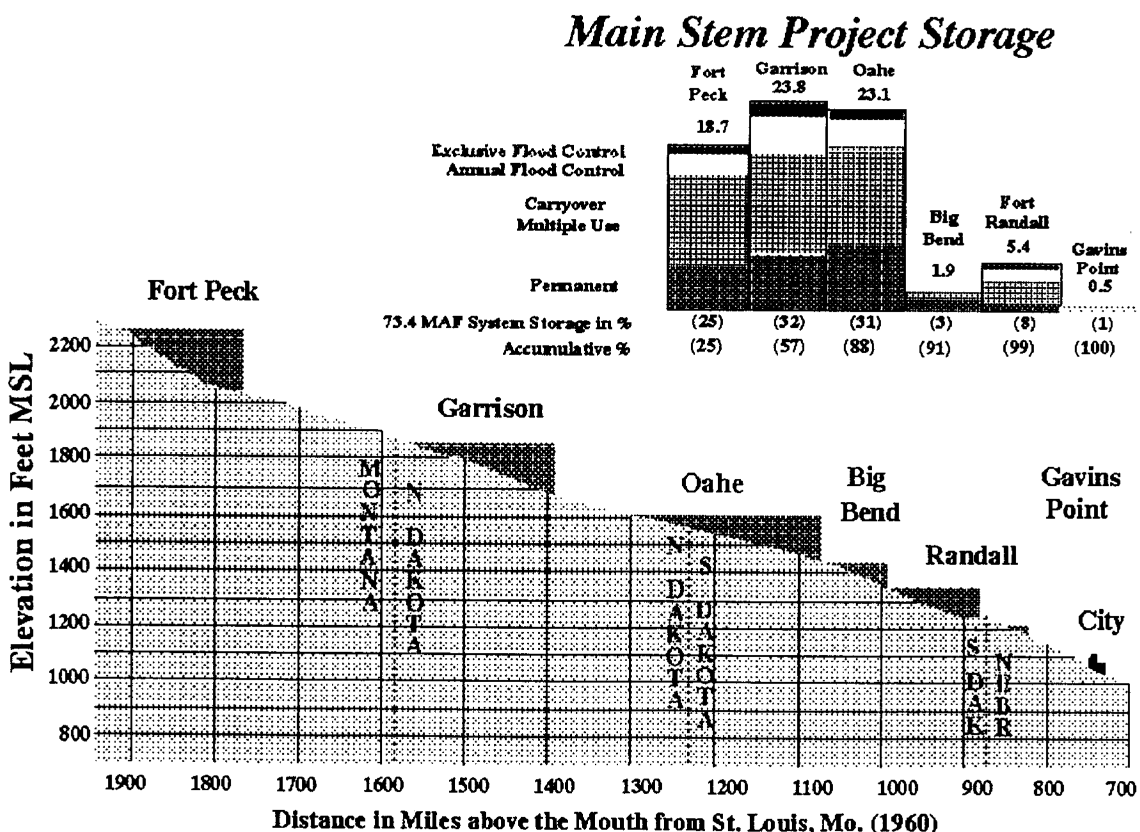


Figure 5-1 Missouri River Basin & Figure 5-2 Profile of Main Stem Reservoir System



Profile of Missouri River Main Stem Reservoir System

5.1.3 Missouri River Basin Description

The Missouri River basin has an area of 529,000 square miles, including about 9,700 square miles located in Canada. The basin spans 10 states, including all of Nebraska; most of Montana, Wyoming, North Dakota, and South Dakota; about half of Kansas and Missouri; and smaller parts of Iowa, Colorado, and Minnesota. A map of the Missouri River basin identifying the major main stem and tributary Corps' and certain Bureau of Reclamation civil works projects is presented on **Figure 5-1**. A summary of engineering data for the six main stem reservoirs is shown in **Appendix A**. **Figure 5-2** shows a profile of the main stem projects and displays the relative proportion of storage in the projects.

Basin topography varies from the 56,000 square miles in the Rocky Mountain area in the West, where many peaks exceed 14,000 feet in elevation, to the approximately 370,000 square- mile Great Plains area in the heartland of the basin, to the 90,000 square-mile Central Lowlands in the lower basin where the elevation is 450 feet above mean sea level (msl) near the mouth at St. Louis, Missouri. The Black Hills in South Dakota and the Ozarks in Missouri, consisting of 13,000 square miles, are isolated domelike uplifts that have been eroded into a hilly and mountainous topography. Stream slopes vary from about 200 feet per mile in the Rockies to an average of a foot per mile on the Missouri River as it flows through the Great Plains and Central Lowlands.

There are several major Missouri River tributaries. They are the Yellowstone River, which drains an area of over 70,000 square miles, joining the Missouri River near the Montana-North Dakota boundary; the Platte River, with a 90,000 square mile drainage area entering the Missouri River in eastern Nebraska; and the Kansas River, which empties into the Missouri River in eastern Kansas and drains an area of approximately 60,000 square miles. A prominent feature in the drainage pattern of the upper portion of the basin is that every major tributary, with the exception of the Milk River in Montana, is a right bank tributary flowing to the east or to the northeast. Only in the extreme lower basin, below the mouth of the Kansas River, is a fair balance reached between left and right bank major tributaries. The direction of flow of the major tributaries is of particular importance from the standpoint of potential concentration of flows from storms that typically move across the basin in an easterly direction. It is also important in another respect on the Yellowstone River, since early spring temperatures in the headwaters of the Yellowstone and its tributaries are normally from 8 to 12 degrees Fahrenheit higher than along the northern most reach of the Missouri near the Yellowstone confluence. This ordinarily results in ice breakup on the Yellowstone prior to the time the ice goes out of the Missouri River, thereby contributing to ice jam floods along the Missouri River downstream from the confluence to near Williston, North Dakota.

5.1.3.1 Climatology. 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 results in a wide variation in climatic conditions. The climate of the basin is produced largely by interactions of three great air masses that have their origins over the Gulf of Mexico, the northern Pacific Ocean, and the northern Polar Regions. They regularly invade and pass over the basin throughout the year, with the Gulf air tending to dominate the weather in summer and the polar air dominating in winter. This seasonal domination by the air masses and the frontal activity caused by their collisions produce the general weather regimens found within the basin. As is typical of a continental-interior plains area, the variations from normal climatic conditions from season to season and from year to year are extreme. The outstanding climatic rarity in the basin was the severe drought of the 1930's when excessive summer temperatures and subnormal precipitation continued for more than a decade.

Average annual precipitation ranges from as low as 8 inches just east of the Rocky Mountains to about 40 inches in the southeastern part of the basin and in parts of the Rocky Mountains at higher elevations. Prolonged droughts of several years' duration and frequent shorter periods of deficient moisture, interspersed with periods of abundant precipitation, are characteristic of the plains area. The normal seasonal maximum precipitation is observed throughout the basin during the spring and early summer months. Precipitation during the late summer and fall months is usually of the short-duration thunderstorm type with small centers of high intensity, although widespread general rains do occasionally occur, especially in the lower basin. Winter precipitation occurs in the form of snow in the northern and central portions of the basin and, in the lower basin states, it may occur as rain or snow or a mixture of both. Average annual snowfall ranges from 20 inches in the lower basin to 30 inches in the eastern Dakotas to near 50 inches in the high plains areas in the West. High elevation stations in the Black Hills and in the Rockies along the western edge of the basin receive in excess of 100 inches of snowfall. Following the winter season, snow depths up to 6 feet, with a water equivalent of 2 feet, are not uncommon at mountain locations. Snow does not usually progressively accumulate over the plains but is melted by intervening thaws. However, there have been exceptions over the northern plains when snow that accumulated on the ground throughout the winter had a water equivalent of 6 inches or more.

Due to its mid-continent location, the basin experiences temperatures noted for wide fluctuations and extremes. Winters are relatively long and cold over much of the basin, while summers vary from mild to hot. Spring is normally cool, humid, and windy; autumn is normally cool, dry, and fair. The basin experiences temperatures above 100 degrees Fahrenheit in summer and below -20 degrees Fahrenheit in winter.

5.1.3.2 Main Stem and Tributary Streamflow Characteristics. Streams having their source in the Rocky Mountains are fed by snowmelt. They are clear flowing and have steep gradients with cobble-lined channels. Stream valleys often are narrow in the mountain areas and widen out as they emerge from the mountains onto the outwash plains. Flood flows in this area are generally associated with the snowmelt runoff period occurring in May and June. Occasionally, summer rainfall floods having high, sharp peaks occur in the lower mountainous areas, such as the Big Thompson River flood in July 1976 and the Rapid City flood in June 1972.

Streams flowing across the plains area of Montana, Wyoming, and Colorado have variable characteristics. The larger streams with tributaries originating in the mountain areas carry sustained spring and summer flows from mountain snowmelt, and they have moderately broad alluvial valleys. Streams originating locally often are wide, sandy-bottomed, and intermittent, and they are subject to high peak rainfall floods. Streams in the plains region of North and South Dakota, Nebraska, and Kansas with the exception of the Nebraska sandhills area generally have flat gradients and broad valleys. Except for the Platte River, most of the streams originate in the plains area and are fed by snowmelt in the early spring and rainfall runoff throughout the warm season. Streamflow is erratic. Stream channels are small for the size of the drainage areas, and flood potentials are high. When major rainstorms occur in the tributary area, streams are forced out of their banks onto the broad flood plains.

Streams in the regions east of the Missouri River have variable characteristics. Those in the Dakotas, such as the Big Sioux and James Rivers, are meandering streams with extremely flat gradients and very small channel capacities in relation to their drainage areas. These areas are generally covered with glacial drift and contain many pothole lakes and marshes. Rainfall in the spring often combines with the annual plains snowmelt to produce floods that exceed channel capacities and spread onto the broad flood plains.

Streams in the Ozark Highlands of Missouri resemble mountain streams with their clear, dependable base flows. Much of the area is underlain by limestone, and there are cavernous underground springs. The hilly terrain produces high peak runoff, which contributes to frequent floods with large volumes due to this area's higher annual rainfall.

Regulation provided by the six large Corps reservoirs on the main stem and by upstream tributary reservoirs has greatly reduced flood flows on the Missouri River from Fort Peck Dam downstream to the mouth of the Platte River below Omaha, Nebraska. Critical stages can be reached for a short time below the upper three main stem reservoirs during the winter freeze-up of the Missouri River. During this period, key locations are frequently monitored so those reservoirs can be regulated to prevent localized flooding. From Sioux City to the mouth of the Platte River, damaging floods are still possible, but their frequency of occurrence has been greatly reduced by the System. Below the Platte River to the mouth near St. Louis, the incremental drainage area is of sufficient size that above bankfull stages can be expected to occur frequently as a result of flood runoff from major storms over the tributary areas, although significant stage reductions due to System regulation will usually occur.

5.1.4 System Operation Overview.

The System is operated to serve the multiple uses of flood control, recreation, irrigation, water supply and water quality, navigation, hydropower generation, and fish and wildlife including endangered species. System operation is in many ways a repetitive annual cycle. Winter snows and spring and summer rains that increase the water in System storage (storage) produce most of the annual water supply. After reaching a peak, usually during July, storage declines until late in the winter, when the cycle begins anew. A similar pattern may be found in rates of releases from the System, with the higher levels of flow from mid-March to late November, followed by low rates of winter discharge from late November until mid-March because of winter icing, after which the cycle repeats. The Water Control Calendar of Events, shown on **Figure 3,** displays the time sequence of many of these cyclic events that necessitates the varied regulation plans to accommodate the multipurpose objectives of the System.
The two primary high risk flood seasons shown are the plains snowmelt and rainfall season extending from late February through April and the mountain snowmelt and rainfall period extending from May through July. Also the winter ice jam flood period extends from mid-December through February. The highest average power generation period extends from

mid-April to mid-October with high peaking loads during the winter heating season (mid-December to mid-February) and the summer air conditioning season (mid-June to mid-August). The power needs during the winter are supplied primarily with Fort Peck and Garrison releases and the peaking capacity of Oahe and Big Bend. During the spring and summer period, releases are geared to navigation and flood control requirements and primary power loads are supplied using the four lower dams. During the fall when power needs diminish, Fort Randall pool is drawn down to permit generation during the winter period when the pool is refilled by Oahe-Bend peaking power releases. The major maintenance periods for the System hydropower facilities extend from March through mid-June and September through November. Both periods are normally the lower demand and off-peak energy periods. The exception is Gavins Point where maintenance is performed after the end of the navigation season since all three power facilities are normally required to provide navigation flow needs. The normal 8-month navigation season extends from April 1 through December 1 during which System releases are increased and combined with downstream tributary inflows (to meet downstream target flows). Much of the increased flow for navigation comes from the large carryover storage in Oahe Reservoir which is replenished by releases from Garrison and Fort Peck. Winter releases after the close of navigation season are much lower and vary depending on the need to conserve or evacuate System storage volumes, downstream ice conditions permitting. Minimum release restrictions and pool fluctuations for fish spawning management generally occur from April 1 through July. Endangered species nesting occurs from early May through mid-August.

Other factors may vary widely from year to year, such as the amount of water in storage and the magnitude and distribution of inflow received during the coming year. All of these factors will affect the timing and magnitude of project releases. The gain or loss in the water stored at each reservoir must also be considered in scheduling the amount of water transferred between reservoirs to achieve storage balance and to generate power. These items are continually reviewed as they occur and are appraised with respect to the expected range of operations discussed in succeeding sections of this report.

5.2 Main Stem Operations

5.2.1 General

The System was built and is operated to store water when there is an excess above and below the System and to use the stored water when there are shortages. The lesser the volume of stored water remaining in the reservoir system, the lesser the amount released in support of the various multi-purpose uses.

The existing Master Manual documents guidelines for the operation of the System for the multiple project purposes. For operating and planning purposes, the Master Manual separates the total available storage volume in the main stem reservoirs into four zones. **Table 5-1** below, shows the flood control levels for each reservoir.

Water Control Calendar of Events

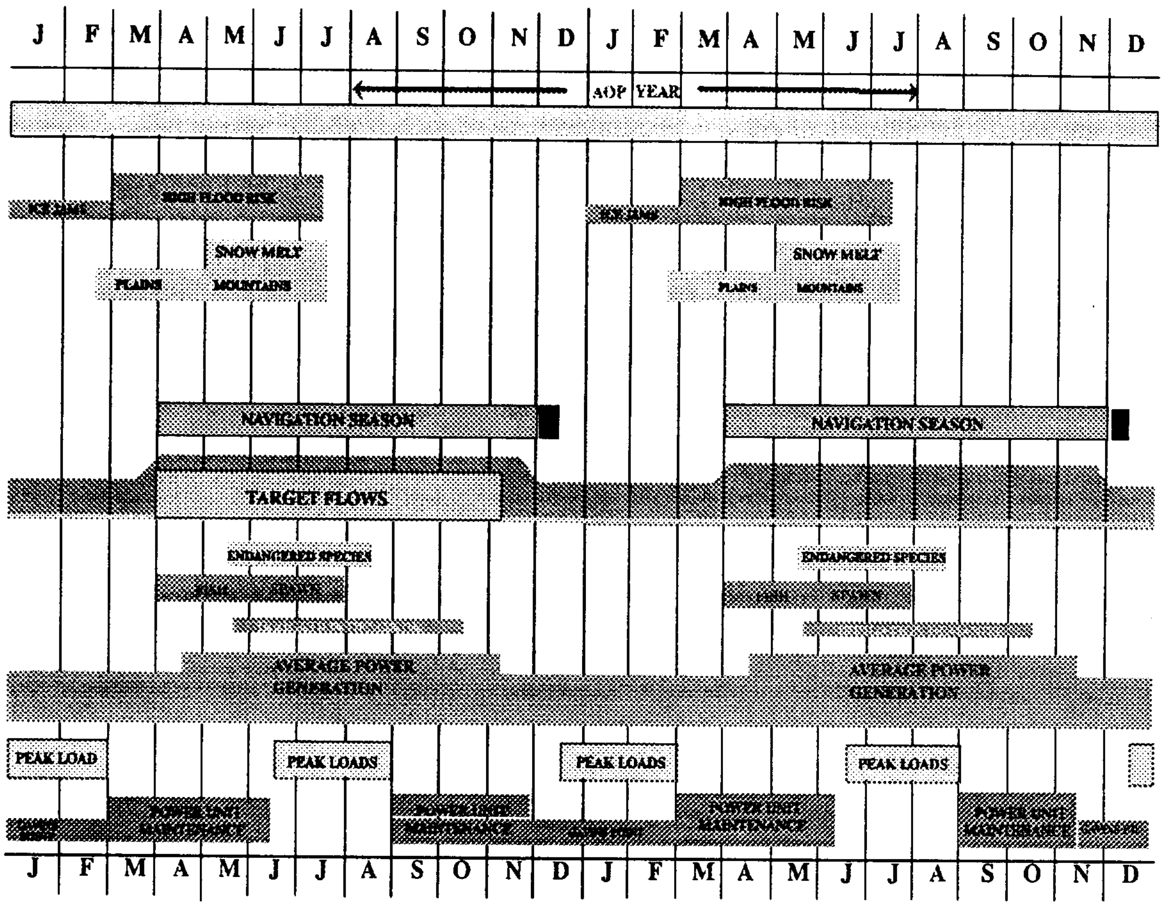


Figure 5-3

Table 5-1

MAIN STEM PROJECT STORAGE LEVELS

	BASE OF ANNUAL FLOOD CONTROL Storage (MAF)	Elev. (ft)	BASE OF EXLUSIVE F.C. Storage (MAF)	Elev. (ft)	TOP OF EXLUSIVE F.C. Storage (MAF)	Elev. (ft)
Fort Peck	15.0	2234.0	17.7	2246.0	18.7	2250.0
Garrison	18.1	1837.5	22.3	1850.0	23.8	1854.0
Oahe	18.8	1607.5	22.0	1617.0	23.1	1620.0
Big Bend	1.7	1420.0	1.8	1422.0	1.9	1423.0
Ft Randall	3.1	1350.0	4.4	1365.0	5.4	1375.0
Gavins Point	0.3	1204.5	0.4	1208.0	0.5	1210.0
Total	57.1		68.7		73.4	

The exclusive flood control zone is the total upper volume of the System reservoirs (lakes) that is reserved for extremely high flood events. Water is released from this zone as quickly as downstream channel conditions permit so that sufficient space remains for storing future incoming floodwaters. The annual flood control and multiple use zone is used to store moderate spring and summer inflow. Water stored in this zone is released later in the year so that the zone is emptied by the beginning of the next flood season on March 1st. This zone provides benefits to all multi-purpose uses and, like the exclusive flood control zone, most of the water is released from the reservoirs during the summer and fall navigation season. Water also accumulates in these two zones as a result of reduced System releases in order to help alleviate downstream flooding. The large carryover multiple use zone is to provide for continuity of service to multi-purpose uses even during an extreme drought period such as the 1930's. In general the lower the amount of stored water in this zone, the more releases are reduced at all the projects to conserve the remaining supply. The remaining storage capacity, the permanent pool, provides a minimum head for power generation, assures a minimum level where there will be pumping at a reservoir, provides an assured minimum recreation and fish and wildlife pool, and serves as storage for sediment.

The Master Manual specifies the Current Water Control Plan (CWCP) guidelines for releasing water from the upper three storage zones to help fulfill project uses. The Master Manual provides guidelines for water releases from the System at Gavins Point and general water release guidelines for the other five dams (there are separate Reservoir Regulation Manuals for each of the six System reservoir projects). In general, the movement of water in storage from one lake to another follows the basic pattern (mentioned in I.(C) above) each year. The Water Control Calendar of Events shown on **Figure 5-3** displays the timing of cyclic events, which influence the multi-purpose objectives of the System. Despite even below or greater than normal inflows, the Corps strives to hold water in the three large upstream reservoirs relatively in balance so that intrasystem effects are shared equally among these three reservoirs. Current practice is to attempt to balanced storage in these three reservoirs by March 1st of each year near the base of their individual annual flood control zones.

5.2.2 Guidelines for Water Use Purposes

5.2.2.1 Flood Control Guidelines. 5.2.2.1.1 Scheduling System Releases. When developing operational plans and during real time operation, the flood control function of the system continues to be a consideration in scheduling system releases, irrespective of the amount of storage contained in the System or the variability of inflows to the System. Multi-purpose regulation of the System is implemented consistent with flood control objectives. During the winter months, multi-purpose releases are restricted due to the possibility of ice formation that severely limits channel capacity. Since the ability to evacuate system storage is severely restricted during the winter months, the necessary increases in system release rates for storage evacuation purposes above the rates necessary for navigation and other multi-purposes will be largely made during the navigation season. Normally, the flood control storage space of the entire system is evacuated by March 1st. The usual operation is to allow partial filling of the annual flood control and multiple-use zone during the flood season, provided inflows greater than multiple-use releases occur. The exclusive flood control storage space provided in the system is reserved entirely for the control of floods, and will not be encroached on unless necessary for that purpose. Surcharge storage space, above exclusive flood control zone space, is provided to assure project integrity and will be utilized only in the case of extreme floods.

The method of scheduling above-normal System releases as well as reduced releases during periods of flood events below the System utilizes the concept of "service level" and "target flows" described below. It is well to remember that navigation releases during the open-water season are also based on maintaining specified target flows at downstream control points. This multi-purpose regulation serves flood control as well as the other authorized purposes, including navigation, most of the time. There are times however, when the service provided to other purposes must be modified in the interest of flood control.

5.2.2.1.2 Service Level. Based on experience the minimum downstream target flows that will permit satisfactory navigation are 25,000 cubic feet per second (cfs) at Sioux City and Omaha, 31,000 cfs at Nebraska City, and 35,000 cfs at Kansas City. This is called the "29,000 cfs-service level" or <u>minimum-service</u>. Open-water target flows for <u>full-service</u> are for a flow of not less than 31,000 cfs at Sioux City and Omaha, 37,000 cfs at Nebraska City, and 41,000 cfs at Kansas City. Utilization of the target flow concept, with target flow levels 6,000 cfs greater than minimum service has result in an average annual navigation season flow at Sioux City of about 35,000 cfs. Service levels are dependent upon System storage and other factors.

Release reductions below minimum service for flood control purposes could have a serious adverse affect on navigation because of inadequate channel depths. Release reductions below minimum navigation service level are made when it appears that the reductions will be of benefit from the flood control standpoint. Increases above full-service navigation flows may be necessary for flood storage evacuation.
The minimum release rate out of the System from Fort Randall is 5,000 cfs. The full-service concept corresponds to a 15,000-cfs average winter release from Fort Randall. Experience has

shown that the Fort Randall release rate can usually be increased to 20,000 cfs without serious ice jam flooding. In higher inflow years when full evacuation of the accumulated flood control storage zone during even an extended navigation season would require higher release rates during the winter months, consideration will be given to increases above the 20,000 cfs level.

Plate 44 of the Master Manual presents the "service level" at any time throughout the year for levels less than full-service and for storage evacuation purposes. It relates the water supply and time of year to the appropriate service level. Essentially, Plate 44 presents ("water supply") curves that can be expected to occur if the indicated service level is sustained through the remainder of the navigation season with specified releases through the winter to the succeeding March 1st. "Water supply" is defined as a combination of forecast runoff above Gavins Point Dam from the current date through December, current system storage, and tributary reservoir storage. **See Appendix A of this report for an example of the use of Plate 44.**

If increased System releases are required to evacuate flood control storage by the next March 1st, the initial increase (in the total volume of System release) above the full service level is designated the expanded full-service level. Its major feature is the extending of the navigation season 10 days beyond the normal 1 December closing date at the mouth. Additionally, for storage evacuation, winter releases averaging 20,000 cfs are scheduled from Gavins Point.

Service level above that required for "full service navigation flows", is referred to as evacuation service level. The selection of appropriate service levels for flood storage evacuation in excess of expanded full-service levels are/will be dependent upon anticipated above-normal runoff in the drainage above the System and time of year.

5.2.2.1.3 Modified Target Flows for Flood Control. Similar to navigation targets, storage evacuation targets are for specific flows at the controlling downstream location. As a flood control measure, the normal relationship between service levels and downstream target flows will be modified when large inflows are anticipated between Gavins Point and downstream control points.

In the first stage of system release cutbacks for flood control, target flows are reduced to those consistent with the full-service level. The resultant downstream flows will not exceed the *current service level flow values* by more than *6,000 cfs* at Omaha (target flow **plus 10,000 cfs**), *12,000 cfs* at Nebraska City (target flow **plus 10,000 cfs**), and *36,000 cfs* at Kansas City (target flow **plus 30,000 cfs**). The reduction of releases to full service is scheduled when flow levels are forecast to rise.

In the second stage, target flows will be reduced further consistent with the minimum service level. This reduction in System releases is scheduled when current service target flow levels are forecast to exceed more than target flow **plus 15,000 cfs** at Omaha, target flow **plus 20,000 cfs** at Nebraska City, and target flow **plus 60,000 cfs** at Kansas City.

For example, if the current service level was 40,000 cfs (*full service + 5,000 cfs*) system releases would be reduced consistent with the full service level if this was necessary to maintain flow at or below 46,000 cfs at Omaha (31,000 cfs + 5,000 cfs **plus 10,000 cfs**), 52,000 cfs at Nebraska

City (37,000 cfs + 5,000 cfs **plus 10,000 cfs**), Or 76,000 cfs at Kansas City (41,000 cfs + 5,000 cfs **plus 30,000 cfs**)

5.2.2.1.4 Main Stem and Kansas River Basin Tributary Reservoir Relationship. At Kansas City, the lowest downstream control point used for scheduling System releases, control of river flow is also provided by tributary reservoirs in the Kansas Basin. If the System water supply is such that a service level of 35,000 cfs is applicable, Kansas River basin reservoirs will have priority for evacuation and first utilize the Missouri River channel capacity. Releases from Kansas River basin reservoirs with accumulated flood storage at extremely high levels (as in 1993) will usually have priority over System releases for the available channel capacity, irrespective of the current System storage level. If main stem storage evacuation requires a service level greater than the 35,000-cfs level, the main stem release requirements will have priority over releases from Kansas River basin reservoirs with accumulated flood control storage that is not at extremely high levels. Refer to the Corps Master Manual, Section X for a detailed explanation of this.

Several Corps reservoirs located in the Kansas River basin also have storage authorized for use to supplement Missouri River navigation flows when required. The criteria for the amount of flow support from these projects is documented in the Lower Kansas Basin Master Manual.

5.2.2.1.5 Scheduling Releases from the Upper Five Reservoirs. Master Manual criteria is followed to accomplish flood control in the best possible way while at the same time providing maximum possible service to other multiple-use functions of the system. The available flood control storage space contained in the upstream Fort Peck, Garrison, and Oahe reservoirs is utilized first for the control of floods in preference to the available space contained in downstream reservoirs. The allocated flood control storage space in the downstream Big Bend, Fort Randall, and Gavins Point reservoirs will be utilized to the degree necessary to re-regulate upstream reservoir releases and to control floods originating below the Oahe project. Maximum releases during the open-water season will be based on downstream channel capacities at all times when flood control storage space is available to control existing or anticipated inflows.

Due to restricted channel capacities under ice conditions, daily average releases from specific projects during the winter ice-cover period are limited to below maximum powerplant capacity while the head of the ice cover moves upstream past critical locations.

Evacuation of accumulated storage within the System immediately following flood inflows is accomplished, insofar as practicable, based on the following priorities as follows:

1) Surcharge storage from all reservoirs.
2) Exclusive flood control storage in the downstream Gavins Point, Fort Randall, and Big Bend projects.
3) Exclusive flood control storage in the upstream Fort Peck, Garrison, and Oahe projects.
4) Annual flood control and multiple-use storage in Gavins Point and the Fort Randall annual flood control and multiple-use storage space above elevation 1360.
5) Annual flood control and multiple-use storage in the upstream Fort Peck, Garrison, and Oahe projects.

5.2.2.2 Navigation Guidelines

5.2.2.2.1 Scheduling System Releases. Navigation is limited to the open-water season, and based on experience, has opening and closing dates of March 23rd and November 22nd at Sioux City and April 1st and December 1st at St. Louis for a normal 8-month season. The navigation season is shortened during extreme drought periods when the amount of water in system storage drops below a specified level. A full 8-month season can be provided during most years. Under the CWCP inflows to the System are sufficient to support "minimum service" (i.e. a 29,000 cfs service level, see **Table 5-2** below) flows or higher about 91 per cent of the time without any loss in storage. A release rate near the long-term normal that can be sustained from the System provides the most efficient regulation of an essentially filled system. This is accomplished by the "full service" level for navigation under present-day depletions. Utilization of the target flow concept, with downstream target flow levels 6,000 cfs greater than minimums, will result in average navigation season flows at Sioux City of about 35,000 cfs. This "full service" level (35,000 cfs service level) approximates the normal 8-month flow past Sioux City and relates target flows at downstream control points on the Missouri River as follows. The control points at Sioux City and Omaha have a target discharge deviation of –4,000 cfs from the selected service level, at Nebraska City a +2,000-cfs target deviation from the selected service level, and at Kansas City a +6,000-cfs target discharge deviation. The flow targets for the control points are determined by first computing the necessary service level and then applying a flow deviation of –4,000 cfs for Sioux City and Omaha,, +2,000 cfs for Nebraska City and +6,000 cfs for Kansas City.

TABLE 5-2
GAVINS POINT RELEASES NEEDED TO MEET
NAVIGATION REQUIREMENTS
1954-1979
(Discharges in 1,000 cfs)

Service Level	Mar	Apr	May	Jun	Month Jul	Aug	Sep	Oct	Nov	Average
Minimum	22.8	22.8	24.8	24.0	26.7	28.2	28.5	27.5	27.5	25.9
Full	28.8	28.8	30.8	30.0	32.7	34.2	34.5	33.5	33.5	31.9

Selection of the appropriate service level to be maintained is based on accumulated System storage checks on March 15th and July 1st. If System storage on March 15th is 54.5 MAF full service flows are maintained, if 46.0 MAF or less minimum service flows are maintained. If System storage on July 1st is 59.0 MAF or more, full service flows are maintained, if 50.5 MAF or less minimum service flows are maintained. These storage checks in combination with an expected normal runoff forecast are compatible with service levels obtained from **Plate 44** in the Master Manual. Interpolation between System storages for either of the above dates defines intermediate service levels. In the event of high flood inflows during the early spring flood period after March 15th, an analysis will be made to determine if the service level should be raised prior to July 1st. This was the case in both the high water years of 1996 and 1997 when system releases had to be increased and increased the risk of higher stages on the lower Missouri River. Service levels during the record water year 1997 were computed at least monthly and began in February. When System storage becomes extremely low, and below normal inflow forecasts have the possibility of placing the resulting System storage near the top of the permanent pool in the ensuing months, flow support for navigation may cease. System releases under the CWCP then revert to minimum levels that ensure consumptive use without drawing System storage below the top of the Permanent Pool.

5.2.2.2.2 Forecasts for Navigation Support. Daily regulation of the System to support navigation requires forecasts of inflow for various reaches of the river below the System as described in Section VIII of the Master Manual. Using these forecasts and current target flows, a System control target (either Sioux City, Omaha, Nebraska City, or Kansas City) is determined daily. After selection of the control point, releases from the system are adjusted so that, in combination with the anticipated inflows between Gavins Point and the control point, they will provide the target discharge at the control point. Before system release adjustments from Gavins Point are made, nesting status and location of terns and plovers are checked so that nest inundation and the stranding of chicks are avoided.

5.2.2.2.3 Scheduling Releases from the Reservoirs Upstream of Gavin Point. Oahe storage provides the bulk of the water for navigation, and this water is replenished from releases throughout the year from Fort Peck and Garrison. Because Gavins Point storage capacity is quite small, its reservoir fluctuation is desired to be kept to a minimum. To accomplish this, Fort Randall releases mirror those from Gavins Point, taking into account the incremental inflow between the two projects.

River stretches below five of the projects (Big Bend discharges directly into Lake Francis Case) have various constraints to satisfy multi-purpose objectives. These constraints are checked or reviewed when releases are varied. Annual Operating Plans and all release forecasts recognize these constraints. In real-time, unforeseen conditions such as ice jams, power plant equipment failures, peculiar meteorological events, drownings, and construction in the river channel can effect the scheduling of releases.

5.2.2.3 Irrigation Guidelines. 5.2.2.3.1 Scheduling System Releases. Releases for irrigation below the System are not scheduled from Gavins Point; however, there is usually an ample supply for irrigators because of the scheduled releases for other downstream uses. During extended drought periods, System releases are cut back to conserve the remaining supply, which helps to ensure water for beneficial upstream consumptive purposes including irrigation.

5.2.2.3.2 Scheduling Releases from the Five Upstream Reservoirs. Experience has shown that the estimated minimum daily average releases necessary for adequate continuous irrigation pumping stages below the projects in the May to September time frame are as follows: Fort Peck 7,000 to 8,000 cfs, Garrison 15,000 to 16,000 cfs, Fort Randall and Gavins Point 15,000 cfs. These estimates assume normal inflow between the project and irrigation intakes. Hourly release restriction criteria which relates to specified daily average release rates is put into effect to prevent large sags in river stage below Fort Peck and Garrison during the irrigation season.

During times of low daily average release, there can be several hours of minimum hourly release for irrigation, which can be followed by an abrupt increase in release for power peaking to establish higher nesting elevations for endangered bird nesting. This can cause larger than normal stage fluctuations in the first 20 miles or so downstream of the Garrison and Fort Randall powerplants. During times of extended drought or flood control, releases at the projects may be cut back causing pumping stages to drop below necessary intake operating levels

5.2.2.4 Water Quality Guidelines

5.2.2.4.1 Scheduling System Releases. Downstream water requirements were established by the Federal Water Pollution Control Administration in 1969 and reaffirmed by the EPA in 1974. Refer to **Table 5-3 below** for minimum daily flow requirements on the Missouri River below the System. The minimum daily flow requirements established for water quality control are designed to prevent operational problems at municipal drinking water intakes and municipal and steam/nuclear powerplant intakes at numerous intakes below the system. With System storage at high levels, releases for navigation and for system power production purposes during the nonnavigation season will be at levels which operating experience has indicated are adequate for all downstream needs including water quality. Water quality problems may require increased releases during extended low-flow periods.

TABLE 5-3
MINIMUM DAILY FLOW REQUIREMENTS
FOR ADEQUATE DISSOLVED OXYGEN
(in cubic feet per second)

Metropolitan Area	December thru Febr	March thru Apr	May	June thru Sept	October thru Nov
Sioux City	1,800	1,350	1,800	3,000	1,350
Omaha	4,500	3,375	4,500	7,500	3,375
Kansas City	5,400	4,050	5,400	9,000	4,050

5.2.2.4.2 In and Below the Five Upstream Reservoir Projects. Specific water quality problems detected at Missouri River main stem projects in the late 1990's were the exceedence of state standards for several parameters. Specific Corps AOP's list the issues and problems identified at each of the main stem projects for these years. **Appendix A** lists water quality issues and problems in main stem reservoirs along with standards and quality criteria exceedences for main stem reservoirs and releases. A separate Annual Water Quality Report is prepared each year by the Corps.

5.2.2.5 Water Supply Guidelines. 5.2.2.5.1 Scheduling System Releases. The main stem reservoirs are operated in a manner to provide streamflow in intervening reaches between the reservoirs and in the lower Missouri River reach from Yankton, South Dakota to the mouth at St. Louis, Missouri. There are about 1600 water intakes located along the Missouri River both within and below the System. Below the System, the intakes provide for water for municipal water supply; power plant cooling water; and commercial, industrial, and domestic uses. To supply the minimum water quantity for water supply, winter, spring/fall, and summer nonnavigation flow requirements are expected to be 12,000 cfs, 9,000 cfs, and 9,000 cfs, respectively. Reductions for extreme flood events may cause system releases to be as low as 6,000 cfs as was the case during the flood of 1993. Releases this low, although extremely remote, can uncover large amounts of habitat for terns and plovers and has the potential to interfere with a return to higher release rates later in the nesting season. The low System nonnavigation release rates are always accompanied by low release rates from most of five upstream reservoir projects in order to distribute the conservation of water. This can affect tern and plover nesting below all projects except Oahe and Big Bend.

When it becomes necessary to reduce System releases at Gavins Point below minimum service navigation flows, continued surveillance of these downstream intakes will be necessary and additional releases will be made when required in order to assure adequate water supplies for intake operation. This situation has the potential to affect tern and plover nesting if releases have to be increased significantly after a previous lower established release has been in place during t&e bird nest initiation.

5.2.2.5.2 Scheduling Releases from Individual Reservoir Projects. Channel degradation, sandbar formation, and improper intake elevation and screens may give rise to pumping problems. Under normal open water conditions, a minimum daily average release of 3,000 cfs from Fort Peck is satisfactory for municipal water supply. At Garrison, it is desirable to maintain minimum daily average release no lower than 10,000 cfs during the open water season. No restrictions on minimum releases from Oahe and Big Bend are necessary for adequate service to water intakes, since the headwaters of downstream reservoirs usually extend to near the upstream dam sites. Mean daily releases of 1,000 to 5,000 cfs are adequate to meet supply requirements below Fort Randall while below Gavins Point flows considered necessary for water quality control may or may not be sufficient for water supply requirements depending upon tributary contributions. As they occur, these problems may require a temporary increase in release rates. These temporary increases may have the potential to interfere with tern and plover nesting which has been initiated in close proximity to the river's water surface.

5.2.2.6 Hydropower Generation Guidelines. 5.2.2.6.1 Corps Relationship with Western Area Power Administration. Power generated at the System hydroelectric plants is turned over to Western Area Power Administration (Western) for marketing in their Upper Great Plains Region. By law, Western gives preference in the sale of this firm power to public bodies and cooperatives. The RCC and Western coordinate continuously fine tune operations of the System power plants, consistent with the overall framework of the CWCP, to provide maximum value to hydropower, compatible with other project uses including T&E species. In the scheduling of generation and power releases, the Corps specifies daily total quantities of hydropower generation, but permits Western latitude in hourly loadings to effectively meet customer requirements. Daily power generation from all six System power plants and two Bureau of Reclamation hydro power plants is combined to serve the electrical system demand for roughly two million individual customers.

Reservoir Power System Operation Overview. About 99 per cent of the water released from the System power plants passes through the hydropower units. Generation is foregone if releases must be passed through the outlet works and over spillways. The value of energy produced by System hydropower plants varies from season to season. Power generation at all the dams generally follows the seasonal pattern of water movement through the system. Adjustments, like scheduling hydropower maintenance during the spring and fall and the Drawdown of Lake Francis Case and Recapture at Oahe **(see Section 9-22 of the current Master Manual)**, have been made to provide maximum power production during the summer and winter when demand is high.

During the navigation season, when downstream flow requirements are high, larger amounts of water are usually released from Gavins Point. This requires large volumes of water to be released from the three upstream reservoirs: Fort Randall, Big Bend, and Oahe. High releases at these four plants means high generation rates from these plants. But at Oahe the chain stops because Oahe's storage reserve is large enough to support high releases for extended time periods without correspondingly high inflows. With the onset of the non-navigation season, conditions are reversed. Releases from Gavins Point usually drop to slightly more than one-half of summer levels and the chain reaction proceeds upstream curtailing discharges from Fort Randall, Big Bend, and Oahe. At this time, Fort Peck and Garrison releases are increased to the maximum levels permitted by the downstream ice cover to partially compensate for the reduction in generation downstream.

Hourly patterning of the daily average releases is also of major importance in realizing the full power potential of the System power plants. Based on past experience, it appears that (with the exception of Gavins Point) no limit, except in special circumstances, need be placed upon daily peaking up to the capacities of the individual power plants, provided the limiting mean daily discharge is not exceeded. These special circumstances are during tern and plover nesting and during special operation periods, which include such things as water surface profile measurements and construction work. The minimum allowable hourly generation and corresponding release at a project is dependent upon downstream water supply and irrigation intakes, fish spawning activities downstream, recreation usage and other things. Routine maintenance and inspection outages of power units are usually not scheduled during the December through February and the mid-June through August peak-power demand periods. Scheduled outages affect the power output of a project, but usually do not affect the discharge capability because outlet works and/or spillway discharges are available to satisfy the total required discharge.

Release temperatures can be affected by spillway flows. Intakes in the reservoirs for the powerplants and outlet works are located near the bottom of the reservoirs, which affect temperatures of the release water during different seasons.

5.2.2.6.3 Operation of Individual Hydropower Projects. In general, Western follows the customers system hourly load demand by extensively varying the hydropower releases from Oahe Big Bend, and to a somewhat lesser extent by regulating the other plants except Gavins Point which almost always has steady hourly power plant releases. The Corps adjusts project hydropower releases to avoid adverse impacts to terns and plovers nesting on sandbars downstream from the System dams while continuing to serve all project uses. In all but high water years, hourly power peaking restrictions are implemented to protect these birds when nesting downstream of the Fort Peck, Garrison, and Fort Randall projects. This limits hydropower production during the critical nesting and rearing time period from mid-May to mid-August. A maximum hourly generation limit less than full powerplant capacity and lasting for only 6 hours is normally placed on these three projects during the nesting season unless the daily average release rate approaches powerplant capacity which would be for flood control evacuation purposes.

Also, except in high water years, the daily average release rates at Fort Peck, Garrison, Fort Randall, and Gavins Point are bumped up to a higher than normally required rate when terns or plovers begin scraping nests. The daily average release rate from Gavins Point is increased to the level that would ordinarily be anticipated for downstream full service flows in August. At the three upstream projects, the daily average release rate is increased to a level that will provide adequate service to multi-purpose summer uses. This daily average release increase (along with the hourly peaking restrictions) is intended to remain steady from about mid-May through mid-August in order to help prevent nest inundation. The increase in daily average release from mid-May through mid-June in normal years usually results in more energy than usually required to serve customers load in late spring but limits energy required to serve customer's load during peak load days later in the summer.

Minimum hourly release constraints for irrigation, water supply, recreation, and fish and wildlife constraints in drought years tend to limit water available for hourly peaking releases. Also, the magnitude of hydropower peaking release is decreased due to reduced heads (reservoir pool elevations) and the reduction in the overall total average release specified for the day in order to conserve water.

During release reductions for drought or flood control, energy from sources outside the Federal hydropower system must be purchased or interchanged to satisfy firm customer's demand. Reduced energy production during of the 1987-1992 drought caused Western to purchase large quantities of energy to meet its contractual commitments for which customers ultimately paid through higher rates. In very high water years, like 1996 and 1997, hydropower releases are at high levels for storage evacuation, and they are in excess of customer's demand. Excess energy is sold on the open market.

5.2.2.7 Fish and Wildlife Guidelines. 5.2.2.7.1 System Releases. The six reservoirs of the System contain a diverse community of coldwater, coolwater, and warmwater fishes. The upper three reservoirs have been stocked with coldwater game and forage species to take advantage of the coldwater retained through the summer and fall in the deeper waters of the reservoirs. Fish in the lower three reservoirs and the warmer waters of the upper three reservoirs include native and non-native species that have adapted to the lake habitat along with forage fish. Coldwater fish are also raised in hatcheries and stocked in the reservoirs. The exception is at the Fort Peck project where lake trout are supported by some natural reproduction along the face of the dam. Most of the warmwater and coolwater species spawn in lake shallows or in tributary streams. Because natural spawning and rearing habitat is limited, especially in low-water years, some warmwater and coolwater fishes such as walleye are stocked. The success of fish in the System and the lower river depends on habitat conditions. In the upper three reservoirs, low water levels during droughts limit coldwater fish habitat and shallow spawning and rearing habitat or warmwater and coolwater species. In the lower three reservoirs, high inflow and outflow reduce lake productivity and cause young fish to be flushed from the reservoirs. Native, in the river reaches, which includes the pallid sturgeon, are naturally adapted to the high, warm, and muddy spring and early summer flows, and lower late summer and fall flows characteristic of historic Missouri River flows. Cold, clear tailwaters of the upper three dams are more conducive to trout and salmon, but not the native paddlefish, sturgeon, and other fishes.

It is recognized that fish production and growth in the System is related to releases and reservoir levels. Therefore, when compatible with other project purposes, special reservoir operations for fish and wildlife are undertaken. The operation of the System dams has altered the natural streamflow of the Missouri River thus altering the habitat of native riverine fish species as well as that of other flora and fauna. With an increasing voice in the 1990's, biologists throughout the basin have conveyed to the Corps that the health of the entire Missouri River ecosystem is dependent upon a more natural spring rise. To date no simulated "spring rise" has been attempted although from about the mouth of the Platte River in Nebraska to St. Louis there is usually a spring rise due to flows from the large number of uncontrolled tributary streams. There is usually also a spring-summer rise on the Yellowstone River in Montana due to the large uncontrolled area of that basin. The System reservoirs are producing more sport fish than the river did before impoundment. There has been an effort by the Corps, to honor as many of the annual requests of the Missouri River Natural Resources Committee as possible by manipulating dam releases to provide rising spring reservoir levels and scheduling certain minimum releases during the annual spawning periods. The Corps realizes that forage fish reproduction is also very important. Except for flood control, water releases are not reduced in the May-June spawn reaches of the System for fish spawning in this time period.

5.2.2.7.2 Operations at the Individual Reservoir Projects. At Fort Peck, a minimum instantaneous powerplant discharge of 3,000 cfs has been established year round to keep the coldwater spawning and rearing side channel below the powerplant inundated. From April 1st through the summer, a minimum daily average of 4,500 cfs is targeted to insure trout recruitment, water conditions permitting. Except in severe drought years, releases are usually increased in May to benefit e&t bird nesting, also benefiting fish in the river downstream. A cutback in releases from Fort Peck in summer is not uncommon when the Milk River flows increase due to rainfall and snowmelt runoff. Spillway releases are initiated in the summer during high runoff years when the total release called for is in excess of powerplant capacity. Usually in all but below normal inflow years, and depending on System water supply, the lake is steady or rising in the April to June spawning period to accommodate late spring and early summer spawners and provide rearing cover. This reservoir has been operated for a special elevation rise during the spring sport fish spawning period (dependent upon hydrologic conditions).

At Garrison, except in severe drought years, May powerplant releases are usually increased to benefit e&t bird nesting, perhaps benefiting fish in the river downstream. The daily average minimum of 10,000 cfs for water supply also serves as a minimum for fish and wildlife. In all but below normal inflow years, and depending on the timing of runoff, the lake is steady or rising in the April to June spawning period to accommodate late spring and early summer spawners and provide rearing cover. Occasionally this lake has been operated for a special elevation rise during the spring sport fish-spawning period, depending upon hydrologic conditions. This operation may involve a combination of increased Fort Peck releases and decreased Garrison outflows.

At Oahe, the general level of powerplant releases increase in late March just before the start of navigation season. There is a minimum 3,500-cfs hourly release to attract fish for fisherman below the project during daylight hours on the weekends from April through October. Lake Sharpe elevation (Big Bend reservoir) extends right up to the Oahe powerplant so when the Oahe release goes to zero release for periods of up to a day during drought periods, there is water in the river downstream of the Oahe project. There are usually fluctuations of from 2 to a maximum of 7 feet in the 8-mile river stretch below this project due because Oahe's hourly powerplant output varies to follow the fluctuation in the System's power demand. There has been an increase in the flood potential in the Pierre-Fort Pierre area due to sediment build-up in Lake Sharpe from the Bad River. In all but below normal inflow years (depending on system water supply) the Oahe reservoir is steady or rising in the April to June spawning period to accommodate late spring and early summer spawners and provide rearing cover. This reservoir has been scheduled for a special elevation rise during the spring sport fish-spawning period dependent upon hydrologic conditions. This operation involved increased Garrison outflow.

Hourly Big Bend powerplant releases can vary from zero to as much as 100,000 cfs during peak winter and summer power demand days. On a low power demand weekend day, the powerplant daily release can be zero. Lake Francis Case elevation extends up to the back of the Big Bend powerplant so the tailrace is not unwatered. Because Big Bend reservoir elevation is scheduled to fluctuate very little, releases are of about the same magnitude as Oahe's, the exceptions being when there is high tributary runoff into Big Bend reservoir and/or when Big Bend is scheduled to produce more hydropower. Big Bend reservoir is operated between elevation 1419.5 msl and 1421 feet msl. If possible, the lake is not scheduled to be operated below elevation 1420 in the spring in order to limit stranding of fish eggs and young fish. In the high water years of 1996 and 1997, the average Big Bend reservoir elevation was held below 1420 msl in late spring and summer to help ease river stages in the Pierre-Fort Pierre area during high Oahe releases.

At Fort Randall, a minimum instantaneous discharge of 15,000 cfs is scheduled during the downstream fish spawning season from late April through June 15th. During flood periods on the river below Gavins Point, this minimum has been suspended due to severe release reductions at Gavins Point. Tributary inflow between the Fort Randall and Gavins Point projects will also result in Fort Randall release restrictions during these periods. The minimum hourly release during other time periods of the year is zero. In the spring-summer period of the 1993 flood year, Fort Randall daily average releases were as low as 6,000 to 10,000 cfs. This had a negative effect on fish spawning in the river below Fort Randall. At Fort Randall, the general level of powerplant release increases in March just before the start of navigation. On average Fort Randall reservoir elevation increases 3 to 5 feet during March and is scheduled to be held no less than elevation 1355 msl from April 1st through mid-summer. This may aid some spawners and young fish at that project. The reservoir is drawn down from Labor Day to late November to elevation 1337.5 msl.

Releases and reservoir operations at Gavins Point are discussed below in **5.2.2.9. Endangered Species Guidelines**.

5.2.2.8 Recreation Guidelines. Most of the recreation opportunities are in the System reservoirs. There are over 80,000 acres of recreational lands along the nearly 6,000 miles of shoreline. River recreation, like reservoir recreation, is predominately water-based, with boating and fishing as major activities. Portions of the river above Fort Peck Lake, below Fort Randall Dam, and below Gavins Point Dam have been designated "National River Reaches" under the National Wild and Scenic River Act.

Steady releases and reservoirs at adequate levels are most desirable for recreationists, marina operators, resort operators, and others. Unfortunately, because of the seasonable variability and distribution of runoff and evacuation of water for various functions, these are impossible to accomplish. Nevertheless the Corps has, through the years, planned releases below the various projects to better serve recreationists and has had the opportunity to lessen the rate of drawdown at certain projects. Special release rates below some of the projects for fishing, fishing tournaments and boating have been scheduled. At low reservoir levels, some boat ramps are unusable while recreational areas at upper ends of reservoirs may not provide access to the reservoirs. Low river flows affect boat access and maneuverability. Certain kinds of fishing and hunting depend upon adequate lake levels and river flows. Visitors are less likely to frequent reservoirs and river reaches at low water for aesthetic reasons.

In the 1987 to 1993 drought, access was reduced and many lake recreational areas were closed. Many boat ramps had to be extended and facilities had to be improved at the recreation sites that were still open to minimize over crowding. Overall, the quality of recreation at the System reservoirs suffered during the drought. The Corps tries to operate for river recreators both within and below the System, and during the majority of the years, recreational use opportunities along the Missouri River have been outstanding.

5.2.2.9 Endangered Species Guidelines. The interior least terns and piping plover nest on barren sandbars in reservoir areas and on the open river below the System projects. Since 1986, the Corps has adjusted project <u>releases</u> to avoid adverse impacts to birds nesting downstream. To regulate System <u>reservoir levels</u> that have large areas of uncontrolled inflow would require adjusting releases, which might take birds, or nests downstream where population densities are the greatest. So opportunities for water control regulation for terns and plovers on the reservoirs are and have been nearly impossible. In accordance with the 1990 Biological Opinion, the Corps adjusts releases to benefit birds nesting on the river reach below the projects and reservoir elevations conducive to nesting necessarily become incidental. Terns and plovers have continued to nest successfully on beaches and island areas in the reservoirs however. Refer to **Sections I.2.3.3 and I.3.3.3.**

The Corps provided additional habitat below Garrison, Fort Randall, and Gavins Point during the recent 1987 through 1993 drought through island shaping or vegetation control. Adult populations generally increased during this time, but then generally declined with the recent large system inflows and accompanying high reservoir elevations and releases of 1995 through 1997. The high scouring flows of the record water year of 1997 produced vast amounts of viable habitat and adult numbers of both species increased in 1998 as river flows were only about half as great as the previous high water year and most reservoir peak elevations were lower. Fledge ratio goals applicable to the System (suggested by the Service in 1990) to recover tern and plover populations were exceeded for both species for the first time in 1998. It has become obvious that abundance of habitat, other things being equal, leads to increased recruitment of the species.

In order to reduce the flooding potential for nests and young birds, two water control strategies are employed. First, when birds commence nesting in May, daily releases are bumped up to a level that will provide anticipated adequate service to project uses later in the summer. This level of release is intended to remain nearly constant the entire nesting season. Releases are sometimes adjusted downward to provide safe water elevations for nesting areas if it is wet downstream. An increase above this steady release level is made for necessary reservoir storage evacuation caused by high runoff events. Releases are reduced for downstream flood control, and this uncovers sandbar habitat below the projects that invites birds to nest at elevations that could be inundated on a return to pre-flood releases. **Refer to Section II.5.4.2 Gavins Point** of this report on spiking project releases during flood control events to prevent low elevation nesting. Second, an hourly hydropower peaking release pattern is established in May for Fort Peck, Garrison, and Fort Randall that will later insure river stages conducive to safe nesting through the summer, but also satisfy the increased hydropower peaking demands later in the summer. The amount of hourly peaking power scheduled is usually more than needed in May and early June but close to what is needed in July and August. These strategies are to minimize effects on endangered species during the early-May through August nesting period. Details of main stem operation incorporating these two strategies are described below in **Section II.5.3 of this report**.

Releases from the System at Gavins Point are scheduled to be increased for navigation in March. They are further bumped up in May and are usually scheduled to be held steady through August for e&t bird reproduction. High system inflow years can cause releases to be increased above normal levels for storage evacuation, and there is always the chance that release reductions may be necessary for downstream flood control. Every third day spiking of Gavins Point releases is thought to be detrimental to downstream river fish and e&t bird reproduction, and this operation will only be scheduled during downstream flooding. Gavins Point reservoir is subject to unscheduled fluctuations of several feet in a few days time span due to varying inflow and outflow scenarios. The travel time of water released from Fort Randall to Gavins Point has been 1 to 2 days depending upon the effect of the delta at Niobrara and the delta at the headwaters of Lewis and Clark Lake (Gavins Point reservoir). Steep cutbacks in the Gavins Point release can produce a rapid rise in Lewis and Clark Lake due to water already on the way from Fort Randall. Under normal lake elevations and river flows, the Gavins Point reservoir influences the Missouri River stage up to about 3 to 4 miles above Springfield, South Dakota.

Ten stream gages were automated with data collection platforms during the 1986-1988 period in the river downstream from Garrison, Fort Randall, and Gavins Point Dams to provide the information needed to correlate nesting habitat with reservoir releases. These 10 gages along with others below the above mentioned dams plus Fort Peck have proven to be invaluable. The river reaches have been modeled using a dynamic routing model so that stages can be estimated prior to making the releases. **Appendix A** contains a list of these automated stream gages.

A Geographic Information System (GIS) of the nesting site areas by river reach is being developed by the Corps to provide spatial analysis of nesting site and better represent historic nesting information. Digital ortho photography was obtained in 1998 to establish the amount of habitat created by the high releases dam releases of 1997.

Beginning with the high runoff years of 1995, 1996 and 1997, the Corps successfully incubated, reared, and released fledglings of both t&e bird species as nests were in danger of being flooded. The Corps obtained permission from the Service to attempt this operation, which is only an alternative means of propagation when faced with extremely high river stages at nesting sites. For details of captively rearing terns and plovers refer to **II.2.7.2.1** and **II.3.7.2.1**.

The results of routing the historic 100-year water supply through the System with current operating constraints (the CWCP) shows that there are a number of high water years and accompanying high release scouring flows that might produce viable habitat below the System projects. An analysis of the number of years of occurrence of scouring flows below Gavins Point, Garrison, and Fort Randall can be found in **Appendix A**. This analysis shows the number of years in the 100-year record where there would have been flows of at least 5,000 cfs and 10,000 cfs than the preceding year. These higher flows would provide scouring and some sand bar formation.

5.3 Results of Operations Under Current Water Control Plan for Tern and Plover Nesting Support

5.3.1 General

The real-time operation of the System conforms to the **Section II 5.2.2 Guidelines for Water Use Purposes** as anticipated by long-range computer studies using varied monthly inflows. Also, the annual preparation of each year's AOP has, over the years, consisted primarily of working out release and storage schedules aimed at optimum use of the estimated water supplies to serve the various requirements, including those of endangered species.

The effect of using the existing T&E guidelines to reduce the flooding potential of nesting habitats under a full range of water conditions can be studied and predicted by reviewing the CWCP Daily Routing Model (DRM) results (1898-1997). The CWCP 100-year study examines the period of record using current operational constraints for the birds. Lessons learned from the 1987 through 1998 actual operation have contributed to the criteria that are included in the studies. The main thrust of this operating criteria for the birds used in the CWCP studies is: 1. Increase releases to a level needed in August for all water uses when the birds show up in May, and 2. Limit hourly peaking below the projects to secure habitat and prevent flooding of nests. The CWCP model cannot predict stage increases and nest flooding due to rainfall events. The model also has cycling (one day high release followed by two lower days) built into it to provide release reductions for flood control and during extreme drought periods.

In order to look at a range of operational results using t&e guidelines in the CWCP model output, starting system storages, on March 1st of each year were chosen for (1) 54.5 to 58.2 million acre-feet (MAF), average to upper decile starting storage on March 1st (this is near the top of conservation storage); near 48.1MAF, a lower quartile starting storage; (3) near 38.2 MAF, a lower decile starting storage, where conservation measures begin to greatly affect traditional reservoir operations and (4) near 25 MAF or below, near where System storage would be from 1935 to 1942 during the record drought.

Annual runoff data were developed for specific reservoir reach inflows, as well as the total flow above Sioux City to be used in the CWCP DRM study. Inflows used for the CWCP studies are historical, adjusted for the 1949 level of basin development. The 1949 level represents a base prior to recent emphasis on water resource development and prior to the time that the System and many tributary projects were constructed. Five representative levels of annual runoff have been chosen from the 100 years of runoff input into the CWCP model. These are:

1. An Upper Decile Year (UD), with 1 chance in 10 of greater runoff: 34.7 MAF.
2. An Upper Quartile Year (UQ), with one chance in four of greater runoff: 30.3 MAF.
3. A Median Year (M), with an equal chance of greater or lower runoff: 24.9 MAF.
4. A Lower Quartile Year (LQ), with one chance in four of lower runoff: 19.8 MAF.
5. A Lower Decile (Year), with 1 chance in 10 of lower runoff: 15.9 MAF.

In order to observe results for nesting success, years that had five levels of inflows (runoff) from the CWCP which were close to UD, UQ, M, LQ and LD and that also had starting storages close to 54.5 to 58.2 MAF, 48.1 MAF, 38.1 MAF, and 25 MAF were chosen from the CWCP annual output.

For very high inflow years, the actual historic operation was used for review of nesting opportunities as personal decisions that guided flood control operations varied slightly from the computerized CWCP model results. Refer to **Appendix A** for representative years chosen from the CWCP study or historical record to cover the range of starting storages and annual inflows mentioned above.

5.3.2 Computer Study Constraints and Objectives

Computer model constraints and objectives for all reservoir purposes used in the CWCP study for this report are the same as used in the Master Manual preliminary RDEIS. The primary objective for endangered species nesting support is to provide near steady summer release rates and/or release patterns downstream from those reservoir projects where nesting colonies exist. A sample year from the CWCP study run for this report is shown in **Appendix A.**

5.3.3 Study Results Showing Operational Opportunities for Nesting Success

Terns and plovers on the Missouri main stem occur much more on the free-flowing stretches of the river containing sandbars below the dams. Loss of nests and young can result from excessive water releases that inundate these habitats. Consequently, those areas where the birds nest must have daily average release rate and hourly release rate constraints that translate into a maximum stage below nesting elevations. In recent years, the Corps of Engineers has compiled nest elevation data. Releases are controlled at the dams, but no control exists over the intervening

flow to the streams between the dam and the nesting sites. Little control of reservoir elevations behind the dams is possible due to the greatly varied patterns of inflows. Maintaining steady or slightly declining main stem reservoir elevations levels solely in support of bird colonizing and nesting would most often conflict with one or more of the project uses, and would nearly always conflict with protection of birds nesting downstream. Incidental support can occur, however, (1) when prolonged drought conditions result in greatly increased sandbar habitat below dams due to decreased releases for conservation purposes, and in reservoir areas due to long prolonged drawdowns, and, however, (2) in years following previous large release years for flood storage evacuation. This is in contrast to intentional or planned support which occurs as a result of deliberate, controlled modification of the discharges.
An example of peak historic regulated and non-regulated flows is provided in **Appendix A**. This data shows the protection afforded to locations downstream of System dams. On the other hand, more frequent large scouring and deposition type flows have been eliminated since construction of the projects.

5.3.3.1 Simplified Study Results. The effects of modification of releases below Fort Peck, Garrison, Fort Randall, and Gavins Point is obtainable from either (1) All 100 years of output of the CWCP study (which has current constraints in place) or from (2) actual historic operation from 1987 through 1997. Individual years from the 100-year CWCP study were picked out to coincide with starting system storages of near 54.5 to 58.2 MAF, near 48.1 MAF, near 38.2 MAF, and near 25.0 MAF (or below) assuming annual runoffs near UD, UQ, M, LQ, and LD for each starting storage are analyzed for nesting opportunity.

Table 5-4 below contains simplified study results of release regulation opportunities for tern and plover nesting support for each of the six System projects based on the CWCP study and historic operation.

Table 5-4

RELEASE REGULATION RESULTS FOR TERN AND PLOVER NESTING SUPPORT

	Water Supply	Starting Storage Near Full	Starting Storage Near 48 MAF	Starting Storage Near 38 MAF	Starting Storage < than 25 MAF
	UD	none	some	some	some
	UQ	some	some	good	some
FTPK	M	some	good	good	some
	LQ	good	good	good	some
	LD	good	good	good	some
	UD	none	some	good	some to good
	UQ	some	good	good	some to good
GARR	M	good	good	good	some to good
	LQ	good	good	some to good	some to good
	LD	good	good	some to good	some to good
	UD	none	none	none	none
	UQ	none	none	none	none
OAHE	M	none	none	none	none
	LQ	none	none	none	none
	LD	none	none	none	none
	UD	none	none	none	none
	UQ	none	none	none	none
BEND	M	none	none	none	none
	LQ	none	none	none	none
	LD	none	none	none	non
	UD	none	some	none to some	none to some
	UQ	none to some	some	none to some	none to some
FTRA	M	some	some to good	none to some	none to some
	LQ	some	some to good	none to some	none to some
	LD	some	some	none to some	none to some
	UD	none	good	some to good	some
	UQ	none to some	good	some to good	some
GAPT	M	some to good	good	some to good	some
	LQ	some to good	good	some to good	some
	LD	some to good	good	some to good	some

*Note: With few exceptions, intentional lake level regulation for bird reproduction is not possible.
**UD = Upper Decile; UQ = Upper Quartile; M = Median; LQ = Lower Quartile; LD = Lower Decile.

It should be noted that, unlike the 100 years of the CWCP study in this BA, the AOP and monthly operation forecasts performed by the Corps' Reservoir Control Center serve as a forecast guide for planned operation. Actual inflow patterns and reservoir conditions will vary from those presented in each AOP and monthly operation forecast. "Real-time" daily regulation of the System will only approximate the results shown in the AOP and monthly forecasts. Additionally, it should be recognized that the regulator has little ability to forecast the runoff that actually happens, especially runoff that is much greater or less than normal.

A detailed discussion of planned and incidental support for bird colonizing and nesting through release and lake regulation follows. The following discussion assumes no unforeseen conditions such as unprecedented meteorological events, and equipment failures, which interfere with the intended reservoir operations and are beyond the control of the System operators.

5.3.3.2 Operational Results of Individual Projects. 5.3.3.2.1. Regulation Results for Terns and Plovers at Fort Peck.

a) System Starting Full (54.5 to 58.2MAF)

1) With inflow near upper decile.

This magnitude of inflow into the lake would demand increased high releases by/during the summer near or exceeding full powerplant capacity in order to evacuate storage for flood control. There would be no opportunity for steady release regulation for birds. Nesting below the project would be minimal because of reduced habitat associated with high flows downstream. Successful nesting in the reservoir would be nonexistent because of a steady rising high pool. No chance of maintaining a steady lake level during nesting would exist. The high releases needed to evacuate high runoff may create improved habitat in subsequent years.

2) With inflow near upper quartile.

This inflow would demand high summer releases near full powerplant capacity to evacuate storage for flood control. There would be only some opportunity for steady release regulation for birds. Nesting below the project would be below normal because of reduced habitat. No hourly peaking power restrictions in place because daily average releases would be too high. Reservoir nesting would be impacted moderately because of a high rising pool.

3) With inflow near median.

Average daily power plant releases during the summer would be increased to satisfy power and irrigation demands as well as to evacuate flood storage. Daily stage fluctuations would likely reflect normal peaking power restrictions. Nesting on the river would be about normal, but the lake habitat would be reduced by rising water levels.

4) With inflow near lower quartile.

River stages would be similar to those noted under median. Hourly peaking restrictions would be in place. A slightly greater chance of incidental nesting during the summer would exist along the shoreline of the reservoir due to somewhat lower and decreasing reservoir elevations during the summer.

5) With inflow near lower decile.

Same as 4) above.

b) System Near 48.1 MAF

1) With inflow near upper decile.

Although beginning the year 10 feet below the starting pool, large inflows could dictate an increase in the summer release rate to: evacuate flood water, initiate balancing intra-system storage, improve recreation levels at Lake Sakakawea, and improve irrigation pumping stages. Remembering that capability to forecast large runoffs is limited, there would be less than a 50 per cent chance opportunity to establish steady release regulation for birds. Peaking power restrictions would be in place. Nesting on the reservoir is unlikely since the lake level would rise nearly 10 feet during the nesting period. Increased habitat area would be provided by initial lower reservoir levels, but would be quickly reduced by the rapidly rising reservoir level.

2) With inflow near upper quartile.

Although there may not be as much water stored in the flood pool for this case, the reasons mentioned above under upper decile inflow dictate some opportunity for release regulation for birds. Stages on the river would probably be good and steady summer flows may be possible more than 50 per cent of the time. Peaking power restrictions would be in place. On the reservoir success would be unlikely as mentioned above.

3) With inflow near median.

Summer release rates required would be near the long-term average and would usually not have to be increased. Nesting stages on the river would be good, and steady summer flows would be possible most of the time. Nesting on the river would be good, but on the reservoir marginal because of the rising lake level.

4) With inflow near lower quartile or lower decile.

The daily average release rate during the summer may be varied only occasionally for System storage balance. Daily average release rates should be low despite the need to peak high for power. Restrictions will be in place, however, so more habitat should be available than with median flows. Nesting downstream should increase. Some incidental nesting on the lake would exist because of reduced reservoir elevation increases.

There may be some chance to regulate the maximum reservoir elevation, dependent upon inflow, if this project is chosen as the one to be kept below a certain elevation to establish vegetative growth for subsequent inundation in future years for fish spawning.

c) System Starting Near 38.2 MAF

1) With inflow near upper decile or upper quartile.

There is opportunity to provide consistent daily release patterns during the summer most years to support bird nesting below the project. The lower summer releases would provide a moderate nesting area along the river as peaking restrictions would be in place. Initial nesting on the reservoir would be subject to inundation more than 50% of the time as reservoir elevation increases of 10 feet could occur and success could be poor.

2) With inflow near median.

Opportunity on the river same as 1) directly above except that the summer lake elevation rise may not be as great and incidental nesting there could increase.

3) With inflow near lower quartile and lower decile.

There is opportunity to provide consistent daily release patterns during the summer to support bird nesting below the project. With release levels near minimum and power peaking restrictions in place, river-nesting area should be moderate to large. Incidental nesting in the reservoir would vary, dependent upon the amount of inflow and the amount of nesting habitat. Reservoirs would not be deliberately held down through the summer for fish or bird reproduction at such low system storage levels (<38 MAF or so) since balancing reservoir storage deficits would be that much harder later in the year.

d) System near 25.0 MAF or below.

Under historic annual inflow scenarios for 1935-1942 (inflow 12.1 to 30.9 MAF), the monthly summer release level would be low, the months averaging from 3,500 cfs to 8,400 cfs but usually near 3,600 cfs. The release probably would not be constant every day of the summer because of minimum energy demands from firm power customers. Also, with extremely low power capability at Fort Peck, Garrison, and Oahe, maximum hourly power plant releases would be necessary at certain times during summer peak demand. This maximum hourly discharge capability would be 2,000 cfs to 3,000 cfs less than the normal 16,000-cfs maximum release. There would be some incidental opportunity downstream because of the low overall monthly average release rates and lower limit peaking releases because of the extremely low reservoir storage (conservation). Incidental nesting in the reservoir would vary, dependent upon the amount of inflow and the amount of nesting habitat. Individual reservoirs would not be imbalanced for fish or bird reproduction.

5.3.3.2.2 Regulation Results for Terns and Plovers at Garrison.

a) System Starting Full (54.5 to 58.2 MAF)

1) With inflow near upper decile.

This magnitude of inflow would demand an increase in the daily average release to full power plant capacity or greater by/during the summer in order to evacuate storage for flood control. There would be little opportunity for steady regulation during the nesting season and little habitat downstream. The high releases needed in these high runoff years may provide improved habitat to be used in subsequent years. Incidental nesting on the reservoir would be low to nonexistent because the lake level would be 10 feet higher than normal during the nesting season.

2) With inflow near upper quartile.

Releases would need to be increased to near full powerplant capacity during nesting to evacuate flood storage as pool levels approached the exclusive flood control level. Limited downstream habitat is expected to be available at this level of release. Occasionally, repetitive daily peaking patterns can be established that result in consistent daily downstream peak stages, and the relatively high average daily release required for flood evacuation would limit available nesting habitat. Incidental nesting on the above-normal reservoir elevation would be low due to a moderate pool rise during the nesting period.

3) Within inflow near median

The summer release to evacuate floodwater, adequately distribute yearly power, and satisfy river users could be in the 24,000- to 30,000-cfs range. Consistent daily regulation and power peaking restrictions would result in habitat being available for nesting. Nesting habitat areas downstream would be increased compared to upper decile and upper quartile inflow scenarios. Hourly peaking restrictions would be in place A likely greater-than-5 foot pool rise during the nesting season would, like the upper decile and upper quartile inflow scenarios, limit incidental nesting habitat on the reservoir.

4) With inflow near lower quartile.

There would be an opportunity for nesting success for the reasons mentioned for median inflow. Regulation in recent years has demonstrated that the system can be regulated to support terns and plovers during lower runoff periods. Hourly peaking restrictions would be in place.

5) With inflow near lower decile.

There would be, at a minimum, an opportunity for nesting success for the reasons mentioned for median inflow, although a greater opportunity may occur due to less inflow and resulting releases.

b) System Starting Near 48.1 MAF

1) With inflow near upper decile and upper quartile.

There would be only opportunity to provide consistent daily release patterns most years during the summer to support bird nesting below the project. The level of summer release should provide a moderate nesting area along the river. Hourly peaking restrictions would be in place most of the time but not during times of high daily average discharge. Incidental nesting habitat on the lake should be meager but slightly better than with higher system storage amounts; however, pool rises of 10 feet or more during the nesting period would severely hamper a successful hatch

2) With inflow near median

There would be an opportunity to provide desirable habitat on the river with steady summer releases in the 16,000-cfs to 26,000-cfs range with hourly peaking also in place. This level of more normal summer release should provide a moderate area of habitat. Incidental nesting on the reservoir should be productive and about average compared to higher inflow scenarios.

3) With inflow near lower quartile or below.

There would be an opportunity to provide desirable habitat for bird nesting on the river downstream with summer releases below normal and peaking restrictions in place. Incidental nesting on the lake could possibly be increased due to low lake levels; however, the pool level for all runoff scenarios could still rise during the nesting period. There may be limited opportunity during the very lowest runoff years to schedule releases that would result in moderate pool rises during the nesting season.

c) System Storage Starting near 38.2 MAF

1) With inflow near upper decile, upper quartile, or median.

The daily average release rate during the summer would be steady with most of the inflows in the 16,000- to 28,000-cfs range. Hourly peaking restrictions would be in place. Water would be put into storage (conservation). Incidental nesting on the reservoir would be below normal as reservoir elevation increases up to 10 feet could be possible and habitat, although available at lower elevations initially, would be subject to inundation.

2) With inflow lower quartile of lower decile.

There would be an opportunity to provide consistent daily release patterns at least half of the time during the summer to support bird nesting below the project. Occasionally the need to satisfy intra-system storage balance and cover critical hydropower demand would interfere with safe nesting. Hourly peaking restrictions would be in place most of the time. Some incidental nesting on the reservoir would exist because smaller reservoir increases would occur than with higher inflow scenarios.

d) With System Storage Near 25.0 MAF or less

Under historic annual inflow for 1935-drought period (12.1 to 30.9 MAF), the monthly summer release level would be in the 10,000- to 35,600-cfs range with an average about 16,000 cfs. The release would not be constant every day of the summer because of minimum energy demands from firm power customers. Also, with extremely low power capability at Fort Peck, Garrison, and Oahe, maximum hourly power plant releases could be necessary at certain times during System summer peak demand. This maximum hourly discharge capability would be 4,000 to 5,000 cfs less than the normal 40,000-cfs maximum release. There would be little chance for constant day-to-day release regulation for birds. There would be some incidental opportunity downstream because of the usual low overall monthly average release rates because of the extremely low reservoir storage (conservation). Incidental nesting in the reservoir would vary, dependent upon the amount of inflow and the amount of nesting habitat. Individual reservoirs would not be imbalanced for fish or bird reproduction.

5.3.3.2.3 Regulation Results for Terns and Plovers at Oahe. Lack of suitable habitat downstream of this project precludes the necessity of release regulation for birds. Incidental nesting of birds along Oahe Reservoir is a function of reservoir elevation and inflows.

a) System Starting Full (54.5 MAF to 58.2 MAF)

1) With inflow near upper decile or upper quartile.

Large lake elevation increases would severely limit habitat.

2) With inflow median or less.

Moderate to low elevation increases could impact nesting habitat depending on the timing of inflows and nest initiation.

b) System Starting Near 48.1 MAF or less

3) With inflow near upper decile or upper quartile.

Large lake elevation increases could severely limit habitat, depending on the timing of inflows and nest initiation and amount of viable habitat that was afforded by the previous years' reservoir elevations.

4) With inflow median or less.

Moderate to low elevation increases could impact nesting habitat depending upon timing of inflows and nest initiation and the amount of viable habitat that was afforded by the previous year(s) lake elevation(s).

5.3.3.2.4 Regulation Results for Terns and Plovers at Big Bend. The Big Bend project, which has little storage capacity, is operated primarily as a run-of-river powerplant to help serve firm power contracts. Daily hourly release rates usually fluctuate from several hours of zero to 60,000+ cfs. Because there is no suitable habitat within the reservoir and the project releases directly into the headwaters of Lake Francis Case, there is no opportunity for regulation for birds under any of the inflow or System storage scenarios.

5.3.3.2.5 Regulation Results Terns and Plovers at Fort Randall. There have been no reports of birds nesting on the reservoir shoreline of this project; however, there is nesting on the river downstream.

a) System Starting Full (54.5 MAF to 58.2 MAF)

1) With inflow near upper decile.

Extremely large increases in the release rate by/during the summer would be necessary to evacuate floodwater; therefore, no release activities for birds would be possible. The high releases associated with the extremely large runoff could be expected to improve habitat for future runoff years when releases would be lower.

2) With inflow near upper quartile.

Same as above. But in addition, releases would be less, affording some opportunity for nesting although only within the first 15 miles below the project as downstream tributary flows have the potential to flood nests farther downstream.

3) With inflow near median.

The average monthly release rates during the summer nesting periods could be adequate and reasonably constant, but they are dependent on consistent incremental inflows between Fort Randall and Gavins Point. Additionally, Gavins Point releases would need to be near constant throughout the period to provide constant Fort Randall releases. Attempts will be made to maintain consistent daily peaks in order to compensate for the needed variations in daily releases. Success cannot be expected to occur frequently because of a normally wide range of tributary inflow. At the typical Fort Randall release for a median inflow scenario (30,000 to 33,000 cfs), suitable habitat remains primarily when preceded by a much higher flow year and/or vegetation control is undertaken.

4) With inflow near lower quartile or lower decile.

There would be a small chance that the combination of tributary inflows and Gavins Point releases would couple with the planned daily release pattern to produce near consistent daily maximum river stages in the Fort Randall to Gavins Point reach. It must be remembered that with near full system storage at the beginning of the year, system releases are scheduled to maintain full service to all functions, regardless of the runoff. High downstream stages are possible.

b) System Starting Near 48.1 MAF

Under all inflow scenarios, Fort Randall summer release levels must vary daily to compensate for the varying inflow to Gavins Point and any variance in Gavins Point releases. With lower System storage and less System hydropower capability at other projects, Fort Randall hourly peaking capability has increased value and would be in greater demand. An effort, however, would be made to establish a peak release cycle within any day to permit the mean daily discharge to vary with little change in the peak daily stage at downstream locations.

c) System Starting Near 38.2 MAF

Reduced project pool elevations at the projects would result in low to critically reduced System power production capability, depending upon the amount of System storage. Hourly power fluctuations at all plants except Gavins Point would be required at times to bolster the sagging power system capability due to low heads (pools). Water supply minimums downstream from Gavins Point may also require increases from Fort Randall during extremely low summer flow periods. This would make it increasingly difficult to regulate steady releases for all purposes during those low runoff times. Adequate habitat would also depend on the previous year's level of release.

d) System Storage Near 25.0 MAF or less

Nesting success would be the same as with System storage at or below 38.1 MAF. In addition, the summer release rate for navigation (backed up by Fort Randall) during a series of extremely dry years might require increased flows. Actual service to navigation could, at extremely low storages, be nonexistant. It would be increasingly difficult to regulate steady releases for all purposes during those critical low runoff times although the generally low, overall release level could provide additional habitat. Adequate habitat would also depend on the previous year's level of release.

5.3.3.2.6 Regulation Results for Terns and Plovers at Gavins Point.

a) System Starting Full (54.5 MAF to 58.2 MAF)

1) With inflow near upper decile.

Very large increases in the release rate before/during the summer would be necessary to evacuate floodwater; therefore, no regulation activities for birds would be possible. Nesting on the river below the project and in the reach from Niobrara, Nebraska to the Gavins Point reservoir headwaters would barely occur due to inundation of practically all suitable habitat. Such high releases could be expected to be highly beneficial for development of improved habitat for future years.

2) With inflow near upper quartile.

There would be limited opportunities for nesting success for the reasons mentioned under upper decile above. Historic regulation in 1986 demonstrate the ability to maintain near constant releases, but at rates that severely limited habitat availability. There would be a slight increase in habitat, dependent upon the lack of high tributary inflow, in the Niobrara, NE to Springfield, South Dakota reach afforded by release levels lower than upper decile.

3) With inflow near median.

Assuming no large inflows downstream of the Gavins Point project, the opportunity for nearly constant flows for bird nesting would be good. Without cutbacks for flood control, the general level of constant release will be in the 32,000- to 34,000-cfs range, providing vegetative growth is minimized. Some small release adjustments during the season may be necessary to serve other functions. There would be low to adequate habitat in the Niobrara, Nebraska to Springfield, South Dakota reach with normal release levels and lack of high tributary inflows.

4) With inflow near lower quartile and lower decile.

A good opportunity would exist to maintain constant releases for birds for the reasons mentioned above under the median inflow.

b) System Storage Starting Near 48.1 MAF

1) With inflow median or above.

Assuming no large flood inflows downstream of the Gavins Point project that cannot be compensated for due to runoff travel time, the opportunity for nearly constant flows during the nesting season would be good. Moderate downstream habitat area should exist at this level of release when system storage begins near 48 MAF. Some small flow adjustments may be necessary to serve other functions. The level of runoff does not affect projected pool elevations, so incidental lake area habitat would be low to adequate, dependent upon no high tributary flows.

2) With inflow lower quartile or lower decile.

Same as above only habitat should increase slightly because flow requirements would be less than full service and in the 27,000- to 31,000-cfs range. There should be adequate habitat, assuming the lack of large tributary inflow in the Niobrara, Nebraska to Springfield, South Dakota reach because flows and river stages are below normal.

c) System Storage Starting below 38.1 MAF

Barring any acute drought emergency intervention, large flood inflows from downstream tributaries, or other intervening circumstances, there would be an opportunity for low, steady releases from Gavins Point, providing nesting opportunities for birds. Service to navigation would be reduced, and releases could even be cut back to nonnavigation levels when System storage is extremely low. There should be adequate habitat, dependent on no large tributary inflow in the Niobrara to Springfield reach because flows and river stages would be below normal. Increased releases above minimum levels could occur anytime during the summer to provide vital increased service to downstream functions.

5.4 Events that Cause Suspension of Regulation for Terns and Plovers under Current Water Control Plan.

5.4.1 General

The following discussed situations that result in suspension of regulation for birds. This discussion is not all-inclusive, but it should serve as a general guide on the subject. As demonstrated in the past 12 years, the Corps will continue to regulate for endangered species. Emergency situations; where health and safety are endangered by flooding, lack of water, power brownouts, etc., may result in suspension of release regulations for terns and plovers.

Suspension of regulation for birds because of System inflows (too great and too small) was discussed in regulation alternatives mentioned in the previous section. In addition to the varying of monthly project reach inflows, short-term (1 day to several weeks) flood inflows above or below any project during the nesting season could require project release adjustments during the nesting season. When flood control criteria dictate that project releases are to be cut, the resulting reduced discharges have the potential for exposing river sandbar habitat directly below the dam but upstream of the flooding area. Often nesting terns and plovers find this newly created sand attractive for nesting. In order to keep the birds from nesting at this newly created lower elevation which would jeopardize nesting upon a return to pre-flood flows, a higher level release **(spike)** is scheduled every third day to discourage low nesting. Also during extended extreme drought periods it may be necessary to cycle releases for periods of several days to serve critical water uses for project uses. The release adjustment possibilities and their causes are infinite.

The Corps satellite Data Collection Platform network provides hourly stage information near nesting sites at least once every 4 hours. The Corps monitors DCP river gages during critical periods through the nesting season to prevent nest inundation. Due to water travel time, reduced project releases during short-duration high tributary inflows below System reservoirs may not be effective in preventing increased stages at nesting areas. **Table 5-5** lists some of the average travel times between the dams and pertinent locations on the river.

Unprecedented inflows into the System projects may require increased releases at any time in order to maintain dam safety and to preserve future flood control capability. This occurrence, during the runoff of record into the System in 1997, generally followed the service level guidelines described by Plate 44 in the Master Manual. Plate 44 describes the System storage service level (Gavins Point release) that is necessary for orderly evacuation of water stored in the System's annual and exclusive flood control zones as mentioned in **Section II. 5.2.2** of this report. Guidelines for flood control operations, as used during 1997, at individual System reservoirs are found in the individual project Reservoir Regulation Manuals and also follow the general rules discussed in **Section II. .5.2.2**.

TABLE 5-5

FLOW TRAVEL TIMES

River Reach	Travel Time (days)
Fort Peck to the Wolf Point Gage	1.0
Fort Peck to the Culbertson Gage	2.0
Garrison to the Stanton Gage	0.2
Garrison to the Washburn Gage	0.5
Garrison to the Price Gage	0.8
Garrison to the Bismarck Gage	1.5
Ft. Randall to Verdel Gage (above Niobrara River)	0.8
Gavins Point to the Gayville Gage	0.2
Gavins Point to the Maskell Gage	0.5
Gavins Point to the Ponca Gage	0.9
Gavins Point to the Sioux City Gage	1.8

As a general rule the Corps does not anticipate high downstream river stages due to rainfall forecasts but adjusts releases as needed when runoff is observed in the Missouri River or its tributaries. A rise at a tributary gage large enough to cause a significant rise on the Missouri or a stage increase on the main stem is an indicator that releases may have to be reduced to preserve nesting habitat. However, if the rise is significant, nesting habitats could unintentionally be inundated before reductions in reservoir releases become effective because of travel times involved. A Corps hydraulic routing model, UNET, for forecasting downstream stages dependent upon reservoir discharge patterns and intervening inflow has been developed to help forecast river stages. This tool, when used with nest elevation and location reports, is valuable in determining if release adjustments are needed to maintain near constant river stages and the extent of those adjustments. Downstream stage predictions can occasionally be off by several tenths of a foot off.

It is the Corps understanding that, once a nesting elevation has been established and the river elevation is raised to that level at least every second or third day, terns and plovers will not initiate nests lower than the established nesting elevation. Verification of this has been made by field observations over the past 10 years. Because of the large amount of high elevation habitat created in the record 1997 water year, this spiking would have not been needed. The birds nested at high elevations and did not use sand exposed at lower elevations.

5.4.2 Gavins Point

If the river stage rises or is predicted to rise based on tributary flow in the reach between Gavins Point Dam and Ponca, Nebraska, the Corps will consider reducing Gavins Point releases. When release reductions have been made, releases may need to be increased as soon as tributary river flows (above nesting areas) start falling. This action maintains navigation, recreation, and water supply flows downstream. Factors limiting the magnitude of the reduction in Gavins Point releases include (1) the Yankton stage for water supply, and (2) downstream river stage effects on marinas and other key locations that require a minimum elevation during the summer. Although releases have been reduced once to only 6,000 cfs, a release of 10,000 cfs or less can be expected very infrequently.

If flood inflows to the Missouri River occur or are predicted to occur downstream from the nesting areas, Gavins Point releases may also have to be reduced accordingly. Should the downstream flood flows be of long duration, the Corps will strive to cycle the reduced releases to satisfy the "every second or third day" requirement. The example in **Fig. 4 shows the "spiking"** of flows every third day from Gavins Point to reduce downstream flows and to discourage birds from nesting the 2 days of low release. However as long a large amount of habitat exists at high elevations this spiking is not needed.

A major flood control operation to evacuate System storage requiring full power plant discharge plus spills could occur at any time, effects can be detrimental to nesting. During extended drought periods when navigation flows at downstream locations are discontinued, increases from non-navigation flow levels to provide minimum service to water supply and water quality may be needed. Increased flows, although increased from a low level, could be detrimental to nesting.

5.4.3 Fort Randall

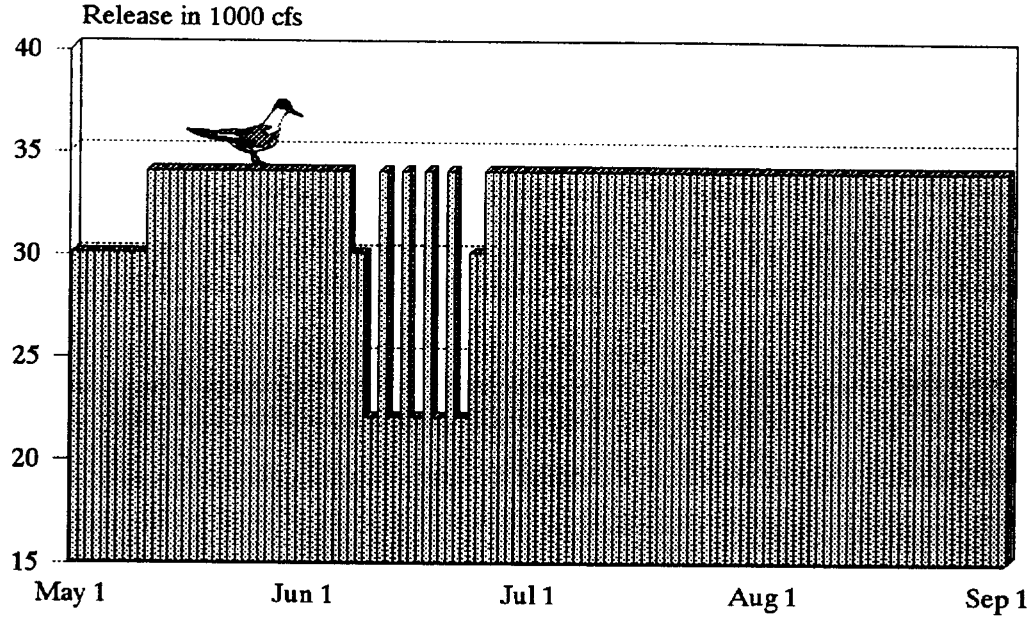
Fort Randall releases cannot be maintained at a constant summer rate. Holding a maximum hourly discharge pattern for bird nesting is difficult when hourly fish minimums are in place and a low daily average release rate is specified. Releases also vary daily, dependent upon incremental inflow, to keep the downstream Lewis and Clark Lake level near elevation 1206 in early summer and 1207 later in the summer. Incremental inflow to Lewis and Clark Lake can frequently vary several 1,000 cfs from week to week during the summer. **Appendix A shows the monthly incremental inflow** in acre-feet between Fort Randall and Gavins Point from 1898 through 1997. Fort Randall releases varied to allow for sudden increases or deficits of tributary inflow into Gavins Point and for variances in the Gavins Point release. Birds that attempt to nest within the first 15 miles downstream directly below Fort Randall Dam can be subject to the greatest increase in daily stage caused by releases from Fort Randall. Birds nesting from Niobrara to Springfield usually nest closest to the water and are subject more to fluctuations due to uncontrolled tributary inflows.

The Corps limits the maximum discharge during nesting season to 85 percent of power plant capacity (equivalent to seven of the eight power units). When the daily average discharge specified approaches this seven-unit maximum, the maximum discharge is increased to as high as an eight-unit discharge (full powerplant capacity). A major flood control operation to evacuate System storage requiring full power plant discharge plus spills could occur just prior to and during nesting season, which could be detrimental to nesting.

Gavins Point Daily Releases

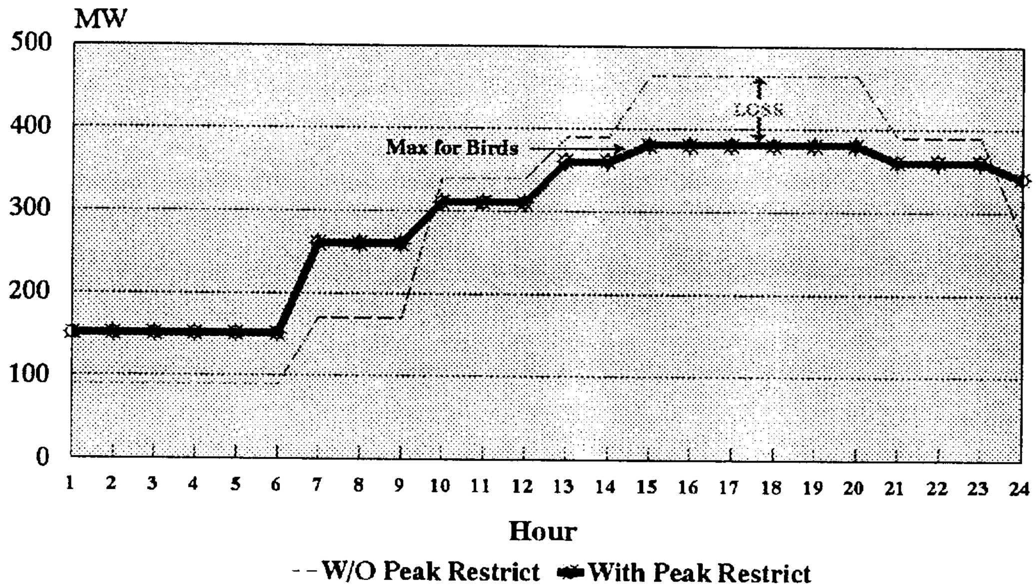
Reduced for Flood Control

Spiked to Prevent Low Nests



Garrison Reduced Peaking For Nesting

Daily Average Discharge = 24,000 cfs



Powerplant restricted to no more than 380 Mw (30,000 cfs) for 6 hours.

Fig. 5.4 & Fig. 5.5

5.4.4 Garrison

At nesting locations below Garrison, tributary flood inflows can also cause stage rises at nesting locations. There is no need to maintain constant flows downstream as at Gavins Point, but the Corps will strive to maintain the established maximum elevation heights reached during the power peaking cycle at least every second or third day. In recent years it has been easier for Western to maintain a controlled power peaking pattern almost all days. This may not be the case during years with very low releases when diminishing the daily release on a non-peak day will conserve water and alternately increasing the daily release may be necessary to keep water intakes operational, to keep birds nesting high, and to satisfy peaking power demands.

Maximum hourly discharges from the Garrison power plant are limited to about 80 per cent of maximum capability for 6 hours a day to accommodate downstream nesting **(see Fig. 5-5)** until the daily average discharge specified approaches the 80 per cent maximum. In the event of a power emergency during the six-hour scheduled peaking routine, Western has been given instructions for a 1-hour full powerplant discharge to be followed by an appropriate sag in release to prevent potential power brownouts. Model studies have shown that the river stage will rise slightly for such an operation but should not harm nests. Power peaking will be more in demand during severe droughts due to less power capability of the entire System because of less head (lower reservoir elevations).

A major flood control operation to evacuate system storage requiring full power plant discharge plus spills, could occur just prior to and/or during nesting season, which can be detrimental to nesting.

5.4.5 Fort Peck

At nesting locations below Fort Peck, tributary flood inflows, most notably out of the Milk River, can cause stage rises at nesting locations. Most of the birds nest in the Wolf Point to Culbertson stretch of the river, quite far downstream, and even as far downstream as near the mouth of Yellowstone river. Flows from Fort Peck are reduced when tributary inflow is high, down to as low as 3,000 cfs per day, the minimum recommended release necessary to keep the cold water fishery viable below the project. Pallid sturgeon have been observed in the Fort Peck power plant tailwaters. On rare occasions the combination of the minimum Fort Peck release and the high Milk River discharge increase Missouri River stage where birds nest to levels that can flood low lying nests. The Corps strives to maintain the established maximum elevation heights reached during the power peaking cycle for safe nesting at least every second or third day. In recent years it has been easier for Western to maintain the power peaking pattern almost every day. The hourly peaking power release is held to 85 to 90 per cent of the maximum output of the five power units for 6 hours a day, except when the daily average discharge specified approaches this 85 to 90 per cent maximum. It is estimated that restricting the Fort Peck powerplant to 85 to 90 per cent of maximum reduces the value provide to hydropower about $93,500 per (**see Appendix A**).

5.4.6 Conservation Releases

Table 5-6 shows the minimum daily releases during prolonged drought periods to serve multi-purpose uses below the projects where nesting has been observed.

Table 5-6

PROJECT	MIN ANTICIPATED DAILY SUMMER RELEASE* FOR CONSERVATION
Fort Peck	3,000 cfs
Garrison	10,000 cfs
Fort Randall	Min. service for navig. or 5,000 cfs
Gavins Point	Min. service for navig. or 6,000 cfs.

*Does not include even smaller releases for flood control.

It may become necessary, after the above releases have been established, to increase the minimum in real-time for a period of time to maintain adequate river stages for municipal and/or industrial water supply or irrigation. River stage elevations necessary for municipal or irrigation supply and power plant cooling intakes may begin to be affected by the above non-navigation minimum releases. River interests with water intakes too high have been urged to adjust their intakes. Short periods of increased releases must be considered during water emergencies and this may be detrimental to birds that are nesting low.

The detrimental effects of a near steady Gavins Point release in the 31,000 to 32,000-cfs range over the summer of 1988 were reduced barge loadings, reduced tow sizes, and damage to barges and boats because of shallow river depths and scraping the river bottom. Under different conditions the situation could have been worse. Increasing Gavins Point releases to supplement navigation flows will normally not be undertaken once the summer release rate has been established unless conversations with the Service indicate that there is room, stage wise, for a slight increase in release. Opportunities to move nests to higher elevations may also be discussed with the Service.

At reservoir storage near or below 38 MAF and dependent upon ever changing inflow conditions, individual reservoir storage distribution, etc, there will be summer days when hydropower plant releases will be at full capacity for several hours in order to attempt to furnish the 2070 MW of system hydropower. The 2070 MW marketed by Western is termed the marketing base capability of 1961, so termed because it is the capability that existed at the end of the moderately severe drought of the 1950's. It is considered by Western to be a reliable system capability except in years of extreme and prolonged drought.

The actual low system capability due to low head (reservoir levels) could be substantially below the marketing base capability of 1961, and maximum output (releases) from the dams, in addition to purchased energy from other sources, would be needed over the daily peak demand periods. **Table 5-7** shows the summer firm marketing power capability by plant for 1961, and the projected capability of the existing plants given another 1930's drought.

Table 5-7

POWER CAPABILITY AT MAXIMUM RELEASE

Project	Normal Summer Capability	Marketing Base Capability of 1961	1937 Drought Year Capability
Fort Peck	215	179	118
Garrison	485	370	126
Oahe	720	580	445
Big Bend	515	533	517
Fort Randall	345	300	347
Gavins Point	115	106	109
System	2395	2070	1662

Purchasing additional capability (from neighboring utilities) may be nonexistent in such a period.

Except in the event of a greater National need or emergency, acts of God, or reasons described earlier, the Corps does not anticipate increasing releases to levels detrimental to t&e birds nesting below the projects. As an example, the 1988 summer drought could have developed into an emergency that could have dictated higher releases in order to serve the National interest. It did not but in the event it did happen, the Service would be consulted regarding the action prior to its occurrence.

The regulation afforded by the System limits summer peak flows which, under natural conditions, would have replaced or maintained sandbars free of vegetation. The current regulated flows, limiting stage fluctuation and frequency, results in sandbar vegetation encroachment near the water surface more frequently. Degradation, on the other hand, makes added habitat available. Since the System reservoirs serve many project purposes, the System may not have the flexibility to overcome all reservoir effects, i.e., provide sustained flows adequate to rebuild nesting habitat on a dependable basis.

5.5 SUMMARY

The Corps of Engineers initiated special Missouri River System operations in 1987 to reduce inundation of tern and plover nests and maintain consistent nesting habitat throughout the nesting period. During the past 12 years, the Corps modified project regulation and coordinated with the Service to help with the recovery of the tern and plover along the Missouri River. The DCP network of river stage recorders when accompanied by field monitoring ensures proper release decisions that help support nesting success.

Uniform release rates during summer nesting were modeled for the 100-year CWCP Long Range Study and the results are shown in this biological assessment. The feasibility of uniform release rates and/or special power peaking operations were predicted at the projects for varied System storages and inflows throughout the 100-year period. In some of the years, the CWCP study could not be modified without interfering with specified releases for other project uses. The results of the CWCP studies, as well as lessons learned from real-time operation, demonstrate that release alternatives for birds usually exist below Fort Peck, Garrison and Gavins Point, but to a much lesser degree below Fort Randall, and are not viable below Oahe and Big Bend where birds are not known to nest at this time. Nesting on System reservoirs is subject to the natural variability of individual project inflows as priority is given to scheduling project releases to safeguard human health and safety downstream of river bird nesting areas. As indicated by study results, reservoir System storage and the amount of inflow at any time has a great bearing on maintaining release patterns suitable for birds.

In general, when the System storage starts any year near full (54.5 MAF to 58.2 MAF) and reservoir reach inflows are above normal, it becomes increasingly difficult to maintain uniform steady summer releases below most reservoir projects. When System storage starts from near 48.1 MAF to 38.2 MAF and reservoir reach inflows are below upper quartile, there is more opportunity to provide uniform releases than when the reservoir storage levels are high. Exceptions may be when minimum service flows aren't sufficient enough to satisfy downstream navigation, water supply or water quality demands. As System storage approaches the Permanent Pool (below 25.0 MAF in the CWCP results) and assuming normal to below normal reservoir reach inflows, there is less opportunity to provide uniform releases for the bird nesting. Additionally, extremely heavy inflows at any time to any of the System reservoirs may require release adjustments for flood control from one or more projects that could be detrimental to nesting. Substantial increased or decreased flows on uncontrolled tributary streams or areas may also increase river stages at nesting areas.

It is highly unlikely that reservoir levels can be regulated to support reservoir nesting habitat for birds while at the same time supporting nesting in the river reaches below. Although during drought periods, natural runoff may result in steady or falling pool levels at Fort Peck, Garrison and Oahe that could permit or encourage shoreline nesting.

The proposed action for this biological assessment is the operation of the Missouri River main stem projects according to the current Master Water Control Manual. In addition, it addresses certain Kansas River Reservoir System projects as they relate to the Missouri River project operations. As new scientific data is collected, the Corps proposes that the operations be reviewed and modified as supported by any new biological information. This adaptive management process should include input by affected State, Tribes and other interested parties.

III. Determination of the Effect of Missouri River Mainstem Operations on Three Federally Listed Species and Two Candidate Species

Using the preceding information, it is determined that the continued operation of the Missouri River Reservoir System, as outlined in the Current Master Manual and implemented through the Annual Operating Plans, will likely adversely affect the endangered interior least tern and the pallid sturgeon as well as the threatened piping plover. Current in formation on the sicklefin chub and sturgeon chub, two candidate species indicates they will also be affected. This determination is based on the following:

6.1 Effect on Long Term Habitat Availability for Terns and Plovers

Experience gained from the past 3 years of high runoff followed by a year of near normal runoff has demonstrated that large amounts of new sandbar habitat result in nesting success reportedly needed to support recovery. Prior to the 1995 – 1998 period, the last event that produced habitat in sufficient quantity to support successful nesting occurred in 1975 and 1978. Reservoir flood control operations during the intervening years resulted in rapid vegetation encroachment on nesting sandbars and subsequent nesting by the birds at lower and lower elevations resulting in nesting success lower than that reportedly needed to benefit the species. A review of the results of the simulation of the current Water Control Plan shows that the series of years of runoff needed to produce large amounts of sandbar habitat have not occurred frequently enough to prevent vegetation encroachment and loss of nesting habitat. Therefore the current Water Control Plan may result in a loss of habitat similar to the 1979 to 1986 period. Depending on future runoff, this could occur in approximately 7 years as was witnessed from 1979 to 1986. Very high runoff years could delay this loss of habitat.

6.2 Effect on Short Term Habitat Availability for Terns and Plovers (during the Nesting Season)

As was seen during the 1998 nesting season, the current Water Control Plan will have very little adverse effect on habitat availability during the nesting season as long as sufficient high elevation habitat remains. Water control operations to serve project uses during the summer of 1998 generally had little effect on nesting habitat availability. This situation will exist as long as large amounts of high elevation habitat remain. If this habitat disappears over the years as happened from 1979-1986, experience has shown that System reservoir operations may adversely affect the remaining habitat. This remaining habitat is affected because it occurs at very low elevations relative to the water surface generated for flows needed to support project uses. The reduced acreage of habitat has been shown to result in very high predation of nests and chicks.

6.3 Direct Effect on Survival and Productivity of Terns and Plovers

As was observed in 1998, the current water control plan has very little effect on tern and plover chick survival when sufficient high elevation habitat exists. The exceptions to this are the potential effects of hydro peaking on some of the river reaches and of storage of summer snowmelt runoff on reservoir shorelines.

Regardless of the elevation of the nests on the river, the hydropeaking has the potential to strand foraging chicks on low-elevation sandbars. As the daily peak moves by the foraging site the sandbar may be inundated and wash the chicks into the river. These events are very hard to quantify but the threat is known to exist. Nests initiated on the shorelines of the lakes may be subject to inundation depending on the elevation of the nests and the volume of the runoff in any given year.

The direct effect on survival and productivity is more pronounced as the volume of habitat is lost through vegetation encroachment and sandbar erosion. The resulting habitat is generally at elevations close to the water surface and minor adjustments to meet project purposes may inundate nests. While operations strive to avoid this, the ability to regulate reservoir releases to the fine detail needed does not always exist.

6.4 Effect of Missouri River Mainstem Reservoir System on Terns and Plovers Nesting on the Kansas River

The terns and plovers nesting on the Kansas River may also be adversely affected by the operation of the Missouri River Mainstem Reservoir System. The operation described in Sec. II (Main Stem and Kansas Tributary Relationship) may result in the Kansas Reservoirs holding water in their flood pools some years, causing them to release water during the middle of the tern and plover nesting season. Depending on the elevations of the nests this may cause inundation of nests, chicks and nesting habitat on the Kansas River.

Under certain circumstances, (see Mainstem and Kansas River Basin Tributary Reservoir Relationship) the Kansas River Reservoir system makes releases to support Missouri River navigation. These releases have the potential to adversely affect terns and plovers on the Kansas River, if they occur after the initiation of nesting and before chicks have fledged. The magnitude of the effect would depend on the elevation of the nests and the amount of rise in the Kansas River level caused by the releases.

6.5 Effect of Operation on the Pallid Sturgeon, Sicklefin Chub, and Sturgeon Chub

There is scientific evidence suggesting that a rising river level in spring and early summer initiates spawning activity in shovelnose sturgeon and paddlefish, two native Missouri River fish species. There is a paucity of scientific data on pallid sturgeon. Flood control operations by design prevent a rising river level where possible, which very likely adversely affect sturgeon spawning. In addition, if spawning did take place, cold water releases from the dam powerplants could inhibit growth and survival of larval sturgeon. High late summer, fall, and winter releases may reduce the biomass of food organisms utilized by pallid sturgeon, sicklefin chub and sturgeon chub. Data presented on the distribution of sicklefin chub and sturgeon chub suggest they are found in greater numbers in reaches of the river with some rising river level in the spring and early summer as well as an abundance of shallow slow water in the late summer and fall. The sicklefin chub and sturgeon chub may be affected in areas closer to project releases than those areas farther downstream of the projects.

APPENDIX A

Explanation of Master Manual Plate 44 and Example .... pg 134-138

Main Stem Water Quality Issues .... pg 139

Representative Years Used to Show Operational Opportunities for Nesting .... pg 140

Monthly Incremental Inflow Fort Randall to Gavin Point .... pg 141

Example of Historic Regulated and Non-regulated Flows .... pg 142

Lost Revenue Caused by Peaking Restrictions .... pg 143

Analysis of Number of Years of Potential Habitat Creating Flows .... pg 144-150

Output of CWCP for 100 years (example shown is 1898 only) .... pg 151-153

Summary of Engineering Data – Main Stem Reservoirs .... pg 154-155

Automated Stream Gages .... pg 156

SCHEDULING OF MISSOURI RIVER MAIN STEM SYSTEM RELEASES

(PLATE 44)

The Corps of Engineers maintains and operates the Missouri River System for the Congressionally authorized project purposes previously described in this report. The flood control function of the System continues to be a consideration in scheduling system releases, irrespective of the amount of storage contained in the system or the variability of inflows to the System. Multi-purpose regulation is always pursued consistent with flood control objectives, due to the potential affect to human health and safety. During the winter months, multi-purpose releases are restricted due to the possibility of ice formation and consequent severe loss in channel capacity. Navigation releases during the open-water season are based on maintaining specified target flows at downstream control points; this type of multi-purpose regulation serves flood control as well as navigation most of the time.

Since the ability to evacuate system storage is severely restricted during the winter months, the necessary increase in System release rates for storage evacuation purposes (System storage no higher than 57.1 MAF on March 1st) above rates necessary for navigation and other multi-purposes will largely be made during the navigation season.

Selection of appropriate service levels for flood storage evacuation purposes in excess of the full-service levels are/will be dependent upon anticipated runoff from the Missouri River drainage area above the System; depletions to this runoff that can be expected to occur prior to the time this runoff appears as inflows to the System reservoirs; current total storage in the System and in major tributary reservoirs above the System; and evaporation from the main stem reservoirs. **Plate 44 in the current Master Manual has been developed for definition of the service level at any time throughout the year. The "water supply" to be used for service level definition is a combination of (A) forecast runoff above Gavins Point Dam from the current date through December; (B) current System storage; and (C) tributary reservoir storage deficiency. "A" and "B" are added together and "C" is subtracted to arrive at the current water supply used to enter Plate 44 to determine the appropriate service level on which system releases should be based. One further adjustment to "water supply" is based on the fact that the total storage capacity of the System has been reduced by about 2 million acre-feet due to sedimentation since Plate 44 was originally conceived.**

Plate 44 consists of storage (water supply) curves that can be expected to occur if the indicated service level is sustained through the remainder of the open-water season and comparable releases are also maintained through the winter to the succeeding March 1st. Because forecasts of future runoff (which may not materialize) are basic to use of this plate and also since the potential for downstream flood inflows is greater during the spring and early summer months, the actual service level should not be increased above the 35,000 cfs full service level prior to 1 July unless an indicated service level of 40,000 cfs or greater is identified in Plate 44. For the indicated service levels greater than 40,000 cfs, the actual service level prior to 1 July should be 5,000 cfs less than indicated by use of plate 44.

The 35,000-cfs service level is considered to be the full-service level for multi-purpose functions of the system. The initial increase above this full-service level has been designated as the "expanded full-service" level and consists of extending the navigation season 10 days. Additionally, as a storage evacuation measure, winter releases averaging 20,000 cfs will be scheduled from Gavins Point. While a primary purpose of this expanded full-service is storage, evacuation it is also of benefit to other functions.

An example computation for service level and associated Gavins Point releases for multi-purpose uses and e&t birds is attached:

Fig. A-1. Service Level Determination for Total Water Supply
Fig. A-2. Plate 44 (from which Service Level is Obtained)
Fig. A-3. Gavins Point Release Determinations & April 1996
Most Likely Forecast

SERVICE LEVEL DETERMINATION

Estimated 1 April 1996

Main stem System Storage	**62.5 MAF**
Runoff above Gavins Point thru end of year	**21.6 MAF**

Tributary Storage Deficiency/Excess

Lima	**120.3 KAF**
Clark Canyon	**162.3 KAF**
Hebgen	**262.7 KAF**
Canyon Ferry	**1493.8 KAF**
Gibson	**59.8 KAF**
Tiber	**920.1 KAF**
Bull Lake	**98.9 KAF**
Boysen	**605.4 KAF**
Buffalo Bill	**490.6 KAF**
Yellowtail	**857.2 KAF**
Total	**5,071.1 KAF**

Deficiency = 5.5 MAF – 5.1 MAF = -0.4 MAF

System Storage Reduction = 2.0 MAF

****

Total Water Supply 85.7 MAF ←

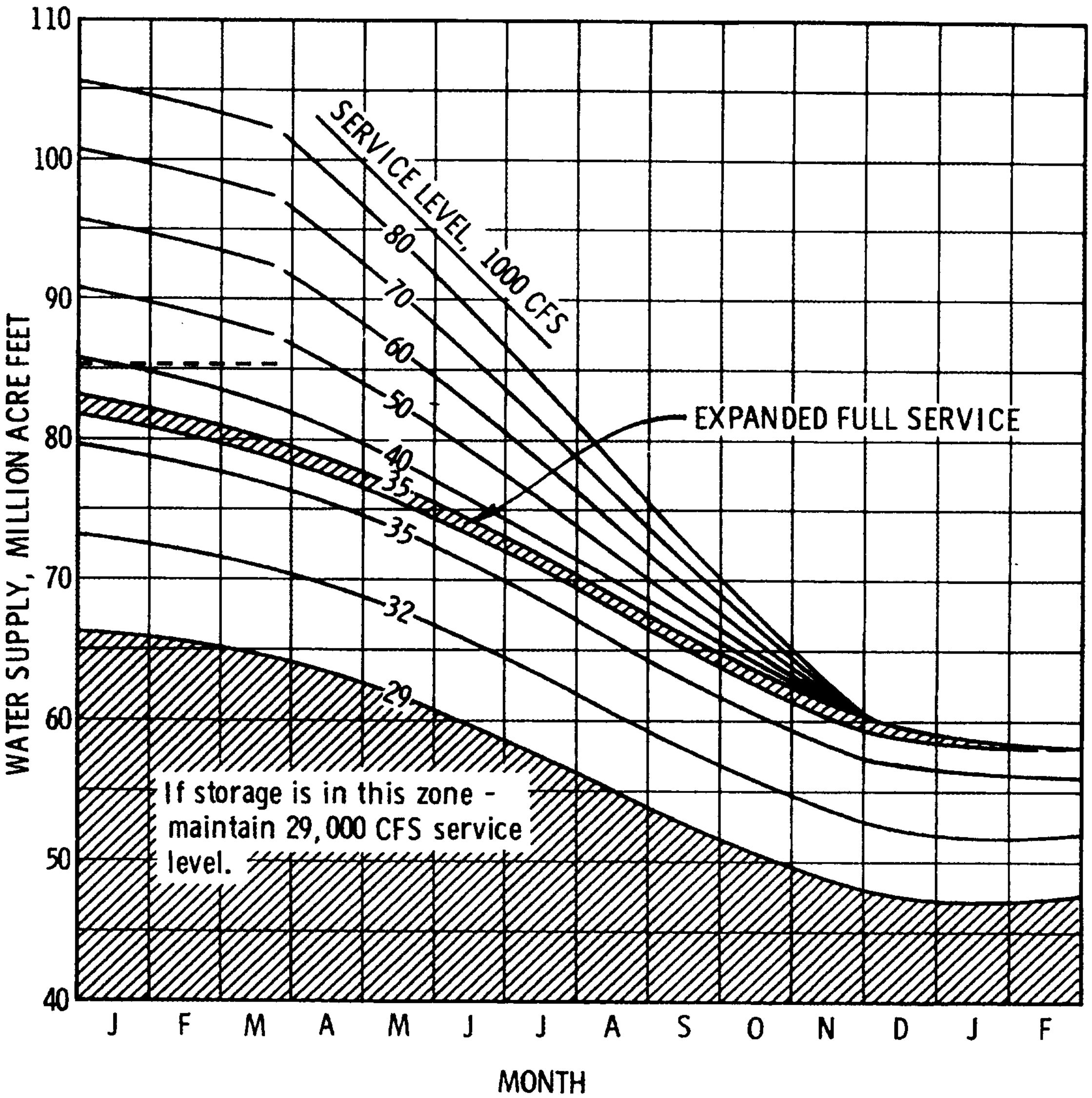
Revised Service Level (from Plate 44)	**47,000 cfs**
Target Level Increase (47,000 cfs – 35,000 cfs)	**12,000 cfs**
Reduction prior to 1 July	**-5,000 cfs**
	*********
Net Target Level Increase	**7,000 cfs**

Revised Target Levels:

Sioux City	38,000 cfs
Omaha	38,000 cfs
Nebraska City	44,000 cfs
Kansas City	48,000 cfs

Figure A-1

85.7



April 1st

FigureA-2

GAVINS POINT RELEASES NEEDED TO MEET NAVIGATION REQUIREMENTS
(Based on 1 April 85.7 MAF Water Supply)

Service Level ******	Apr ***	May ***	Jun ***	Jul ***	Aug ***	Sep ***	Oct ***	Nov ***
35 kcfs (full)	28.8	30.8	30.0	32.7	34.2	34.5	33.5	33.5
47 kcfs (+12)	40.8	42.8	42.0	44.7	46.2	46.5	45.5	45.5
-5 kcfs before 1 July +3 kcfs after 1 July	35.8	37.8	37.0	47.7	49.2	49.5	48.5	48.5
Adjusted for birds to a steady release	38.8	44.4	44.4	44.4	44.4	46.5	45.5	45.5
		--water averaged for birds-						
FINAL APRIL FCST	38.8	44.4	44.4	44.4	44.4	45.8	45.8	45.8
						-Fall water averaged-		

APRIL 1 1996 MOST LIKELY RUNOFF FORECAST
Elevati;ns & Storages are for Date Shown
Discharge & Energy are Period Values
Date: 04/02/96

1997						1996						
	31MAR96	30APR	31MAY	30JUN	31JUL	31AUG	30SEP	31OCT	30NOV	31DEC	31JAN	28FEB
FORT PECK-------------												
ELEV FTMSL	2241.3	2242.2	2243.2	2245.9	2246.1	2244.0	2241.9	2239.7	2237.9	2236.9	2235.5	2234.1
DISCH KCFS	6.4	9.0	13.7	13.7	13.7	13.7	13.7	13.7	12.8	10.0	12.5	14.0
GARRISON--------------												
ELEV FTMSL	1841.8	1842.9	1843.3	1848.2	1850.2	1847.8	1845.4	1842.9	1840.9	1840.0	1838.6	1837.5
DISCH KCFS	18.4	26.0	35.4	35.5	35.5	35.5	35.5	35.4	32.4	20.0	26.0	28.0
OAHE------------------												
ELEV FTMSL	1612.7	1612.8	1612.5	1612.8	1611.6	1609.8	1608.4	1608.5	1607.7	1605.7	1606.1	1607.5
DISCH KCFS	24.6	34.1	40.4	39.6	42.3	43.4	42.7	34.4	36.6	29.4	23.4	21.3
BIG BEND--------------												
ELEV FTMSL	1420.9	1420.5	1420.5	1420.5	1420.5	1420.5	1420.5	1420.5	1420.5	1420.5	1420.5	1420.5
DISCH KCFS	24.3	34.4	40.4	39.6	42.2	43.1	42.3	34.1	36.3	29.2	23.4	21.3
FORT RANDALL----------												
ELEV FTMSL	1354.3	1355.0	1355.2	1355.2	1355.2	1355.2	1353.5	1345.1	1337.5	1345.3	1349.8	1353.0
DISCH KCFS	27.0	35.7	42.1	41.9	42.7	43.1	44.8	44.2	44.2	21.0	18.4	17.3
GAVINS POINT---------												
ELEV FTMSL	1205.8	1206.0	206.0	1206.0	1206.0	1206.5	1207.0	1207.0	1207.0	1207.0	1207.0	1206.0
DISCH KCFS	31.1	38.8	44.4	44.4	44.4	44.4	45.8	45.8	45.8	23.1	20.0	20.0
SYSTEM----------------												
STORAGE 1000 AF	62289	62931	63232	65661	66015	64078	62160	60171	58386	57771	57482	57470
ENERGY GWH	12626	1061	1336	1289	1375	1386	1328	1248	1175	848	833	749
PEAK POWER MW		2421	2420	2433	2428	2418	2411	2378	2332	2316	2330	2330

Figure A-3

WATER QUALITY ISSUES AND PROBLEMS IN MAIN STEM LAKES – 1997

Project	Alagal Blooms	Fish Kills	Potential Problems Areas	State Standard or EPA Ambient Water Quality Criteria; Exceedences
Fort Peck Lake	No	No	Coal & oil development, algal blooms and shoreline erosion	Inflow: none identified Reservoir: dissolved oxygen Releases: none identified
Lake Sakakawea	No	No	Oil drilling, strip mining, algal blooms low dissolved oxygen	Inflow: none identified Reservoir: dissolved oxygen, phosphorus, and pH Releases: none identified
Lake Oahe	No	No	Agricultural runnoff, bioaccumul-ation of mercury	Inflow: sulfate Reservoir: dissolved oxygen and pH Releases: dissolved oxygen and pH
Lake Sharpe	No	No	Agricultural runnoff and winter kills	Inflow: none identified Reservoir: dissolved oxygen and pH Releases: arsenic, dissolved oxygen, and pH
Lake Francis Case	No	No	Intrustion of the White River delta	Inflow: arsenic, dissolved oxygen, and pH Reservoir: dissolved oxygen, pH , arsenic & lead Releases: dissolved oxygen and pH
Lewis and Clark Lake	No	No	Emergent aquatic vegetation, atrazine, banvel, and metribuzin	Inflow: none identified Reservoir: dissolved oxygen, pH, arsenic and iron Releases: arsenic, dissolved oxygen, and pH

OPERATION STUDIES/ HISTORICAL RECORD USED FOR BIOLOGICAL ASSESSMENT

Sys Storage on 1 Mar, maf	Annual R.O. maf	Used for BA	Sys Storage on 1 Mar, maf	Actual/Hist. R.O.,maf
Highest		1997 Actual	59.4	49.7
	34.7	1996 Actual	60.2	35.6
	30.3	1984 Actual	60.4	30.8
58.2	24.9	1968 CWCP	57.3	24.2
	19.8	1966 CWCP	56.6	19.7
	15.9	1977 CWCP	56.0	15.9
	34.7	1909 CWCP	57.6	35.0
	30.3	1969 CWCP	56.6	30.1
56.8	24.9	1968 CWCP	57.3	24.2
	19.8	1966 CWCP	56.6	19.7
	15.9	1977 CWCP	56.0	15.9
	34.7	1995 CWCP	54.3	36.1
	30.3	1923 CWCP	53.7	31.2
54.5	24.9	1903 CWCP	54.3	25.3
	19.8	1930 CWCP	55.5	19.9
	15.9	1977 CWCP	56.0	15.9
	34.7	1982 CWCP	50.3	36.1
	30.3	1920 CWCP	48.1	29.2
48.1	24.9	1964 CWCP	49.2	23.1
	19.8	1946 CWCP	49.5	19.7
	15.9	1989 CWCP	45.5	15.9
	34.7	1993 CWCP	40.0	35.7
	30.3	1962 CWCP	40.5	30.1
38.2	24.9	1957 CWCP	44.7	21.7
	19.8	1933 CWCP	38.2	18.2
	15.9	1990 CWCP	43.8	15.9
Lowest		1941 CWCP	20.8	16.6
Lowest		1937 CWCP	19.2	14.1

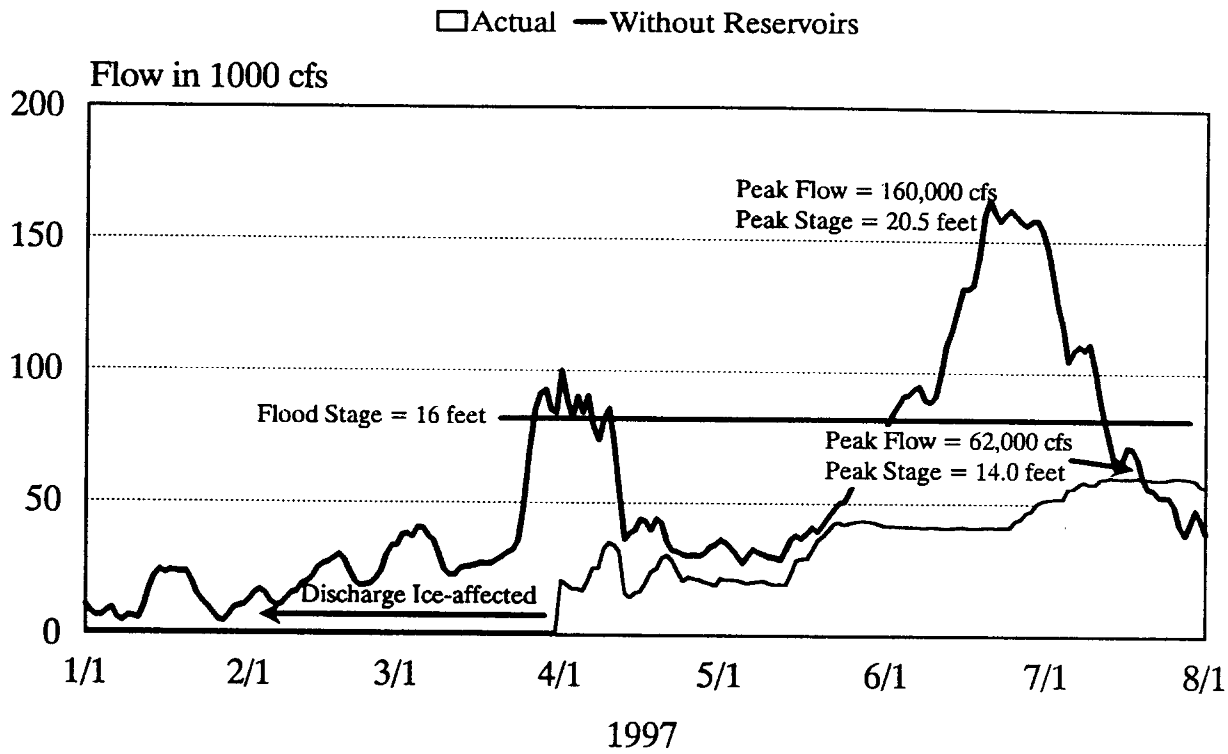
FORT RANDALL - GAVINS POINT

RUNOFF IN 1000 ACRE-FEET

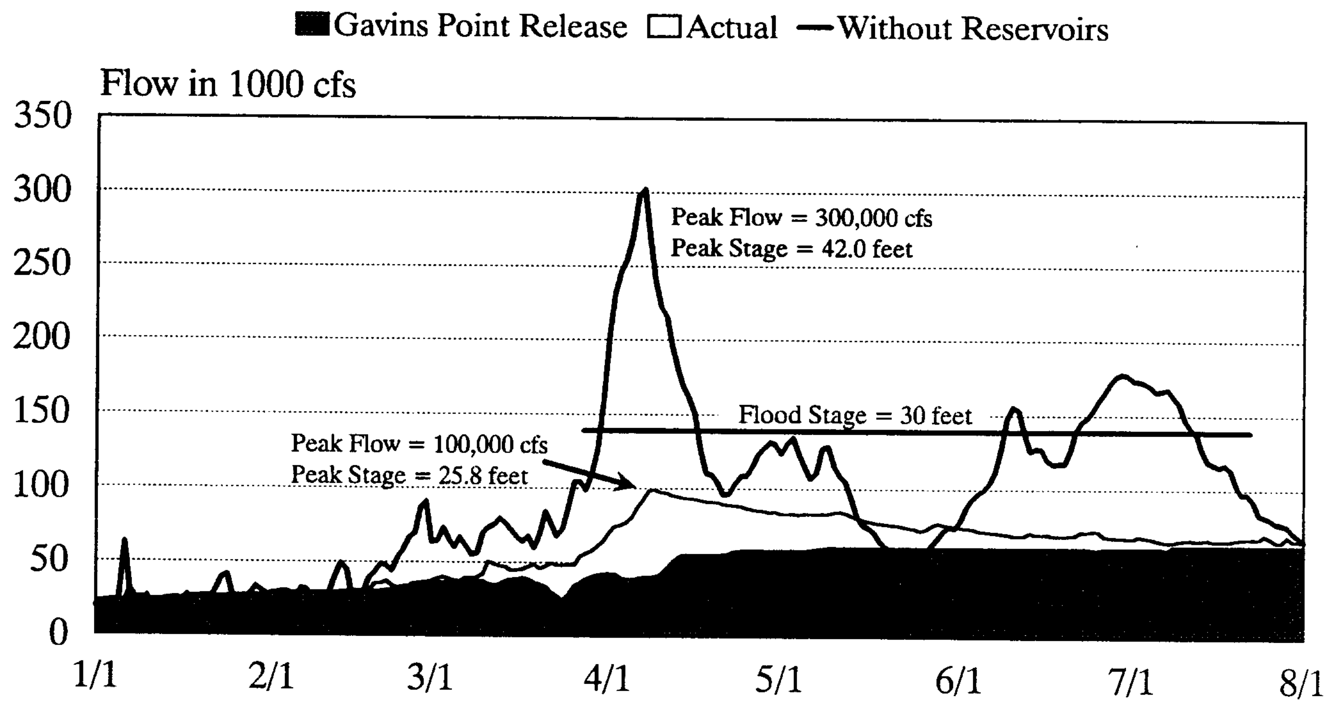
ADJUSTED TO 1949 LEVEL OF DEPLETION DEVELOPMENT

WAT-YR YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	CAL-YR OCT	NOV	DEC	TOTAL
1898	75	97	143	119	127	127	77	67	73	1186	99	91	75	1170
1899	73	93	141	115	125	125	73	67	71	1148	95	87	73	1138
1900	77	99	149	123	133	133	79	69	75	1192	101	93	77	1208
1901	85	109	165	135	147	147	87	75	83	1304	111	101	85	1330
1902	83	107	161	131	143	143	85	75	85	1310	109	99	83	1304
1903	79	101	153	125	135	137	83	73	77	1254	105	95	79	1242
1904	77	99	149	121	131	133	79	71	75	1214	101	91	77	1204
1905	89	113	171	139	153	153	91	83	83	1344	117	105	89	1386
1906	95	123	182	151	163	165	99	89	93	1471	125	113	95	1493
1907	85	111	165	135	147	147	89	81	85	1378	113	101	85	1344
1908	85	111	165	135	147	149	89	81	85	1346	113	101	85	1346
1909	91	117	175	143	157	159	95	85	89	1410	119	109	91	1430
1910	79	101	151	125	135	137	83	73	77	1280	103	93	79	1236
1911	75	97	145	117	129	131	79	69	75	1192	97	89	75	1178
1912	81	103	155	127	139	139	83	75	79	1242	105	95	81	1262
1913	79	101	153	125	137	137	83	75	77	1248	105	93	79	1244
1914	79	103	153	125	137	137	83	75	79	1248	105	95	81	1252
1915	99	127	188	155	169	171	103	91	97	1481	131	117	99	1547
1916	89	115	173	143	155	157	95	83	89	1446	119	107	91	1416
1917	75	97	147	119	131	131	79	71	75	1242	99	91	75	1190
1918	75	97	147	119	131	131	79	71	75	1190	99	91	75	1190
1919	76	99	150	121	133	135	81	71	77	1208	101	91	76	1211
1920	85	111	165	135	147	149	89	81	85	1315	113	103	85	1348
1921	85	111	163	135	147	149	89	79	85	1344	113	103	85	1344
1922	83	105	159	131	141	143	87	75	81	1306	109	99	83	1296
1923	89	113	171	139	153	155	93	81	87	1372	117	105	89	1392
1924	87	111	167	137	149	151	91	79	83	1366	113	103	87	1358
1925	79	101	151	123	135	137	83	73	77	1262	103	93	79	1234
1926	75	95	143	117	129	129	79	69	73	1184	97	89	75	1170
1927	81	103	155	127	139	141	85	85	71	1248	97	73	52	1209
1928	97	111	171	127	105	105	99	75	83	1195	103	109	99	1284
1929	56	67	175	109	113	141	89	69	95	1225	105	115	75	1209
1930	75	155	137	163	196	121	69	81	91	1383	111	99	107	1405
1931	109	137	125	129	105	79	65	71	67	1204	85	77	103	1152
1932	79	135	133	113	143	147	71	69	71	1226	91	89	65	1206
1933	103	83	151	105	131	67	73	91	73	1122	87	97	79	1140
1934	107	97	125	95	85	81	54	67	101	1075	93	95	77	1077
1935	69	133	125	147	119	133	75	65	69	1200	83	95	77	1190
1936	79	79	212	121	129	75	46	58	63	1117	93	85	107	1147
1937	77	83	79	111	60	67	87	83	155	1087	93	54	91	1040
1938	81	93	141	131	105	71	87	85	91	1123	95	83	91	1154
1939	95	63	155	131	71	58	84	95	85	1106	105	89	83	1114
1940	79	93	167	133	87	109	48	61	63	1117	77	81	111	1109
1941	75	93	131	117	85	89	81	67	75	1082	97	91	83	1084
1942	85	91	143	129	339	149	83	77	85	1452	93	91	87	1452
1943	67	117	137	117	99	139	73	65	65	1150	83	93	77	1132
1944	89	87	177	182	145	218	137	103	79	1470	101	107	87	1512
1945	113	133	214	139	115	173	91	111	81	1465	99	97	64	1430
1946	107	123	165	101	111	89	77	74	115	1222	157	115	93	1327
1947	99	109	173	159	115	488	171	34	155	1868	107	40	34	1684
1948	60	97	141	262	149	397	268	186	20	1761	157	67	52	1856

Missouri River at Bismarck, ND



Missouri River at Sioux City, IA



1997

LOST MAIN STEM REVENUE DUE TO PEAKING RESTRICTIONS FOR TERNS AND PLOVERS

1. Assumptions:
   a. Terns or plovers are nesting/fledging from May 10 thru Aug 20: 82 days.
   b. One-half of all 82 days full powerplant peaking is needed by firm customers or can be sold at above firm rates.
   c. The average full powerplant capacity is:
      Fort Peck = 16,000 cfs @ 210 Mw
      Garrison = 40,000 cfs @ 475 Mw
      Ft Randall = 44,000 cfs @ 360 Mw
   d. Peaking usually restricted to 87.5% @ Ft Peck, 85% @ Garrison, 85%@ Ft Randall.
   e. Peaking power purchased to cover firm demand or sold during the summer = $29/MWh. $29?MWh.
   f. Firm non-peak generation is sold to customers at a rate = $14.5/MWh.
   g. When full powerplant release cannot be made because of bird restrictions, this water must usually be released during off-peak demand hours in order to meet the specified total daily average discharge for all project purposes.
   h. Peaking during bird season is limited to 6 hrs/day every day.

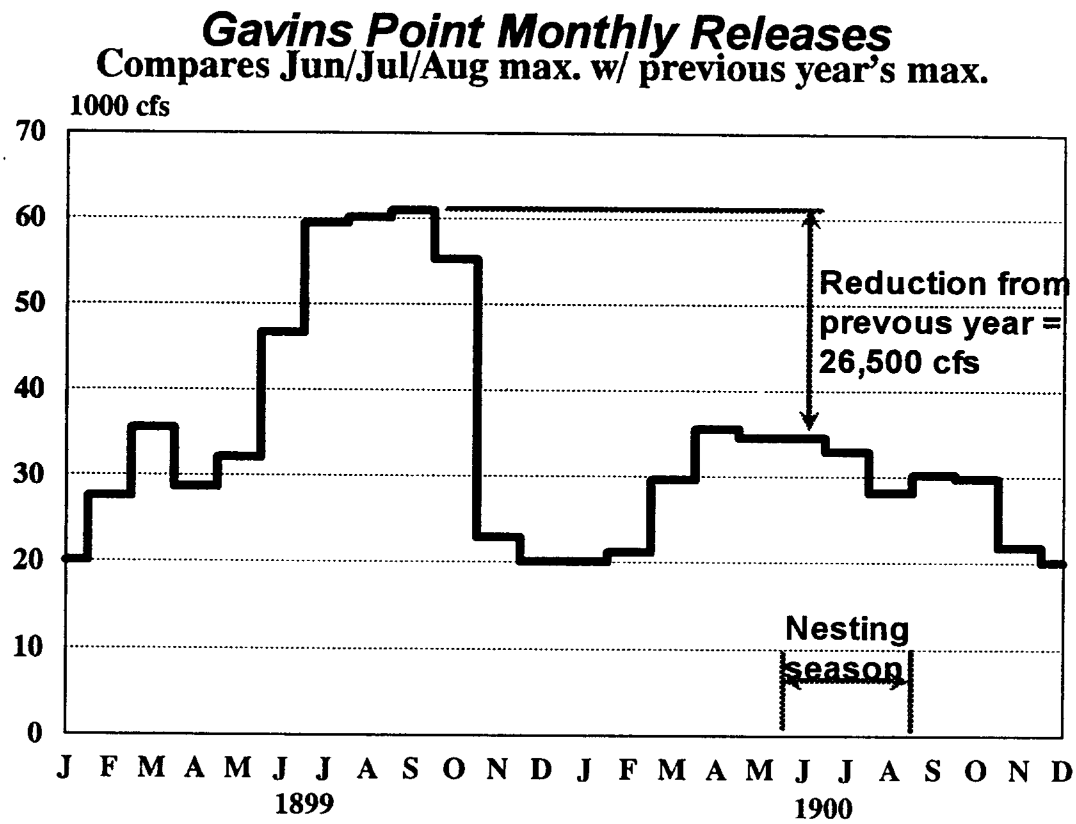
2. Avg lost revenue = (Full peaking -restricted peaking) x(no. of hours/day)x($29-$14.5)x0.5 days

	MW lost	hrs/day	price differ	0.5 days	$/day
Ft Peck lost revenue/day:	26.2	6	14.5	0.5	**$1,140**
Garrison lost revenue/day:	71.2	6	14.5	0.5	**$3,097**
Ft Randall lost revenue/day:	54	6	14.5	0.5	**$2,349**
				Total	**$6,586**

3. Average lost revenue for 82-day summer period for all 3 projects = $6,586 x 82 days = $540,000

4. Lost revenue as a percentage of total average annual revenue for all 6 main stem projects:

Avg annual lost due to bird restrictions:	$540,000	or less than 1/2 %
Avg annual power revenue all 6 projects:	$140 M	



Using CWCP run, reductions of at least 5,000 & 10,000 cfs for JJA nesting season are tallied for 100 yr

ABAA10
Gavins Pt

Year	Ann. Max.	J/J/A Max	Red. Prev. Yr.	Red. > 5	Red. > 10
1898	60.5	60.5			
1899	61	61	-0.5	0	0
1900	34.5	34.5	26.5	1	1
1901	40.08	39.68	-5.18	0	0
1902	34.5	34.5	5.58	1	0
1903	36.13	34.5	0	0	0
1904	56.7	56.7	-20.57	0	0
1905	34.5	34.5	22.2	1	1
1906	34.05	34.05	0.45	0	0
1907	61.5	61.5	-27.45	0	0
1908	61.5	61.5	0	0	0
1909	62	61.5	0	0	0
1910	39.5	37.67	24.33	1	1
1911	41.67	41.17	-1.67	0	0
1912	57.02	54.57	-12.9	0	0
1913	61.5	61.5	-4.48	0	0
1914	46.7	39.55	21.95	1	1
1915	62	61	-14.3	0	0
1916	62	61.5	0.5	0	0
1917	61.5	61	1	0	0
1918	43.62	43.62	17.88	1	1
1919	35.11	35.11	8.51	1	0
1920	33.63	32.89	2.22	0	0
1921	34.86	34.5	-0.87	0	0
1922	40.77	38.44	-3.58	0	0
1923	61.5	34.44	6.33	1	0
1924	51.61	47.46	14.04	1	1
1925	43.98	43.98	7.63	1	0
1926	40.78	37.98	6	1	0
1927	34.5	34.5	6.28	1	0
1928	61	55.51	-21.01	0	0
1929	48.04	40.92	20.08	1	1
1930	46.85	36.42	11.62	1	1
1931	41.97	38.28	8.57	1	0
1932	36.88	35.88	6.09	1	0
1933	39.45	39.45	-2.57	0	0
1934	38.46	38.46	0.99	0	0
1935	38.54	37.84	0.62	0	0
1936	39.32	39.32	-0.78	0	0
1937	14.37	14.37	24.95	1	1
1938	38.03	38.03	-23.66	0	0
1939	37.71	35.49	2.54	0	0
1940	38.5	38.5	-0.79	0	0
1941	39.08	39.08	-0.58	0	0
1942	32.31	32.31	6.77	1	0
1943	41.55	33.97	-1.66	0	0
1944	34.94	28.86	12.69	1	1
1945	37.63	34.33	0.61	0	0
1946	44.15	44.15	-6.52	0	0
1947	44.02	44.02	0.13	0	0

1948	45.38	45.38	-1.36	0	0
1949	41.67	40.79	4.59	0	0
1950	55.09	47.11	-5.44	0	0
1951	64.51	59	-3.91	0	0
1952	84.57	60	4.51	0	0
1953	41.22	41.22	43.35	1	1
1954	56.7	56.7	-15.48	0	0
1955	34.5	34.5	22.2	1	1
1956	36.9	36.77	-2.27	0	0
1957	33.95	32.53	4.37	0	0
1958	30.63	30.63	3.32	0	0
1959	33.92	33.92	-3.29	0	0
1960	41.39	30.23	3.69	0	0
1961	30.59	30.59	10.8	1	1
1962	37.81	29.13	1.46	0	0
1963	38.16	38.16	-0.35	0	0
1964	35.67	35.67	2.49	0	0
1965	56.49	54.46	-18.79	0	0
1966	37.84	36.48	20.01	1	1
1967	38.43	38.43	-0.59	0	0
1968	38.09	38.09	0.34	0	0
1969	53.23	53.23	-15.14	0	0
1970	53.04	53.04	0.19	0	0
1971	55.77	55.77	-2.73	0	0
1972	53.71	53.71	2.06	0	0
1973	35.77	35.77	17.94	1	1
1974	37.12	35.73	0.04	0	0
1975	61	61	-23.88	0	0
1976	50.39	50.39	10.61	1	1
1977	34.5	34.5	15.89	1	1
1978	60	58.87	-24.37	0	0
1979	49	44.73	15.27	1	1
1980	34.93	34.5	14.5	1	1
1981	38.26	33.18	1.75	0	0
1982	44.55	38.39	-0.13	0	0
1983	47.69	47.69	-3.14	0	0
1984	48.28	48.28	-0.59	0	0
1985	34.5	34.5	13.78	1	1
1986	64.5	49.7	-15.2	0	0
1987	45.38	42.83	21.67	1	1
1988	35.05	34.69	10.69	1	1
1989	31.63	31.63	3.42	0	0
1990	30.53	28.5	3.13	0	0
1991	33.2	31.61	-1.08	0	0
1992	28.5	28.5	4.7	0	0
1993	28.5	28.5	0	0	0
1994	34.5	34.5	-6	0	0
1995	56.82	55.03	-20.53	0	0
1996	56.77	56.77	0.05	0	0
1997	65	65	-8.23	0	0
			TOT YRS	31	22

ABAA10 Garrison Year	Ann. Max.	J/J/A Max	Red. Prev. Yr.	Red. > 5	Red. > 10
1898	65	65			
1899	65	65	0	0	0
1900	40.58	33.4	31.6	1	1
1901	35.95	35.95	4.63	0	0
1902	41.25	22	13.95	1	1
1903	38	19.74	21.51	1	1
1904	42.02	42.02	-4.02	0	0
1905	41.07	22.37	19.65	1	1
1906	42.19	42.19	-1.12	0	0
1907	65	65	-22.81	0	0
1908	65	65	0	0	0
1909	65	65	0	0	0
1910	41.79	41.79	23.21	1	1
1911	41.21	41.21	0.58	0	0
1912	42.05	42.05	-0.84	0	0
1913	65	65	-22.95	0	0
1914	41.95	41.95	23.05	1	1
1915	42.03	42.03	-0.08	0	0
1916	65	65	-22.97	0	0
1917	65	65	0	0	0
1918	65	65	0	0	0
1919	28	27.27	37.73	1	1
1920	41.5	16	12	1	1
1921	41.42	23.41	18.09	1	1
1922	41.25	27.86	13.56	1	1
1923	41.6	28.2	13.05	1	1
1924	41.97	41.97	-0.37	0	0
1925	41.92	41.92	0.05	0	0
1926	40.95	33.16	8.76	1	0
1927	41.25	22	18.95	1	1
1928	49.37	49.37	-8.12	0	0
1929	42.03	42.03	7.34	1	0
1930	41.03	41.03	1	0	0
1931	32.6	29.22	11.81	1	1
1932	39.79	39.79	-7.19	0	0
1933	38.72	38.72	1.07	0	0
1934	31.74	26.36	12.36	1	1
1935	36.06	36.06	-4.32	0	0
1936	32.4	32.4	3.66	0	0
1937	27.71	26.92	5.48	1	0
1938	35.93	35.93	-8.22	0	0
1939	36.05	26.05	9.88	1	0
1940	35.3	35.3	0.75	0	0
1941	52.95	38	-2.7	0	0
1942	37.67	37.67	15.28	1	1
1943	39.44	39.44	-1.77	0	0
1944	41.04	41.04	-1.6	0	0
1945	41.09	41.09	-0.05	0	0

1946	34.67	34.67	6.42	1	0
1947	41.85	41.85	-7.18	0	0
1948	61.74	61.74	-19.89	0	0
1949	41.38	17.05	44.69	1	1
1950	33.48	25.47	15.91	1	1
1951	41.9	41.9	-8.42	0	0
1952	65	65	-23.1	0	0
1953	46.78	46.78	18.22	1	1
1954	42.02	42.02	4.76	0	0
1955	41.07	22.37	19.65	1	1
1956	33.38	31.04	10.03	1	1
1957	39.88	39.88	-6.5	0	0
1958	37.71	37.71	2.17	0	0
1959	40.13	40.13	-2.42	0	0
1960	31.78	16	24.13	1	1
1961	37.78	37.78	-6	0	0
1962	24.02	21.7	16.08	1	1
1963	40.58	40.58	-16.56	0	0
1964	41.14	41.14	-0.56	0	0
1965	42.03	42.03	-0.89	0	0
1966	41.02	22.06	19.97	1	1
1967	41.8	23.54	17.48	1	1
1968	41.68	22.82	18.98	1	1
1969	41.82	41.82	-0.14	0	0
1970	42.1	42.1	-0.28	0	0
1971	42.17	42.17	-0.07	0	0
1972	41.92	41.92	0.25	0	0
1973	28	16.82	25.1	1	1
1974	33.04	23.1	4.9	0	0
1975	65	65	-31.96	0	0
1976	41.97	41.97	23.03	1	1
1977	31.88	28.37	13.6	1	1
1978	42.23	42.23	-10.35	0	0
1979	41.88	41.88	0.35	0	0
1980	40.92	40.92	0.96	0	0
1981	40.77	40.77	0.15	0	0
1982	41.73	41.73	-0.96	0	0
1983	41.23	41.23	0.5	0	0
1984	41.17	41.17	0.06	0	0
1985	40.69	40.69	0.48	0	0
1986	42.28	42.28	-1.59	0	0
1987	28	16	26.28	1	1
1988	26.3	24.39	3.61	0	0
1989	39.51	39.51	-13.21	0	0
1990	39.11	39.11	0.4	0	0
1991	39.7	39.7	-0.59	0	0
1992	38.86	38.86	0.84	0	0
1993	18	16	22.86	1	1
1994	22	16	2	0	0
1995	42.14	42.14	-20.14	0	0
1996	65	65	-22.86	0	0
1997	65	65	0	0	0
			TOT YRS	35	30

ABAA10
Fort Peck

Year	Ann. Max.	J/J/A Max	Red. Prev. Yr.	Red. > 5	Red. > 10
1898	35	35			
1899	23.21	23.21	11.79	1	1
1900	16.32	16.23	6.98	1	0
1901	16.46	9.9	6.42	1	0
1902	16.47	16.09	0.37	0	0
1903	16.27	16.12	0.35	0	0
1904	16.45	13.2	3.07	0	0
1905	16.45	9.9	6.55	1	0
1906	11.28	3.65	12.8	1	1
1907	34	34	-22.72	0	0
1908	35	35	-1	0	0
1909	35	35	0	0	0
1910	21.53	21.53	13.47	1	1
1911	16.51	13.2	8.33	1	0
1912	16.18	13.39	3.12	0	0
1913	35	35	-18.82	0	0
1914	16.11	16.11	18.89	1	1
1915	16.11	12.15	3.96	0	0
1916	35	35	-18.89	0	0
1917	35	35	0	0	0
1918	14	13.2	21.8	1	1
1919	16.6	13.2	0.8	0	0
1920	16.38	3.65	12.95	1	1
1921	16.38	9.9	6.48	1	0
1922	16.41	16.13	0.25	0	0
1923	15.49	15.49	0.92	0	0
1924	13.79	9.9	5.59	1	0
1925	16.38	13.2	0.59	0	0
1926	16.41	13.2	3.18	0	0
1927	16.47	16.09	0.32	0	0
1928	16.36	16.16	0.31	0	0
1929	11.86	3.64	12.72	1	1
1930	16.52	13.2	-1.34	0	0
1931	16.6	16.6	-0.08	0	0
1932	15.27	3.64	12.96	1	1
1933	14.25	14.25	1.02	0	0
1934	14.97	14.97	-0.72	0	0
1935	11	7.46	7.51	1	0
1936	13.87	13.87	-2.87	0	0
1937	8.66	3.5	10.37	1	1
1938	15.11	15.11	-6.45	0	0
1939	15.09	15.09	0.02	0	0
1940	14	14	1.09	0	0
1941	12.91	8.4	5.6	1	0
1942	15.03	13.54	-0.63	0	0
1943	16.53	4.76	10.27	1	1

1944	11.67	3.65	12.88	1	1
1945	15.12	3.65	8.02	1	0
1946	16.63	16.61	-1.49	0	0
1947	16.43	6.89	9.74	1	0
1948	35	35	-18.57	0	0
1949	16.43	12.28	22.72	1	1
1950	14	3.65	12.78	1	1
1951	16.31	16.25	-2.25	0	0
1952	19.71	19.71	-3.4	0	0
1953	35	35	-15.29	0	0
1954	16.45	13.2	21.8	1	1
1955	16.45	9.9	6.55	1	0
1956	16.64	16.61	-0.16	0	0
1957	16.64	10.78	5.86	1	0
1958	16.65	16.61	0.03	0	0
1959	16.65	15.97	0.68	0	0
1960	16.63	16.61	0.04	0	0
1961	16.57	16.57	0.06	0	0
1962	10.75	3.65	12.92	1	1
1963	16.56	16.56	-5.81	0	0
1964	16.54	16.35	0.21	0	0
1965	16.48	16.05	0.49	0	0
1966	16.51	15.67	0.81	0	0
1967	13.29	12	4.51	0	0
1968	16.38	13.2	0.09	0	0
1969	16.4	16.24	0.14	0	0
1970	16.41	13.97	2.43	0	0
1971	23.99	23.99	-7.58	0	0
1972	25.82	21.24	2.75	0	0
1973	16.4	3.64	22.18	1	1
1974	16.42	13.2	3.2	0	0
1975	35	35	-18.58	0	0
1976	23.55	22.59	12.41	1	1
1977	16.6	16.56	6.99	1	0
1978	22.69	16	0.6	0	0
1979	25	24.73	-2.04	0	0
1980	16.5	13.2	11.8	1	1
1981	16.61	16.61	-0.11	0	0
1982	23.62	23.62	-7.01	0	0
1983	15.72	14.91	8.71	1	0
1984	16.41	12.02	3.7	0	0
1985	16.52	16.47	-0.06	0	0
1986	16.17	9.9	6.62	1	0
1987	16.39	9.9	6.27	1	0
1988	16.64	16.6	-0.21	0	0
1989	16.65	16.63	0.01	0	0
1990	16.64	16.64	0.01	0	0
1991	16.65	16.64	0	0	0
1992	14.21	4.61	12.04	1	1
1993	12.33	3.65	10.56	1	1
1994	16.43	16.38	-4.05	0	0
1995	16.47	16.47	-0.04	0	0
1996	28.79	16.13	0.34	0	0
1997	35	35	-6.21	0	0
			TOT YRS	36	20

1 1898-1996 ABAA10

1898

1898 FORT PECK **1898**

		22MAR	31MAR	30APR	31MAY	30JUN	31JUL	31AUG	30SEP	31OCT	15NOV	30NOV	31DEC	31JAN	28FEB	15MAR
REACH INF,KAF	9025	122	157	776	1529	2786	1342	386	320	353	170	170	313	232	232	138
EVAP,1000 AF	493	0	0	0	32	23	96	101	95	64	29	29	24	0	0	0
INF ADJST,KAF	-552	3	4	-18	-150	-183	-310	-130	34	76	26	26	32	20	14	4
MOD INF,KAF	7980	125	161	758	1347	2580	936	155	259	365	166	166	321	252	246	141
STORAGE,KAF	14939	14976	15003	15095	15743	17503	17706	17225	16972	16737	16657	16599	16268	15808	15420	15315
POOL ELEV,FT	2234.00	2234.2	2234.3	2234.7	2237.7	2245.4	2246.0	2244.2	2243.1	2242.1	2241.8	2241.5	2240.1	2238.0	2236.2	2235.7
RELEASE,KAF	7604	89	134	666	699	819	734	636	512	601	246	224	652	712	633	247
RELEASE,KCFS	10.5	6.4	7.5	11.2	11.4	13.8	11.9	10.3	8.6	9.8	8.3	7.5	10.6	11.6	11.3	8.3
AVE POWER,MW	146	88	103	153	158	192	169	146	121	137	116	106	148	161	156	114
MRKT POWER,MW		208	208	209	211	217	217	216	215	214	214	214	213	211	210	209
ENERGY,KMWH	1282.9	14.8	22.3	110.0	117.2	138.3	125.5	108.7	87.4	102.1	41.8	38.2	110.2	119.5	105.6	41.2

1898 GARRISON **1898**

		22MAR	31MAR	30APR	31MAY	30JUN	31JUL	31AUG	30SEP	31OCT	15NOV	30NOV	31DEC	31JAN	28FEB	15MAR
REACH INF,KAF	13610	210	269	1228	2066	4478	2245	816	607	458	155	155	186	272	280	186
EVAP,1000 AF	552	0	0	0	34	25	107	116	106	72	33	32	27	0	0	0
INF ADJST,KAF	-605	4	5	-13	-213	-148	-292	-179	0	87	32	32	38	24	16	4
MOD INF,KAF	20057	302	408	1881	2519	5124	2579	1157	1013	1073	399	378	849	1008	929	437
STORAGE,KAF	17949	18112	18130	18057	19043	21668	22288	21326	21239	20873	20622	20606	20071	19389	18814	18759
POOL ELEV,FT	1837.50	1838.0	1838.1	1837.9	1841.0	1848.7	1850.0	1847.7	1847.4	1846.4	1845.6	1845.6	1844.0	1842.0	1840.3	1840.1
RELEASE,KAF	19248	139	390	1954	1533	2499	1960	2120	1100	1439	650	394	1383	1691	1504	492
RELEASE,KCFS	26.6	10.0	21.8	32.8	24.9	42.0	31.9	34.5	18.5	23.4	21.8	13.2	22.5	27.5	26.8	16.5
AVE POWER,MW	341	135	276	405	316	513	421	453	247	308	287	179	294	352	340	215
MRKT POWER,MW		474	474	473	481	513	518	509	508	505	502	502	496	488	482	481
ENERGY,KMWH	2992.7	22.7	59.5	292.0	235.3	369.5	313.2	337.0	178.0	229.4	103.4	64.6	218.4	261.9	230.7	77.3

1898 OAHE **1898**

		22MAR	31MAR	30APR	31MAY	30JUN	31JUL	31AUG	30SEP	31OCT	15NOV	30NOV	31DEC	31JAN	28FEB	15MAR
REACH INF,KAF	3014	252	325	478	396	473	300	71	98	46	90	90	6	12	36	341
EVAP,1000 AF	456	0	0	0	31	23	91	94	87	57	26	26	21	0	0	0
INF ADJST,KAF	-171	0	0	0	-8	-26	-84	-65	-14	10	4	4	5	2	1	0
MOD INF,KAF	21634	392	715	2432	1890	2923	2085	2031	1097	1438	718	462	1373	1705	1541	833
STORAGE,KAF	18791	18869	19100	19388	19952	20914	20586	20026	19146	18703	18694	18429	18154	18489	18780	19244
POOL ELEV,FT	1607.50	1607.7	1608.5	1609.4	1611.1	1614.0	1613.0	1611.3	1608.6	1607.2	1607.2	1606.3	1605.4	1606.5	1607.5	1608.9
RELEASE,KAF	21182	314	484	2144	1326	1962	2412	2592	1976	1881	727	726	1649	1370	1249	369
RELEASE,KCFS	29.2	22.6	27.1	36.0	21.6	33.0	39.2	42.2	33.2	30.6	24.4	24.4	26.8	22.3	22.3	12.4
AVE POWER,MW	386	295	355	474	285	442	529	564	439	400	318	317	347	288	290	162

MRKT POWER,MW		710	714	719	728	742	737	729	715	707	707	703	698	704	709	717
ENERGY,KMWH	3381.8	49.6	76.7	341.4	211.7	318.2	393.4	419.8	316.3	297.9	114.6	114.3	258.1	214.6	196.8	58.4

1898 BIG BEND **1898**

EVAP,1000 AF	60	0	0	0	4	3	11	12	11	8	4	4	3	0	0	0
AVE POWER,MW	138	105	126	167	98	152	181	195	156	148	121	123	135	111	107	57
MRKT POWER,MW		504	501	496	494	493	493	493	514	527	537	538	537	526	506	501
ENERGY,KMWH	1214.0	17.7	27.2	120.5	73.1	109.3	134.7	144.9	112.2	110.0	43.7	44.4	100.6	82.6	72.7	20.4

1898 FORT RANDALL **1898**

REACH INF,KAF	1023	44	57	111	240	63	190	24	32	14	29	29	2	4	14	170
EVAP,1000 AF	67	0	0	0	5	4	14	14	14	8	3	3	2	0	0	0
INF ADJST,KAF	-72	1	1	2	-1	-19	-47	-33	-4	9	4	4	4	5	3	1
MOD INF,KAF	22005	358	541	2257	1556	1999	2530	2557	1979	1888	752	752	1650	1379	1266	540
STORAGE,KAF	3381	3419	3457	3521	3540	3546	3548	3548	3240	2933	2626	2320	2568	2974	3381	3462
POOL ELEV,FT	1353.00	1353.5	1353.9	1354.7	1354.9	1355.0	1355.0	1355.0	1351.2	1347.0	1342.6	1337.5	1341.6	1347.6	1353.0	1354.0
RELEASE,KAF	21924	320	504	2193	1537	1993	2528	2556	2287	2196	1059	1059	1402	972	860	459
RELEASE,KCFS	30.3	23.1	28.2	36.8	25.0	33.5	41.1	41.6	38.4	35.7	35.6	35.6	22.8	15.8	15.3	15.4
AVE POWER,MW	258	205	247	319	223	294	355	355	329	296	283	269	180	138	139	143
MRKT POWER,MW		349	351	354	353	355	355	355	339	322	304	283	301	324	347	351
ENERGY,KMWH	2261.1	34.4	53.5	230.0	165.6	211.3	264.0	264.0	236.9	220.1	101.9	97.0	134.0	102.5	94.4	51.5

1898 GAVINS POINT **1898**

REACH INF,KAF	1178	42	54	119	130	131	80	70	75	99	46	46	75	73	93	47
EVAP,1000 AF	25	0	0	0	2	1	5	5	5	3	1	1	1	0	0	0
INF ADJST,KAF	-35	0	0	0	0	-3	-17	-15	-1	1	0	0	0	0	0	0
RELEASE,KAF	23043	362	557	2312	1665	2120	2587	2606	2357	2293	1103	1103	1476	1045	953	506
RELEASE,KCFS	31.8	26.1	31.2	38.8	27.1	35.6	42.1	42.4	39.6	37.3	37.1	37.1	24.0	17.0	17.0	17.0
AVE POWER,MW	76	80	80	80	102	80	80	80	80	80	80	80	80	62	62	62
MRKT POWER,MW		80	80	80	81	80	80	80	80	80	80	80	80	80	80	80
ENERGY,KMWH	668.9	13.4	17.3	57.6	59.5	57.6	59.5	59.5	57.6	59.5	28.8	28.8	59.5	46.0	41.9	22.2

1898 MAIN STEM SYSTEM **1898**

REACH INF,KAF	29359	734	944	2861	4839	8183	4286	1466	1203	998	501	501	598	603	697	946
EVAP,1000 AF	1653	0	0	0	107	79	324	342	317	213	96	95	79	0	0	0
INF ADJST,KAF	-1566	8	10	-29	-374	-404	-818	-468	13	188	66	66	81	52	35	9
STORAGE,KAF	57139	57454	57768	58140	60356	65709	66206	64202	62675	61323	60677	60032	59139	58737	58474	58858
AVE POWER,MW	1346	908	1187	1599	1159	1673	1734	1793	1373	1370	1206	1076	1184	1112	1095	753
MRKT POWER,MW		2325	2328	2330	2348	2400	2401	2382	2372	2356	2344	2319	2324	2334	2333	2339

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  ENERGY,KWH  11801.4  152.6  256.4 1151.4  862.4 1204.3 1290.3 1334.0  988.3 1018.9  434.2  387.2  880.9
827.1  742.1  271.1
  NAV LVL,KCFS          35.0   35.0   35.0   35.0   35.9   40.1   40.4   37.6   35.3   35.0   35.0   35.0
35.0   35.0   35.0
  NAV LENGTH            8.00   8.00   8.00   8.00   8.32   8.32   8.32   8.32   8.32   8.32   8.32   8.32
8.32   8.32   8.32
  CONTROL POINT           11      4    803  80004 200803 200005 200005 200004 200005 200005 200005 200011
200011 200011 200011
  GP TERMQ,KCFS           .0     .0     .0   33.0   33.0   33.0   33.0     .0     .0     .0     .0     .0
.0     .0     .0
                         **1898**                    SIOUX CITY                         **1898**
  REACH INF,KAF    1509     64     83    149    478    252    129     99     71     28     12     12     16
10     42     65
  INF ADJST,KAF    -131      0      0      0     -2    -25    -68    -46     -2      5      2      2      2
1      1      0
  MOD INF,KAF      1378     64     83    149    476    227     61     53     69     33     14     14     18
11     43     65
  FLOW, 1000AF    24421    426    640   2461   2141   2347   2648   2659   2426   2326   1116   1116   1494
1056    996    570
  FLOW, 1000CFS    33.7   30.7   35.8   41.4   34.8   39.4   43.1   43.2   40.8   37.8   37.5   37.5   24.3
17.2   17.8   19.2
                         **1898**                      OMAHA                            **1898**
  REACH INF,KAF    1095     24     30     27    153    207     72     90     90     81     32     32     90
99     54     15
  INF ADJST,KAF    -293     -5     -7    -27    -40    -31    -43    -40    -22    -18     -8     -8    -18   -
12     -9     -6
  MOD INF,KAF       802     18     24      0    113    176     29     50     68     63     24     24     72
87     45      9
  FLOW, 1000AF    25226    413    648   2444   2274   2509   2666   2709   2501   2397   1141   1140   1605
1165   1039    575
  FLOW, 1000CFS    34.8   29.7   36.3   41.1   37.0   42.2   43.4   44.1   42.0   39.0   38.4   38.3   26.1
18.9   18.5   19.3
                         **1898**                  NEBRASKA CITY                        **1898**
  REACH INF,KAF    3772     81    105     93    527    713    248    310    310    279    109    109    310
341    186     52
  INF ADJST,KAF   -2493    -61    -79    -93   -330   -330   -248   -310   -180   -180    -90    -90   -150   -
150   -150    -52
  MOD INF,KAF      1279     20     26      0    197    383      0      0    130     99     19     19    160
191     36      0
  FLOW, 1000AF    26506    422    669   2439   2477   2888   2662   2708   2634   2499   1160   1159   1779
1363   1074    574
  FLOW, 1000CFS    36.6   30.4   37.5   41.0   40.3   48.5   43.3   44.0   44.3   40.6   39.0   38.9   28.9
22.2   19.2   19.3
                         **1898**                   KANSAS CITY                         **1898**
  REACH INF,KAF    7300    158    203    180   1020   1380    480    600    600    540    210    210    600
660    360    100
  INF ADJST,KAF   -2234    -33    -42   -180   -226   -248   -361   -316   -158   -181    -79    -79   -135   -
68    -90    -38
  MOD INF,KAF      5066    125    160      0    794   1132    119    284    442    359    131    131    465
592    270     62
  FLOW, 1000AF    31575    504    808   2416   3297   4001   2767   2992   3086   2870   1292   1290   2296
1983   1342    631
  FLOW, 1000CFS    43.6   36.3   45.3   40.6   53.6   67.2   45.0   48.7   51.9   46.7   43.4   43.3   37.3
32.3   23.9   21.2
                         **1898**                    BOONVILLE                          **1898**
  REACH INF,KAF    5664    289    372    544   1472    384    288    320    416    416    144    144    320
192    128    235
  INF ADJST,KAF    -256     -5     -7    -23    -36    -30    -33    -28    -23    -13     -7     -7    -13   -
13    -13     -6
  MOD INF,KAF      5408    284    365    521   1436    354    255    292    393    403    138    138    307
179    115    229
  FLOW, 1000AF    36987    745   1153   2915   4759   4337   3007   3283   3488   3285   1431   1427   2656
2191   1455    854
  FLOW, 1000CFS    51.1   53.7   64.6   49.0   77.4   72.9   48.9   53.4   58.6   53.4   48.1   48.0   43.2
35.6   26.0   28.7
                         **1898**                     HERMANN                           **1898**
  REACH INF,KAF   12037    615    791   1156   3128    816    612    680    884    884    306    306    680
408    272    499
  INF ADJST,KAF    -340     -7     -9    -38    -48    -44    -38    -27    -17    -20    -12    -12    -20   -
20    -20     -8
  MOD INF,KAF     11697    608    782   1118   3080    772    574    653    867    864    294    294    660
388    252    491
  FLOW, 1000AF    48685   1332   1925   4022   7853   5099   3574   3936   4360   4155   1725   1721   3343
2593   1705   1341
  FLOW, 1000CFS    67.2   95.9  107.8   67.6  127.7   85.7   58.1   64.0   73.3   67.6   58.0   57.9   54.4
42.2   30.4   45.1
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(The above printout is an example of output for the year 1898)

Summary of Engineering Data -- Missouri River Main Stem Reservoirs

Item No.	Subject	Fort Peck Lake	Garrison Dam - Lake Sakakawea	Oahe Dam - Lake Oahe
1	Location of Dam	Near Glasgow, Montana	Near Garrison, ND	Near Pierre, SD
2	River Mile - 1960 Mileage	Mile 1771.5	Mile 1389.9	Mile 1072.3
3	Total & incremental drainage areas in square miles	57,500	181,400 (2) 123,900	243,490 (1) 62,090
4	Approximate length of full reservoir (in valley miles)	134, ending near Zortman, MT	178, ending near Trenton, ND	231, ending near Bismarck, ND
5	Shoreline in miles (3)	1520 (elevation 2234)	1340 (elevation 1837.5)	2250 (elevation 1607.5)
6	Average total & incremental inflow in cfs	10,200	25,600 15,400	28,900 3,300
7	Max. discharge of record near damsite in cfs	137,000 (June 1953)	348,000 (April 1952)	440,000 (April 1952)
8	Construction started - calendar yr.	1933	1946	1948
9	In operation (4) calendar yr.	1940	1955	1962
	Dam and Embankment			
10	Top of dam, elevation in feet msl	2280.5	1875	1660
11	Length of dam in feet	21,026 (excluding spillway)	11,300 (including spillway)	9,300 (excluding spillway)
12	Damming height in feet (5)	220	180	200
13	Maximum height in feet (5)	250.5	210	245
14	Max. base width, total & w/o berms in feet	3500, 2700	3400, 2050	3500, 1500
15	Abutment formations (under dam & embankment)	Bearpaw shale and glacial fill	Fort Union clay shale	Pierre shale
16	Type of fill	Hydraulic & rolled earth fill	Rolled earth filled	Rolled earth fill & shale berms
17	Fill quantity, cubic yards	125,628,000	66,500,000	55,000,000 & 37,000,000
18	Volume of concrete, cubic yards	1,200,000	1,500,000	1,045,000
19	Date of closure	24 June 1937	15 April 1953	3 August 1958
	Spillway Data			
20	Location	Right bank - remote	Left bank - adjacent	Right bank - remote
21	Crest elevation in feet msl	2225	1825	1596.5
22	Width (including piers) in feet	820 gated	1336 gated	456 gated
23	No., size and type of gates	16 - 40' x 25' vertical lift gates	28 - 40' x 29' Tainter	8 - 50' x 23.5' Tainter
24	Design discharge capacity, cfs	275,000 at elev 2253.3	827,000 at elev 1858.5	304,000 at elev 1644.4
25	Discharge capacity at maximum operating pool in cfs	230,000	660,000	80,000
	Reservoir Data (6)			
26	Max. operating pool elev. & area	2250 msl 246,000 acres	1854 msl 380,000 acres	1620 msl 374,000 acres
27	Max. normal op. pool elev. & area	2246 msl 240,000 acres	1850 msl 364,000 acres	1617 msl 360,000 acres
28	Base flood control elev & area	2234 msl 212,000 acres	1837.5 msl 307,000 acres	1607.5 msl 312,000 acres
29	Min. operating pool elev. & area	2160 msl 90,000 acres	1775 msl 128,000 acres	1540 msl 117,000 acres
	Storage allocation & capacity			
30	Exclusive flood control	2250-2246 975,000 a.f.	1854-1850 1,489,000 a.f.	1620-1617 1,102,000 a.f.
31	Flood control & multiple use	2246-2234 2,717,000 a.f.	1850-1837.5 4,222,000 a.f.	1617-1607.5 3,201,000 a.f.
32	Carryover multiple use	2234-2160 10,785,000 a.f.	1837.5-1775 13,130,000 a.f.	1607.5-1540 13,461,000 a.f.
33	Permanent	2160-2030 4,211,000 a.f.	1775-1673 4,980,000 a.f.	1540-1415 5,373,000 a.f.
34	Gross	2250-2030 18,688,000 a.f.	1854-1673 23,821,000 a.f.	1620-1415 23,137,000 a.f.
35	Reservoir filling initiated	November 1937	December 1953	August 1958
36	Initially reached min. operating pool	27 May 1942	7 August 1955	3 April 1962
37	Estimated annual sediment inflow	18,100 a.f. 1030 yrs.	25,900 a.f. 920 yrs.	19,800 a.f. 1170 yrs.
	Outlet Works Data			
38	Location	Right bank	Right Bank	Right Bank
39	Number and size of conduits	2 - 24' 8" diameter (nos. 3 & 4)	1 - 26' dia. and 2 - 22' dia.	6 - 19.75' dia. upstream, 18.25' dia. downstream
40	Length of conduits in feet (8)	No. 3 - 6,615, No. 4 - 7,240	1529	3496 to 3659
41	No., size, and type of service gates	1 - 28' dia. cylindrical gate 6 ports, 7.6' x 8.5' high (net opening) in each control shaft	1 - 18' x 24.5' Tainter gate per conduit for fine regulation	1 - 13' x 22' per conduit, vertical lift, 4 cable suspension and 2 hydraulic suspension (fine regulation)
42	Entrance invert elevation (msl)	2095	1672	1425
43	Avg. discharge capacity per conduit & total	Elev. 2250 22,500 cfs - 45,000 cfs	Elev. 1854 30,400 cfs - 98,000 cfs	Elev. 1620 18,500 cfs - 111,000 cfs
44	Present tailwater elevation (ft msl)	2032-2036 5,000 - 35,000 cfs	1670-1680 15,000- 60,000 cfs	1423-1428 20,000-55,000 cfs
	Power Facilities and Data			
45	Avg. gross head available in feet (15)	194	161	174
46	Number and size of conduits	No. 1-24'8" dia., No. 2-22'4" dia.	5 - 29' dia., 25' penstocks	7 - 24' dia., imbedded penstocks
47	Length of conduits in feet (8)	No. 1 - 5,653, No. 2 - 6,355	1829	From 3,280 to 4,005
48	Surge tanks	PH#1: 3-40' dia., PH#2: 2-65' dia.	65' dia. - 2 per penstock	70' dia., 2 per penstock
49	No., type and speed of turbines	5 Francis, PH#1-2: 128.5 rpm, 1-164 rpm , PH#2-2: 128.6 rpm	5 Francis, 90 rpm	7 Francis, 100 rpm
50	Discharge cap. at rated head in cfs	PH#1, units 1&3 170', 2-140' 8,800 cfs, PH#2-4&5 170'-7,200 cfs	150' 38,000 cfs	185' 54,000 cfs
51	Generator nameplate rating in kW	1&3: 43,500; 2: 18,250; 4&5: 40,000	3 - 109,250, 2 - 95,000	112,290
52	Plant capacity in kW	185,250	517,750	786,030
53	Dependable capacity in kW (9)	181,000	388,000	534,000

EXHIBIT 952

040263

Summary of Engineering Data -- Missouri River Main Stem Reservoirs

Big Bend Dam - Lake Sharpe	Fort Randall Dam - Lake Francis Case	Gavins Point Dam - Lewis & Clark Lake	Total	Item No.
21 miles upstream Chamberlain, SD	Near Lake Andes, SD	Near Yankton, SD		1
Mile 987.4	Mile 880.0	Mile 811.1		2
249,330 (1) 5,840	263,480 (1) 14,150	279,480 (1) 16,000		3
80, ending near Pierre, SD	107, ending at Big Bend Dam	25, ending near Niobrara, NE	755 miles	4
200 (elevation 1420)	540 (elevation 1350)	90 (elevation 1204.5)	5,940 miles	5
28,900	30,000 1,100	32,000 2,000		6
440,000 (April 1952)	447,000 (April 1952)	480,000 (April 1952)		7
1959	1946	1952		8
1964	1953	1955		9
1440	1395	1234		10
10,570 (including spillway)	10,700 (including spillway)	8,700 (including spillway)	71,596	11
78	140	45	863 feet	12
95	165	74		13
1200, 700	4300, 1250	850, 450		14
Pierre shale & Niobrara chalk	Niobrara chalk	Niobrara chalk & Carlile shale		15
Rolled earth, shale, chalk fill	Rolled earth fill & chalk berms	Rolled earth & chalk fill		16
17,000,000	28,000,000 & 22,000,000	7,000,000	358,128,000 cu. yds	17
540,000	961,000	308,000	5,554,000 cu. yds.	18
24 July 1963	20 July 1952	31 July 1955		19
Left bank - adjacent	Left bank - adjacent	Right bank - adjacent		20
1385	1346	1180		21
376 gated	1000 gated	664 gated		22
8 - 40' x 38' Tainter	21 - 40' x 29' Tainter	14 - 40' x 30' Tainter		23
390,000 at elev 1433.6	620,000 at elev 1379.3	584,000 at elev 1221.4		24
270,000	508,000	345,000		25
1423 msl 61,000 acres	1375 msl 102,000 acres	1210 msl 31,000 acres	1,194,000 acres	26
1422 msl 60,000 acres	1365 msl 95,000 acres	1208 msl 28,000 acres	1,147,000 acres	27
1420 msl 57,000 acres	1350 msl 77,000 acres	1204.5 msl 24,000 acres	989,000 acres	28
1415 msl 51,000 acres	1320 msl 38,000 acres	1204.5 msl 24,000 acres	450,000 acres	29
1423-1422 60,000 a.f.	1375-1365 985,000 a.f.	1210-1208 59,000 a.f.	4,670,000 a.f.	30
1422-1420 117,000 a.f.	1365-1350 1,309,000 a.f.	1208-1204.5 90,000 a.f.	11,656,000 a.f.	31
	1350-1320 1,607,000 a.f.		38,983,000 a.f.	32
1420-1345 1,682,000 a.f.	1320-1240 1,517,000 a.f.	1204.5-1160 321,000 a.f.	18,084,000 a.f.	33
1423-1345 1,859,000 a.f.	1375-1240 5,418,000 a.f.	1210-1160 470,000 a.f.	73,393,000 a.f.	34
November 1963	January 1953	August 1955		35
25 March 1964	24 November 1953	22 December 1955		36
4,300 a.f. 430 yrs.	18,300 a.f. 250 yrs.	2,600 a.f. 180 yrs.	92,500 a.f.	37
	Left Bank			38
None (7)	4 - 22' diameter	None (7)		39
	1013			40
	2 - 11' x 23' per conduit, vertical lift, cable suspension			41
1385 (12)	1229	1180 (12)		42
	Elev 1375 32,000 cfs - 128,000 cfs			43
1351-1355(11) 25,000-100,000 cfs	1228-1239 5,000-60,000 cfs	1155-1163 15,000-60,000 cfs		44
70	117	48	764 feet	45
None: direct intake	8 - 28' dia., 22' penstocks	None: direct intake		46
	1,074		55,083	47
None	59' dia, 2 per alternate penstock	None		48
8 Fixed blade, 81.8 rpm	8 Francis, 85.7 rpm	3 Kaplan, 75 rpm	36 units	49
67' 103,000 cfs	112' 44,500 cfs	48' 36,000 cfs		50
3 - 67,276, 5 - 58,500	40,000	44,100		51
494,320	320,000	132,300	2,435,650 kw	52
497,000	293,000	74,000	1,967,000 kw	53

Remarks

(1) Includes 4,280 square miles of non-contributi areas.
(2) Includes 1,350 square miles of non-contributi areas.
(3) With pool at base of flo control.
(4) Storage first available f regulation of flows.
(5) Damming height is hei from low water to maxi operating pool. Maxim height is from average streambed to top of dan
(6) Based on latest availabl storage data.
(7) River regulation is attai by flows over low-crest spillway and through turbines.
(8) Length from upstream of outlet or to spiral cas
(9) Based on 8th year (196 of drought drawdown (From study 8-83-1985
(10) Storage volumes are exclusive of Snake Cre arm.
(11) Affected by level of Lal Francis case. Applicab pool at elevation 1350.
(12) Spillway crest.
(13) 1967-1997 Average
(14) Source: Annual Report Civil Works Activities Corps of Engineers. E Report Fiscal Year 199
(15) Based on Study 8-83-1

AUTOMATED STREAM GAGES

Location	River Mile
Below Fort Peck	
Wolf Point	1701.4
Culbertson	1620.8
Below Garrison Dam	
Stanton	1376.0
Washburn	1354.7
Price	1338.6
Bismarck	1314.5
Below Fort Randall Dam	
Greenwood	880.0
Verdel	865.0
Niobrara	844.4
Springfield	832.2
Below Gavins Point Dam	
Yankton	805.8
Gayville	796.1
Maskell	772.0
Ponca	753.6