Missouri River
Recovery Program

FINAL
Missouri River Recovery Management Plan and Environmental Impact Statement

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Missouri River Recovery Management Plan and Environmental Impact Statement

Volume 3

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3.14 Irrigation

3.14.1 Affected Environment

Irrigators in 42 counties in Montana, North Dakota, South Dakota, and Nebraska hold permits to use water from the Missouri River for the purpose of agricultural production. This generally includes the area extending from Fort Peck Reservoir to Rulo, Nebraska. No irrigation permits were identified for counties from the states of Iowa, Kansas, or Missouri. Based on conversations with the Divisions of Natural Resources in these states and local agricultural extension specialists, irrigation along the Missouri River in Iowa, Kansas, and Missouri is isolated and, even when permits are in place, they are used infrequently. Corn and soybeans are predominantly grown along the river in these states, and rainfall is often sufficient for those crops' needs. The irrigation intakes permitted on the Missouri River are a mix of semi-permanent (portable) and permanent structures.

This analysis uses the most recent crop data available: the most recent USDA Census of Agriculture, in 2012, and crop data provided by the North Dakota State Water Commission from 2017 (USDA 2012; Sorenson 2017). Of 12.5 million acres of harvested cropland in the 42 counties along the Missouri River, approximately 2,266,000 acres of irrigated cropland were harvested in 2012, or approximately 18.1 percent of all cropland. According to the State Department of Natural Resources and State Water Commission records, 238,766 of these acres are permitted for irrigation using Missouri River water, or approximately 11 percent of all irrigated acres harvested (Table 3-141). In addition, data on the actual acres irrigated was obtained from North Dakota and South Dakota agencies, which require water permit irrigators to report annual water usage. Although actual acres irrigated with Missouri River water was not available from Montana and Nebraska, the South Dakota and North Dakota data indicates that actual acres irrigated is typically lower than permitted acres in most counties.

Almost all of the permitted acres are located in the upper basin, where lower annual rainfall and a shorter growing season leaves irrigators more dependent on river and reservoir water. For example, McCone County, Montana recorded 17.5 inches of precipitation in 2014.[4] However, the highest recorded precipitation in the 42-county area was in Washington County, Nebraska, which recorded 41.3 inches in 2014. The growing season in the upper basin counties is largely constrained by snowfall and low average temperatures. In the upper reaches of the river, the irrigation season lasts approximately from May through September. The planting and harvesting dates were derived from the NASS Agricultural Handbook Number 628: "Field Crops: Usual Planting and Harvesting Dates." In the lower river reaches, in Nebraska, the irrigation season also begins in May but typically extends through October.

[4] County precipitation for 2014 is the average value recorded at varying number of weather stations throughout the county over the course of the calendar year.

Table 3-141. Precipitation, Irrigated Crop Acreage, and Intakes for the 42-County Area

County	State	County Precipitation (Inches, 2014)	Irrigated Crop Acres Harvested (All Water Sources, 2012)	Acres Permitted (Missouri River Only, 2015)	Actual Acres Irrigated (Missouri River Only, 2015)
McCone	Montana	17.5	83,141	16,209	not reported
Valley	Montana	15.4	194,605	4,978	not reported
Roosevelt	Montana	13.6	74,200	21,284	not reported
Richland	Montana	15.9	132,818	18,156	not reported
Williams	North Dakota	10.2	83,007	39,966	1,969
McKenzie	North Dakota	16.4	37,635	11,030	735
Mountrail	North Dakota	20.1	0	1,094	250
McLean	North Dakota	20.3	74,852	5,875	2,212
Mercer	North Dakota	n/a	14,965	5,463	1,946
Oliver	North Dakota	n/a	38,852	6,784	3,643
Burleigh	North Dakota	14.3	58,428	4,723	2,543
Morton	North Dakota	19.9	49,601	3,985	1,166
Emmons	North Dakota	17.9	16,310	9,508	5,496
Sioux	North Dakota	n/a	0	679	0
Corson	South Dakota	22.0	0	1,261	51
Campbell	South Dakota	16.0	14,574	2,261	704
Walworth	South Dakota	19.8	23,971	2,193	258
Dewey	South Dakota	n/a	0	766	37
Potter	South Dakota	21.0	0	929	356
Sully	South Dakota	17.9	67,654	22,950	7,744
Stanley	South Dakota	18.4	644	1,447	26
Hughes	South Dakota	16.0	21,211	20,307	10,048
Buffalo	South Dakota	15.0	12,779	5,979	2,915
Hyde	South Dakota	15.0	4,800	0	0
Lyman	South Dakota	15.4	21,745	2,961	684
Brule	South Dakota	20.7	19,005	2,580	608
Charles Mix	South Dakota	19.2	64,649	12,492	4,391
Gregory	South Dakota	20.2	2,066	534	163
Boyd	Nebraska	21.0	18,425	274	not reported
Bon Homme	South Dakota	19.6	23,411	5,529	2,827
Knox	Nebraska	25.9	137,176	455	not reported
Cedar	Nebraska	31.7	257,655	1,498	not reported
Yankton	South Dakota	27.9	49,080	685	353
Clay	South Dakota	28.1	62,404	247	21

County	State	County Precipitation (Inches, 2014)	Irrigated Crop Acres Harvested (All Water Sources, 2012)	Acres Permitted (Missouri River Only, 2015)	Actual Acres Irrigated (Missouri River Only, 2015)
Dixon	Nebraska	35.4	87,943	1,341	not reported
Union	South Dakota	n/a	122,751	265	0
Thurston	Nebraska	31.6	64,988	154	not reported
Burt	Nebraska	32.0	130,807	839	not reported
Washington	Nebraska	41.3	59,355	762	not reported
Cass	Nebraska	n/a	33,555	37	not reported
Otoe	Nebraska	33.2	48,989	256	not reported
Nemaha	Nebraska	33.3	57,935	32	not reported
Total	-	-	2,265,986	238,766	64,952

Sources: National Climatic Data Center 2016; NASS 2016; Montana Department of Natural Resources and Conservation 2016; North Dakota State Water Commission 2016; South Dakota Department of Environment and Natural Resources 2016; Nebraska Department of Natural Resources 2016.

Note: The most recent data was obtained for irrigated crop acres and permitted acres which represent different years. This is a relevant comparison as permitted acres tends to be stable over time (Sorenson 2018).

Table 3-142 summarizes the irrigation intakes by state. A majority (94 percent) of the 816 intakes identified in the Master Manual are in Montana, North Dakota, and South Dakota. Montana has the greatest number of intakes of the four states, whereas relatively fewer intakes are in Nebraska. North Dakota has the greatest number of permitted acres of the four states where in 2015, the state permitted 89,106 acres for irrigation using Missouri River water. South Dakota and Montana also permit a considerable number of acres for irrigation, with 83,385 acres and 60,628 acres, respectively.

Table 3-142. Irrigation Intakes and Permitted Acres by State

State	Number of Counties	Acres Permitted (2015)	Number of Intakes Permitted (2015)
Montana	4	60,628	276
North Dakota	10	89,106	265
South Dakota	18	83,385	224
Nebraska	10	5,647	51
Total	42	238,766	816

Source: Missouri River Master Water Control Manual Review and Update, Montana Department of Natural Resources and Conservation 2016; North Dakota State Water Commission 2016; South Dakota Department of Environment and Natural Resources 2016; Nebraska Department of Natural Resources 2016

Table 3-143 summarizes the harvested acres irrigated by crop type across the 42-county study area. The most abundant crop grown in the 42 counties is corn, with 323,000 irrigated acres harvested in 2012, according to the Census of Agriculture (USDA 2012). The next most-abundant crop is soybeans, with 162,000 acres irrigated (Table 3-143).

Table 3-143. Harvested Acres Irrigated in the 42-County Area, 2012

Crop	Acres Irrigated	Percentage of Irrigated Acres Harvested in Counties in the State			
		Montana	North Dakota	South Dakota	Nebraska
Corn	322,653	3.5%	5.9%	26.4%	64.2%
Soybeans	162,458	0.0%	3.7%	32.2%	64.1%
Hay	110,957	72.7%	11.2%	7.2%	8.9%
Wheat	90,848	70.9%	23.9%	4.0%	1.2%
Hay and Haylage	62,723	68.7%	10.8%	8.8%	11.7%
Sugarbeets	25,086	70.1%	29.9%	0.0%	0.0%
Barley	21,219	63.3%	36.7%	0.0%	0.0%
Beans	10,349	89.2%	10.8%	0.0%	0.0%
Haylage	1,257	0.0%	0.0%	0.0%	100.0%
Peas	669	82.4%	17.6%	0.0%	0.0%
Lentils	300	0.0%	100.0%	0.0%	0.0%
Canola	145	0.0%	100.0%	0.0%	0.0%
Oats	54	0.0%	0.0%	0.0%	100.0%
Total (Acres)	**808,718**	**240,188**	**82,696**	**154,842**	**330,992**

Source: USDA Census of Agriculture 2012

3.14.1.1 Irrigation Resources on Tribal Lands

It is estimated that Tribes irrigate more than 350,000 acres of agricultural lands using water from either the Missouri River or Mainstem reservoirs. Many of the mechanical intakes used for water access are outdated and are prohibitively expensive to repair and may need to be replaced in order to accommodate changing levels of sediment, high levels of erosion, or reduced access to water.

3.14.2 Environmental Consequences

The environmental consequences analysis for irrigation intakes focuses on changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives. This section summarizes the irrigation impact assessment methodology and presents the results of the assessment. A detailed description of the methodology and results are provided in the “Irrigation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.14.2.1 Impacts Assessment Methodology

The irrigation environmental consequences were evaluated using three of the four accounts (NED, RED, and OSE) and are summarized according to the impact definitions provided in Section 3.1. Impacts to irrigators are modeled based on changing river and reservoir conditions. As river flows and reservoir elevations fall below minimum operating requirements, intakes become unavailable to provide water to farm operations (including private farms, Tribes, and commercial operations). This, in turn, can result in changes to net farm income. The analysis used outputs from the HEC-RAS and HEC-ResSim models to simulate river and reservoir conditions for several locations along the river over the POR. No county in the study area relies exclusively on the Missouri River for irrigation. Counties were included in the impact analysis if more than 1,000 acres in the county were irrigated using water from the Missouri River and if the river conditions evaluation showed that irrigation intakes in a given county would experience an intensive short-term impact or a series of consecutive impacts to water access when compared to Alternative 1. Counties evaluated included Richland, Roosevelt, McCone, and Valley in Montana; Burleigh, McLean, Morton, Oliver, Williams, Mercer, and Emmons in North Dakota; and Sully in South Dakota. Thus, the analysis of irrigation operations in these particular counties represents the likely impacts that would occur under the MRRMP-EIS alternatives. The analysis does not evaluate all agriculture production within each of these counties but only the portion that is irrigated with water from the Missouri River.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

National Economic Development

The NED analysis estimated changes in net farm income from irrigated agricultural operations in 12 counties expected to experience measurable impacts as a result of changing physical conditions along the Missouri River from the MRRMP-EIS alternatives. The analysis evaluated the impact of access to water on expected yields for crops grown, as reported by relevant state agriculture crop extension budgets. Estimates of harvested acres for each crop were obtained from the 2012 Census of Agriculture and the North Dakota State Water Commission. Net farm income was calculated by estimating expected yield per acre for crops irrigated with Missouri River water multiplied by the normalized crop prices, taking into account local factors such as amount of rainfall and local water usage for irrigation, and then subtracting the expected cost of production. Cost of production was obtained from relevant crop extension budgets. The change in yield per acre is assumed to be driven by the change in access to water—as the number of consecutive days an intake would not have access to water increases, the expected yield decreases.

Regional Economic Development

The RED analysis used the results from the NED analysis to estimate regional economic effects of MRRMP-EIS alternatives. The RED analysis focused on changes in employment, income, and sales to counties that could be potentially affected by the MRRMP-EIS alternatives. RED impacts were estimated with IMPLAN®, an input-output modeling software program. IMPLAN® uses inter-industry relationships to estimate the change in economic activity that can be expected in the study area as a result of generated demand for goods and services associated with the directly affected industry—in this case, agricultural crop production. Value of crop production estimated under the NED analysis was used as the direct input into IMPLAN® to estimate the regional economic benefits of irrigated agriculture. The study area for the IMPLAN® analysis was the state in which the irrigated agriculture was produced.

Other Social Effects

Changes in irrigation operations have a potential to cause other types of effects on individuals and communities. These impacts are often evaluated under the OSE account. The OSE analysis for irrigation relied in part on the results of the NED and RED analysis to determine the scale of impacts that could occur to community well-being, traditional ways of life, and economic vitality. Impacts of the alternatives on OSE are discussed qualitatively.

3.14.2.2 Summary of Environmental Consequences

Table 3-144 summarizes the impacts to irrigation intakes from each of the MRRMP-EIS alternatives.

Table 3-144. Environmental Consequences Relative to Irrigation, 2018 Dollars

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Management Actions Common to All Alternatives	No NED impacts	No RED impacts	No OSE impacts	Management actions common to all alternatives would likely have no impacts on irrigation intakes.
Alternative 1	Average annual net farm income of $6.8 million, with annual values ranging from $3.4 to $9.0 million. Management actions would have a negligible contribution to the impacts due to minor changes in river stages and reservoir elevations associated with the spawning cue release.	Average annual labor income $13.6 million; average annual employment of 341 jobs. Management actions would have a negligible contribution to the impacts.	Management actions would have a negligible contribution to OSE impacts.	Temporary, small, localized, adverse impacts that would be limited to intakes near the site of ESH construction.
Alternative 2	Decrease in average annual net farm income of $83,000 or -1.2%; negligible impacts in most locations and years; potential for small adverse impacts to counties bordering Lake Oahe and Lake Sakakawea and downstream of Fort Peck Dam from lower reservoir elevations and rivers flows associated with the spawning cue.	Decrease in average annual labor income of $28,000 and decrease in average annual employment of less than one job. Negligible changes on average and in most years, with small adverse and beneficial RED impacts in some years as the reservoirs rebalance following the spawning cue release.	Negligible OSE impacts in most years, with relatively small, localized, adverse impacts in the short-term in years of or following the spawning cue release.	Temporary, relatively small, localized, adverse impacts that would be limited to intakes near the site of ESH construction, although considerably more construction would be required with potentially more intakes affected compared to Alternative 1
Alternative 3	Increase in average annual net farm income of $15,000 or 0.2%; negligible change in net farm income as a result of the elimination of the spawning cue pulse.	Increase in average annual labor income of $4,000; increase in average annual employment of less than one job. Negligible changes in RED impacts	Negligible OSE Impacts	Negligible change from Alternative 1

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Alternative 3: Gavins Point One-Time Spawning Cue Test	Negligible to small, temporary, adverse impacts to net farm income from lower river stages and reservoir elevations associated with the one-time spawning cue test.	Negligible RED impacts from one-time implementation	Negligible OSE impacts from one-time implementation.	Not applicable
Alternative 4	Decrease in average annual net farm Income of $69,000 or -1.0%; negligible impacts in most locations and years; potential for small adverse impacts to counties bordering Lake Oahe and Lake Sakakawea from lower reservoir elevations following the spring release.	Decrease in average annual labor income of $14,000; decrease in average annual employment of less than one job. Negligible changes on average and in most years, with small adverse and beneficial RED impacts in some years as the reservoirs rebalance following the spring.	Negligible long-term OSE Impacts	Negligible change from Alternative 1
Alternative 5	Increase in average annual net farm income of $44,000 or 0.6%; negligible to small changes in NED impacts in the worst change years.	Increase in average annual labor income of $21,000 or 0.5%; increase in average annual employment of less than 1 job. Negligible changes in RED impacts	Negligible OSE Impacts	Negligible change from Alternative 1
Alternative 6	Decrease in average annual net farm income of $115,000 or -1.7 percent; negligible impacts in most locations and years; potential for small adverse impacts to counties bordering Lake Oahe and Lake Sakakawea and downstream of Fort Peck Dam from lower reservoir elevations and rivers flows associated with the spawning cue release.	Decrease in average annual labor income of $30,000; decrease in average annual employment of less than one job. Negligible changes on average and in most years, with small adverse and beneficial RED impacts in some years as the reservoirs rebalance following the spawning cue release.	Negligible long-term OSE Impacts	Negligible change from Alternative 1

3.14.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include predator management, vegetation management, and human restriction measures. These actions are not expected to have any impacts on irrigation intakes along the Missouri River.

3.14.2.4 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 represents current System operations including a number of management actions associated with MRRP implementation. Management actions under Alternative 1 include construction of both early life stage habitat and ESH habitat and a spring spawning cue release.

Mechanical Habitat Construction

Management focused on mechanical construction of ESH has the potential to adversely affect irrigation operations and impact irrigation intakes. For instance, constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in aggradation segments of the river. This can result in increased maintenance issues to irrigation intakes in areas of aggradation (USACE 2011a). Irrigation intakes are not expected to be impacted by the construction of early life stage habitat because the habitat would not be constructed in reaches of the river where irrigation is occurring.

The extent of these impacts would be dependent on where the MRRP actions occur relative to any irrigation intakes. The potential impacts of ESH construction on infrastructure such as irrigation intakes was evaluated in the *Final Programmatic Environmental Impact Statement for Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011a). The PEIS noted that in order to mitigate impacts of habitat creation, USACE would identify sensitive resource categories and subsequent protective or exclusionary zones associated with these resources. Site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources. Intakes and other infrastructure were one of the categories of sensitive resources.

ESH would be constructed in the Garrison reach from Garrison Dam to Lake Oahe and in the Gavins Point reach from Gavins Point Dam to Ponca Nebraska. The construction of habitat where irrigation intakes are located has the potential to cause temporary, small, and adverse impacts on irrigation intakes, although site specific planning would reduce these adverse effects. Because very few intakes are located below Ponca, Nebraska, there would be negligible impacts to irrigation impacts from early life stage habitat construction.

National Economic Development

Table 3-145 summarizes the NED analysis for Alternative 1. Overall, average annual net farm income for all 12 counties evaluated would be approximately $6.8 million. Much of the variation in annual net farm income is a result of the natural cycles of drought and high water conditions. Management actions under Alternative 1, including the spring pulse, would have a negligible contribution to reductions in net farm income because of the very small changes in river stages and reservoir elevations associated with the pulse.

Table 3-145. National Economic Development Analysis for Alternative 1, 2018 Dollars

State	County	Total Net Farm Income	Average Annual Net Farm Income
Montana	McCone	$82,220,000	$1,003,000
	Valley	$35,888,000	$438,000
	Roosevelt	$69,526,000	$848,000
	Richland	$99,631,000	$1,215,000
North Dakota	Williams	$45,721,000	$558,000
	McLean	$58,913,000	$718,000
	Mercer	$5,770,000	$70,000
	Oliver	$13,596,000	$166,000
	Burleigh	$30,488,000	$372,000
	Morton	$27,933,000	$341,000
	Emmons	$17,039,000	$208,000
South Dakota	Sully	$69,925,000	$853,000
Total		$556,650,000	$6,788,000

Regional Economic Development

The RED analysis for Alternative 1 estimated the employment, labor income, and sales supported from irrigated crop production in the 12 counties. The RED analysis estimated the direct, indirect, and induced economic activity resulting from gross sales of irrigated crops. Table 3-146 summarizes the economic contribution for all 12 counties evaluated. Under Alternative 1, irrigated agriculture would contribute on average 341 jobs, $14 million in labor income and $53 million in sales per year. Under the worst year modeled under Alternative 1, approximately 301 jobs would be supported, with $12 million in labor income and $45 million in sales. This reduction in jobs, labor income, and sales occurs during years of drought, especially as simulated in the 1930s; the spring pulse under Alternative 1 would not have a noticeable impact on these adverse impacts. Under the best year modeled in Alternative 1, 358 jobs would be supported, with $14 million labor income and $55 million in sales.

Table 3-146. Alternative 1 RED Analysis for Value of Irrigated Crop Production, 2018 Dollars

RED Metric	Average Annual Contribution	Worst Year Contribution	Best Year Contribution
Employment	340.8	300.6	358.1
Labor Income	$13,555,000	$11,612,000	$14,027,000
Total Sales	$52,698,000	$44,782,000	$54,802,000

Other Social Effects

Agriculture has historically been a critical economic component and way of life for many of the communities within the counties evaluated under this analysis. Compared to all irrigated acreage, the number of acres irrigated by the Missouri River would be relatively small, with less than eight percent of all irrigated acreage in the 12 counties relying on water from the Missouri

River. Alternative 1 could have a notable impact to farms that rely on the Missouri River during drought conditions as a source of water for irrigation, with the potential for adverse impacts to economic vitality, community well-being, and traditional ways of life. However, management actions under Alternative 1 would have a negligible contribution to Other Social Effects because of the very small change in river flows, reservoir elevations, and irrigation operations associated with the spring pulse.

Conclusion

Under current System operations, including the management actions associated with MRRP implementation, the Missouri River and the reservoirs will remain a viable source of water for irrigation operations with the majority of the irrigation occurring in the upper river. Relative to all irrigated acreage, the number of acres irrigated by the Missouri River under Alternative 1 would be relatively small, with less than eight percent of all irrigated acreage in the 12 counties relying on water from the Missouri River. Considering these conditions, farm operations using water from the Missouri River for irrigation in the 12 counties evaluated are expected on average to support over $6.8 million annually in NED benefits (net farm income). On average, this agricultural production would support 341 jobs, $13.6 million in labor income, and $52.7 million in sales under Alternative 1 annually. While net farm income would be lower particularly during drought conditions under Alternative 1, management actions under Alternative 1 would have negligible contribution to irrigation NED, RED and OSE impacts. In addition, the construction of ESH habitat has potential to cause temporary, small, and adverse impacts on irrigation intakes near the construction sites, although site specific planning would reduce these adverse effects. As there are very few intakes located below Ponca, Nebraska, there would be negligible impacts to irrigation impacts from early life stage habitat construction. Alternative 1 is not expected to have significant impacts on irrigation operations because management actions would have negligible to small adverse impacts on water access for irrigation.

3.14.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under an adaptive management plan. Actions in this alternative that may have impacts to irrigation intakes include a spawning cue release, low summer flow, and the construction of ESH.

Mechanical Habitat Construction

Considerably more ESH habitat construction would occur in the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches under Alternative 2 than under Alternative 1. Considerably more early life stage habitat construction would also occur between Ponca and the mouth of the Missouri River, near St. Louis, however, it is not expected to have any impacts on irrigation in these river reaches as farms do not tend to rely on irrigation from the Missouri River. Due to the large amount of ESH construction, it is likely that irrigation intakes located in the Garrison and Fort Randall reaches would have small short-term term adverse impacts from habitat construction, primarily as a result of sediment buildup and costs associated with relocating these intakes. However, impacts are small because USACE would seek to minimize impacts to sensitive resources (such as intakes) through site-specific planning.

National Economic Development

The NED results for Alternative 2 are summarized in Table 3-147. On average net farm income would total $6.7 million for all twelve counties per year under Alternative 2. This represents a slight decrease from Alternative 1 of $83,000 or -1.2 percent. On average, all counties under this alternative would experience negligible adverse impacts. However, in certain years, impacts would be small especially in certain counties that border Lake Sakakawea and Lake Oahe due to the spawning cue release decreasing lake elevations at these two reservoirs reducing access to water for irrigation. During the worst difference years from Alternative 1, the change in net farm income would be temporary and small across a number of counties, with Sully County experiencing a decrease of $238,000 in net farm income in the average of the eight worst difference years from Alternative 1. Irrigation in Richland County would experience decreases in net farm income in the eight worst difference years of $343,000. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to Alternative 1, many of these adverse impacts would be offset, resulting in very small changes in average annual net farm income under Alternative 2 relative to Alternative 1.

Table 3-147. Summary of National Economic Development Analysis for Alternative 2, 2018 Dollars

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	% Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)	% Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)
Montana	McCone	-0.2%	$1,001,000	-$2,000	$146,000	14.6%	-$140,000	-14.0%
	Valley	-0.3%	$436,000	-$1,000	$63,000	14.3%	-$64,000	-14.5%
	Roosevelt	-0.6%	$843,000	-$5,000	$209,000	24.6%	-$217,000	-25.6%
	Richland	-1.1%	$1,202,000	-$13,000	$287,000	23.6%	-$343,000	-28.3%
North Dakota	Williams	-0.3%	$556,000	-$2,000	$43,000	7.6%	-$52,000	-9.2%
	McLean	-0.4%	$715,000	-$3,000	$96,000	13.3%	-$108,000	-15.0%
	Mercer	-0.2%	$70,000	$,000	$33,000	46.4%	-$29,000	-40.8%
	Oliver	-3.2%	$160,000	-$5,000	$58,000	35.0%	-$102,000	-61.6%
	Burleigh	-1.1%	$368,000	-$4,000	$16,000	4.4%	-$57,000	-15.3%
	Morton	-0.7%	$338,000	-$2,000	$6,000	1.8%	-$30,000	-8.9%
	Emmons	-11.6%	$184,000	-$24,000	$72,000	34.5%	-$188,000	-90.7%
South Dakota	Sully	-2.4%	$832,000	-$21,000	$94,000	11.0%	-$238,000	-27.9%
Total		-1.2%	$6,705,000	-$83,000	$794,000	11.7%	-$817,000	-12.0%

Additional modeling results are summarized in Table 3-148, which shows the difference in annual net farm income during years when there is a release action or a low summer flow. Years of full release and low summer flow correspond to the years of highest impact, as shown in Table 3-148. The year of highest adverse impact (-$1.1 million) occurred in conditions similar to 1988, when reservoir elevations at Lake Sakakawea and Lake Oahe would decrease, and net farm income in McLean, Morton, Emmons Counties would decrease in particular relative to Alternative 1. The one-year decrease in net farm income for the most affected county (McLean County, with a decline of $467,000) in 1988 represents 0.3 percent of net cash farm income of all farming operations in that county ($149.8 million) (USDA 2012).[5]

Years with partial flow releases also correspond with lower annual net farm income. For example, the second-highest adverse impact year relative to Alternative 1 would occur in 2010, the year following a partial release when reservoir releases would be lower than under Alternative 1. In this year, adverse impacts would be more concentrated downstream of Fort Peck Lake, with reductions in net farm income occurring in Richland County (with a decrease of $726,000 relative to Alternative 1), neighboring Roosevelt County (with a decrease of $367,000), and McCone County (with a decrease of $230,000 relative to Alternative 1). The decrease in net farm income in Richland County would represent 1.7 percent of net cash farm income of all farm operations in the county ($41.5 million) (USDA 2012).

Increases in net farm income relative to Alternative 1 would also occur in some years, increasing by as much at $1.6 million across all counties (Table 3-148).

Table 3-148. Impacts from Modeled Flow Releases to Net Farm Income in the Twelve County Area under Alternative 2; Change in Net Farm Income Relative to Alternative 1, 2018 Dollars

Full Release + Lower Summer Flow [a]		Year After Full Release		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
Low	High	Low	High	Low	High	Low	High
-$1,105,635	$119,303	-$657,696	-$122,221	-$694,233	$309,939	-$1,105,635	$1,604,576

a Spawning cue releases and low summer flow events would be fulling implemented occur in three years of the POR. Data represents the lowest and highest dollar impacts in the years the action would be implemented. Negative values indicate reductions in net farm income relative to Alternative 1. It should be noted that the low summer flow event would also occur in the year following a full spawning cue release and low summer flow.

b Spawning cue release would be partially implemented in 31 years of the POR.

Regional Economic Development

For the 12 counties evaluated, employment would be reduced by an average of 1 job and $28,000 in labor income per year compared to Alternative 1 (Table 3-149). For the eight years with the greatest reduction in crop production relative to Alternative 1, there would be 40 fewer jobs on average across all 12 counties and labor income would decrease by $1.4 million. However, in the years with the greatest increase in net farm income relative to Alternative 1, there would be an increase in 34 jobs.

[5] Net cash farm income is the gross cash income—all income, such as crop value of production—minus any expenses, which would include raw materials, employees, and even payments on debt. This is a simpler estimation of net farm income as it does not include depreciation and amortization expenses.

McLean County would experience the greatest decrease in jobs and labor income relative to Alternative 1 during the average of the eight worst difference years of 26 jobs and $854,000, respectively, from the reduction in reservoir elevations following the spawning cue release at Lake Sakakawea. A reduction of 26 jobs represents approximately 3 percent of farm jobs (862 farm jobs) in McLean County in 2016 (U.S. Bureau of Economic Analysis 2016). On average, there would be negligible to small temporary changes in the RED effects with small increases and decreases in some years with the spawning cue releases and low summer flow events increasing and decreasing reservoir elevations and river flows and stages.

Table 3-149. Alternative 2 RED Analysis for Value of Irrigated Crop Production, 2018 Dollars

Economic Impact	Scenario	Total
Direct, indirect, and induced jobs	Average Annual	340.2
	Change in Average Annual from Alternative 1	-0.6
	Average of the Eight Best Difference Years Relative to Alternative 1	34.0
	Average of the Eight Worst Difference Years Relative to Alternative 1	-39.6
Direct, indirect, and induced labor income	Average Annual	$13,017,000
	Change in Average Annual from Alternative 1	-$28,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$1,152,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$1,373,000
Direct, indirect, and induced sales	Average Annual	$50,600,000
	Change in Average Annual from Alternative 1	-$116,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$4,486,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$5,460,000

Other Social Effects

Changes in irrigation operations have the potential to cause other types of effects, such as changes in community well-being, traditional ways of life, and economic vitality. On average, annual net farm income under Alternative 2 would decrease slightly relative to Alternative 1 as would employment, labor income, and sales. During certain years, these impacts would be small in some counties due to lower reservoir elevations and river stages. However, even during the worst difference years, reductions in net farm income would represent a small percentage of net cash farm income in counties affected. Alternative 2 would not likely result in long-term OSE impacts to communities or the region because NED and RED impacts would be negligible to small and temporary. However, short-term small adverse impacts to economic vitality and well-being could occur during a few years if reductions in irrigation are concentrated within the affected counties.

Conclusion

Farms using Missouri River water for irrigation would experience negligible to small adverse impacts to net farm income under Alternative 2 relative to Alternative 1. Across all of the counties, average annual net farm income is expected to decrease by $83,000 (-1.2 percent) under Alternative 2. For the 12 counties evaluated, employment would be reduced by an average of 1 job per year and approximately $28,000 in average annual labor income. Alternative 2 would not likely result in long-term OSE impacts to communities or the region because NED and RED impacts would be negligible to small and temporary. Farms that rely on the Missouri River for irrigation, especially those bordering Lake Sakakawea and Lake Oahe and downstream of Fort Peck Dam, could experience isolated adverse impacts in a few years, with short-term, small, adverse impacts to RED and OSE. Considerably more ESH habitat construction actions would occur in the Garrison, Fort Randall, and Gavins Point reaches under Alternative 2 than under Alternative 1. Due to the large amount of ESH construction, it is likely that irrigation intakes located in the Garrison and Fort Randall reaches would have short-term, localized, adverse impacts from habitat construction, primarily as a result of sediment buildup and costs associated with relocating these intakes. Impacts to irrigation would not be significant because on average in most years, there would be negligible to small impacts to NED, RED, and OSE, and adverse impacts would be temporary.

3.14.2.6 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include the construction of ESH and early life stage habitat through mechanical means. Reoccurring flow releases or pulses would not be implemented under this alternative.

Mechanical Habitat Construction

Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, these adverse impacts are expected to be temporary and small because site specific planning would seek to reduce impacts to sensitive infrastructure. Early life stage habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches.

National Economic Development

Under Alternative 3, average annual net farm income would be approximately $6.8 million (Table 3-150). This represents a small increase in average annual net farm income relative to Alternative 1 of $15,000 for all 12 counties, an increase of 0.2 percent. In general, the benefits of Alternative 3 would be the result of the elimination of the spawning cue release under Alternative 1, which would result in small increases in net farm income under Alternative 3. The highest beneficial impact would occur in conditions similar to 1955, when net farm income in Sully County would increase by $197,000 relative to Alternative 1.

Small decreases in net farm income would occur in some years relative to Alternative 1, but would be more than offset by increases in net farm income in other years. The highest adverse impact would occur under conditions similar to those modeled in 2008. Flows out of Fort Peck Lake would very briefly decrease under Alternative 3 relative to Alternative 1 and affect access to irrigation. Overall, the changes in net farm income would be negligible and beneficial because of continued access to water for irrigation and only minor changes in annual irrigation operations and net farm income compared to Alternative 1.

Table 3-150. Summary of National Economic Development Analysis for Alternative 3, 2018 Dollars

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	% Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)	% Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)
Montana	McCone	0.1%	$1,004,000	$1,000	$23,000	2.3%	-$11,000	-1.1%
	Valley	0.1%	$438,000	$1,000	$11,000	2.5%	-$4,000	-0.9%
	Roosevelt	0.1%	$849,000	$1,000	$42,000	4.9%	-$29,000	-3.5%
	Richland	-0.1%	$1,214,000	-$1,000	$62,000	5.1%	-$74,000	-6.1%
North Dakota	Williams	0.0%	$558,000	$,000	$4,000	0.8%	-$3,000	-0.6%
	McLean	-0.1%	$718,000	-$1,000	$3,000	0.4%	-$10,000	-1.4%
	Mercer	0.0%	$70,000	$,000	$2,000	3.3%	-$3,000	-3.7%
	Oliver	-0.1%	$166,000	$,000	$15,000	9.1%	-$16,000	-9.5%
	Burleigh	-0.1%	$371,000	$,000	$1,000	0.3%	-$5,000	-1.2%
	Morton	-0.1%	$340,000	$,000	$1,000	0.3%	-$4,000	-1.1%
	Emmons	2.8%	$214,000	$6,000	$48,000	23.2%	-$9,000	-4.5%
South Dakota	Sully	1.1%	$862,000	$10,000	$111,000	13.0%	-$34,000	-4.0%
Total		0.2%	$6,804,000	$15,000	$183,000	2.7%	-$128,000	-1.9%

Notes: Numbers and percentages shown in tables are the result of a first level of rounding; there may be instances where results are not replicable through recalculation of values shown here.

Regional Economic Development

On average, the change in RED effects would result in an average increase in annual employment of less than one job and an increase in labor income of $4,000 across all twelve counties (Table 3-151). Alternative 3 would result in negligible RED impacts relative to Alternative 1. On average, approximately half of the counties in this analysis (seven) experience small, beneficial impacts in economic activity, while the other half experience small, adverse impacts. During the eight worst difference years relative to Alternative 1, the average annual number of jobs for all twelve counties would decrease by 4, and labor income would decrease by $153,000. McLean County would experience the greatest decrease in employment and labor income relative to Alternative 1 of 2 jobs and $78,000, respectively, during the average of the eight worst change years.

Table 3-151. Alternative 3 RED Analysis for Value of Irrigated Crop Production, 2018 Dollars

Economic Impact	Scenario	Total
Direct, indirect, and induced jobs	Average Annual	340.9
	Change in Average Annual from Alternative 1	0.1
	Average of the Eight Best Difference Years Relative to Alternative 1	30.4
	Average of the Eight Worst Difference Years Relative to Alternative 1	-4.3
Direct, indirect, and induced labor income	Average Annual	$13,049,000
	Change in Average Annual from Alternative 1	$4,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$1,005,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$153,000
Direct, indirect, and induced sales	Average Annual	$50,737,000
	Change in Average Annual from Alternative 1	$21,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$4,055,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$592,000

Other Social Effects

Annual net farm income would vary the least under Alternative 3, relative to Alternative 1, with on average an increase in annual net farm income of $15,000 (0.2 percent). RED impacts would be negligible under Alternative 3 relative to Alternative 1. Negligible to very small changes in NED and RED under Alternative 3 would result in negligible OSE impacts; the changes would likely have no impact to communities located along the Missouri River.

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release that may be implemented under Alternative 3 was not included in the hydrologic modeling for the alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Flows equivalent to the one-time spawning cue test were modeled for multiple years in the period of record under Alternative 6. Impacts to irrigators under Alternative 6 were described on average as negligible to small, temporary, and adverse. On an annual basis, the adverse impacts tend to be greatest in years with a full or partial release and years after a full release, especially with the onset of drought conditions. Because Alternative 6 modeling results show a small increase in the number of days falling below irrigation operating thresholds in the period of record, the one-time implementation of the pulse would likely cause small temporary adverse impacts to irrigation intakes in the year the one-time spawning cue test is implemented and potentially 1 to 2 years following the test flow when the reservoir levels are relatively lower than under Alternative 1. Impacts to RED and OSE would likely be negligible because the test release would only be implemented once under Alternative 3.

Conclusion

On average, farms using Missouri River water for irrigation would experience a slight increase in net farm income of $15,000 (0.2 percent) under Alternative 3 relative to Alternative 1 as a result of the elimination of the spawning cue release under Alternative 3. Overall, the change in NED would be negligible even in the best and worst change years relative to Alternative 1. There would be negligible changes in RED and OSE impacts relative to Alternative 1 because irrigation operations would not noticeably be affected under Alternative 3. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, these adverse impacts are expected to be temporary and small as site-specific planning would seek to reduce impacts to sensitive infrastructure. Impacts to irrigation would not be significant because impacts to irrigation operations, NED, RED, and OSE would be negligible and construction impacts on irrigation intakes would be temporary, small, and adverse.

3.14.2.7 Alternative 4 – Spring ESH Creating Release

Management actions under Alternative 4 would include the construction of ESH and early life stage habitat through mechanical means. Alternative 4 also includes a spring release in April and May to create ESH.

Mechanical Habitat Construction

Early life stage habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would seek to avoid or minimize impacts to sensitive infrastructure.

National Economic Development

The NED analysis for Alternative 4 is summarized in Table 3-152. Overall, Alternative 4 would have a small, adverse impact on irrigation relative to Alternative 1, with average annual net farm income of $6.7 million, a slight decrease of $69,000 from Alternative 1 (1.0 percent). Adverse impacts under Alternative 4 would occur in the counties bordering Lake Sakakawea (Williams, Mercer, and McLean) and Lake Oahe (Sully) in the years of or following the spring release, which reduces the reservoir elevations during the irrigation seasons. On average, the counties in Montana would experience small increases in annual net farm income during the releases that would partly occur during the growing seasons, resulting in an increase in water access for irrigation in the Montana counties. In the eight worst difference years, decreases in net farm income range from $14,000 to $402,000 with Sully County experiencing the greatest decrease in the worst difference years compared to Alternative 1. However, during the best difference years, with increased net farm income compared to Alternative 1, many of these adverse impacts would be offset, resulting in very small changes on average to net farm income under Alternative 4 relative to Alternative 1.

Table 3-152. Summary of National Economic Development Analysis for Alternative 4, 2018 Dollars

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	% Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)	% Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)
Montana	McCone	1.1%	$1,014,000	$11,000	$127,000	12.7%	-$37,000	-3.7%
	Valley	1.3%	$443,000	$6,000	$65,000	14.8%	-$14,000	-3.3%
	Roosevelt	1.6%	$862,000	$14,000	$175,000	20.6%	-$76,000	-8.9%
	Richland	1.5%	$1,233,000	$18,000	$249,000	20.5%	-$119,000	-9.8%
North Dakota	Williams	-3.0%	$541,000	-$17,000	$4,000	0.7%	-$110,000	-19.7%
	McLean	-1.2%	$710,000	-$9,000	$65,000	9.0%	-$128,000	-17.8%
	Mercer	-11.9%	$62,000	-$8,000	$9,000	12.6%	-$56,000	-79.2%
	Oliver	-1.9%	$163,000	-$3,000	$45,000	26.9%	-$66,000	-40.0%
	Burleigh	-1.2%	$367,000	-$4,000	$10,000	2.6%	-$53,000	-14.2%
	Morton	-0.9%	$338,000	-$3,000	$1,000	0.4%	-$32,000	-9.4%
	Emmons	-11.5%	$184,000	-$24,000	$43,000	20.9%	-$183,000	-88.1%
South Dakota	Sully	-5.9%	$803,000	-$50,000	$41,000	4.8%	-$402,000	-47.1%
Total		-1.0%	$6,719,000	-$69,000	$621,000	9.1%	-$808,000	-11.9%

Table 3-153 summarizes changes in net farm income associated with different flow events compared to Alternative 1. The most adverse impacts to net farm income would occur during full release events when releases are followed by the onset of a drought or relatively drier conditions, with a decrease across all counties of $1.6 million. In conditions similar to 1963, a full release would be implemented. Low flow out of Fort Peck during the growing season would adversely impact the four counties located in Montana by as much as $277,000 for all four counties. In addition, the counties bordering Lake Oahe and Lake Sakakawea (Sully, Mercer, McLean, and Williams) would be adversely impacted in this year. The highest adverse impact would occur in Sully County, with a decrease of $896,000 due to low reservoir elevations on Lake Oahe. In Sully County, $896,000 would represent approximately 1.2 percent of net cash farm income of all operations ($76.1 million) (USDA 2012). The second-highest year of adverse impact ($1.1 million) would occur in conditions similar to 1964, when the reservoirs would be lower following the full spawning cue release in 1963.

Years with increases in net farm income compared to Alternative 1 would also occur as the reservoirs rebalance after the spring release, with the greatest increase in net farm income of $1.5 million across all counties. The counties that would experience the highest beneficial impact relative to Alternative 1 are located downstream of Fort Peck Dam in Montana (Valley, Roosevelt, Richland, and McCone counties).

Table 3-153. Impacts to Net Farm Income in the Twelve County Area from Modeled Flow Releases under Alternative 4; Change in Net Farm Income Relative to Alternative 1, 2018 Dollars

Full Release [a]		Year After Full Release		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
Low	High	Low	High	Low	High	Low	High
-$1,638,763	$255,112	-$1,103,359	$1,501,312	-$661,462	$381,149	-$1,638,763	$1,501,312

Note: Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a decrease in net farm income compared to Alternative 1.

a The spring release would be fully implemented in 9 years of the POR.

b Flow action would be partially implemented in 7 years of the POR.

Regional Economic Development

On average, the change in RED effects would result in an average decrease in annual employment of less than one job and a reduction in labor income of $14,000 across all twelve counties (Table 3-154). In the average of the eight worst difference years, labor income would be $1.4 million lower than Alternative 1, and the number of jobs would decrease by 40. The largest adverse RED effects would occur from decreases in reservoir elevations at Lake Sakakawea following the spring release. McLean County would experience the greatest decrease in employment and labor income relative to Alternative 1, with a decrease of 31 jobs and $1.0 million, respectively, in the worst change year. Thirty-one jobs represent 3.6 percent of all part- and full-time jobs in McLean County (862 jobs) in 2016 (U.S. Bureau of Economic Analysis 2016). Impacts would be negligible to small and adverse in most counties on average and in most years. In a couple of years, there could be notable RED impacts in McLean and Sully counties, especially if concentrated in a specific region within the counties. However, the impacts are anticipated to be temporary and would be offset by a number of years when there would be increases in RED effects compared to Alternative 1.

Table 3-154. Alternative 4 RED Analysis for Value of Irrigated Crop Production, 2018 Dollars

Economic Impact	Scenario	Total
Direct, indirect, and induced jobs	Average Annual Employment	340.6
	Change in Average Annual Employment from Alternative 1	-0.2
	Average of the Eight Best Difference Years Relative to Alternative 1	24.1
	Average of the Eight Worst Difference Years Relative to Alternative 1	-39.7
Direct, indirect, and induced labor income	Average Annual Labor Income	$13,031,000
	Change in Average Annual Labor Income from Alternative 1	-$14,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$817,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$1,376,000
Direct, indirect, and induced sales	Average Annual Sales	$50,625,000
	Change in Average Annual Sales from Alternative 1	-$91,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$3,138,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$5,630,000

Other Social Effects

On average, annual net farm income under Alternative 4 would decrease slightly relative to Alternative 1 as would employment, labor income, and sales. During certain years, the NED and RED impacts would be notable in a few counties due to lower reservoir levels following the spring release. However, even during the worst difference years, reductions in net farm income and employment would represent a small percentage of net cash farm income and farm employment in counties affected. Alternative 4 would not likely result in long-term OSE impacts to communities or the region because NED and RED impacts would be negligible to small and temporary. Farms that rely on the Missouri River for irrigation, especially those bordering Lake Sakakawea and Lake Oahe, could experience isolated adverse impacts in a few years, with short-term small adverse impacts to economic vitality and well-being.

Conclusion

Farms using Missouri River water for irrigation would experience negligible to small adverse impacts to net farm income under Alternative 4 relative to Alternative 1. Overall, average annual net farm income is expected to decrease by $69,000 (-1.0 percent) under Alternative 4. For the 12 counties evaluated, employment would be reduced by an average of one job per year and approximately $14,000 in average annual labor income. The worst difference years from Alternative 1 would result in small adverse impacts in RED and NED. Alternative 4 would not likely result in long-term OSE impacts to communities or the region because NED and RED impacts would be negligible to small and temporary. Farms that rely on the Missouri River for irrigation, especially those bordering Lake Sakakawea and Lake Oahe, could experience isolated adverse impacts in a few years, with short-term small adverse impacts to RED and OSE in a few years. Additional ESH habitat construction would occur in the Garrison, Fort Randall, and Gavins Point reaches under Alternative 4 compared to Alternative 1, with temporary, small, and adverse impacts to intakes associated with sediment, although site-specific planning would seek to minimize or avoid adverse impacts to this infrastructure. Impacts to irrigation would not be significant because on average in most years, there would be negligible impacts to NED, RED, and OSE, and adverse impacts would be temporary and small.

3.14.2.8 Alternative 5 – Fall ESH Creating Release

Management actions under Alternative 5 would include the construction of ESH and early life stage habitat through mechanical means. Alternative 5 also includes a fall release to create ESH habitat.

Mechanical Habitat Construction

Early life stage habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches compared to Alternative 1. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would seek to reduce impacts to sensitive infrastructure.

National Economic Development

Under Alternative 5, average annual net farm income would be approximately $6.8 million, an increase of $44,000 (0.6 percent) for all twelve counties relative to Alternative 1 (Table 3-155). In general, there would be negligible to small increases in net farm income in the Montana counties downstream of Fort Peck Dam, associated with the fall release. There would be negligible to small decreases in net farm income in a couple of years following the fall releases for irrigation operations on the counties bordering Lake Sakakawea and Lake Oahe. Releases from Fort Peck Dam associated with the implementation of the fall release would increase river stages and flows during the growing season below Fort Peck Dam, with small increases in net farm income for irrigators in the Montana counties under these conditions. However, in a few years following the fall release, reservoir elevations at Lake Oahe and Lake Sakakawea would be lower than under Alternative 1, with adverse impacts to net farm income to operations in counties that border these reservoirs. In the eight worst difference years, decreases in net farm income range from $3,000 to $83,000 with negligible changes even in the worst change years. However, during the best difference years, with increased net farm income compared to Alternative 1, these adverse impacts would be offset, resulting in very small increases on average in net farm income under Alternative 5 relative to Alternative 1.

Table 3-155. Summary of National Economic Development Analysis for Alternative 5, 2018 Dollars

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	% Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)	% Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)
Montana	McCone	0.8%	$1,011,000	$8,000	$94,000	9.4%	-$20,000	-2.0%
	Valley	1.0%	$442,000	$4,000	$46,000	10.5%	-$5,000	-1.1%
	Roosevelt	1.7%	$862,000	$14,000	$151,000	17.8%	-$29,000	-3.4%
	Richland	1.9%	$1,238,000	$23,000	$231,000	19.0%	-$38,000	-3.1%
North Dakota	Williams	-0.6%	$554,000	-$3,000	$8,000	1.5%	-$34,000	-6.1%
	McLean	-0.2%	$717,000	-$2,000	$19,000	2.6%	-$36,000	-5.0%
	Mercer	-1.7%	$69,000	-$1,000	$6,000	8.8%	-$16,000	-23.0%
	Oliver	-0.9%	$164,000	-$2,000	$25,000	15.2%	-$41,000	-24.5%
	Burleigh	0.0%	$372,000	$,000	$5,000	1.4%	-$5,000	-1.2%
	Morton	0.0%	$341,000	$,000	$2,000	0.7%	-$3,000	-1.0%
	Emmons	-1.0%	$206,000	-$2,000	$47,000	22.7%	-$83,000	-39.9%
South Dakota	Sully	0.5%	$857,000	$4,000	$96,000	11.3%	-$71,000	-8.3%
Total		0.6%	$6,833,000	$44,000	$529,000	7.8%	-$224,000	-3.3%

Table 3-156 summarizes changes in net farm income associated with different flow events compared to Alternative 1. The greatest increases in net farm income would occur during the years when there would be a full release simulated to occur, with most of the beneficial effects to irrigation occurring in Montana counties when river stages and flows are relatively higher under Alternative 5.

The year of highest adverse impact to net farm income relative to Alternative 1 would occur under conditions similar to 1988, in the year following a full release when reservoirs and river stages would be lower than under Alternative 1. Adverse impacts would be highest for the counties located downstream of Fort Peck Lake, ranging from a decrease of $176,000 in Richland County to a decrease of $37,000 in Williams County. In 1984, the year following a fall release, McLean County would be the most adversely impacted county, with a decrease of $129,000 in net farm income relative to Alternative 1.

The greatest increases in net farm income would occur during the full release years and the years following full releases, when releases from Fort Peck Dam would be higher than under Alternative 1, with small increases in net farm income for irrigators in the Montana counties.

Table 3-156. Impacts to Net Farm Income in the Twelve County Area from Modeled Flow Releases under Alternative 5; Change in Net Farm Income Relative to Alternative 1, 2018 Dollars

Full Release [a]		Year After Full Release		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
Low	High	Low	High	Low	High	Low	High
-$7,403	$1,173,733	-$703,302	$1,078,897	$8,333	$8,333	-$703,302	$1,173,733

Note: Data represents the lowest and highest dollar impacts in the years the action would be implemented. Negative values indicate reductions in net farm income relative to Alternative 1.

a The fall release would be fully implemented in 7 years.

b The fall release would be partially implemented in 2 years.

Regional Economic Development

On average, the change in RED effects would result in an average increase in annual employment of less than one job and an increase in labor income of $21,000 across all twelve counties (Table 3-157). In the average of the eight worst difference years, labor income would be $391,000 million lower than Alternative 1, and the number of jobs would decrease by 11. McLean County would experience the greatest decrease in employment and labor income of 9 jobs and $285,000, respectively, in the worst change year compared to Alternative 1. Nine jobs represent 1.0 percent of all part- and full-time jobs in McLean County (862 jobs) in 2016 (U.S. Bureau of Economic Analysis 2016). On average and in all years, RED impacts would be negligible and beneficial and adverse depending on the location of the counties because of the small change in irrigation operations under Alternative 5.

Table 3-157. Alternative 5 RED Analysis for Value of Irrigated Crop Production, 2018 Dollars

Economic Impact	Scenario	Total
Direct, indirect, and induced jobs	Average Annual Employment	341.4
	Change in Average Annual Employment from Alternative 1	0.5
	Average of the Eight Best Difference Years Relative to Alternative 1	12.1
	Average of the Eight Worst Difference Years Relative to Alternative 1	-11.4
Direct, indirect, and induced labor income	Average Annual Labor Income	$13,066,000
	Change in Average Annual Labor Income from Alternative 1	$21,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$435,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$391,000
Direct, indirect, and induced sales	Average Annual Sales	$50,781,000
	Change in Average Annual Sales from Alternative 1	$65,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$1,618,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$1,609,000

Other Social Effects

OSE impacts under Alternative 5 would be similar to Alternative 1. Actions under this alternative would affect a very small percentage of net cash farm income from all operations, and OSE impacts would be negligible under this alternative because of the very small changes in NED and RED effects.

Conclusion

On average, farms using Missouri River water for irrigation would experience a slight increase in net farm income of $44,000 (0.6 percent) under Alternative 5 relative to Alternative 1 primarily associated with higher releases from Fort Peck Dam associated with the fall releases increasing net farm income for irrigators located in Montana below the dam. Overall, the change in NED would be negligible and beneficial and adverse depending on the location and the year. There would be negligible changes to RED impacts in most years and locations; OSE impacts under Alternative 1 would be negligible because irrigation operations would only have small NED and RED impacts in a few years. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, these adverse impacts are expected to be temporary and small as site-specific planning would seek to reduce impacts to sensitive infrastructure. Alternative 5 is not expected to have significant impacts on irrigation operations because of the negligible to small changes compared to Alternative 1.

3.14.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Management actions under Alternative 6 would include the construction of ESH and early life stage habitat through mechanical means. Alternative 6 also includes a spawning cue release to support the pallid sturgeon.

Mechanical Habitat Construction

Early life stage habitat construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis, and irrigation intakes are not expected to be impacted by actions in these reaches. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches. Although there are irrigation intakes in these reaches, the impacts are expected to be temporary and small because site specific planning would avoid or minimize impacts to sensitive infrastructure.

National Economic Development

Under Alternative 6, average annual net farm income would be $6.67 million, a decrease of $115,000 relative to Alternative 1 (-1.7 percent) (Table 3-158). Sully County would experience the greatest average annual decrease in net farm income (-$75,000) associated with reduced lake elevations at Lake Oahe following the spawning cue release. To a lesser extent, North Dakota counties bordering Lake Sakakawea would also experience small adverse reductions in net farm income from relatively lower reservoir elevation following the spawning cue release. In the average of the eight worst years, Sully County would experience a decrease in net farm income of $523,000. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to Alternative 1, many of these adverse impacts would be offset, resulting in very small changes on average to net farm income under Alternative 6 relative to Alternative 1.

Table 3-158. Summary of National Economic Development Analysis for Alternative 6, 2018 Dollars

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	% Increase during eight greatest crop production value years compared to Alternative 1 (average annual)	Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)	% Decrease during eight lowest crop production value years compared to Alternative 1 (average annual)
Montana	McCone	0.4%	$1,007,000	$4,000	$101,000	10.1%	-$67,000	-6.7%
	Valley	0.5%	$440,000	$2,000	$50,000	11.5%	-$29,000	-6.7%
	Roosevelt	1.3%	$859,000	$11,000	$178,000	21.0%	-$102,000	-12.0%
	Richland	1.0%	$1,227,000	$12,000	$251,000	20.7%	-$185,000	-15.2%
North Dakota	Williams	-0.9%	$552,000	-$5,000	$8,000	1.5%	-$34,000	-6.1%
	McLean	-1.6%	$707,000	-$11,000	$10,000	1.4%	-$107,000	-14.8%
	Mercer	-6.5%	$66,000	-$5,000	$4,000	6.3%	-$29,000	-41.6%
	Oliver	-3.7%	$160,000	-$6,000	$15,000	9.3%	-$63,000	-38.2%
	Burleigh	-0.6%	$369,000	-$2,000	$7,000	2.0%	-$29,000	-7.8%
	Morton	-0.4%	$339,000	-$1,000	$3,000	0.9%	-$15,000	-4.3%
	Emmons	-18.7%	$169,000	-$39,000	$29,000	13.9%	-$229,000	-110.3%
South Dakota	Sully	-8.8%	$778,000	-$75,000	$9,000	1.0%	-$523,000	-61.4%
Total		-1.7%	$6,674,000	-$115,000	$498,000	7.3%	-$921,000	-13.6%

Table 3-159 summarizes changes in net farm income tied to different flow events relative to Alternative 1. Full releases would result in adverse impacts to net farm income. As simulated in 1963, a full release would occur under Alternative 6. The counties in Montana would experience adverse impacts during this year, with decreases in net income as large as $277,000 relative to Alternative 1. However, reservoir elevations at Lake Oahe would decrease by as much as 8 feet during this year relative to Alternative 1, and Sully County would experience the highest adverse impact to net farm income with a decrease of $961,000. This decrease in net income would represent 1.4 percent of net cash farm income of all farming operations in Sully County (USDA 2012).

The year of highest adverse impact to net farm income relative to Alternative 1 would occur under conditions similar to 2010, the year following a partial release, when net farm income would be $1.8 million lower than under Alternative 1. During reservoir rebalancing, the counties in Montana would be adversely impacted relative to Alternative 1 as a result of lower releases from Fort Peck Dam, with decreases in net farm income ranging from $39,000 to $574,000 relative to Alternative 1. The decrease in Richland County, the county to experience the largest adverse impact in this year, would equal a decrease of 1.5 of net cash farm income of all operations in that county (USDA 2012).

Generally, the greatest increases in net farm income relative to Alternative 1 would occur in the counties in Montana. In several years over the POR river stages downstream of Fort Peck are higher as releases increase during reservoir rebalancing in the years following full and partial releases. The greatest increase in net farm income would occur in 1983, with an increase of $1.3 million in net farm income compared to Alternative 1. This is particularly true for Richland County, which would experience an increase of $638,000 in net farm income relative to Alternative 1, which would account for 1.7 percent of net cash farm income of all farming operations in that county (USDA 2012).

Table 3-159. Impacts to Net Farm Income in the Twelve County Area from Modeled Flow Releases under Alternative 6; Change in Net Farm Income Relative to Alternative 1, 2018 Dollars

Full Release [a]		Year After Full Release		Partial Flow Release [b]		Years with Greatest Range in Impacts Regardless of Flow Actions	
Low	High	Low	High	Low	High	Low	High
-$1,686,313	-$234,197	-$1,074,027	-$8,268	-$654,960	$1,071,640	-$1,863,480	$1,305,152

Note: Data represents the lowest and highest dollar impacts in the years the action would be implemented. Negative values indicate reductions in net farm income relative to Alternative 1.

a Spawning cue release would be fully implemented in 6 years.

b The spawning cue release was partially implemented in 29 years (partial implementation years are defined as years when a partial cue in March and/or May would occur OR years when a full cue in March or May would occur).

Regional Economic Development

The twelve counties evaluated would experience small, adverse RED impacts under Alternative 6. On average the change in economic activity would lead to a decrease in annual employment of less than one job and a reduction in labor income of $30,000 across all twelve counties (Table 3-160).

RED impacts under Alternative 6 are mixed relative to Alternative 1, with counties in Montana experiencing a slight increase and all other counties experiencing slight decrease in jobs, income, and sales. During the modeled worst eight difference years relative to Alternative 1, employment would decrease by 35.6 jobs across all twelve counties, and labor income would decrease by $1.3 million (Table 3-160). McLean County would experience the greatest annual decrease in employment and labor income relative to Alternative 1, with a decrease of 26 jobs and $847,000, respectively.

On average, the change in RED effects would result in an average decrease in annual employment of less than one job and a reduction in labor income of $30,000 across all twelve counties (Table 3-160). In the average of the eight worst difference years, labor income would be $1.1 million lower than Alternative 1, and the number of jobs would decrease by 36. The largest adverse RED effects would occur from decreases in reservoir elevations at Lake Sakakawea and Lake Oahe following the spawning cue release. McLean County would experience the greatest decrease in employment and labor income relative to Alternative 1, with a decrease of 26 jobs and $847,000, respectively, during the average of the eight worst change years relative to Alternative 1. Twenty-six jobs represent 3.0 percent of all part- and full-time jobs in McLean County (862 jobs) in 2016 (U.S. Bureau of Economic Analysis 2016). Impacts would be negligible to small and adverse in most counties on average and in most years. In a couple of years, there could be notable RED impacts in McLean and Sully counties as well as the four Montana counties, especially if concentrated in a specific region within the counties. However, the impacts are anticipated to be temporary and would be offset by a number of years when there would be increases in RED effects.

Table 3-160. Alternative 6 RED Analysis for Value of Irrigated Crop Production, 2018 Dollars

Economic Impact	Scenario	Total
Direct, indirect, and induced jobs	Average Annual Employment	340.4
	Change in Average Annual Employment from Alternative 1	-0.5
	Average of the Eight Best Difference Years Relative to Alternative 1	10.0
	Average of the Eight Worst Difference Years Relative to Alternative 1	-35.6
Direct, indirect, and induced labor income	Average Annual Labor Income	$13,015,000
	Change in Average Annual Labor Income from Alternative 1	-$30,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$355,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$1,274,000
Direct, indirect, and induced sales	Average Annual Sales	$50,560,000
	Change in Average Annual Sales from Alternative 1	-$156,000
	Average of the Eight Best Difference Years Relative to Alternative 1	$1,258,000
	Average of the Eight Worst Difference Years Relative to Alternative 1	-$5,200,000

Other Social Effects

On average, annual net farm income under Alternative 6 would decrease slightly relative to Alternative 1 as would employment, labor income, and sales. During certain years, the NED and RED impacts would be notable in a few counties due to lower reservoir levels following the spring release and lower river stages from lower releases out of Fort Peck Dam. However, even during the worst difference years, reductions in net farm income and employment would represent a small percentage of net cash farm income and farm employment in counties affected. Alternative 6 would not likely result in long-term OSE impacts to communities or the region because NED and RED impacts would be negligible to small and temporary. Farms that rely on the Missouri River for irrigation, especially those bordering Lake Sakakawea and Lake Oahe, could experience isolated adverse impacts in a few years, with short-term small adverse impacts to economic vitality and well-being.

Conclusion

Farms using Missouri River water for irrigation would experience negligible to small adverse impacts to net farm income under Alternative 6 relative to Alternative 1. Overall, average annual net farm income is expected to decrease by $115,000 (-1.7 percent) under Alternative 6. For the 12 counties evaluated, employment would be reduced by an average of one job per year and approximately $30,000 in average annual labor income. The worst difference years from Alternative 1 would result in small adverse impacts in RED and NED. Alternative 6 would not likely result in long-term OSE impacts to communities or the region because NED and RED impacts would be negligible to small and temporary. Farms that rely on the Missouri River for irrigation, especially those bordering Lake Sakakawea and Lake Oahe and downstream of Fort Peck Dam, could experience isolated adverse impacts in a few years, with temporary small adverse impacts to RED and OSE in a few years. Additional ESH habitat construction would occur in the Garrison, Fort Randall, and Gavins Point reaches under Alternative 6 compared to Alternative 1, with temporary, small, and adverse impacts to intakes associated with sediment, although site-specific planning would seek to minimize or avoid adverse impacts to this infrastructure. Impacts to irrigation would not be significant because on average in most years, there would be negligible to small impacts to NED, RED, and OSE, and adverse impacts would be temporary.

3.14.2.10 Tribal Effects

Tribal lands are located below Fort Peck Dam in Roosevelt and Valley counties. Tribal land held by sovereign nations in these two counties represent 73.9 percent and 22.2 percent of all county land, respectively (USGS 2012a). It is likely that any Tribal intakes in these areas would experience similar impacts to those described in the NED, RED, and OSE analysis above. Tribal land is also located adjacent to Sully County, McLean County, Morton County, Emmons County, and Mercer County. In these areas, Tribal entities involved with irrigation operations may experience similar impacts to those realized in the counties being evaluated. As a result, the change in economic activity and net farm income in Roosevelt, Valley, Sully, Emmons, and Mercer counties could be of importance to Tribes.

3.14.2.11 Climate Change

Section 3.2.2.7 has a summary of the climate change assessment, and the "Climate Change Assessment - Missouri River Basin" report is available online (www.moriverrecovery.org). In addition, the main climate change consequences under the various alternatives are summarized in Table 3-7.

In the future, climate change would have an increasing influence on irrigators. Earlier spring snowmelt and lower summer flows could reduce irrigators' access to water. More irregular rainfall could also result in irrigators needing to rely more on the Missouri River and other water sources for irrigation. With earlier spring runoff, there could be more frequent and larger spring and fall release events under Alternatives 2, 4, 5, and 6 compared to Alternative 1, which could reduce access to water for irrigators in the years following the releases in the upper three reservoirs especially during relatively drier conditions. Larger, more sporadic rain events could adversely impact irrigation intakes through sediment deposition; these impacts could be exacerbated during spring or fall releases under Alternatives 2, 4, 5, and 6. Longer duration of lower river flows may adversely impact access to water for irrigation. With earlier snowmelt, the fall releases under Alternative 5 may not be able to run as frequently with climate change because mid-summer System storage may be lower, with some benefits to irrigation intakes.

3.14.2.12 Cumulative Impacts

The Missouri River Mainstem Reservoir System, along with controlled flow releases from the upper river into the lower river, fulfills multiple management objectives, including providing water for irrigators along the Missouri River. Natural variability in hydrologic conditions (precipitation and snowmelt, which include periods of drought and high runoff) and the “rules” governing System operation would continue to dominate the flows in the Missouri River into the future. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impact to irrigation access of the Missouri River. However, other actions and programs, such as water depletions or withdrawals for water supply, municipal, and industrial uses have and would continue to have adverse impacts to irrigation access, as they would notably affect the water surface elevations and flows of the river and reservoirs.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses (Section 3.2), the elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in year 15 under all alternatives compared to year 0. The change in stage in the riverine areas in year 15 in the inter-reservoir river reaches and the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. Higher reservoir elevations could have some benefits to irrigation access in these locations, but adverse impacts from sediment clogging intakes could also occur.

Furthermore, many of the mechanical intakes may be nearing the end of their useful life and will require further investments to continue operation. Other changes in the reliability of the Missouri River as a water source may further encourage irrigators to turn to other sources of water, such as groundwater adjacent to the Missouri River, or turn to other farming methods. Depending on the frequency and duration of these impacts, irrigation operators may realize an increase in costs associated with moving intakes more frequently, pumping, and/or cleaning screens when intakes become clogged with sediment.

Cumulative actions that impact agricultural operations include federal technical and financial assistance programs such as Environmental Quality Incentives Program, which support the replacement or upgrade of existing irrigation intakes, or expand the number of acres irrigated as more water becomes available (Nixon 2013; Waas 2015).

State and federal regulations governing water quality have the potential to create adverse impacts and impose additional costs to farm operations including irrigated agriculture. Non-point source agricultural runoff was not included in the 2015 EPA Clean Water Act rulemaking, but as national attention is increasingly focused on the Gulf of Mexico’s dead zone and toxic blooms in the country's lakes, it is likely that states would increase restrictions on non-point source agricultural runoff in the future which potentially could lead to fewer irrigated acres using Missouri River water in the future (EPA 2015e).

Under Alternative 1, existing geomorphological processes and trends would continue, consisting primarily of river degradation and bank erosion, reservoir sediment deposition and aggradation, shoreline erosion in reservoirs, and ice dynamics. Along the stretches of river still used for irrigation (primarily upriver of Lewis and Clark lake), streambank erosion has slowed and further degradation is unlikely to occur.

Current System operations under Alternative 1 would continue to support water for irrigation. Precipitation and snowpack would vary over the period of record, with drought conditions reducing access to irrigation water, with adverse impacts to irrigation operations. However, management actions under Alternative 1, the spring plenary pulse, would provide a negligible contribution to these impacts. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts to irrigation access associated with Alternative 1 would continue to be small, adverse, and long-term primarily due to natural variability in hydrologic conditions, the need for future investments in irrigation infrastructure, and aggradation and degradation in the System. The implementation of the plenary pulse and ESH construction as part of Alternative 1 would provide a negligible contribution to these cumulative impacts because of the small changes in reservoir elevations and river flows.

Under Alternative 2 the spawning cue releases and low summer flows would result in a negligible to small adverse impact on irrigators relative to Alternative 1. These impacts would be due to lower reservoir elevations and river stages, usually following a spawning cue release. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 2 would be small and adverse, similar to Alternative 1, and the implementation of Alternative 2 would provide a negligible contribution to cumulative impacts in most years and counties. In a few locations there could be a temporary, small, and adverse contribution to these cumulative impacts from the spawning cue release reducing reservoir elevations and river stages in a few years.

Under Alternative 3, the absence of the spring plenary pulse in March and May relative to Alternative 1 would result in negligible beneficial impacts on irrigators because river flows would be slightly higher in some years. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3 would be similar to Alternative 1, small and adverse, from drought conditions, degradation and aggradation, and the need for irrigation investments. Implementation of Alternative 3 would have a negligible contribution to these cumulative impacts because of the very small change in irrigation operations under Alternative 3.

Alternatives 4 and 6 would result in similar impacts as Alternative 1. The spring release and spawning cue releases would result in a negligible to small adverse impact on irrigators relative to Alternative 1 due to lower reservoir elevations and river stages, usually following a spawning cue or spring release. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts under Alternatives 4 and 6 would be small and adverse, and the implementation of these alternatives would provide a negligible contribution to cumulative impacts in most years and counties. In a few locations there could be a temporary, small, and adverse contribution to these cumulative impacts from the spawning cue and spring releases reducing reservoir elevations and river stages in a few years.

Alternative 5 would result in similar impacts as Alternative 1. The fall releases would result in negligible impacts on irrigators relative to Alternative 1 due to the very small change in access to water for irrigation operations. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 5 would be small and adverse, and the implementation of Alternative 5 would provide a negligible contribution to cumulative impacts because of the slight change in river stages and reservoir elevations associated with the fall release.

3.15 Navigation

3.15.1 Affected Environment

As authorized by The Rivers and Harbors Act of 1945, the federally authorized and maintained navigation channel of the Mainstem of the Missouri River stretches 735 miles, from Sioux City, Iowa to St. Louis, Missouri (Figure 3-62). This stretch of the river includes a navigation channel measuring nine feet deep and 300 feet wide.

Navigation industries operate barges and freight vessels, transporting various commodities along the river. These commodities generally include agricultural products, chemicals, petroleum products, manufactured goods, and basic manufacturing materials such as gravel and sand. In 2016, the latest year with available data, there were about 113 active docks and ports along the Missouri River. Ninety-nine docks were located around and downstream of Kansas City, Missouri, while the remaining fourteen were located between Kansas City, and Omaha, Nebraska. While the Missouri River between Omaha and Sioux City, Iowa reach does contain docks, none were active in 2016 (USACE 2018).

In August of 2015, the Port of Kansas City re-opened (having closed since 2007). In the past couple of years, commercial tonnage has increased on the Missouri River, with the opening of the Port of Kansas City and sufficient System storage levels to provide full navigation service in 2015, 2016, and 2017. The Port of Kansas City moved 285,000 tons of freight in 2017 and forecasts over 300,000 tons moving through the port in 2018 (Port of Kansas City 2017).

USACE supports a navigation season when the river is ice-free and navigable and USACE releases water from Gavins Point Dam, just above Sioux City to supplement flows from the major tributaries. While the length of the flow supported navigation season varies along the river, a full-length season is considered eight months from April 1 to December 1 at the mouth of the Missouri River. According to the Master Manual, the decision to have a navigation season and the initial service level provided is made on March 15. On the July 1, a storage check is performed to determine the level of navigation service (e.g., minimum, full) and the length of the navigation supported season. Further discussion of these dates and the criteria for length of the season is described in this section.

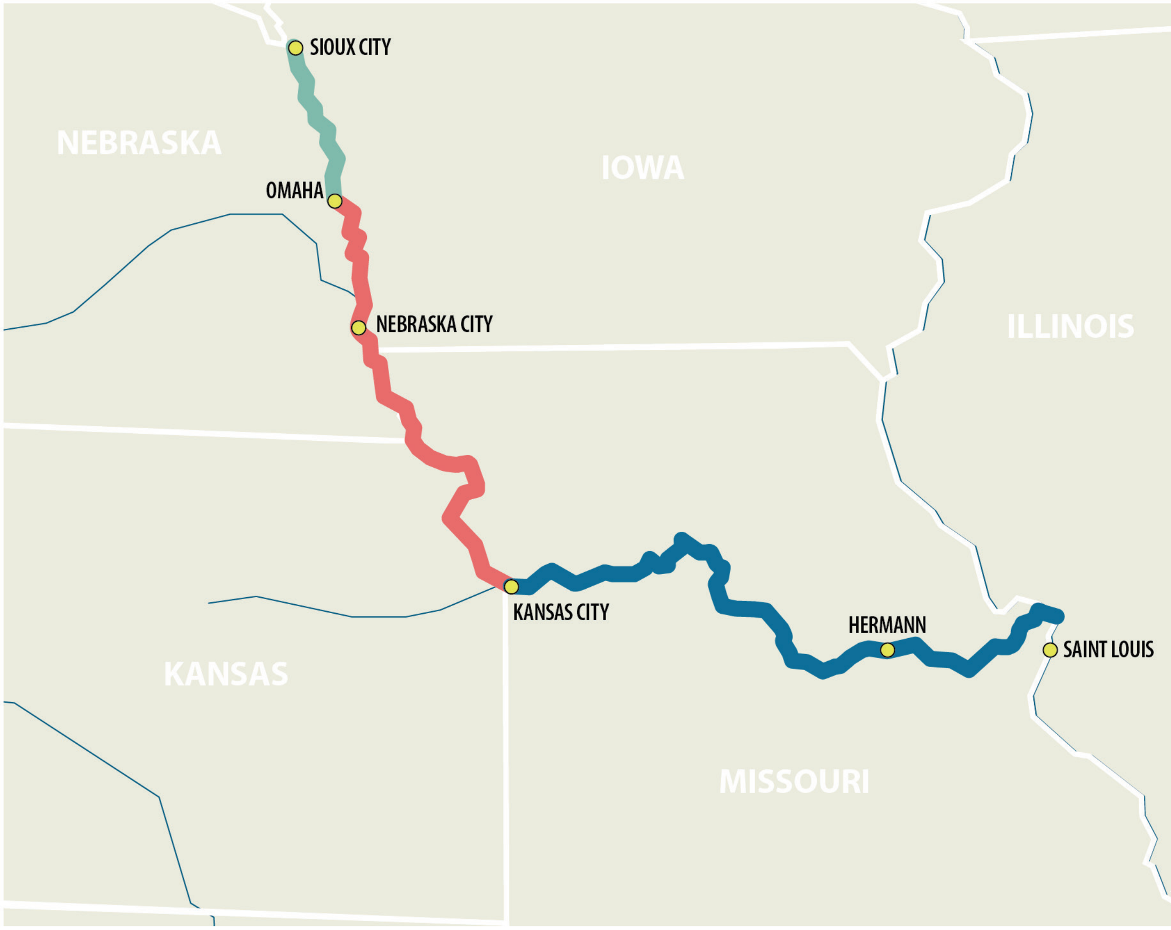
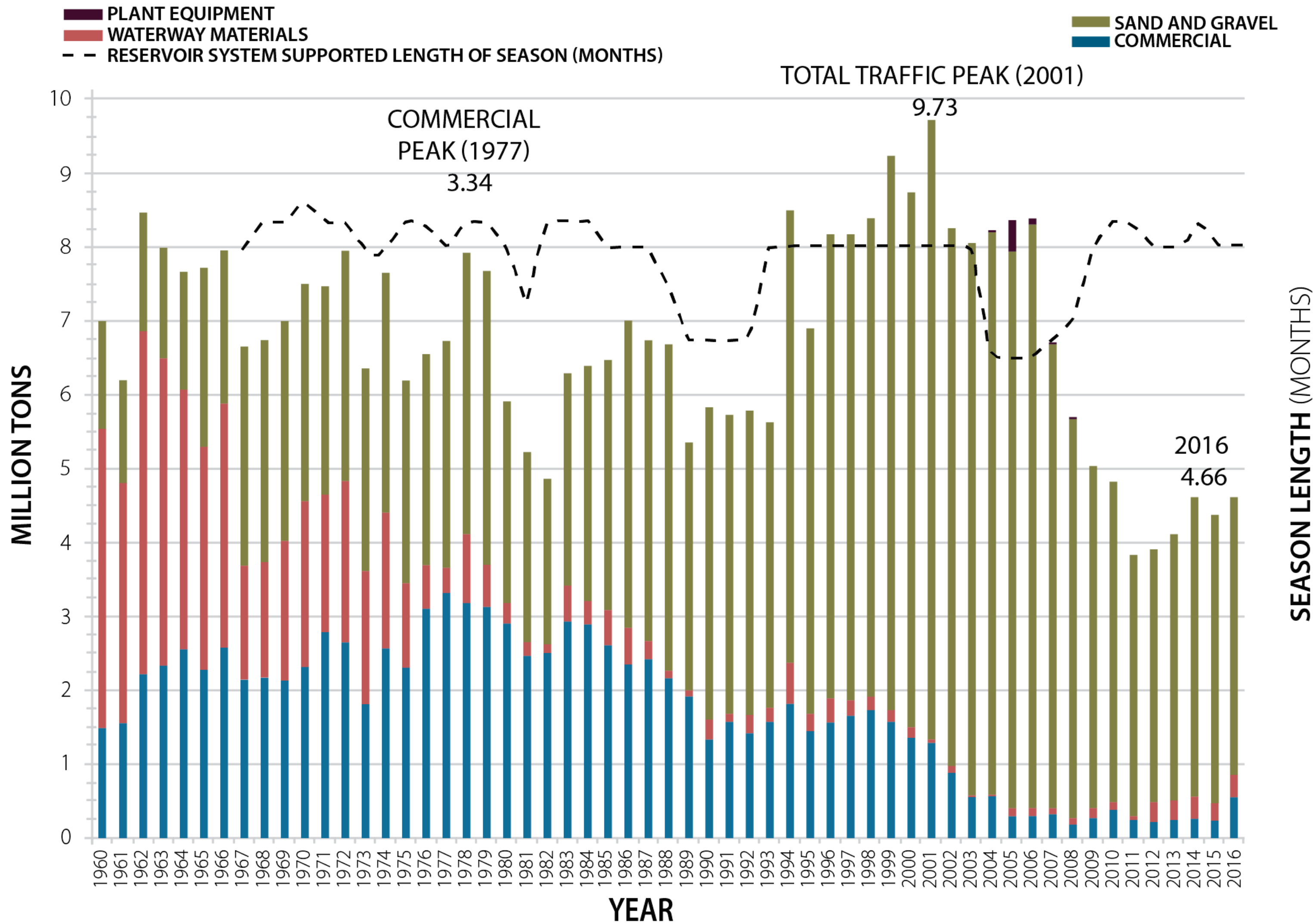


Figure 3-62. Map of Federally Authorized and Maintained Navigation Channel of the Mainstem Missouri River

The types of commodities traveling on the Missouri River are typically grouped into four broad categories (USACE 2006a, Appendix G-1.1): sand and gravel, waterway improvement materials, commercial cargo, and oversized goods. Figure 3-63 presents tonnage levels for these four commodity groups from 1960 to 2016 along with the USACE System-supported navigation season length. The commercial traffic has generally been declining since 1977, although the total amount of traffic (including sand and gravel) peaked of 9.7 million tons in 2001 (USACE 2018). The increase in total traffic during this time was dominated by an increase in the amount of sand and gravel being dredged and transported on the river. Oversized power plant equipment (noted as "plant equipment" in Figure 3-63) is also moved on the Missouri River. These movements have occurred in five years, 2004 to 2008, and ranged from 10,000 tons to 425,000 tons.



Source: USACE 2018.

Figure 3-63. Total Navigation Tonnage and System Supported Length of Season (1960–2016)

For many years, sand and gravel and waterway improvement materials have dominated the types of commodities moving on the Missouri River. In 1982, sand, gravel, and waterway improvement materials accounted for 49 percent of total tonnage; since 2000, sand and gravel has represented greater than 85 percent of the commodities shipped on the Missouri River. Unlike commercial traffic which is more likely to travel regionally or nationally, 91 percent of sand and gravel tonnage on the Missouri River travels less than 10 miles (USACE 2018). The reason for the relatively shorter trips is because much of the sand and gravel is dredged from the bottom of the river, and then moved to the nearest dock for transit to local markets. As shown in Table 3-161, 77 percent of sand and gravel tonnage is shipped five miles or less, with over half of sand and gravel tonnage shipped one mile or less.

Table 3-161. Sand and Gravel Distances Traveled on the Missouri River (2012 to 2016)

0 to 1 Mile	2 to 5 Miles	6 to 9 Miles	10 Miles or More
59%	18%	16%	7%

Source: USACE 2018.

Figure 3-64 summarizes the commercial cargo moved on the Missouri River, which can be associated with the following eight categories:

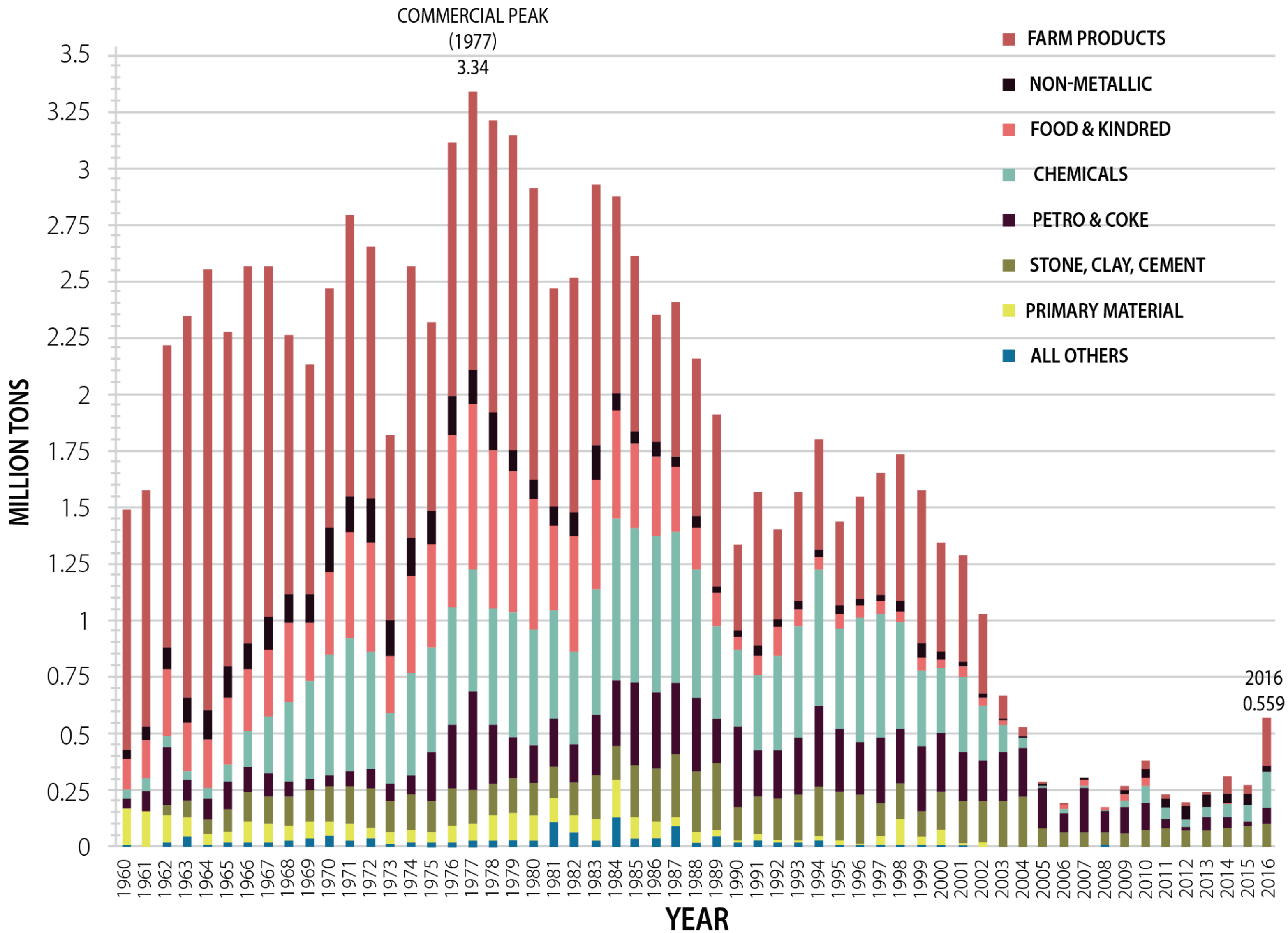
- Farm products, such as corn, sorghum, wheat, and soybeans.
- Non-metallic products, such as clays, salt including sea water, and limestone flux.
- Food and kindred materials, such as molasses, bran, sharps, and other cereal residue.
- Chemical products, including urea fertilizers, ammonium nitrate fertilizers, and sodium hydroxide.
- Petroleum products and coke, including pitch and pitch coke, fuel oils, and asphalt.
- Primary metals, such as iron and steel wire, flat rolled iron and steel, and aluminum.
- Stone, clay, and cement types, including Portland, aluminous, slag, or super sulfate.
- All other commercial cargo, including coal, wood, autos, machinery, and other materials.

As shown in Figure 3-64, farm products were the main commercial commodities moving on the Missouri River from 1960 to 1992, accounting for 71 percent of total commercial tonnage in 1960. By 1992, the percentage for farm products had fallen to 29 percent of total commercial tonnage. From 1992 to 1997, slightly more chemical products, including fertilizers (an average of 0.51 million tons), were shipped on the Missouri River than farm products (an average of 0.46 million tons). However, farm products were the primary commodity shipped again from 1997 to 2002. From 2003 to 2010, petroleum products including pitch coke were the leading commodity moving on the Missouri River. From 2012 to 2016, the leading commercial cargo commodity was stone, clay, and cement, which accounted for 29 percent of commercial cargo tonnage. Farm products accounted for 19 percent of the commercial commodities between 2012 and 2016.

Currently, sand and gravel remains the major commodity moving on the Missouri River. Although commercial sand and gravel is extracted from the Missouri River, it is not identified as “commercial” because the movement of sand and gravel occurs from the dredging or extraction location to the sand plant, usually in nearby ports. Most of the sand and gravel extraction locations are between Kansas City and St. Charles, Missouri. As a result, the majority of all commercial sand and gravel movements along the river occur between these locations (Figure 3-65).

As shown in Figure 3-65, 4.06 million tons a year were transported between Kansas City and the mouth of the Missouri River, whereas approximately 520,000 tons were transported annually between Omaha and Kansas City on average between 2012 and 2016.

Tow configurations on the Missouri River are three to four barges (per tow) in the reaches above Kansas City and six to nine loaded barges or twelve empty barges in the reaches below Kansas City (Petersen 1997). Barge sizes on the Missouri River are similar to other rivers, with a width of 35 feet and a length of 195 feet. Towboats on the Missouri River tend to range from approximately 50 feet to 110 feet in length, 20 feet to 35 feet in breadth, 6 to 9 feet in depth, and generally have engines that range from approximately 800 to 3,000 horsepower. The lower horsepower engines are necessary for use on the Missouri River because they produce less draft and hull dragging.



Source: USACE 2018.

Figure 3-64. Commercial Tonnage by Category on the Missouri River, 1960–2016

Source: USACE 2018.

Figure 3-65. Five-Year Average Annual Tonnage including Sand and Gravel by Missouri River Segment

3.15.1.1 Navigation Service

Navigation service on the lower river between Sioux City and St. Louis is supported by a combination of water from major tributaries, such as the Platte and the Kansas Rivers and the release of water from the Mainstem dams as necessary to maintain eight to nine feet of water depth in the navigation channel. The level of navigation service (full, reduced, or minimum) provided by USACE depends on the quantity of water in System storage. As described in the Master Manual, USACE has identified target river flows for full-service navigation as 31 kcfs (thousands of cubic feet per second) at Sioux City and Omaha, 37 kcfs at Nebraska City, and 41 kcfs at Kansas City (USACE 1998c). These full-service flows generally provide the authorized 9-foot navigation channel and allow the capability to load barges to an 8.5-foot draft. River flows that are six kcfs lower than the full-service flows are designated as minimum service flows at the associated location. These flows generally provide a minimum 8-foot navigation channel, and barges can be loaded to a 7.5-foot draft.

Commercial navigation declines precipitously below an 8-foot navigation channel. There is generally very little navigation when the navigation channel is below 7 feet. Although the above-noted river flows are generally adequate to provide the indicated drafts, the Missouri River is a dynamic system with tributary inflows and sediment movement, which can result in navigation difficulties (bumpings and groundings) even when USACE is providing navigation service. During years with lower tributary flows, releases from Gavins Point Dam are increased to meet target flows depending on the System storage and service level being provided.

The level of navigation service is determined according to how much water is available in System storage on two key dates (March 15 and July 1) of each year. On March 15, if the total System storage is greater than 54.5 million acre-feet (MAF), full-service is provided. If the System storage is between 31.0 and 49.0 MAF, minimum-service is provided. If the System storage is less than 31.0 MAF, no navigation service is provided.

On July 1, another System storage check occurs. If System storage is 57.0 MAF or greater, full service is provided for the remainder of the navigation season. If the System storage is 50.5 MAF or less, minimum service is provided for the remainder of the navigation season. USACE uses straight-line interpolation defines intermediate service levels between full and minimum service. The criteria for service level, based on System storage, is detailed in Table 3-162.

Table 3-162. Determination of Navigation Service Level with the Volume of Water in System Storage

Date	Water in System Storage (MAF)	Service Level Threshold (cfs)
March 15	54.5 or higher	35,000: full service
	49 to 31	29,000: minimum service
	Less than 31	No navigation service that year
July 1	57 or more	35,000: full service
	50.5 or less	29,000: minimum service

Source: USACE 1998c.

Table 3-163 summarizes the navigation service levels and season lengths provided by USACE along with the total commercial (non-sand and gravel) tonnage moved annually on the Missouri River between 1990 and 2016. In the past 26 years, there have been variable conditions on the Missouri River with varying impacts to navigation service levels and season lengths. Higher river flows and/or flooding conditions have resulted in adverse impacts to navigation in a number of years, notably in 1995, 1997, and 2011. Reduced system storage from relatively drier and drought conditions have resulted in minimum service levels for navigation in the early 1990s, most of the 2000s, and 2013. Full navigation service levels have occurred in the mid to late 1990s, 2010, 2012, and more recently in the second half of the season in 2014, 2015, and 2016. The natural variability of the Missouri River can result in a lack of navigation reliability. Without the ability to reliably navigate on the Missouri River, it is difficult for operators to secure future contracts, and even in the short-run, to ship products for customers. This business uncertainty may have contributed to decreased commercial shipments over the 26-year period.

Table 3-163. Navigation Service Levels, Navigation Season Length, and Tonnage Moved on the Missouri River (1990-2016)

Year	Reservoir System Supported Length of Season	Commercial Tons (does not include sand and gravel)	Annual Total Tons	Target Flows: March 15 Check				Target Flows: July 1 Check				Season Date	
				Sioux City, IA	Omaha, NE	Nebraska City, NE	Kansas City, MO	Sioux City, IA	Omaha, NE	Nebraska City, NE	Kansas City, MO	1st Half Start	2nd Half Finish
1990	6 3/4	1,329,000	5,841,000	Min								April	Oct
1991	6 3/4	1,563,000	5,729,000	Min								April	Oct
1992	6 3/4	1,403,000	5,783,000	Min								April	Oct
1993	8[e]	1,570,000	5,631,000	Min								April	Oct
1994	8	1,800,000	8,501,000	Full								April	Dec
1995	8[a,e]	1,439,000	6,884,000	Full				Full + 20,000				April	Dec
1996	8[a]	1,547,000	8,165,000	Full + 10,000				Full + 20,000				April	Dec
1997	8[a]	1,651,000	8,172,000	Flood								April	Dec
1998	8[a]	1,735,000	8,379,000	Full								April	Dec
1999	8[a,e]	1,576,000	9,252,000	Full								April	Dec
2000	8	1,344,000	8,733,000	Full				Reduced				April	Dec
2001	8	1,288,000	9,732,000	Reduced								April	Dec
2002	8[b]	1,025,000	8,266,000	Min								April	Dec
2003	8[c]	670,000	8,050,000	Min								April	Nov
2004	6 1/2[d]	525,000	8,207,000	Min								April	Oct
2005	6 1/2[d]	285,000	8,361,000	Min								April	Oct
2006	6 1/2[d]	195,000	8,380,000	Min								April	Oct
2007	6 3/4[d]	303,000	6,702,000	Min								April	Oct
2008	7[d]	175,000	5,681,000	Min								April	Oct
2009	8	270,000	5,036,000	Min				Full				April	Nov
2010	8[a]	379,000	4,830,000	Full								April	Dec

Year	Reservoir System Supported Length of Season	Commercial Tons (does not include sand and gravel)	Annual Total Tons	Target Flows: March 15 Check				Target Flows: July 1 Check				Season Date	
				Sioux City, IA	Omaha, NE	Nebraska City, NE	Kansas City, MO	Sioux City, IA	Omaha, NE	Nebraska City, NE	Kansas City, MO	1st Half Start	2nd Half Finish
2011	8[a,e]	230,000	3,832,000	Full				Flood[f]				April	May[f]
2012	8	197,000	3,906,000	Full								April	Dec
2013	8	245,000	4,105,000	Min				Reduced				April	Dec
2014	8[a]	293,000	4,671,000	Reduced				Full				April	Dec
2015	8	269,000	4,402,000	Full								April	Dec
2016	8	559,000	4,656,000	Full								April	Dec

a 10-day extension of season provided.

b To protect endangered shore birds below Gavins Point Dam, USACE did not support navigation from July 3 to August 14, 2002. Average days towing industry off the river was 23 days.

c 6-day shortening of season to follow CWCP. From August 11 to September 1, USACE did not support navigation flows to comply with lawsuit to follow 2000 Biological Opinion. Navigation industry left the river during this period.

d Season shortening; 47-days, 2004; 48-days, 2005; 44-days, 2006; 35-days, 2007; 30-days, 2008.

e Lower Missouri River closed due to high flow conditions: 57 days in 1993; 20 days in 1995; 18 days in 1999; and between 45 and 93 days in 2011 depending on the location within the river.

f Releases determined by flood control storage evacuation criteria and not adjusted to meet specific navigation targets. Different sections of the river were open and closed at different times.

Sources:

USACE 2015a: Table 16, Navigation Season Target Flows (p. 63) and Table 17, Missouri River Tonnage and Season Length (p. 64)

USACE 2018.

3.15.1.2 Navigation Season Length

Navigation on the Missouri River is limited to the normal ice-free season, with a full-length season defined as 8 months. Each year a water-in-storage check for navigation season length is taken on March 15, to determine if a navigation season will occur, and on July 1, to determine the length of the season. If the System water-in-storage is above 31 MAF on March 15, a navigation season is supported. During the July 1st System water-in-storage check, the length of the season is decided. If System water-in-storage is at or above 51.5 MAF, a full 8-month navigation season would be provided, unless the season is extended to evacuate System flood control storage. However, if System water-in-storage falls below 51.5 MAF on July 1, a shortened navigation season would be provided to conserve water stored in the System in the case of an extended drought. The specific technical criteria for season length are shown in Table 3-164. Straight-line interpolation between 51.5 and 46.8 MAF of water-in-storage on July 1 provides the closure date for a season length between 8 and 7 months (USACE 1998c).

Based on historical records of ice formation on the Missouri River and USACE experience gained from System regulation, the opening and closing dates for a normal 8-month navigation season are shown in Table 3-165.

Table 3-164. Relation of System Storage to Season Length

Date	System Storage (MAF)	Season Closure Date at Mouth of the Missouri River
March 15	31.0 or less	No season
July 1	51.5 or more	December 1: 8-month season
July 1	46.8 through 41.0	November 1: 7-month season
July 1	36.5 or less	October 1: 6-month season

Table 3-165. Season Open and Close Dates for Missouri River Sections

Location	Open Date	Close Date
Sioux City	March 23	November 22
Omaha	March 25	November 24
Nebraska City	March 25	November 24
Kansas City	March 28	November 27
Mouth of the Missouri River	April 1	December 1

In some years, ice conditions will undoubtedly delay the opening of the season and in other years ice may force an early end to the season. Fall extensions of the season beyond the normal 8-month length will usually occur (ice conditions permitting) in years with above-normal System storage and when such extensions will not result in a drawdown into the Missouri River system carryover multiple use zone.[6] Based on experience to date, these season extensions normally are limited to 10 days beyond the typical closure date of December 1.

[6] The carryover multiple use zone provides storage for active project purposes. The water stored in this zone at the three larger reservoirs (Fort Peck, Garrison, and Oahe) will maintain downstream flows through a succession of well-below-normal runoff years into the System. Serving the authorized purposes during an extended drought is an important regulation objective of the System.

3.15.1.3 Air Quality

Impacts to navigation on the Missouri River can result in indirect impacts to air emissions in the region due to shifts in transportation modes. A shift in mode from navigation to truck transportation can affect the number of trucks on the highways and contribute to relatively higher levels of air emissions, notably hydrocarbons, carbon monoxide, nitrogen oxides, and particulate matter. For a description of the air quality affected environment please see Section 3.8, Air Quality.

3.15.2 Environmental Consequences

This evaluation focuses on how changes in river flows and System storage associated with each of the MRRMP-EIS alternatives could affect commercial navigation and commercial sand and gravel dredging. These two activities were evaluated separately because changes in river flows and water in System storage may affect dredgers differently from the waterway operators that ship commercial commodities on the river. Dredging operations could be affected through higher operating costs or through the reduced ability to dredge material. Waterway operators will be affected by changes in the System storage which will affect USACE-provided navigation service and season length. These in turn will affect transportation costs, including changes in rates to transport commodities (i.e., through truck or rail) and navigation channel operating and maintenance costs. This section summarizes the methodology and presents the results of these two assessments: impacts to commercial navigation (does not include commercial sand and gravel dredging); and navigation impacts associated with commercial sand and gravel dredging. A detailed description of the methodology and results is provided in the “Navigation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.15.2.1 Commercial Navigation (not including sand and gravel)

The navigation evaluation includes an assessment of how changes in river flows and service levels can affect commercial navigation on the Missouri River. The impacts to commercial navigation are evaluated using three of the four accounts (NED, RED, and OSE). The accounts framework enables consideration of a range of both monetary and non-monetary values and interests, while ensuring impacts are not double-counted.

Changes to System storage and releases can impact navigation service level flows and season length. This analysis used the output from the HEC-ResSim Missouri River model, which simulates System storage and navigation-supported flows released from Gavins Point Dam over the POR under each of the MRRMP-EIS alternatives. These modeled simulations were used to determine navigation performance over the POR and how these changing conditions impact navigation. In addition, the impacts of mechanical habitat construction on navigation operations were considered and are described in this section.

Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As described in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or historic conditions but provides an assessment of how the System would be operated under existing conditions, as described in the Master Manual; Alternative 1 serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

Methodology

This section describes the NED, RED, and OSE methodology for commercial navigation.

National Economic Development

The NED account includes an evaluation of both the transportation rate savings and non-routine repair, replacement, and rehabilitation (RR&R) costs to maintain the navigation channel. The navigation evaluation used the unit transportation rate savings obtained from the Transportation Rate Analysis from the Master Manual (USACE 2002), updated to FY 2018 dollars with the Producer Price Index for Inland Water Freight Transportation (US Bureau of Labor Statistics 2018) as the basis for the transportation rate savings. These unit transportation rate savings by commodity type were then multiplied by a service level ratio which was generated using the transportation rate savings functions from the Master Manual Transportation Rate Analysis (USACE 1998c). The service level ratio indexes the transportation rate savings to different service levels based on the Master Manual Transportation Rate Savings Functions. The result is a unit transportation rate savings per commodity for different navigation service levels. Navigation service data from HEC-ResSim was used to estimate the daily navigation service level over the POR under the MRRMP-EIS alternatives. The most recent navigation tonnage data available for a full-service reference year (2016) by commodity type and month was used to assess the affected tonnage by service level. The transportation rate savings were then applied to the affected tonnage by service level over the POR by month, commodity, and river reach.

A scenario analysis was conducted on the transportation rate savings with a relatively higher amount of tonnage to evaluate the potential impact on the alternatives. The 1994 commercial tonnage shipments, the year with the highest level of commercial tonnage on the Missouri River since 1990, were used to estimate the transportation rate savings (NED value). The commercial tonnage in 1994 was over three times higher than the tonnage in 2016. This scenario analysis provides very conservative estimates, which results in relatively higher impacts than those estimated with 2016 tonnage; however, the results of the scenario analysis would not change the ranking of the alternatives or the identification of the preferred alternative. The results of the scenario analysis are provided in the “Navigation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

The RR&R costs include an evaluation of the changes in non-routine repair, replacement and rehabilitation costs associated with support of two river field offices, including any funds necessary for rescues, repairs of equipment, staff, and other expenses; repair, replacement, and rehabilitation of thousands of river structures; and emergency dredging that is required for extreme river conditions. Costs by service level from the Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (USACE 1998c) were used to estimate the RR&R costs under the MRRMP-EIS alternatives. The costs were adjusted to 2018 price levels with the USACE Civil Works Construction Cost Index System (USACE 2016e).

Net navigation NED benefits were estimated by subtracting the RR&R costs from the transportation rate savings.

Regional Economic Development

The RED evaluation for navigation used the results from the commercial navigation NED analysis to evaluate how changes in the amount of commercial commodities (not including sand and gravel) transported on the river under the MRRMP-EIS alternatives may affect local economic conditions, including sales, labor income, and employment. Employment is defined as including both full-time and part-time jobs. The RED evaluation focused on how the commercial commodities shipped (and the amount of tonnage that would shift off the river) on the Missouri River support the waterway industries (shippers, warehousing, and port services) and multiplier economic activity. The RED evaluation was conducted with the Regional Economic System (RECONS), which is based on the principles of input-output analysis. RECONS is a certified USACE model that customizes IMPLAN® ratios and multipliers to USACE projects and study areas. IMPLAN® is an industry-standard input-output data and software system widely used by academics, government, and industry. A RED evaluation of the commercial sand and gravel industry was not conducted because impacts to the dredging industry are likely to be negligible to small with very little impacts to regional economic conditions (see section 3.15.2.1 of this section). Potential impacts to over-sized shipments were discussed qualitatively.

A discussion of water-compelled rates is provided in the "Navigation Environmental Consequences Analysis Technical Report," which provides a qualitative evaluation conducted by the University of Tennessee Center for Transportation Research (UT-CTR) (Burton and Bray 2016). The issues are complicated surrounding water-compelled rates and the dynamic economic conditions and context of the rail industry create uncertainties regarding the effect of Missouri River navigation on railroad pricing. However, the authors conclude that unless the reliability and long-run availability for navigation of the Missouri River are reversed, water-compelled railroad rates attributable to Missouri River navigation seem improbable. A number of key points in the UT-CTR report are described in the "Navigation Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Other Social Effects

Since moving commodities on the waterway results in fewer air emissions compared to truck and rail transportation, changes to navigation service could potentially affect air emissions and possibly impact health and safety. It should be noted that the Inter-modal Surface Transportation Efficiency Act (ISTEA) supports linked transportation connectivity, promoting reduced energy consumption, air pollution, and traffic congestion while promoting economic development and supporting the Nation's preeminent position in international commerce modes; these objectives are consistent with the effects evaluated under the OSE account.[7]

The OSE effects to navigation consider changes in air quality if commodities moving on the waterway could potentially shift off the Missouri River to overland modes as a result of the MRRMP-EIS alternatives. The air emission rates provided by Texas A&M University, Texas Transportation Institute (TTI) (2012) were used in the evaluation (in grams per ton-mile) for four "criteria" pollutants: hydrocarbons (or volatile organic compounds for trucks); carbon monoxide (CO), particulate matter (PM), and nitrogen oxides (NOx).

To assess the range of miles traveled for each transportation mode, the evaluation used information on the state to state origin destination pairs from the Waterborne Commerce Statistics Center (WCSC) to estimate the number of miles traveled (USACE 2018). A weighted

[7] H.R.2950 - Intermodal Surface Transportation Efficiency Act of 1991, passed in the 102nd Congress.

average of the distance traveled for waterway transportation was estimated using the 2016 reported tonnage for each state origin destination pair. Circuity factors of 1.3:1 for truck trip length and 1.1:1 for rail trip length were applied to the weighted average distance for the waterway trip (Texas A&M University 2017).[8] The final step in the evaluation was to apply the emissions rates for waterway, railroad, and truck to the tonnage that shifts transportation modes and average mileage traveled by alternative mode to estimate the anticipated air emissions by mode. The difference between waterway air emissions and truck and rail air emissions are presented in the OSE environmental consequences section. Air emissions from natural and human sources in Missouri as well as the location of counties that are in non-attainment were used to assess the importance of the potential increase in emissions. Impacts to traffic congestion, public health and safety, and infrastructure costs are qualitatively assessed based on the number of truck trips that may be required associated with the tonnage diverted off the waterway.

Summary of Environmental Consequences

The environmental consequences relative to navigation are summarized in Table 3-166. A discussion of each alternative follows the table.

Table 3-166. Environmental Consequences for Navigation

Alternative	NED Impacts	RED Impacts	OSE Impacts
Management Actions Common to All Alternatives	Actions such as the human restriction measures, vegetation management, and predator management would have no impacts on navigation.		
Alternative 1	Average annual NED values of $7.4 million, ranging from $0 to $12.0 million annually over the POR. Drought conditions would cause most of the adverse impacts, and management actions under Alternative 1 would have a negligible to small contribution to these adverse impacts from reductions in System storage and navigation service levels in the years when the spring pulse would be implemented.	Average annual jobs of 154 and labor income of $8.8 million. Range in annual jobs from 0 to 173 and labor income of $0 to $9.9 million over the POR. Reductions in RED from drought conditions would be negligible to small in the regional context but could be important to waterway industries. The spring pulse would have a negligible contribution to these impacts.	Negligible impacts to air quality, traffic congestion, public health and safety, and infrastructure costs in the regional context.
Alternative 2	A small decrease in average annual navigation NED value of $35,000 (−0.5%); however, impacts would be temporary, large, and adverse in low summer flow years. Repeated implementation of the low summer flow event could affect the reliability of navigation on the river and the ability of the industry to obtain long-term contracts, with long-term, large, and adverse impacts that could likely be significant.	No change in average annual jobs and decrease in average annual labor income of $11,000. Negligible to small temporary adverse impacts to RED compared to Alternative 1 in the regional context from reduced navigation service.	Negligible change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the minor change air emissions and truck transportation in the region.

[8] A circuity factor is a multiplier to estimate distances to approximate actual travel distances.

Alternative	NED Impacts	RED Impacts	OSE Impacts
Alternative 3	Negligible to small temporary increases in average annual navigation NED value (+$21,000 or 0.3%) due to slightly higher System storage and reduced RR&R costs in some years from the elimination of the plenary pulse.	Increase of $13,000 in average annual labor income and no change in jobs. Negligible change in RED effects compared to Alternative 1.	Negligible change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the minor change air emissions and truck transportation in the region.
Alternative 3: Gavins Point One-Time Spawning Cue Test	A negligible to small decrease in annual NED value from decreased System storage the year or years following the one-time pulse decreasing service levels and potentially shortening the navigation season.	Negligible to small adverse impacts to RED compared to Alternative 1.	Negligible change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the minor change air emissions and truck transportation in the region.
Alternative 4	A small decrease in average annual navigation NED values (-$181,000 or -2.4%) compared to Alternative 1, with the potential for temporary large adverse impacts following the full release from reduced System storage reducing navigation seasons and service levels. Alternative 4 could contribute to further uncertainty around the reliability of navigation, with the potential for large adverse NED effects in the long-term with further reductions in navigation.	Decrease in average annual jobs of two and decrease in average annual labor income of $94,000. Negligible to small adverse impacts to RED compared to Alternative 1.	Negligible to small change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the minor change air emissions and truck transportation in the region.
Alternative 5	A negligible to small decrease in average annual navigation NED values (-$57,000 or -0.8%) compared to Alternative 1, with the potential for temporary, large adverse impacts in some years following the full release from lower System storage reducing navigation seasons and service levels. Alternative 5 could contribute to further uncertainty around the reliability of navigation, with the potential for additional adverse NED effects in the long-term with further reductions in navigation.	No change in average annual jobs and decrease of $9,000 in average annual labor income. Negligible adverse impacts to RED compared to Alternative 1.	Negligible change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the minor change air emissions and truck transportation in the region.

Alternative	NED Impacts	RED Impacts	OSE Impacts
Alternative 6	A small decrease in average annual navigation NED benefits (-$127,000 or -1.7%) compared to Alternative 1, with the potential for temporary, large adverse impacts following the spawning cue release which lowers System storage reducing navigation seasons and service levels. Alternative 6 could contribute to further uncertainty around the reliability of navigation, with the potential for large adverse NED effects in the long-term with further reductions in navigation.	Decreases in average annual jobs (-1) and average annual labor income (-$85,000). Negligible to small adverse impacts to RED compared to Alternative 1.	Negligible change in air quality, traffic congestion, public health and safety, and infrastructure costs because of the minor change air emissions and truck transportation in the region.

Impacts from Management Actions Common to All Alternatives

A number of actions are common to all alternatives including vegetation management, predator management, and human restriction measures. These actions occur upstream of Gavins Point Dam and would not affect navigation. Pallid sturgeon propagation and augmentation is also common to all alternatives, but would have no impact on navigation.

Alternative 1 – Alternative 1 (Current System Operation and Current MRRP Implementation)

As described in Section 3.1, the basis for analysis was simulating the implementation of the alternatives over the historic POR resulting in changes in System storage and flow releases. Alternative 1 includes the simulation of current operations of the System, including a spring plenary pulse.

Mechanical Habitat Construction

For early life stage pallid sturgeon habitat, Alternative 1 would result in the construction of 3,999 acres with 1,021 acres located between Sioux City and the Platte River; 672 acres located between the Platte River and Rulo, Nebraska; 1,129 acres located between Rulo and the Kansas River; and 937 acres located between the Kansas River and Osage River. Each project will be designed to minimize or avoid impacts to the authorized purposes including navigation. Prior to any construction, site-specific NEPA would be conducted on the project. In addition, Alternative 1 would also include the construction of an average of 164 acres per year of ESH, which involves mechanical excavation and placement of sand with large construction equipment or hydraulic dredge. This activity would not occur in the navigable portion of the river so there would be no impacts to navigation.

National Economic Development

Table 3-167 summarizes the navigation NED value under Alternative 1. The average annual navigation NED value is estimated to be $7.4 million, ranging between $0 in the simulated years when navigation is not provided and $12 million during full service years. Most of the value is associated with transportation rate savings. Management actions under Alternative 1 would have a negligible to small adverse contribution to these effects resulting from minor changes in System storage associated with the spring pulse. There would be seven years over the period of record when no navigation service would be provided by USACE (1935–1942) due to drought conditions and low System storage as simulated by HEC-ResSim; during these years, all tonnage would be assumed to be transported by alternate overland modes.

In the short term, adverse impacts would be temporary and would improve with normal precipitation and snowpack conditions. However, more frequent onset of drought conditions and reductions in navigation service would reduce the reliability of Missouri River navigation and result in long-term adverse impacts to navigation and net NED value that may not be captured here.

Table 3-167. Transportation Rate Savings, RR&R Costs, and Net NED Benefits for Alternative 1 (FY 2018$)

Navigation NED Value	Transportation Rate Savings	RR&R Costs	Net NED Value
Average Annual Value	$7,990,000	$570,000	$7,420,000
Max Annual Over the POR	$12,040,000	$1,260,000	$11,980,000
Min Annual Value Over the POR	$0	$0	$0

Note: Numbers were rounded; the net NED value may not exactly equal transportation rate savings less RR&R costs. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year but are from three different years in the POR. Values are estimated using 2016 baseline tonnage.

Regional Economic Development

Under Alternative 1, the RED effects associated with commercial navigation on the waterway (using 2016 reference year) would support 154 average annual jobs (direct and multiplier jobs) and $8.8 million in labor income on average over the POR. The RED effects range from no jobs and income supported when no commercial tonnage is moved (due to no navigation service conditions) on the Missouri River to 173 jobs and $9.9 million in labor income during full service navigation years. The spring pulse under Alternative 1 would have a negligible contribution to these effects. Table 3-168 provides a summary of the RED effects under Alternative 1.

While Alternative 1 would result at times in reductions in jobs and income to waterway and supporting industries with a reduction in commercial navigation on the Missouri River, employment and income in other transportation industries would likely increase as industries that need to ship their products would turn to alternative modes of transportation. Since most of these commodities are moved through Missouri, some of the economic contribution would occur within Missouri, although there may be some small economic effects in adjacent states where these commodities would be shipped to or from. The fluctuations in navigation RED effects would be negligible to small in the large economic context of Kansas City and St. Louis and other relatively larger port cities; the shippers, port services, and warehousing industries would experience employment and income losses during reduced navigation periods.

Repeated adverse conditions that reduce the reliability navigation on the Missouri River would result in long-term reductions in associated jobs and income that may not be captured here. In addition, when navigation service is reduced or not provided, industries that ship their products via the waterway (for example, agriculture, fertilizer manufacturers, petroleum producers and refiners, utilities shipping large plant and equipment, and others) could be adversely affected if transportation costs are higher via rail or truck.

Table 3-168. RED Effects Associated with Commercial Navigation (does not include sand and gravel) on the Missouri River under Alternative 1 (FY 2018 Dollars)

Economic Impact Parameter	Scenario	Economic Contribution
Direct, Indirect, and Induced Jobs	Annual Average RED Benefit over the POR	154
	Smallest Annual RED Benefit over the POR	0
	Largest Annual RED Benefit over the POR	173
Direct, Indirect, and Induced Labor Income (2018$)	Annual Average RED Benefit over the POR	$8,793,396
	Smallest Annual RED Benefit over the POR	$0
	Largest Annual RED Benefit over the POR	$9,917,027
Direct, Indirect, and Induced Sales (2018$)	Annual Average RED Benefit over the POR	$29,414,566
	Smallest Annual RED Benefit over the POR	$0
	Largest Annual RED Benefit over the POR	$33,173,196

Other Social Effects

Table 3-169 summarizes the air emissions under Alternative 1 associated with the commercial tonnage that would be assumed to shift off the Missouri River to truck and rail, given conditions over the POR when navigation service would not be supported. There would be tonnage that shifts off the river to alternate overland modes of transportation in Omaha, Nebraska City, and Kansas City reaches. There would be only a small amount of affected tonnage in the Omaha and Nebraska City reaches, with negligible changes in air emissions in these reaches.

Assuming a shift annually of 57,600 tons on average to alternate overland modes in the Kansas City reach, the pollutant with the largest range of emissions impacts (from rail to truck) would be nitrous oxides with an annual average change ranging from 1,700 kg (shift to rail) to 27,800 kg (shift to truck). The second greatest change in annual emissions would be carbon monoxide, ranging from 300 kg (rail) to 9,000 kg (truck) in the Kansas City reach. Changes in air emissions would be negligible when the tonnage shifts to rail transportation because the rail air emissions factors are only slightly higher than the waterway emission factors (refer to the “Navigation Environmental Consequences Analysis Technical Report,” Table 12, Summary of Emission Rates).

Table 3-169. Average Annual Tonnage Assumed to Shift to Overland Modes of Transportation and Emissions under Alternative 1 by Reach

Reach	Average Annual Tonnage Assumed to Shift to Overland Modes (tons)	Hydrocarbon (kg)	CO (kg)	NOx (kg)	PM (kg)
Omaha	**690**				
Annual Average Emissions – Shift in Mode to Truck		30	110	330	20
Annual Average Emissions – Shift in Mode to Rail		0	0	20	0
Nebraska City	**7,400**				
Annual Average Emissions – Shift in Mode to Truck		400	1,200	3,600	200
Annual Average Emissions – Shift in Mode to Rail		0	0	200	0
Kansas City	**57,600**				
Annual Average Emissions – Shift in Mode to Truck		2,800	9,000	27,800	1,800
Annual Average Emissions – Shift in Mode to Rail		100	300	1,700	0

Note: The tonnage shifting to alternate modes and the impacts to air emissions were estimated with 2016 baseline tonnage. It should be noted that the tonnage moving off the river is not mutually exclusive for the river reaches. For example, tonnage impacts if moving from the Nebraska City reach to the Kansas City reach would be counted in both reaches.

As described in Section 3.8, Air Quality, a non-attainment area is defined as a locality where air pollution levels persistently exceed national ambient air quality standards (NAAQS) or that contributes to ambient air quality in a nearby area that fails to meet standards. In Missouri, Franklin County, St. Charles County, St. Louis County, and St. Louis City are designated as non-attainment areas for 8-hour ozone and particulate matter with particles less than 2.5 microns in diameter. There are also non-attainment areas in Pottawattamie County, Iowa, for lead and Jackson County, Missouri for sulfur dioxide standard (EPA 2016a).

NOx, CO, and VOCs (hydrocarbons) are notable precursors to ozone formation. Since most of the affected tonnage would be shipped to or from Missouri (even the tonnage that is affected in Omaha and Nebraska City), the proportion of the air emissions in the Kansas City reach as a percent of all air emissions in Missouri was assessed (Table 3-170), with very little to no contribution to air emissions. There would be increases in air emissions in many other states because the commodities that would divert off the river would travel to or from other regions, including Louisiana, Illinois, and Oklahoma. Because of the small change in the amount of air emissions, the small proportion of emissions as a percent of all air emissions in Missouri, and the dispersal of air emissions across multiple regions, there would be negligible changes in air emissions and air quality in Missouri, in non-attainment counties, and across the region under Alternative 1.

Table 3-170. Air Emissions for Alternative 1 for the Kansas City Reach as a Percent of Missouri Air Emissions

Pollutant	Total Emissions Within Missouri in 2014 (thousands of kg) [a]	Change in Average Annual Air Emissions from Modal Shift to Truck Transportation under Alternative 1 (kg)	Percent Change of Missouri Air Emissions
Hydrocarbons/VOCs	1,332,200	2,800	0.0002%
CO	1,866,600	9,000	0.0005%
NOx	363,100	27,800	0.0077%
PM	214,460	1,800	0.0008%

a Source: EPA Air Emissions Inventory (2014)

The modal shift to alternate transportation, specifically truck transportation, could result in additional adverse impacts to public health and safety, including traffic congestion, highway accidents, and infrastructure repair maintenance. With a general estimate of 25 tons of commodities per truck, the average annual tonnage moving off the Missouri River (57,600 tons) under Alternative 1 would result in up to 2,304 truck-trips, some of which would occur on the highways along the Missouri River in Missouri. The adverse impacts to public safety, infrastructure repair, and highway congestion would be negligible to small because of the small number of vehicles traveling, the large transportation network and region in which the trucks would travel, and the shift in mode to rail for some of the tonnage.

Conclusion

Alternative 1 represents the continuation of current System operation and MRRP implementation. During a full-service navigation year (as represented by 2016 tonnage levels), an estimated 559,000 tons of commercial commodities would be shipped on the Missouri River. However, the tonnage moved on the Missouri River ranges from zero to 559,000 tons, depending on the water in System storage over the period of record. During drought conditions when no or lower levels of navigation is supported by USACE, there would be reductions in transportation rate savings and RED benefits (jobs and income), along with increases in air emissions, traffic congestion, the potential for accidents, and infrastructure repair associated with additional truck transportation. An estimated 501,400 average annual tons were transported on the Missouri River over the period record, with an average annual navigation NED value of $7.4 million, supporting 154 average annual jobs, and $8.8 million in average annual labor income associated with waterway industries and multiplier effects.

The management actions under Alternative 1 would have negligible to small adverse impacts to navigation from the spring pulse reducing System storage, navigation service levels, and navigation season lengths. Impacts to navigation under Alternative 1 are not anticipated to be significant because continued management of the System for navigation would occur, the spring pulse would have negligible to small impacts on navigation service levels and season length, and adverse impacts to RED, air emissions and public safety would be negligible in the regional context.

Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 would include additional iterative actions that USFWS anticipates would be implemented under an adaptive management framework. Management actions under Alternative 2 would include spawning cue releases, low summer flows, and the construction of considerably more early life stage habitat and ESH than under Alternative 1.

Mechanical Habitat Construction

Alternative 2 would result in the construction of 10,758 additional acres of early life stage pallid sturgeon habitat, with 2,421 acres located between Sioux City and Platte; 1,642 acres located between Platte River and Rulo, Nebraska; 2,439 acres located between Rulo and the Kansas River; 3,307 acres located between Kansas River and Osage River; and 529 acres located between Osage River and the mouth of the Missouri River. Each project will be designed to minimize or avoid impacts to the authorized purposes including navigation. Prior to any construction, site-specific NEPA would be conducted on the project. Because of considerably more early life stage habitat constructed for the pallid sturgeon under Alternative 2, there would be the potential for more adverse impacts to the navigation channel and navigation when compared to Alternative 1.

In addition, Alternative 2 would include the construction of an average of 1,331 acres per year of ESH when construction occurs, which involves mechanical excavation and placement of sand with large construction equipment or hydraulic dredge. This activity would not occur in the navigable portion of the river so there would not be direct impacts to navigation.

National Economic Development

The NED analysis for Alternative 2 is summarized in Table 3-171. Alternative 2 would result in an average annual net NED value of $7.4 million, a decrease of $35,000 (0.5 percent) compared to Alternative 1. Alternative 2 would result in the simulation of six split navigation seasons over the POR for the following years: 1963, 1964, 1988, 1989, 2002, and 2003. These split navigation seasons would eliminate USACE-supported flows for navigation for approximately 10 weeks in June, July, and August. During these low summer flow events, it is assumed that commodities would be shipped via alternate overland modes of transportation and there would be no transportation rate savings associated with navigation. However, in the low summer flow event years, as simulated, there would be relatively more water in System storage at the July System storage check, resulting in relatively higher navigation service levels after the low summer flow event ends and a longer navigation season compared to Alternative 1. RR&R costs would decrease under Alternative 2 (average annual decrease of $16,000 or 2.9 percent change relative to Alternative 1) due to no navigation during low flow events and higher service levels in some years.

Table 3-171. Transportation Rate Savings, RR&R Costs, and Net NED Value for Alternative 2 (FY 2018 Dollars)

NED Value	Transportation Rate Savings	RR&R Costs	Net NED Value
Average Annual Value	$7,940,000	$550,000	$7,380,000
Max Annual Over the POR	$12,620,000	$1,260,000	$12,560,000
Min Annual Value Over the POR	0	0	0
Change from Alternative 1	-$51,000	-$16,000	-$35,000
% Change from Alternative 1	-0.6%	-2.9%	-0.5%

Note: Numbers were rounded; the net NED value may not exactly equal transportation rate savings less RR&R costs. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year but are from three different years in the POR.

Additional results of flow actions are summarized in Table 3-172. These results show the difference in annual navigation NED values (transportation rate savings and RR&R costs) during years when there would be a release action or a low summer flow. Results from the simulations show that the largest adverse impacts occur during the years with the full spawning cue and low summer flows when navigation support would be eliminated. The years with full spawning cue releases and low summer flows and the year after low summer flows would occur would result in an annual reduction of up to $2.0 million (24 percent decrease compared to Alternative 1 in those years) in transportation rate savings compared to Alternative 1. In the years with simulated low summer flow events, RR&R costs would be lower than Alternative 1 due to less navigation service provided in those years.

Of the 31 partial releases simulated over the POR, nine would have an adverse impact on navigation NED benefits with the largest annual decrease ($1.1 million) during conditions similar to those simulated for 1964. In general, the release of water in the spring would reduce the water in System storage compared to Alternative 1 during the System storage criteria check on July 1, resulting in lower service levels and lower transportation rate savings and higher RR&R costs compared to Alternative 1. However, the partial releases in some years would result in small increases in NED from increases in the service level during the release in May.

Although the change in average annual navigation NED values from Alternative 1 would be small and adverse (0.5 percent for navigation NED values), in the low summer flow years, there could be other notable impacts relative to Alternative 1 that are not being measured. USACE would notify the navigation industry regarding the implementation of spawning cue releases and low summer flows, and therefore, these adverse impacts could be partially mitigated if the industry could plan around these events. However, low summer flow events as well as their repeated implementation would affect the ability of the industry to provide reliable navigation service and to establish long-term contracts with their customers (including the potential shipment of large-scale items). With the variation in hydrology of the Missouri River causing an unreliable navigation resource, the implementation of low summer flow events would contribute to further uncertainty for industry and customers associated with navigation on the Missouri River.

Table 3-172. Impacts to Net NED values from Modeled Flow Releases under Alternative 2 Compared to Alternative 1 (FY 2018 Dollars)

Release	NED Value Change	Navigation NED Values	Transportation Rate Savings	RR&R Costs
Full Flow Release + Low Summer Flow (Includes Low Summer Flows) [a]	Lowest NED Value Change	-$1,659,000	-$1,953,000	-$295,000
	Highest NED Value Change	-$818,000	-$1,004,000	-$186,000
Partial Flow Release [b]	Lowest NED Value Change	-$1,141,000	-$892,000	-$340,000
	Highest NED Value Change	$1,386,000	$1,047,000	$248,000
Year after a Full Release (Includes Low Summer Flows)	Lowest NED Value Change	-$1,152,000	-$1,391,00	-$240,000
	Highest NED Value Change	-$818,000	-$1,004,000	-$186,000
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	-$1,659,000	-$1,953,000	-$340,000
	Highest NED Value Change	$1,386,000	$1,047,000	$281,000

Note: Negative RR&R costs reflect a cost reduction while positive RR&R numbers reflect a cost increase. Data represents the lowest and highest change dollar impacts in the years the action was implemented. These NED values were estimated with 2016 baseline tonnage.

a Flow action was fully implemented in 3 years of the POR. Note that the years after a full release also include a low summer flow event.

b Flow action was partially implemented in 31 years of the POR, as defined as years when a partial cue in March and/or May would occur or years when a full cue in March or May would occur.

Regional Economic Development

Under Alternative 2, average annual RED effects supported by commercial navigation are estimated to be 154 jobs and $8.8 million in labor income. When compared to Alternative 1, Alternative 2 would result in no changes in jobs and $11,000 less in labor income on average over the POR associated with the changes in navigation on the Missouri River. Table 3-173 summarizes the RED impacts under Alternative 2.

Shortened or eliminated navigation seasons under Alternative 2 during low summer flows or when System storage did not meet navigation targets would have an adverse impact on waterway industries and supporting sectors. Under Alternative 2, the economic impacts in the eight worst years relative to Alternative 1 would result in an average reduction of 14 jobs and $789,000 in labor income. In these worst-difference years compared to Alternative 1 when low summer flows would occur, there would be negligible impacts to waterway industries and supporting sectors compared to Alternative 1 in the large regional context of the lower river; however, the majority of these reductions would be experienced in the shipping industries, port services, and warehousing industries and could be important to these industries.

Industries that ship their products via the waterway (for example, agriculture, fertilizer manufacturers, petroleum producers and refiners, utilities shipping large plant and equipment, and others) would be adversely affected with reduced ability to navigate (and the ability to secure a future contract to navigate) causing potentially higher transportation costs for these industries and sectors. In addition, increases in jobs and income would occur in other transportation sectors, such as truck and rail transportation.

These impacts are likely to be temporary, small, and adverse because of the small overall change in NED and RED values with the potential for long-term impacts if navigation decreases in the future due to impacts to reliability.

Table 3-173. RED Effects Associated with Commercial Navigation on the Missouri River under Alternative 2 Compared to Alternative 1 (FY 2018$)

Economic Impact Parameter	Scenario	Economic Impact
Direct, Indirect, and Induced Jobs (no. of part-time and full-time jobs)	Annual Average RED Benefit	154
	Change in Annual Average RED Benefit Relative to Alternative 1	0
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-14
	Average Annual Change in 8 Best Years Relative to Alternative 1	8
Direct, Indirect, and Induced Labor Income (2018$)	Annual Average RED Benefit	$8,782,047
	Change in Annual Average RED Benefit Relative to Alternative 1	-$11,349
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$789,164
	Average Annual Change in 8 Best Years Relative to Alternative 1	$482,404
Direct, Indirect, and Induced Sales (2018$)	Annual Average RED Benefit	$29,376,603
	Change in Annual Average RED Benefit Relative to Alternative 1	-$37,963
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$2,639,811
	Average Annual Change in 8 Best Years Relative to Alternative 1	$1,613,679

Other Social Effects

An estimated additional 600 average tons of commercial commodities are assumed to be shipped annually under Alternative 2 via overland modes compared to Alternative 1 in the Kansas City reach. As shown in Table 3-174, Alternative 2 would result in a one percent increase in air emissions (CO and NOx) if all affected tonnage shifted to truck in the Kansas City reach compared to Alternative 1. Alternative 2 would also result in very small increases in CO and NOx emissions up to 100 kg and 300 kg, respectively, compared to Alternative 1. These changes in air emissions would be negligible to Missouri and non-attainment counties (see Table 3-170). There would be fewer tons shifting to alternate overland modes in the Omaha and Nebraska City reach, with negligible beneficial impacts to air emissions compared to Alternative 1.

With an estimated 25 tons per truck, Alternative 2 would result in an additional 24 trucks on the highways, mostly in Missouri. The impacts to public health and safety, infrastructure repair, and highway congestion would be temporary, negligible to small, and adverse given the small number of trucks and the broad region that would be impacted.

Table 3-174. Average Annual Tonnage Assumed to Shift to Overland Modes and Air Emissions for Alternative 2

Reach	Average Annual Tonnage Assumed to Shift to Overland Modes (change in tons)	Hydrocarbons (kg)	CO (kg)	NOx (kg)	PM (kg)
Omaha	**650 (-40)**				
Annual Average Emissions – Shift in Mode to Truck		30	100	310	20
Change from Alternative 1		0	-10	-20	0
Percent Change from Alternative 1		0%	0%	0%	0%
Annual Average Emissions – Shift in Mode to Rail		0	0	20	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Nebraska City	**7,200 (-200)**				
Annual Average Emissions – Shift in Mode to Truck		400	1,100	3,500	200
Change from Alternative 1		0	-100	-100	0
Percent Change from Alternative 1		0.0%	-8.0%	-3.0%	0.0%
Annual Average Emissions – Shift in Mode to Rail		0	0	200	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Kansas City	**58,200 (600)**				
Annual Average Emissions – Shift in Mode to Truck		2,800	9,100	28,100	1,800
Change from Alternative 1		0	100	300	0
Percent Change from Alternative 1		0.0%	1.0%	1.0%	0.0%
Annual Average Emissions – Shift in Mode to Rail		100	300	1,700	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%

Note: The tonnage assumed to shift to alternate modes and the impacts to air emissions were estimated with 2016 baseline tonnage. It should be noted that the tonnage moving off the river is not mutually exclusive for the river reaches. For example, tonnage impacts if moving from the Nebraska City reach to the Kansas City reach would be counted in both reaches.

Conclusion

Alternative 2 would result in small adverse impacts to average annual navigation NED value compared to Alternative 1 (reduction of $35,000 in NED benefits or 0.5 percent) primarily driven by the low summer flow events reducing the navigation season in certain years. In the years when low summer flows would occur, there would be small to large adverse effects to navigation transportation rate savings from reduced navigation service. There would be negligible to small adverse RED impacts, including impacts to waterway industries and industries that ship their products on the waterway because of the relatively small amount of tonnage that would shift to overland modes compared to Alternative 1 (1 percent). Average annual changes in air quality and public health and safety would be negligible and temporary and adverse due to the minor impact on regional air quality and a very small increase in the number of trucks on the highways in the region.

Under Alternative 2, the short-term impacts caused by a low summer flow event would not be significant; however, repeated implementation of low summer flow events could affect the reliability of navigation on the river and the ability of the industry to obtain long-term contracts. These impacts would likely be significant to the industry in the long term.

Alternative 3 – Mechanical Construction Only

Alternative 3 management actions would include the construction of early life stage habitat for the pallid sturgeon and ESH for the birds. In addition, the spring pulse that would occur under Alternative 1 would not be implemented under Alternative 3. However, there would be a one-time spawning cue test.

Mechanical Habitat Construction

Alternative 3 would result in the construction of 3,380 additional acres of early life stage habitat with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, Nebraska; 670 acres located between Rulo and the Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Each project will be designed to minimize or avoid adverse impacts to the authorized purposes including navigation. Prior to any construction, site-specific NEPA would be conducted on the project.

In years where construction is needed, Alternative 3 would construct 332 acres per year on average of ESH. Because this ESH construction would not occur in the navigable portion of the river, there would be no impacts to navigation.

National Economic Development

The navigation NED results for Alternative 3 are summarized in Table 3-175. Overall, Alternative 3 would result in negligible to small, beneficial impacts (average annual increase of $21,000 or 0.3 percent) to navigation NED value relative to Alternative 1 due a slight increase in System storage because of the elimination of the spring pulse under Alternative 3.

Table 3-175. Transportation Rate Savings, RR&R Costs, and Net Navigation NED Values for Alternative 3 (FY 2018$)

Navigation NED Value	Transportation Rate Savings	RR&R Costs	Net NED Value
Average Annual Value	$8,010,000	$570,000	$7,440,000
Max Annual Over the POR	$12,040,000	$1,260,000	$11,980,000
Min Annual Value Over the POR	$0	$0	0
Change from Alternative 1	$19,000	-$2,000	$21,000
% Change from Alternative 1	0.2%	-0.3%	0.3%

Note: Numbers were rounded; the net NED value may not exactly equal transportation rate savings less RR&R costs. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year but are from three different years in the POR. Values were estimated using 2016 baseline tonnage.

Table 3-176 summarizes the largest changes in navigation NED value over the POR under Alternative 3 compared to Alternative 1. In general, transportation rates saving would increase and RR&R costs would decrease under Alternative 3 compared to Alternative 1, although the changes would be small. In the highest NED value years compared to Alternative 1, as simulated in 1949, Alternative 3 would result in an increase of $754,000 (9.2 percent change compared to Alternative 1 in this year) due to higher navigation service levels resulting from the elimination of the spring plenary pulse.

Table 3-176. Impacts from Modeled Flow Releases under Alternative 3 Compared to Alternative 1 (FY 2018$)

Navigation NED Value	Years in Period of Record with Greatest Range in Impacts Regardless of Flow Actions	
	Lowest NED Value Change	Highest NED Value Change
Navigation NED Value	-$186,000	$754,000
Transportation Rate Savings	-$117,000	$579,000
RR&R Costs	-$250,000	$68,000

Note: The lowest value change in RR&R costs (negative numbers) reflect a reduction in cost, while increases in RR&R Costs (positive number) reflect an increase in costs. Values were estimated using 2016 baseline tonnage.

Regional Economic Development

Under Alternative 3, average annual RED effects supported by commercial navigation are estimated to be 154 jobs and $8.8 million in labor income. When compared to Alternative 1, Alternative 3 would result in no changes in jobs and an increase of roughly $13,000 in labor income on average over the POR associated with the changes in navigation on the Missouri River. Alternative 3 would result in negligible changes in navigation RED effects compared to Alternative 1, even in the largest difference years. Table 3-177 summarizes the RED effects under Alternative 3.

Table 3-177. RED Effects Associated with Navigation on the Missouri River under Alternative 3 and Compared to Alternative 1 (FY 2018$)

Economic Impact Parameter	Year	Economic Impact
Direct, Indirect, and Induced Jobs	Annual Average RED Benefit	154
	Change in Annual Average RED Benefit Relative to Alternative 1	0
	Average Annual Change in 8 Worst Years Relative to Alternative 1	0
	Average Annual Change in 8 Best Years Relative to Alternative 1	2
Direct, Indirect, and Induced Labor Income (2018$)	Annual Average RED Benefit	$8,805,931
	Change in Annual Average RED Benefit Relative to Alternative 1	$12,535
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$105,872
Direct, Indirect, and Induced Sales (2018$)	Annual Average RED Benefit	$29,456,496
	Change in Annual Average RED Benefit Relative to Alternative 1	$41,930
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$354,149

Other Social Effects

Alternative 3 would result in fewer commercial commodities shifting from navigation to alternate transportation modes than under Alternative 1. An estimated increase of 700 tons (1 percent) on average per year would be transported on the waterway under Alternative 3 relative to Alternative 1 in the Kansas City reach. If 700 fewer tons on average per year are assumed to shift off the waterway to alternate modes, there would be decreases in CO and NOx air emissions under Alternative 3 compared to Alternative 1 (Table 3-178). There would also be a small reduction in the average tons assumed to annually shift to alternate overland modes of transportation in the Omaha and Nebraska City reaches. The relative change in air emissions across all locations would be small and would result in a negligible decrease in the regional air emissions and in non-attainment area counties.

A decrease of 700 tons of commercial commodities shipped via truck transportation (25 tons/truck) would result in a reduction of 28 trucks making trips on the highways per year, some of which would be in Missouri. The impacts to public health and safety, infrastructure repair, and highway congestion would be negligible and beneficial given the small number of trucks and the wide region that would be affected.

Table 3-178. Average Annual Tonnage Assumed to Shift to Overland Modes and Air Emissions for Alternative 3

Reach	Average Annual Tonnage Assumed to Shift to Overland Modes (change in tons)	Hydrocarbons (kg)	CO (kg)	NOx (kg)	PM (kg)
Omaha	**640 (-40)**				
Annual Average Emissions – Shift in Mode to Truck		30	100	310	20
Change from Alternative 1		0	-10	-20	0
Percent Change from Alternative 1		0%	-9%	-6%	0%
Annual Average Emissions – Shift in Mode to Rail		0	0	20	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Nebraska City	**7,300 (-100)**				
Annual Average Emissions – Shift in Mode to Truck		400	1,100	3,500	200
Change from Alternative 1		0	-100	-100	0
Percent Change from Alternative 1		0.0%	-8.0%	-3.0%	0.0%
Annual Average Emissions – Shift in Mode to Rail		0	0	200	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Kansas City	**56,800 (-700)**				
Annual Average Emissions – Shift in Mode to Truck		2,800	8,900	27,400	1,800
Change from Alternative 1		0	-100	-400	0
Percent Change from Alternative 1		0.0%	-1.0%	-1.0%	0.0%
Annual Average Emissions – Shift in Mode to Rail		100	300	1,600	0
Change from Alternative 1		0	0	-100	0
Percent Change from Alternative 1		0%	0%	-6%	0%

Note: The tonnage shifting to alternate modes of transportation and the impacts to air emissions were estimated with 2016 baseline tonnage. It should be noted that the tonnage moving off the river is not mutually exclusive for the river reaches. For example, tonnage impacts if moving from the Nebraska City reach to the Kansas City reach would be counted in both reaches.

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release under Alternative 3 was not included in the hydrologic modeling for this alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

Spawning cue releases as simulated under Alternative 6 would result in small adverse impacts to average annual navigation NED value compared to Alternative 1 (reduction of $127,000 or 1.7 percent) primarily driven by the spawning cue releases decreasing System storage and reducing the navigation season and/or service level in these years and the years following the releases. Full implementation of the spawning cue can result in a range of impacts, from very little impact on navigation service and season length with reductions in NED and RED benefits. For example, a worst-case change would result in $1.1 million or 10.7 percent reduction in transportation rate savings compared to Alternative 1 in this year. During the eight years when navigation would be most affected compared to Alternative 1, when spawning cues would be fully or partially implemented, there would be an average of 52 fewer days of full service, 10 fewer days of minimum service, and the navigation season would be shortened by an average of 13 days (refer to Section 3.0 of the "Navigation Environmental Consequences Analysis Technical Report" for additional details). Because the spawning cue would be implemented as a one-time event, there would likely be small adverse impacts to navigation because the temporary one-time implementation would not adversely contribute to the reliability of navigation service, notification would allow the industry to plan around the implementation, and the magnitude of NED, RED, and OSE impact is relatively small in the regional and national context.

Conclusion

Alternative 3 would result in negligible to small beneficial impacts to average annual navigation NED values compared to Alternative 1 (increase of $21,000 or 0.3 percent) primarily driven by higher navigation service levels because the spring pulse would not be implemented under Alternative 3. There would be negligible changes in RED and OSE effects because of the small decrease in tonnage shifting to alternate overland modes of transportation. The one-time implementation of the spawning cue would have temporary, negligible to small, and adverse impacts to navigation NED and RED effects from reduced System storage in the year or years following the flow release. The impacts would not be significant because the change in navigation NED, RED, and OSE from Alternative 1 would be temporary and negligible to small.

Alternative 4 – Spring ESH Creating Release

Alternative 4 focuses on developing ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis.

Mechanical Habitat Construction

Alternative 4 would involve the construction of an additional 3,380 acres of early life stage habitat for the pallid sturgeon, with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, Nebraska; 670 acres located between Rulo and the Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Each project will be designed to minimize or avoid impacts to the authorized purposes including navigation. Prior to any construction, site-specific NEPA would be conducted on the project.

In years where construction is needed, Alternative 4 would construct 195 acres per year on average of ESH, which involves mechanical excavation and placement of sand with typical large construction equipment or hydraulic dredge. The construction of ESH habitat would not occur in the navigable portion of the river and therefore would result in no impacts to navigation.

National Economic Development

Alternative 4 would result in an average annual decrease in net NED value of $181,000, a decrease of 2.4 percent compared to Alternative 1 (Table 3-179). The spring releases under Alternative 4 would reduce System storage, negatively impacting navigation service levels and the length of the navigation season. The bulk of the impact would be associated with transportation rate savings, with an average annual savings of $7.8 million, ranging from $0 when navigation support is not provided (and it is assumed that no navigation would occur) to $12.0 million during a full-service navigation year.

Table 3-179. Transportation Rate Savings, RR&R costs, and Net NED for Alternative 4 (FY 2018$)

Navigation NED Value	Transportation Rate Savings	RR&R Costs	Net NED Value
Average Annual Value	$7,830,000	$590,000	$7,240,000
Max Annual Over the POR	$12,040,000	$1,260,000	$11,980,000
Min Annual Value Over the POR	$0	$0	$0
Change from Alternative 1	-$160,000	$20,000	-$181,000
% Change from Alternative 1	-2.0%	3.5%	-2.4%

Note: Numbers were rounded; the net NED value may not exactly equal transportation rate savings less RR&R costs. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year but are from three different years in the POR. Values were estimated using 2016 baseline tonnage.

Additional results of flow actions are summarized in Table 3-180. These results show the difference in annual navigation NED values (transportation rate savings and RR&R costs) during years when there would be a full release action, partial release action, or a year after a full release. Full releases under Alternative 4 would result in the greatest decreases of annual net navigation NED values, with a large decrease of $1.5 million in the lowest NED value change year compared to Alternative 1, which represents a decrease of 14.1 percent compared to Alternative 1 in this year.

While the length of the navigation season between Alternative 1 and Alternative 4 during these simulated years would usually be the same, the full releases cause reductions in System storage, which reduces the navigation service level supported by USACE. The reduction in service level would increase the RR&R costs and reduce the transportation rate savings resulting in a decrease in the NED benefits compared to Alternative 1. Adverse impacts to navigation NED value would also occur in the years following the full releases and during partial release years, with less water in System storage decreasing the navigation service level, resulting in decreased transportation rate savings, and increased RR&R costs under Alternative 4 compared to Alternative 1. The spring releases under Alternative 4 could contribute to further uncertainty around the reliability of navigation, with large adverse NED effects in the long-term with further reductions in navigation.

Table 3-180. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1 (FY 2018$)

Release	NED Value Change	Navigation NED Value	Transportation Rate Savings	RR&R Costs
Full Flow Release [a]	Lowest NED Value Change	-$1,569,000	-$1,170,000	-$103,000
	Highest NED Value Change	$0	-$7,000	$398,000
Partial Flow Release [b]	Lowest NED Value Change	-$914,000	-$633,000	-$44,000
	Highest NED Value Change	$0	-$34,000	$281,000
Year after a Full Release	Lowest NED Value Change	-$1,303,000	-$1,019,000	-$54,000
	Highest NED Value Change	$20,000	$20,000	$284,000
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	-$1,569,000	-$1,170,000	-$103,000
	Highest NED Value Change	$81,000	$55,000	$398,000

Note: The lowest value change in RR&R costs (negative numbers) reflect a reduction in cost, while the highest NED value for RR&R costs (positive number) reflects an increase in costs. Data represents the lowest and highest change dollar impacts in the years the action was implemented over the period of record. These values were estimated using 2016 baseline tonnage.

a Flow action was fully implemented in 9 years of the POR

b Flow action was partially implemented in 7 years of the POR.

Regional Economic Development

Under Alternative 4, average annual RED benefits supported by navigation would be 152 jobs and $8.7 million in labor income. Compared to Alternative 1, Alternative 4 would result in two fewer jobs and $94,000 less in labor income on average over the POR associated with the reduced ability to navigate in some years, a change of 1.1 percent. There would be small adverse impacts to waterway industries and supporting sectors in the years with the largest reductions in commercial tonnage, resulting in a relative decrease in 12 jobs and $666,000 in labor income compared to Alternative 1. Table 3-181 summarizes the RED impacts under Alternative 4.

There would be negligible impacts to waterway industries and supporting sectors compared to Alternative 1 in the large regional context of the lower river; however, the majority of these reductions would be experienced in the shipping industries, port services, and warehousing industries and could be important to these industries. When navigation service is reduced or not supported, industries that ship their products via the waterway (for example, agriculture, fertilizer manufacturers, petroleum producers and refiners, utilities shipping large plant and equipment, and others) would be adversely affected with potentially higher transportation costs for these industries. Meanwhile, increases in jobs and income would occur in other transportation sectors, such as truck and rail transportation.

These impacts are likely to be temporary, small, and adverse because of the small overall change in NED and RED values with the potential for long-term impacts if navigation decreases in the future with reductions in the reliability of navigation.

Table 3-181. RED Effects Associated with Navigation on the Missouri River under Alternative 4 and Compared to Alternative 1 (FY 2018$)

Economic Impact Parameter	Scenario	Economic Impact
Direct, Indirect, and Induced Jobs (no. of part-time and full-time jobs)	Annual Average RED Benefit	152
	Change in Annual Average RED Benefit Relative to Alternative 1	–2
	Average Annual Change in 8 Worst Years Relative to Alternative 1	–12
	Average Annual Change in 8 Best Years Relative to Alternative 1	0
Direct, Indirect, and Induced Labor Income (2018$)	Annual Average RED Benefit	$8,699,195
	Change in Annual Average RED Benefit Relative to Alternative 1	–$94,201
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$666,422
	Average Annual Change in 8 Best Years Relative to Alternative 1	$6,737
Direct, Indirect, and Induced Sales (2018$)	Annual Average RED Benefit	$29,099,457
	Change in Annual Average RED Benefit Relative to Alternative 1	-$315,109
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$2,229,231
	Average Annual Change in 8 Best Years Relative to Alternative 1	$22,536

Other Social Effects

The spring releases result in decreases in System storage in some years, shortening the navigation seasons and potentially moving commodities off the waterway to other modes of transportation. As shown in Table 3-182, Alternative 4 would result in 5,300 tons on average of commercial commodities that would be assumed to shift from the waterway in the Kansas City reach to alternate overland transportation modes compared to Alternative 1. This change is driven by shorter navigation seasons under Alternative 4. For the Kansas City reach, the increase in NOx emissions under Alternative 4 would range from 100 kg (6 percent) for rail transport to 2,500 kg (9 percent) for truck transportation compared to Alternative 1. These changes in air emissions would be negligible to Missouri and non-attainment counties. There would be small increases in average annual air emissions in the Nebraska City and Omaha reaches under Alternative 4 compared to Alternative 1; although the percent changes from Alternative 1 are notable, the changes in air emissions would be negligible in magnitude.

With an estimated 25 tons per truck, Alternative 4 would result in an additional average annual 212 trucks on the highways, mostly in Missouri. The impacts to public health and safety, infrastructure repair, and highway congestion would be temporary, negligible to small, and adverse given the small number of trucks and the broad region that would be impacted.

Table 3-182. Average Annual Tonnage Assumed to Shift to Overland Modes and Air Emissions for Alternative 4

Reach	Average Annual Tonnage Assumed to Shift to Overland Modes (change in tons)	Hydrocarbons (kg)	CO (kg)	NOx (kg)	PM (kg)
Omaha	**980 (290)**				
Annual Average Emissions – Shift in Mode to Truck		50	150	470	30
Change from Alternative 1		20	40	140	10
Percent Change from Alternative 1		67%	36%	42%	50%
Annual Average Emissions – Shift in Mode to Rail		0	0	30	0
Change from Alternative 1		0	0	10	0
Percent Change from Alternative 1		0%	0%	50%	0%
Nebraska City	**8,500 (1,100)**				
Annual Average Emissions – Shift in Mode to Truck		400	1,300	4,100	300
Change from Alternative 1		0	100	500	100
Percent Change from Alternative 1		0.0%	8.0%	14.0%	50.0%
Annual Average Emissions – Shift in Mode to Rail		0	0	200	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Kansas City	**62,900 (5,300)**				
Annual Average Emissions – Shift in Mode to Truck		3,100	9,800	30,300	1,900
Change from Alternative 1		300	800	2,500	100
Percent Change from Alternative 1		11.0%	9.0%	9.0%	6.0%
Annual Average Emissions – Shift in Mode to Rail		100	400	1,800	0
Change from Alternative 1		0	100	100	0
Percent Change from Alternative 1		0%	33%	6%	0%

Note: The tonnage shifting to alternate modes and the impacts to air emissions were estimated with 2016 baseline tonnage. It should be noted that the tonnage moving off the river is not mutually exclusive for the river reaches. For example, tonnage impacts if moving from the Nebraska City reach to the Kansas City reach would be counted in both reaches.

Conclusion

Alternative 4 would result in small adverse impacts to average annual navigation NED values compared to Alternative 1 (reduction of $181,000 or 2.4 percent). These impacts are primarily caused by the spring releases decreasing System storage and reducing the navigation season and/or service level in these years and the years following the releases. In the years most affected, there would be large adverse effects to navigation transportation rate savings compared to Alternative 1. There would be negligible to small adverse RED impacts because decreases would not be perceptible in the regional context and would be offset with gains in other transportation sectors. Impacts to air quality and public health and safety would be negligible to small, temporary and adverse due to the minor impact on regional air quality and the small number of additional trucks on the highways in the region. Continued implementation of full spring releases could affect the ability of the industry to provide reliable navigation service and to establish contracts with their customers, with the potential for large adverse impacts to navigation NED value in the long-term.

Under Alternative 4, the impacts would not be significant because on average the adverse impacts to navigation NED value are small (2.4 percent) and RED and OSE impacts would be negligible in the regional context.

Alternative 5 – Fall ESH Creating Release

Alternative 5 would include fall releases from Gavins Point Dam and mechanical construction to create ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches. Under Alternative 5, IRC habitat to support early life stage requirements of the pallid sturgeon would be constructed in the lower river below Ponca, Nebraska.

Mechanical Habitat Construction

Alternative 5 would include the construction of 3,380 additional acres with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, Nebraska; 670 acres located between Rulo and the Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Each project will be designed to minimize or avoid impacts to the authorized purposes including navigation. Prior to any construction, site-specific NEPA would be conducted on the project.

In years where construction is needed, Alternative 5 would construct 253 acres per year on average of ESH which involves mechanical excavation and placement of sand with typical large construction equipment or hydraulic dredge. The construction of ESH habitat would not occur in the navigable portion of the river, and therefore, there would be no impacts to navigation.

National Economic Development

The navigation NED values under Alternative 5 are summarized in Table 3-183. On average, Alternative 5 would result in lower transportation rate savings and higher RR&R costs, resulting in a negligible to small decrease in navigation NED value compared to Alternative 1 ($57,000 or 0.8 percent). The annual difference in navigation NED value under Alternative 5 would range from a minimum of $0 when navigation service is assumed to not be supported such as under modeled years 1935 to 1942 to a maximum of $12 million when a full navigation service would be supported.

Table 3-183. Transportation Rate Savings; RR&R costs, and Net NED for Alternative 5 (FY 2018$)

Navigation NED Value	Transportation Rate Savings	RR&R Costs	Net NED Value
Average Annual Value	$7,940,000	$574,000	$7,360,000
Max Annual Over the POR	$12,040,000	$1,260,000	$11,980,000
Min Annual Value Over the POR	$0	$0	$0
Change from Alternative 1	-$50,000	$7,000	-$57,000
% Change from Alternative 1	-0.6%	1.2%	-0.8%

Note: Numbers were rounded; the net NED value may not exactly equal transportation rate savings less RR&R costs. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year but are from three different years in the POR. Values were estimated using 2016 baseline tonnage.

Table 3-184 presents the lowest and highest differences in annual net NED values between Alternative 1 and Alternative 5 that occur under various flow scenarios. Alternative 5 would include fall releases that are simulated to be fully implemented in seven years over the POR. The largest adverse impacts to navigation occur in the year or years following the fall releases, with a large decrease of $1.6 million in navigation NED value. For example, the simulated years of 1988 and 1995 are years that follow a fully implemented fall release. In these years, the decreased NED value was caused by lower System storage levels and navigation service levels in subsequent years, resulting in relatively higher RR&R costs and decreases in transportation rate savings. The fall releases under Alternative 5 could contribute to further uncertainty around the reliability of the Missouri River as a navigation source, with the potential for additional adverse NED effects in the long-term with further reductions in navigation.

Table 3-184. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1 (FY 2018$)

Release	NED Value Change	Navigation NED Values	Transportation Rate Savings	RR&R Costs
Full Flow Release [a]	Lowest NED Value Change	-$120,000	-$110,000	$0
	Highest NED Value Change	$0	-$76,000	$44,000
Partial Flow Release [b]	Lowest NED Value Change	$59,000	$20,000	-$39,000
	Highest NED Value Change	$59,000	$20,000	-$39,000
Year after a Fall Release	Lowest NED Value Change	-$1,574,000	-$1,400,000	$0
	Highest NED Value Change	-$39,000	-$39,000	$284,000
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	-$1,574,000	-$1,400,000	-$250,000
	Highest NED Value Change	$709,000	$459,000	$284,000

Note: The negative RR&R costs represent a cost savings, while positive RR&R costs represent a cost increase. Data represents the lowest and highest change in dollar impacts in the years the action was implemented. The values are estimated with 2016 baseline tonnage.

a Flow action was fully implemented in 7 years of the POR.

b Flow action was partially implemented in 2 years of the POR.

Regional Economic Development

Under Alternative 5, average annual RED effects supported by commercial navigation are estimated to be 154 jobs and $8.8 million in labor income. When compared to Alternative 1, Alternative 5 would result in no changes in jobs and $9,000 less in labor income on average over the POR associated with the changes in navigation on the Missouri River. Alternative 5 would result in negligible change in RED impacts compared to Alternative 1, even in the lowest difference years, because of the minor shift in additional tonnage being transported by alternate modes. Table 3-185 summarizes the RED impacts under Alternative 5. When navigation service is reduced or not provided, industries that ship their products via the waterway would be adversely affected with a potential for higher transportation costs for these industries. However, increases in jobs and income would occur in other transportation sectors, in truck and rail transportation. These RED impacts are likely to be negligible and adverse because of the small overall change in navigation service in most years.

Table 3-185. RED Effects Associated with Navigation on the Missouri River under Alternative 5 and Compared to Alternative 1 (FY 2018$)

Economic Impact Parameter	Scenario	Economic Impact
Direct, Indirect, and Induced Jobs (no. of part-time and full-time jobs)	Annual Average RED Benefit	154
	Change in Annual Average RED Benefit Relative to Alternative 1	0
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-4
	Average Annual Change in 8 Best Years Relative to Alternative 1	2
Direct, Indirect, and Induced Labor Income (2018$)	Annual Average RED Benefit	$8,784,033
	Change in Annual Average RED Benefit Relative to Alternative 1	-$9,363
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$212,163
	Average Annual Change in 8 Best Years Relative to Alternative 1	$103,963
Direct, Indirect, and Induced Sales (2018$)	Annual Average RED Benefit	$29,383,246
	Change in Annual Average RED Benefit Relative to Alternative 1	-$31,320
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$709,701
	Average Annual Change in 8 Best Years Relative to Alternative 1	$347,763

Other Social Effects

There would be negligible changes in average annual air emissions in the Nebraska City and Omaha reaches under Alternative 5 compared to Alternative 1. For the Kansas City reach, there would be negligible to small increases in average annual emissions of 100 kg of carbon monoxide and 200 kg of nitrogen oxide, with no change of hydrocarbons and particulate matter compared to Alternative 1 (Table 3-186). However, the change in air emissions would be negligible in the regional context and in non-attainment area counties.

An increase of an additional 500 tons of commercial commodities shipped via truck transportation in the Kansas City reach would result in an approximate increase of 20 trucks on average per year on the highways, mostly in Missouri, compared to Alternative 1. The impacts to public health and safety, infrastructure repair, and highway congestion would be negligible given the small number of trucks and the wide region that would be affected.

Table 3-186. Average Annual Tonnage Assumed to Shift to Overland Modes and Air Emissions for Alternative 5

Reach	Average Annual Tonnage Assumed to Shift to Overland Modes (change in tons)	Hydrocarbons (kg)	CO (kg)	NOx (kg)	PM (kg)
Omaha	**690 (0)**				
Annual Average Emissions – Shift in Mode to Truck		30	110	330	20
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Annual Average Emissions – Shift in Mode to Rail		0	0	20	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Nebraska City	**7,400 (100)**				
Annual Average Emissions – Shift in Mode to Truck		400	1,200	3,600	200
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0.0%	0.0%	0.0%	0.0%
Annual Average Emissions – Shift in Mode to Rail		0	0	200	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Kansas City	**57,600 (500)**				
Annual Average Emissions – Shift in Mode to Truck		2,800	9,100	28,000	1,800
Change from Alternative 1		0	100	200	0
Percent Change from Alternative 1		0.0%	1.0%	1.0%	0.0%
Annual Average Emissions – Shift in Mode to Rail		0	0	0	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%

Note: The tonnage shifting to alternate modes and the impacts to air emissions were estimated using 2016 baseline tonnage. It should be noted that the tonnage moving off the river is not mutually exclusive for the river reaches. For example, tonnage impacts if moving from the Nebraska City reach to the Kansas City reach would be counted in both reaches.

Conclusion

Alternative 5 would result in small adverse impacts to average annual navigation NED value and in most years over the period of record compared to Alternative 1 (average annual reduction of $57,000 or 0.8 percent) primarily caused by the fall flow releases reducing System storage and the navigation season in the years following the release. However, in a couple of the years following a flow release, there would be large adverse effects to navigation transportation rate savings from reduced System storage and navigation service. There would be negligible impacts to regional economic effects, including impacts to waterway industries and industries that ship their products on the waterway because of the relatively small amount of tonnage that would shift to overland modes compared to Alternative 1 (1 percent). Impacts to air quality and public health and safety would be negligible to small, temporary and adverse due to the negligible impact on regional air quality and the additional number of trucks on the highways in the region. Continued implementation of fall releases could affect the ability of the industry to provide reliable navigation service and to establish contracts with their customers, with the potential for additional adverse impacts to navigation NED value in the long-term.

Under Alternative 5, the impacts would not be significant because short-term impacts on average would be small (0.8 percent) and RED and OSE impacts would be negligible in the regional context.

Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, USACE would attempt a spawning cue pulse every three years in March and May. In addition, management actions under Alternative 6 include mechanical construction to create ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska; and the construction of IRC habitat in the lower river below Ponca, Nebraska, to support the pallid sturgeon.

Mechanical Habitat Construction

Alternative 6 would result in the construction of 3,380 additional acres with 276 acres located between Sioux City and Platte; 585 acres located between Platte River and Rulo, Nebraska; 670 acres located between Rulo and the Kansas River; 1,389 acres located between Kansas River and Osage River; 460 acres located between Osage River and the mouth of the Missouri River. Each project will be designed to minimize or avoid impacts to the authorized purposes including navigation. Prior to any construction, site-specific NEPA would be conducted on the project.

In years where construction is needed, 245 acres would be constructed per year on average of ESH under Alternative 6. Construction would require mechanical excavation and placement of sand with typical large construction equipment or hydraulic dredge. This would not occur in the navigable portion of the river, with therefore, there would be no impacts to navigation.

National Economic Development

The navigation NED results for Alternative 6 are summarized in Table 3-187. Relative to Alternative 1, Alternative 6 would result in the reduction in average annual transportation rate savings of $119,000 and an increase in RR&R costs of $8,000, with an average annual decrease in navigation NED benefits of $127,000 or 1.7 percent.

Table 3-187. Transportation Rate Savings, RR&R costs, and Net NED for Alternative 6 (FY 2018$)

Navigation NED Value	Transportation Rate Savings	RR&R Costs	Net NED Value
Average Annual Value	$7,870,000	$580,000	$7,290,000
Max Annual Over the POR	$12,280,000	$1,260,000	$12,270,000
Min Annual Value Over the POR	$0	$0	$0
Change from Alternative 1	-$119,000	$8,000	-$127,000
% Change from Alternative 1	-1.5%	1.4%	-1.7%

Note: Numbers were rounded; the net NED value may not exactly equal transportation rate savings less RR&R costs. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year but are from three different years in the POR. Values were estimated using 2016 baseline tonnage.

Under Alternative 6, there would be six years with a fully implemented spawning cue release and 30 years of full implementation of one of the spawning cue releases (March or May) or partial release of one or both of the bimodal releases. Table 3-188 summarizes the lowest and highest annual difference in transportation rate savings and navigation NED benefits between Alternative 1 and Alternative 6 by flow action. The largest adverse impacts to navigation NED value occur in the years when a full or partial release would be simulated to occur. As simulated, three full or partial release years would experience a large decrease between $900,000 and $1.5 million in annual navigation NED benefits compared to Alternative 1. These impacts would be due to the releases reducing System storage, which would affect the level of navigation service, which leads to an increase in RR&R costs and a decrease in transportation rate savings, decreasing navigation NED value. The spawning cue under Alternative 6 could contribute to further uncertainty around the reliability of the Missouri River as a navigation source, with large adverse NED effects in the long-term with further reductions in navigation.

Table 3-188. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1 (FY 2018$)

Release	NED Value Change	Navigation NED Values	Transportation Rate Savings	RR&R Costs
Full Flow Release [a]	Lowest NED Value Change	-$1,446,000	-$1,051,000	-$64,000
	Highest NED Value Change	$0	-$7,000	$395,000
Partial Flow Release [b]	Lowest NED Value Change	-$1,386,000	-$1,047,000	-$102,000
	Highest NED Value Change	$289,000	$188,000	$340,000
Year after a Full Release (Includes Low Summer Flows)	Lowest NED Value Change	-$333,000	-$390,000	-$54,000
	Highest NED Value Change	$0	-$261,000	$0
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	-$1,446,000	-$1,051,000	-$102,000
	Highest NED Value Change	$557,000	$570,000	$395,000

Note: Negative RR&R costs represent costs savings while positive RR&R costs represent a cost increase. Data represents the lowest and highest change dollar impacts in the years the action was implemented. These NED values were estimated using 2016 baseline tonnage.

a Flow action was fully implemented in 6 years of the POR.

b Flow action was partially implemented in 29 years of the POR; partial implementation years are defined as years when a partial cue in March and/or May would occur or years when a full cue in March or May would occur.

Regional Economic Development

Under Alternative 6, average annual RED benefits supported by navigation would be 152 jobs and $8.7 million in labor income. Compared to Alternative 1, Alternative 6 would result in one less job and $85,000 less in labor income on average over the POR associated with the reduced ability to navigate in some years, a change of 1.0 percent. There would be small adverse impacts to waterway industries and supporting sectors in the years with the largest reductions in shipments compared to Alternative 1. In the eight worst change years, there would be a relative decrease in nine jobs and $528,000 in labor income compared to Alternative 1. There would be negligible impacts to waterway industries and supporting sectors compared to Alternative 1 in the large regional context of the lower river; however, the majority of these reductions would be experienced in the shipping industries, port services, and warehousing industries and could be important to these industries. Table 3-189 summarizes the RED impacts under Alternative 6. When navigation service is reduced or not provided, industries that ship their products via the waterway would be adversely affected with potentially higher transportation costs for these industries. However, increases in jobs and income would occur in other transportation sectors, such as truck and rail transportation.

These impacts are likely to be temporary, small, and adverse because of the small overall change in NED and RED values with the potential for long-term impacts if navigation decreases in the future with reductions in the reliability of navigation.

Table 3-189. RED Effects Associated with Navigation on the Missouri River under Alternative 6 and Compared to Alternative 1 (thousands of FY 2018 $)

Economic Impact Parameter	Scenario	Economic Impact
Direct, Indirect, and Induced Jobs (no. of part-time and full-time jobs)	Annual Average RED Benefit	152
	Change in Annual Average RED Benefit Relative to Alternative 1	-1
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-9
	Average Annual Change in 8 Best Years Relative to Alternative 1	1
Direct, Indirect, and Induced Labor Income (2018$)	Annual Average RED Benefit	$8,708,140
	Change in Annual Average RED Benefit Relative to Alternative 1	-$85,256
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$527,532
	Average Annual Change in 8 Best Years Relative to Alternative 1	$60,301
Direct, Indirect, and Induced Sales (2018$)	Annual Average RED Benefit	$29,129,378
	Change in Annual Average RED Benefit Relative to Alternative 1	-$285,188
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$1,764,633
	Average Annual Change in 8 Best Years Relative to Alternative 1	$201,710

Other Social Effects

The spawning cue releases could cause System storage to decrease in some years, shortening the navigation seasons in the year(s) following the releases, which increases the commodities that shift from the waterway to alternate modes of transportation. There would be small increases in average annual air emissions in the Nebraska City and Omaha reaches under Alternative 6 compared to Alternative 1; although the percent changes are noticeable, the change in air emissions is negligible in magnitude in these reaches.

As shown in Table 3-190, 62,400 tons on average could potentially shift off the waterway per year in the Kansas City reach to alternate transportation modes under Alternative 6, an increase of 4,800 tons (8 percent) compared to Alternative 1. Nitrous oxide air emissions would have the largest change from Alternative 1, ranging from 100 kg (6 percent) for rail transportation to 2,300 kg (8 percent) for truck transportation in the Kansas City reach. These changes in air emissions would be negligible to Missouri and non-attainment counties. The OSE results for Alternative 6 are summarized in Table 3-190.

With an estimated 25 tons per truck, Alternative 6 would result in an additional 192 trucks on average per year on the highways, mostly in Missouri. The impacts to public health and safety, infrastructure repair, and highway congestion would be temporary, negligible to small, and adverse given the small number of trucks and the broad region that would be impacted.

Table 3-190. Average Annual Tonnage Assumed to Shift to Overland Modes and Air Emissions for Alternative 6

Reach	Average Annual Tonnage Assumed to Shift to Overland Modes (change in tons)	Hydrocarbons (kg)	CO (kg)	NOx (kg)	PM (kg)
Omaha	**990 (300)**				
Annual Average Emissions – Shift in Mode to Truck		50	150	480	30
Change from Alternative 1		20	40	150	10
Percent Change from Alternative 1		67%	36%	45%	50%
Annual Average Emissions – Shift in Mode to Rail		0	10	30	0
Change from Alternative 1		0	10	10	0
Percent Change from Alternative 1		0%	0%	50%	0%
Nebraska City	**8,400 (1,000)**				
Annual Average Emissions – Shift in Mode to Truck		400	1,300	4,100	300
Change from Alternative 1		0	100	500	100
Percent Change from Alternative 1		0.0%	8.0%	14.0%	50.0%
Annual Average Emissions – Shift in Mode to Rail		0	0	200	0
Change from Alternative 1		0	0	0	0
Percent Change from Alternative 1		0%	0%	0%	0%
Kansas City	**62,400 (4,800)**				

Reach	Average Annual Tonnage Assumed to Shift to Overland Modes (change in tons)	Hydrocarbons (kg)	CO (kg)	NOx (kg)	PM (kg)
Annual Average Emissions – Shift in Mode to Truck		3,100	9,700	30,100	1,900
Change from Alternative 1		300	700	2,300	100
Percent Change from Alternative 1		11.0%	8.0%	8.0%	6.0%
Annual Average Emissions – Shift in Mode to Rail		100	400	1,800	0
Change from Alternative 1		0	100	100	0
Percent Change from Alternative 1		0%	33%	6%	0%

Note: The tonnage shifting to alternate modes and the impacts to air emissions were estimated with 2016 baseline tonnage. It should be noted that the tonnage moving off the river is not mutually exclusive for the river reaches. For example, tonnage impacts if moving from the Nebraska City reach to the Kansas City reach would be counted in both reaches.

Conclusion

Alternative 6 would result in small adverse impacts to average annual navigation NED values compared to Alternative 1 (reduction of $127,000 or 1.7 percent) primarily driven by the spawning cue releases decreasing System storage and reducing the navigation season and/or service level in the years the releases occur and the years following the releases. In the years most affected, there would be large adverse effects to navigation transportation rate savings compared to Alternative 1. There would be negligible to small adverse RED impacts because decreases would not be perceptible in the regional context and would be offset with gains in other transportation sectors. Impacts to air quality and public health and safety would be negligible to small, temporary and adverse due to the minor impact on regional air quality and the small number of additional trucks on the highways in the region. Continued implementation of spawning cue releases could affect the ability of the industry to provide reliable navigation service and to establish contracts with their customers, with the potential for large adverse impacts to navigation NED value in the long-term.

Under Alternative 6, the impacts would not be significant because on average the adverse impacts to navigation NED value are small (1.7 percent) and RED and OSE impacts would be negligible in the regional context.

3.15.2.2 Commercial Sand and Gravel Navigation

This section describes the methods used to evaluate the potential for NED, RED, and OSE impacts to commercial sand and gravel navigation impacts. The impacts were evaluated qualitatively with an assessment of the river flows and stages and recorded sand and gravel extraction data because of the minor changes in river flows and dredging operations. Detailed NED, RED, and OSE evaluation was not undertaken. Additional evaluation will be conducted prior to the implementation of any flow releases.

Please note that this evaluation focuses on the impacts to dredgers associated changes in river flows affecting the ability of dredgers to extract and transport material; Section 3.11, Commercial Sand and Gravel Dredging, describes the impacts of the MRRMP-EIS alternatives on the sediment accumulation rate and resulting availability of sand.

Methodology

Commercial sand and gravel dredging occurs on the Missouri River between St. Joseph and St. Louis, Missouri. When water levels are low or high, commercial dredgers need to dredge closer to their sand plants and use their dredges to maintain adequate depths for the dredge barges (USACE 2011, page 3.6-7). Commercial dredging generally occurs year-round when temperatures are above freezing. During the winter months, during the non-navigation season when river flows are relatively low, repair and maintenance activities are typically conducted on dredges and sand production is lower than in the spring, summer, and fall. However, at times during the winter months when conditions are favorable, commercial sand and gravel dredgers are able to operate within a limited range of their sand plants. Additional information on commercial sand and gravel dredging is provided in Missouri River Commercial Dredging Final EIS (USACE 2011).

The commercial sand and gravel navigation evaluation used information on river flow and stage thresholds from the Missouri River Master Manual, Water Flow Changes and the Impact on the Missouri River Sand Industry, Appendix 10: Sand and Gravel Dredging (USACE 2002). As part of the Master Manual evaluation, the Tennessee Valley Authority conducted surveys with the sand and gravel companies that operate on the Missouri River. Dredging companies operating downstream of Kansas City noted that 26,000 cfs is a low flow threshold below which dredging operations would be affected. For example, dredgers noted that operations would have to be shifted to the lowest dock on the river to accommodate lower water levels, necessitating more trips and the possibility of purchasing new equipment if conditions persisted.

Dredging operators in the Kansas City and St. Joseph segments can also be affected by relatively higher river stages (USACE 2002); the evaluation assessed the number of days when river stages are above flood stage and above five feet below flood stage in Kansas City and St. Joseph.

These high and low thresholds were compared to HEC-RAS data, showing the number of days when river flows were above and below these thresholds over the period of record. In addition, USGS river gage data at St. Joseph, Kansas City, Waverly, Glasgow, Booneville, Jefferson City, Hermann, Washington, and St. Charles was reviewed between 2006 and 2016, along with the recorded sand and gravel extraction data to assess how rivers flows and stages affect dredgers. This information was used along with the HEC-RAS data on the prevalence of low and high flows over the period of record under the MRRMP-EIS alternatives to assess potential impacts to commercial sand and gravel dredgers.

Summary of Environmental Consequences

Table 3-191 summarizes the environmental consequences to commercial sand and gravel dredging operations associated with high and lower river flows and stages under each of the MRRMP alternatives.

Table 3-191. Navigation Environmental Consequences for Commercial Sand and Gravel Dredging

Alternative	Impacts for Commercial Sand and Gravel Dredging Operations
Alternative 1	Dredging operations would continue under Alternative 1, with low and high flows potentially affecting dredging operations in extreme conditions. Management actions under Alternative 1 would result in a negligible contribution to these effects.
Alternative 2	Negligible changes in dredging operations from low river flows on average across the period of record; however, there could be small and adverse impacts to dredging operations (e.g., short delays in extraction) and potentially additional dredging operating costs compared to Alternative 1 during relatively drier years following the releases. There would be negligible impacts to dredgers in the St. Joseph and Kansas City segment from relatively higher river flows compared to Alternative 1 because of the minor change in the days above flood thresholds in these reaches even in the worst affected years.
Alternative 3	Negligible changes in dredging operations from low river flows on average across the period of record. There would be negligible impacts to dredgers in the St. Joseph and Kansas City segment from relatively higher river flows compared to Alternative 1 because of the minor change in the days above flood thresholds in these reaches even in the worst affected years.
Alternative 4	Same as Alternative 2
Alternative 5	Same as Alternative 3
Alternative 6	Same as Alternative 2

Alternative Results

According to the Master Manual (USACE 2002), lower water levels can impact commercial sand and gravel dredging through the ability to extract material as well as the extraction location (i.e., may need to dredge in areas closer to their plant or in relatively deeper river areas); the location for the unloading of the dredged material (i.e., may need to move to downstream docks); the need to light-load barges; and the ability to move the dredged material from the barges to the conveyor at the dock (i.e., may need special equipment for transfer). Higher river flows can affect the ability to dredge because some dredges and equipment are not suited for high flow conditions.

The 2006 recorded sand and gravel extraction data was evaluated when drought conditions caused river flows to drop below 26,000 cfs in the lower river. At some locations on the river, when river flows fell below 26,000 cfs, even when river flows were as low as 21,000 cfs, companies have been able to operate and extract material. However, in the downstream segments, for example in the St. Charles segment, near the confluence with the Mississippi River, some of the permitted dredges operated during low flow conditions in November 2006, while others were not operating.[9] Based on a review of the recorded sand and gravel extraction data, it is uncertain if the reduced extraction volumes were due to the relatively lower river flows or due to other factors or a combination of multiple factors. The recorded extraction data also indicates that there are times during the navigation season when companies are not operating even though river flows are above 26,000 cfs.

On average, there would be a very little change in the number of days below 26,000 during the navigation season across the alternatives. Even in the eight worst-change years from

[9] The year 2006 was a relatively drier year, and the minimum navigation service level was provided through October 16th. In November 2006, navigation service was not provided by USACE releases.

Alternative 1, there would be less than an average of 14 additional days below 26,000 under Alternatives 2, 4, and 6 across the river reaches from St. Joseph downstream (Table 3-192). In many other years, there would be more days above this threshold compared to Alternative 1. On average there is a negligible change in average annual days below 26,000 cfs across all river reaches downstream of St. Joseph.

Given the small amount of change in river flows below 26,000 cfs compared to Alternative 1 and continued dredging extraction during low flow conditions, it is likely that adverse impacts on average across the POR would be negligible; however, there could be small and adverse impacts to dredging operations (e.g., short delays in extraction) and potentially additional dredging operating costs under Alternatives 2, 4, and 6 during relatively drier years following the releases. These impacts would be localized and temporary and would occur in the fall months when the navigation season is ending. There would be no to negligible impacts to dredging operations due to low flow conditions under Alternatives 3 and 5 compared to Alternative 1 because of the minor change in the number of days below 26,000 cfs.

Table 3-192. Prevalence of River Flows Below 26,000 cfs (Days below Threshold) during the Navigation Season (April through November)

Location and Statistic	Alternative					
	1	2	3	4	5	6
St. Joseph						
Average Annual Days Below Threshold	27	28	26	28	27	28
Change Average Annual Days from Alternative 1		1	0	2	0	2
Average Number of Days in the 8 Worst Years, Change from Alternative 1		14	0	11	4	9
Average Number of Days in the 8 Best Years, Change from Alternative 1		-4	-2	0	-2	0
Kansas City						
Average Annual Days Below Threshold	20	20	20	21	20	22
Change Average Annual Days from Alternative 1		0	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1		7	0	9	4	9
Average Number of Days in the 8 Best Years, Change from Alternative 1		-7	-2	0	-2	0
Waverly						
Average Annual Days	19	19	19	20	19	20
Change Average Annual Days from Alternative 1		0	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1		6	0	9	3	8
Average Number of Days in the 8 Best Years, Change from Alternative 1		-8	-3	0	-3	0

Location and Statistic	Alternative					
	1	2	3	4	5	6
Booneville (RM 197)						
Average Annual Days Below Threshold	16	15	15	17	16	17
Change Average Annual Days from Alternative 1		-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1		3	0	9	3	9
Average Number of Days in the 8 Best Years, Change from Alternative 1		-13	-2	0	-1	0
Jefferson City (RM 144)						
Average Annual Days Below Threshold	15	15	15	16	15	16
Change Average Annual Days from Alternative 1		0	0	1	0	1
90th Percentile Days	40	41	39	47	44	47
Average Number of Days in the 8 Worst Years, Change from Alternative 1		5	0	9	3	9
Average Number of Days in the 8 Best Years, Change from Alternative 1		-10	-1	0	-1	0
Hermann (RM 98)						
Average Annual Days Below Threshold	10	9	10	11	10	11
Change Average Annual Days from Alternative 1		-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1		3	0	7	1	8
Average Number of Days in the 8 Best Years, Change from Alternative 1		-11	-1	0	-1	0
Washington (RM 68)						
Average Annual Days Below Threshold	10	9	10	11	10	11
Change Average Annual Days from Alternative 1		-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1		2	1	7	2	7
Average Number of Days in the 8 Best Years, Change from Alternative 1		-10	-1	0	-1	0
St. Charles (RM 28)						
Average Annual Days Below Threshold	10	9	10	11	10	11
Change Average Annual Days from Alternative 1		-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1		3	0	7	2	7
Average Number of Days in the 8 Best Years, Change from Alternative 1		-10	-2	0	-1	0

For dredgers in the upper segments of the river (Kansas City and St. Joseph), relatively higher river flows can affect the ability of the dredgers to extract sand and gravel (USACE 2002). In the Master Manual, the industry noted that they are typically impacted when the river is five feet below flood stage. The Kansas City District identified that the flood stage at the USGS St.

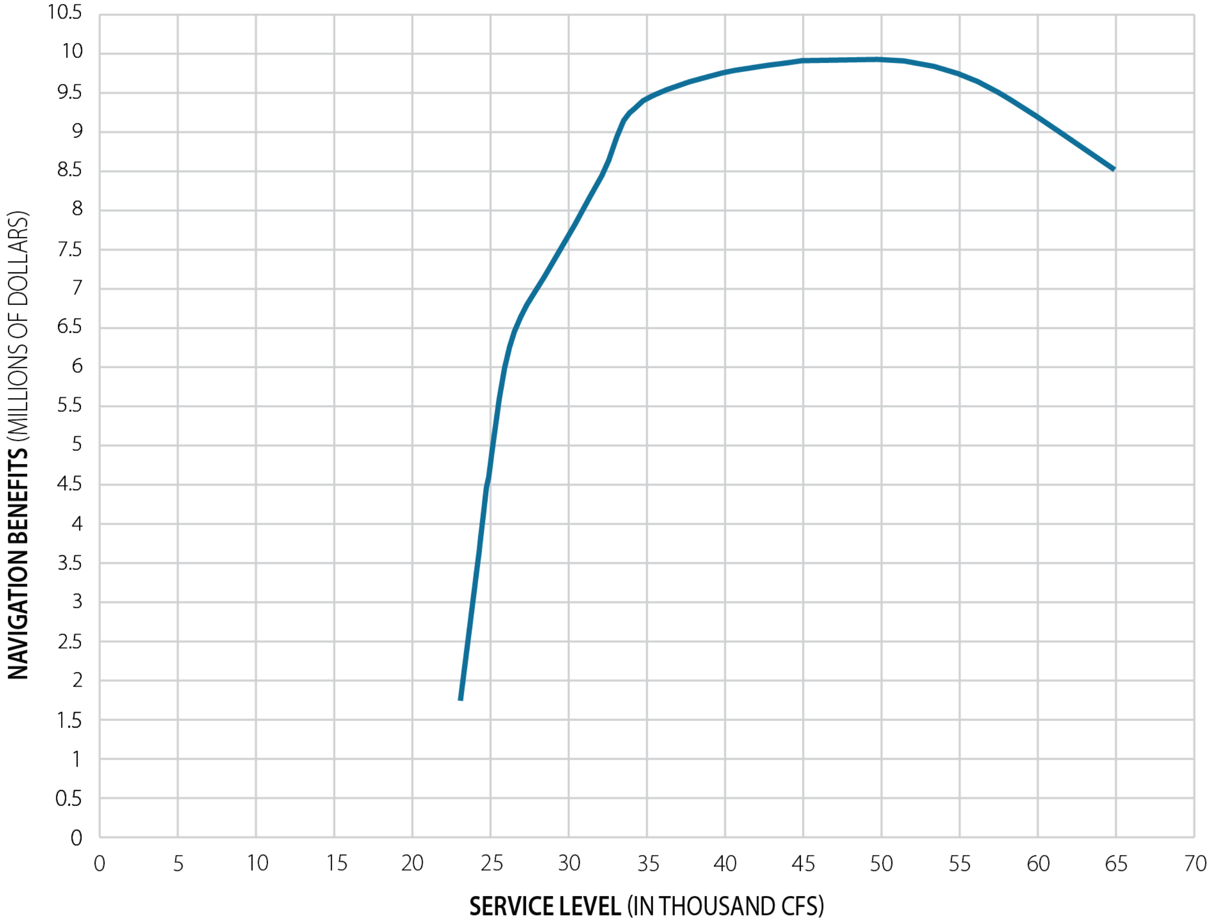
Joseph gage is 17 feet and 32 feet at the USGS Kansas City gage. On average, there is very little change in the number of days above flood stage under the alternatives in Kansas City and St. Joseph reaches. Considering the days at five feet below flood stage (27 feet at the Kansas City gage), there is very little change in stages at the Kansas City gage across the alternatives, with at most six more days over the POR under Alternative 2 compared to Alternative 1 (average annual increase compared to Alternative 1 of 0.1 days). There would not be noticeable changes in higher river flows under the action alternatives in the Kansas City reach compared to Alternative 1, with no to negligible impacts to dredging operators in this segment.

On average at St. Joseph, there would be four additional days under Alternative 4; and two additional days under Alternative 5; and three additional days under Alternative 6 above the river stage of twelve feet (five feet below flood stage) compared to Alternative 1. An evaluation of the 2011 sand and gravel extraction data provided by the Kansas City District indicated that in the St. Joseph segment, dredgers were operating when river stages were between 12 and 17 feet. Because of the minimal change in river flows at flood stage and at five feet below flood stage across the alternatives, and because dredgers in St. Joseph have demonstrated that they can dredge when the river stage is between 12 and 17 feet, there would be negligible impacts to dredgers in the St. Joseph segment under the action alternatives compared to Alternative 1.

3.15.2.3 Climate Change

The Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998) estimated the relationship between service level flows and navigation benefits. As shown in Figure 3-66, navigation benefits initially increase as the flow increases. However, at a certain point, navigation benefits reach a maximum and start to decline. The decrease in benefits during higher river flows are due to higher costs that waterway operators incur. This relationship is important to keep in mind when considering the potential impacts to navigation benefits from climate change.

A discussion on the influence of climate change on the alternatives is included in Section 3.2 River Infrastructure under Climate Change. The climate change section of this report discusses the anticipated changes in temperatures, precipitation, and stream flows for the Missouri River Basin. Any increase in these climatic variables could lead to shifting of standard service level and navigation benefits along the curve as shown in Figure 3-66. In accordance with *Engineering and Construction Bulletin: Guidance for Climate Change Adaptation Engineering Inputs to Inland Hydrology for Civil Works Studies, Designs, and Projects* (USACE 2016d), this section provides a qualitative assessment of the climate change effects to navigation for each alternative.



Source: USACE 1998c.

Figure 3-66. Relationship between Navigation Service Level Flows and Navigation Benefits on the Missouri River

As shown in Table 3-193, the following six climate change variables were evaluated for potential impacts to navigation: increased air temperature, increased precipitation and stream flow, decreased peak snow water equivalent, earlier snowmelt date and decreased snow accumulation season duration, increased sedimentation, and increased irregularity of flood and droughts.

Table 3-193. Discussion of Risk to Navigation from Climate Change Variables for Alternatives 1–6

Climate Change Variables	Alternatives	Relevant Description of Climate Change Variable	Description of Risk to Navigation
Increased Air Temperature	1, 2, 3, 4, 5, 6	During summer water supply operations, could potentially have water quality issues with lower Gavins Point releases if water temperature increases.	No identified impact to risk to navigation benefits.

Climate Change Variables	Alternatives	Relevant Description of Climate Change Variable	Description of Risk to Navigation
Increased Precipitation and Streamflow	1, 2, 4, 5, 6	May be able to run spring pulses more often due to increased System storage. However, the frequency of a completed pulse would likely decrease due to exceeding flood targets more frequently.	(+ and –) Reduce risk of adverse impact to navigation benefits by increasing the supply of water to support navigation. However, additional pulses would adversely affect navigation service and season length through reducing System storage for the following seasons.
Decreased Peak Snow Water Equivalent	1, 2	Forecasting calendar year runoff has the potential to become less accurate, since forecasting runoff based on precipitation is much more difficult than forecasting runoff based on snow water equivalent. Less accurate forecasts may result in an increased risk of overall System impacts (e.g., lower System storage and reservoir elevations) if setting pulse magnitude too high.	(–) Increase risk of adverse impact to navigation benefits by lowering System storage and navigation service level and season length.
Earlier Snowmelt Date and Decreased Snow Accumulation Season Duration	1, 2, 3, 4, 5, 6	May be able to run spring pulses more frequently due to System storage rising earlier in the year. Potentially lower snow runoff and lower System storage in the summer and fall months.	(– and +) Increase risk of adverse impact to navigation benefits in the short term by increasing the risk of lower service level in 2nd half of navigation season and in the long term by increasing the risk of a less reliable navigation system. Higher System storage in March would increase navigation service levels through July, although a greater number of pulses would reduce System storage, navigation service levels and season length in the fall months.
Increased Sedimentation	1, 2, 4, 5, 6	Decreased System storage may lead to decreased frequency of all pulses (assuming pulse requirements remain the same and sedimentation is not addressed).	(– and +) Increase risk of adverse impact to navigation benefits by decreasing System storage available to support navigation. With fewer numbers of pulses, there would be relatively smaller impacts from storage impacts on service levels and season length.
Increased Irregularity of Floods and Droughts	1, 2, 4, 5, 6	Accuracy of downstream forecasting may decrease, resulting in more frequent flood impacts caused by pulses. Have a greater potential to impact System storage with pulses if more droughts occur.	(–) Increase risk of adverse impact to navigation benefits in the short term by increasing the risk of more frequent extreme events (droughts and floods) which suspend navigation and in long term by increasing the risk of less reliability to navigation.

Climate change variables under Alternative 1 would result in beneficial and adverse impacts to navigation. However, the management actions under Alternative 1 (plenary pulse and mechanical habitat) would not be substantially affected by climate change.

Impacts to navigation under Alternatives 2, 3, 4, 5, and 6 with climate change would be similar to Alternative 1. With earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses relative to Alternative 1 may result in lower System storage and lower river flows in the second half of the navigation season, with greater impacts to navigation season level and season length compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Large and more sporadic rain events could exacerbate the possibility of flooding during spring or fall releases under Alternatives 2, 4, 5, and 6, with adverse impacts to navigation and commercial sand and gravel operations. Impacts to navigation service levels with climate change along with adverse impacts under Alternatives 2, 4, 5, and 6, and especially under Alternative 2 with the split navigation season, would provide additional adverse impacts to the reliability of navigation on the Missouri River.

3.15.2.4 Cumulative Impacts

Past, present, and reasonably foreseeable future actions that impact commercial navigation and commercial sand and gravel dredging on the Missouri River include the following:

- changes in the world economic market, such as changes in grain prices, agricultural exports to Asia, exports of raw materials and petroleum products, and U.S. and global demand for coal;
- changes in navigation infrastructure, such as expansion of the Panama Canal;
- changes in the industrial profile of the Missouri River basin, such as the growth of ethanol industry;
- changes to commercial sand dredging permit allocations and locations;
- changes in the local market for commercial sand in the construction industry;
- changes in rail and highway transportation markets and infrastructure, such as an increase in the capacity of railways and highways, labor shortage of truck drivers, and mandates for Positive Train Controls on freight rail shipments;
- and federal, state, and local laws and efforts to encourage waterway transportation such as the U.S. Department of Transportation’s America’s Marine Highway Program, the recently re-opening of the Port of Kansas City, and the Inter-modal Surface Transportation Efficiency Act.

These past, present, and reasonably foreseeable actions could result in both beneficial and adverse impacts to navigation and commercial sand and gravel dredging on the Missouri River.

Construction of the Missouri River Mainstem Reservoir System and the associated dams allows operation with controlled flow releases from the upper river into the lower river to achieve multiple management objectives, including providing support for navigation. Variability in natural hydrologic conditions (precipitation and snowmelt, which include periods of drought and high runoff) and the “rules” governing System operation would continue to dominate the flows in the Missouri River into the future. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impact to

System storage and river flows in the lower river, thus impacting commercial sand and gravel dredging, navigation service levels, and season lengths. The considerable droughts and floods that have occurred since the late 1980s have had a profound impact on Missouri River navigation. Other actions and programs, such as water depletions or withdrawals for agriculture, municipal, and industrial uses have and would continue to have adverse impacts to System storage and river flows, as they could affect the ability to support navigation.

Future aggradation and degradation trends would have similar effects under all the alternatives. HEC-RAS modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses (Section 3.2.2.3, Impacts on Hydrology from the Alternatives), the elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in year 15 under all alternatives compared to year 0. The change in stage in the riverine areas in year 15 in the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15. However, in Kansas City, the projected river stage in year 15 would only be slightly lower (less than one inch of the mean stage) than year 0. Activities that affect degradation and aggradation could adversely affect ports and marinas and other navigation and/or dredging infrastructure along the Missouri River from impacts to the structural integrity of the structures and infrastructure.

Current management of the MRRP program would continue under Alternative 1, with habitat development and the spring plenary pulse. Current management of the System under Alternative 1 would provide navigation benefits, with drought and relatively drier conditions causing reductions in transportation rate savings and RED jobs and income benefits, increases in air emissions, and impacts to health and safety; the management actions under Alternative 1 would have negligible to small contribution to these adverse impacts. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be small to large and beneficial depending on future hydrological conditions and transportation market conditions because navigation would continue to be supported by USACE. The contribution of management actions under Alternative 1 would be negligible because of the relatively large impact of natural hydrologic variability in the Missouri River system and of market and economic forces affecting navigation.

Alternative 2 would result in negligible to small adverse impacts to average annual navigation NED, RED, and OSE effects compared to Alternative 1. In the years when low summer flows would occur, there would be small to large adverse effects to navigation transportation rate savings, and repeated implementation of low summer flow events would likely affect navigation reliability in the long-run. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts on navigation associated with Alternative 2 would be short-term and small to large and adverse; however, in the long-term, the low summer flow events under Alternative 2 would result in a large contribution to cumulative adverse impacts as reliability on the river becomes uncertain.

Alternative 3 would result in negligible to small beneficial impacts to navigation NED and RED effects compared to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts on navigation associated with Alternative 3 would result in beneficial impacts to navigation, and hydrological conditions and transportation market conditions would affect the magnitude of these beneficial effects. Alternative 3 would provide a negligible contribution to these impacts because of the very small changes in navigation NED, RED, and OSE effects and the temporary and small adverse effects of the one-time spawning cue test.

Alternatives 4, 5, and 6 would result in small to large adverse impacts to navigation, depending on the amount of System storage and navigation service that is affected in the year of or years following the flow releases. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts in the short-run associated with Alternatives 4, 5, and 6 would be beneficial because navigation would continue to be supported by USACE. The contribution of Alternatives 4, 5, and 6 to these cumulative impacts in the short-term would be negligible to small and adverse. In the long-term, cumulative impacts could be adverse depending on how the repeated implementation of the flow releases affects the ability of the industry to provide reliable navigation service on the Missouri River. The contribution of these alternatives to the cumulative impacts would be small and adverse because USACE will still be providing navigation flows and service and the hydrologic and market conditions play a large role in the cumulative impacts to navigation.

3.16 Recreation

3.16.1 Affected Environment

The Missouri River corridor between Fort Peck Lake and St. Louis, Missouri, supports a wide range of water, land, and wildlife-related activities. Recreational opportunities, settings, and access to public facilities vary considerably along the river. For this analysis, the river was divided into three main geographic locations: Mainstem reservoirs; inter-reservoir river reaches; and the lower river below Gavins Point Dam to the confluence with the Mississippi River.

The natural amenities and features of the Missouri River corridor are a popular destination for outdoor enthusiasts, attracting millions of visitors to the corridor each year. Recreational opportunities supported by the Missouri River corridor include a variety of land- and water-based activities. Water-based recreation includes shoreline fishing, boat fishing, power boating, waterskiing, tube towing, jet skiing, tubing, canoeing, kayaking, and swimming. Sport fishing (i.e., fishing for sport or recreation) is a prevalent activity in all locations along the Missouri River and its reservoirs, including cold water and cool water reservoir fishing for salmon and walleye; rainbow trout fishing along the river reaches of Montana; and warm water fishing for bass and catfish. Wetlands, sandbars, and shoreline along the river corridor serve as waterfowl habitat and support opportunities for waterfowl hunting and bird watching. Natural landscapes and viewscapes surrounding the reservoirs and inter-reservoir river reaches of the Missouri River also attract a large number of sightseers.

As visitors travel to and from recreation areas along the Missouri River, they spend money in local communities on food, gas, lodging, and other trip-related expenses. Visitors who live outside the river corridor stimulate economic activity and inject new money into local economies within the corridor, supporting jobs and income of residents.

3.16.1.1 Reservoirs

In 2012, the six Mainstem reservoirs were estimated to support more than 5.5 million recreation visitor days[10] (Table 3-194). Recreational opportunities at these reservoirs range from primitive to more developed, providing the general public with access to facilities that enhance recreational experiences. Most recreational use of the lakes occurs during the spring, summer, and fall months, with Lakes Sakakawea and Oahe supporting the highest annual visitation of the six Mainstem reservoirs.

[10] Visits are defined as one person visiting the reservoir for a day or a number of days. Recreation visitor days is an estimate of the total number of person-days for all visits; visits are adjusted to account for certain types of visitors (i.e., campers) that recreate at a reservoir for multiple days to estimate recreational visitor days.

Table 3-194. Annual Recreation Visitor Days on the Reservoirs, 2012

Reservoir	Winter Recreation Days	Spring, Summer, and Fall Recreation Days	Total Recreation Days
Fort Peck Lake	58,540	541,458	599,998
Lake Sakakawea	83,292	1,328,064	1,411,356
Lake Oahe	199,617	1,317,681	1,517,298
Lake Sharpe	111,261	659,029	770,290
Lake Francis Case	8,076	152,253	160,329
Lewis and Clark Lake	105,282	894,376	999,658
Total	566,068	4,892,861	5,458,929

Source: USACE OMBIL 2012h

The 2012 recreation visitor days for the reservoirs were adjusted to 2015 levels to maintain consistency across the locations by using the change in population growth in the adjacent counties between 2012 and 2015. Table 3-195 summarizes the baseline recreation visitor days adjusted to 2015.

Table 3-195. Annual Recreation Visitor Days on the Reservoirs, 2015

Reservoir	Population Change (2012-2015)	Winter Recreation Days	Spring, Summer, and Fall Recreation Days	Total Recreation Days
Fort Peck Lake	-0.4%	58,285	539,095	597,380
Lake Sakakawea	7.4%	89,476	1,426,669	1,516,146
Lake Oahe	7.2%	214,063	1,413,039	1,627,102
Lake Sharpe	2.3%	113,794	674,033	787,827
Lake Francis Case	0.7%	8,133	153,321	161,454
Lewis and Clark Lake	0.0%	105,273	894,302	999,575
Total	NA	589,024	5,100,460	5,689,484

Source: USACE OMBIL 2012h

Note: Population-adjusted with the average change in population between 2012 and 2015 for counties adjacent to the reservoirs (US Census Bureau 2012; US Census Bureau 2015).

Visitation to the reservoirs varies from year to year in response to environmental conditions and water elevations, which can affect fishing opportunities and access to shoreline facilities and boat ramps. Storage volumes and lake elevations in the upper three reservoirs (Fort Peck Lake, Lake Sakakawea, and Oahe Lake) fluctuate more than those of the three downstream reservoirs (Lake Sharpe, Lake Francis Case, and Lewis and Clark Lake). Table 3-196 summarizes the visitation at the lakes during low, middle, and high water years between 2002 and 2012.

Table 3-196. Average Annual Visitation on the Reservoirs during Low, Middle, and High Water Years, 2002 to 2012

Mainstem Reservoir	Low Water Year	Middle Water Years	High Water Years
Fort Peck Lake	236,372	307,110	396,333
Lake Sakakawea	866,188	1,031,992	982,612
Lake Oahe	746,111	939,335	1,032,676
Lake Sharpe	572,413	651,453	591,477
Lake Francis Case	120,196	159,113	148,548
Lewis and Clark Lake	687,532	705,894	694,589

Source: USACE OMBIL 2012h

Notes: 2004, 2005, 2006, and 2007 are considered to be low water years (below 40 MAF in System storage); 2002, 2003, 2009, and 2012 are middle water years (between 40 and 60 MAF in System storage); and 2010 and 2011 are high water years (more than 60 MAF in System storage). Note that this table presents visits and not recreation visitor days, presented in the previous table.

USACE and state, county, and local government agencies manage the recreation facilities at the reservoirs. The quality and quantity of amenities varies across recreation sites and may include: interpretive centers, boat ramps, camp sites, swimming beaches, picnic areas, playgrounds, bathrooms and showers, handicap accessible facilities, electrical hookups and dump stations, grills, fish cleaning stations, and small bait or grocery stores. Public recreation facilities at each of the lakes are summarized in Table 3-197.

Table 3-197. Recreation Facilities at Mainstem Reservoirs

Reservoir	USACE Sites	Ramps, Main (Low-water)	Marinas (Resorts)	Camping Areas (Primitive)	Swim Areas
Fort Peck Lake	27	20 (8)	4 (0)	14 (3)	5
Lake Sakakawea	183	67 (42)	7 (1)	38 (30)	19
Lake Oahe	145	50 (5)	3 (2)	14 (14)	9
Lake Sharpe	58	20 (0)	1 (0)	7 (8)	6
Lake Francis Case	59	62 (0)	2 (1)	7 (0)	8
Lewis and Clark Lake	59	26 (0)	3 (0)	14 (3)	7

Sources: For USACE reservoirs: USACE 2003, 2004, 2007, 2008, 2010; USACE Boating and Recreation Guides for each lake; Operation and Maintenance Business Information Link (OMBIL) data, which include USACE-owned areas and many areas for which USACE transferred title under Title VI. Personal communications: Three Legs 2012; Rousseau 2012; Fletcher 2012; Wells 2012; LaPointe 2012; Little Swallow 2012; Magnan 2009; Persoon 2011; Schuckman 2009a; Shafer 2009

Reservoir visitors participate in a variety of land and water-based activities. Water-based activities that attract a large number of visitors to the reservoirs each year include boating, swimming, and waterskiing. Although most boating is associated with hook-and-line fishing, many visitors partake in pleasure boating and sailing during the warm summer months. Wind surfing, waterskiing, tubing, and jet skiing are also popular water-based activities, as is swimming and sunbathing along the shoreline or in designated swimming areas during the summer months.

Fish and wildlife-associated recreation are some of the most popular uses of the reservoirs. The reservoirs support both cool and cold-water fisheries and provide critical nesting and feeding habitat for upland birds and waterfowl. Several of the lake fisheries are recognized nationally and support competitive fishing events. Chinook salmon, walleye, catfish, bass, northern pike, sauger, crappie, trout, and yellow perch are the primary gamefish. Since wildlife is abundant in areas surrounding the lakes, opportunities exist for wildlife photographers and enthusiasts, birders, and upland game and waterfowl hunters. In addition, the diverse natural landscapes surrounding the six reservoirs attract a large number of sightseers each year.

Camping and picnicking are very popular activities at many of the recreation areas during the warmer months. More developed camping and picnicking facilities are available at many of the public and semi-private recreation sites. These areas are popular destinations for visitors making weekend trips or traveling with families. On summer weekends, especially holiday weekends, these campgrounds are often near capacity.

Recreational opportunities on these reservoirs attract thousands of visitors to local communities surrounding the lakes. Visitors coming from outside of the region stay in local gateway communities and spend their money on food, gas, lodging, and supplies. These expenditures stimulate economic activity and support jobs and income in these communities and counties. The residency of the visitors can affect the economic impact of spending in local economies; Table 3-198 summarizes recent data on the residency of visitors to the six Mainstem lakes.

Table 3-198. Residency of Visitors to the Reservoirs

Reservoir	Visitors from Counties Surrounding or Adjacent to Project Area	Non-local Visitors*
Fort Peck Lake	8%	92%
Lake Sakakawea	22%	78%
Lake Oahe	30%	70%
Lake Sharpe	45%	55%
Lake Francis Case	21%	79%
Lewis and Clark Lake	57%	43%

Source: Longhenry pers. comm. 2016; Fryda pers. comm. 2016; USGS 2011; South Dakota Game Fish and Parks 2016.
*Non-local visitors include visitors from counties with population centers greater than 50 miles from the reservoir project area.

3.16.1.2 Inter-Reservoir River Reaches

The Missouri River System includes four free-flowing river segments between the dam and reservoir projects. Unlike the reservoir projects, USACE does not manage most of the lands adjacent to the riverine reaches. Instead, the inter-reservoir river reaches pass through a variety of Tribal, state, municipal, and private lands. River access along these reaches is limited and usually restricted to designated access points at recreation sites. Partner agencies and local businesses manage most of the river accesses and recreational facilities within these reaches. Recreation specialists with USACE conducted an extensive effort to reach out to partner agencies, local organizations, and private businesses to collect data on recreational facilities and visitation to non-USACE-administered sites along the inter-reservoir river reaches conducted in 2009 and 2010. Information collected on facilities are summarized in Table 3-199.

Recreation opportunities and facilities within these riverine reaches differ from those at the reservoirs. A number of recreation sites within the riverine reaches are “low density use” sites, with relatively low visitation and few facilities. However, some “intensive use” recreation sites also exist within the inter-reservoir river reaches, such as those in proximity to Bismarck and Pierre. These areas tend to offer more amenities and support much higher visitation levels. Both low density and intensive use areas within the riverine reaches include interpretative centers, swimming beaches, boat ramps, and marinas.

Because the most comprehensive estimates for visitation across both USACE and non-USACE-administered sites were for 2009, annual visitation for this year is presented to provide a more complete picture of river use in the inter-reservoir river reaches. Adjusting for multi-day campers who visit the river recreation areas for an average of 3.8 days per visit, the inter-reservoir river reaches were estimated to support more than 1.2 million recreational visitor days in 2009. Recreation days for each of the inter-reservoir river reaches are summarized in Table 3-200.

Table 3-199. Recreation Facilities at Inter-Reservoir River Reaches

River Reaches	Recreation Sites	Boat Ramps	Marinas or Resorts	Camp Sites	Swim Areas
Fort Peck Dam to Lake Sakakawea	19	14	0	121	4
Garrison Dam to Lake Oahe	22	20	2	489	2
Oahe Dam to Lake Sharpe	6	6	2	322	4
Fort Randall Dam to Lewis and Clark Lake	18	11	0	346	2

Sources: USACE 2003, 2004b, 2007, 2008, 2010; OMBIL data; Hesse et al. 1992, 1993; Sheriff et al. 2011; Missouri Department of Conservation 2012; Iowa Department of Natural Resources 2010a, 2010b, 2010c; North Dakota Game and Fish Department 2009); Nebraska Game and Parks Commission 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2010e; NPS 2003, 2009, 2010a, 2010b; and personal communications by telephone and email with various local, state, private land managers.

Table 3-200. Recreation Visitor Days in the Inter-Reservoir River Reaches, 2009

River Reaches	Winter Recreation Days	Spring, Summer, and Fall Recreation Days	Total Recreation Days
Fort Peck Dam to Lake Sakakawea	21,683	285,655	307,338
Garrison Dam to Lake Oahe	13,036	285,702	298,738
Oahe Dam to Lake Sharpe	26,505	414,011	440,516
Fort Randall Dam to Lewis and Clark Lake	24,228	171,009	195,237
Total Recreation Visitor Days	85,452	1,156,377	1,241,829

Sources: USACE OMBIL 2012h; Hess et al. 1992, 1993; Iowa Department of Natural Resources 2010a, 2010b, 2010c; North Dakota Game and Fish Department 2009); Nebraska Game and Parks Commission 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2010e; NPS 2003, 2009, 2010a, 2010b; and personal communications by telephone and email between USACE and private, state, and local land managers.

The 2009 recreation visitor days for the inter-reservoir river reaches were adjusted to 2015 levels to maintain consistency across the locations by using the change in population growth in the adjacent counties between 2009 and 2015. Table 3-201 summarizes the baseline recreation visitor days adjusted to 2015.

Table 3-201. Recreation Visitor Days in the Inter-Reservoir River Reaches, 2015

River Reaches	Population Change 2009-2015	Winter Recreation Days	Spring, Summer, and Fall Recreation Days	Total Recreation Days
Fort Peck Dam to Lake Sakakawea	32.9%	28,816	379,623	408,439
Garrison Dam to Lake Oahe	13.5%	14,796	324,265	339,060
Oahe Dam to Lake Sharpe	4.1%	27,580	430,798	458,378
Fort Randall Dam to Lewis and Clark Lake	0.5%	24,354	171,899	196,253
Total Recreation Visitor Days	-	95,545	1,306,585	1,402,130

Sources: USACE OMBIL 2012h; Hess et al. 1992, 1993; Iowa Department of Natural Resources 2010a, 2010b, 2010c; North Dakota Game and Fish Department 2009); Nebraska Game and Parks Commission 2009a, 2009b, 2010a, 2010b, 2010c, 2010d, 2010e; NPS 2003, 2009, 2010a, 2010b; and personal communications by telephone and email between USACE and private, state, and local land managers.

Note: Population-adjusted with the average change in population between 2009 and 2015 for counties adjacent to the reservoirs (US Census Bureau 2009; US Census Bureau 2015).

The inter-reservoir river reaches are very popular with hunters and anglers. River access points within the inter-reservoir reaches are used for launching boats for fishing, waterfowl hunting, pleasure boating, and other water-based recreational activities. These riverine reaches act as a staging area for migrating geese and ducks in the spring and fall, where they rest and forage before continuing their migration. Waterfowl hunters access these islands and shoreline by boats and from shore (USACE 2011a). Northern pike, salmon, bullhead, sauger, bass, walleye, paddlefish, catfish, panfish, and trout are popular species harvested by both shore and boat anglers.

Recreational use of the river increases considerably near the Bismarck-Mandan area in the Garrison Dam to Lake Oahe reach, which has marinas, public boat access sites, and popular intensive use areas like the Kimball Bottoms Recreation Area (also known as the Desert). The overall concentration of marinas, private docks, and boat access in and around Bismarck is the greatest concentration of boating activity in any of the inter-reservoir river reaches. The river reach between Oahe Dam and the headwaters of Lake Sharpe includes the cities of Fort Pierre and Pierre in South Dakota. These larger population centers have a number of river developments, including the Fort Pierre and Pierre waterfronts, nature trail and bicycling trails, sand volleyball court, picnic areas, camping facilities, and an amphitheater.

The Fort Randall Dam to Lewis and Clark Lake river reach is un-channelized and relatively undeveloped, with only a small number of low-density recreation areas. NPS administers a scenic water trail within this reach as part of the Missouri National Recreational River.

3.16.1.3 Lower River

The lower Missouri River includes 811 river miles downstream of Gavins Point Dam to the mouth of the Mississippi River just above St. Louis. Like the inter-reservoir river reaches, the lower river and floodplain are characterized by an extensive patchwork of natural landscapes that are a diverse mix of riverine, floodplain, prairie, wetland and forest habitats. Also, similar to the inter-reservoir river reaches, the lower river passes through a variety of Tribal, state, municipal, and private lands. Although USACE manages a few recreation sites and facilities within the lower portion of the river, much of the river access and recreational facilities are managed and maintained by partner agencies and local businesses whose livelihoods are closely tied to recreation on the river.

The lower Mainstem can be divided into two distinct segments based on the types of engineering structures within each reach: the upper segment from Gavins Point Dam to Rulo, Nebraska, and the lower segment between Rulo, Nebraska, and the mouth of the Mississippi. The upstream segment between Gavins Point Dam and Rulo, Nebraska, is the only portion of the lower river not channelized or modified by dikes or revetments. This 59-mile portion of the river is designated as a National Recreational River under the Wild and Scenic Rivers Act and has retained a meandering natural channel with many chutes, backwater marshes, sandbars, islands, changing shorelines, and variable current velocities. The lower segment, specifically between Ponca, Nebraska, and the mouth of the Mississippi, was channelized under the BSNP and is used for commercial navigation.

Recreational settings and opportunities within the lower river are diverse and located much closer to larger population centers than those in the inter-reservoir river reaches in the upper river. Approximately 75 percent of visitors to the lower river traveled fewer than 30 miles to get to their recreation destination along the river from their residence, and 95 percent of visitors were within 150 miles of their home (Sheriff et al. 2011).

Outreach to partner agencies and private businesses or organizations was conducted to collect data on recreational facilities and visitation to non-USACE-administered sites along the lower river. Information collected on facilities within the lower river reaches is summarized in Table 3-202.

The Missouri Department of Conservation and the Nebraska Game and Parks Commission, in cooperation with other state and federal partners, estimated public use of the Missouri River between Gavins Point Dam near Yankton, South Dakota, to the mouth of the river near St. Louis, Missouri (Sheriff et al. 2011). The Public Use Assessment collected information on the types and amount of public use, fish and wildlife harvested from the river, socio-demographic characteristics of users, and the economic value of the river to users over a 13-month period. The lower river was estimated to support over 2.4 million recreation visitor days between January 2004 and January 2005 (Sheriff et al. 2011; Sheriff 2015). This estimate includes visitation to public accesses and recreation areas, private lands not generally accessible by the public, fishing tournaments, and excursion boats. The estimated recreation visitor days for the two lower river reaches are summarized in Table 3-203.

Table 3-202. Recreation Facilities in the Lower River

River Reaches	Recreation Sites	Boat Ramps	Marinas or Resorts	Camp Sites	Swim Areas
Gavins Point Dam to Rulo, Nebraska	71	65	12	1,445	12
Rulo to the mouth of the Missouri River	102	70	2	820	2

Sources: USACE 2004a; OMBIL data; Missouri Department of Conservation (MDC) 2011, 2012a; Missouri Department of Natural Resources 2010a, 2010b, 2010c, 2010d, 2010e, 2010f, 2010g, 2010h, 2010i, 2010j, 2010k, 2010l; and personal communications by telephone and email with between USACE and federal, state, and local managing agencies.

Table 3-203. Recreation Visitor Days in the Lower River, 2004

River Reaches	Winter Recreation Days	Spring, Summer, and Fall Recreation Days	Total Recreation Days
Gavins Point Dam to Rulo, Nebraska	183,121	1,030,415	1,213,535
Rulo, Nebraska to the mouth of the Missouri River	190,866	1,038,553	1,229,419
Total	373,986	2,068,968	2,442,955

Source: Calculated with data from Sheriff et al. (2011) and USACE OMBIL databases 2012h.

The 2004 recreation visitor days for the lower river were adjusted to 2015 levels to maintain consistency across the locations by using the change in population growth in the adjacent counties between 2004 and 2015. Table 3-204 summarizes the baseline recreation visitor days adjusted to 2015.

Table 3-204. Recreation Visitor Days in the Lower River, 2015

River Reaches	Population Change 2004–2015	Winter Recreation Days	Spring, Summer, and Fall Recreation Days	Total Recreation Days
Gavins Point Dam to Rulo, Nebraska	8.7%	199,116	1,120,422	1,319,538
Rulo, Nebraska to the mouth of the Missouri River	4.5%	199,540	1,085,752	1,285,292
Total	NA	398,656	2,206,174	2,604,830

Source: Calculated with data from Sheriff et al. (2011) and USACE OMBIL databases 2012h.

Note: Population-adjusted with the average change in population between 2004 and 2015 for counties adjacent to the river reaches (US Census Bureau 2004; US Census Bureau 2015).

Collectively, the 59 river miles between Gavins Point Dam and Ponca, Nebraska, are designated as a national water trail and administered by NPS as part of the Missouri River National Recreational River. Popular water-based activities within the Missouri River National Recreational River include canoeing, kayaking, tubing, and fishing; picnicking, hunting, bird watching, and camping. Outside of the Missouri River National Recreational River, the lower river between Gavins Point Dam and Ponca, Nebraska is heavily used for land- and water-based recreation.

Waterfowl hunting is a popular activity in this river reach and typically occurs by boat, where hunters access islands and shorelines. In the fall, flows in the Missouri River below Gavins Point Dam are reduced and sandy islands become exposed, providing access for waterfowl hunters. In addition to providing critical habitat to numerous species, sandbars are popular recreational features in this part of the lower river (USACE 2011a).

Fishing is a prevalent activity in the Gavins Point Dam tailwaters downstream of the dam. Main sport fish species caught in the tailrace just downstream of the dam are walleye, catfish, and paddlefish. Further downstream from the dam, anglers fish for catfish, walleye, carp, freshwater drum, buffalo, and smallmouth bass and crappie. Approximately 30 percent of angling in this upper part of the lower river is done from shore, while 70 percent is by boat (USACE 2011a).

The lower river becomes channelized just below Ponca, Nebraska, through a series of stone wing dams and levees. Recreation in this part of the river tends to be relatively unaffected by drought as long as navigation season flows are maintained (USACE 2011a). All or portions of the marina facilities are generally closed during the non-navigation season (generally November 21 through March 20) when river flows are low or iced over. Trail systems along the river have been developed in many municipal areas, including a non-motorized trail bridge between Omaha, Nebraska, and Council Bluffs, Iowa. Many visitors engage in camping, picnicking, sightseeing, observing wildlife, and outdoor photography.

The region surrounding the Missouri River between Rulo, Nebraska, and the mouth of the Mississippi River is heavily populated. The primary activities along this portion of the river are fishing and sightseeing; additional activities include boating, picnicking, hunting, and camping. The Katy Trail State Park is a state park that contains a recreational rail trail that follows the floodplain on the north side of the Missouri River from St. Charles to Franklin, Missouri, before turning south, away from the Missouri River. Many cultural and historical resources are also located along this reach, including Fort Osage Park and five state historic sites. USFWS manages Squaw Creek NWR, which is located near Mound City, Missouri; and Big Muddy NWR, which was established one year after the Great Flood of 1993. State and local government agencies manage boat ramp access areas, which are relatively evenly spaced along the river. Below Rulo, Nebraska, approximately half of anglers fish by boat, while the other half fish from shore (Korman pers. comm. 2015; Niswonger pers. comm. 2016).

There are several recreational events that occur on or near the Missouri River that attract hundreds to thousands of visitors every year. Several of these events are in the lower reach of the river such as Race to the Dome, Katy Trail Bike Ride, Missouri River Outdoor Expo, Missouri River 340, Hartsburg Pumpkin Festival and Pedaler’s Jamboree. These events include kayak races, bicycle rides, festivals and outdoor expositions and are located on or near the lower Missouri River.

3.16.1.4 Recreation Resources on Tribal Lands

There are 13 Native American Tribes, plus the Turtle Mountain Band of Chippewa Indians, who continue to live in rural areas along the Mainstem of the Missouri River. While each of these Tribes has a unique history and heritage, Native American cultures can share land-based worldviews rooted in the active recognition of kinship with the natural world. Thus, culture and lifestyles on Tribal reservations do not always create a clear distinction between work, leisure, family, and spirituality. Some Tribal members participate in a number of outdoor activities along the Mainstem of the Missouri River, including hunting, fishing, trapping, berry and mushroom picking, camping, hiking, swimming, and collecting medicinal plants. Although these activities at times may include a subsistence component, many Tribal members also view them as recreational experiences that provide personal enjoyment.

In addition to supporting recreational opportunities for Tribal members, many Tribes have begun to manage reservation lands for recreational use and enjoyment by Tribal and non-Tribal members. Several Tribes along the Missouri River have developed public recreation areas to attract outdoor enthusiasts and visitors interested in learning about the heritage and culture of native Tribes. Many of these reservations are in rural areas with outstanding opportunities for fishing and hunting. Although it is illegal for non-Tribal members to harvest plants or animals from reservation lands without Tribal consent, many Tribes have begun selling special hunting and fishing permits to non-Tribal members. Non-Tribal visitor spending and revenues from non-Tribal hunting and fishing permits help fund Tribal operations and support economic opportunities for those living on Tribal reservations.

A number of Tribes regularly hold pow-wows and recreation-related events along Lake Sakakawea and Lake Oahe. Some of these Tribal events are held on lands administered by USACE and leased in perpetuity by the Three Affiliated Tribes and South Dakota Game, Fish and Parks. Pow-wows and other Tribal events held along the river promote community empowerment and social cohesion, contribute to the spiritual and social well-being of Tribal members, and attract non-Tribal members interested in learning about Native American cultures and traditions. Many Tribal and non-Tribal visitors who attend these events (on or off USACE lands) often visit other recreational sites and use facilities at nearby USACE recreation areas (USACE 2010c).

3.16.2 Environmental Consequences

The environmental consequences analysis for recreation focuses on how changes in the prevalence of habitat and river and reservoir conditions under the MRRMP-EIS alternatives could affect visitation, recreational opportunities, and the value of the recreational experiences. This section provides an overview of the recreation impact assessment methodology and presents the result of the assessment. A more detailed description of the methodology and results is provided in the “Recreation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.16.2.1 Impact Assessment Methodology

Environmental consequences associated with recreation were evaluated using three of the four Principles and Guidelines accounts (NED, RED, and OSE). These accounts provide a framework for evaluating and displaying effects of management actions to ensure monetary and non-monetary values and interests expressed as important to stakeholders and Tribes are considered, while ensuring impacts are not double-counted. The following section provides a brief overview of the methodology that was used to evaluate impacts reflected in each account.

River flows and reservoir elevations can fluctuate, causing changes in access to recreational resources and fishing opportunities. Changes in environmental conditions and the quantity and quality of recreational experiences along the Missouri River affect recreation benefits to users and costs associated with maintaining recreation access. The analysis of impacts on recreation used outputs from the HEC-RAS and HEC-ResSim Missouri River models to simulate river and reservoir operations over an 81-year POR under each of the MRRMP-EIS alternatives.[11] These modeled simulations were then used to determine boat ramp operability and reservoir elevations under the alternatives.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

National Economic Development

Contributions to the NED account reflect net benefits that accrue in the planning area and the rest of the Nation from recreation opportunities along the Missouri River. These consumer

[11] An 81-year period of record was used for the recreation evaluation because of how the seasons were defined in the modeling and because there was a one-year lagged variable in the upper three reservoirs visitation regression modeling.

surplus benefits are measured using a hybrid approach that considers both the Unit Day Value (UDV) and travel cost method (TCM) approach (U.S. Water Resources Council 1983; USACE ER 1105-2-100 Appendix E; USACE 2017b) and reflect the maximum amount individuals are willing to pay to engage in recreation activities on the Missouri River, rather than forego them (Walsh 1986). The TCM is a revealed preference method of economic valuation that deduces willingness to pay through observing human behavior (i.e., the number and trips and costs per trip to a recreation area). The UDV method of estimating willingness to pay relies on expert and informed opinion to assign relative values to recreation days based on the quality of recreational opportunities supported by individual recreation areas. The approach to estimate the consumer surplus recreation values uses the UDV, which is based on USACE guidance and site-specific ratings and activities, but also recognizes that the UDV may reflect a relatively lower estimate of the consumer surplus value for a recreation visitor-day. Therefore, the UDV (in 2018$) was estimated and then proportionally increased based on the difference between the UDV and TCM as estimated in the Recreation Economics Volume 6C of the Master Water Control Manual Missouri River Review and Update (USACE 1994). The UDV ratings were obtained from the USACE Rec-BEST database and applied to the visitation to estimate recreation NED benefits. The UDV ratings were adjusted to reflect higher values associated with ESH and early life stage habitat for pallid sturgeon.

In the inter-reservoir and lower river reaches and the lower three reservoirs, boat ramp operability, as estimated from modeled river and reservoir elevations, was used to assess recreational access and visitation at these locations. A statistical process was used to estimate the best variables in predicting visitation at the upper three reservoirs. As a result, mid-August lake elevations, the price of gas, and the fishing success dummy variables were determined to be the greatest influential factors to predict visitation and were used to estimate visitation at each of the upper three reservoirs.

Potential capital costs to extend and/or replace low-water boat ramps and maintain recreational access at the upper three reservoirs during severe low-water conditions were assessed based on the drought of the 2000s. In addition, operational costs to maintain access to boat ramps were also evaluated when reservoir elevations decrease in subsequent summers. Natural resource managers at the lakes provided information on which the capital and operations and maintenance costs were developed. The recreation NED benefits reflect TCM and UDV benefits of visitation (including habitat) less the capital and operating costs and were evaluated based on a POR analysis.

Regional Economic Development

The RED analysis estimates the direct, indirect, and induced effects to local regions as measured through jobs, labor income, and sales. The recreation RED analysis assesses how changes in visitation under the MRRMP-EIS alternatives, as estimated in the NED analysis, would affect non-local visitor spending and associated impacts on regional economic conditions. Because results from the NED analysis showed that visitation to Lake Sharpe would be unaffected by actions under the MRRMP-EIS alternatives, Lake Sharpe was not evaluated in the RED analysis. The inter-reservoir river reaches and lower river segments were also excluded from the RED analysis because these river reaches primarily wind through private lands where public access is limited, and previous reports indicate that visitation is primarily by residents who live nearby (USACE 2006a; USACE 2011a; Sheriff et al. 2011). As a result, the RED analysis assesses economic impacts of non-local visitor spending in regional and state economies surrounding five of the six Mainstem reservoirs. These economic impacts were estimated using the USACE-certified RED model, RECONS.

Other Social Effects

OSE associated with recreation include contributions to individual and community well-being and quality of life; these considerations are evaluated qualitatively based on the results from the recreation NED and RED analyses.

3.16.2.2 Summary of Environmental Consequences

Table 3-205 provides a summary of the impacts under the MRRMP-EIS alternatives.

Table 3-205. Summary of Environmental Consequences for Recreation

Alternative	NED	RED	OSE	Other Impacts
Management Actions Common to All Alternatives	No NED impacts.	No RED impacts.	No OSE impacts.	Short-term, small adverse impacts on recreation from human restriction measures.
Alternative 1	Average annual benefits of $102.4 million, with annual benefits ranging from $63.2 during low visitation years typically during drought or drier conditions when recreational access and opportunities are lower to $123.9 million during normal or relatively higher precipitation and snowpack conditions that are favorable to recreational access and opportunities. Large and long-term benefits; variations in the natural hydrological cycles during drought years cause relatively lower recreation NED benefits over the POR. Alternative 1 management actions would have negligible impacts recreation NED benefits.	1,512 jobs and $42.4 million in labor income on average over the POR. Jobs would range from 538 to 1,872 and labor income from $22.6 million to $52.5 million over the POR associated with hydrologic conditions affecting recreation access and opportunities. Alternative 1 management actions would negligible RED effects.	Alternative 1 would continue to provide large long-term OSE benefits associated with recreational opportunities. Continued development of habitat areas would support quality of life and educational amenities for residents.	Small, localized, temporary, adverse impacts from mechanical habitat construction. In the long-term, increased abundance and diversity of fish and wildlife species would provide small localized benefits for recreational opportunities (e.g., waterfowl hunting, walleye and northern pike fishing).
Alternative 2	Annual average increase of $112,000 or 0.1 percent compared to Alternative 1. Negligible impacts in the upper three reservoirs on average, large adverse impacts in the upper three reservoirs due to flow releases. Negligible impacts on the lower three reservoirs. Relatively small benefits in the inter-reservoir reaches and lower river from habitat construction and spawning cue releases.	Negligible changes to RED in the river reaches. Average annual change in recreation benefits: 3 fewer jobs and $108,000 less in labor income at reservoirs. Negligible RED impacts in the regional context but impacts could be large and adverse on tourism businesses in some years in the upper three reservoirs.	Relatively higher OSE benefits to recreation from additional early life stage and ESH habitat areas.	Potentially small to large, temporary, adverse impacts from large quantities of ESH and early life stage habitat construction; similar to Alternative 1, although relatively small to large increases in long-term recreation benefits associated with species diversity and abundance from relatively more ESH and early life stage habitat.

Alternative	NED	RED	OSE	Other Impacts
Alternative 3	Annual average increase in NED benefits of $83,000 or 0.1 percent compared to Alternative 1. The change compared to Alternative 1 would be negligible across all locations.	Negligible changes to RED in the river reaches due to local visitation. Average annual change in recreation benefits: two additional jobs and $70,000 more in labor income at the reservoirs; negligible change in RED benefits in all locations.	Small increases in OSE effects to recreation from IRC and ESH.	Similar to Alternative 1, although greater impacts from ESH construction in the Fort Randall reach and relatively smaller construction impacts from fewer acres of IRC habitat in the lower river.
Alternative 3: Gavins Point One-Time Spawning Cue Test	The inter-reservoir river reaches, the lower three reservoirs, and the lower river would experience negligible to small effects from Alternative 1 because changes in reservoir elevations at the lower three reservoirs and river stages would continue to provide recreational access and habitat development would be small compared to the scale of the river. Adverse impacts under one-time spawning cue test would occur at the upper three reservoirs in the year or years following the one-time spawning cue test, with the potential for small impacts when the reservoirs are drawn down during relatively drier conditions, adversely affecting recreation access and opportunities.	Negligible changes in RED benefits from Alternative 1 at the inter-reservoir river reaches and lower river because most visitation is associated with local residents. Negligible changes in RED benefits from Alternative 1 at the lower three reservoirs due to minimal changes in visitation. For the upper three reservoirs, negligible RED impacts in the regional context but could be small and adverse to tourism businesses in the year(s) following the one-time spawning cue test when reservoir elevations would reduce recreation access and opportunities.	Negligible changes in recreation OSE from the one-time spawning cue test.	No impacts.

Alternative	NED	RED	OSE	Other Impacts
Alternative 4	Annual average reduction of $1.1 million in NED benefits or 1.1 percent compared to Alternative 1. Under some years and conditions, small to large adverse impacts to recreation benefits in the upper three reservoirs following spring releases during relatively drier periods; negligible impacts to the lower three reservoirs, inter-reservoir reaches, and lower river.	Negligible changes to RED in the river reaches due to local visitation. Average annual change in RED recreation benefits: 21 fewer jobs and $585,000 less in labor income at reservoirs. Small RED impacts in regional context but impacts on tourism businesses could be large and adverse in some years in the upper three reservoirs.	Small increases in OSE benefits to recreation from IRC and ESH development.	Same as Alternative 3.
Alternative 5	Annual average decrease of $86,000 or -0.1 percent. Negligible changes in recreation NED across all locations. Under some years and conditions, small adverse impacts to recreation NED benefits in the upper three reservoirs following fall releases; negligible impacts to the lower three reservoirs, inter-reservoir reaches, and lower river.	Negligible changes to RED in the river reaches due to local visitation. Average annual change in recreation RED benefits: 1 less job and $29,000 less in labor income at reservoirs. Small to negligible adverse impacts on recreation RED benefits because of the small change in visitation, even in the years following fall releases.	Small increases in OSE benefits to recreation from IRC and ESH development.	Same as Alternative 3.
Alternative 6	Small decreases in Annual average NED benefits of $846,000 or 0.8 percent compared to Alternative 1. Small to large adverse impacts in some years in the upper three reservoirs following spawning cue releases; negligible impacts on the lower three reservoirs, inter-reservoir river reaches, and lower river.	Negligible changes to RED in the river reaches due to local visitation. Average annual change in recreation RED benefits: 18 fewer jobs and $511,000 less in labor income at reservoirs. Small RED impacts in regional context but could be large and adverse to tourism businesses in some years in the upper three reservoirs.	Small increases in OSE benefits to recreation from IRC and ESH development.	Same as Alternative 3.

3.16.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include vegetation management, predator management, and human restriction measures. These actions have the potential to affect recreation opportunities and experiences along the Missouri River. Human restriction measures during the tern and plover nesting season include restricting public access to sandbars with known nests and posting signs to prevent disturbance by people and pets. Although sandbar use would be prohibited during nesting season, birdwatchers who view wildlife from boats or the shore would still benefit from these areas while access is prohibited. Outside the nesting season, the construction and maintenance of additional sandbars should enhance recreational experiences on the Missouri River because these areas would provide additional opportunities for low-density recreation. Impacts on recreation from human restriction measures would be small, short term, and adverse for some types of visitors; no adverse impacts on recreation associated with vegetation management and predator management are anticipated.

3.16.2.4 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 would include a spring pulse, the construction of ESH habitat in the Garrison and Gavins Point Dam river reaches, and the construction of early life stage habitat for the pallid sturgeon in the lower river below Ponca, Nebraska.

Mechanical Habitat Construction

The construction of ESH and early life stage habitat for the pallid sturgeon under Alternative 1 would result in short-term, small, and adverse impacts from construction-related noise, vibration, and fugitive emissions; temporary localized deterioration in water quality; temporary decreased visual aesthetics; and temporary access limitations during the construction period. Project construction and equipment at habitat sites could impede access to hunting, fishing, and wildlife viewing and the noise and vibrations may deter wildlife and recreationists from using areas near habitat construction sites. These impacts would be temporary in years when construction would occur. These impacts would be localized affecting only those visitors or recreation areas adjacent to project sites. Habitat construction in relatively more populated areas near recreation areas (e.g., Bismarck, Omaha, Kansas City) would result in larger adverse impacts as more people and visitors could potentially be impacted.

Over the long term, increased prevalence of ESH and early life stage habitat would benefit species diversity and abundance along the Missouri River, provide additional primitive areas for recreation outside of nesting season, and enhance the topography and visual aesthetics of the river where projects occur. These enhancements would improve aesthetics, resulting in higher consumer surplus values for recreation in these areas of the river. The increased value of the recreational experience associated with the prevalence of habitat is monetized in the NED evaluation, described below.

The increased prevalence of ESH and early life stage habitat would benefit some fish and other aquatic species. Shorebird species other than the least tern and piping plover have been documented nesting on constructed ESH. The constructed ESH would potentially provide increased opportunities for breeding success of reptiles and most amphibian species have been spotted using the islands and sandbars. Fisheries biologists have noted that submerged areas associated with sandbars provide rearing areas for a number of species (i.e., walleye, northern pike, emerald shiner, etc.) due to the shallower, warmer water with less current. These areas are thought to be crucial rearing areas for most species (USACE 2011a). The increased prevalence of aquatic habitat from construction of early life stage pallid sturgeon habitat would attract species that use these habitats (e.g., aquatic furbearers) and could increase the diversity once a project is complete. Increased wetted shoreline habitat would benefit wading birds and shorebirds that use sandbars and mudflats during the migratory period. Early life stage pallid sturgeon habitat could also benefit a number of fish species (e.g., paddlefish, shovelnose sturgeon) that spawn in this habitat. Backwaters, side channels, and other low-velocity habitat are currently limited in some of the remaining river reaches and construction of these habitats would have long-term, large, beneficial impacts to species that use these habitats. The additional lands that would be acquired for habitat development would benefit fish and wildlife species as well. Increased abundance and diversity of fish and wildlife species would provide increased recreational opportunities (e.g., waterfowl hunting, walleye and northern pike fishing).

National Economic Development

Under Alternative 1, average annual recreation NED benefits would be $102.4 million, $71.5 million of which would be attributable to the upper three reservoirs (Table 3-206). The upper three reservoirs would have the largest variation in NED benefits, ranging from $38.5 million in a severe low-water year to $87.0 million in higher water years. On annual average, the upper three reservoirs would support $71.5 million in recreation NED benefits. The lower three reservoirs have relatively stable pool levels, and Alternative 1 would result in average annual NED benefits of nearly $16.8 million from these reservoirs.

Section 3.5, Fish and Wildlife Habitat, describes how fish, other aquatic resources, and wildlife would be affected by the spring pulse in various locations. Because only a small amount of water compared to natural flow variability would be released during implementation of the spring pulse and the impacts on fish and wildlife under Alternative 1 are generally small compared to the impacts caused by the extreme hydrologic events in the POR, the indirect impacts on recreation from changes in fish and wildlife under Alternative 1 from spring pulse would be negligible, occurring seasonally during years when downstream flow limits allow.

Average annual recreation NED benefits supported by the inter-reservoir river reaches would be $2.9 million, and habitat-related benefits would account for 0.7 percent of total NED benefit in the inter-reservoir river reaches. Average annual NED benefits in the lower river would be $11.2 million, ranging between $4.4 and $18.1 million in low and high visitation years based on fluctuations in the natural hydrologic cycles that affect accessibility of boat ramps. The prevalence of ESH and early life stage habitat would account for approximately 1.5 percent of total recreation NED benefits in the lower river. In addition, some visitors prefer lower river flows, such as those using paddle craft or swimming, because lower flows offer additional shoreline and sandbars amenities and/or perceptions of safer conditions. During the spawning cue releases in March and May, visitors who may prefer lower river flows could experience adverse impacts. Peak summer visitation would not be affected under the spawning cue releases.

The NED evaluation also assesses costs associated with maintaining accessibility of boat ramps and other recreation facilities when the upper three reservoir elevations experience severe low-water conditions for consecutive years. Results from reservoir simulations show that these Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs associated with extending and/or replacing current ramps, providing infrastructure and road access to low boat ramp locations, and maintaining access to boat ramps when reservoir elevations fall in consecutive summers would be approximately $3.4 million under Alternative 1 over the POR.

Overall, recreation NED benefits supported by the Missouri River under Alternative 1 would be large and long term, providing local residents and non-local visitors with considerable recreational opportunities. The largest annual decreases in the recreation NED benefits under Alternative 1 would occur on the upper three reservoirs when access to the lakes and fishing opportunities are directly affected by lower lake elevations during the natural cycles of drought and relatively drier periods. Management actions under Alternative 1 would have a negligible contribution to the variation in recreation NED benefits.

Table 3-206. Summary of National Economic Development (NED) Analysis for Alternative 1, 1932–2012 (thousands of 2018 dollars)

Benefits or Costs	Upper Three Reservoirs	Lower Three Reservoirs	Inter-Reservoir River Reaches	Lower River	All Locations
Total Visitation* Benefits	$5,797,376	$1,358,489	$233,337	$890,060	$8,279,262
Total Habitat Benefits	NA	NA	$1,631	$13,196	$14,827
OMRR&R Costs	$3,373	NA	NA	NA	$3,373
Total NED Benefits	$5,794,003	$1,358,489	$234,968	$903,256	$8,290,716
Annual Average NED Benefits	$71,531	$16,771	$2,901	$11,151	$102,355
Maximum Annual NED Benefits	$87,045	$17,248	$3,177	$18,083	$123,887
Minimum Annual NED Benefits	$38,478	$16,183	$2,349	$4,370	$63,188

* Total Visitation includes lake elevation and non-lake elevation affected visits at the reservoirs and boat accessed and non-boat accessed visits in the river reaches and lower river. For more details, refer to the "Recreation Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Regional Economic Development

Reservoir conditions can adversely affect visitation, which in turn can affect the amount of visitor spending in local economies. Non-local visitor spending injects new money into local economies, stimulating sales (i.e., economic output), jobs, and income in local businesses. Table 3-207 summarizes the economic contributions of non-local visitor spending under Alternative 1. On average, spending by these non-local visitors supports 1,512 jobs and $42.4 million in labor income under Alternative 1. These contributions vary between 538 and 1,872 jobs and $22.6 and $52.5 million in labor income across all five reservoirs during low and high visitation years. In the highest visitation year, the upper three reservoirs were shown to support approximately 1,590 total jobs and $38.5 million labor income, while in the worst drought conditions in the lowest visitation year, the non-local visitor spending was estimated to support 321 jobs and $14.2 million in labor income.

Table 3-207. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 1 (thousands of 2018 Dollars)

Economic Impact Parameter	Year	Upper Three Reservoirs [a]	Lake Francis Case and Lewis and Clark Lake [a]	Total
Direct, Indirect, and Induced Jobs	Lowest visitation year	321	217	538
	Highest visitation year	1,590	282	1,872
	Average	1,258	254	1,512
Direct, Indirect, and Induced Labor Income	Lowest visitation year	$14,221	$5,349	$22,594
	Highest visitation year	$38,498	$6,942	$52,461
	Average	$30,486	$6,263	$42,427
Direct, Indirect, and Induced Sales	Lowest visitation year	$45,664	$17,167	$72,539
	Highest visitation year	$123,757	$22,263	$168,580
	Average	$98,009	$20,078	$136,332

a The lowest visitation year and highest visitation years are not necessarily the same year at each reservoir. The analysis used the annual visitation at each of the upper three reservoirs and the lower two reservoirs to estimate the RED figures.

The economic contributions of non-local visitor spending to communities surrounding these lakes would be large and beneficial in the context of their relatively small rural economies. For example, recreation-based employment (i.e., in the food and beverage, accommodations, arts, entertainment, and recreation, and retail trade businesses) account for approximately 11,801 jobs in the communities surrounding the upper three reservoirs, as summarized in Table 3-208 (US Census Bureau 2015). According to the estimates of non-local visitors impacted, approximately 11 percent of the recreation jobs in these communities are supported by non-local visitors to the upper three reservoirs in the average visitation year (1,258 jobs divided by 11,801 jobs).

When lake elevations are lower because of drought conditions, limited boat access and reduced fishing opportunities would considerably reduce economic activity in these local economies as non-local visitation falls. Declines in non-local visitation and recreation-related spending during drought or drier periods would have large, adverse impacts on regional economic conditions in the local economies surrounding the lakes. A reduction of up to 937 jobs (1,258 during average conditions less 321 jobs during the lowest visitation year) would represent approximately 8 percent of recreation jobs in adjacent communities and 1 percent of all jobs in these communities. However, if the bulk of the reduction in visitation was experienced in the smaller rural communities, the impacts would be relatively larger. Removing Bismarck and Pierre from the employment figures, the reduction in jobs during drought conditions could represent up to 30 percent of the recreation employment in these communities and over three percent of all employment in adjacent communities. The spring pulse under Alternative 1 would have a negligible contribution to the adverse RED impacts during drought or relatively drier conditions.

Table 3-208. Employment in Adjacent Communities to the Upper Three Reservoirs

Reservoirs	Recreation Employment	Total Employment	Recreation Employment as a Percent of Total Employment
Fort Peck Lake	611	4,745	13%
Lake Sakakawea	9,319	74,764	12%
Lake Oahe	1,871	14,856	13%
Upper Three Lakes	11,801	94,365	13%

Source: U.S. Census Bureau 2015.

Notes: The adjacent communities included in the recreation employment for the upper three reservoirs include Fort Peck Lake: Glasgow, Fort Peck, and Wolf Point; Lake Sakakawea: Bismarck, New Town, Pick City, Riverdale, Garrison, and Williston; and Lake Oahe: Pierre, Mobridge, Cannon Ball, and Fort Yates.

Fort Peck Lake, Lake Sakakawea, and Lake Oahe are world-famous for their walleye, northern pike, and other boating and fishing opportunities. In general, the upper three reservoirs provide a remote and unique recreational experience. There are limited recreational opportunities located within the local region (defined at 50-miles from the lakes) that provide similar substitute recreational opportunities (refer to Section 2.6 of the "Recreation Environmental Consequences Analysis Technical Report" for additional details on substitute recreation sites). During adverse recreation conditions on the Missouri River reservoirs, visitors would likely choose to visit alternative reservoirs or recreation areas in other locations; therefore, the visitor spending and associated regional jobs and income would be reduced in the communities surrounding the Missouri River reservoirs. Limited alternative sites within the region would not be able provide recreational opportunities to offset the RED impacts in adjacent communities.[12]

Other Social Effects

OSE associated with recreation include factors such as individual and community well-being and quality of life. The Missouri River, including the reservoirs, inter-reservoir reaches, and lower river, provides considerable recreational opportunities with large long-term benefits to individual and community well-being and quality of life amenities. Management actions under Alternative 1 include the continued construction of ESH and early life stage habitat along river reaches in the upper and lower river. This habitat would provide some OSE benefits from viewscapes with more varied landscape topography and benefits from public accessibility and more diverse and abundant wildlife-related recreational opportunities. These attributes may increase social benefits derived from recreation along the river, including promoting a sense of place and quality of life enjoyed by individuals and communities.

Conclusion

Under Alternative 1, the Missouri River and its reservoirs would continue to provide a variety of recreational opportunities that would support large NED, RED, and OSE benefits on average, over the long term. Variation in recreation NED and RED would occur in some locations from natural variations in the hydrologic cycle. Generally, higher river flows and stages and reservoir elevations (but not flooding) would support greater access and improved fishing opportunities.

[12] It should be noted that as part of regional economic analysis for the recreation evaluation for the Missouri River Master Water Control Manual, Review and Update, Volume 6C: Recreation Economics (USACE 1994), the modeling indicated that there was not a statistically significant association between substitute recreation opportunities and visitation to the upper three reservoirs (see Table 1 in Recreation Economics Technical Report Appendix D within Volume 6C). Additional description of substitute recreation area is provided in the "Recreation Environmental Consequences Analysis Technical Report" (Section 2.6).

The lower three reservoirs and inter-reservoir reaches would experience negligible variations in visitation because of the relatively stable reservoir and river elevations and stages that would maintain access and recreational opportunities under Alternative 1.

The lower river would experience variations in annual recreation NED benefits from natural cycles of drought and flooding that affect boat ramp operability and access to recreational areas, although changes in recreation RED as a result of these natural variations would be negligible over the POR because changes in non-local visitation would be minimal. Small increases in recreation NED and OSE benefits would occur from enhanced recreational experiences through the construction of ESH and early life stage habitat. The upper three reservoirs would have the greatest variation in visitation, with the largest decreases occurring on the upper three reservoirs when access to the lakes and fishing opportunities are adversely affected by lower lake elevations during drought or relatively drier periods.

During the worst visitation year attributable to drought conditions, 937 fewer jobs would be supported across these three reservoirs from non-local visitor spending compared to average annual jobs of 1,258. These decreases in recreation RED benefits would be small in the regional context of all county economies surrounding the lakes but would be relatively large in small rural communities adjacent to the reservoirs whose economies may rely on reservoir tourism and outdoor recreation, accounting from between 8 and 30 percent of recreation-based jobs in adjacent communities. The spring pulse under Alternative 1 would have negligible impacts on recreation NED, RED, and OSE benefits. Impacts on recreation from habitat construction would be temporary, localized and small, depending on the proximity of the habitat site to the recreation activity.

Alternative 1 would not result in significant adverse impacts on recreation because the Missouri River and its reservoirs would continue to provide a variety of recreational opportunities that would support NED, RED, and OSE benefits annually, over the long term; adverse impacts from habitat construction would be localized and temporary; and the spring pulse would have negligible impacts on recreation NED, RED, and OSE benefits.

3.16.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 would include additional iterative actions that USFWS anticipates would be implemented under an adaptive management framework. Management actions under Alternative 2 would include spawning cue releases, low summer flows, and the construction of considerably more early life stage habitat and ESH than under Alternative 1.

Mechanical Habitat Construction

Compared to Alternative 1, considerably more ESH construction would occur in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches, as well as more early life stage habitat construction between Ponca, Nebraska, and the mouth of the river near St. Louis, when compared to Alternative 1. Mechanical habitat construction would result in localized, adverse impacts to recreation sites and would occur at a greater number of sites within these river reaches compared to Alternative 1. Localized, adverse impacts associated with habitat construction would be temporary and similar to those described under Alternative 1 (i.e., noise, closures, water quality degradation, aesthetics) but would be more prevalent across these reaches because considerably more habitat would be constructed under this alternative. If habitat construction in and around high-density recreation sites occurs during the summer periods, such as sites near Bismarck, it could have relatively large, temporary adverse impacts to visitation and the quality of the recreational experience during these construction periods.

Similar to Alternative 1, increased prevalence of ESH and early life stage habitat under Alternative 2 would benefit species diversity and abundance along the Missouri River, provide additional primitive areas for recreation outside of nesting season, and enhance the topography and visual aesthetics of the river; these benefits would be more pronounced and long-term with more habitat constructed. The increased prevalence of ESH and early life stage habitat compared to Alternative 1 would likely increase the abundance of some types of fish and other aquatic species relative to Alternative 1. The recreational benefits described under Alternative 1 from the increased prevalence in these two habitat types would be increased under Alternative 2 compared to Alternative 1. The additional lands that would be acquired for habitat development that would benefit fish and wildlife species would result in a relatively small to large increase in recreation benefits under Alternative 2 compared to Alternative 1. The increased value of the recreational experience associated with the prevalence of habitat under Alternative 2 is monetized in the NED evaluation and described below.

National Economic Development

Under Alternative 2, average annual NED benefits would be $102.5 million, an increase of $112,000 on average compared to Alternative 1 (Table 3-209). The lower river would experience the largest increase in NED benefits under Alternative 2, with an increase by 1.8 percent or approximately $199,000 relative to Alternative 1. Declines in average annual NED benefits at the upper three reservoirs would be driven by the lower reservoir elevations in the years following the spawning cue releases. Management actions under Alternative 2 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits at the lower three reservoirs under this alternative because these reservoirs are managed as flow-through reservoirs with relatively stable elevations.

Section 3.5, Fish and Wildlife Habitat, describes how fish, other aquatic resources, and wildlife would be affected by the spawning cue release in various locations. The bi-modal spawning cue would result in adverse impacts to fish and recreational fishing opportunities from fish entrainment as well as from the potential for large drawdowns of the upper three reservoirs, especially in the spring when the pool rise is critical for fish spawning. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 2 would remain relatively stable, with minimal indirect impacts to recreation.

Management actions under Alternative 2 would have long-term, small, and beneficial NED impacts on recreation in the inter-reservoir river reaches compared to Alternative 1, leading to an average annual increase in recreation NED benefits of $62,000 (2.1 percent). The majority of impacts on recreation in the inter-reservoir river reaches under Alternative 2 would be attributable to higher value recreational experiences in the Garrison Dam to Lake Oahe and Fort Randall Dam to Lewis and Clark River reaches from the extensive construction of ESH. Under Alternative 2, total habitat-related NED benefits in the inter-reservoir river reaches over the POR would increase to approximately $7.8 million from $1.6 million under Alternative 1. In addition, spawning cue releases could have both beneficial and adverse impacts to fish and other aquatic resources in the river reaches below the dams, with indirect impacts to recreation (See Section 3.5 for additional details). However, only a small amount of water compared to natural flow variability would be released during implementation of the spawning cue release and the indirect impacts to recreation associated with fish and wildlife under Alternative 2 are generally small compared to the impacts caused by the extreme hydrologic events in the POR.

Compared to Alternative 1, average annual NED benefits in the lower river would increase by $199,000, or 1.8 percent, as a result of management actions under Alternative 2. The increase in recreation NED benefits would primarily be driven by greater prevalence of ESH and early life stage habitat in the lower river, resulting in relatively small and beneficial impacts on recreation compared to Alternative 1. Visitors who prefer lower river flows in the lower river may experience adverse impacts during spawning cue releases, although this alternative would not affect peak summer visitation. Long-term, beneficial impacts on fish and wildlife could occur under Alternative 2 in channel margins in the lower river, with a net increase in native vegetation and fish and wildlife habitat in localized areas, with indirect benefits to recreation.

OMRR&R costs associated with the upper three reservoirs would be lower under Alternative 2, decreasing by a total of $102,000 compared to OMRR&R costs under Alternative 1 due to relatively lower maintenance requirements at Lake Sakakawea and Lake Oahe from slightly higher pool elevations following the low summer flows as simulated in 2002 and 2003. As a result, OMRR&R costs associated with low-water recreation infrastructure would decrease slightly to maintain reservoir access during relatively drier periods, as simulated in the 2000s.

Table 3-209. Summary of National Economic Development Analysis for Alternative 2, 1932–2012 (thousands of 2018 dollars)

Benefits or Costs	Upper Three Reservoirs	Lower Three Reservoirs	Inter-Reservoir River Reaches	Lower River	All Locations
Total Visitation* Benefits	$5,780,962	$1,362,718	$232,197	$882,145	$8,258,023
Total Habitat Benefits	NA	NA	$7,760	$37,247	$45,007
OMRR&R Costs	$3,271	NA	NA	NA	$3,271
Total NED Benefits	$5,777,692	$1,362,718	$239,957	$919,392	$8,299,762
Percent Change from Alternative 1	−0.3%	0.3%	2.1%	1.8%	0.1%
Annual Average NED Benefits	$71,329	$16,824	$2,962	$11,351	$102,466
Change in Annual Average NED Benefits from Alternative 1	−$201	$52	$62	$199	$112

* Total Visitation includes lake elevation and non-lake elevation affected visits at the reservoirs and boat accessed and non-boat accessed visits in the river reaches and lower river. For more details, refer to the "Recreation Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Additional results of flow actions are summarized in Table 3-210. These results show the difference in annual recreation NED benefits during years when there would be a release action or a low summer flow. Results from the simulations show both beneficial and adverse impacts on recreation in the upper river (includes the reservoirs and inter-reservoir river reaches) during full and partial flow releases. In the lower river, relatively more early life stage habitat areas and full and partial spawning cues under Alternative 2 would result in increased recreation NED benefits.

Large, adverse impacts at the upper three reservoirs under Alternative 2 would occur in the years following a spawning cue release. These releases would draw down reservoir elevations farther than what would occur under Alternative 1, having up to a $3.7 million reduction in recreation NED benefits in the worst change year. In the worst difference years from Alternative 1, the largest, adverse impacts would result in a reduction in recreation NED benefits of $3.6 million, $2.7 million, and $1.2 million at Fort Peck Lake, Lake Sakakawea, and Lake Oahe, respectively, as simulated in 1974, 1984, and 1998 associated with lower reservoir elevations affecting recreation access and fishing opportunities.

Table 3-210. Changes in NED Benefits from Flow Releases under Alternative 2 Compared to Alternative 1 (thousands of 2018 dollars)

		Upper River [c]	Lower River [c]
Full Flow Release + Low Summer Flow [a]	Lowest Benefit Change	-$2,674	-$149
	Highest Benefit Change	$1,267	$305
Year after a Full Flow Release	Lowest Benefit Change	$686	$140
	Highest Benefit Change	$1,818	$330
Partial Flow Release [b]	Lowest Benefit Change	-$3,724	-$227
	Highest Benefit Change	$3,741	$869
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Benefit Change	-$3,736	-$1,268
	Highest Benefit Change	$3,848	$1,326

a The full spawning cue release and low summer flow were implemented in 3 years of the POR, and the low summer flow was also implemented in the years following the full spawning cue release (3 additional years). Data represent the lowest and highest dollar impacts in the years the action was fully implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

b Flow action was partially implemented in 31 years (partial implementation years are defined as years when a partial cue in March and/or May would occur OR years when a full cue in March or May would occur). Data represent the lowest and highest dollar impacts in the years the action was partially implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

c The upper river includes the reservoirs and the inter-reservoir river reaches, and the lower river includes the river reaches from Gavins Point Dam to the confluence with the Mississippi River.

Regional Economic Development

Under Alternative 2, non-local visitor spending associated with the reservoirs would support sales in local businesses, 1,509 jobs, and $36.7 million in labor income on an annual basis. Most of these economic contributions would occur in the communities surrounding and adjacent to the upper three reservoirs. Compared to Alternative 1, Alternative 2 would have greater adverse RED impacts in the upper three reservoirs and would support 6 fewer jobs and $176,000 less in labor income on average per year (Table 3-211).

Management actions under Alternative 2 would cause visitation to the reservoirs to decrease in some of the years following a fully or partially implemented spawning cue release, when reservoir elevations are lower than under Alternative 1. Reduced non-local visitation would result in a reduction in recreation RED benefits at the upper three reservoirs while these conditions persist. Lake Oahe would experience the largest adverse impacts to economic conditions under these scenarios. During the eight lowest visitation years relative to Alternative 1, average annual RED benefits supported by the upper three reservoirs would be reduced by 62 jobs and $1.5 million in labor income under Alternative 2. Sixty-two jobs represents 2 percent of recreation employment in the communities adjacent to the upper three reservoirs (not including Bismarck and Pierre). Although the decrease in employment under the eight lowest visitation years compared to Alternative 1 represents less than one percent of regional employment in rural adjacent communities, local employment opportunities associated with non-local visitor spending can be important to the tourism industries that support the recreation activities and visitation at these lakes, and could result potentially in large and adverse impacts for specific industries and small communities that support these recreational activities.

Impacts to regional economic conditions surrounding Lake Francis Case and Lewis and Clark Lake would be negligible because pool elevations would remain relatively stable, providing recreational access and visitation at these lakes even during drier conditions.

Table 3-211. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 2 Relative to Alternative 1 (Thousands of 2018 Dollars)

Economic Impact Parameter	Year	Upper Three Reservoirs	Lake Francis Case and Lewis and Clark Lake	Total Economic Impacts [a]
Direct, Indirect, and Induced Jobs	Average annual over 81 years	1,252	257	1,509
	Change in annual average over 81 years relative to Alternative 1	−6	2	−3
	Annual average during 8 lowest visitation years relative to Alternative 1	−62	−12	−73
	Annual average during 8 highest visitation years relative to Alternative 1	55	19	73
Direct, Indirect, and Induced Labor Income	Annual average over 81 years	$30,334	$6,322	$36,655
	Change in annual average over 81 years relative to Alternative 1	−$176	$68	−$108
	Annual average during 8 lowest visitation years relative to Alternative 1	−$1,484	−$289	−$1,773
	Annual average during 8 highest visitation years relative to Alternative 1	$1,420	$458	$1,879
Direct, Indirect, and Induced Sales	Annual Average over 81 years	$97,510	$20,269	$117,779
	Change in average annual average over 81 years relative to Alternative 1	−$576	$220	−$357
	Annual average during 8 lowest visitation years relative to Alternative 1	−$4,770	−$928	−$5,697
	Annual average during 8 highest visitation years relative to Alternative 1	$4,021	$1,472	$5,493

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis aggregated the reservoir-specific impacts (average, 8 best and worst change years) to provide the estimates.

a Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

Other Social Effects

OSE associated with recreation include factors such as individual and community well-being and quality of life. Alternative 2 would include extensive construction of ESH and early life stage habitat along many of the river reaches, with target habitat acres at the end of the implementation period substantially higher than under Alternative 1. The greater prevalence of early life stage habitat and ESH, and diversity and abundance of wildlife and aquatic life it supports, would have benefits for residents who live near and recreate on the river, improving the quality of life and providing educational opportunities that connect residents to the natural environment. These beneficial impacts associated with recreation opportunities enjoyed by local residents would be higher under Alternative 2 compared to Alternative 1.

Conclusion

Under Alternative 2, the increases in average recreation NED benefits for all locations would be small compared to Alternative 1 (0.1 percent). Because considerable ESH and early life stage habitat would be constructed in the inter-reservoir and lower river reaches, there would be small increases in recreation NED benefits compared to Alternative 1 (2.1 to 1.8 percent, respectively) small increases in recreation OSE benefits, and negligible impacts in recreation RED benefits. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because reservoir elevations would be fairly stable resulting in relatively constant visitation at these reservoirs. The upper three reservoirs would experience small adverse impacts on average (−0.3 percent). However, in specific years under certain conditions, decreases in recreation NED and RED benefits under Alternative 2 compared to Alternative 1 would be temporary, large, and adverse. The spawning cue release would reduce reservoir elevations in the years following the release. Under these conditions, non-local visitation at the upper three reservoirs would support 62 fewer jobs (in the eight worst difference years compared to Alternative 1) across the region compared to Alternative 1. Although these adverse impacts would be negligible in the context of the larger regional economy, changes in economic activity and opportunities could be large for tourism industries in affected rural communities. Habitat construction would have temporary, small to large, and adverse impacts on recreation from closures, noise, and other disturbances.

Alternative 2 would not have significant impacts on recreation because increases in recreation NED would be small on average annually; large impacts would be temporary for all locations; and changes in RED and OSE benefits would be negligible in the regional context.

3.16.2.6 Alternative 3 – Mechanical Construction Only

Alternative 3 does not include any spring or fall flow releases to create habitat; all ESH and habitat to support early life stage of the pallid sturgeon would be mechanically constructed. The spring plenary pulse that would occur under Alternative 1 would not occur under Alternative 3.

Mechanical Habitat Construction

Relative to Alternative 1, more acres of ESH would be mechanically constructed in the Garrison, Fort Randall, and Gavins Point river reaches under Alternative 3. However, fewer acres of habitat to support early life stage requirements would be constructed between Ponca, Nebraska, and the mouth of the river compared to Alternative 1 because habitat construction for the pallid sturgeon under Alternative 3 would focus on functional IRCs. Compared to Alternative 1, localized, adverse construction-related impacts would occur at a greater number of sites in the river reaches where ESH would be constructed, and at fewer sites below Ponca, Nebraska. The localized, adverse impacts would be temporary and small, with impacts similar to those described under Alternative 1 (i.e., noise, closures, water quality degradation, aesthetics). Similar to Alternative 1, early life stage habitat for the pallid sturgeon and ESH for the piping plover and least tern under Alternative 3 would benefit species diversity and abundance and enhance recreational experiences along the Missouri River in the long-term. The increased prevalence of ESH would benefit some fish and other aquatic species. The benefits described under Alternative 1 from the increased prevalence of constructed ESH would be increased under Alternative 3 compared to Alternative 1. However, while early life stage habitat would be constructed under Alternative 3, there would be fewer acres constructed and fewer acres of additional lands that would be acquired for habitat development. Recreation benefits associated with fish and wildlife would still occur but would be slightly reduced under Alternative 3 compared to Alternative 1. The increased value of the recreational experiences associated with the prevalence of habitat under Alternative 3 is monetized in the NED evaluation and described below.

National Economic Development

Under Alternative 3, average annual NED benefits would be $102.4 million, an annual increase of $83,000 compared to Alternative 1 (Table 3-212). The largest change in recreation NED benefits would occur in the upper three reservoirs, where recreation benefits would be slightly higher as a result of small increases in reservoir access and visitation in the absence of the spring plenary pulse. On average, changes in recreation NED benefits in the upper three reservoirs would be negligible, increasing by approximately $101,000 per year relative to Alternative 1. Management actions under Alternative 3 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits at the lower three reservoirs because these reservoirs have relatively stable elevations. The elimination of the spring pulse under Alternative 3 would eliminate adverse or beneficial impacts to fish in the reservoirs or below the dams from these pulses.

Relative to Alternative 1, average annual recreation NED benefits in the inter-reservoir reaches would increase slightly, driven by the greater prevalence of ESH under Alternative 3. Average annual recreation NED benefits in the lower river would be approximately $11.1 million, a decrease of $26,000 from Alternative 1. Recreation NED benefits over the POR associated with habitat construction in the lower river would be negligible compared to Alternative 1, with fewer acres of early life stage habitat and a greater number of acres of ESH. Alternative 3 would result in $11.9 million in total habitat benefits over the POR, approximately $1.6 million less than under Alternative 1. Visitors in the river reaches who prefer lower river flows, such as those using paddle craft or swimming, would experience no impacts under Alternative 3 compared to Alternative 1 because changes in river flows would be negligible.

The OMRR&R costs at the upper three reservoirs would be slightly lower under Alternative 3 ($3.31 million) compared to Alternative 1 ($3.37 million) as a result of relatively higher reservoir elevations during drought conditions because the spring plenary pulse would not occur. Relative to Alternative 1, impacts would be negligible.

Table 3-212. Summary of National Economic Development Analysis for Alternative 3, 1932–2012 (thousands of 2018 dollars)

Benefits or Costs	Upper Three Reservoirs	Lower Three Reservoirs	Inter-Reservoir River Reaches	Lower River	All Locations
Total Visitation* Benefits	$5,805,483	$1,358,856	$233,325	$891,181	$8,288,844
Total Habitat Benefits	NA	NA	$1,908	$9,957	$11,865
OMRR&R Costs	$3,308	NA	NA	NA	$3,308
Total NED Benefits	$5,802,175	$1,358,856	$235,233	$901,138	$8,297,401
Percent Change from Alternative 1	0.1%	0.0%	0.1%	−0.2%	0.1%
Annual Average NED Benefits	$71,632	$16,776	$2,904	$11,125	$102,437
Change in Annual Average NED Benefits	$101	$5	$3	−$26	$83

Note: Total visitation includes lake elevation and non-lake elevation affected visits at the reservoirs and boat accessed and non-boat accessed visits in the river reaches and lower river. For more details, refer to the “Recreation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Regional Economic Development

Under Alternative 3, non-local visitor spending associated with recreation on the reservoirs would support on average 1,515 jobs and $36.8 million in labor income annually. Annually, recreation at the Mainstem reservoirs would support approximately 2 more jobs and $70,000 in labor income on average than under Alternative 1. Even in the 8 lowest visitation years compared to Alternative 1, impacts to regional economic conditions would be negligible. The recreation RED benefits supported under Alternative 3 and anticipated changes relative to Alternative 1 are summarized in Table 3-213.

Table 3-213. Economic Benefits of Non-Local Visitor Spending at the Three Reservoirs under Alternative 3 (thousands of 2018 Dollars)

Economic Impact Parameter	Year	Upper Three Reservoirs	Lake Francis Case and Lewis and Clark Lake	Total Economic Impacts [a]
Direct, Indirect, and Induced Jobs	Average annual over 81 years	1,260	255	1,515
	Change in annual average over 81 years relative to Alternative 1	2	0	2
	Annual average during 8 lowest visitation years relative to Alternative 1	−4	−5	−9
	Annual average during 8 highest visitation years relative to Alternative 1	11	8	18
Direct, Indirect, and Induced Labor Income	Annual average over 81 years	$30,542	$6,267	$36,809
	Change in annual average over 81 years relative to Alternative 1	$64	$5	$70
	Annual average during 8 lowest visitation years relative to Alternative 1	−$97	−$134	−$231
	Annual average during 8 highest visitation years relative to Alternative 1	$261	$196	$457
Direct, Indirect, and Induced Sales	Annual average over 81 years	$98,190	$20,093	$118,283
	Change in average annual average over 81 years relative to Alternative 1	$208	$17	$225
	Annual average during 8 lowest visitation years relative to Alternative 1	−$313	−$430	−$743
	Annual average during 8 highest visitation years relative to Alternative 1	$842	$632	$1,474

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis aggregated the reservoir-specific impacts (average, 8 best and worst change years) to provide the estimates.

a Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

Other Social Effects

Recreation OSE associated with the construction of early life stage habitat for the pallid sturgeon and ESH under Alternative 3 would contribute benefits to quality of life and individual well-being, and impacts would be similar to those described under Alternative 1.

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test release (Level 2) that may be implemented under Alternative 3 was not included in the NED and RED modeling. The potential impacts on recreation of a one-time spawning cue test release under Alternative 3 would be bounded by the range of impacts described for individual releases under Alternative 6 in Section 3.16.2.9.

The inter-reservoir river reaches, the lower three reservoirs, and the lower river would experience negligible to small effects from Alternative 1 because changes in reservoir elevations at the lower three reservoirs and river stages would continue to provide recreational access. Adverse impacts of a one-time spawning cue test could occur to recreation at the upper three reservoirs in the year or years following a release. This is especially true if the release were to occur during relatively drier conditions. It can take a number of years for the reservoirs to refill after a spawning cue release, especially in relatively drier or drought conditions, with prolonged adverse impacts to the fishery, visitation, and recreation NED and RED benefits. It is expected that a one-time spawning cue test could result in small adverse effects to recreation depending on the natural hydrologic conditions in the year and years following the test flow.

Conclusion

Alternative 3 would result in negligible changes in recreation NED benefits across all locations compared to Alternative 1 (0.1 percent). Although additional acres of ESH would be constructed in the inter-reservoir and lower river reaches, changes in recreation NED, RED, and OSE benefits compared to Alternative 1 would be negligible because of the relatively small change in habitat prevalence and river stages and flows would not noticeably affect recreational access. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because the fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs. In the upper three reservoirs, recreation NED benefits would be slightly higher as a result of small increases to reservoir access and visitation in the absence of the spring plenary pulse under Alternative 1 (0.1 percent), although the impacts on recreation NED, RED, and OSE benefits would be negligible. Habitat construction would have temporary and localized, small, adverse impacts on recreation from closures, noise, and other disturbances during construction activities.

Alternative 3 would not have significant adverse impacts on recreation because changes in NED, RED, and OSE benefits across all locations would be negligible compared to Alternative 1 and adverse impacts from habitat construction would be temporary and localized.

3.16.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 would include spring releases from Gavins Point Dam and Garrison Dam and mechanical construction of ESH and habitat to support early life stage requirements of the pallid sturgeon to achieve habitat targets.

Mechanical Habitat Construction

Management actions under Alternative 4 would include the construction of more ESH in the Garrison, Fort Randall, and Gavins Point river reaches compared to Alternative 1. Efforts to create habitat to support the support early life stage requirements of the pallid sturgeon under Alternative 4 would focus on functional IRC areas and include fewer acres of habitat between Ponca, Nebraska, and the mouth of the river near St. Louis. Impacts of habitat construction would be similar to those described under Alternative 1—temporary and localized, small, and adverse, depending on the proximity of the construction to the recreational activity. Similar to Alternative 1, early life stage habitat for the pallid sturgeon and ESH for the piping plover and least tern under Alternative 4 would benefit species diversity and abundance and enhance recreational experiences along the Missouri River. The increased prevalence of ESH and early life stage habitat would benefit some fish and other aquatic species. The benefits described under Alternative 1 from the increased prevalence of constructed ESH would be increased under Alternative 4 compared to Alternative 1. However, while early life stage pallid sturgeon habitat would be constructed under Alternative 4, there would be fewer acres of construction and fewer acres of additional lands that would be acquired for habitat development. Recreation benefits to fish and wildlife would still occur but would be slightly reduced under Alternative 4 compared to Alternative 1. The increased value of the recreational experiences associated with the prevalence of habitat under Alternative 4 is monetized in the NED evaluation and described below.

National Economic Development

Under Alternative 4, average annual NED benefits would be $101.2 million, a decrease of $1.1 million (-1.1 percent) on average compared to Alternative 1 (Table 3-214). The upper three reservoirs would have the largest change in NED benefits, with a decrease of approximately $1.1 million (-1.5 percent) relative to Alternative 1. Decreases in average annual NED benefits supported by the upper three reservoirs would occur in the years following a spring release when relatively low precipitation or snowmelt conditions occur and the reservoir elevations as simulated under Alternative 4 are lower than under Alternative 1. Management actions under Alternative 4 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits in the lower three reservoirs because these reservoirs maintain relatively stable elevations, providing consistent recreational access and opportunities.

Section 3.5, Fish and Wildlife Habitat, describes how fish, other aquatic resources, and wildlife would be affected by the spring release in various locations. The spring release would occur under Alternative 4 and would be fully implemented in nine years and partially implemented in seven years over the period of record. The spring release would result in adverse impacts to fish and recreational fishing opportunities from fish entrainment as well as from the potential for large drawdowns of the upper three reservoirs, especially in the spring when the pool rise is critical for fish spawning. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 4 would remain relatively stable, with minimal indirect impacts to recreation.

Relative to Alternative 1, average annual recreational NED benefits in inter-reservoir reaches would decrease slightly. This change, however, would be negligible since river stages and boat ramp operability would not noticeably change. Impacts associated with ESH construction under Alternative 4 would increase habitat-related benefits over the POR in the inter-reservoir river reaches by approximately $1.7 million, which would account for less than one percent of total recreation NED benefits. In addition, spring releases could have both beneficial and adverse impacts to fish and other aquatic resources in the river reaches below the dams, with indirect impacts to recreation (See Section 3.5 for additional details). However, only a small amount of water compared to natural flow variability would be released during implementation of the spring release and the indirect impacts to recreation associated with fish and wildlife under Alternative 4 are generally small compared to the impacts caused by the extreme hydrologic events in the POR.

Average annual recreation NED benefits in the lower river would be $11.1 million under Alternative 4, with average NED benefits decreasing by $7,000 relative to Alternative 1. Annual impacts to recreation NED benefits in the lower river would be beneficial and adverse compared to Alternative 1 and would be attributable to changes in boat ramp operability and the construction of ESH and IRC habitat, with negligible changes on average compared to Alternative 1. Habitat-related recreation benefits would account for 1 percent of total recreation NED benefits in the lower river and would be slightly lower than those under Alternative 1. In addition, visitors in the lower river that prefer lower river flows, such as those using paddle craft or swimming, would experience some adverse impacts during the spring releases and negligible changes at other times under Alternative 4.

OMRR&R costs at the upper three reservoirs would be approximately $452,000 higher under Alternative 4 than under Alternative 1 ($3.4 million under Alternative 1 and $3.8 million under

Alternative 4) because the spring release would draw down reservoir elevations further than under Alternative 1 during relatively drier periods. As a result, there would be additional capital investments and operating costs needed to extend or replace low water boat ramps, with relatively small to large adverse impacts depending on the timing and location of investments.

Table 3-214. Summary of National Economic Development Analysis for Alternative 4, 1932–2012 (thousands of 2018 dollars)

Benefits or Costs	Upper Three Reservoirs	Lower Three Reservoirs	Inter-Reservoir River Reaches	Lower River	All Locations
Total Visitation* Benefits	$5,709,778	$1,357,128	$232,020	$892,897	$8,191,823
Total Habitat Benefits	NA	NA	$1,703	$9,752	$11,455
OMRR&R Costs	$3,825	NA	NA	NA	$3,825
Total NED Benefits	$5,705,953	$1,357,128	$233,723	$902,649	$8,199,453
Percent Change from Alternative 1	−1.5%	−0.1%	−0.5%	-0.1%	−1.1%
Annual Average NED Benefits	$70,444	$16,755	$2,885	$11,144	$101,228
Change in Annual Average NED Benefits	−$1,087	−$17	−$15	-$7	−$1,127

* Total Visitation includes lake elevation and non-lake elevation affected visits at the reservoirs and boat accessed and non-boat accessed visits in the river reaches and lower river. For more details, refer to the “Recreation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Additional results of flow actions are summarized in Table 3-215. These results show the difference in annual recreation NED benefits during years when there would be a release action. The results show that adverse impacts would be most prevalent in the upper river during full release years, in the years following a full spring release, and in other years, when the upper reservoirs would be lower than under Alternative 1. The largest decrease in recreation NED benefits is $5.1 million. In contrast, recreation benefits in the lower river would be highest during full spring release actions when boat ramp operability would be improved under Alternative 4 relative to Alternative 1 providing additional access for visitors.

There would be both beneficial and adverse impacts to recreation during full and partial flow releases, with reductions in annual benefits outweighing increases in benefits across the POR. The reduction in recreation NED benefits at the upper three reservoirs would occur in a period when visitation and associated recreation NED benefits would already be quite low due to drought or relatively drier conditions. Annual recreation NED benefits at Fort Peck Lake, Lake Sakakawea, and Lake Oahe would decrease by $3.5 million, $2.5 million, and $1.5 million, respectively, during the worst-case year simulated under Alternative 4. As drought conditions are alleviated with typical rainfall and snowpack, System storage would be replenished and adverse NED impacts at the upper three reservoirs would be reduced. With large decreases in reservoir elevations, the fishery and fishing opportunities could take years to recover. As a result, there would be relatively large adverse impacts in these years, which would be prolonged and more pronounced during drier conditions following flow releases.

Table 3-215. Changes in NED Benefits from Flow Releases under Alternative 4 Compared to Alternative 1 (thousands of 2018 dollars)

Type of Release	Type of Change	Upper River [c]	Lower River [c]
Full Flow Release [a]	Lowest Benefit Change	−$4,293	$4
	Highest Benefit Change	$61	$1,874
Year After Full Flow Release	Lowest Benefit Change	−$5,057	−$774
	Highest Benefit Change	−$1,520	−$26
Partial Flow Release [b]	Lowest Benefit Change	−$1,999	−$108
	Highest Benefit Change	−$214	$425
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Benefit Change	−$5,057	−$774
	Highest Benefit Change	$1,436	$1,874

a Flow action was fully implemented in 9 years of the POR. Data represents the lowest and highest change in benefits in the years the action was fully implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

b Flow action was partially implemented in 7 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

c The upper river includes the reservoirs and the inter-reservoir river reaches, and the lower river includes the river reaches from Gavins Point Dam to the confluence with the Mississippi River.

Regional Economic Development

Under Alternative 4, non-local visitor spending associated with recreation on the reservoirs would support on average 1,492 jobs and $36.2 million in labor income on an annual basis. Compared to Alternative 1, Alternative 4 would have greater adverse impacts to recreation RED benefits, supporting 21 fewer jobs and $585,000 less in labor income on average (Table 3-216).

Similar to the NED analysis, the largest changes in recreation RED benefits relative to Alternative 1 would occur in the upper three reservoirs in the years following a spring release. During the eight worst years relative to Alternative 1, average annual RED benefits in the upper three reservoirs would decrease by 88 jobs and $2.1 million in labor income compared to RED benefits under Alternative 1, with Lake Oahe experiencing the largest adverse impacts. Eighty-eight jobs represent almost three percent of the recreation-based jobs in the rural communities surrounding the upper three reservoirs (excluding Bismarck and Pierre). Similar to Alternative 2, adverse recreation RED impacts would be small in the context of the broader regional economy, but could be locally large and adverse to the tourism industries and communities most affected by decreases in non-local visitation. As System storage is replenished with typical rainfall and snowpack, reservoir elevations and recreation RED benefits would increase, and become similar to those under Alternative 1. However, recurring implementation of the spring release and draw down of the reservoirs may lead to long-term reductions in visitation and associated employment and income in sectors that support recreation at the upper three reservoirs due to uncertain provision of recreation access and opportunities at the reservoirs.

Impacts to regional economic conditions surrounding Lake Francis Case and Lewis and Clark Lake would be negligible to small because pool elevations remain relatively stable, providing recreational access and visitation even during drier conditions.

Table 3-216. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 4 Relative to Alternative 1 (Thousands of 2018 Dollars)

Economic Impact Parameter	Year	Upper Three Reservoirs	Lake Francis Case and Lewis and Clark Lake	Total Economic Impacts [a]
Direct, Indirect, and Induced Jobs	Average Annual over 81 years	1,238	254	1,492
	Change in Annual Average over 81 years Relative to Alternative 1	−20	−0	−21
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−88	−9	−97
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	13	9	23
Direct, Indirect, and Induced Labor Income	Annual Average over 81 years	$29,992	$6,251	$36,243
	Change in Annual Average over 81 years Relative to Alternative 1	−$571	−$13	−$585
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−$2,104	−$217	−$2,320
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	$325	$233	$558
Direct, Indirect, and Induced Sales	Annual Average over 81 years	$96,417	$20,041	$116,458
	Change in Average Annual Average over 81 years Relative to Alternative 1	−$1,839	−$43	−$1,882
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−$6,751	−$695	−$7,446
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	$979	$750	$1,729

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis aggregated the reservoir-specific impacts (average, 8 best and worst change years) to provide the estimates.

a Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

Other Social Effects

Recreation OSE associated with IRC and ESH under Alternative 4 would be very similar to those described under Alternative 1, with small increases in OSE benefits from the establishment of ESH and early life stage habitat for the pallid sturgeon.

Conclusion

Under Alternative 4, on average there would be small decreases in recreation NED benefits across all locations compared to Alternative 1 (−1.1 percent). Although additional acres of ESH would be constructed in the inter-reservoir and lower river reaches, there would be negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because of the relatively small change in habitat prevalence and river stages and flows would have a negligible impact on recreational opportunities. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because fairly stable reservoir elevations would support relatively constant visitation at these reservoirs. The upper three reservoirs would experience small adverse impacts on average (−1.5 percent). However, in some years following the spring release under relatively drier climactic conditions, decreases in visitation under Alternative 4 would be large and adverse compared to those under Alternative 1 and would persist until precipitation and snowmelt were able to increase System storage to normal conditions; adverse impacts to the fishery could persist longer. Recurring implementation of the spring pulse could lead to long-term adverse impacts to visitation and associated NED at the upper three reservoirs, more than estimated under this NED evaluation.

In these worst-change years compared to Alternative 1, non-local visitation at the upper three reservoirs would support on average 88 fewer jobs across the region compared to Alternative 1. Although these adverse impacts would be negligible in the context of the larger regional economy, changes in economic activity and opportunities could be large for tourism industries in affected communities and recurring implementation of the spring release could result in long-term adverse impacts to jobs and income. Habitat construction would have temporary and localized, small, adverse impacts to recreation from closures, noise, and other disturbances during construction activities.

Alternative 4 would not have significant adverse impacts to recreation because changes in recreation NED, RED, and OSE would be small to negligible and adverse on an annual average basis compared to Alternative 1; large impacts in some years would be temporary if normal precipitation and snowpack conditions occur; and RED impacts would be small in a regional context.

3.16.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 would include fall releases from Gavins Point Dam and mechanical construction to create ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches. Under Alternative 5, IRC habitat to support early life stage requirements of the pallid sturgeon would be constructed in the lower river below Ponca, Nebraska.

Mechanical Habitat Construction

Similar to Alternatives 3 and 4, target acres for habitat construction under Alternative 5 are higher for ESH and lower for habitat to support the early life stage requirements of the pallid sturgeon compared to Alternative 1. Impacts would be very similar to those described under Alternative 1, with temporary, small, adverse impacts to recreation. The increased prevalence of ESH and early life stage habitat would benefit some fish and other aquatic species. The benefits described under Alternative 1 from the increased prevalence of constructed ESH would be increased under Alternative 5 compared to Alternative 1. However, while early life stage habitat would be constructed under Alternative 5, there would be fewer acres of construction and fewer acres of additional lands that would be acquired for habitat development. Recreational benefits associated with fish and wildlife would still occur but would be slightly reduced under Alternative 5 compared to Alternative 1. The value of the recreational experiences associated with the prevalence of habitat under Alternative 5 is monetized in the NED evaluation and described below.

National Economic Development

Under Alternative 5, average annual recreation NED benefits would decrease by $86,000, a decrease of approximately 0.1 percent compared to Alternative 1 (Table 3-217). The recreation NED benefits for the upper three reservoirs would be lower than under Alternative 1 in the year following a fall release. Average annual decrease in recreation NED benefits are estimated to be $84,000 compared to Alternative 1 at the upper three reservoirs. Impacts of fall releases under Alternative 5 would result in negligible changes to boat ramp operability, visitation, and recreation NED benefits at the lower three reservoirs because reservoir elevations in these flow-through reservoirs would remain relatively stable.

The fall release that occur under Alternative 5 would be fully implemented in seven years and partially implemented in two years over the period of record. During full and partial fall releases, there is the potential for adverse impacts to fish and recreational fishing opportunities. Section 3.5, Fish and Wildlife Habitat, describes how fish, other aquatic resources, and wildlife would be affected by the fall release in various locations. The fall release would result in adverse impacts to fish and recreational fishing opportunities from fish entrainment as well as from the potential for large drawdowns of the upper three reservoirs, especially in the spring when the pool rise is critical for fish spawning. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 5 would remain relatively stable, with minimal indirect impacts to recreation.

In the inter-reservoir river reaches, Alternative 5 would result in negligible change in benefits of 0.1 percent. Even in the largest difference years, changes in recreation NED benefits would be very small. Although the construction of ESH in the Garrison and Fort Randall river reaches would generate nearly twice as many recreation NED benefits as under Alternative 1, the habitat benefits would be a very small part of the overall recreation NED benefits in the inter-reservoir river reaches. In addition, the fall releases could have both beneficial and adverse impacts to fish and other aquatic resources in the river reaches below the dams, with indirect impacts to recreation (See Section 3.5 for additional details). However, only a small amount of water compared to natural flow variability would be released during implementation of the fall release and the indirect impacts to recreation associated with fish and wildlife under Alternative 5 are generally small compared to the impacts caused by the extreme hydrologic events in the POR.

Alternative 5 would result in an increase of $5,000 in average annual recreation NED benefits in the lower river, a negligible change relative to Alternative 1. Increases in recreation NED benefits under Alternative 5 would occur from relatively higher amount of ESH and fall releases increase recreational access compared to Alternative 1. In addition, visitors in the lower river that prefer lower river flows, such as those using paddle craft or swimming, would experience some adverse impacts during the fall releases and negligible changes at other times under Alternative 5. The OMRR&R costs at the upper three reservoirs would be relatively the same as those under Alternative 1.

Table 3-217. Summary of National Economic Development Analysis for Alternative 5, 1932–2012 (thousands of 2018 dollars)

	Upper Three Reservoirs	Lower Three Reservoirs	Inter-Reservoir River Reaches	Lower River	All Locations
Total Visitation* Benefits	$5,790,559	$1,358,006	$233,194	$893,985	$8,275,743
Total Habitat Benefits	NA	NA	$1,620	$9,687	$11,306
OMRR&R Costs	$3,328	NA	NA	NA	$3,328
Total NED Benefits	$5,787,231	$1,358,006	$234,813	$903,672	$8,283,721
Percent Change from Alternative 1	−0.1%	0.0%	-0.1%	0.0%	−0.1%
Annual Average NED Benefits	$71,447	$16,766	$2,899	$11,156	$102,268
Change in Annual Average NED Benefits	−$84	-$6	-$2	$5	−$86

* Total Visitation includes lake elevation and non-lake elevation affected visits at the reservoirs and boat accessed and non-boat accessed visits in the river reaches and lower river. For more details, refer to the “Recreation Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Impacts by flow type for Alternative 5 relative to Alternative 1 are summarized in Table 3-218. These results show the difference in annual benefits during years when there would be full or partial release action or in the years after a full release. Adverse impacts would occur in the year following a full fall release when the lake elevations at the upper three reservoirs would be lower than under Alternative 1. In contrast, recreation NED benefits in the lower river would be highest during full fall release actions when boat ramp operability would be improved under Alternative 5 relative to Alternative 1.

At Lake Sakakawea and Lake Oahe, in the years following a fall release, the reservoirs could be drawn down up to 6 feet and 3 feet lower than under Alternative 1, respectively, during the spring, summer, and fall, causing impacts to recreational access and decreased fishing opportunities. Because the lake elevations would typically recover to levels consistent with Alternative 1 within a year, the impacts would be relatively small and adverse to visitation at the upper three reservoirs in the release years. With decreased lake levels relative to Alternative 1, the fishery in these reservoirs would take a relatively longer period of time to recover, with possibly prolonged impacts to angling and visitation.

Table 3-218. Changes in NED Benefits from Flow Releases under Alternative 5 Compared to Alternative 1 (thousands of 2018 dollars)

		Upper River [c]	Lower River [c]
Full Flow Release [a]	Lowest Benefit Change	−$373	$546
	Highest Benefit Change	$380	$1,462
Year After Full Flow Release	Lowest Benefit Change	−$1,261	−$782
	Highest Benefit Change	−$340	−$155
Partial Flow Release [b]	Lowest Benefit Change	$230	$514
	Highest Benefit Change	$230	$514
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Benefit Change	−$1,588	−$1,299
	Highest Benefit Change	$602	$1,462

a Flow action was fully implemented in 7 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was fully implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

b Flow action was partially implemented in 2 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

c The upper river includes the reservoirs and the inter-reservoir river reaches, and the lower river includes the river reaches from Gavins Point Dam to the confluence with the Mississippi River.

Regional Economic Development

Under Alternative 5, non-local visitor spending associated with recreation on the reservoirs would support an average of 1,511 jobs and $36.7 million in labor income. Compared to Alternative 1, Alternative 5 would support approximately one less job and $29,000 less in labor income on annual average in communities located near the upper three Mainstem reservoirs, with negligible impacts to recreation RED benefits (Table 3-219). The largest changes in recreation RED benefits relative to Alternative 1 would occur in the upper three reservoirs in the years following a release event. During the 8 worst years relative to Alternative 1, average annual RED benefits in the upper three reservoirs would decrease by 26 jobs and $644,000 in labor income, while in the eight highest visitation years relative to Alternative 1 average annual RED benefits in the upper three reservoirs would increase by 13 jobs and $336,000 in labor income. Even in the eight worst years relative to Alternative 1, there would be relatively small and temporary decreases in RED benefits that would be negligible in the regional context and potentially locally small and adverse impacts to the tourism industries and communities most affected by decreases in non-local visitation.

Impacts to regional economic conditions surrounding Lake Francis Case and Lewis and Clark Lake would be relatively small because pool elevations remain relatively stable, resulting in minimal changes in recreational access and visitation at these lakes even during drier conditions.

Table 3-219. Economic Benefits of Non-Local Visitor Spending at the Reservoirs under Alternative 5 (thousands of 2018 Dollars)

Economic Impact Parameter	Year	Upper Three Reservoirs	Lake Francis Case and Lewis and Clark Lake	Total Economic Impacts [a]
Direct, Indirect, and Induced Jobs	Average Annual over 81 years	1,257	255	1,511
	Change in Annual Average over 81 years Relative to Alternative 1	−1	0	−1
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−26	−9	−36
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	13	10	12
Direct, Indirect, and Induced Labor Income	Annual Average over 81 years	$30,462	$6,266	$36,727
	Change in Annual Average over 81 years Relative to Alternative 1	−$29	$4	−$25
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−$644	−$201	−$845
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	$336	$245	$581
Direct, Indirect, and Induced Sales	Annual Average over 81 years	$97,930	$20,089	$118,020
	Change in Average Annual Average over 81 years Relative to Alternative 1	−$91	$13	−$79
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−$2,076	−$737	−$2,812
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	$1,071	$789	$1,860

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis aggregated the reservoir-specific impacts (average, 8 best and worst change years) to provide the estimates.

a Total economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

Other Social Effects

Recreation OSE associated with IRC and ESH under Alternative 5 would be very similar to those described under Alternative 1, with small increases in OSE benefits from the establishment of ESH and early life stage habitat for the pallid sturgeon.

Conclusion

Alternative 5 would result in negligible changes in recreation NED benefits across all locations compared to Alternative 1 (-0.1 percent). Although additional acres of ESH would be constructed in the inter-reservoir reaches, there would be negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because of the relatively small change in habitat prevalence and changes in river stages and flows would not noticeably affect recreational access. Alternative 5 would support small benefits to recreation NED benefits in the lower river from additional ESH and fall releases increasing recreational access. The lower three reservoirs would have negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs. The upper three reservoirs would experience a negligible change in recreation NED benefits on average (-0.1 percent). However, in the year following the fall release, there would be temporary and small decreases in recreation NED and RED benefits under Alternative 5 compared to Alternative 1 because reservoir elevations would be reduced from the previous year release, affecting recreational access and fishing opportunities. In these years, non-local visitation at the upper three reservoirs would support 26 fewer jobs when compared to Alternative 1, with possibly small impacts to recreation RED and OSE benefits in the local communities. Habitat construction would have temporary and localized, small, adverse impacts to recreation from closures, noise, and other disturbances during construction activities.

Alternative 5 would not have significant adverse impacts to recreation because changes in recreation NED, RED, and OSE would be small to negligible adverse in all locations and years compared to Alternative 1 and impacts in habitat construction would be temporary and localized.

3.16.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, USACE would attempt a spawning cue pulse every three years in March and May. In addition, management actions under Alternative 6 include mechanical construction of ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska reaches; and the construction of IRC habitat in the lower river below Ponca, Nebraska to support the pallid sturgeon.

Mechanical Habitat Construction

Similar to Alternatives 3, 4, and 5, target acres for habitat construction under Alternative 6 are higher for ESH and lower for habitat to support the early life requirements of the pallid sturgeon compared to Alternative 1. Impacts would be very similar to those described under Alternative 1, with temporary, small, adverse impacts to recreation. The increased prevalence of ESH and early life stage habitat would benefit some fish and other aquatic species. The benefits described under Alternative 1 from the increased prevalence of constructed ESH would be increased under Alternative 6 compared to Alternative 1. However, while early life stage habitat would be constructed under Alternative 6, there would be fewer acres of construction and fewer acres of additional lands that would be acquired for habitat development. As a result, recreational benefits to some fish and wildlife could be slightly reduced under Alternative 6 compared to Alternative 1. The value of the recreational experiences associated with the prevalence of habitat under Alternative 6 is monetized in the NED evaluation and described below.

National Economic Development

Under Alternative 6, average annual recreation NED benefits would decrease by $846,000, a decrease of 0.8 percent compared to Alternative 1 (Table 3-220). Similar to Alternatives 2 and 4, the adverse impacts under Alternative 6 would be focused in the upper three reservoirs in the years following a spawning cue release when lake elevations are lower than those under Alternative 1.

Spawning cue releases would occur under Alternative 6 and would be fully implemented in six years and partially implemented 29 years over the period of record (partial implementation years are defined as years when a partial cue in March and/or May would occur OR years when a full cue in March or May would occur). During full and partial spawning cue releases, there is the potential for adverse impacts to fish and recreational fishing opportunities. Section 3.5, Fish and Wildlife Habitat, describes how fish, other aquatic resources, and wildlife would be affected by the spawning cue release in various locations. The spawning cue release would result in adverse impacts to fish and recreational fishing opportunities from fish entrainment as well as from the potential for large drawdowns of the upper three reservoirs, especially in the spring when the pool rise is critical for fish spawning. Pool elevations in Lake Francis Case and Lewis and Clark Lake under Alternative 6 would remain relatively stable, with minimal indirect impacts to recreation.

Management actions under Alternative 6 would result in small increases in recreation access and associated visitation at the lower three reservoirs, inter-reservoir reaches, and lower river, with negligible changes to boat ramp operability, visitation, and recreation NED benefits at these locations because reservoir elevations and river stages would remain relatively stable. In the lower river, recreational NED benefits would decrease on average by $5,000 annually, a negligible change compared to Alternative 1. Some visitors that prefer lower river flows, such as those using paddle craft or swimmers, may be adversely impacted during the spawning cue releases, but would have negligible impacts during at other times under Alternative 6. In addition, the spawning cue releases could have both beneficial and adverse impacts to fish and other aquatic resources in the river reaches below the dams, with indirect impacts to recreation (See Section 3.5 for additional details). However, only a small amount of water compared to natural flow variability would be released during implementation of the spawning cue release and the indirect impacts to recreation associated with fish and wildlife under Alternative 6 are generally small compared to the impacts caused by the extreme hydrologic events in the POR.

OMRR&R costs would be higher under Alternative 6, $3.8 million compared to $3.3 million under Alternative 1. The upper three reservoir elevations would be relatively lower during conditions similar to those simulated in the 2000s drought under Alternative 6, with small to large adverse impacts depending on the timing and location of needed investments.

Table 3-220. Summary of National Economic Development Analysis for Alternative 6, 1932–2012 (thousands 2018 dollars)

Benefits or Costs	Upper Three Reservoirs	Lower Three Reservoirs	Inter-Reservoir River Reaches	Lower River	All Locations
Total Visitation* Benefits	$5,727,841	$1,361,061	$232,873	$893,013	$8,214,794
Total Habitat Benefits	NA	NA	$1,340	$9,870	$11,210
OMRR&R Costs	$3,835	NA	NA	NA	$3,835
Total NED Benefits	$5,724,012	$1,361,061	$234,213	$902,883	$8,222,169
Percent Change from Alternative 1	−1.2%	0.2%	−0.3%	0.0%	−0.8%
Annual Average NED Benefits	$70,667	$16,803	$2,892	$11,147	$101,508
Change in Annual Average NED Benefits	-$864	$32	-$9	-$5	-$846

* Total Visitation includes lake elevation and non-lake elevation affected visits at the reservoirs and boat accessed and non-boat accessed visits in the river reaches and lower river. For more details, refer to the "Recreation Environmental Consequences Analysis Technical Report" available online (www.moriverrecovery.org).

Impacts by flow type for Alternative 6 relative to Alternative 1 are summarized in Table 3-221. These results show the difference in annual recreation benefits during years when there is a release action. Recreation NED benefits under Alternative 6 in the lower river would be highest during full spawning cue release when boat ramp operability would be improved relative to Alternative 1. The largest adverse impacts in the upper river (includes the reservoirs and inter-reservoir river reaches) would occur in the year following a full spawning cue release.

Adverse impacts under Alternative 6 would occur in the year or years following a full or partially implemented spawning cue release during relatively drier conditions. Under these conditions it can take a number of years for the reservoirs to refill, the fishery to recover, and visitation to increase, with prolonged adverse impacts to recreation benefits. The reduction in recreation benefits under Alternative 6 would occur in a period when under Alternative 1, the benefits would already be quite low due to drought or relatively drier conditions. Lake Oahe would experience the biggest reductions in NED benefits during these conditions when the reservoirs could be drawn down up to 9 feet lower than with conditions under Alternative 1, causing impacts to recreational access to the lake and decreased fishing opportunities. Lake Oahe would experience a decrease of up to $1.9 million in recreation NED benefits in the worst difference year compared to Alternative 1. Lake Sakakawea would decrease up to 5 feet in the years following a flow release, with a decrease in recreation NED benefits in the worst-difference years of $1.4 million relative to Alternative 1.

Table 3-221 Changes in NED Benefits from Flow Releases under Alternative 6 Compared to Alternative 1 (Thousands of 2018 dollars)

		Upper River [c]	Lower River [c]
Full Flow Release [a]	Lowest Benefit Change	−$2,401	−$61
	Highest Benefit Change	−$505	$1,096
Year After a Full Flow Release	Lowest Benefit Change	-$2,809	-$771
	Highest Benefit Change	$71	-$38
Partial Flow Release [b]	Lowest Benefit Change	−$3,244	−$800
	Highest Benefit Change	$2,656	$1,258
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Benefit Change	−$3,244	−$800
	Highest Benefit Change	$3,258	$1,258

a Flow action was fully implemented in 6 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was fully implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

b Flow action was partially implemented in 29 years over the POR (partial implementation years are defined as years when a partial cue in March and/or May would occur OR years when a full cue in March or May would occur). Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative values reflect decreases in recreation benefits compared to Alternative 1.

c The upper river includes the reservoirs and the inter-reservoir river reaches, and the lower river includes the river reaches from Gavins Point Dam to the confluence with the Mississippi River.

Regional Economic Development

Under Alternative 6, non-local visitor spending associated with recreation on the reservoirs would support 1,495 jobs and $36.3 million on average per year in labor income. Compared to Alternative 1, Alternative 6 would support 18 fewer jobs and $511,000 less in labor income on average over the POR (Table 3-222). During the 8 worst years relative to Alternative 1, average annual RED benefits in the upper three reservoirs would decrease by 67 jobs and nearly $1.7 million in labor income compared to RED benefits under Alternative 1. Adverse RED impacts would be small in the regional context but could be locally large and adverse to the tourism industries and communities most affected by decreases in non-local visitation. These impacts would be especially large in low precipitation years following a spawning cue release. As drought conditions are alleviated with typical rainfall and snowpack, System storage would be replenished and RED benefits would increase and become similar to those under Alternative 1. However, recurring implementation of the spawning cue release and draw down of the reservoirs may lead to long-term reductions in visitation and associated employment and income in sectors that support recreation at the upper three reservoirs due to uncertain provision of recreation access and opportunities at the reservoirs.

Impacts on regional economic conditions at Lake Francis Case and Lewis and Clark Lake would be negligible because stable pool elevations would not noticeably affect recreational access and visitation to these lakes.

Table 3-222. Economic Benefits of Non-Local Visitor Spending at the Reservoirs under Alternative 6 Relative to Alternative 1 (Thousands of 2018 Dollars)

Economic Impact Parameter	Year	Upper Three Reservoirs	Lake Francis Case and Lewis and Clark Lake	Total Economic Impacts [a]
Direct, Indirect, and Induced Jobs	Average Annual over 81 years	1,239	256	1,495
	Change in Annual Average over 81 years Relative to Alternative 1	−19	2	−18
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−67	−7	−75
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	53	18	71
Direct, Indirect, and Induced Labor Income	Annual Average over 81 years	$29,998	$6,309	$36,306
	Change in Annual Average over 81 years Relative to Alternative 1	−$564	$53	−$511
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−$1,678	−$179	−$1,858
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	$444	$440	$884
Direct, Indirect, and Induced Sales	Annual Average over 81 years	$96,425	$20,428	$116,853
	Change in Average Annual Average over 81 years Relative to Alternative 1	−$1,829	$403	−$1,426
	Annual Average during 8 Lowest Visitation Years Relative to Alternative 1	−$5,431	−$575	−$6,006
	Annual Average during 8 Highest Visitation Years Relative to Alternative 1	$1,295	$1,417	$2,712

Note: The lowest visitation year and highest visitation years would not necessarily be the same year at each reservoir. The analysis aggregated the reservoir-specific impacts (average, 8 best and worst change years) to provide the estimates.

a Economic impacts may not equal to the sum of impacts at the upper three reservoirs and at Lake Francis Case and Lewis and Clark Lake due to rounding.

Other Social Effects

Recreation OSE associated with IRC and ESH under Alternative 6 would be very similar to those described under Alternative 1, with small increases in OSE benefits from the establishment of ESH and early life stage habitat for the pallid sturgeon.

Conclusion

Under Alternative 6, there would be small decreases in total recreation NED benefits for all locations compared to Alternative 1 (−0.8 percent). Although additional acres of ESH would be constructed in the inter-reservoir and lower river reaches, there would be negligible changes in recreation NED, RED, and OSE benefits compared to Alternative 1 because of the relatively small change in habitat prevalence and river stages and flows and thus not a noticeable affect to recreational access. The lower three reservoirs would have negligible changes in recreation NED and RED benefits compared to Alternative 1 because fairly stable reservoir elevations would maintain relatively constant visitation at these reservoirs.

The upper three reservoirs would experience small adverse impacts on average (−1.2 percent). However, in specific years under certain conditions, decreases in visitation, NED and RED benefits under Alternative 6 compared to Alternative 1 would be small to large and adverse and could perpetuate for a number of years. The spawning cue release could exacerbate reductions in reservoir elevations when releases occur at the beginning of a relatively drier period with lower precipitation. Under these relatively drier conditions after a spawning cue release, non-local visitation at the upper three reservoirs would support 67 fewer jobs across the region compared to Alternative 1. Although these adverse impacts would be negligible in the context of the larger regional economy, changes in economic activity and opportunities could be large for tourism industries in affected gateway communities and recurring implementation of the spawning cue release could result in long-term adverse impacts to jobs and income. In addition, recurring implementation of the spawning cue release could lead to long-term adverse impacts to visitation and associated NED at the upper three reservoirs, more than estimated under this NED evaluation. Habitat construction would have temporary and localized, small, adverse impacts to recreation from closures, noise, and other disturbances during construction activities.

Alternative 6 would not have significant adverse impacts to recreation because decreases in recreation NED, RED, and OSE would be small to negligible on annual average in all locations; large impacts in some years would be temporary if normal precipitation and snowpack conditions occur; and large RED impacts would be small in a regional context.

3.16.2.10 Tribal Resources

Impacts on Tribal recreation resources would depend on the location of Tribes and reservations. (Figure 1-2). Changes in recreation NED benefits to reservations and their residents vary depending on hydrologic conditions, but generally include large NED benefits to visitors and residents under all alternatives. RED benefits to Tribes from non-local visitor spending at the reservoirs may be small in the context of the broader regional economy under the MRRMP-EIS alternatives, but could be important to Tribes, especially where opportunities for employment and income are limited. Impacts to Tribal RED benefits in the river reaches would be negligible. The construction of habitat and non-local visitor spending would generate OSE benefits for Tribes and those living on reservations along the Missouri River.

Impacts to Tribal recreation under the alternatives would be similar to those described in Section and NED, RED, and OSE results described above. In most years, there would be negligible impacts under MRRMP-EIS alternatives relative to Alternative 1. Flow releases under Alternatives 2, 4, 5, and 6 would, however, draw down the upper three reservoir elevations more than under Alternative 1 under some conditions in years following the flow releases, causing temporary, small to large, adverse impacts on recreation. Impacts would range from negligible under Alternative 3 to relatively large under Alternative 4 under certain conditions. Impacts under Alternatives 2, 4, 5, and 6 would be more pronounced during drought or drier conditions in the years following flow releases. Adverse impacts on recreation NED, RED, and OSE benefits during these conditions may also adversely affect Tribal communities and lifestyles.

Recreational opportunities associated with reservations and Tribes near and/or adjacent to the lower three reservoirs would experience negligible impacts to recreational resources under all alternatives because pool elevations at these reservoirs are relatively stable. Impacts to Tribal recreation in the inter-reservoir river reaches and lower river would include temporary adverse impacts from mechanical habitat construction, and long-term benefits from increased diversity and abundance of wildlife following habitat construction under Alternatives 2–6. Short-term, adverse impacts from habitat construction to Tribes and Tribal communities would be greatest under Alternative 2 since target acreages for mechanical construction are substantially higher under these alternatives.

3.16.2.11 Climate Change

All of the climate change variables described in Section 3.2 could have implications for recreation resources and the associated NED, RED, and OSE effects under the MRRMP-EIS alternatives. Earlier snowmelt may cause spring System storage targets at the upper three reservoirs to be met more frequently, increasing the regularity of spring plenary pulses under Alternative 1, and the potential for adverse impacts associated with the subsequent lower reservoir elevations. Adverse recreational impacts associated with more frequent spring plenary pulses may be offset in part by higher levels of precipitation limiting the implementation of the full release because flood targets may be exceeded more frequently.

Under Alternatives 2–6, more sporadic large rain events and flooding could adversely impact access to recreation resources; these impacts could be exacerbated during spring or fall releases. In addition, the risk of releases occurring which may be followed by prolonged drought periods at the upper three reservoirs could reduce reservoir elevations more under Alternatives 2, 4, 5, and 6, causing greater adverse impacts to recreation with climate change.

Climate change may result in more extreme drought or flood conditions, with the potential to reduce the frequency of full releases under Alternatives 2, 4, 5, and 6 and the adverse impacts associated with full releases at the upper three reservoirs. Adverse impacts associated with partial releases may, however, increase as the frequency in which release events are started and then prematurely stopped increases. With these factors, the impact of climate change would both increase and decrease recreation benefits under Alternatives 2, 4, 5, and 6 relative to Alternative 1.

3.16.2.12 Cumulative Impacts

Past, present, and future construction projects, including those to maintain the Mainstem dams, roads, developed recreational areas, native fish and wildlife habitat areas, and the BSNP, can cause temporary localized adverse impacts to the quality and quantity of recreational visits as a result of construction-related noise, vibration, fugitive emissions, deterioration in water quality, decreased visual aesthetics, and access limitations. However, many of these actions result in recreational benefits over the long-term by increasing access and providing a range of recreational opportunities available to a variety of users.

Continued management of recreation, wildlife, and natural areas by USFWS, NPS, and agencies that manage these resources at the state and local level generally benefit recreation along the river because they promote conservation and are focused on safeguarding and enhancing wildlife and recreational resources for current and future users. In addition, land easements and agricultural technical and financial programs administered by NRCS support restoring or maintaining natural habitats, with potential benefits to fish and wildlife and associated recreational opportunities.

Variability in natural hydrologic conditions (precipitation and snowmelt, which include periods of drought and high runoff) and the “rules” governing System operation would continue to dominate the flows in the Missouri River into the future. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impacts to recreation opportunities and access of the Missouri River. However, other actions, such as water depletions or withdrawals for agriculture, municipal, and industrial uses have and would continue to have adverse impacts to recreational access and opportunities, as they would notably affect the reservoir elevations and river stages.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation. As described as part of the Year 0 and Year 15 analyses (Section 3.2), the elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in Year 15 under all alternatives compared to Year 0. The change in stage in the riverine areas in Year 15 in the inter-reservoir river reaches and the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in Year 15. However, in Kansas City, the projected river stage in Year 15 would only be slightly lower (less than one inch of the mean stage) than Year 0.

Past, present, and future actions that would affect bed degradation or aggradation of the Missouri River can impact the accessibility of recreational areas, including boat ramps, when water surface elevations and river stages increase or decrease, causing boat ramp and recreation areas to become inaccessible. It is possible that sediment deposition in the reservoirs may benefit recreational access during relatively drier conditions because reservoir elevations would increase slightly providing more access to boat ramps. In addition, any resulting changes in aggradation, degradation, and sediment deposition in the reservoirs would increase the need for investment in infrastructure (i.e., boat ramps or recreational access infrastructure) repairs and/or upgrades to mitigate these impacts.

Although recreational experiences supported by the river are cumulatively impacted by human actions, visitation is largely influenced by a number of other factors, including the health of the economy and the price of gasoline. Many recreational areas along the river are destination locations that attract hunters, anglers, boaters, and other outdoor enthusiasts from across the country. When gas prices are low and economic conditions are favorable, households have greater disposable income and are more likely to travel for recreational activities. As gas prices rise or households face greater economic uncertainty, recreationists often take trips closer to home. These factors can have mixed effects on visitation to reservoirs, where destination recreation increases during more prosperous periods and visitation by local residents increases during periods of high gas prices or economic downturns.

With the variable hydrology and precipitation within the System and its interaction with the past, present and foreseeable actions as described in Section 3.1, cumulative impacts under Alternative 1 would be long-term, large, and beneficial, with recreation resources supporting diverse recreational activities and opportunities to visitors and residents, jobs and income in local economies, and quality of life and social connectedness for surrounding communities. However, over time, the cumulative actions, variability in hydrology, and geomorphic processes and trends (e.g., aggradation, degradation, reservoir sediment deposition) can have both adverse or beneficial impacts on recreation; adverse and beneficial impacts to recreation are influenced by natural cycles of dry and wet periods (including snowpack and precipitation), and lesser so, by the price of gas, the state of the national and regional economy, trends in outdoor recreation use, and other public land management, programs, and activities. Alternative 1 would provide a small contribution to these cumulative impacts.

Alternatives 2, 4, and 6 would exacerbate adverse impacts to recreation in the years following releases during the drought or drier years because the releases would reduce reservoir elevations and the lower precipitation and/or snowpack would not be able to replenish the water storage at the upper three reservoirs. This could result in a large contribution to cumulative adverse effects in years after releases, especially at Lake Oahe. In the lower three reservoirs, and river reaches, implementation of Alternatives 2, 4, and 6 would have a negligible contribution to cumulative impacts because of the small change in river stages and reservoir elevations impacting recreational access in these areas and small beneficial impact from habitat on recreational opportunities.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3 would be similar to those described for Alternative 1, with a small contribution to these cumulative impacts.

When combined with other past, present, and reasonably foreseeable actions, cumulative impacts of Alternative 5 would be long-term large and beneficial. Implementation of Alternative 5 would contribute temporary small adverse impacts to cumulative impacts in the upper three reservoirs, mostly occurring in Lake Sakakawea and Lake Oahe that would dissipate within two years following the fall release. Cumulative impacts under Alternative 5 would also be beneficial in the lower river, inter-reservoir river reaches, and lower three reservoirs, although the overall contributions of Alternative 5 to cumulative impacts would be negligible because of the small change in river stages and reservoir elevations impacting recreational access in these areas.

3.17 Thermal Power

3.17.1 Affected Environment

There are 21 thermal power plants (2 nuclear and 19 coal-fired power plants) located along the Mainstem of the Missouri River and its reservoirs. One power plant is located on Lake Sakakawea in North Dakota; six are located on the river below Garrison Dam in North Dakota; and the remaining fourteen power plants are located on the river downstream of Sioux City, Iowa.

Coal combustion at these plants produces heat energy, which is used to boil water into steam. The steam turns the turbines, which spin the generators to produce electricity. Like coal-fired plants, nuclear power plants produce electricity by boiling water into steam. However, nuclear power plants do not burn any fuel. Instead, they obtain the heat needed to produce steam through a physical process called fission, which involves the splitting of uranium atoms in a nuclear reactor. The power plants operate generating units and one or more intakes for withdrawing water for once through cooling or for use in recirculating cooling systems. Of the 21 power plants, 9 have units with recirculating cooling systems or cooling ponds, while 12 plants withdraw water for once-through cooling.

These plants are mainly base load plants used to meet customers' continuous minimum demand for electricity. Base load plants typically run at all times of the year except during repairs or scheduled maintenance. The nuclear plants generally run at close to peak output continuously (except for maintenance). Although coal-fired plants may be cycled over a 24-hour period to meet fluctuations in demand, it is most economical if they are operated at constant production levels. The power plants, notably the coal-fired plants, are increasingly being called on for "dispatchable" generation, providing flexible power generation in peak seasons to complement renewable energy sources.

Thermal power plants access water for once through cooling or recirculating through their cooling systems through intakes. River flows and the associated water surface elevations can affect the amount, timing, frequency, and duration of access to water through the intakes. Intake elevation data was initially collected from the Master Manual and survey data conducted by the Missouri River Basin Water Management Division in 2012; power plant representatives have updated or confirmed the intake elevations during outreach with plants between 2015 and 2017.

All of the power plants discharge wastewater into the river and have NPDES permits that guide the effluent and temperature requirements based on state water quality standards. Low river flows and high river water temperatures can affect plant operational efficiency as well as the ability of the plants to meet their NPDES effluent and temperature requirements.

The NPDES permit of a thermal power facility includes temperature limits for maximum river water temperature and maximum change in river water temperature within the mixing zone (the volume and flow of the receiving water below the outfall). A number of factors are part of the estimation of these temperature requirements, including the flow of the receiving river, temperature of the receiving water, and the volume and temperature of effluent (i.e., the discharge water). Critical low flow conditions are used to define mixing zones and the effluent requirements. Maximum temperature requirements, as described in state regulations, range from 90°F for plants along the Missouri River in Missouri, Nebraska, Kansas, and Iowa to 85°F for plants in northern Nebraska and North Dakota.[13]

[13] For the Missouri River in Nebraska, from the South Dakota-Nebraska state line near Ft. Randall Dam to Sioux City, Iowa, the maximum river water temperature limit is 85°F. For warmer water below Sioux City in Nebraska, the maximum limit is 90°F (Nebraska Administrative Code Title 117, Chapter 4 2016).

3.17.1.1 Gross Capacity of Power Plants along the Missouri River

The thermal plants along the Missouri River have a nameplate capacity of 17,134 MW (EIA 2015). Nameplate capacity is the maximum rated output of a generator or power production equipment under specific conditions designated by the manufacturer (EIA 2016a). The 19 coal-fired plants have a combined gross megawatt capacity of 15,097 MW. The two nuclear plants have a combined gross generating capacity of 2,037 MW. Table 3-223 summarizes the location and gross megawatt capacity of the power plants.

Table 3-223. Gross Capacity of Missouri River Power Plants

Name	River Mile	County	State	Nameplate Capacity (MW)[a]
Lake Sakakawea	–	–	–	–
Basin Electric – Antelope Valley [b]	1415.5	Mercer	ND	870
Garrison Dam to Lake Oahe	–	–	–	–
Montana Dakota Utilities – Coyote [b]	1372.4	Mercer	ND	450
Great River Energy – Stanton	1372	Mercer	ND	191
Basin Electric – Leland Olds Station	1371.6	Mercer	ND	656
Minnkota Power Coop – Missouri River Pump for Milton R. Young [b]	1364.4	Oliver	ND	734
Great River Energy – Coal Creek [b]	1362.4	McLean	ND	1,210
Montana Dakota Utilities – Heskett	1319.5	Morton	ND	203
Gavins Point Dam to Rulo	–	–	–	–
MidAmerican – Neal North	718.3	Woodbury	IA	1,280
Rulo to the Mouth of the Missouri River	–	–	–	–
OPPD – North Omaha Power	625.3	Douglas	NE	655
MidAmerican – Walter Scott Energy Center [b]	606	Pottawattamie	IA	1,648
OPPD – Nebraska City [b]	556.3	Otoe	NE	1,390
NPPD – Cooper Nuclear	532.6	Nemaha	NE	801
KCPL – St. Joseph – Lake Road	446	Buchanan	MO	90
KCPL – Iatan Power Station [b]	411	Platte	MO	1,640
KCBPU – Nearman Creek [b]	378.7	Wyandotte	KS	355
KCBPU Quindaro	373.5	Jackson	MO	66
Veolia Energy – Kansas City	367.7	Jackson	MO	5
KCPL Hawthorne	358.3	Jackson	MO	740
KCPL – Sibley	336.4	Jackson	MO	524
Ameren – Callaway Nuclear [b]	115.5	Callaway	MO	1,236
Ameren – Labadie	57.9	Franklin	MO	2,390

Source: EIA 2015; Report EIA-860.

a Plant nameplate capacity was obtained from the U.S. Energy Information Administration and reflects 2014 data.

b Indicates that the power plant has a recirculating cooling system or pond for at least one unit.

3.17.1.2 Energy Generation for Power Plants along the Missouri River

Monthly energy generation is provided to the U.S. Energy Information Administration by the power plants. Table 3-224 summarizes the available average daily seasonal net generation for the Missouri River power plants based on monthly generation reported to the U.S. Energy Information Administration between 2012 and 2015. Power generation and market energy prices vary by season, with higher energy generation and market prices in the peak demand seasons of summer (July and August) and winter (January and February). For all of the units, average daily generation is highest during the summer and winter months, when peak demands for energy are highest.

Table 3-224. Average Daily Net Generation for Missouri River Thermal Power Plants by Season (MWh)

Thermal Power Plant	Winter (January and February)	Spring (March through June)	Summer (July and August)	Fall (September through December)
Basin Electric – Antelope Valley[a]	18,778	14,536	18,056	17,238
Montana Coyote Utilities – Coyote[a]	4,005	6,556	4,876	11,023
Great River Energy – Stanton	3,659	3,764	4,035	2,964
Basin Electric – Leland Olds Unit 1	7,680	3,078	3,854	2,751
Basin Electric – Leland Olds Unit 2	8,860	6,89	7,267	6,080
Minnkota Power – Missouri River Pump Unit 2[a]	26,462	8,750	10,069	8,577
Great River Energy – Coal Creek[a]	1,839	21,292	25,260	25,867
Montana Dakota Utilities – Heskett[b]	20,158	1,379	1,495	1,457
MidAmerican – Neal North	2,950	15,205	21,803	14,203
OPPD – North Omaha	3,659	3,913	3,790	5,589
MidAmerican – Walter Scott Energy Unit 3[a]	13,228	12,919	14,497	11,258
MidAmerican – Walter Scott Energy Unit 4[a]	16,314	12,991	17,683	15,938
OPPD – Nebraska City Unit 1[a]	12,954	7,809	12,739	13,836
OPPD – Nebraska City Unit 2[a]	13,397	14,882	15,178	13,502
NPPD – Cooper Nuclear	18,842	18,635	17,958	18,897
KCPL – St. Joseph – Lake Road	1,526	646	1,293	190
KCPL – Iatan Power Station[a]	7,671	13,616	14,982	12,868
KCBPU – Nearman Creek[a]	3,787	2,389	3,485	3,855
KCBPU Quindaro	2,620	2,235	3,094	2,531
Veolia Energy – Kansas City[b]	–	–	–	–

Thermal Power Plant	Winter (January and February)	Spring (March through June)	Summer (July and August)	Fall (September through December)
KCPL Hawthorne	11,612	6,739	12,448	8,724
KCPL – Sibley	6,449	3,883	8,267	1,278
Ameren – Callaway[a]	29,933	24,856	24,757	25,578
Ameren – Labadie	47,520	39,646	49,146	43,078

Source: EIA 2016c. Report EIA-923

Note: Data from the U.S. Energy Information Administration between 2012 and 2015 were used unless otherwise noted. All relevant units are included in the energy generation estimates; based on input from the power plants, energy generation from units that have been or are planning on being decommissioned were not included in the energy generation estimates.

a Indicates that the power plant has a recirculating cooling system or pond for at least one unit.

b U.S. Energy Information Administration data was only available for December 2013 and 2014.

3.17.1.3 Tribal Resources and Perspectives on Thermal Power

There are no power plants located on Tribal lands.

3.17.2 Environmental Consequences

The environmental consequences analysis for thermal power plants focuses on changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives. The sections that follow provide a summary of the analysis and a description of environmental consequences related to thermal power plants. Additional details on the methodology and results are provided in the “Thermal Power Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.17.2.1 Impact Assessment Methodology

This section describes the methodology for the NED, RED, and OSE analyses. The analysis focuses on the costs (replacement costs of reduced power generation, capital costs for lost capacity, and variable costs) to power plants and utilities to adapt to changing river and reservoir conditions. As river flows and reservoir elevations fall below intake operational requirements or river temperatures increase above operational or regulatory thresholds, access to water, power plant operational efficiencies, and regulatory constraints could affect power generation and variable costs. Reductions in power generation can in turn drive costs to replace power generation and lost capacity. The following section provides a brief overview of the overall methodology for evaluating impacts to thermal power plants as well as the approach for each planning account evaluated.

It should be noted that there are two time periods that are used in the evaluation: 1) the time period from 1975 to 2012, excluding 2011, which includes the impacts to power generation and capacity associated with river temperatures and river flows and stages; and 2) the time period between 1931 and 2012, which includes impacts from river temperature and river flows and stages for the years 1975 to 2012 (excluding 2011) and the time period 1931 to 1974, which includes adverse effects to power generation associated with river flows and stages (not temperature).[14]

[14]The impacts to power generation from 1975 to 2012 were evaluated to remove any double-counting of impacts from both river temperatures and river flows/stages.

There could also be potential impacts to thermal plants associated with construction and channel reconfiguration for early life stage habitat for the pallid sturgeon due to the possible disruption of water intakes to thermal power plants. The analysis used previous reports (USACE 2011a) and information provided by USACE to qualitatively describe these impacts in the NED section.

Alternative 1 is considered the baseline against which the other alternatives are measured and compared. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serve as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

National Economic Development

The environmental consequences for the NED analysis evaluated the potential effects from changes in river stage, river flow, or temperatures at specified locations along the river near power plants. The hydrologic and hydraulic (H&H) data on river stages and flows were used to assess when and how often intake access to water was affected. In addition, the Engineering Research and Development Center (ERDC) developed a temperature model (HEC-NSM [Nutrient Simulation Modules]) to estimate daily temperatures for a 37-year period between 1975 and 2012 (excluding 2011).

An extensive data collection effort was undertaken with power plants and utilities to obtain information on how river conditions affect power generation, operations, and variable costs. An important step in the process was to obtain the average daily power generation for the affected power plants for years when no adverse conditions occurred. Monthly generation was obtained from the U.S. Energy Information Administration for monthly net generation for each power plant and confirmed with the plant representatives. Power generation was evaluated seasonally because replacement costs of power vary by season, with peak demand for electricity forcing replacement prices higher in the winter and summer months.

The changes in power generation relative to Alternative 1 were used to estimate replacement power costs (changes in energy values) and capital costs to replace lost capacity (changes in capacity values). A 37-year period of analysis (1975–2012, excluding 2011) was used to assess both access to water and river temperatures. To account for all potential impacts across the period of record, the annual impacts in terms of the worst-case changes compared to Alternative 1 were assessed over this time period, 1931 to 2012 (excluding 2011). However, the impacts to power generation as estimated through the model between 1931 and 1974 only includes impacts from river flows and stages falling below intake elevations (and not from river water temperature).

The analysis assumed that power generation from the market would be available to supply replacement power and that energy prices would remain constant for the analysis. Energy values for the Missouri River were estimated by the Hydropower Analysis Center using locational marginal pricing from the Western Area Power Administration hub of both the Midwest Independent System Operator (MISO) Regional Transmission Organization (RTO) and the Southwest Power Pool (SPP) RTO. Locational marginal pricing is a computational technique that determines a shadow price for an additional MWh of demand. The monthly and weekend/weekday energy values were obtained from the USACE Hydropower Analysis Center, from which seasonal energy values were estimated for spring, summer, fall, and winter. Energy values or prices are higher in the summer and winter seasons during peak energy demand.

The unit capacity value was based on a FERC spreadsheet model that estimates annual regional capacity values for different generating resources (Hydropower Analysis Center 2018). The unit capacity value was estimated to be $133.65 per KW-year for a combined cycle natural gas unit.

The estimates of the changes in power generation were reviewed with representatives from Southwest Power Pool (SPP) to better understand the context and importance of these reductions in power generation, the available capacity, and the impacts on wholesale electricity prices. Impacts to wholesale power prices were evaluated qualitatively with input from these experts.

Regional Economic Development

The RED analysis used power generation information from the SPP Regional Transmission Organization (RTO) and consultation with RTO experts to describe the potential impacts of the changes in power generation on wholesale electricity prices and how changes to those prices could impact consumer electricity rates that are set by retail electricity providers. Any changes in retail electricity rates could impact household and business spending, with implications for jobs and income in regional economies. If consumers must spend more of their income on higher electricity rates, they would have less disposable income to spend on other goods and services, which could adversely impact jobs and income in affected industries.

Consumer electricity rates are typically regulated by the state utility commissions. Retail electricity providers must petition the state utility commission to change the rates. Input was also obtained from experts to better understand the magnitude of power reductions during peak seasons, which could affect wholesale electricity prices such that retail electricity providers would have justification to petition for electricity rate changes (SPP pers. comm. 2016; WAPA pers. comm. 2016). The RED analysis considered the worst-case peak seasonal reduction in power generation relative to Alternative 1 as a percent of total seasonal generation for the RTOs, the timing of the reductions in power generation within the peak season, and input from SPP to qualitatively assess the potential impacts to electricity rates and RED effects.

Other Social Effects

The OSE impacts are based on changes in thermal power generation under the MRRMP-EIS alternatives. The OSE impacts addressed in this evaluation include access to reliable power and impacts to air quality as a result of replacement electricity generation (and associated air emissions) that may replace power generation from Missouri River thermal plants. Access to reliable power was qualitatively evaluated with the estimates of the reductions in power generation and expert opinion (SPP pers. comm. 2016; SPP pers. comm. 2018). Coal-fired power plants generate air emissions, including greenhouse gas emissions, while the operation of nuclear power plants does not result in air emissions. The air quality evaluation estimated the anticipated changes in air emissions under the action alternatives relative to Alternative 1. Plant-specific emissions factors were obtained from EPA (2016d). It was assumed that reductions in thermal power generation under the MRRMP-EIS alternatives would be replaced with power generation from the market, specifically eGrid sub-regions (EPA 2016c). This replacement power generation could come from the next most expensive replacement unit of power in the RTO, which could be supplied by power producers using wind, solar, hydropower, nuclear, gas, or coal as a fuel source. Specific air emission changes were estimated for each alternative.

In general, the coal-fired power plants emit more per unit carbon dioxide and nitrous oxide emissions than the average replacement power sources from the market. Plant-specific methane emission sources have both higher and lower emissions depending on the power plant when compared with the average replacement power sources from the market. Therefore, there may be some reductions in certain emissions and increases in others under an alternative.

The OSE evaluation also included an evaluation of the social cost of carbon, which includes evaluating the social cost of carbon dioxide and the carbon dioxide equivalent impacts of nitrous oxide and methane. The combined cost impacts of these gases are expressed together as the "social cost of carbon equivalent" in this document (EPA 2016b). The social cost of carbon equivalent can vary based on the discount rate, the year, and probability of impacts in the future. For this evaluation, a range of social cost of carbon equivalent values was used in the analysis from $48 per metric ton (2018) to $253 (2050) per metric ton of carbon equivalent, consistent with EPA guidance (2016b). This range was used to reflect the societal costs from the release of a ton of carbon dioxide or the carbon dioxide equivalent impact of a release of nitrous oxide and methane into the atmosphere. The high estimate provides the 95th percentile of the cost simulations presenting a worst-case social cost of carbon equivalent.

Coupled Effects from Thermal Power and Hydropower Plants

If both hydropower and thermal power generation are affected during peak demand periods, there is potential for coupled effects from simultaneous reductions in power generation. To evaluate this potential effect, power generation estimates for both hydropower and thermal power were compared for each peak demand season (for every year) over the period of analysis (1975–2012, not including 2011) to evaluate the potential for coupled effects. In addition, the changes in power generation relative to Alternative 1 were compared with the seasonal RTO generation using Excel® to provide a market context for the changes in power generation. Changes in power generation during peak demand seasons in the summer and winter could exacerbate (i.e., increase) adverse impacts to wholesale power prices and potentially electricity rates, electricity reliability, and regional economic conditions. These effects were described qualitatively with input from industry experts (pers. comm. SPP 2018).

3.17.2.2 Summary of Environmental Consequences

Table 3-225 provides a summary of the environmental consequences relative to thermal power.

Table 3-225. Environmental Consequences Relative to Thermal Power

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Management Actions Common to All Alternatives	No NED Impacts.	No RED Impacts.	No OSE Impacts.	No Other Impacts.

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Alternative 1	Average annual NED value of $3.6 billion; average annual energy values: $2.3 billion; average annual capacity values: $1.4 billion (summer) to $1.6 billion (winter); average annual variable costs: $309,000.	Variations in power generation would range considerably with a worst-case decrease in ~6 million MWh during drought conditions, with potential implications for wholesale energy prices, and possibly electricity rates and associated household and business spending. Alternative 1 management actions would have a negligible impact from the spring pulse.	Alternative 1 management actions would have a negligible impact on electricity reliability. Average annual air emissions: • 167 billion lbs of CO_2 • 14.7 million lbs of methane • 2.8 million lbs of NOx The average annual social cost of carbon equivalent would range between $3.6 billion (2018) and $10.6 billion (2050).	Negligible to small, temporary adverse impacts associated with early life stage habitat and ESH construction. During drought conditions, decreases in power generation from thermal power and hydropower generation (*coupled effects*) could represent up to 3.2% of MISO and SPP power generation; the spring plenary pulse under Alternative 1 would have a negligible contribution to these impacts.
Alternative 2	Reduction in average annual NED value of $60.0 million (-1.6%) relative to Alternative 1; average annual reduction in energy values of $6.7 million from Alternative 1; average annual reduction in capacity values of $58.5 million from Alternative 1. Overall, relatively small adverse impacts to power generation, with large adverse impacts to NED value in the lower river from the low summer flows.	Relatively higher wholesale energy prices, especially during low summer flow events, with the potential for an increase in retail electricity rates over time compared to Alternative 1. Relatively long-term and adverse impacts to spending and regional economic conditions could occur.	Potentially large, temporary adverse impacts to electricity reliability, with a higher risk of occurrence than under Alternative 1 during low summer flow events. Average annual change from Alternative 1 air emissions: • Increase of 15.4 million lbs of CO_2 • Decrease of 3,501 lbs of methane • Decrease of 102 lbs of NOx Increase in average annual social cost of carbon equivalent on average from $340k and $1.8 million compared to Alternative 1.	Small to large, temporary adverse impacts could result from construction actions associated with early life stage and ESH habitat. Relative to Alternative 1, *coupled effects* (simultaneous reductions in thermal and hydropower generation) could occur during low summer flow months; power generation reductions could account for up to 4 percent of all power generation in the MISO and SPP RTOs, exacerbating adverse effects to NED, RED, and OSE impacts.

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Alternative 3	Average annual increase in NED value of $16,813 relative to Alternative 1; average annual increase in energy values of $363,000; average annual reduction in capacity values of $346,498 compared to Alternative 1. Negligible to small benefits to NED value from higher river flows from the elimination of the spring plenary pulse.	Negligible change from Alternative 1.	Negligible change in electricity supply and reliability from Alternative 1. Average annual change from Alternative 1 air emissions: • Decrease of 5.8 million lbs of CO_2 • Decrease of 117 lbs of methane • Increase of 415 lbs of NOx The average annual social cost of carbon equivalent would decrease from $131k to $694k compared to Alternative 1.	Negligible change in the effects of habitat construction compared to Alternative 1. There would negligible impacts from *coupled effects* associated with simultaneous reductions of hydropower and thermal power generation compared to Alternative 1.
Alternative 3: Gavins Point One-Time Spawning Cue Test	Negligible to small temporary adverse impacts to thermal power NED value and power generation.	Negligible change from Alternative 1.	Negligible change in electricity supply and reliability from Alternative 1.	Negligible change from Alternative 1.
Alternative 4	Average annual reduction in NED value of $3.1 million (-0.1%) relative to Alternative 1; average annual reduction in energy values of $2.2 million; average annual reduction in capacity values of $836,642 compared to Alternative 1. Small to large, temporary adverse impacts to power plants from reductions in river flows as reservoirs rebalance after a spring release.	Negligible change from Alternative 1.	Negligible change in electricity supply and reliability from Alternative 1. Average annual change from Alternative 1 air emissions: • Decrease of 113.8 million lbs of CO_2 • Decrease of 1,964 lbs of methane • Increase of 321 lbs of NOx The average annual social cost of carbon equivalent would decrease between $2.5 million and $13.5 million compared to Alternative 1.	Negligible change in the effects of habitat construction compared to Alternative 1. Relative to Alternative 1, *coupled effects* associated with simultaneous reductions in hydropower and thermal power generation could occur during fall months, accounting for up to 1.3 percent of MISO and SPP RTO generation. Replacement capacity within the RTOs should be available to offset this impact, with negligible additional impacts from coupled effects.

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Alternative 5	Average annual reduction in NED value of $1.0 million (0.03%) relative to Alternative 1; average annual reduction in energy values of $124,248; average annual reduction in capacity values of $824,656 compared to Alternative 1. Negligible to small adverse impacts to NED value and power generation from the fall release and subsequent lower river flows.	Negligible change from Alternative 1.	Negligible change in electricity supply and reliability from Alternative 1. Average annual change from Alternative 1 air emissions: • Decrease of 18.9 million lbs of CO_2 • Decrease of 340 lbs of methane • Increase of 358 lbs of NOx The average annual social cost of carbon equivalent would decrease between $423k and $2.2 million compared to Alternative 1.	Negligible change in the effects of habitat construction compared to Alternative 1. There would negligible impacts from *coupled effects* associated with simultaneous reductions in hydropower and thermal power generation compared to Alternative 1.
Alternative 6	Average annual reduction in NED value of $1.2 million (0.03%) relative to Alternative 1; reduction in average annual energy values of $603,137; average annual reduction in capacity values of $480,772 compared to Alternative 1. Small adverse impacts to NED value and power generation in most years from small reductions in river flows in the fall and winter following the spawning cue release.	Negligible change from Alternative 1.	Negligible change in electricity supply and reliability from Alternative 1. Average annual change from Alternative 1 air emissions: • Decrease of 33.9 million lbs of CO_2 • Decrease of 580 lbs of methane • Increase of 4,288 lbs of NOx The annual average social cost of carbon equivalent would decrease between $757k and $4.0 million compared to Alternative 1.	Negligible change in the effects of habitat construction compared to Alternative 1. There would negligible impacts from *coupled effects* associated with simultaneous reductions in hydropower and thermal power generation compared to Alternative 1.

3.17.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include pallid sturgeon propagation and augmentation, predator management, vegetative management, and human restrictions measures. These actions are not expected to have any impacts on thermal power intakes or power generation for power plants located along the Missouri River.

3.17.2.4 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 represents current System operations including a number of management actions associated with MRRP implementation. Management actions under Alternative 1 include construction of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring plenary pulse.

Mechanical Habitat Construction

The construction of habitat would be focused in the Garrison and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for early life stage habitat, and power plant intakes in these reaches could be impacted. Constructing early life stage habitat can accelerate bedload movement from degradation segments and accelerate deposition in aggregation segments of the river. This can result in increased maintenance issues to thermal power intakes in areas of aggradation (USACE 2011a). The extent of these impacts would be dependent on the location of the management action relative to thermal power intakes. The construction of habitat below Gavins Point Dam could affect 14 power plants in the lower river. However, most of the power plants are in urban areas where habitat would likely not be constructed. There are six power plants in the Garrison Dam to Lake Oahe reach that could be affected by the construction of ESH, although these power plants have been working with USACE to place acceptable buffers around their infrastructure.

Potential impacts of ESH on infrastructure such as thermal power intakes were evaluated in the *Final Programmatic Environmental Impact Statement for Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011a). Each habitat site would continue to be designed to avoid impacts to environmental, cultural, and socioeconomic resources. In addition, USACE has identified sensitive resource categories and subsequent restrictive or exclusionary zones associated with many of these resources. A more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases, which would further mitigate impacts associated with these actions on thermal power plants, if needed. With the site-specific planning and sensitive resource restrictions in place, the impacts of the habitat construction management actions on thermal power plant intakes would be negligible to small, temporary, and adverse.

National Economic Development

Management of the Missouri River system under Alternative 1 would result in annual average power generation of 98.4 million MWh, equivalent to $2.3 billion in energy values over the 37-year period of analysis. The NED analysis for Alternative 1 is summarized in Table 3-226. Most (71 percent) of this power generation would come from thermal power plants in the lower river and the remainder (29 percent) is associated with generation from power plants in the upper river. The spring plenary pulse under Alternative 1 would not contribute to these adverse effects.

Capacity values are defined as the amount of capacity that a power plant can reliably contribute to meeting peak demand season needs (USACE EM 1110-2-1701). The total value of dependable capacity in the summer under Alternative 1 would be $386.1 million in the upper river and $970.6 million in the lower river. Under Alternative 1, dependable capacity would be higher in the winter (11,894 MW) compared to the summer (10,152 MW) for all power plants. Average annual variable costs would be small under Alternative 1, averaging $308,760 annually over the period of analysis. When considering the entire POR between 1931 and 2012, power generation would vary, with a low of 93.8 million MWh in 1937 and a high of almost 100 million MWh in years with no adverse river conditions; the drought in the 1930s and early 1940s would result in reductions in power generation from river flows falling below shut down intake elevations.

Table 3-226. Summary of Thermal Power NED Value for Alternative 1, 1975–2012 (2018 Dollars)

NED Value	Upper River [a]	Lower River	All Locations
Average Annual Missouri River Power Generation (MWh)	28,225,382	70,162,262	98,387,644
Average Annual Energy Value	$656,024,824	$1,632,903,376	$2,288,928,200
Average Annual Dependable Capacity – Summer (MW)	2,889	7,262	10,152
Average Annual Dependable Capacity Value – Summer	$386,141,980	$970,625,337	$1,356,767,317
Average Annual Dependable Capacity – Winter (MW) [b]	2,970	8,924	11,894
Average Annual Dependable Capacity Value – Winter	$396,957,835	$1,192,648,235	$1,589,606,071
Average Annual Variable Costs [c]	−$308,760	NA	−$308,760
Average Annual NED Valued	$1,041,858,044	$2,603,528,713	$3,645,386,757

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Capacity values are estimated by multiplying the 15th percentile of the available seasonal capacity during the summer and winter peak demand seasons from 1975 to 2012 by the unit capacity value. Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $133,650/MW-year (Hydropower Analysis Center 2018).

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. Estimates of variable costs were provided by three power plants in the upper river; no variable cost data was provided by power plants in the lower river. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

d Thermal power NED value for Alternative 1 include summer capacity figures because the bulk of the capacity impact occurs during the summer months. Thermal power NED value equals the sum of energy values, capacity values in the summer, and variable costs.

Regional Economic Development

Under Alternative 1, as simulated between 1975 and 2012, there would be varying impacts to power generation, with some of the lower power generation years occurring in the late 1980s and mid-2000s, when drought conditions would affect river flows and temperatures. Drier conditions, higher ambient temperatures, and lower river flows can increase river water temperatures during peak demand summer seasons and decrease river flows below intake elevations, causing reductions in power generation. In the worst-case summer (as modeled in 1980), power generation from power plants along the Missouri River in the SPP RTO would be reduced by 1,684,712 MWh. This reduction in power generation represents a 22 percent decrease from the highest power generation summer (available generation with no adverse conditions) and accounts for 3.6 percent of SPP generation during the summer season (Table 3-227). Within the MISO RTO, power generation from all power plants during the worst-case summer season would be reduced by 2,590,991 MWh (as modeled in 2003), which is a reduction of 23 percent from the highest summer power generation (available generation with no adverse conditions) and accounts for 2.6 percent of MISO generation during the summer season. There would be only small changes in winter power generation under Alternative 1.

In some years during drought conditions, it is possible that seasonal reductions in power generation could occur during peak power demand periods putting additional upward pressure on wholesale electricity prices. In addition, these impacts could occur over multiple years during the POR, supporting the rationale for retail electricity providers to increase consumer electricity rates compared to current rates because of the higher prices to purchase the wholesale electricity. The reductions in power generation and increase in wholesale prices would be temporary, driven by drier and drought conditions and lower System storage; continued drought conditions could result in relatively higher wholesale prices, which could cause providers to increase consumer electricity rates in the long-term. The exact impact on electricity prices (wholesale prices) and consumer electricity rates are uncertain. If retail electricity rates increase in the long-term, there may be indirect impacts to household and business spending with higher rates as there would be less disposable income to spend on other goods and services in the community or region, causing indirect but adverse effects to local and regional economies. Impacts on wholesale power prices, electricity rates, and regional economic conditions are likely to be temporary, negligible to small, and adverse, depending on hydrology and precipitation; the spring plenary pulse and habitat construction would not result in noticeable impacts to RED effects.

Table 3-227. Impacts to Power Generation by RTO and Season under Alternative 1 (1975-2012)

Season	SPP	MISO
Lowest Power Generation Season (MWH)		
Winter	6,419,124 (2004)	10,667,282 (1994)
Summer	5,879,876 (1980)	8,689,583 (2003)
Highest Power Generation Season (MWH)		
Winter	6,603,508 (1979)	10,709,591 (1975)
Summer	7,564,048 (1992)	11,280,574 (1992)
Change and Percent Change in Power Generation from Highest Generation Season (MWH and %)		
Winter	184,384 (2.8%)	42,308 (0.4%)
Summer	1,684,172 (22.3%)	2,590,991 (23.0%)
Impacted Power Generation as a Percent of the RTO’s Generation		
Winter	0.5%	0.0%
Summer	3.6%	2.6%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Other Social Effects

Changes in power generation would occur under Alternative 1 associated with changes in river conditions. Both coal-fired and nuclear power plants on the Missouri River would be affected under Alternative 1, which could have implications for air emissions and air quality. In general, the coal-fired power plants emit more per unit carbon dioxide and nitrous oxide emissions than the average replacement power sources from the market. Plant-specific methane emission sources have both higher and lower emissions depending on the power plant when compared with the average replacement power sources from the market. Under Alternative 1, the Missouri River power plants would generate 167 billion pounds of carbon dioxide, 14.7 million pounds of methane, and 2.8 million pounds of nitrous oxide on average annually over the period of analysis (1975–2012, excluding 2011). The average annual social cost of the carbon equivalent under Alternative 1 is estimated to be between $3.6 billion in 2018 and $10.6 billion in 2050.

Under Alternative 1, during drought and relatively drier conditions, power generation would be lower as river water temperatures are relatively higher and water surface elevations fall below intake elevations. During drought conditions, it is probable that replacement capacity is available in the market, with minimal impacts to power supply and electricity reliability (SPP pers. comm. 2018). Under extreme drought conditions with other contributing factors, if multiple plants in one location (i.e., Kansas City or Omaha) are affected, it is possible that there could be temporary and local power outages, although the spring plenary pulse and habitat construction would not contribute to these impacts.

Reduced power supply and electricity reliability can impact the health and safety of community residents who depend on this power supply to heat and cool the places where they live and work. Under this alternative there are likely to be no impacts to power supply, with negligible impacts to community residents, including children and the elderly, who are the most susceptible to high heat conditions. Low flow and drought conditions may also result in safety concerns at power plants when water availability is limited, such as impacts to water supply for fire protection; management actions under Alternative 1 would not affect these conditions.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Seasonal power generation under Alternative 1 from both hydropower and thermal power plants along the Missouri River generally accounts for between 12 and 15 percent of seasonal power generation in the MISO and SPP RTOs across the period of analysis (1975–2012, excluding 2011). During drought conditions, power generation under Alternative 1 would be a relatively lower percentage, especially in the summer season, from lower power generation from both hydropower and thermal power plants. During drought conditions, power generation from Missouri River power plants accounts for 11.7 percent of the RTO generation (summer of 1980), a drop of 3.2 percent from a high of 14.9 percent (summer of 1975). In 1975, power generation from hydropower as modeled is estimated to be 3.2 million MWh and thermal power would be 18.7 million MWh, and in 1980, power generation from hydropower and thermal power plants would reduce to 2.2 million MWh and 14.9 million MWh, respectively.

The simultaneous reductions in power generation from both hydropower and thermal power plants during drought and relatively drier conditions would put further upward pressure on wholesale electricity prices. However, replacement power would be available from alternate sources (pers. comm. SPP 2018) and additional impacts from coupled effects to electricity rates and electricity reliability would be negligible to small. The management actions under Alternative 1 of the spring plenary pulse and habitat development would not have a noticeable contribution to these coupled effects.

Conclusion

The average annual thermal power NED value under Alternative 1 is estimated to be $3.6 billion, with average annual power generation estimated to be 98.4 million MWh over the 37-year period of analysis. Alternative 1 would result in average annual energy value of $2.3 billion. The annual value of dependable capacity is estimated to range from $1.4 billion (summer) to $1.6 billion (winter). Continued management of the System under Alternative 1 would provide large energy and capacity benefits; adverse impacts to energy and capacity values and variable costs would occur during relatively drier and drought conditions. The management actions under Alternative 1, including the spring pulse and habitat development would not noticeably contribute to these adverse effects. The simultaneous reductions in power generation from both hydropower and thermal power plants during drought and relatively drier conditions would occur although the management actions under Alternative 1 of the spring plenary pulse and habitat development would not have a noticeable contribution to these coupled effects.

During drought conditions, there could be relatively higher wholesale electricity prices with the potential to impact to retail electricity rates and regional economic conditions. It is likely that replacement capacity would be available in the market during drought and relatively drier conditions, with minimal impacts to power supply and electricity reliability under Alternative 1 (SPP pers. comm. 2018). Under Alternative 1, there would be continued adverse impacts to air quality associated with the Missouri River power plants. The spring plenary pulse and habitat construction would not result in a noticeable contribution to these effects.

The construction of ESH and early life history habitat in the Garrison reach and the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants. In addition, most of the power plants in the lower river are in urban areas where habitat would likely not be constructed.

Alternative 1 provides the baseline conditions against which Alternatives 2–6 are compared. Alternative 1 is not anticipated to have significant impacts on thermal power because the habitat development would result in negligible to small temporary adverse impacts and the spring plenary pulse would not have noticeable impacts on power generation.

3.17.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 includes a spring pallid sturgeon flow release and low summer flows, as well as considerably more early life stage habitat and ESH construction than would occur under Alternative 1.

Mechanical Habitat Construction

A targeted 10,758 additional acres of early life stage habitat would be constructed for the pallid sturgeon between Ponca, Nebraska, and the mouth of the river near St. Louis; an average of 1,331 acres per year of ESH would be constructed in years when construction occurs in the Garrison Dam to Lake Oahe river reach; Fort Randall Dam to Lewis and Clark Lake river reach; Gavins Point Dam to Ponca, Nebraska river reach; and Lewis and Clark Lake. The mechanical construction of significantly more early life stage and ESH habitat could have the potential to lead to more issues associated with sediment erosion and deposition affecting thermal power intakes than under Alternative 1. However, similar to Alternative 1, sensitive resource restrictions and buffers would minimize and attempt to avoid adverse impacts to power plants. USACE would work closely with nearby facility-owners to minimize impacts, and site-specific NEPA analyses would be conducted prior to constructing the habitat. Because considerably more sediment would be moved under Alternative 2, the potential for adverse effects associated with silt and sediment obstructing intakes and the need to dredge around intakes would be higher under this alternative. Timing restrictions to clean and maintain intakes (March 1 to June 30) due to current protections for the pallid sturgeon could cause further adverse effects to power plants and possibly power generation if intake issues persist without the ability to dredge or take other actions to mitigate the sediment and silt during this period. Therefore, direct impacts of the habitat construction on thermal power plant intakes could range from small to large, temporary, and adverse compared to Alternative 1, depending on the proximity of the habitat sites to thermal power plants, the ability of buffers around the plants to reduce sediment and silting in of intakes, and timing restrictions on dredging and intake maintenance.

National Economic Development

Alternative 2 would result in $3.6 billion in average annual thermal power NED value, a decrease of $60.0 million (1.6 percent) compared to Alternative 1 (summarized in Table 3-228). Table 3-228 summarizes the NED analysis for Alternative 2 for the period from 1975 to 2012. Average annual reduction in energy value is estimated to be $6.6 million over the 37-year period of analysis when compared to Alternative 1, a decrease of 0.3 percent. Most of this adverse impact (85 percent) would occur at power plants in the lower river. The simulated years with low summer flows would cause the largest adverse impacts to energy value compared to Alternative 1, with a worst-case reduction of $138.5 million (6.2 percent) compared to Alternative 1 occurring in 1988. Modeled river water temperatures during the low summer flow events and during the peak summer demand period would range from 1°F to 3°F higher than under Alternative 1. In addition, slightly higher river water temperatures would adversely impact energy value during non-low summer flow years compared to Alternative 1. The higher amount of early life stage habitat under Alternative 2 relative to Alternative 1 would slightly increase river water temperatures in the peak summer demand season as more surface area and associated shallow water would increase river water temperatures relative to Alternative 1 under similar flow conditions.

On average, energy value under Alternative 2 would decrease in the Garrison reach relative to Alternative 1 by $1.0 million or 0.2 percent. Alternative 2 would result in an average annual increase in variable costs compared to Alternative 1 of $226,000 in the upper river.

Lost capacity occurs if power generation would be impacted during peak demand periods in the summer and winter compared to Alternative 1. Dependable capacity for power plants in the lower river would decrease by an estimated 396 MWh relative to Alternative 1, representing approximately 2.4 percent of nameplate capacity for all power plants in the lower river. Average annual capacity replacement costs (reduction in capacity value), relative to Alternative 1, are estimated to be $52.9 million over the 37-year period of analysis for power plants in the lower river. There would be negligible impacts to replacement capacity costs to power plants in the Garrison reach as the value of impacts would be orders of magnitude lower than in the lower river and negligible relative to the overall value of the power plants under study in the Garrison reach. However, impacts to capacity value, especially as estimated for this alternative, could be underestimated, as decommissioning costs are not included in these capacity replacement estimates.[15]

The reductions in power generation in the lower river would typically occur during peak summer demand periods when multiple plants with simultaneous reductions in power generation would be affected; these conditions could have impacts to energy prices (wholesale power prices) as well as costs to replace lost capacity, possibly resulting in more adverse impacts than reported here. Alternative 2 would result in small to large adverse impacts to thermal power NED value, with large impacts occurring to most of the power plants in the lower river during the low

[15] Additional details on dismantling and decommissioning power plants are available in the “Thermal Power Environmental Consequences Analysis Technical Report.”

summer flow events affecting both energy and capacity impacts.[16] The NED analysis for Alternative 2 is summarized in Table 3-228.

Table 3-228. Summary of Thermal Power NED Value for Alternative 2, 1975–2012 (2018 Dollars)

NED Value	Upper River[a]	Lower River	All Locations
Average Annual Missouri River Power Generation (MWh)	28,184,800	69,951,218	98,136,018
Change in Average Annual Generation from Alternative 1 (MWh)	−40,582	−211,044	−251,626
Average Annual Energy Value	$655,003,759	$1,627,349,240	$2,282,241,157
Change in Average Annual Energy Value from Alternative 1	−$1,021,065	−$5,554,136	−$6,687,044
Percent Change in Average Energy Value from Alternative 1	−0.2%	−0.3%	−0.3%
Average Annual Dependable Capacity – Summer (MW)	2,888	6,866	9,754
Average Annual Dependable Capacity Value – Summer	$385,979,045	$917,707,322	$1,303,686,367
Average Annual Dependable Capacity – Winter (MW)[b]	2,970	8,926	11,896
Average Annual Dependable Capacity Value – Winter	$396,957,835	$1,192,969,705	$1,589,927,540
Max Change in Average Annual Capacity Value from Alternative 1	−$162,936	−$52,918,015	−$53,080,950
Average Annual Variable Costs [c]	−$535,100	NA	−$535,100
Change in Average Annual Variable Costs from Alternative 1	−$226,341	NA	−$226,341
Average Annual NED Value [d]	$1,040,447,704	$2,545,056,562	$3,585,392,423
Change in Average Annual NED Value from Alternative 1	−$1,410,341	−$58,472,151	−$59,994,334
Percent Change in Average Annual NED Value	−0.1%	−2.2%	−1.6%

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Capacity values are estimated by multiplying the 15th percentile of the available seasonal capacity during the summer and winter peak seasons from 1975 to 2012 by the unit capacity value. Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $133,650 /MW-year (Hydropower Analysis Center 2018).

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. Estimates of variable costs were provided by three power plants in the upper river; no data was provided by power plants in the lower river on variable costs. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

d NED value for Alternative 1 include summer capacity figures because the majority of the capacity impact occurs during the summer months. For Alternatives 2–6, either the winter or summer dependable capacity by power plant is used to calculate the maximum change in capacity value compared to Alternative 1. Therefore, the average annual NED value is estimated by aggregating the action alternative energy values, variable costs, and max change in capacity value, along with Alternative 1 summer capacity value.

[16] Refer to the "Thermal Power Environmental Consequences Analysis Technical Report" for additional details on the number of power plants impacted by river temperatures and low river stage conditions.

Additional NED results of flow actions are summarized in Table 3-229 for the POR between 1931 and 2012 (excluding 2011). These results show the difference in annual thermal power NED value during years when there would be a release action or a low summer flow. Results from the simulations show that the largest adverse effects occur when a full spawning cue release and low summer flows would occur resulting in reductions in thermal power generation (Table 3-229).

Overall changes in NED value for thermal power are primarily driven by impacts to thermal power plants in the lower river during the summer. Low summer flow events, as simulated under Alternative 2 in 1988, 1989, 2002, and 2003, would result in adverse impacts to thermal power NED value, with a worst-case change in thermal power NED value of $200 million in 1988 relative to Alternative 1. The low summer flow events as simulated in 1988 would result in adverse impacts to power generation and energy values in the Garrison reach as releases out of Garrison Dam would be between 8,000 and 10,000 cfs under Alternative 2 in July and August compared to between 17,000 and 22,000 cfs under Alternative 1. All power plants in the Garrison reach would be affected as river stages would fall below shut down intake elevations.

Partial release years in the Garrison reach would have both adverse and beneficial impacts to thermal power NED value compared to Alternative 1.

Table 3-229. Impacts from Flow Releases under Alternative 2 Compared to Alternative 1, 1931–2012 (2018 Dollars)

Release	NED Value Change	Lower River [a]	Upper River[a]	Total
Full Flow Release + Low Summer Flow [b]	Lowest NED Value Change	−$124,557,152	−$75,791,976	−$200,349,129
	Highest NED Value Change	−$47,233,484	−$162,936	−$47,396,420
Partial Flow Release [c]	Lowest NED Value Change	−$56,917,832	−$298,581	−$57,216,412
	Highest NED Value Change	−$50,730,726	$29,899,852	−$20,830,874
Year after a Full Release (Includes Low Summer Flows)	Lowest NED Value Change	−$82,853,584	−$1,718,382	−$84,571,966
	Highest NED Value Change	−$51,335,112	−$162,936	−$51,498,047
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	−$124,557,152	−$75,791,976	−$200,349,129
	Highest NED Value Change	−$47,233,484	$29,899,852	−$17,333,632

Note: Impacts include changes in energy values, capacity values, and variable costs. Higher values represent higher NED value changes (beneficial impacts); negative values indicate reductions in the NED value or increased costs relative to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Flow action and low summer flow was fully implemented in 3 years over the POR. Note that the low summer flow events are implemented in the year after a full spawning cue release. Data represents the lowest and highest dollar impacts in the years the action was implemented.

c Flow action was partially implemented in 31 years of the POR; partial implementation years are defined as years when a partial cue in March and/or May would occur OR years when a full cue in March or May would occur. Data represents the lowest and highest dollar impacts in the years the action was partially implemented.

Regional Economic Development

Alternative 2 would result in the largest reductions in power generation compared to Alternative 1, relative to the other action alternatives. This would be driven by changes in power generation from power plants in the lower river affected by low summer flow events. Adverse effects from the low summer flow also affected upper river power plants in the simulated year of 1988. The adverse impacts to power generation would occur during a drought year when System storage and water levels are already relatively low. In the worst-case year, as simulated in 1988, power generation for power plants in the SPP RTO would be reduced relative to Alternative 1 during the summer by 1.5 million MWh, representing a change of 3.2 percent of total generation in SPP during this summer period. Within the MISO RTO, the largest decrease in power generation during the summer months compared to Alternative 1 is estimated to be 3.7 million MWh, which represents 3.7 percent of total generation of the MISO RTO. Table 3-230 presents largest seasonal reduction in power generation relative to Alternative 1 as a percent of total generation for each RTO for the peak electricity demand summer and winter seasons for the period between 1975 and 2012.

Further analysis of the impacts to power generation during low summer flow events in 1988, 1989, 2002, and 2003 indicates that high river water temperatures tend to affect multiple plants simultaneously in the lower river in one or two periods within the summer season. During these low summer flow events, it is probable that there is capacity elsewhere on the grid to replace lost thermal power plant capacity (SPP, pers. comm. 2018). In extreme conditions (with potentially other factors or circumstances), it is possible that local power providers would need to shed load to reduce power demand during these conditions, which could result in localized issues maintaining voltage pressure and power outages (SPP, pers. comm. 2018).

Table 3-230. Largest Season Reduction in Power Generation from Alternative 1 under Alternative 2, 1975–2012

Season	SPP	MISO
Largest Reduction in Power Generation Relative to Alternative 1 (MWH)		
Winter	−3,787 (2005)	−1,839 (1988)
Summer	−1,465,488 (1988)	−3,705,979 (1988)
Percent of Power Generation Reduction as a Percent of the RTO’s Generation		
Winter	0.0%	0.0%
Summer	−3.2%	−3.7%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

When baseload plants, such as those along the Missouri River, must reduce electricity, they are replaced with relatively higher cost power sources, increasing wholesale electricity prices. Low summer flows would affect multiple power plants in the lower river and possibly power plants in the upper river as well. As a result, replacement energy prices would be higher than under Alternative 1 and with re-occurring low summer flow events under Alternative 2, there would be the potential for higher retail electricity prices in the long-term compared to Alternative 1 (SPP pers. comm. 2016). Re-occurring higher wholesale electricity prices would provide the rationale for state regulating agencies to increase consumer electricity rates to levels higher than under Alternative 1. Indirect impacts to retail electricity rates under Alternative 2 could be long-term, negligible to small and adverse due to many other factors affecting electricity rates, including trends and business cycles affecting electricity demand and fuel costs. While the impacts would be more adverse under Alternative 2 compared to Alternative 1, the exact impact on energy prices (wholesale prices) and consumer electricity rates is uncertain. Higher electricity rates under Alternative 2 would result in adverse impacts to household and business spending because with higher electricity rates, households and business would have less money to spend on personal or business expenses, with resulting impacts to regional economic conditions.

Other Social Effects

Under Alternative 2, there would be an increase in average annual carbon dioxide emissions (15.4 million lbs or 0.009 percent) relative to Alternative 1 because reductions in power generation primarily from the Missouri River nuclear plants would be replaced by the regional power mix with thermal power sources that produce more air emissions than those that are being replaced. However, there would be small average annual reductions in methane (-3,501 lbs or -0.024 percent) and nitrous oxide (-102 lbs or -0.004 percent) emissions compared to Alternative 1 from reductions in power generation from Missouri River coal-fired power plants with relatively higher methane and nitrous oxide emissions being replaced with lower per unit air emission sources from the market. The average annual social cost of carbon equivalent under Alternative 2 would increase by 0.01 percent, or between $340,000 in 2018 and $1.8 million in 2050, relative to Alternative 1 due to the relatively larger increase in carbon dioxide emissions compared to the small decrease in emissions of methane and nitrous oxides. The adverse impacts from increased air emissions and social cost of carbon equivalent would be negligible to small due to a small percentage change in emissions and some small reductions in methane and nitrous oxides partially offsetting the increases in carbon dioxide emissions.

The OSE impacts to power availability and electricity reliability as described under Alternative 1 would also occur under Alternative 2, but would be more adverse under Alternative 2 compared to Alternative 1 from low summer flows increasing river water temperatures and reducing power generation. However, even in the peak summer demand season with the largest reduction in power generation compared to Alternative 1, it is probable that replacement capacity is available in the market, with minimal impacts to power supply and electricity reliability on average annually (SPP pers. comm. 2018). Under extreme conditions and other contributing factors, if multiple plants in one location (i.e., Kansas City or Omaha) are affected, it is possible that there could be temporary local power outages; the risks are higher under Alternative 2 when compared to Alternative 1. Any power outages could have health and safety impacts from lost cooling abilities, which could result in adverse impacts to children and the elderly. In addition, relatively lower river flows following the spawning cue release could result in safety concerns at power plants, such as availability of water supply for fire protection.

Alternative 2 would likely result in negligible adverse effects to power availability, reliability, and health and safety impacts because replacement power and capacity would be available under most circumstances and USACE would work to minimize severe impacts to power availability and health and safety. However, in some years the low summer flows under Alternative 2 could result in an extreme situation when power outages and localized issues with maintaining voltage pressure could occur (SPP, pers. comm. 2018), with relatively large but temporary OSE impacts relative to Alternative 1.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Under Alternative 2, simultaneous reductions in hydropower and thermal power could potentially occur during peak summer demand months when low summer flow events would be implemented. During the low summer flow events, as simulated over the period of analysis (1975–2012, excluding 2011) in 1988, 1989, 2002, and 2003, both hydropower and thermal power generation would be reduced during a season when demand for electricity is also typically high. These reductions in power generation in the summer would come during relatively drier conditions when power generation is already being affected, especially as simulated in 1988, 2002, and 2003. Reductions in power generation compared to Alternative 1, as simulated, would be greatest in a modeled year like 1988 with a reduction of 5.9 million MWH, the bulk of which (88 percent) would be from reductions in thermal power generation. In the summer of 1988, the change in power generation from both hydropower and thermal power plants accounts for 4.0 percent of SPP and MISO power generation. Table 3-231 summarizes these changes in power generation for the period from 1975 to 2012 when the largest impacts to power generation would occur.

These coupled effects in the summer season during the low summer flow events would exacerbate impacts to wholesale power prices. Although replacement capacity within the markets is likely to be available during these conditions, it is possible that simultaneous reductions in power generation especially during a condensed period of time could adversely impact voltage pressure, power availability, and local grid stability (SPP pers. comm. 2018).

Table 3-231. Seasonal Changes in Power Generation under Alternative 2 Compared to Alternative 1, 1975–2012

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	−30,522	130,015	−93,426	−2,690
	Thermal Power (MWh)	689	11,874	−284,880	27,313
MISO and SPP	Worst Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	−403,744	−300,495	−5,907,389	−573,247
	Worst Case Change from Alternative 1 (% of RTO generation)	−0.3%	−0.1%	−4.0%	−0.2%
	Worst Case Change from Alternative 1 – Year	1987	2000	1988	1983
	Average Annual Change from Alternative 1 (% of RTO generation)	−0.0%	0.1%	−0.3%	0.0%
MISO	Worst Case Change from Alternative 1 (% of RTO generation)	0.0%	−0.0%	−3.7%	−0.2%
	Worst Case Change from Alternative 1 – Year	1988	1988	1988	2007
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	−0.2%	0.0%
SPP	Worst Case Change from Alternative 1 (% of RTO generation)	−1.0%	−0.4%	−4.7%	−0.8%
	Worst Case Change from Alternative 1 – Year	1987	2000	1988	1983
	Average Annual Change from Alternative 1 (% of RTO generation)	−0.1%	0.2%	−0.5%	0.0%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Conclusion

Alternative 2 would result in a decrease of $60 million (1.6 percent) in average annual thermal power NED value, primarily from reductions in power generation affecting dependable capacity in the lower river. Reductions in capacity in the lower river would decrease average annual capacity value by $58.5 million compared to Alternative 1, a 5.4 percent change from average annual summer capacity value. On average, reductions in energy value would be $6.7 million, a change of 0.3 percent compared to Alternative 1. However, in years when low summer flow events are simulated to occur, higher river water temperatures impact power plant operating efficiencies and increase above regulatory thresholds, with a worst case decrease of 5.2 million MWh compared to Alternative 1 as simulated in 1988. Alternative 2 would result in small to large adverse impacts to thermal power NED value, with large impacts occurring, especially to power plants in the lower river, during the low summer flow events affecting both energy and capacity values.

The low summer flows and lower river stages in the years following the spawning cue release would increase replacement energy prices higher than under Alternative 1 and with re-occurring low summer flow events under Alternative 2, there would be the potential for higher retail electricity prices in the long-term (SPP pers. comm. 2016) and adverse impacts to household and business spending and regional economic conditions. Alternative 2 would likely result in negligible adverse OSE effects to power availability, reliability, and health and safety because replacement power and capacity would usually be available and USACE would work to minimize severe impacts to power availability and health and safety. However, the low summer flows under Alternative 2 could result in a situation when power outages and localized issues with maintaining voltage pressure could occur (SPP pers. comm. 2018), with relatively larger OSE impacts.

Under Alternative 2, average annual carbon dioxide emissions relative to Alternative 1 would increase, while there would be small average annual reductions in methane and nitrous oxide emissions compared to Alternative 1. The changes in air emissions and social cost of carbon equivalent would be negligible to small, and adverse due to the small percentage change in emissions and some small reductions in methane and nitrous oxides emissions partially offsetting the increases in carbon dioxide emissions.

Under Alternative 2, reductions in power generation from both hydropower and thermal power plants would occur during summer months when low summer flow events occur. Although replacement capacity within the markets is likely to be available during these conditions, it is possible that simultaneous reductions in power generation especially during a condensed period of time could contribute to additional adverse impacts to voltage pressure, power availability, and local grid stability during extreme situations (SPP pers. comm. 2018).

The considerable amount of ESH construction in the upper river reaches and early life stage habitat in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. Although buffers around sensitive infrastructure and site-specific planning would reduce these impacts, construction activities could cause large temporary impacts to intakes located nearby where these actions are occurring because of the considerable amount of sediment being moved under Alternative 2.

Alternative 2 has the potential to have significant impacts to capacity values and energy values associated with power generation reductions during low summer flow events; Alternative 2 would increase the risk of an extreme event affecting power availability and electricity reliability.

3.17.2.6 Alternative 3 – Mechanical Construction Only

Alternative 3 includes mechanical construction of ESH and IRC habitat. Alternative 3 includes fewer acres of IRC habitat compared to the acres of early life stage habitat constructed under Alternative 1.

Mechanical Habitat Construction

ESH construction would include an average of 332 aces per year in years when construction occurs. Alternative 3 would result in fewer acres of IRC habitat compared to the acres of early life stage habitat under Alternative 1 (3,380 acres under Alternative 3 and 3,999 acres under Alternative 1). Construction of IRC habitat and ESH could have some adverse impacts to thermal power plants in the Garrison reach and lower river, but similar to Alternative 1, impacts would be negligible to small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

National Economic Development

Alternative 3 would result in small benefits compared to Alternative 1, with an average annual increase in thermal power NED value of $16,800 compared to Alternative 1 over the 37-year period of analysis. Table 3-232 summarizes the NED analysis for Alternative 3. The lower river would experience small increases in power generation and energy value, on average, while the upper river would experience small reductions in power generation and energy value. There would be increases to power generation compared to Alternative 1 in the lower river due to slightly higher river flows from the lack of a spring pulse under Alternative 3 compared to Alternative 1, with an increase in average annual energy value of $545,000. In addition, the power plants in the lower river would experience slightly lower river water temperatures under Alternative 3 compared to Alternative 1 in the summer months because of fewer acres of early life history habitat for the pallid sturgeon would be constructed under Alternative 3 compared to Alternative 1.

While energy values would increase with increases in power generation compared to Alternative 1 in the lower river, there would be small decreases in capacity value. The maximum decrease in capacity value reflects the worst-case change in dependable capacity for either winter or summer season for each power plant, and therefore, small decreases in capacity value can occur when there are average annual energy value increases. Overall, there would be negligible changes in energy value, variable costs and capacity value compared to Alternative 1.

Table 3-232. Summary of National Economic Development Analysis for Alternative 3, 1975–2012 (2018 Dollars)

NED Value	Upper River [a]	Lower River	All Locations
Average Annual Missouri River Power Generation (MWh)	28,217,480	70,183,229	98,400,709
Change in Average Annual Generation from Alternative 1 (MWh)	−7,902	20,967	13,065
Average Annual Energy Value	$655,842,581	$1,633,448,405	$2,289,290,985
Difference in Average Annual Energy Value	−$182,243	$545,028	$362,785
Percent Change in Average Energy Value from Alternative 1	0.0%	0.0%	0.0%

NED Value	Upper River [a]	Lower River	All Locations
Average Annual Dependable Capacity – Summer (MW)	2,889	7,317	10,206
Average Annual Dependable Capacity Value – Summer	$386,092,400	$977,970,563	$1,364,062,963
Average Annual Dependable Capacity – Winter (MW) [b]	2,970	8,924	11,894
Average Annual Dependable Capacity Value – Winter	$396,957,835	$1,192,648,235	$1,589,606,071
Max Change in Average Annual Capacity Value from Alternative 1	−$49,580	−$296,918	−$346,498
Average Annual Variable Costs [c]	−$308,235	NA	−$308,235
Change in Average Annual Variable Costs	$525	NA	$525
Average Annual NED Value[d]	$1,041,626,746	$2,603,776,824	$3,645,403,570
Change in Average Annual NED Value	−$231,298	$248,111	$16,813
Percent Change in Average Annual NED Value	0.0%	0.0%	0.0%

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Capacity values are estimated by multiplying the 15th percentile of the available seasonal capacity during the summer and winter peak seasons from 1975 to 2012 for each power plant by the unit capacity value. Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $133,650 /MW-year (Hydropower Analysis Center 2018).

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. Estimates of variable costs were provided by three power plants in the upper river; no data was provided by power plants in the lower river on variable costs. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

d NED value for Alternative 1 include summer capacity figures because the majority of the capacity impact occurs during the summer months. For Alternatives 2–6, either the winter or summer dependable capacity by power plant is used to calculate the maximum change in capacity value compared to Alternative 1. Therefore, the average annual NED value is estimated by aggregating the action alternative energy values, variable costs, and max change in capacity value, along with Alternative 1 summer capacity value.

Table 3-233 summarizes the largest annual change in NED value for the POR. On average across all locations, there would be a very small increase in power generation and thermal power NED value under Alternative 3 compared to Alternative 1. Power plants in the lower river would experience small increases in thermal power NED value from small increases in power generation due to slight reductions in river water temperatures that are likely attributable to the reduced early life stage habitat that would be created under Alternative 3 relative to Alternative 1. For example, river flows in the modeled years 1980, 1987, 1988, 1990, and 1991 would be relatively similar under both Alternatives 1 and 3; however, Alternative 3 shows that fewer plants would be impacted by temperature than under Alternative 1 in these years.

As simulated in 2005 in the upper river, there would be a decrease in thermal power NED value of about $6.0 million compared to Alternative 1, most of which would occur in the fall when the releases out of Garrison Dam would be less than those simulated under Alternative 1.

Table 3-233. Impacts from Flow Releases under Alternative 3 Compared to Alternative 1, 1930 to 2012 (2018 Dollars)

River Reach [a]	Years with Greatest Range in Impacts Regardless of Flow Actions	
	Lowest NED Value Change	Highest NED Value Change
Lower River	−$1,502,382	$3,178,571
Upper River	−$6,004,782	$2,625,024
Total	−$7,507,165	$5,803,595

Note: Impacts include changes in energy values, capacity values, and variable costs. Higher values represent higher NED value changes (beneficial impacts); negative values indicate reductions in the NED value or increased costs relative to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

Regional Economic Development

Under Alternative 3, power generation would be very similar to Alternative 1. Even under the worst-case summer scenario, there would be a negligible change from Alternative 1 (Table 3-234), resulting in no change to wholesale electricity rates, consumer electricity rates, and household and business spending and associated regional economic conditions compared to Alternative 1.

Table 3-234. Largest Season Reduction in Power Generation from Alternative 1 under Alternative 3, 1975–2012

Season	SPP	MISO
Largest Reduction in Power Generation Relative to Alternative 1 (MWH)		
Winter	0 (1975)	0 (1975)
Summer	−7,491 (2010)	−39,343 (2010)
Percent of Power Generation Reduction as a Percent of the RTO's Generation		
Winter	0.0%	0.0%
Summer	0.0%	0.0%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Other Social Effects

Higher power generation by nuclear plants along the Missouri River under this alternative would reduce carbon dioxide (-5.8 million lbs or -0.003 percent) and nitrous oxide (-117 lbs or -0.004 percent) emissions relative to Alternative 1. Methane emissions would increase only slightly (415 lbs or 0.003 percent) under this alternative. There would be an average annual decrease in the social cost of carbon equivalent emissions under Alternative 3 (benefits), ranging from $131,000 to $694,000, or 0.003 percent relative to Alternative 1. The changes in air emissions and social cost of carbon equivalent would be negligible due to the very small percentage change in emissions.

Impacts to electricity reliability would be negligible relative to Alternative 1 as power generation under this alternative would be very similar to Alternative 1. There are no anticipated impacts to health and safety under Alternative 3. Low flow and drought conditions may also result in safety concerns at power plants, such as availability of water supply for fire protection; there would be negligible changes from Alternative 1.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Under Alternative 3, there would be negligible impacts from simultaneous reductions in hydropower and thermal power generation during the 37-year period of analysis, when the largest change in power generation would occur. The fall of the modeled year 2005 shows the greatest impact, with a reduction of 259,022 MWh, which accounts for 0.10 percent of both MISO and SPP generation (Table 3-235).

Table 3-235. Seasonal Changes in Power Generation under Alternative 3 Compared to Alternative 1, 1975–2012

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	2,963	−9,464	3,322	8,936
	Thermal Power (MWh)	NA	−736	17,860	−4,404
MISO and SPP	Worst Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	−7,341	−63,206	−37,566	−264,886
	Worst Case Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.1%
	Worst Case Change from Alternative 1 – Year	1996	1977	1998	2005
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
MISO	Worst Case Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	−0.1%
	Worst Case Change from Alternative 1 – Year	1975	2005	2010	2005
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
SPP	Worst Case Change from Alternative 1 (% of RTO generation)	0.0%	−0.1%	0.0%	0.0%
	Worst Case Change from Alternative 1 – Year	1996	1977	1998	1997
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release that might be implemented under Alternative 3 was not included in the hydrologic modeling for this alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

The one-time implementation of the spawning cue release would cause temporary, small, adverse impacts to power plants in the year the pulse is implemented. In addition, impacts may occur 1 to 2 years following the pulse when releases from Garrison and Gavins Point Dams are lower than under Alternative 1 causing relatively lower river flows impacting access for water and increasing river water temperatures. In some years and conditions, there is the potential for large adverse impacts to power generation and energy value for power plants in the Garrison reach in the years following the spawning cue test from relatively low river flows impacting access to cooling water, although USACE would attempt to work with utilities and plant representatives to provide sufficient water supplies for cooling water access. Modeling results show that 6 of the 21 thermal power plants would experience a small increase in the average number of days when water surface elevations would fall below the shutdown intake elevations. Impacts to RED (wholesale power prices, electricity rates, and regional economic conditions) and OSE (air quality, power supply and reliability) would be negligible because the pulse would only be implemented once under Alternative 3.

Conclusion

Under Alternative 3, the change in thermal power NED value would be negligible compared to Alternative 1. Energy value would be lower in the upper river and higher in the lower river relative to Alternative 1, with overall negligible to small long-term benefits to thermal power NED value. The benefits to power generation to power plants in the lower river would occur from slightly higher river flows from the lack of the spring pulse under Alternative 3 and from slightly lower summer river water temperatures from the construction of fewer acres of early life stage habitat for the pallid sturgeon compared to Alternative 1. Alternative 3 would result in an average annual increase in energy values of $363,000 and an average annual decrease in capacity values of $346,000 compared to Alternative 1, with negligible changes in thermal power NED value. There would be negligible changes to variable costs and capacity value compared to Alternative 1.

There would be negligible changes in wholesale electricity prices, electricity rates, electricity reliability, and regional household and business spending and associated regional economic conditions compared to Alternative 1 because replacement energy is likely to be available from the market when needed (SPP pers. comm. 2018). Under Alternative 3, there would be negligible impacts to air quality associated with the Missouri River power plants, with a decrease in average annual social cost of carbon equivalent ranging between $131,000 in 2018 and $694,000 in 2050 compared to Alternative 1.

The coupled effects from reductions in power generation from both hydropower and thermal power plants during drought and relatively drier conditions would put further upward pressure on wholesale electricity prices, similar to the impacts under Alternative 1. However, additional impacts from coupled effects to electricity rates, household and business spending, power availability, and electricity reliability would be negligible to small and beneficial compared to Alternative 1 from slightly greater power generation under Alternative 3.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 3 would not have significant impacts on thermal power because NED, RED, and OSE impacts across all locations would be negligible to small compared to Alternative 1 and adverse impacts from habitat construction would be temporary and localized.

3.17.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 includes a spring release in April and part of May to create ESH. In addition, mechanical ESH and early life stage habitat would also be constructed. Compared to Alternative 1, Alternative 4 includes fewer acres of early life stage habitat for pallid sturgeon in the river below Ponca, Nebraska.

Mechanical Habitat Construction

ESH construction would include an average of 195 acres per year in years when construction occurs. Construction of ESH would occur in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches. Construction of IRC habitat and ESH could have some adverse impacts to thermal power, but the impacts would be negligible to small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

National Economic Development

Alternative 4 would result in adverse impacts to thermal power operations in the lower and upper river, with an average annual decrease in thermal power NED value of $3.1 million, of which $2.2 million is a result of decreased energy value relative to Alternative 1. Table 3-236 summarizes the change in NED value under Alternative 4 compared to Alternative 1 for the period of analysis from 1975 to 2012. Under Alternative 4, the upper river would account for the majority (approximately 80 percent) of the adverse impact, driven by a number of years following the spring release when river flows drop below intake elevations compared to Alternative 1. In four years over the period of record, energy values would decrease between $20 and $60 million compared to Alternative 1 in the upper river as power generation is affected by low river flows.

These adverse impacts to energy value for power plants in the upper river would be temporary and small to large depending on the subsequent flow releases from Garrison Dam and downstream river flows. The adverse impacts to lower river energy value would be small and adverse, with an average annual decrease of $318,000. Capacity value would decrease under Alternative 4 in the upper river (average annual decrease of $540,000) and lower river (average annual decrease of $297,000) compared to Alternative 1. Variable costs for power plants in the upper river would be higher than the costs incurred under Alternative 1 with a negligible change compared to Alternative 1 (average annual increase of $91,551).

Table 3-236. Summary of Thermal Power NED Value for Alternative 4, 1975–2012 (2018 Dollars)

NED Value	Upper River [a]	Lower River	All Locations
Average Annual Missouri River Power Generation (MWh)	28,143,640	70,146,181	98,289,821
Change in Average Annual Generation from Alternative 1 (MWh)	−81,742	−16,080	−97,823
Average Annual Energy Value	$654,145,676	$1,632,585,801	$2,286,731,477
Difference in Average Annual Energy Value	−$1,879,148	−$317,575	−$2,196,723

NED Value	Upper River [a]	Lower River	All Locations
Percent Change in Average Energy Value from Alternative 1	−0.3%	0.0%	−0.1%
Average Annual Dependable Capacity – Summer (MW)	2,887	7,312	10,199
Average Annual Dependable Capacity Value – Summer	$385,817,155	$977,220,505	$1,363,037,660
Average Annual Dependable Capacity – Winter (MW) [b]	2,970	8,924	11,894
Average Annual Dependable Capacity Value – Winter	$396,957,835	$1,192,648,235	$1,589,606,071
Max Change in Average Annual Capacity Value from Alternative 1	−$539,725	−$296,918	−$836,642
Average Annual Variable Costs [c]	−$400,311	NA	−$400,311
Change in Average Annual Variable Costs	−$91,551	NA	−$91,551
Average Annual NED Value [d]	$1,039,347,621	$2,602,914,220	$3,642,261,841
Change in Average Annual NED Value	−$2,510,423	−$614,493	−$3,124,916
Percent Change in Average Annual NED Value	−0.2%	0.0%	−0.1%

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Capacity values are estimated by multiplying the 15th percentile of the available seasonal capacity during the summer and winter peak seasons from 1975 to 2012 by the unit capacity value. Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $133,650 /MW-year (Hydropower Analysis Center 2018).

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. Estimates of variable costs were provided by three power plants in the upper river; no data was provided by power plants in the lower river on variable costs. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

d NED value for Alternative 1 include summer capacity figures because the majority of the capacity impact occurs during the summer months. For Alternatives 2–6, either the winter or summer dependable capacity by power plant is used to calculate the maximum change in capacity value compared to Alternative 1. Therefore, the average annual NED value is estimated by aggregating the action alternative energy values, variable costs, and max change in capacity value, along with Alternative 1 summer capacity value.

Additional results of flow actions are summarized in Table 3-237, which considers the period of record, from 1931 to 2012. These results show the annual difference in thermal power NED value during years when there would be a release action. The results show that the greatest adverse impact to power plants would occur in the upper river when there is a full spring release due to lower fall flows in the Garrison reach. Much of the adverse impacts to power plants in the upper river would occur in 1994 as simulated, when a full release would result in relatively lower flows in the fall months in the Garrison reach, causing adverse impacts to power generation from river stages falling below shut down intake elevations more than under Alternative 1. The worst-case change would result in a reduction of NED value of $56.8 million relative to Alternative 1.

In the lower river, years that have a full spring release would have the greatest beneficial impacts to thermal power plants relative to Alternative 1 due to relatively higher river flows during the summer months, reducing peak river water temperatures. The largest adverse effects to thermal power NED value in the lower river would occur in eliminated release years, usually occurring two or three years after a full release, when river flows would be lower than under Alternative 1 with reduced access to water for cooling impacting power generation. Fully implemented spring releases would be simulated to occur in 1988 and 2002, which would reduce river flows in the subsequent years.

Table 3-237. Impacts from Flow Releases under Alternative 4 Compared to Alternative 1, 1930–2012 (2018 Dollars)

Release	NED Value Change	Lower River [a]	Upper River[a]	Total
Full Flow Release [b]	Lowest NED Value Change	−$2,931,134	−$56,806,899	−$59,738,032
	Highest NED Value Change	$3,178,571	−$259,142	$2,919,429
Partial Flow Release [c]	Lowest NED Value Change	−$1,078,395	−$2,888,048	−$3,966,443
	Highest NED Value Change	$858,670	$1,046,147	$1,904,817
Year after a Full Release	Lowest NED Value Change	−$2,182,287	−$553,934	−$2,736,222
	Highest NED Value Change	$183,988	$3,099,294	$3,283,282
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	−$6,408,506	−$56,806,899	−$63,215,405
	Highest NED Value Change	$3,178,571	$20,996,398	$24,174,969

Note: Impacts include changes in energy values, capacity values, and variable costs. Higher values represent higher NED value changes (beneficial impacts); negative values indicate reductions in the NED value or increased costs relative to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Flow action was fully implemented in 9 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was implemented.

c Flow action was partially implemented in 7 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was partially implemented.

Regional Economic Development

There would be small changes in power generation under Alternative 4 in the lower river and upper river compared to Alternative 1. Within the SPP RTO, power generation would be slightly lower in the summer and have no reductions in the winter under the worst-case change from Alternative 1 (see Table 3-238). Impacts to power generation in the summer under Alternative 4 within the MISO RTO would be small as a percent of total MISO power generation, 0.2 percent, with the bulk of the power generation impacts occurring during non-peak periods. There would be negligible change in power generation during the winter season. Because most of the adverse impacts to power generation would occur in the fall under Alternative 4, there would be negligible to small adverse impacts to wholesale power prices, with the potential for small indirect and long-term increases in electricity rates, household spending and associated regional economic conditions.

Table 3-238. Largest Season Reduction in Power Generation from Alternative 1 under Alternative 4, 1975–2012

Season	SPP	MISO
Largest Reduction in Power Generation under the MRRMP-EIS Alternative Relative to Alternative 1 (MWH)		
Winter	0 (1975)	−20,234 (1993)
Summer	−23,767 (1982)	−225,581 (2010)
Percent of Power Generation Reduction as a Percent of the RTO's Generation		
Winter	0.0%	0.0%
Summer	−0.1%	−0.2%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Other Social Effects

Average annual carbon dioxide (-113.8 million lbs or -0.068 percent) and nitrous oxide (-1,964 lbs or -0.069 percent) emissions would decline under Alternative 4 relative to Alternative 1. The decrease would result from power plants that would replace the reduced power generation from thermal power plants under Alternative 4 would generate relatively fewer air emissions. Methane (321 lbs or 0.002 percent) emissions would increase only slightly under this alternative relative to Alternative 1. There would be decreased average annual social costs of carbon equivalent under Alternative 4 (benefits), ranging from $2.5 million in 2018 to $13.5 million in 2050, or 0.068 percent compared to Alternative 1. The changes in air emissions and social cost of carbon equivalent would be negligible due to small percentage change in emissions.

Impacts to electricity reliability would be negligible relative to Alternative 1 because the replacement power would likely be available from the market even during the worst-case reduction in power generation (2.4 million MWH). There are no anticipated impacts to health and safety under Alternative 4. Low flow and drought conditions may result in safety concerns at power plants, such as availability of water supply for fire protection; there could be adverse effects in some years following spring flow releases when river flows fall below shutdown intake elevations.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Alternative 4 could result in adverse impacts from coupled effects of power generation from hydropower and thermal power. These impacts would occur primarily in the fall as relatively lower flows in the late summer and fall cause adverse impacts to power generation as a result of river stages falling below shut down intake elevations. For example, in the modeled year 1994, a full spring release is simulated to occur, which would result in the largest power reduction of 2.6 million MWh compared to Alternative 1, 2.4 million (93 percent) of which would be from reductions in thermal power generation. These reductions would be up to one percent of MISO and SPP generation in (see Table 3-239). Because the reductions in power generation from hydropower and thermal power would occur in the fall and demand for electricity is lower during the fall season, there would be replacement capacity available resulting in minimal impacts to wholesale power prices, power supply, electricity rates, grid stability, and regional economic conditions.

Table 3-239. Seasonal Changes in Power Generation under Alternative 4 Compared to Alternative 1, 1975–2012

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	−11,515	83,397	−24,308	−88,031
	Thermal Power (MWh)	−387	−9,493	11,632	−97,000
MISO and SPP	Worst Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	−119,731	−791,421	−378,766	−2,623,569
	Worst Case Change from Alternative 1 (% of RTO generation)	−0.1%	−0.3%	−0.3%	−1.0%
	Worst Case Change from Alternative 1 – Year	1983	2010	2010	1994
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	−0.1%
MISO	Worst Case Change from Alternative 1 (% of RTO generation)	0.0%	0.2%	−0.2%	−1.3%
	Worst Case Change from Alternative 1 – Year	1993	2010	2010	1994
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	−0.1%
SPP	Worst Case Change from Alternative 1 (% of RTO generation)	−0.3%	−0.8%	−0.4%	−1.0%
	Worst Case Change from Alternative 1 – Year	1983	1995	1982	1982
	Average Annual Change from Alternative 1 (% of RTO generation)	−0%	0.12%	0.0%	−0.1%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Conclusion

Alternative 4 would result in adverse impacts in the lower and upper river when compared to Alternative 1, with an average annual decrease in thermal power NED value of $3.1 million, of which $2.2 million is a result of a decrease in energy value relative to Alternative 1. Under Alternative 4, the upper river would account for the majority (approximately 80 percent) of the adverse impact, driven by a number of years following a spring release when river flows decrease below intake elevations in the fall season compared to Alternative 1. These adverse impacts to energy value for power plants in the upper river would be temporary and small to large depending on the impacts of flow releases from the Garrison Dam. There would be both beneficial and adverse impacts to power generation and energy value for power plants in the lower river from less habitat creation reducing river water temperature impacts (beneficial effects) and lower river flows following the spring release impacting access for cooling water (adverse effects). Dependable capacity would decrease slightly under Alternative 4 in the summer in the lower river, with small annual decreases in capacity value relative to Alternative 1. There would be negligible impacts to variable costs compared to Alternative 1.

Because most of the adverse impacts to power generation would occur in the fall under Alternative 4, there would be negligible to small adverse impacts to wholesale power prices, with the potential for small increases in electricity rates and reductions in household spending and associated regional economic conditions. Impacts to electricity reliability would be negligible relative to Alternative 1 because the replacement power would likely be available from the market even during the worst-case reduction in power generation.

There would be decreased average annual social costs of carbon equivalent emissions under Alternative 4 (benefits), ranging from $2.5 million in 2018 to $13.5 million in 2050 compared to Alternative 1, as the power plants that would replace the reduced power generation from thermal power plants under Alternative 4 would generate relatively fewer air emissions under this alternative. The changes in air emissions and social cost of carbon equivalent would be negligible due to small percentage change in emissions.

The coupled effects from reductions in power generation from both hydropower and thermal power plants could put further upward pressure on wholesale electricity prices, similar to the impacts under Alternative 1. Because the reductions in power generation from hydropower and thermal power would occur in the fall and demand for electricity is lower during the fall season, there would be replacement capacity available resulting in minimal impacts to wholesale power prices, power supply, electricity rates, grid stability, and regional economic conditions from coupled effects.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 4 is not anticipated to have significant impacts on thermal power because of the relatively small impacts to power generation and most adverse impacts to power generation would occur during off-peak seasons.

3.17.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 includes a fall release in October and November to create ESH. Alternative 5 includes fewer acres of constructed IRC habitat compared to the acres of early life stage habitat constructed under Alternative 1 in the lower river.

Mechanical Habitat Construction

ESH construction would include an average of 253 acres per year in years when construction occurs. Construction of ESH would occur in the Garrison, Fort Randall, and Gavins Point to Ponca, Nebraska river reaches. Construction of IRC habitat and ESH could have some adverse impacts to thermal power impacts in the Garrison and lower river reaches, but similar to Alternative 1, the impacts would be negligible to small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

National Economic Development

Alternative 5 would result in an average annual decrease of $1.0 million in thermal power NED value compared to Alternative 1 over the 37-year period of analysis. The Missouri River power plants in the upper river would experience a decrease in average annual energy value of $305,103, while power plants in the lower river would experience an average annual increase of $180,855 when compared to energy value under Alternative 1. These overall decreases in power generation and energy value would be temporary, small, and adverse because of the minor change from Alternative 1.

Alternative 5 would result in a small decrease in average annual capacity value in the upper and lower river of $824,656, most of which would be associated with decreases in dependable capacity in the lower river. Similar to Alternative 3, in the lower river under Alternative 5, the maximum decrease in capacity value reflects the worst-case change in dependable capacity for either winter or summer season for each power plant. Therefore, small decreases in capacity value can occur when there are average annual energy value increases. Changes in variable costs under Alternative 5 would be negligible compared to Alternative 1. Table 3-240 summarizes the thermal power NED value.

Table 3-240. Summary of Thermal Power NED Value for Alternative 5, 1975–2012 (2018 Dollars)

NED Value	Upper River[a]	Lower River	All Locations
Average Annual Missouri River Power Generation (MWh)	28,212,552	70,168,340	98,380,892
Change in Average Annual Generation from Alternative 1 (MWh)	−12,830	6,079	−6,752
Average Annual Energy Value	$655,719,721	$1,633,084,231	$2,288,803,952
Change in Average Annual Energy Value from Alternative 1	−$305,103	$180,855	−$124,248
Percent Change in Average Energy Value from Alternative 1	0.0%	0.0%	0.0%
Average Annual Dependable Capacity – Summer (MW)	2,889	7,309	10,198
Average Annual Dependable Capacity Value – Summer	$386,123,097	$976,787,709	$1,362,910,806
Average Annual Dependable Capacity – Winter (MW) [b]	2,969	8,924	11,893
Average Annual Dependable Capacity Value – Winter	$396,853,663	$1,192,648,235	$1,589,501,898
Max Change in Average Annual Capacity Value from Alternative 1	−$127,277	−$697,379	−$824,656
Average Annual Variable Costs [c]	−$366,700	NA	−$366,700
Change in Average Annual Variable Costs from Alternative 1	−$57,940	NA	−$57,940
Average Annual NED Value [d]	$1,041,367,724	$2,603,012,189	$3,644,379,913
Change in Average Annual NED Value from Alternative 1	−$490,320	−$516,524	−$1,006,844
Percent Change in Average Annual NED Value	0.0%	0.0%	0.0%

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Capacity values are estimated by multiplying the 15th percentile of the available seasonal capacity during the summer and winter peak seasons from 1975 to 2012 by the unit capacity value. Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $133,650 /MW-year (Hydropower Analysis Center 2018).

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. Estimates of variable costs were provided by three power plants in the upper river; no data was provided by power plants in the lower river on variable costs. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

d NED value for Alternative 1 include summer capacity figures because the majority of the capacity impact occurs during the summer months. For Alternatives 2–6, either the winter or summer dependable capacity by power plant is used to calculate the maximum change in capacity value compared to Alternative 1. Therefore, the average annual NED value is estimated by aggregating the action alternative energy values, variable costs, and max change in capacity value, along with Alternative 1 summer capacity value.

Additional results of flow actions are summarized in Table 3-241 for the POR from 1931 to 2012. These results show the difference in annual thermal power NED value during years when there would be a release action. The largest annual decreases in the NED value in the upper river ($10.8 million) are driven by lower river flows in the spring and summer following a fall full release under Alternative 4.

In the lower river, as simulated in 1990, the Missouri River power plants would experience almost a $5 million decrease in thermal power NED value in the fall when river flows would be lower than under Alternative 1 as the reservoir System re-balances following the fall release in 1987. Fewer acres of habitat development under Alternative 5 would result in a small decrease in river water temperatures during summer peak demand seasons, with small increases in power generation for power plants in the lower river, with benefits to NED value. For example, in 2003, one plant in the lower river would experience fewer days above the 90°F threshold, and a number of other plants would also experience small increases in power generation from slightly lower river water temperatures under Alternative 5 compared to Alternative 1.

Table 3-241. Impacts from Flow Releases under Alternative 5 Compared to Alternative 1, 1931–2012 (2018 Dollars)

Release	NED Value Change	Lower River[a]	Upper River[a]	Total
Full Flow Release [b]	Lowest NED Value Change	−$761,364	−$198,704	−$960,068
	Highest NED Value Change	−$7,946	−$83,792	−$91,737
Partial Flow Release [c]	Lowest NED Value Change	−$104,615	−$127,277	−$231,892
	Highest NED Value Change	−$104,615	−$127,277	−$231,892
Year after a Full Release	Lowest NED Value Change	−$2,391,349	−$10,838,458	−$13,229,807
	Highest NED Value Change	$165,396	$4,961,204	$5,126,600
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	−$4,931,687	−$10,838,458	−$15,770,145
	Highest NED Value Change	$2,576,683	$4,961,204	$7,537,887

Note: Impacts include changes in energy value, capacity value, and variable costs. Higher values represent higher NED value changes (beneficial impacts); negative values indicate reductions in the NED value or increased costs relative to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Flow action was fully implemented in 7 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was implemented.

c Flow action was partially implemented in 2 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was partially implemented.

Regional Economic Development

Impacts to power generation during peak demand seasons within the SPP and MISO RTOs would result in very small changes in power generation. In the worst change year as a percent of the RTO power generation (Table 3-242). The potential impacts to consumer electricity rates associated with higher wholesale electricity prices would be negligible to small relative to prices under Alternative 1, although the exact impact on electricity prices is uncertain. Because of the negligible to small adverse impacts to wholesale power prices, the indirect impacts to electricity rates, household spending and associated regional economic conditions would be negligible.

Table 3-242. Largest Season Reduction in Power Generation from Alternative 1 under Alternative 5, 1975–2012

Season	SPP	MISO
Largest Reduction in Power Generation under the MRRMP-EIS Alternative Relative to Alternative 1 (MWH)		
Winter	0 (1975)	−20,234 (1993)
Summer	−16,051 (1975)	−184,440 (1984)
Percent of Power Generation Reduction as a Percent of the RTO's Generation		
Winter	0.0%	0.0%
Summer	0.0%	−0.2%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Other Social Effects

Under Alternative 5, average annual carbon dioxide (-18.9 million lbs or -0.011 percent) and nitrous oxide (-340 lbs or -0.012 percent) emissions relative to Alternative 1 would decrease, as the power plants that would replace the reduced power generation from thermal power plants under Alternative 5 would generate relatively fewer air emissions under this alternative. Methane (358 lbs or 0.002 percent) emissions would increase only slightly under this alternative. There would be decreased average annual social cost of carbon equivalent under Alternative 5 (benefits), ranging from $423,000 to $2.2 million, or 0.011 percent compared to Alternative 1. The changes in air emissions and social cost of carbon equivalent would be negligible and beneficial due to small percentage change in emissions.

Impacts to electricity reliability would be negligible relative to Alternative 1 as replacement power would be available and power generation under this alternative would be very similar to Alternative 1. There are no anticipated impacts to health and safety under Alternative 5. Low flow and drought conditions may result in safety concerns at power plants, such as availability of water supply for fire protection; there could be adverse effects in some years following fall flow release when river flows fall below shutdown intake elevations.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Alternative 5 could result in adverse impacts from coupled effects of power generation from hydropower and thermal power, and these conditions would primarily occur in the spring months. The year after a simulated full fall release that occurs in 1984 would result in the largest power reduction of 709,000 MWH compared to Alternative 1, 654,000 MWH of which would be from hydropower plants. These reductions would be driven by lower reservoir elevations and releases in the spring and summer following a fall full release in 1983. These power reductions, as simulated, would be up to 0.3 percent of MISO and SPP generation in the spring (see Table 3-243). Because of the relatively small amount of power generation affected and because the reductions in power generation from hydropower and thermal power would occur in the spring non-peak power demand season, there would likely be replacement capacity available, with minimal impacts to wholesale power prices, electricity rates, grid stability, and regional economic conditions.

Table 3-243. Seasonal Changes in Power Generation under Alternative 5 Compared to Alternative 1, 1975–2012

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	−8,736	−77,202	−8,233	46,914
	Thermal Power (MWh)	−464	−2,881	12,321	−15,551
MISO and SPP	Worst Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	−117,725	−708,680	−269,864	−354,383
	Worst Case Change from Alternative 1 (% of RTO generation)	−0.1%	−0.3%	−0.3%	−0.1%
	Worst Case Change from Alternative 1: Year	1996	1984	1984	1975
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
MISO	Worst Case Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	−0.2%	−0.2%
	Worst Case Change from Alternative 1: Year	1993	2005	1984	2005
	Average Annual Change from Alternative 1 (% of RTO generation)	0.00%	0.00%	0.00%	−0.01%
SPP	Worst Case Change from Alternative 1 (% of RTO generation)	−0.3%	−1.0%	−0.2%	−0.5%
	Worst Case Change from Alternative 1: Year	1996	1984	1995	1975
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	−0.1%	0.0%	0.1%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Conclusion

Alternative 5 would result in an average annual decrease of $1.0 million (0.03 percent) in thermal power NED value compared to Alternative 1. Average annual decreases in power generation and decreases in energy value of $305,000 would occur in the upper river. Adverse impacts would occur to capacity values in the upper and lower river, resulting in additional capacity costs of $490,000 and $517,000, respectively, in the upper and lower river. Impacts to energy and capacity value would be temporary, small, and adverse due to the very small percentage change relative to Alternative 1. There would be negligible impacts to variable costs compared to Alternative 1.

Because of the small impacts to power generation in off-peak seasons under Alternative 5, there would be negligible to small adverse impacts to wholesale power prices, with negligible change in electricity rates, household spending and associated regional economic conditions relative to Alternative 1. Impacts to electricity reliability would be negligible relative to Alternative 1 because the replacement power would likely be available from the market even during the worst-case reduction in power generation.

There would be decreased average annual social costs of carbon equivalent under Alternative 5 (benefits), ranging from a reduction of $423,000 (2018) to a reduction of $2.2 million (2050) compared to Alternative 1, as the power plants that would replace the reduced power generation from thermal power plants under Alternative 5 would generate relatively fewer air emissions under this alternative. The changes in air emissions and social cost of carbon equivalent would be negligible due to small percentage change in emissions.

The coupled effects from reductions in power generation from both hydropower and thermal power plants could put further upward pressure on wholesale electricity prices, similar to the impacts under Alternative 1. Because of the relatively small amount of power generation affected and because the reductions in power generation from hydropower and thermal power would occur in the spring non-peak power demand season, there would likely be replacement capacity available, with minimal impacts to wholesale power prices, electricity rates, grid stability, and regional economic conditions from coupled effects.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 5 is not anticipated to have significant impacts on thermal power because of the relatively small impacts to power generation and most adverse impacts would occur during off-peak seasons.

3.17.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes a bi-modal spawning cue release in March and May to benefit the pallid sturgeon. Alternative 6 includes construction of fewer acres of IRC habitat compared to the acres of early life stage habitat constructed under Alternative 1 in the lower river.

Mechanical Habitat Construction

ESH construction would include an average of 245 aces per year in years when construction occurs. Construction of ESH would occur in the Garrison, Fort Randall, and Gavins Point to Ponca, Nebraska river reaches, while IRC habitat would be constructed in the lower river below Ponca, Nebraska. Construction of IRC habitat and ESH could have some adverse impacts to thermal power plant intakes in the Garrison and lower river reaches, but similar to Alternative 1, the impacts would be negligible to small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

National Economic Development

Alternative 6 would result in an average annual reduction of $1.2 million in thermal power NED value compared to Alternative 1 over the 37-year period of analysis (Table 3-244). On average, there would be small adverse impacts to power generation and energy value in the upper and lower river, and small adverse impacts to capacity value in the upper river. However, in two years over the period of analysis, energy value would decrease between $10 and $24 million compared to Alternative 1 in the upper river as power generation is affected by low river flows. The adverse impacts would occur in relatively drier years during the fall and winter when the reservoir System is rebalancing in the year or two following a spawning cue release, reducing power generation, and affecting dependable capacity in the upper river. Adverse impacts to lower river energy and capacity values would be small and adverse driven by relatively lower river flows in the fall and winter causing river stages to fall below shut down intake elevations and increase river water temperatures. The worst-case change from Alternative 1 would result in a decrease of less than 0.4 percent. There would be negligible change in variable costs from Alternative 1.

Table 3-244. Summary of Thermal Power NED Value for Alternative 6, 1975–2012 (2018 Dollars)

NED Value	Upper River [a]	Lower River	All Locations
Average Annual Missouri River Power Generation (MWh)	28,213,091	70,146,945	98,360,036
Change in Average Annual Generation from Alternative 1 (MWh)	−12,291	−15,317	−27,608
Average Annual Energy Value	$655,734,747	$1,632,590,316	$2,288,325,063
Change in Average Annual Energy Value from Alternative 1	−$290,077	−$313,060	−$603,137
Percent Change in Average Energy Value from Alternative 1	0.0%	0.0%	0.0%
Average Annual Dependable Capacity – Summer (MW)	2,887	7,314	10,202
Average Annual Dependable Capacity Value – Summer	$385,903,896	$977,575,698	$1,363,479,594
Average Annual Dependable Capacity – Winter (MW) [b]	2,970	8,924	11,894
Average Annual Dependable Capacity Value – Winter	$396,957,835	$1,192,648,235	$1,589,606,071
Max Change in Average Annual Capacity Value from Alternative 1	−$412,690	−$68,082	−$480,772
Average Annual Variable Costs [c]	−$470,375	Not Available	−$470,375
Change in Average Annual Variable Costs from Alternative 1	−$161,615	Not Available	−$161,615
Average Annual NED Value[d]	$1,040,993,662	$2,603,147,570	$3,644,141,233
Change in Average Annual NED Value from Alternative 1	−$864,382	−$381,143	−$1,245,525
Percent Change in Average Annual NED Value	−0.1%	0.0%	0.0%

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Capacity values are estimated by multiplying the 15th percentile of the available seasonal capacity during the summer and winter peak seasons from 1975 to 2012 by the unit capacity value. Capacity values represent an annualized capital cost to replace the estimated lost capacity; the unit capacity value was $133,650 /MW-year (Hydropower Analysis Center 2018).

c Variable costs include operations and maintenance costs incurred under adverse conditions when power generation is not affected. Estimates of variable costs were provided by three power plants in the upper river; no data was provided by power plants in the lower river on variable costs. In addition, the variable costs include losses in renewable energy credits for Minnesota Power when Minnkota Power Cooperative Missouri River intake is impacted during the summer.

d NED value for Alternative 1 include summer capacity figures because the majority of the capacity impact occurs during the summer months. For Alternatives 2–6, either the winter or summer dependable capacity by power plant is used to calculate the maximum change in capacity value compared to Alternative 1. Therefore, the average annual NED value is estimated by aggregating the action alternative energy values, variable costs, and max change in capacity value, along with Alternative 1 summer capacity value.

Additional results of flow actions are summarized in Table 3-245. These results show the difference in annual thermal power NED value over the 81-year period of record during years when there would be a release action. The largest adverse impacts to power plants in the upper river would occur in two or more years following a partial or full spawning cue release, with a worst-case change of −$31.2 million. As simulated in 1935, 1937, 2007, and 2010, low river flows would affect power generation at power plants in the upper river in the fall in these years. As simulated under Alternative 6, there would be partial spawning cue releases in 2000, 2001, and 2009, and a full spawning cue release in 2002, which would reduce the river flows in the Bismarck reach in 2007 and 2010, reducing river stages below shut down intake elevations at three power plants. These relatively lower river flows in some years would contribute to decreases in power generation and energy values, increased variable costs, a reduction in dependable capacity, and decreased capacity value. However, there are also years with increases in thermal power NED value relative to Alternative 1 ($22 million) from relatively higher river flows in the Garrison reach as the reservoir System rebalances after the spawning cue releases.

In the lower river, there would be a number of years when adverse impacts to power generation and energy values would occur in the year after a full or partial release, with a worst-case change of −$6.6 million. The adverse impacts would be driven by relatively lower river flows in the fall and winter in the year or years following the spawning cue releases as the reservoir System rebalances. In 1932 and 1990 as simulated, five power plants in the lower river would have lower power generation and higher energy replacement costs than under Alternative 1 due to lower river stages affecting the ability to access water. For power plants in the lower river, full releases can increase thermal power NED value relative to Alternative 1. As simulated in 1988 and 2002, there would be full implementation of the spawning cue release in March and May. During these releases, there would be small reductions in river water temperatures of about 1°F that would result in increased power generation and energy values relative to Alternative 1.

Table 3-245. Impacts from Flow Releases under Alternative 6 Compared to Alternative 1, 1931–2012 (2018 Dollars)

Release	NED Value Change	Lower River [a]	Upper River[a]	Total
Full Flow Release [b]	Lowest NED Value Change	−$2,702,298	−$412,690	−$3,114,988
	Highest NED Value Change	$3,872,223	$201,414	$4,073,636
Partial Flow Release [c]	Lowest NED Value Change	−$3,206,360	−$479,648	−$3,686,008
	Highest NED Value Change	$1,293,588	$1,104,820	$2,398,408
Year after a Full Release	Lowest NED Value Change	−$6,645,605	−$426,900	−$7,072,504
	Highest NED Value Change	$2,177,251	−$412,690	$1,764,561
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest NED Value Change	−$6,645,605	−$31,241,145	−$37,886,749
	Highest NED Value Change	$3,872,223	$22,061,097	$25,933,319

Note: Impacts include changes in energy values, capacity values, and variable costs. Higher values represent higher NED value changes (beneficial impacts); negative values indicate reductions in the NED value or increased costs relative to Alternative 1.

a The upper river includes five power plants in the Garrison Dam to Lake Oahe river reach (Coyote Power Plant was excluded because it does not incur any impacts over the period of record) and one power plant on Lake Sakakawea, while the lower river includes fourteen power plants below Gavins Point Dam.

b Flow action was fully implemented in 6 years of the POR. Note that the low summer flow events are implemented in the year after a full spawning cue release. Data represents the lowest and highest dollar impacts in the years the action was implemented.

c Flow action was partially implemented in 29 years of the POR; partial implementation years are defined as years when a partial cue in March and/or May would occur OR years when a full cue in March or May would occur. Data represents the lowest and highest dollar impacts in the years the action was partially implemented.

Regional Economic Development

Impacts to power generation during peak demand seasons within the SPP and MISO RTOs would result in very small changes in power generation in the worst change year as a percent of the RTO power generation (Table 3-246). The potential impacts to consumer electricity rates associated with higher wholesale electricity prices would be long-term and adverse but negligible to small relative to Alternative 1, although the exact impact on electricity prices is uncertain. Because of the negligible to small adverse impacts to wholesale power prices, the indirect impacts to electricity rates, household spending and associated regional economic conditions would be negligible.

Table 3-246. Largest Season Reduction in Power Generation from Alternative 1 under Alternative 6, 1975–2012

Season	SPP	MISO
Largest Reduction in Power Generation under the MRRMP-EIS Alternative Relative to Alternative 1 (MWH)		
Winter	−6,407 (1975)	−20,234 (1993)
Summer	−81,595 (2010)	−425,586 (2010)
Percent of Power Generation Reduction as a Percent of the RTO's Generation		
Winter	0.0%	0.0%
Summer	−0.2%	−0.4%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Other Social Effects

Under Alternative 6, average annual carbon dioxide (−33.9 million lbs or −0.020 percent) and nitrous oxide (−580 lbs or −0.020 percent) emissions relative to Alternative 1 would decrease, as the power plants that would replace the reduced power generation with power generated at plants with fewer air emissions under this alternative. Methane (4,288 lbs or 0.029 percent) emissions would increase only slightly under this alternative. There would be decreases in the average annual social cost of carbon equivalent under Alternative 6 (benefits), ranging from $757,000 to $4.0 million, or 0.020 percent compared to Alternative 1. The changes in air emissions and social cost of carbon equivalent would be negligible due to small percentage change in emissions.

Impacts to electricity reliability would be negligible relative to Alternative 1 as replacement power would be available and power generation under this alternative would be very similar to Alternative 1. There are no anticipated impacts to health and safety from under Alternative 6. Low flow and drought conditions may result in safety concerns at power plants, such as availability of water supply for fire protection; there could be adverse effects in some years following spawning cue releases when river flows fall below shutdown intake elevations.

Coupled Effects from Changes in Power Generation from Thermal Power and Hydropower Plants

Under Alternative 6, coupled effects associated with simultaneous reductions in thermal power and hydropower generation would affect up to 0.4 percent of SPP and MISO generation during a worst-case scenario. The spring of the modeled year 2010 shows the greatest impact of a reduction of 1.0 million MWh in generation, with thermal power generation representing two-thirds of power reduction (see Table 3-247). Because of the relatively small amount of power generation affected and because the reductions in power generation from hydropower and thermal power would occur in the spring non-peak power demand season, there would likely be replacement capacity available, with minimal impacts to wholesale power prices, electricity rates, grid stability, and regional economic conditions.

Table 3-247. Seasonal Changes in Power Generation under Alternative 6 Compared to Alternative 1, 1975–2012

RTO	Type of Impact	Winter	Spring	Summer	Fall
Average Annual Change from Alternative 1	Hydropower (MWh)	−8,693	42,657	−11,353	−42,479
	Thermal Power (MWh)	−387	−17,200	3,110	−12,404
MISO and SPP	Worst Case Change in Power Generation from Alternative 1 (Hydropower and Thermal Power in MWh)	−72,339	−1,017,689	−523,023	−694,821
	Worst Case Change from Alternative 1 (% of RTO generation)	−0.1%	−0.4%	−0.4%	−0.3%
	Worst Case Change from Alternative 1: Year	1983	2010	2010	2007
	Average Annual Change from Alternative 1 (% of RTO generation)	−0.01%	0.01%	−0.01%	−0.02%
MISO	Worst Case Change from Alternative 1 (% of RTO generation)	0.0%	−0.4%	−0.4%	−0.3%
	Worst Case Change from Alternative 1: Year	1993	2010	2010	2007
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.0%	0.0%	0.0%
SPP	Worst Case Change from Alternative 1 (% of RTO generation)	−0.2%	−0.5%	−0.2%	−0.4%
	Worst-Case Change from Alternative 1: Year	1983	2010	2004	1978
	Average Annual Change from Alternative 1 (% of RTO generation)	0.0%	0.1%	0.0%	−0.1%

Source: SPP 2015; SPP 2016; MISO 2014; MISO 2016

Conclusion

Alternative 6 would result in an average annual reduction of $1.2 million in thermal power NED value compared to Alternative 1. On average, there would be temporary, small adverse impacts to power generation and energy values in the upper and lower river and small adverse impacts to capacity values in the upper river due to low river flows following the spawning cue releases. The adverse impacts would occur in relatively drier years during the fall and winter when the reservoir System is rebalancing. These impacts would occur in the year or two following a spawning cue release, reducing river stages below intake shut down elevations, affecting power generation and dependable capacity in the upper river. There would be negligible change in variable costs from Alternative 1.

Impacts to wholesale power prices would be negligible to small, resulting in negligible indirect impacts to electricity rates, household spending and associated regional economic conditions because power generation changes would be very small within the SPP and MISO RTOs. Impacts to electricity reliability would be negligible relative to Alternative 1 as replacement power would be available and power generation under this alternative would be very similar to Alternative 1.

There would be decreases in the average annual social cost of carbon equivalent under Alternative 6 (benefits), ranging from $757,000 to $4.0 million, or 0.020 percent compared to

Alternative 1. The changes in air emissions and social cost of carbon equivalent would be negligible due to small percentage change in emissions.

The coupled effects from reductions in power generation from both hydropower and thermal power plants could put further upward pressure on wholesale electricity prices, similar to the impacts under Alternative 1. Because of the relatively small amount of power generation affected and because the reductions in power generation from hydropower and thermal power would occur in the spring non-peak power demand season, there would likely be replacement capacity available, with minimal impacts to wholesale power prices, electricity rates, grid stability, and regional economic conditions from coupled effects.

The construction of ESH in the upper river reaches and IRC in the lower river could have temporary and adverse impacts to thermal power intakes from increased maintenance issues. These impacts are anticipated to be negligible to small because buffers around sensitive resources and site-specific planning would reduce the impacts to power plants.

Alternative 6 is not anticipated to have significant impacts on thermal power because of the relatively small impacts to power generation and most adverse impacts to power generation would occur during off-peak seasons.

3.17.2.10 Tribal Resources

There are no power plants located on Tribal lands; all Tribal members would be affected by the RED and OSE effects as described in the previous sections.

3.17.2.11 Climate Change

A discussion on the influence of climate change on the alternatives is included in Section 3.2.2.7. Relatively higher river water temperatures, especially during lower river flows caused by prolonged drought conditions, would adversely affect all power plants that do not have cooling towers. The relatively warmer water is not as efficient in cooling plant condensers and may result in reductions in power generation under these conditions. With higher river temperatures, all power plants would have more difficulty in meeting the 90°F NPDES permit requirement. Prolonged drought conditions may also cause lower river flows to cause river stages to fall below critical intake elevations with adverse impacts to power generation and energy values. Earlier snowmelt may cause spring System storage targets to be met more frequently, increasing the regularity of spring plenary pulses under Alternative 1, and the potential for adverse impacts associated with the subsequent lower rivers flows as the System rebalances. Adverse impacts associated with more frequent spring plenary pulses may be offset in part by higher levels of precipitation limiting the implementation of the pulse because flood targets may be exceeded more frequently. Management actions under Alternative 1 would not be substantially affected by climate change.

Impacts to power generation under Alternatives 2, 3, 4, 5, and 6 with climate change would be similar to Alternative 1. However, the influence of climate change with the low summer flow events and construction of early life stage habitat under Alternative 2 in the lower river during the summer periods would increase the adverse impacts to power plants with relatively higher river water temperatures during these peak demand periods, which would cause decreased power generation compared to Alternative 1. Large more sporadic rain events could adversely impact intakes and outfalls of thermal power plants affected by flooding, possibly shutting plants down; climate change could exacerbate the possibility of flooding during spring or fall releases under Alternatives 2, 4, 5, and 6.

With earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses relative to Alternative 1 may result in lower river flows in the fall and winter compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Longer durations of lower river flows would adversely impact access to water for cooling, especially in the fall and winter months when flows are at their lowest levels.

3.17.2.12 Cumulative Impacts

Consumption of electricity has steadily increased, with sales of electricity increasing by 1.4 percent per year nationwide on average since 1990. Electricity sales in the Missouri River basin states have increased at a slightly higher rate of 2.0 percent on average over the same period. Continued increasing demand for electricity would benefit power generators, with market pressure to maintain generation with capital investments to maintain and increase capacity. In addition, fuel costs for power plants, including the price of coal and natural gas, would have both adverse and beneficial impacts on utilities and power plants, which would affect operating costs, RTO wholesale electricity prices, and potentially retail electricity rates. Costs to maintain operations and power generation and for replacement power would result in temporary and long-term adverse impacts to utilities, power plants, and potentially consumers of electricity.

EPA has proposed or implemented five recent rules that would affect Missouri River thermal power plants, including: the Clean Power Plan; Mercury and Air Toxics Standards (MATS); the Cross-State Air Pollution Rule (CSAPR); the Coal Ash Rule; and the Cooling Water Intake Structures Rule. However, more recently, the Clean Power Plan and the Mercury and Air Toxics Standards are under appeal or review, and it is possible that these rules could be changed or repealed in the future. While there is current uncertainty for some of these rules and regulations, the trend toward policies that reduce the impacts of climate change and increase environmental protection would likely affect industry decisions.

The first three rules pertain to limiting air pollutants from coal-fired power plants including carbon dioxide, sulfur dioxide, nitrous oxide, mercury, hydrogen fluoride, and hydrogen chloride. Implementation of these rules could require additional pollution control equipment to reduce power plant emissions from coal-fired power plants. The Coal Ash Rule would require coal-fired power plants to close surface ash impoundments and dispose of ash in regulated landfills; EPA is currently considering amending the rule to allow states to determine how they would enforce it individually. The Cooling Water Intake Structures Rule would require plants with once through cooling technologies to use best technologies available for their cooling systems, which may force power plants to construct cooling towers or construct intake structures to limit potential impacts to fish and other aquatic organisms from entering cooling water intakes. Utilities may choose to retire power plants rather than comply with the rules because it may not be cost effective to undertake costly investments to comply with these rules or similar future ones.

The MISO RTO is anticipating that it will have sufficient capacity to meet near-term planning requirements. The annual MISO States-MISO Resource Adequacy Survey shows that the RTO will have between 2.7 to 4.8 GW of excess resources available between 2018 to 2022, which would be a 16 to 22 reserve margin and above the 15.8 percent planning reserve margin requirement. There should be adequate power generation in the RTO, resulting in greater flexibility for power generation under adverse conditions, especially during peak demand periods (RTO Insider 2017).

Construction of the Missouri River Mainstem Reservoir System and the associated dams allows operation with controlled flow releases from the upper river into the lower river to achieve multiple management objectives, including providing water supply access for various uses. Variability in natural hydrologic conditions (precipitation and snowmelt, which include periods of drought and high runoff) and the “rules” governing System operation would continue to dominate the flows in the Missouri River into the future. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impact to access to water and river water temperatures on the Missouri River, thus impacting intake access and the ability to discharge water for thermal power plants. Other actions and programs, such as water depletions or withdrawals for agriculture, municipal, and industrial uses would continue to have adverse impacts to intake access to water, as they would affect the water surface elevations and flows of the river and reservoirs.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation. For the year 0 and year 15 aggradation and degradation analyses, as described in Section 3.2.2.3, Impacts on Hydrology from the Alternatives, the elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in year 15 under all alternatives compared to year 0[17]. The change in stage in the riverine areas in year 15 in the upper river and the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The degradation effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15. However, in Kansas City, the projected river stage in year 15 would only be slightly lower (less than one inch of the mean stage) than year 0.

Past, present, and future actions that would affect bed degradation or aggradation in the Missouri River, such as dredging, would continue to have adverse impacts to thermal power plants as reductions in water surface elevations can affect the ability to access water. Actions that affect bed degradation could impact the riverbed and the stage of the river over time as well as the stability of the intake and outfall infrastructure of the power plant and reduce the ability of the plant to access water for cooling. Actions that affect aggradation, such as floodplain development and habitat construction, could impact sediment and/or silting in intakes or outfalls. These types of actions would result in long-term, adverse impacts to power plants and may require power plants to incur operating and maintenance costs or undertake capital investments to modify intakes and/or dredge sediment. It could also impact the ability of power plants to generate power with reduced access to water.

Continued management of the System under Alternative 1 would provide large energy and capacity benefits; adverse impacts to energy and capacity values and variable costs would occur during relatively drier and drought conditions. During drought conditions, it is possible that

[17] Year 0 reflects conditions based on (1) the current storage volume in the six reservoirs along the upper Missouri River and (2) the current geometry of the Missouri River riverbed. In order to account for future reservoir sediment accumulation and riverbed degradation, flows and stage/elevation for the six alternatives were also modeled for year 15. Year 15 reflects conditions that are expected to exist after 15 years of operating a specific alternative.

seasonal reductions in power generation could have negligible to small adverse impacts on wholesale electricity prices with potential impacts to retail electricity rates and regional economic conditions. It is likely that replacement capacity would be available in the market during drought and relatively drier conditions, with negligible impacts to power supply and electricity reliability under Alternative 1. The spring plenary pulse and habitat construction would not result in noticeable impacts to thermal power NED, RED, and OSE impacts under Alternative 1.

When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 1 would be both beneficial and adverse in the short term although in the long-term would likely be primarily adverse. Although power plants would continue to provide essential electricity to the MISO and SPP RTOs, they would be adversely impacted by climate, air quality, water quality, and other environmental regulations, natural cycles of drought, higher fuel costs, and actions that affect bed degradation and aggradation. Natural wet hydrologic periods along with actions such as bank stabilization activities and levee construction and maintenance activities would provide some benefits to power plants but these activities are small in comparison with the potentially large adverse impacts of pending and current environmental regulations, fuel costs, and natural drought periods. The continued implementation of Alternative 1 would provide a negligible contribution to these cumulative impacts.

Alternative 2 would result in small to large adverse impacts to power plants and power generation, including impacts to energy and capacity values, retail electricity rates and associated regional economic conditions, and electricity reliability. The largest adverse impacts, compared to Alternative 1, would occur in the lower river, associated with higher river water temperatures during low summer flow events and from the construction of more early life stage habitat. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts associated with Alternative 2 would be long-term, small to large and adverse. Overall, management actions under Alternative 2 would on average annually contribute small adverse impacts to the cumulative impacts to thermal power plants in the lower river, but could be large during low summer flow events.

The impacts of Alternative 3 would result in relatively small beneficial impacts to energy and capacity values because of small increases in river flows in the fall and slight reductions in river water temperatures compared to Alternative 1. Alternative 3 would result in negligible changes in RED and OSE relative to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3 would be similar to those described for Alternative 1. Power plants would continue to be adversely impacted by climate, air quality, water quality, and other environmental regulations, potentially higher fuel prices, natural cycles of drought, and actions that affect bed degradation and aggradation. Management actions of Alternative 3 would provide a negligible contribution to cumulative impacts to thermal power plants.

There would be small to large, temporary adverse impacts to power plants in the upper river under Alternative 4, compared to Alternative 1, because of reductions in river flows in the fall following a spring release as the reservoir System rebalances. Power plants in the lower river would experience relatively smaller adverse impacts to power generation under Alternative 4. Overall, impacts of Alternative 4 would result in the potential for small adverse impacts to wholesale power prices, retail electricity rates and associated regional economic conditions, and electricity reliability compared to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the impacts of Alternative 4 would be similar to those of

Alternative 1. Alternative 4 would provide a negligible contribution to these cumulative impacts, with the potential for small and adverse contribution in the fall following the spring release.

Under Alternative 5, impacts to energy and capacity values and wholesale power prices would be temporary, small, and adverse primarily from lower river flows in the lower river in the years following the fall release. Alternative 5 would result in negligible changes in RED and OSE relative to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 5 would be similar to those described for Alternative 1. Alternative 5 would provide a negligible contribution to these cumulative impacts.

Alternative 6 would result in temporary, small adverse impacts to power generation and energy values in the upper and lower river and small adverse impacts to capacity values in the upper river. The adverse impacts would occur in relatively drier years during the fall and winter when the reservoir System is rebalancing in the year or two following a spawning cue release, reducing power generation and affecting dependable capacity in the upper river. Alternative 6 would result in negligible changes to RED and OSE relative to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 would be similar to those described for Alternative 1. Power plants would continue to be adversely impacted by climate, air quality, water quality, and other environmental regulations, natural cycles of drought and associated management actions, potentially higher fuel prices, and actions that affect bed degradation and aggradation. Alternative 6 would provide a negligible contribution to these cumulative impacts.

3.18 Water Supply

3.18.1 Affected Environment

Water is withdrawn from the Missouri River and its Mainstem lakes for multiple purposes including municipal, industrial, and commercial water supply as well as domestic and public uses. Municipal water supply includes Tribal and public supply of water to reservations, residents of cities and towns, and customers of rural water districts and associations. The larger municipal water supply intakes are in the river segments below Gavins Point Dam and serve major urban areas including Omaha, Kansas City, and St. Louis. Most of the smaller municipal water supply intakes and rural water districts are located on the lakes and the river reaches above Gavins Point Dam. The large municipal and industrial intakes are permanent/fixed structures associated with large facilities that also treat the raw water. The large intakes typically operate full-time whereas some of the small intakes operate part-time especially during the winter months. Treated water is provided for drinking water and other household uses, as well as, for businesses and industries. Water is withdrawn from the river and reservoirs and sent to water treatment facilities. Following treatment, the supply is sent to the various water systems for distribution to users. Most municipalities located on the river or reservoirs have limited or no alternative sources of water other than the Missouri River. Some have existing wells that serve only as backup systems whereas others can store a limited volume of water for use.

Commercial and industrial intakes are those that do not derive water from a public source for commercial, manufacturing, and other processing uses other than thermal power use. The Missouri River and reservoirs also supply water to domestic and public users. Most domestic intakes are portable, providing water to one household and are sometimes used for drinking water. However, more often the water is used for other domestic uses such as small lawn or garden irrigation, stock watering, or washing cars, with many only used seasonally. Public water supply intakes typically provide water for fish and wildlife uses and recreation such as parks and golf courses. Municipal, commercial, and industrial intakes are the focus of the water supply analysis as these intakes tend to be larger and at a fixed location, and are more likely to be impacted by MRRMP-EIS alternatives. Table 3-248 presents the distribution of water supply intakes by location along the Missouri River.

Table 3-248. Number of Water Supply Intakes by River/Reservoir Location

River/Reservoir Reach	Intakes			
	Municipal	Commercial/Industrial	Domestic	Public
Fort Peck Lake	1	0	101	2
Fort Peck Dam to Lake Sakakawea	4	0	162	1
Lake Sakakawea	15	27	228	11
Garrison Dam to Lake Oahe	7	7	28	3
Lake Oahe	8	0	21	8
Oahe Dam to Lake Sharpe	1	0	0	0
Lake Sharpe	3	0	19	2
Lake Francis Case	5	0	4	3
Fort Randall Dam to Lewis and Clark Lake	0	0	0	0

River/Reservoir Reach	Intakes			
	Municipal	**Commercial/Industrial**	**Domestic**	**Public**
Lewis and Clark Lake	2	0	6	2
Gavins Point Dam to Rulo, Nebraska	4	1	10	8
Rulo, Nebraska to the Mouth of the Missouri River	14	0	0	4
Total	**64**	**35**	**579**	**44**

Sources: USACE 2015c, 2006a; USACE and USFWS 2012; Personal communication with water supply intake managers and operators.

There are an estimated 64 municipal intakes and 35 commercial/industrial water supply intakes on the reservoirs and river reaches of the Missouri River Mainstem. Approximately 3.2 million people are served by Missouri River municipal water supply intakes and associated facilities. Several Tribes are served by water supply intakes along the Missouri River including the Assiniboine and Sioux, Three Affiliated Tribes, Standing Rock Sioux, Cheyenne River Sioux, and lower Brule Sioux. The Mni Wiconi Pipeline project supplies water to several reservations that are not located on the Missouri River including the Oglala Sioux Tribe and Rosebud Sioux Tribe. Of the estimated 35 commercial/industrial water supply intakes operating along the Missouri River, 34 are in North Dakota and one in Iowa.

Water supply for municipal and industrial/commercial uses along the Missouri River can be affected by conditions such as river flows and stages, reservoir water surface elevations, river water chemistry including sediment, and channel locations. Changes to these physical components, in turn, lead to changes in water supply f access, operation and maintenance, and water treatment requirements.

Access to water is vital to the operations of water supply intakes. The ability of the water supply intakes to access water is typically affected by the river flow or river/reservoir elevation, the amount of sediment in the water and around the intake and, less frequently, by the presence of ice. Each water supply intake typically has a minimum elevation necessary for normal operation as well as a critical shutdown elevation. River or reservoir conditions above the minimum flow/elevation allow for the unimpeded pumping of water or free-flow of water through the intake. However, when the conditions are below the minimum flow/elevation, the ability for free-flow or pumping becomes more difficult requiring additional measures as discussed in the "Operations, Maintenance, and Modifications" section (Section 3.18.1.3). An intake cannot access water when the elevation falls below the intake screen. Suspended sediment can clog intake screens and impede the withdrawal of water through the intake. Depending on the position of the screen, ice can build up or be pulled through the intake. If sediment and ice issues do occur, it is usually during periods of low flow/elevation or during conditions specific to a site (e.g., wind). Permanent water supply intakes have been built at specific elevations and locations to access river and reservoir water. If access to river water is decreased or interrupted, permanent intakes would require more effort (i.e., labor, cost, infrastructure modification, etc.) to ensure continued water withdrawal compared to portable intakes.

3.18.1.1 Water Quality and Water Treatment

Water quality is important to municipal and commercial/industrial water supplies because it can affect the level of treatment required to provide potable water for various needs. Various treatment requirements, processes, and associated costs are necessary to protect public health by limiting the levels of contaminants, pollutants, and other undesirable characteristics in drinking water. The Safe Drinking Water Act of 1974 established the basic framework for protecting drinking water used by public water systems in the United States. EPA sets the national standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. The amount and type of treatment applied to drinking water can vary greatly depending on the quality of the source. Water suppliers use one or a combination of treatment processes to remove contaminants from drinking water including flocculation and sedimentation, filtration, ion exchange, absorption, and disinfection (EPA 2004). Monitoring ensures that treated water complies with federal and state or Tribal standards. Changes in the level of contaminants, pollutants, and river sediment concentration and in the size of suspended sediment particles can affect the level of treatment, operations, and maintenance activities required for water supply needs.

The chemical and physical properties of the Missouri River affect human uses of the river including water supply. The primary sources of pollution, both point and non-point sources, along the Missouri River are from urban, agricultural, and industrial land uses. The construction of dams and impoundments trap suspended sediment and particulates, modify the flow regime of the river, and influence water quality within the reservoirs and the downstream reaches. Additionally, the river flows, stages and channel geometry can influence water quality within the river. A more detailed discussion of water quality of the Missouri River is discussed in section 3.7, Water Quality.

3.18.1.2 Intake Operations, Maintenance, and Modifications

Physical and chemical river conditions described above influence operational and maintenance activities and associated operational, maintenance, and capital costs. Low flows or low pool elevations can affect the efficiency of intake pumping operations and can require operational shutdown if water levels are too low. Inadequate access to water requires intake operators to alter operations and/or modify their intake structures. Intakes can be extended or pumping operations modified. Other modifications include installation of new pumps or a new intake or screen, modification of the intake screen position, enhanced connections to other water providers for emergency supplies, temporary modifications of intakes, or drilling of a well for an alternative water source. Ice deflectors can be installed to prevent water access issues from ice jams. Changes or extreme fluctuations to river stages would require pumps to be reset. Frequent disruptions in water supply due to access issues may require intake modification and/or investment in substitute water sources.

Transport of sediment during high flows and sedimentation during low flows can affect operations and maintenance in various ways. Increased suspended sediment or bed load material can clog screens and settle around the intakes reducing their pumping efficiency and cause instability to the intake structure. This situation would require increased maintenance efforts such as cleaning and restabilization to allow for reliable access to water and efficient pumping. The deposition of sediment around an intake structure can be beneficial by providing support and stability whereas too little sediment could adversely affect the structural integrity of the intake. Algal blooms and sedimentation could lead to increased water treatment costs. Extreme situations require the replacement of equipment or the shutdown of an intake or associated water treatment facility.

Operating and shut-down elevations of water supply intakes are designed to accommodate changing water surface elevations of the river and reservoirs. If the water surface elevation falls below the operating elevation, the intake begins to require more than “normal” measures in order to operate, in the form of increased pumping or operations, maintenance, and water treatment. The shutdown elevation is the point at which the intake is no longer operable or can no longer function without damaging the infrastructure.

3.18.2 Environmental Consequences

Alternative means of achieving species objectives are evaluated for their effects on access to water supply. The alternatives evaluated include management actions with potential to affect river flows, reservoir elevations, channel form, and river stage. The water supply impact analysis focuses on determining if changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives could result in an impact to water supply access and costs. This section summarizes the water supply methodology and presents the results of the assessment. A detailed description of the methods used for the analysis of water supply access including data sources and assumptions can be found in the “Water Supply Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.18.2.1 Impact Assessment Methodology

The impacts to water supply access and costs are evaluated using three of the four accounts (NED, RED, and OSE). The analysis focuses on the costs to water supply operations to adapt to changing river and reservoir conditions. The costs estimated for each management plan alternative are compared to the costs incurred under Alternative 1.

As river flows and reservoir elevations fall below minimum operating requirements, intakes are unable to access water for municipalities, Tribes, commercial operations, and others. This in turn can drive changes in costs to operate water supply intakes. The analysis used outputs from the HEC-RAS and HEC-ResSim Missouri River models to simulate river and reservoir operations over the POR. The impact analysis first determined the operating and shut-down thresholds for each water intake. Model simulations were used to determine how many days each intake would be below each threshold annually under the respective alternative. The analysis focuses on 59 municipal and commercial intakes[18] used for water supply along the river from Montana to Missouri that were determined to be operable during the MRRMP-EIS study period and could potentially be impacted by the MRRMP alternatives. These fixed intakes are likely to realize any impacts that may occur from the MRRMP-EIS alternatives and are representative of the impacts that may occur to other intakes.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

[18] The data in Table 3-229 was obtained from various sources and include intakes that are permitted but not necessarily operating or will be operating during the study period. In other instances, multiple entities may share an intake; all of which require a permit. Finally, in some cases, the project team was unable to obtain necessary information (operating and shut-down thresholds) in order to include the intake within the analysis. The 59 intakes that were evaluated provide a representative sample of intakes and impacts that may occur from the MRRMP alternatives.

National Economic Development

The NED analysis calculated the change in costs from changes in access to water from the Missouri River. An Excel®-based model was developed that estimated the costs to access water under each alternative. The NED analysis for water supply access focuses on the change in variable and fixed costs to municipal and commercial water facilities.

Regional Economic Development

The RED analysis for water supply was based on the results of the NED analysis. The NED analysis showed small changes in costs to access water from the Missouri River under each of the MRRMP-EIS alternatives relative to Alternative 1. Although there are measurable differences in costs between alternatives, these differences are not large enough to result in measurable impacts to water rates and regional economic conditions. Therefore, any RED effects are discussed qualitatively.

Other Social Effects

Changes in water supply access have a potential to cause other types of effects on individuals and communities, which are analyzed under the OSE account. The OSE analysis for water supply relied on the results of the NED and RED analysis to determine the scale of impacts that could occur to individual and community well-being, access to safe water sources, and economic vitality. Although there are measurable differences in costs between alternatives, these differences are not large enough to result in measurable OSE impacts. Impacts of the alternatives on OSE are discussed qualitatively.

3.18.2.2 Summary of Environmental Consequences

The environmental consequences relative to water supply are summarized in Table 3-249.

Table 3-249. Environmental Consequences Relative to Water Supply

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Management Actions Common to All Alternatives	No NED impacts because these actions do not impact flows or water surface elevations.	No RED impacts.	No OSE impacts.	Management actions common to all alternatives would have no impacts on water supply intakes because these actions do not impact flows or water surface elevations.
Alternative 1	Average Annual Costs: $584,000. Range of Annual Costs: ($78,300 to $2.3 million). Long-term adverse impacts would occur mainly from the variability in hydrology and change in hydrologic conditions over the POR.	Intake improvements may result in increases in water utility rates to customers.	Negligible OSE impacts.	Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.

Alternative	NED Impacts	RED Impacts	OSE Impacts	Other Impacts
Alternative 2	Change in Average Annual Costs: −$6,000 or −1.0%. Small short-term, beneficial impacts would occur in the late fall and winter months in certain years.	Negligible change in RED impacts.	Negligible OSE impacts.	Potential for small, short-term, and adverse impacts to water supply intakes located in reaches where the habitat construction would take place.
Alternative 3	Change in Average Annual Costs: −$3,600. Small, beneficial impact with an elimination of the spring pulse.	Negligible change in RED impacts.	Negligible OSE impacts.	Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.
Alternative 4	Change in Average Annual Costs: $28,000. Small, adverse impact on water supply intakes which occur in the late fall and winter months in certain years.	Negligible change in RED impacts.	Negligible OSE impacts.	Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.
Alternative 5	Change in Average Annual Costs: $1,200. Small, adverse impact on water supply intakes. Some years show adverse impacts likely due to System rebalancing.	Negligible change in RED impacts.	Negligible OSE impacts.	Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.
Alternative 6	Change in Average Annual Costs: $24,800. Small, temporary, and adverse impact on water supply intakes, which are likely indirect impacts of the pulses when the System is rebalancing.	Negligible change in RED impacts.	Negligible OSE impacts.	Impacts from habitat construction actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.

Impacts of the MRRMP Alternatives on water quality are discussed in detail under Section 3.7. In general, the MRRMP alternatives are expected to have temporary, negligible adverse impacts from increased nutrients, pollutants, water temperatures, and lower dissolved oxygen concentrations and small temporary adverse impacts from increased sediment and turbidity. Overall, the long-term impacts from the alternatives are expected to be negligible. However, habitat construction could have localized impacts that could impact certain intakes. While it is not possible to determine which intakes would be affected it is expected the impacts would be short-term and temporary.

3.18.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include predator management, vegetation management, and human restrictions measures. These actions are not expected to have any impacts on water supply intakes along the Missouri River because these actions do not affect flows or water surface elevations.

3.18.2.4 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 represents current System operations including a number of management actions associated with MRRP implementation. Management actions under Alternative 1 include construction of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring plenary pulse.

These actions would be focused in the Garrison and Gavins Point reaches for ESH habitat construction and between Ponca to the mouth of the river near St. Louis for early life stage habitat. Only intakes in these reaches would be impacted. Impacts of the spring plenary pulse are evaluated below.

Consistent water supply for communities requires intakes to be submerged in the water at all times and at the same time to not be buried by sediment deposits. Water supply intakes are thus affected from the variability in hydrology and change in hydrologic conditions over the POR as well as aggradation and degradation processes (see Section 3.2 “River Infrastructure and Hydrologic Processes”). The POR is characterized by substantial variability in hydrologic conditions which includes periods of drought (i.e., 1930s) and high runoff. This variation results in substantial variability in impacts to water supply intakes in the basin which can be adverse or beneficial depending on the conditions at the site of the intake.

Modeling results for Alternative 1 indicate that water supply intakes, if they were to remain at existing elevations, would experience long-term, adverse impacts under continuation of current System operations. These impacts would be due to instances when water surface elevations fall below critical operating thresholds (operating and shut-down). The modeling results show that 36 of the 59 intakes would experience on average 71.4 days per year when water surface elevations would fall below operating thresholds. In addition, 26 of the 59 intakes would experience on average 22.7 days when water surface elevations are below shut-down elevations under Alternative 1. These impacts are occurring in both the upper and lower river and along riverine areas as well as reservoirs, although the drivers of these impacts vary by location. For intakes in the upper river located on the reservoirs, impacts appear to occur most often during extended drought periods like those of the 1930s when reservoir storage levels would fall to a point where releases are reduced to non-navigation support. Intakes in the lower river located in riverine stretches appear to be affected most directly from bed degradation issues.

System operations under Alternative 1 would be the same as the current operations. However, as described in Section 3.1, Introduction, the impacts modeled do not account for the ability of water management to adapt to changing conditions on the System to serve authorized purposes, such as water supply. It also does not account for what activities may be implemented in the future relative to bed degradation which may be influencing model results. This is because the 2012 river geometry used in HEC-RAS modeling reflects a level of bed degradation that was not present in prior years included in the POR analysis. These impacts are discussed in more detail in Section 3.2, River Infrastructure and Hydrologic Processes.

Given the frequency and duration of these periods where water surface elevations fall below critical operational thresholds, it is likely that water supply operators would need to make intake improvements, modifications, or relocation to adapt to changing conditions along the river. For instance, USACE evaluated the impacts of bed degradation on intakes and other structures in the lower river in the “Missouri River Bed Degradation Study Technical Report” (May 2017). The report stated that “River bed degradation has caused the low-flow water-surface elevations to decrease, forcing utilities to make modifications to their intake structures to obtain water” (USACE, 2017). Utilities in Kansas City, Missouri, Johnson County, Kansas and Leavenworth, Kansas have all made modifications to their intakes to account for degradation or have had to utilize auxiliary pumps. USACE estimated that water utilities would incur $23 million for auxiliary intake equipment, $244.8 million for new intake construction and $135.6 for alternative water supply sources to adapt to continued bed degradation in the lower river.[19]

Mechanical Habitat Construction

Management actions associated with habitat construction have the potential to impact access to water supply. In particular, management actions focused on mechanical construction of ESH and early life stage habitat for pallid sturgeon, have the potential to disrupt water supply operations. For instance, constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in aggregation segments of the river. This can result in increased maintenance issues to water supply intakes in areas of aggradation (USACE 2011).

While the construction of habitat using similar means is common across all alternatives, the location and magnitude of these actions varies by alternative. The extent of these impacts would be dependent on where the MRRMP-EIS actions would occur relative to any water supply intakes. The potential impacts of ESH on infrastructure such as water supply intakes was evaluated in the *Final Programmatic Environmental Impact Statement for Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011a). The PEIS noted that in order to mitigate impacts of habitat creation, USACE would identify sensitive resource categories and subsequent protective or exclusionary zones associated with these resources. These practices would continue to occur. Site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources. Intakes and other infrastructure were included as categories of sensitive resources. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases which would identify approaches to avoid or mitigate impacts associated with these actions on water supply intakes. With these restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, localized, temporary, and adverse and limited to intakes near the site of habitat construction.

National Economic Development

Under Alternative 1, several of the water supply intakes would experience long-term, adverse impacts. The project team did not attempt to evaluate the cost of intake modifications that may occur due to bed degradation or prolonged drought conditions as modeled under Alternative 1 because these modifications would likely address any short-term impacts that are likely to occur under the MRRMP alternatives. Instead, the NED analysis focused on actions that water supply operators can take to adapt to small changes in river flows and reservoir elevations that are expected to occur under the MRRMP-EIS alternatives compared to Alternative 1. One such approach would be to use different-sized submersible pumps; a method that has been applied

[19] All figures are in FY 2017 dollars.

by intake operators during periods of low water surface elevations. In order to compare the MRRMP-EIS alternatives to Alternative 1, this same approach of using submersible pumps to adapt to periods of low water surface elevations was used in the NED analysis for Alternative 1. The NED analysis evaluated the costs of using submersible pumps under Alternative 1 to adapt to periods when water surface elevations would be below critical water supply intake thresholds.

The NED analysis for Alternative 1 is summarized in Table 3-250. Water supply intake operators along the Missouri River would incur average annual costs of over $584,000 to adapt to changing conditions of the river. Average costs would be higher in the lower river than in the upper river in part due to the size of the intakes, which require larger pumps to move the required amount of water to the intake than for intakes in the upper river. Total annual costs for all intakes would range from a low of just under $78,000 to over $2.3 million. Higher costs in some years would be caused by extended drought conditions and the spring plenary pulse under Alternative 1 would have negligible contributions to these effects.

Table 3-250. Summary of National Economic Development Analysis for Alternative 1

Costs	Upper River	Lower River	All Locations
Total Variable Costs (POR) [a]	$18,886,938	$21,018,040	$39,904,978
Total Fixed Costs (POR) [b]	$4,717,950	$3,264,149	$7,982,099
Total Costs (POR)	$23,604,888	$24,282,188	$47,887,077
Annual Average Total Costs	$287,864	$296,124	$583,989
Annual Average Total Costs per Intake	$7,197	$15,585	$9,898
Maximum Annual Costs	$765,490	$1,649,254	$2,326,102
Minimum Annual Costs	$52,816	$3,160	$78,345

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Regional Economic Development

The RED analysis for water supply intakes focuses on the potential for local customers to realize an increase in rates due to changes in operations, which could have implications for regional economic conditions. Under Alternative 1, some water supply operators would consider making capital investments for intake modifications to adapt to changing river conditions. The NED analysis showed that on average water supply operators would incur just under $9,900 per year to adapt to changing conditions along the river and reservoirs using submersible pumps. For intakes in the lower river, costs would approach $15,600 on average per year per intake. For many of the larger facilities, these average annual cost increases would be a small percentage of annual operating budgets that can exceed $100 million. However, the costs to deal with conditions under Alternative 1 are likely already affecting costs and potentially rates, and management actions under Alternative 1 may affect rates and regional economic conditions.

Other Social Effects

Changes in access to water supply have the potential to cause other types of effects on individuals and communities such as community well-being, access to safe water sources, and economic vitality. While water supply intakes are expected to experience long-term, adverse impacts under Alternative 1, OSE would be negligible. Adverse impacts under Alternative 1 can be described as the increased frequency and duration of periods of inaccessibility to water. However, the modeled results do not show instances with individual intakes where access is completely eliminated. These impacts are likely to result in increased costs and possible subsequent rate increases; however, OSE including community well-being, economic vitality and public health and safety are not expected under Alternative 1.

Conclusion

Consistent water supply for communities requires that intakes be submerged in the water at all times while not getting buried by sediment deposits. Water supply intakes are thus affected from the variability in the hydrologic conditions over the POR and aggradation and degradation processes. Modeling results for Alternative 1 indicate that water supply intakes, if they were to remain at existing elevations, would experience long-term, adverse impacts under continuation of current operations. These impacts would be due to instances when water surface elevations fall below critical operating thresholds (operating and shut-down). It was estimated that water supply intake operators along the Missouri River would incur on average annual costs of over $584,000 to adapt to changing conditions of the river. Total annual costs for all intakes would range from a low of just under $78,300 to over $2.3 million and management actions included under Alternative 1 would have a negligible contribution to these costs. Under Alternative 1, some water supply facilities would likely consider making capital investments associated with intake modifications to adapt to changing conditions. These cost increases have the potential to lead to an increase in rates although the magnitude of the rate increases is unknown; however, OSE including community well-being, economic vitality, and public health and safety are not expected under Alternative 1.

Management actions focused on mechanical construction of ESH and SWH would have the potential to disrupt water supply operations. Constructing large areas of ESH can accelerate bedload movement from degradation segments and accelerate deposition in aggregation segments of the river. With site selections restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, localized, temporary, and adverse and limited to intakes near the site of habitat construction and thus management actions implemented under Alternative 1 would not have a significant impact to water supply access.

3.18.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under an adaptive management framework. Actions under this alternative that may have impacts to water supply intakes include a spring pallid sturgeon flow release; low summer flow; and construction of early life stage habitat and ESH habitat.

Mechanical Habitat Construction

Habitat construction actions would be focused in the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for early life stage habitat. Because of the substantial amount of habitat that would be constructed under this alternative, there would be the potential for small, short-term, and adverse impacts to water supply intakes. These impacts would be limited to those water supply intakes that are in the reaches where the habitat construction would take place. In addition, site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources such as water supply intakes. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases which would identify approaches to avoid and/or mitigate impacts associated with these actions on water supply intakes. With these restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.

NED Analysis

The NED Analysis for Alternative 2 is summarized in Table 3-251. Water supply operations along the Missouri River would incur on average $578,000 per year to adapt to changing conditions of the river. Total annual costs range from $93,400 to $2.3 million. This represents an overall small decrease in costs (-$6,000) to water supply intakes of 1.0 percent relative to Alternative 1.

Table 3-251. Summary of National Economic Development Analysis for Alternative 2

Costs	Upper River	Lower River	All Locations
Total Variable Costs (POR) [a]	$18,796,947	$20,655,748	$39,452,695
Total Fixed Costs (POR) [b]	$4,727,615	$3,218,059	$7,945,674
Total Costs (POR)	$23,524,562	$23,873,807	$47,398,369
Difference in Total Costs from Alternative 1	−$80,326	−$408,382	−$488,708
Percentage Difference from Alternative 1	−0.3%	−1.7%	−1.0%
Annual Average Total Costs	$286,885	$291,144	$578,029
Difference in Annual Average Costs from Alternative 1	−$980	−$4,980	−$5,960
Difference in Annual Costs per Intake	-$24	−$262	−$101
Maximum Annual Costs	$776,955	$1,651,173	$2,329,425
Minimum Annual Costs	$58,998	$6,272	$93,365

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

When evaluating the impacts of each MRRMP-EIS alternative, annual impacts as well as those that would occur on average were examined. The annual analysis shows that access to water supply in both the lower and upper river would experience more years when costs would increase than when costs would decrease under Alternative 2. However, the overall costs are dominated by four years when costs would decrease in the lower river by more than $100,000 relative to Alternative 1. These beneficial impacts are occurring in the fall and winter months after a low summer flow event when river flows are higher in the lower river under Alternative 2. Water supply access in the upper river, including Tribal intakes, would also experience a small beneficial impact under Alternative 2 due to higher levels in the reservoirs from a low summer flow. The difference in costs from Alternative 1 for intakes in the upper river ranged from −$210,000 to $72,000.

Additional modeling results are summarized in Table 3-252, which shows the difference in annual costs to water supply during years when there is a release action or a low summer flow. The results show that the greatest beneficial impacts to intakes in the lower river would occur in years when there is full release and a low summer flow or the following years when these events occur. These beneficial impacts would occur during the winter or fall months when flows are slightly higher under Alternative 2 after a low summer flow. Table 3-252 also summarizes the impacts by flow type for intakes in the upper river for Alternative 2 relative to Alternative 1. In the upper river, beneficial impacts are occurring in years after a full release and low summer flow as reservoir levels would be higher benefiting intakes in the upper river. The increase in costs to access water in the upper river would be relatively small with the largest annual increase of approximately $72,000 for all 40 intakes located in the upper river.

Table 3-252. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1

Release	Cost Change	Lower River	Upper River
Full Flow Release + Low Summer Flow [a] (Change in $ from Alternative 1)	Lowest Cost Change	−$179,000	−$9,000
	Highest Cost Change	$11,000	$23,000
Partial Flow Release [b]	Lowest Cost Change	−$42,000	−$48,000
	Highest Cost Change	$54,000	$59,000
Year after Full Flow Release	Lowest Cost Change	−$166,000	−$210,000
	Highest Cost Change	$34,000	$60,000
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Cost Change	−$179,000	−$210,000
	Highest Cost Change	$54,000	$72,000

a Flow action plus low summer flow would be fully implemented in 3 years of the period of record. Low summer flow events would also be implemented in the year after the full spawning cue release. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action would be partially implemented in 31 years of the period of record. A partial release year is defined as a year when a partial spawning cue occurs in March and/or May or a full release happens in March or May. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

Regional Economic Development

It is anticipated that Alternative 2 would have negligible RED impacts. Under Alternative 2, a number of water supply facilities would likely realize a small decrease in costs associated with changing river conditions, especially on the lower river. While these cost decreases have the potential to result in lower operating costs, impacts on rates and regional economic conditions are expected to be negligible under Alternative 2.

Other Social Effects

On average, water supply intakes are expected to experience short-term, relatively small, beneficial impacts under Alternative 2 with negligible other social effects.

Conclusion

Under Alternative 2, water supply intakes would experience relatively small, short-term, beneficial impacts relative to Alternative 1. These impacts would be due to a slight reduction in the number of days when water surface elevations fall below critical operating thresholds (operating and shut-down) for water supply intakes relative to Alternative 1. On average, water supply intakes along the Missouri River would experience a reduction in costs of $6,000 (1.0 percent) per year to adapt to changing conditions of the river under Alternative 2 relative to Alternative 1. While on average these impacts are small in nature there are some years when water supply intakes would experience small adverse impacts. The greatest adverse impacts to water supply in the lower occur in years when there is a partial release; in the upper river it is in a year that is not attributable to a flow release. It is anticipated that Alternative 2 would have negligible RED and OSE impacts.

Habitat construction actions would be focused in the Garrison, Fort Randall, Lewis and Clark, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for early life stage habitat for pallid sturgeon. Because of the substantial amount of habitat that would be constructed under this alternative, there would be the potential for localized adverse impacts to water supply intakes. However, these impacts would be small and temporary due to sight selection criteria that would avoid critical infrastructure. In addition, these impacts would be limited to those water supply intakes that are in the reaches where the habitat construction would take place. Alternative 2 is not expected to have significant impacts on water supply access.

3.18.2.6 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include those that focus on the construction of ESH and IRC through mechanical means. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis.

Mechanical Habitat Construction

Habitat construction actions would be focused in the Garrison, Fort Randall, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for early life stage habitat. Construction of habitat under this alternative would have the potential for small, short-term, and adverse impacts to water supply intakes. These impacts would be limited to those water supply intakes that are in the reaches where the habitat construction would take place. In addition, site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources such as water supply intakes. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases which would identify approaches to avoid and/or mitigate impacts associated with these actions on water supply intakes. With these restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.

National Economic Development

The NED effects associated with Alternative 3 are summarized in Table 3-253. Overall, Alternative 3 would have a small, beneficial impact on water supply access relative to Alternative 1. The modeling results show that 36 of the 59 intakes would experience a slight decrease in the average number of days (71.0) when water surface elevations would fall below operating thresholds under Alternative 3. In addition, 26 of the 59 intakes would experience on average 22.5 days when water surface elevations are below shut-down elevations under Alternative 3; a slight decrease (−0.2 days) from Alternative 1. Total costs for all water supply intakes would decrease by an average of $3,600 per year or a decrease of 0.6 percent from Alternative 1. Most of these cost decreases would occur almost equally between the upper and lower river.

Evaluation of annual NED impacts to water supply access in the upper and lower river shows most years with a reduction in costs relative to Alternative 1. In fourteen years of the POR, costs for water supply access would decrease in the lower river, however, in only four years do these costs exceed $1,500 for all 19 intakes in this region. These same locations would also realize a reduction in costs relative to Alternative 1 of greater than $20,000 in two years of the POR.

Water supply access in the upper river, including Tribal intakes, would experience more beneficial impacts under Alternative 3 than locations in the lower river. In 61 years of the POR, water supply access in the upper river experience a decrease in costs. Intakes in the upper river experience cost decreases greater than $5,000 in 13 of the 61 years with three years being greater than $15,000. Annual costs to access water in the upper river would range from a low of −$54,600 to $765,000 under Alternative 3.

Table 3-253. Summary of National Economic Development Analysis for Alternative 3

Costs	Upper River	Lower River	All Locations
Total Variable Costs (POR) [a]	$18,741,290	$20,915,863	$39,657,152
Total Fixed Costs (POR) [b]	$4,686,271	$3,249,391	$7,935,662
Total Costs (POR)	$23,427,561	$24,165,254	$47,592,815
Difference in Total Costs from Alternative 1	−$177,327	−$116,935	−$294,262
Percentage Difference from Alternative 1	−0.75%	−0.5%	−0.6%
Annual Average Total Costs	$285,702	$294,698	$580,400
Difference in Annual Average Costs from Alternative 1	−$2,163	−$1,426	−$3,589
Difference in Annual Costs per Intake	−$54	−$75	−$61
Maximum Annual Costs	$765,156	$1,649,129	$2,325,851
Minimum Annual Costs	$54,597	$2,847	$73,840

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Regional Economic Development

It is anticipated that Alternative 3 will have negligible RED impacts. Under Alternative 3, a number of water supply facilities would likely realize a small decrease in costs associated with changing river conditions, especially along the lower river. The cost decreases predicted under Alternative 3 are not expected to lead to a change in water rates or regional economic conditions.

Other Social Effects

Access to water supply from the Missouri River is expected to experience relatively small beneficial impacts under Alternative 3; however, these beneficial impacts are not expected to result in changes in OSE. Beneficial impacts predicted under Alternative 3 can be described as a decrease in the frequency and duration of periods of inaccessibility to water relative to Alternative 1. These impacts are likely to result in a relatively small decrease in costs; however, OSE including community well-being, economic vitality, and public health and safety are not expected to occur under Alternative 3.

Gavins Point One-Time Spawning Cue Test

The one-time spawning cue test (Level 2) release that may be implemented under Alternative 3 was not included in the hydrologic modeling for the alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Flows equivalent to the one-time spawning cue test were modeled for multiple years in the POR under Alternative 6. Water supply impacts under Alternative 6 were described on average as small, temporary, and adverse. On an annual basis the adverse impacts tend to be greatest in the lower and upper river in years with a full or partial release and years after a full release, especially with the onset of drought conditions. RED impacts and OSE impacts were estimated to be negligible. Because Alternative 6 modeling results show a small increase in the number of days falling below thresholds in the POR, the one-time implementation of the pulse would likely cause small temporary impacts to water intakes in the year the pulse is implemented and the 1 to 2 years following the pulse when the reservoir levels are recovering. Impacts to RED and OSE would likely be negligible because the pulse would only be run once under Alternative 3.

Conclusion

Overall, Alternative 3 would have a relatively small, beneficial impact on water supply access relative to Alternative 1. Over all locations, average annual costs would decrease by $3,600 (−0.6 percent) from Alternative 1. These cost decreases would occur across both the upper and the lower river and are likely the result of the elimination of the spring pulse release under this alternative. The one-time implementation of a test pulse would likely cause small temporary impacts to water intakes in the year the pulse is implemented and the 1 to 2 years following the pulse when the reservoir levels are recovering. Alternative 3 is expected to have negligible RED and OSE impacts. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Only water supply intakes in these reaches would be affected similar to the impacts discussed under Alternative 1. Alternative 3 is not expected to have significant impacts on water supply access.

3.18.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 focuses on developing ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis.

Mechanical Habitat Construction

Habitat construction actions would be focused in the Garrison, Fort Randall, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for early life stage habitat. Construction of habitat under this alternative would have the potential for small, short-term, and adverse impacts to water supply intakes. These impacts would be limited to those water supply intakes that are in the reaches where the habitat construction would take place. In addition, site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources such as water supply intakes. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases which would identify approaches to avoid and/or mitigate impacts associated with these actions on water supply intakes. With these restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.

National Economic Development

The NED effects of Alternative 4 are summarized in Table 3-254. On average, Alternative 4 has a small, adverse impact to water supply access relative to Alternative 1. The modeling results show that the same number intakes (36) would experience an increase in the average number of days (74.1) per year when water surface elevations would fall below operating thresholds under Alternative 4. In addition, 28 of the 59 intakes would experience on average 23.4 days per year when water surface elevations are below shut-down elevations under Alternative 4. Over all locations, average annual costs would increase by more than $28,000 or 4.9 percent from Alternative 1. Impacts would occur across both the lower and upper river with annual costs ranging from $84,000 to $2.3 million.

While the changes in average annual costs to access water from the Missouri River relative to Alternative 1 would be small under Alternative 4, facilities would experience an increase in costs much more frequently under this alternative than under Alternative 1. Annual costs in the upper river increased by greater than $60,000 in 9 years during the POR. Releases in combination with the onset of drought conditions similar to those in 1960s and 2000s appear to result in the greatest increase in costs for water supply access in the upper river. Costs for water supply access in the lower river would also increase relative to Alternative 1. Five of these years show an increase in costs greater than $60,000. Differences in annual costs to access water in the lower river over the POR would range from $3,500 to $1.6 million.

Table 3-254. Summary of National Economic Development Analysis for Alternative 4

Costs	Upper River	Lower River	All Locations
Total Variable Costs (POR) [a]	$20,194,641	$21,664,153	$41,858,794
Total Fixed Costs (POR) [b]	$4,992,950	$3,359,730	$8,352,680
Total Costs (POR)	$25,187,591	$25,023,883	$50,211,474
Difference in Total Costs from Alternative 1	$1,582,702	$741,695	$2,324,397
Percentage Difference from Alternative 1	6.7%	3.1%	4.9%
Annual Average Total Costs	$307,166	$305,169	$612,335
Difference in Annual Average Costs from Alternative 1	$19,301	$9,045	$28,346
Difference in Annual Costs per Intake	$483	$476	$480
Maximum Annual Costs	$782,299	$1,649,129	$2,342,390
Minimum Annual Costs	$54,597	$3,552	$84,205

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Table 3-255 shows the difference in NED costs between Alternative 1 and 4 for the type of releases occurring each year for the lower and upper river. The results show that the largest adverse impacts occur the year with a full release and year following a full release to water supply access in the upper river relative to Alternative 1. These impacts are exacerbated if a full release occurs prior to the onset of drought conditions.

Water supply access in the upper river would be affected most often under Alternative 4 in years when there is a full release and years that follow a full release. Adverse impacts are exasperated when these releases occur prior to the onset of drought conditions similar to those of the early 1960s, and mid-2000s. For example, the modeling results show that the spring release under Alternative 4 for hydrological conditions in 1963 would decrease elevations of Lakes Sakakawea and Oahe by several feet. These low reservoir levels would continue for several years. These conditions would result in an increase in costs for water supply access in the upper river. Similar results occurred when drought conditions in the early 1990s coincide with a full release event causing adverse impacts to water supply access in the upper river. Adverse impacts during the worst years would be relatively large with the largest impact resulting in an increase in costs of approximately $155,000 for all 40 intakes located in the upper river.

Table 3-255. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1

Release	Cost Change	Lower River	Upper River
Full Flow Release [a] (Change in $ from Alternative 1)	Lowest Cost Change	$310	−$5,000
	Highest Cost Change	$42,000	$155,000
Partial Flow Release [b]	Lowest Cost Change	−$1,600	−$4,400
	Highest Cost Change	$8,600	$45,000
Years after the Full Flow Release (Change in $ from Alternative 1)	Lowest Cost Change	$360	−$5,600
	Highest Cost Change	$78,500	$101,500
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Cost Change	−$6,600	−$25,400
	Highest Cost Change	$78,500	$155,000

a Flow action would be fully implemented in 9 years of the period of record. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action would be partially implemented in 7 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

Regional Economic Development

In is anticipated that Alternative 4 would have negligible RED impacts. Under Alternative 4, a number of water supply facilities would likely realize a relatively small increase in costs on average associated with changing river conditions, especially for intakes in the upper river. Small annual average increases in costs are not anticipated to result in rate increases with no anticipated impacts to regional economic conditions.

Other Social Effects

While water supply intakes are expected to experience small, short-term, and adverse impacts under Alternative 4, these effects are not expected to lead to OSE impacts over time. Adverse impacts under Alternative 4 can be described as increased frequency and duration of periods of inaccessibility to water relative to Alternative 1. While average annual costs are expected to increase slightly these impacts are not expected to result in in further impacts to community well-being, economic vitality, and public health and safety.

Conclusion

Overall, Alternative 4 is expected to have a small, adverse impact on water supply accessibility. Over all locations, annual average costs would increase by $28,000 (4.9 percent) from Alternative 1. Alternative 4 has the largest impact on water supply access relative to Alternative 1 of any of the MRRMP-EIS alternatives and these impacts would occur across both the lower and upper river. Annual costs range from nearly $84,000 to $2.3 million. For water supply facilities in the lower river, the largest adverse impacts would occur in years after a full release when the System is rebalancing. For years with the largest adverse impacts, these impacts would occur during the winter or fall months when flows tend to be at their lowest levels in the lower river. Water supply access in the upper river would be affected most often under Alternative 4 in the years following a full release during relatively drier or drought conditions similar to those of the 1930s, early 1960s, and mid-2000s. Drought conditions and its effects on reservoirs appear to be exacerbated when a full release occurs prior to drought years under Alternative 4. RED and OSE impacts would be negligible under Alternative 4.

Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Alternative 4 is not expected to have significant impacts on water supply access because of the negligible to small impacts that are expected on water supply intakes.

3.18.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 would focus on developing ESH habitat through both mechanical and reservoir releases that would occur during the fall months. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis.

Mechanical Habitat Construction

Habitat construction actions would be focused in the Garrison, Fort Randall, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for early life stage habitat. Construction of habitat under this alternative would have the potential for small, short-term, and adverse impacts to water supply intakes. These impacts would be limited to those water supply intakes that are in the reaches where the habitat construction would take place. In addition, site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources such as water supply intakes. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases which would identify approaches to avoid and/or mitigate impacts associated with these actions on water supply intakes. With these restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.

National Economic Development

The NED effects of Alternative 5 are summarized in Table 3-256. Overall, Alternative 5 would have a relatively small, adverse impact on water supply access relative to Alternative 1. The modeling results show that one additional intake (37) would experience impacts but the average number of days would decline slightly to 69.6 when water surface elevations would fall below operating thresholds under Alternative 5. In addition, 26 of the 59 intakes would experience on average 22.7 days when water surface elevations are below shut-down elevations under Alternative 5. Over all locations costs would average annual costs would increase by $1,200 or an increase of 0.2 percent from Alternative 1. The majority of these adverse impacts would occur in the lower river. Annual costs to access water along the river would range from over $84,000 to $2.3 million.

Table 3-256. Summary of National Economic Development Analysis for Alternative 5

Costs	Upper River	Lower River	All Locations
Total Variable Costs (POR) [a]	$18,907,623	$21,078,859	$39,986,483
Total Fixed Costs (POR) [b]	$4,722,670	$3,274,864	$7,997,534
Total Costs (POR)	$23,630,294	$24,353,723	$47,984,017
Difference in Total Costs from Alternative 1	$25,405	$71,535	$96,940
Percentage Difference from Alternative 1	0.1%	0.3%	0.2%
Annual Average Total Costs	$288,174	$296,997	$585,171
Difference in Annual Average Costs from Alternative 1	$310	$872	$1,182
Difference in Annual Costs per Intake	$8	$46	$20
Maximum Annual Costs	$765,156	$1,649,129	$2,325,851
Minimum Annual Costs	$57,376	$4,063	$84,216

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Evaluation of annual NED effects to water supply access in the upper and lower river shows that both regions would experience about the same number of years with cost increases and cost decreases under Alternative 5 relative to Alternative 1. This results in a relatively small adverse impact to water supply access in both the lower and upper river. However, three years in the POR show cost increases greater than $50,000. Table 3-257 shows the difference in NED costs between Alternative 1 and 5 for the type of release occurring each year. The results show that the biggest adverse impacts in the lower river are occurring in years when releases were eliminated or the year after a full release. These impacts are likely the result of System rebalancing after a flow event, which are exasperated during drought conditions. However, cost decreases are also occurring in some years when releases are eliminated or a year after a full release; the magnitude of the cost decreases are not as great as the cost increases. Differences in annual costs for intakes in the lower river range from −$23,000 to $56,800.

Table 3-257 also reports the impacts of flow releases on access to water in the upper river for Alternative 5. Water access in the upper river would experience fewer adverse effects under Alternative 5 than facilities in the lower river. Years with the greatest increase in costs are those following a fall release which coincide with the onset of drought conditions similar to those of the 1960s and 1990s when reservoirs would be lower under Alternative 5 compared to Alternative 1. For example, Alternative 5 would allow for a fall release to be initiated for hydrological conditions reflecting those that occurred in 1966. The fall release for hydrological conditions in 1966 would decrease the elevations at Lake Sakakawea by several feet, with a maximum of 7 feet, lasting through 1967 and part of 1968. The impacts that would occur to intakes in the upper river following a fall release are the result of System rebalancing and relatively lower reservoir elevations. Adverse impacts would be relatively small with the largest impact resulting in an increase in annual costs of approximately $55,800 for all 40 intakes located in the upper river. Differences in annual costs would range from a reduction in cost of nearly $25,700 to a cost increase of $55,800.

Table 3-257. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1

Release	Cost Change	Lower River	Upper River
Full Flow Release [a] (Change in $ from Alternative 1)	Lowest Cost Change	−$6,600	−$14,600
	Highest Cost Change	$1,700	−$390
Partial Flow Release [b]	Lowest Cost Change	$0	−$4,600
	Highest Cost Change	$500	$0
Year after a Full Release (Change in $ from Alternative 1	Lowest Cost Change	−$167	−$9,600
	Highest Cost Change	$8,600	$56,000
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Cost Change	−$23,000	−$25,700
	Highest Cost Change	$56,800	$55,800

a A Fall release would be fully implemented in seven years of the POR. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b A Fall release would be partially implemented in two years of the POR. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

Regional Economic Development

In is anticipated that Alternative 5 would have negligible RED impacts. Under Alternative 5, water supply costs in the lower basin are expected to realize on average a relatively small increase associated with changing river conditions. Costs are expected to increase slightly to access water in the upper river. While these cost changes have the potential to result in changes in rates it is anticipated that these rate changes would be negligible, with negligible impacts on regional economic conditions.

Other Social Effects

OSE under Alternative 5 water supply access are expected to be negligible. Annual adverse impacts that may occur under Alternative 5 can be described as increased frequency and duration of periods of inaccessibility to water relative to Alternative 1. These periods are expected to be short and not lead to changes in community well-being, economic vitality and public health and safety under Alternative 5.

Conclusion

Alternative 5 is expected to have a relatively small, adverse impact on water supply access. Over all locations, average annual costs would increase by $1,200 (0.2 percent). Years when access to water in the upper river would experience the greatest increase in costs are those years following a flow release and coincide to the onset of drought conditions similar to those of the 1960s and 1990s. Some adverse impacts would occur in years following a full release event and are likely the result of System rebalancing and relatively lower reservoir elevations. RED and OSE impacts would be negligible under Alternative 5.

Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Alternative 5 is not expected to have significant impacts on water supply access because of the negligible to small impacts that are expected on water supply intakes.

3.18.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes actions that would develop ESH habitat through mechanical means and a spawning cue release that would be mimicked through bi-modal pulses that would occur in March and May. Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis.

Mechanical Habitat Construction

Habitat construction actions would be focused in the Garrison, Fort Randall, and Gavins Point reaches for ESH habitat and between Ponca to the mouth of the river near St. Louis for early life stage habitat. Construction of habitat under this alternative would have the potential for small, short-term, and adverse impacts to water supply intakes. These impacts would be limited to those water supply intakes that are in the reaches where the habitat construction would take place. In addition, site selection for habitat construction would occur with the primary focus on avoiding impacts to sensitive resources such as water supply intakes. In addition, a more detailed hydraulic/geomorphic assessment would be completed during site-specific planning, engineering, and design phases which would identify approaches to avoid and/or mitigate impacts associated with these actions on water supply intakes. With these restrictions in place, the impacts of these management actions on water supply intakes would be relatively small, temporary, and adverse and limited to intakes near the site of habitat construction.

National Economic Development

The NED effects of Alternative 6 are summarized in Table 3-258. On average, Alternative 6 would have a relatively small, adverse impact on water supply access relative to Alternative 1. The modeling results show that the same number of intakes (36 of the 59) would experience an increase in the average number of days (74) when water surface elevations would fall below operating thresholds under Alternative 6. In addition, 28 of the 59 intakes would experience on average 22.9 days when water surface elevations are below shut-down elevations under Alternative 6. Over all locations, average annual costs would increase by $24,800 or an increase of nearly 4.2 percent from Alternative 1. Impacts would occur to water supply access in both the upper and lower river under Alternative 6.

Table 3-258. Summary of National Economic Development Analysis for Alternative 6

Costs	Upper River	Lower River	All Locations
Total Variable Costs (POR) [a]	$19,850,562	$21,771,647	$41,622,209
Total Fixed Costs (POR) [b]	$4,923,685	$3,372,527	$8,296,213
Total Costs (POR)	$24,774,247	$25,144,175	$49,918,422
Difference in Total Costs from Alternative 1	$1,169,359	$861,986	$2,031,345
Percentage Difference from Alternative 1	5.0%	3.5%	4.2%
Annual Average Total Costs	$302,125	$306,636	$608,761
Difference in Annual Average Costs from Alternative 1	$14,260	$10,512	$24,772
Difference in Annual Costs per Intake	$357	$553	$420
Maximum Annual Costs	$784,986	$1,649,129	$2,346,473
Minimum Annual Costs	$54,084	$4,063	$77,177

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Evaluation of annual NED impacts shows that water supply access in both the upper and lower river would experience an increase costs nearly every year of the POR under Alternative 6 relative to Alternative 1. The results overall show a relatively small adverse impact to water supply access. Total annual costs range from $77,000 to $2.3 million.

Table 3-259 shows the difference in NED costs between Alternative 1 and 6 for the type of release occurring each year. In the lower river, the results show that when a full or partial release would occur, access to water supply in the lower river would realize an increase in costs, but the largest increase in costs would occur in the years following a full release. Similar to Alternative 4 these years represent a time when the System is rebalancing after the release resulting in lower water surface elevations in the river relative to Alternative 1. The years with the largest impacts also correspond to the onset of drought conditions which exasperate the impacts to intakes. Differences in annual costs for water supply access in the lower river range from a low of −$7,000 to a high of $78,500.

Access to water supply in the upper river appears to be more adversely affected under Alternative 6 than in the lower river with the greatest impacts occurring in years following a full release and during the onset of drought conditions. Years with the greatest increase in costs would occur during drought conditions similar to those of the 1930s, but also conditions similar to those in the late 1950s, early 1960s, and the early 2000s. Annual costs would increase more than $40,000 for intakes in the upper river in eleven years over the POR for all 40 intakes in the upper river. Differences in annual costs relative to Alternative 1 over the POR would range from a low of −$25,000 to a high of $117,000.

Table 3-259. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1

Release	Cost Change	Lower River	Upper River
Full Flow Release [a] (Change in $ from Alternative 1)	Lowest Cost Change	−$7,800	−$3,300
	Highest Cost Change	$42,000	$64,800
Partial Flow Release [b]	Lowest Cost Change	−$7,000	−$2,500
	Highest Cost Change	$64,500	$83,000
Year after a Full Release (Change in $ from Alternative 1)	Lowest Cost Change	$37	−$10,500
	Highest Cost Change	$78,500	$117,000
Years with Greatest Range in Impacts Regardless of Flow Actions	Lowest Cost Change	−$7,000	−$25,000
	Highest Cost Change	$78,500	$117,000

a Flow action was fully implemented in six years of the POR. Data represents the lowest and highest dollar impacts in the years the action was implemented. Negative costs represent a cost savings from Alternative 1.

b Flow action was partially implemented in 29 years of the POR. Data represents the lowest and highest dollar impacts in the years the action was partially implemented. Negative costs represent a cost savings from Alternative 1.

Regional Economic Development

It is anticipated that Alternative 6 would have negligible RED impacts. Under Alternative 6, access to water supply in the upper and lower river would be expected to realize a relatively small increase in costs associated with changing river conditions. While these cost changes have the potential to result in changes in rates, it is anticipated that these rate changes would be negligible, with negligible impacts on regional economic conditions.

Other Social Effects

Access to water supply is expected to experience negligible OSE under Alternative 6. Annual adverse impacts that may occur under Alternative 6 can be described as increased frequency and duration of periods of inaccessibility to water relative to Alternative 1. These periods are expected to be short and not lead to changes in community well-being, economic vitality, and public health and safety under Alternative 6.

Conclusion

On average Alternative 6 would have a relatively small, adverse impact on water supply access relative to Alternative 1. Over all locations, annual average costs would increase by $25,000 (4.2 percent). Evaluation of annual NED impacts shows that water supply access in both the upper and lower river would experience an increase in costs nearly every year of the POR under Alternative 6 relative to Alternative 1. In the lower river, the results show that the largest impacts are occurring in years after a full release and years with a partial release. Water supply access in the upper river appears to have more adverse effects under Alternative 6 than in the lower river and many of these impacts would occur in years with a full or partial release and years after a full release, when reservoir elevations are lower, especially with the onset of drought conditions. RED and OSE impacts would be negligible under Alternative 6.

Additional ESH habitat would be constructed in the Garrison, Fort Randall, and Gavins Point reaches and IRC construction would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Only water supply intakes in these reaches would be affected in a manner similar to the impacts discussed under Alternative 1. Alternative 6 is not expected to have significant impacts on water supply access because of the negligible to small impacts that are expected on water supply intakes.

3.18.2.10 Tribal Intakes

All the intakes serving Tribal communities are located along the reservoirs and riverine stretches along the Missouri River in the upper river. Similar to other intakes in the upper river, Tribal intakes are likely to experience small, short-term, and adverse impacts under Alternative 1. Total annual average costs under this alternative to access water in the upper river is expected to be just over $288,000 per year which equates to approximately $7,200 per intake. It is expected that intakes in the upper river, including Tribal Intakes, would not realize as many impacts under Alternative 1 as those in the lower river due to the number of improvements and modifications that were made in the late 2000s in response to drought conditions. Several intakes have been extended to avoid low reservoir levels that can occur during extended drought periods. These improvements have made many of the intakes less vulnerable to water surface elevation changes like those modeled under Alternative 1. Similar to other intakes in the upper river, Tribal intakes would experience relatively small, short-term, adverse impacts under Alternatives 4, 5, and 6 and small beneficial impacts under Alternatives 2 and 3 compared to Alternative 1.

3.18.2.11 Climate Change

A discussion on the influence of climate change on the alternatives is included in Section 3.2 River Infrastructure under Climate Change. Higher spring runoff would result in higher spring System storage and the ability to run spring plenary pulses more frequently under Alternative 1. However, relatively lower late summer and fall river flows may have adverse impacts to water supply access with increase periods when water surface elevations fall below critical thresholds. The sporadic drought periods along with decreased peak snow water equivalent would result in difficulties forecasting runoff and System storage. If spring plenary pulses are run in a given year and are followed by longer, drier periods, water supply access would be affected with an increase in the number of days that water surface elevations would fall below critical thresholds for intakes.

Impacts of climate change under Alternatives 2–6 would be similar to those described under Alternative 1. The impacts of climate change under Alternative 3 would be very similar to Alternative 1, except for the absence of the spawning cue release pulses in March and May. With earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses relative to Alternative 1 may result in lower river flows in the fall and winter compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Longer and lower river flows would adversely impact water supply access, especially in the fall and winter months when flows are at their lowest levels.

Impacts of climate change under Alternative 5 would be similar to those described under Alternative 1 although with earlier snowmelt, the fall release may not be able to run as frequently if System storage is lower during the second half of the navigation season. Less frequent releases may increase river flows in the fall and winter compared to Alternative 1, which would benefit water supply access.

3.18.2.12 Cumulative Impacts

Construction of the Missouri River Mainstem Reservoir System and the associated dams allows operation with controlled flow releases from the upper river into the lower river to achieve multiple management objectives, including providing water supply access for various uses. Variability in natural hydrologic conditions (precipitation and snowmelt, which include periods of drought and high runoff) and the "rules" governing System operation would continue to dominate the flows in the Missouri River into the future. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impact to water supply access of the Missouri River. However, other actions and programs, such as water depletions or withdrawals for agriculture, municipal, and industrial uses have and would continue to have adverse impacts to water supply access, as they would notably affect the water surface elevations and flows of the river and reservoirs.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation as described as part of the year 0 and year 15 analyses (Section 3.2.2.3, Impacts on Hydrology from the Alternatives). The elevations in the upper three reservoirs would increase slightly (1 to 2 feet) while changes in elevations in the lower three reservoirs would be negligible in year 15 under all alternatives compared to year 0. The change in stage in the riverine areas in year 15 in the upper river and the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The degradation effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15. However, in Kansas City, the projected river stage in year 15 would only be slightly lower (less than one inch of the mean stage) than year 0.

Past, present, and future actions that would affect bed degradation or aggradation of the Missouri River, such as sand and aggregate mining in the lower river, can impact the stability of the intakes and result in frequent and prolonged instances when water surface elevations fall below critical operating thresholds. Cumulative actions that affect aggradation such as floodplain development including agricultural operations affecting runoff can impact sediment and/or silting in intakes. In addition, much of the water supply infrastructure is nearing the end of its useful life and will require large investments to modernize these systems. Utilities would likely be forced to fund these improvements through increased water utility bills which could be notable to customers served by these utilities. Delaying the investment can result in degrading water service, increasing water service disruptions, and increasing expenditures for emergency repairs (AWRA n.d.).

Under Alternative 1, existing geomorphological processes and trends would continue, consisting primarily of river degradation and bank erosion, reservoir sediment deposition and aggradation, shoreline erosion in reservoirs, and ice dynamics. Continued degradation in the lower Missouri River would be caused by sediment trapped behind dams as well as by continued sand and aggregate mining downstream of Rulo, Nebraska, which lowers the riverbed and the stage of the river over time.

Impacts of Alternative 1 would be adverse and long-term if water supply intakes remain at their existing elevations, but these impacts would not be the result of any of the MRRMP actions under Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts to water supply access associated with Alternative 1 would continue to be large, adverse, and long-term primarily due to natural variability in hydrologic conditions and actions that contribute to bed degradation and aggradation. The implementation of the spawning cue flows and ESH construction as part of Alternative 1 would provide a negligible contribution to these cumulative impacts to water supply access.

Under Alternative 2 the spawning cue releases and low summer flows would modify reservoir releases and river flows to some extent, but would overall have a small beneficial impact on water supply access. These impacts would be due to higher water surface elevations in the fall and early winter months in the lower river and slightly higher reservoir elevations following a low summer flow event relative to Alternative 1. On average these impacts are small in nature but there are a few years when water supply access, especially in the lower river, would experience larger beneficial impacts. The greatest adverse impacts to water supply access in the lower river would occur during the winter or fall months when flows tend to be at their lowest levels in the lower river. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts under Alternative 2 would be large and adverse and the implementation Alternative 2 would provide a negligible contribution to cumulative impacts.

Under Alternative 3, the absence of the spawning cue release pulses in March and May and the larger ESH construction relative to Alternative 1 would have negligible cumulative impacts on water supply access overall because river flows in the lower river would be higher on average with increased storage in the reservoirs relative to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 3 would be similar to Alternative 1. Implementation of Alternative 3 would have a negligible contribution to these cumulative impacts.

Alternative 4 would have the largest cumulative impact on water supply access relative to Alternative 1 of any of the MRRMP-EIS alternatives. The spring release would decrease the elevations of Lake Sakakawea and Lake Oahe by several feet under Alternative 4 and lengthen the time needed for storage recovery and reduce flows following a release event in some years depending on natural hydrologic conditions. These impacts would occur across the lower and upper river. Years with the largest adverse impacts to water supply access in the lower river would occur during the fall or winter months when flows tend to be at their lowest levels. Water supply access in the upper river would be most affected in the reservoirs in the years when a spring release is followed by prolonged drought conditions under Alternative 4. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 4 would be similar to those under Alternative 1. Implementation of Alternative 4 would provide a negligible to small contribution to these cumulative impacts.

Under Alternative 5, water supply access would experience a small adverse impact relative to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 5 would be similar to those of Alternative 1. Implementation of Alternative 5 would have a negligible contribution to these cumulative impacts.

Alternative 6 is expected to have impacts on water supply access similar to those described under Alternative 4. Overall the impacts are expected to be small and adverse as a result of the spawning cue flow. Years with the largest adverse impacts to water supply access in the lower river would occur during the winter or fall months when flows tend to be at their lowest levels. Water supply access in the upper river would be most affected in the reservoirs in the years when a spawning cue release is followed by prolonged drought conditions. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 would be similar to those of Alternative 1. Implementation of Alternative 6 would provide a negligible to small contribution to these cumulative impacts.

3.19 Wastewater Facilities

3.19.1 Affected Environment

Several facilities discharge treated wastewater into the Missouri River and its reservoirs. The facilities include publicly owned treatment works (POTWs) or sewerage facilities and other types of industrial discharges including fertilizer and agricultural chemical companies and meat processing facilities. Most of the discharging facilities are in the lower river below Gavins Point Dam. River flows, stages, and channel geometry can affect these facilities. Thermal power plants are discussed in Section 3.17.

The EPA Enforcement and Compliance History Online (ECHO) database was used to identify the major wastewater facilities that discharge to the Missouri River. The list of facilities was confirmed with the EPA specialist overseeing state wastewater discharge regulations and compliance (Dunn, pers. comm., 2016). Major facilities include all facilities with design flows of greater than 1 million gallons per day and facilities with approved industrial pretreatment programs. Table 3-260 summarizes the 37 major wastewater facilities discharging to the Missouri River.[20]

Table 3-260. Missouri River Major Wastewater Facilities

Name	River Mile	County	State
Fort Peck Dam to Lake Sakakawea			
City of Willison	1546.8	Williams	North Dakota
Garrison Dam to Lake Oahe			
City of Bismarck POTW	1313.6	Burleigh	North Dakota
Roughrider Estates	1313.2	Morton	North Dakota
Lake Oahe			
City of Mobridge Wastewater Treatment Plant	1192.8	Walworth	South Dakota
Oahe Dam to Lake Sharpe			
Pierre Wastewater Treatment Plant	1062.8	Hughes	South Dakota
City of Chamberlain	966.5	Brule	South Dakota
Gavins Point Dam to Rulo			
City of Yankton	804.1	Yankton	South Dakota
City of Vermillion	772.0	Clay	South Dakota
City of Sioux City	729.1	Woodbury	Iowa
Tyson Fresh Meats	726.5	Dakota	Nebraska
CF Industries (Port Neal Corporation)	718.6	Woodbury	Iowa
Gelita North America	718.0	Woodbury	Iowa
Blair Wastewater Treatment	648.3	Washington	Nebraska
City of Omaha – Missouri River Wastewater Treatment Facility	611.9	Douglas	Nebraska

[20] It should be noted that there are “minor” wastewater facilities (discharge less than 1 million gallons per day) that are not included in this list.

Name	River Mile	County	State
City of Council Bluffs	605.5	Pottawattamie	Iowa
Bellevue Wastewater Treatment Plant	601.3	Sarpy	Nebraska
Omaha Papillion Creek Wastewater Treatment Plant	597.0	Sarpy	Nebraska
Plattsmouth Wastewater Treatment Plant	591.3	Cass	Nebraska
GMU Wastewater Treatment Facility	591.2	Mills	Iowa
Nebraska City Wastewater Treatment	562.3	Otoe	Nebraska
Rulo to the Mouth of the Missouri River			
Exide Tech-Canon Hollow	490.9	Holt	Missouri
St. Joseph Wastewater Treatment Plant	446.0	Buchanan	Missouri
City of Atchison	422.7	Atchison	Kansas
Leavenworth Wastewater Treatment	395.6	Leavenworth	Missouri
City of Lansing	389.3	Leavenworth	Missouri
#1 Kansas City Wastewater Treatment Plant	367.4	Wyandotte	Missouri
Kansas City, Westside Wastewater Treatment Plant	367.0	Jackson	Missouri
Blue River Treatment Plant	359.2	Jackson	Missouri
Conservation Chemical Company	358.2	Jackson	Missouri
Bayer Corporation Agriculture Division	358.2	Jackson	Missouri
Birmingham Sewage Treatment Plant	356.8	Clay	Missouri
Atherton Plant	349.0	Jackson	Missouri
Booneville Wastewater Plant	195.2	Cooper	Missouri
Jefferson City	143.5	Cole	Missouri
MSD, Missouri River Wastewater Treatment Plant	62.1	St. Louis	Missouri
St. Charles Missouri River Wastewater Treatment Facility	26.9	St. Charles	Missouri
Coldwater Creek Wastewater Treatment Plant	6.8	St. Louis	Missouri

Source: EPA ECHO database; state websites to verify current NPDES permits.

In order to discharge into a specified water body, wastewater facilities must have a National Pollution Discharge Elimination System (NPDES) permit, which specifies the effluent discharge requirements for the facilities. NPDES permits may include both technology-based effluent limits and water quality-based effluent limits. Technology-based effluent limits are usually used for municipal sewage treatment plants (i.e., POTWs) to regulate limits for biochemical oxygen demand, total suspended solids, oil and grease, *Escherichia coli*, and pH acid/base balance (Dunn, pers. comm., 2016; Wieberg pers. comm. 2015). The technology-based effluent limits are end of the pipe conditions that do not consider low flows in the receiving water body to estimate the effluent limit.

Water quality-based effluent limits are based on the assimilative capacity of the receiving water body and use critical low-flow criteria to estimate the effluent limits that are specified in water quality permits. The relevant parameters regulated by water quality-based effluent limits associated with wastewater discharge to the Missouri River include ammonia, total residual chlorine, whole effluent toxicity, and acute toxicity (Dunn pers. comm. 2015). Critical low flows are measured as the average low flow that occurs over a certain number of days (e.g., 7 days) and has a reoccurrence interval over a certain number of years (e.g., 10 years). For the Missouri River, critical low flows are defined most often as follows:

- 7-consecutive-day, average low flow; reoccurrence 1 in 10 years (7Q10)
- 30-consecutive-day, average low flow; reoccurrence 1 in 10 years (30Q10)
- 1-day, average low flow; reoccurrence 1 in 10 years (1Q10)
- 30-consecutive-day, average low flow; reoccurrence 1 in 5 years (30Q5)

Permits are renewed or reissued every 5 years, and low-flow criteria are re-estimated with updated data at that time. The states along the Missouri River have the following low-flow criteria that can be used to estimate effluent limits for wastewater facilities (Table 3-261).

Table 3-261. Critical Low-Flow Conditions Used to Determine Discharge Limits for National Pollutant Discharge Elimination System Permits

State	Critical Low-Flow Criteria for NPDES Permits
Missouri	7Q10: all criteria, except ammonia nitrogen
	30Q10: chronic criterion for ammonia nitrogen
(Missouri Code of State Regulations, 10 CSR 20-7.031)	1Q10: acute criterion for ammonia nitrogen
Kansas	7Q10: all criteria
	30Q10: ammonia
(Kansas Administrative Rules 28-16-28b through 28-16-28g)	"Alternative low-flow" based on seasonal, hydrological, or biological conditions
Iowa	1Q10: acute criteria (toxics and ammonia)
	7Q10: chronic (toxics)
	30Q10: chronic (ammonia)
(Iowa Administrative Code, 567, Chapter 61)	30Q5: non-carcinogenic
	Harmonic mean: carcinogenic
Nebraska	7Q10 (average dry weather or seasonal flow): all chronic criteria except ammonia
(Nebraska Administrative Code, Title 117, Chapter 4)	30Q5: ammonia criteria
	1Q10: acute criteria for various pollutants
South Dakota	7Q5: warm water
(South Dakota Administrative Code 74:51:01:31)	7Q25: cold water

State	Critical Low-Flow Criteria for NPDES Permits
North Dakota	4-day, 3-year flow: aquatic chronic
	1-day, 3-year flow: aquatic acute
	Harmonic mean flow: carcinogens
(North Dakota Administrative Code Chapter 33-16-02.1)	4-day, 3-year flow: non-carcinogens
	1-day, 3-year flow: non-carcinogens
Montana (Administrative Rules of Montana, Chapter 30, Subchapter 6)	7Q10: all criteria

Tribal Use of Wastewater Facilities

No Tribes own major wastewater facilities along the Missouri River. However, a number of Tribes have minor wastewater NPDES permits that include wastewater lagoon systems, settling tanks, and septic tanks that potentially discharge to the Missouri River. Table 3-262 describes the minor tribal wastewater facilities located adjacent to or proximate to the Missouri River.

Table 3-262. Tribal Minor Wastewater Facilities

Name	Type of NPDES Permit	Discharge	Type of Wastewater Facility
Montana			
City of Wolf Point Wastewater Treatment Facility	Indian Country Minor Permit	Discharge to a ditch leading to the Missouri River	Aerated Lagoon System
North Dakota			
Mandan, Hidatsa, and Arikara Interpretive Center Wastewater Treatment Facility (McKensie County)	Indian Country, Minor Municipal Permit	Discharge via pipe directly to the Missouri River	On-site treatment system, includes three septic tanks
Three Affiliates Tribes Riverview Estates Wastewater Treatment Facility (Mountrail County)	Indian Country, Minor Publicly Owned Treatment Works	Discharge to unnamed tributary of Lake Sakakawea	Settling tanks for primary treatment and two package plants for secondary treatment
City of New Town Water Treatment Plant (Fort Berthold Indian Reservation) (Mountrail County)	Indian country, Minor Permit	Discharge to unnamed tributary of Lake Sakakawea	Stabilization Lagoon
South Dakota			
Lower Brule Wastewater Lagoon System Lyman County)	Indian Country, Minor Municipal Permit	Discharge down the bank of the Missouri River to Lake Sharpe	Three-cell lagoon system
Standing Rock Rural Water System (Corson County)	Indian Country, Minor Permit	Discharge is to an unnamed tributary to Fisher Creek, a tributary to Oahe Reservoir	Settling pond system
Nebraska			
Santee Sioux Tribe of Nebraska, Village of Santee Wastewater Facility (Knox County)	Minor Permit	Discharge to Lewis and Clark Lake	Three-cell lagoon system

Name	Type of NPDES Permit	Discharge	Type of Wastewater Facility
Montana			
Winnebago Tribe of Nebraska Livestock Operations (Dixon County)	Minor Permit	Discharge to Walnut Creek-Missouri River	Not applicable

Source: EPA ECHO database; state websites to verify current NPDES permits.

3.19.2 Environmental Consequences

Wastewater discharge facility operations can be sensitive to changes in river flows. For facilities with water quality-based effluent limits, low river flows can have a direct relationship with the effluent limits and resulting wastewater treatment requirements.

3.19.2.1 Impact Assessment Methodology

This section describes the process used to evaluate the impacts to wastewater discharge facilities under the MRRMP-EIS alternatives. The critical low-flow criteria were obtained for all of the major wastewater facilities either from NPDES permits or state regulators. Most of the low-flow criteria statistics are calculated for an annual season with daily river flow data, providing year-round statistics on the re-occurrence of low-flow conditions. Some of the NPDES permits, primarily in Missouri and Nebraska, specify seasonal criteria (i.e., spring, summer, and winter) and use river flows in specified date ranges to estimate effluent limits for these seasons.

A low-flow criteria analysis was conducted on modeled rivers flows under the MRRMP-EIS alternatives for locations close to the wastewater discharge facilities. The low-flow criteria were estimated under the MRRMP-EIS alternatives with the log-Pearson Type III probability distribution commonly used by USGS and state water quality regulators to estimate effluent limits in NPDES permits (U.S. Interagency Advisory Committee on Water Data 1982). A period from 1960 to 2012 was used for the calculations to ensure consistency across all facilities and be reflective of periods for the criteria in the NPDES permits (Dunn pers. comm. 2015, 2016). EPA water quality specialists, state regulators, and plant representatives provided input on the potential effect of the change of low-flow conditions as estimated on effluent limits and treatment requirements.

The scope of analysis included facilities in Iowa, Nebraska, Kansas, and Missouri. Facilities in North Dakota and South Dakota were considered but eliminated from further analysis because state water quality regulators indicated that low-flow conditions in the Missouri River do not currently drive effluent limits for facilities in these states (Haroldson pers. comm. 2015; Spangler pers. comm. 2015). Twenty-nine major wastewater facilities that discharge to the Missouri River were identified in the four lower river states. An EPA Region 7 NPDES specialist was consulted who has a comprehensive understanding of the wastewater facilities, effluent limits, violations, monitoring reports, and other issues related to these facilities, their NPDES permits, and compliance with permits (Dunn pers. comm. 2015, 2016). The facilities identified could potentially be affected by a change in the low-flow criteria affecting specific pollutant effluent limits. It was determined that wastewater facilities were not affected by potential changes in river flows and the low-flow criteria if:

- The wastewater facilities only had technology-based effluent limits in their NPDES permits;
- The wastewater facilities were not a direct Missouri River discharger;

- The dilution in the river was more than sufficient to meet effluent limits in the NPDES permits (lots of headroom), even in low flow conditions; or
- If facilities were using a relatively new technology called biological nutrient removal[21] or enhanced nutrient removal to treat for ammonia (Dunn pers. comm. 2015, 2016).

Each of these facilities was evaluated with input from the EPA NPDES specialist, and facilities were removed from further analysis if they met any of the criteria listed above. However, facilities were not removed if there was any uncertainty about the facility, its effluent and compliance status, or pending upgrades to the facilities. As a result, five facilities were identified (two in Iowa and three in Missouri) that could potentially be affected under MRRMP-EIS alternatives and were evaluated through further consultation with the facilities and state regulators.

3.19.2.2 Summary of Environmental Consequences

Table 3-263 summarizes the environmental consequences for wastewater discharge facilities.

Table 3-263. Environmental Consequences for Wastewater Facilities

Alternative	Impacts
Management Actions Common to All Alternatives	Impacts to wastewater facilities are not anticipated.
Alternative 1	Current System operations are anticipated to continue to provide stable low-flow criteria in the future, and minimal changes to effluent limits based on low-flow conditions and negligible impacts on wastewater facilities are anticipated in the future. Negligible to small, temporary, adverse impacts to wastewater facility infrastructure are anticipated from habitat construction.
Alternative 2	Negligible impacts to wastewater facilities in most locations because low river flows would not affect the effluent limits. Possible short-term, large, adverse impacts to two wastewater facilities although anticipated future investments in treatment technology could reduce impacts to negligible compared to Alternative 1. Small, short-term, adverse impacts to wastewater facilities are anticipated from considerably more early life stage habitat and ESH constructed compared to Alternative 1.
Alternatives 3–6	Negligible to small adverse impacts to wastewater facilities are anticipated compared to Alternative 1.

3.19.2.3 Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives, such as predator management and human restrictions measures, would not affect wastewater facilities.

[21] Biological nutrient removal is a process used for treating nitrogen, including ammonia-nitrogen, and phosphorus in wastewater. With the new stringent ammonia standards being implemented by EPA and states, more wastewater facilities are upgrading their treatment systems to use biological nutrient removal or enhanced nutrient removal; with these types of technologies, changes in low flows are not likely to affect water quality (Dunn, pers. comm. 2016).

3.19.2.4 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 would continue current System operations, including the current MRRP management actions. Alternative 1 is considered the baseline against which the other alternatives are measured. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or historic conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

Mechanical Habitat Construction

Alternative 1 includes the continued construction of early life stage habitat for the pallid sturgeon from Ponca, Nebraska, to the mouth of the river near St. Louis, Missouri, with a target of 3,999 acres at the end of the 15-year implementation period. Construction of ESH would also continue to occur in the Garrison Dam to Lake Oahe and Gavins Point Dam to Ponca, Nebraska, river reaches, with on average 164 acres constructed per year in years when construction occurs. Construction of ESH in the Garrison and Gavins Point reaches and early life stage habitat construction in lower river reaches in the vicinity of a wastewater facility outfall could lead to issues associated with sediment erosion and deposition and potential impacts to the structural stability of the outfall. The extent of these impacts would depend on the proximity of the location where the habitat site would be constructed relative to any wastewater facility outfall. Each habitat site is designed to avoid significant impacts to infrastructure and sensitive resources. In addition, USACE has identified subsequent restrictive or exclusionary zones associated with many of these resources. A more detailed hydraulic/geomorphic assessment would also be completed during site-specific planning, engineering, and design phases to further mitigate impacts associated with these actions on wastewater facilities. With the site-specific planning and sensitive resource restrictions in place, the impacts of the habitat construction management actions on wastewater facility outfalls would be temporary and negligible to small.

Spring Spawning Cue Flow Release

In general, current System operations and guidelines to meet navigation targets would continue to provide sufficient river flows to assimilate effluent to meet water quality limits. Although lower river flows in the late fall and winter would typically occur and drought periods could exacerbate lower river flows at any time of the year, current flow management under Alternative 1 is anticipated to provide stable low-flow criteria in the future, and minimal changes to effluent limits from spring spawning cue release (plenary pulse) and low-flow conditions are anticipated. Although wastewater facilities would continue to incur capital and operating costs to treat and remove pollutants associated with water quality standards, current management under Alternative 1 would not have noticeable changes to those impacts in the future.

Conclusion

Alternative 1 would result in negligible impacts to wastewater facilities from MRRMP actions; current management of the System would continue to provide relatively stable low-flow criteria in the future allowing wastewater facilities to continue to operate within current parameters. Alternative 1 would result in negligible to small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with early life stage habitat and ESH construction; however, site-specific planning and infrastructure buffers would attempt to minimize the impacts to facilities. Therefore, with implementing site-specific planning and buffers, Alternative 1 would not have significant impacts to wastewater facilities.

3.19.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 would include additional iterative actions that USFWS anticipates would be implemented under an adaptive management framework. Management actions under Alternative 2 would include spawning cue releases, low summer flows, and the construction of considerably more early life stage habitat and ESH than under Alternative 1.

Mechanical Habitat Construction

A targeted 10,758 additional acres of early life stage habitat for the pallid sturgeon would be constructed between Ponca, Nebraska, and the mouth of the river near St. Louis, Missouri. An average of 1,331 acres per year of ESH would be constructed in years when construction occurs in the Garrison Dam to Lake Oahe river reach; Fort Randall Dam to Lewis and Clark Lake river reach; Gavins Point Dam to Ponca, Nebraska, river reach; and Lewis and Clark Lake. The mechanical construction of substantially more early life stage habitat for the pallid sturgeon and ESH would have the potential to lead to more issues associated with local and regional flow patterns and sediment erosion and deposition affecting wastewater facility outfalls relative to Alternative 1. Similar to Alternative 1, sensitive resource restrictions and buffers would minimize and attempt to avoid adverse impacts to wastewater facilities. Impacts of the habitat construction management actions on wastewater facility outfalls could range from small, temporary, and adverse on wastewater facilities compared to Alternative 1, depending on the proximity of the constructed habitat site to wastewater facilities.

Spring Spawning Cue Flow Release and Low Summer Flows

Alternative 2 includes a bi-modal spawning cue release followed by a low summer flow. The estimated low-flow criteria under simulated Alternative 2 river flows were compared to the low-flow criteria estimated for river flows simulated under Alternative 1. The low-flow criteria for two facilities in Iowa under Alternative 2 were estimated to be slightly higher than under Alternative 1, with small, beneficial impacts to the Iowa wastewater facilities.

In Missouri, three wastewater facilities could be affected by low-flow conditions. One Missouri facility uses annual low-flow criteria, and the analysis showed that the low-flow criteria under Alternative 2 could increase by approximately 0.1 percent compared to Alternative 1. This small change is expected to have negligible impacts to effluent limits for this facility such that operations are unlikely to change. According to the calculated low-flow criteria under Alternative 2, the two remaining Missouri facilities would experience decreases in low-flow criteria compared to Alternative 1, with the largest decreases under the summer low-flow criteria. Decreases in low-flow criteria under Alternative 2 compared to Alternative 1 indicate more restrictive effluent limits for these facilities under Alternative 2, which could lead to increased operational or capital costs to meet treatment requirements. Under the low-flow criteria calculated on the modeled river flows for Alternatives 1 and 2, the summer low-flow criteria for the 1Q10 and 30Q10 under Alternative 2 for both facilities could decrease approximately 19 and 6 percent compared to Alternative 1, respectively. The low summer flow events under Alternative 2 would likely cause these decreases in low-flow criteria under Alternative 2, compared to Alternative 1.

While the analysis shows that low summer flows under Alternative 2 have the potential to affect effluent limits for two facilities in Missouri, further discussions with plant operators indicated that these plants either are currently making a capital investment or are developing a master plan that would likely address the options to comply with pending and more stringent ammonia limits in Missouri (O'Kelley pers. comm. 2016; Coles pers. comm. 2016). The master plan would likely not be implemented for 5 to 10 years. The wastewater facility investment decisions would be based on many variables, including the anticipated stringent ammonia water quality regulations as well as many other variables, such as funding, logistics, permitting, and others. If one of these facilities does not make the investments or delays making the investment, the facility would likely experience permit violations and exceedances of effluent limits under Alternative 2, resulting in short-term, large, adverse impacts compared to Alternative 1, especially during low summer flow events. Because the wastewater facilities are currently undergoing or planning to undergo capital investments involving new treatment technologies, the adverse impacts to these facilities under Alternative 2, relative to Alternative 1, are anticipated to be long-term, negligible, and adverse. However, there is uncertainty because of the state of Missouri's pending ammonia standards, the timing or certainty of the technology investment, the effects of low flows under Alternative 2 on the actual effluent limits, and the ability of the new technologies to meet these standards and potential changes in effluent limits.

Conclusion

Alternative 2 would result in negligible impacts to wastewater facilities in most locations because low river flows would not affect the effluent limits. However, two facilities in Missouri could experience large temporary impacts due with low-flow criteria for ammonia, especially with a low summer flow management action. Because pending and more stringent water quality standards are driving near-term capital investments for these facilities, the adverse impacts would be temporary. In the long term these impacts would be negligible because new or planned investments in new treatment technology would likely be able to treat effluent to meet the limits under reduced assimilative capacity with low summer flows.

Although site-specific planning and infrastructure buffers would attempt to minimize impacts to wastewater facilities, Alternative 2 would have the potential for small, temporary, adverse impacts with increases in degradation and aggregation affecting wastewater facility outfalls associated with early life stage habitat and ESH construction. Alternative 2 would not have significant impacts on wastewater facilities because in most locations and current and planned investments in treatment technology in affected facilities would mitigate treatment requirements due to low flows under Alternative 2.

3.19.2.6 Alternative 3 – Mechanical Construction Only

Alternative 3 does not include any spring or fall flow releases to create habitat; all ESH and habitat to support early life stage of the pallid sturgeon would be mechanically constructed. The spring plenary pulse that would occur under Alternative 1 would not occur under Alternative 3.

Mechanical Habitat Construction

Alternative 3 includes construction of up to 3,380 acres of new IRC habitat for the pallid sturgeon which is slightly fewer acres than the early life stage habitat that is expected to be constructed under Alternative 1. Alternative 3 includes an average of 332 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Construction of IRC habitat and ESH could have some adverse impacts to wastewater facilities, but these impacts would be small, temporary, and adverse because site-specific planning would minimize or avoid impacts to sensitive resources such as infrastructure.

Alternative 3 does not include the spring plenary pulse for the pallid sturgeon that would occur under Alternative 1. According to the low-flow criteria analysis estimated for Alternative 1 and Alternative 3 modeled river flows, five facilities under Alternative 3 would experience a one percent or less decrease in low-flow criteria compared to Alternative 1. Some of the low flow criteria would slightly increase under the Alternative 3 simulations relative to Alternative 1. The change in low-flow criteria is expected to have negligible impacts on effluent limits and treatment requirements for these facilities compared to Alternative 1.

The one-time spawning cue test release (Level 2) that may be implemented under Alternative 3 was not included in the low-flow criteria modeling conducted for Alternative 3. The potential impacts of a one-time spawning cue test release under Alternative 3 would be bounded by the range of impacts described for individual releases under Alternative 6. Alternative 6 would result in small adverse impacts to wastewater facilities in Iowa and Missouri (from 1 to 6 percent decrease in low flow criteria) due to the repeated implementation of the spawning cue release reducing river flows in the lower river. Because the spawning cue test release under Alternative 3 is a one-time release, there would be no changes or very minor changes in low flow criteria for these facilities, resulting in negligible changes from Alternative 1 from the spawning cue test release.

Conclusion

Alternative 3 would result in negligible impacts to wastewater facilities in most locations because low river flows would not affect the effluent limits. Alternative 3, including the one-time spawning cue test, would also result in negligible impacts to effluent limits at wastewater facilities in Iowa and Missouri because river flows under Alternative 3 would have only minor changes compared to Alternative 1. Alternative 3 would result in small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with early life stage habitat and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize impacts to those facilities. Alternative 3 would not have significant impacts to wastewater facilities because adverse impacts would be negligible to small at all locations.

3.19.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 would include spring releases from Gavins Point Dam and Garrison Dam and mechanical construction of ESH and habitat to support early life stage requirements of the pallid sturgeon to achieve habitat targets.

Mechanical Habitat Construction

Alternative 4 includes construction of up to 3,380 acres of new IRC habitat for the pallid sturgeon and an average of 195 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Alternative 4 would result in small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with IRC and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize the impacts to facilities.

Spring Habitat-Forming Flow Release

Alternative 4 includes a spring release in April and May to create ESH. The estimated low-flow criteria with river flows simulated under Alternatives 1 and 4 indicates that the low flow criteria under Alternative 4 would decrease from 1 to 6 percent for the summer criteria, and would increase or decrease by 2 percent or less compared to Alternative 1 for the winter and annual criteria. The decreases in low-flow conditions for these facilities in the summer would occur for two of the Missouri wastewater facilities. The impacts would be negligible to small on effluent limits and treatment requirements for these facilities because the change in the simulated low flow criteria is small and the facilities are currently or soon expected to make investments in new treatment technologies.

Conclusion

Alternative 4 would result in negligible to small adverse impacts to wastewater facilities in all locations. Simulated river flows under Alternative 4 would result in small changes in low-flow criteria with negligible changes to wastewater facilities compared to Alternative 1. Alternative 4 would not have significant impacts to wastewater facility operations with only slight changes in low-flow criteria and temporary adverse impacts to wastewater facility outfalls.

3.19.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 would include fall releases from Gavins Point Dam and mechanical construction to create ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska river reaches. Under Alternative 5, IRC habitat to support early life stage requirements of the pallid sturgeon would be constructed in the lower river below Ponca, Nebraska.

Mechanical Habitat Construction

Alternative 5 includes construction of up to 3,380 acres of new IRC habitat for the pallid sturgeon and an average of 253 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Alternative 5 would result in small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with IRC and ESH construction because site-specific planning and infrastructure buffers would attempt to minimize the impacts to facilities.

Fall Habitat-Forming Flow Release

Alternative 5 includes a fall release in October and November to create ESH. The estimated low-flow criteria under river flows simulated under Alternative 5 indicate a decrease of less than two percent for the summer criteria and increase for some of the remaining low-flow criteria compared to Alternative 1. The minor change in low-flow conditions for the summer criteria is expected to have negligible to small adverse impacts on effluent limits and treatment requirements for wastewater facilities compared to Alternative 1 due to the small decrease in low-flow criteria and the investments currently being made or anticipated to be made in the near future for new treatment technologies.

Conclusion

Alternative 5 would result in small impacts to wastewater facilities in all locations. Simulated river flows under Alternative 5 would result in slight changes in low-flow criteria. Alternative 5 would not have significant impacts to wastewater facilities due to only slight changes in low-flow criteria and temporary and negligible to small adverse impacts to wastewater facility outfalls.

3.19.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, the USACE would attempt a spawning cue pulse every three years in March and May. In addition, management actions under Alternative 6 include mechanical construction of ESH in the Garrison, Fort Randall, and Gavins Point Dam to Ponca, Nebraska reaches; and the construction of IRC habitat in the lower river below Ponca, Nebraska to support the pallid sturgeon.

Mechanical Habitat Construction

Alternative 6 includes construction of up to 3,380 acres of new IRC habitat for the pallid sturgeon and an average of 245 acres of ESH per year in years when construction occurs in the Garrison, Fort Randall, and Gavins Point river reaches. Alternative 6 would result in small, temporary, adverse impacts to sediment erosion and deposition affecting wastewater facility outfalls associated with IRC and ESH construction. Impacts are expected to be small because of site-specific planning and infrastructure buffers would attempt to minimize impacts to facilities.

Spring Spawning Cue Flow Release

Alternative 6 includes a bi-modal spawning cue in March and May to benefit the pallid sturgeon. The estimated low-flow criteria with simulated river flows under Alternative 6 indicate that the criteria would decrease from one to six percent for the summer criteria for two Missouri facilities, and change (increase or decrease) by two percent or less compared to Alternative 1 for the remaining criteria. This small change in low-flow conditions is expected to have negligible to small adverse impacts on effluent limits and treatment requirements for wastewater facilities because of the minor change in low-flow criteria and the investments currently being made or anticipated in the near future for new treatment technologies.

Conclusion

Alternative 6 would result in negligible to small adverse impacts to wastewater facilities in all locations. Simulated river flows under Alternative 6 would result in small changes in low-flow criteria with negligible to small adverse impacts to wastewater facilities, similar to Alternative 1. Alternative 6 would not have significant impacts to wastewater facilities because adverse impacts would not occur or would be small at all locations and only minor changes in low-flow criteria would occur.

3.19.2.10 Tribal Resources

Wastewater treatment requirements at Tribal wastewater facilities would not be affected by the MRRMP-EIS alternatives because these facilities have technology-based effluent criteria. Low-flow conditions in the Missouri River would not affect effluent limits for Tribal facilities. In addition, flow releases under the MRRMP-EIS alternatives are not anticipated to affect Tribal wastewater facilities.

3.19.2.11 Climate Change

Earlier snowmelt may result in both lower river flows in the fall and winter and the possibility of the spring plenary pulse under Alternative 1 running more frequently with higher System storage in the spring. The drought conditions and more frequent implementation of the pulse would likely result in lower river flows, especially in the fall and winter, for longer periods, and would have the potential to reduce the low-flow criteria used in the effluent limit calculations.

Impacts of climate change under Alternatives 2 through 6 would be similar to those described for Alternative 1. However, with earlier snowmelt, the spawning cue pulses and spring releases under Alternatives 2, 4, and 6 may be able to run more frequently because System storage would rise earlier in the year. More frequent and larger pulses may result in lower river flows in the fall and winter compared to Alternative 1, especially if the pulses are followed by drought or drier conditions. Longer and lower river flows would reduce low-flow criteria, and the effluent limits on which they are based would become more stringent, resulting in adverse impacts to wastewater facilities.

Large, more sporadic rain events could adversely affect the ability of facilities to discharge wastewater during flood events, possibly shutting down facilities; climate change could exacerbate the possibility of flooding during spring or fall releases under Alternatives 2, 4, 5, and 6.

Impacts of climate change under Alternative 5 would be similar to those described for Alternative 1, although with earlier snowmelt, the fall release may not be able to run as frequently if the navigation service level is lower for the second half of the navigation season. Less frequent releases may benefit river flows in the fall and winter compared to Alternative 1. These changes may benefit wastewater facilities because effluent limits for pollutants specified by low-flow criteria may not become more stringent in the future.

3.19.2.12 Cumulative Impacts

Past, present, and reasonably foreseeable future construction projects, including projects to maintain the levees, roads, floodplain development, and habitat creation, can cause temporary adverse impacts as a result of localized deterioration in water quality. Any habitat construction or channel reconfiguration by state or other federal agencies could have adverse impacts to the stability of the outfalls at the wastewater facilities, although buffers around sensitive resources would reduce these adverse impacts. Continued or future water withdrawals for irrigation, municipal, and industrial uses would adversely affect river flows, with potential adverse impacts to the assimilative capacity of the river, possibly affecting effluent limits and wastewater treatment operations and the need for investment in infrastructure upgrades to mitigate these impacts. Any additional agricultural, municipal, industrial and floodplain development in the service areas of wastewater facilities can put new demands on wastewater facility operations, and may require capital investments to improve and expand the capacity of the facilities.

Changes in federal and state water quality regulations that specify both technology-based effluent limits and low-flow standards for relevant water quality parameters can impact wastewater facilities. Recent revisions in the water quality standards by EPA in 2013 include new recommended ammonia criteria, bacteria criteria, nutrient criteria development for streams, regional dissolved oxygen criteria, and others. The states of Iowa, Nebraska, Kansas, and Missouri are in various stages of implementing new water quality regulations to meet the new EPA standards. Any resulting changes in effluent limits may require that wastewater facilities upgrade their treatment systems to comply with regulations, possibly requiring changes in operating and capital investments.

Construction of the Missouri River Mainstem Reservoir System and the associated dams allows operation with controlled flow releases from the upper river into the lower river to achieve multiple management objectives, including providing water for various uses. Variability in natural hydrologic conditions (precipitation and snowmelt, which include periods of drought and high runoff) and the “rules” governing System operation would continue to dominate the river flows in the Missouri River into the future. Natural flow variability and the requirement to balance authorized purposes under the Master Manual would continue to be the primary drivers of impact to river flows of the Missouri River. Any change in river flows would affect the assimilative capacity of the river. The variable hydrology and precipitation within the System and its interaction with the past, present foreseeable actions as described in Section 3.1 would result in cumulative impacts that would vary seasonally or annually, be long-term and adverse, small to large, with wastewater facilities adversely affected primarily by drought and drier conditions and water quality regulations.

Future aggradation and degradation trends would have similar effects under all of the alternatives. HEC-RAS modeling indicates that the action alternatives would not significantly contribute to aggradation or degradation. As described as part of the year 0 and year 15 analyses (Section 3.2.2.3, Impacts on Hydrology from the Alternatives), the change in stage in the riverine areas in year 15 in the upper portion of the lower river over time relative to Alternative 1 would be nearly the same for all six alternatives. The effect from sediment captured by the reservoirs combined with degradation from sand and aggregate mining in the lower reach of the Missouri River (downstream of Rulo, Nebraska) would also be similar across all alternatives in year 15. HEC-RAS modeling projected a decrease in the mean river stage at St. Joseph, Missouri, by approximately 2.5 feet for the six alternatives in year 15. However, in Kansas City, the projected river stage in year 15 would only be slightly lower (less than one inch of the mean stage) than year 0. Past, present, and future actions that would affect bed degradation or aggradation of the Missouri River, such as sand and aggregate mining in the lower river, can adversely impact the stability of the wastewater facility intakes and outfalls, requiring maintenance, repair, and/or replacement of outfall infrastructure. The facility in St. Joseph would be especially susceptible to these cumulative impacts.

There would be negligible to large adverse cumulative impacts to wastewater facilities under all alternatives, with the cumulative actions of degradation, variability of natural hydrologic conditions, and water quality standards having the largest potential contribution to adverse effects to wastewater facilities. Under Alternative 2, two wastewater facilities in Missouri would experience small, adverse impacts (possible large effects if capital investments are not made) from low summer flow events in the long-term due to lower flow criteria leading to more stringent water quality effluent limits. When combined with other past, present, and reasonably foreseeable future actions, cumulative impacts associated with Alternatives 1–6 would have negligible to large adverse impacts on wastewater operations. Implementation under Alternative 2 would provide a small adverse contribution to cumulative impacts from lower flow criteria in the summer potentially leading to more stringent water quality standards. Alternatives 1, 3, 4, 5, and 6 would provide a negligible contribution to cumulative impacts because of the minor change in low flow criteria and because facilities are already making or planning investments to upgrade facilities to meet more stringent water quality standards.

3.20 Tribal Interests (Other)

3.20.1 Affected Environment

3.20.1.1 Native American Tribes

The Tribes of the Missouri River basin are diverse in their histories and their perspectives regarding the Missouri River. Twenty-nine Tribes are located within or have expressed significant interest in their historical connection to the Missouri River Basin (Figure 3-67). Listed below are each of those 29 Tribes and the location of their Tribal headquarters.

- Apsaalooke (Crow) Tribe—Crow Agency, Montana
- Assiniboine and Sioux Tribes of Fort Peck—Poplar, Montana
- Blackfeet Tribe—Browning, Montana
- Cheyenne River Sioux Tribe—Eagle Butte, South Dakota
- Chippewa Cree Tribe of Rocky Boy's Reservation—Box Elder, Montana
- Crow Creek Sioux Tribe—Fort Thompson, South Dakota
- Eastern Shoshone Tribe—Fort Washakie, Wyoming
- Flandreau Santee Sioux Tribe—Flandreau, South Dakota
- Gros Ventre and Assiniboine Tribes of Fort Belknap—Harlem, Montana
- Iowa Tribe of Kansas and Nebraska—White Cloud, Kansas
- Kickapoo Tribe in Kansas—Horton, Kansas
- Lower Brule Sioux Tribe—Lower Brule, South Dakota
- Northern Arapaho Tribe—Fort Washakie, Wyoming
- Northern Cheyenne Tribe—Lame Deer, Montana
- Oglala Sioux Tribe—Pine Ridge, South Dakota
- Omaha Tribe of Nebraska—Macy, Nebraska
- Osage Nation—Pawhuska, Oklahoma
- Ponca Tribe of Nebraska—Niobrara, Nebraska
- Prairie Band of Potawatomi Nation—Mayetta, Kansas
- Rosebud Sioux Tribe—Rosebud, South Dakota
- Sac and Fox Nation of Missouri in Kansas and Nebraska—Reserve, Kansas
- Santee Sioux Tribe of Nebraska—Santee, Nebraska
- Sisseton-Wahpeton Oyate—Agency Village, South Dakota
- Spirit Lake Sioux Tribe—Fort Totten, North Dakota
- Standing Rock Sioux Tribe—Fort Yates, North Dakota
- Three Affiliated Tribes—New Town, North Dakota

- Turtle Mountain Band of Chippewa—Belcourt, North Dakota
- Winnebago Tribe of Nebraska—Winnebago, Nebraska
- Yankton Sioux Tribe—Marty, South Dakota

These Tribes maintain current and ancestral ties to the Missouri River and possess cultural, economic, and social interests in the river. Federal agencies planning and implementing recovery and mitigation actions on the river have a trust responsibility to work with Tribes on a government-to-government basis in recognition of Tribal sovereignty. Additional Tribes with ancestral ties to the basin continue to be contacted to determine their interest in consultation.

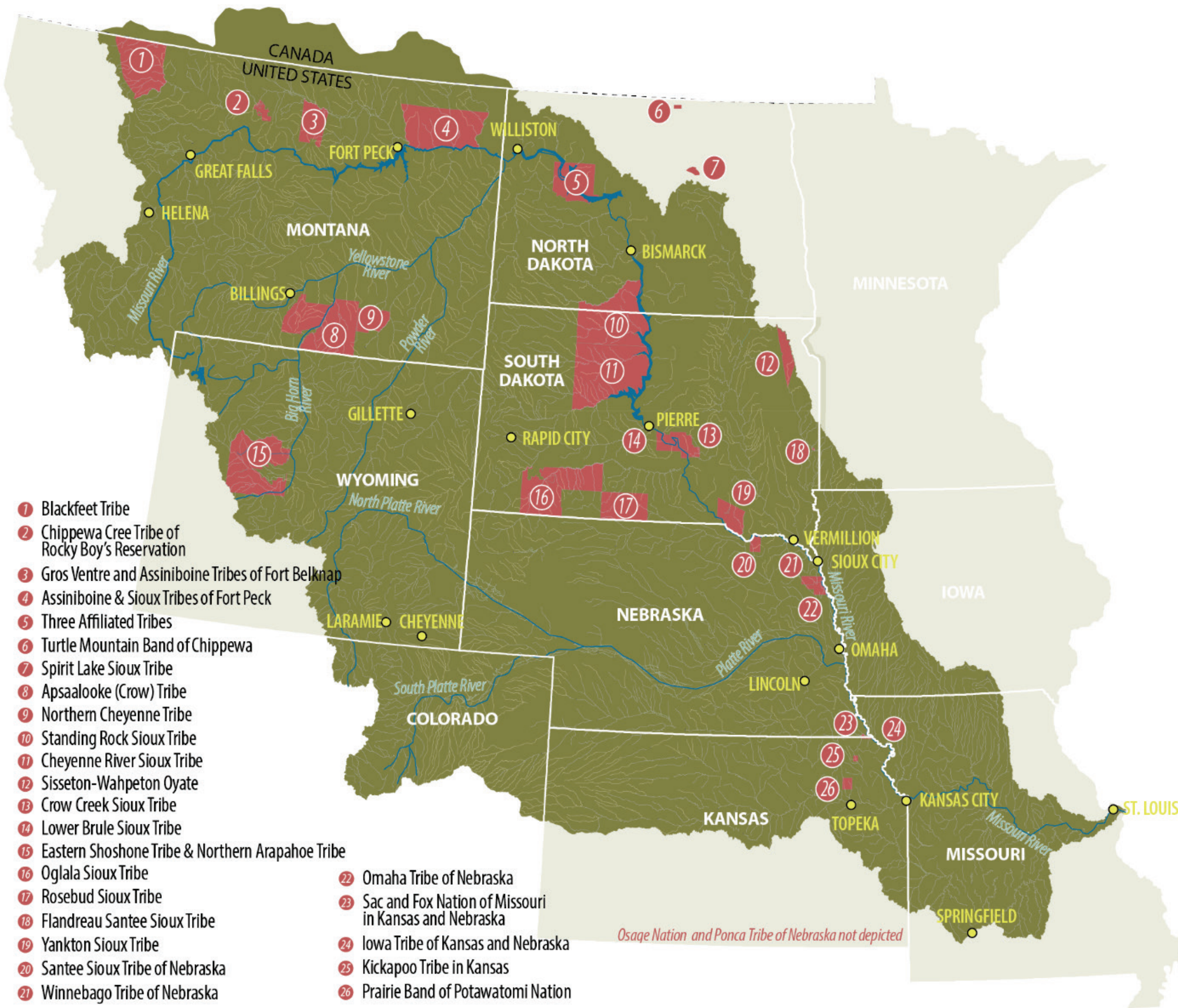


Figure 3-67. Map of Reservations Located Within or Around the Missouri River Basin

3.20.1.2 Tribal Lands

According to the U.S. Department of the Interior "a federal Indian reservation is an area of land reserved for a Tribe or Tribes under treaty or other agreement with the United States, executive order, or federal statute or administrative action as permanent Tribal homelands, and where the federal government holds title to the land in trust on behalf of the Tribe" (U.S. Department of the

Interior 2012). Instead of a reservation, the Ponca Tribe of Nebraska has service areas in 15 counties located in Nebraska, South Dakota, and Iowa (Ponca Tribe of Nebraska 2012). A service area is a location at which the Tribe offers services such as education, healthcare, and social services.

Thirteen of the Tribal reservations (as well as a portion of the Ponca trust land) are adjacent to the river and/or partially within the floodplain (Table 3-264). These reservations vary in size, with Fort Berthold having the most land within the floodplain. Natural vegetation communities (herbaceous grasslands, wetlands, and forest) are the most prevalent land cover feature among Tribal areas in the floodplain; although in general, there are more grasslands present than other natural vegetation. Croplands represent the next largest proportion of land cover type.

Table 3-264. Tribal Reservation Land within the Missouri River Floodplain

Tribal Reservation	Natural Vegetation (Grassland, wetland, and forest)	Croplands	Open Water	Developed/ Low Intensity/ Open Space	Other	Total Reservation Land in the Floodplain
Fort Peck Reservation[1]	32,729	62,422	3,522	6,554	116	**105,343**
Fort Berthold (Three Affiliated)	641	154	108,993	86	36	**109,910**
Standing Rock Reservation[2]	3,830	1,850	29,137	775	11	**35,603**
Cheyenne River Reservation	595	2	27,414	35	3	**28,049**
Lower Brule Reservation	3,817	3,146	27,106	449	3	**34,521**
Crow Creek Reservation	1,602	3,122	25,720	302	2	**30,748**
Yankton Reservation	2,471	6,360	6,365	425	48	**15,669**
Santee Sioux Reservation[3]	2,564	40	5,734	10	80	**8,428**
Winnebago Reservation	2,164	2,322	688	152	81	**5,407**
Ponca Tribe of Nebraska	NA	NA	NA	NA	NA	**NA**
Omaha Tribe of Nebraska Reservation	3,855	6,038	955	565	40	**11,453**
Turtle Mountain Band of Chippewa	263	272	26	22	0	**583**
Iowa Tribes of Kansas and Nebraska Reservation	34	147	42	13	0	**236**
Total for Reservations Along the Missouri River Floodplain	**54,565**	**85,875**	**235,702**	**9,388**	**420**	**385,950**

Source: USDA NASS Agriculture Census 2011 Cropland Data Layer; Numbers presented are in acres

[1] Includes Fort Peck Trust Lands

[2] Includes Standing Rock Trust Lands

[3] Includes Santee Trust Lands

3.20.1.3 Tribal Interests

Tribes of the Missouri River Basin have an interest in many of the resources that are described in the other sections of this chapter. These resources include, but are not limited to agriculture, irrigation, water supply, thermal power, recreation, flood risk management, and fish and wildlife. Each section describing one of these resources also describes the connection to Tribes. However, this section describes additional connections to the Missouri River that are unique to Tribal members.

Subsistence Hunting, Fishing, and Gathering

Opportunities for fishing, hunting, and trapping can be essential for Tribal members. Through hunting, fishing, and gathering, some Tribal members use the fish, wildlife, and vegetation of the Missouri River and its floodplain to account for a significant portion of their food supply. Fishing could include native and nonnative species, depending on the Tribe and location. Subsistence gathering typically consists of native fruits, berries, and vegetables. Many Tribal members also gather native plants for medicinal and ceremonial uses. The availability of resources that allow for subsistence and/or traditional cultural practices contributes to the cultural identity of many Tribal members.

Native American Tribal reservations are located in rural areas where opportunities for fishing, hunting, and trapping are greater than in urban areas. For environmental justice purposes, a distinction is made between fishing, hunting, and trapping for recreational purposes versus for subsistence. In 1997, CEQ defined subsistence consumption of fish and wildlife by minority populations, low income populations, and/or Indian Tribes two ways: (1) dependence on indigenous fish, vegetation, and/or wildlife as the principal portion of their diet; and (2) differences in rates and/or patterns of subsistence consumption by minority populations, low-income populations, and Indian Tribes as compared to rates and patterns of consumption of the general population. The average number of days spent fishing and hunting by residents (Tribal and non-Tribal) at least 16 years old (adults) in each state along the Missouri River in 2001 is shown in Table 3-265.

Table 3-265. Average Hunting and Fishing Days in 2001 by Adult Residents of Missouri River States

State	Adult Residents (1,000s), 2001	Adult Resident Hunting Days (1,000s)	Average Hunting Days per Adult Resident	Adult Resident Fishing Days (1,000s)	Average Fishing Days per Adult Resident
Montana	699	2,112	3.02	3,656	5.23
North Dakota	483	1,417	2.93	2,584	5.35
South Dakota	559	1,347	2.41	2,414	4.32
Nebraska	1,266	1,963	1.55	3,378	2.67
Iowa	2,201	4,086	1.86	8,534	3.88
Kansas	2,017	3,424	1.70	6,426	3.19
Missouri	4,206	6,715	1.60	12,396	2.95
All seven states	11,431	21,064	1.84	39,388	3.45

Source: USFWS / U.S. Census Bureau 2002. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. The 2006 survey was not used because results were affected by drought conditions.

In general, residents of states with high concentrations of Tribal members (Montana, North Dakota, and South Dakota) spend more time hunting and fishing than other states in the Missouri River Basin. Additional information was obtained from knowledgeable members and/or employees of each of the Tribes located along the Missouri River or with service areas along the river. No specific percentages of adult Tribal members who hunt and/or fish were provided, but the average percentages of Tribal members' diets that consist of harvested game, fish, and shellfish that were estimated suggest that the average adult Tribal member spends many more days hunting and/or fishing than the highest state average of 3 days per year hunting and 5 days per year fishing (Table 3-265). Even for Tribes with a relatively small overall percentage of harvested game and fish in their diets, some members may have a much higher percentage and could be considered subsistence hunters and/or anglers on an individual or family basis.

3.20.1.4 Traditional Cultural Practices and Educational Opportunities

Many Tribal members use the Missouri River and its floodplain for traditional cultural practices, including traditional Tribal ways of daily life (which may include seeing and interacting with the river throughout the day) and sacred/spiritual values through ceremonies, sun dances, vision quests, and sweat lodges. Protection of cultural resources (described in Section 3.9, Cultural Resources) and preservation of cultural practices are paramount for many Tribal members. These values and ways of life are affected by the physical components of the Missouri River and its floodplain, including its effect on physical resources such as plants, berries, trees, and water. For example, the availability of cottonwood trees, which have important cultural uses for many Tribes, is dependent on "forested wetland/riparian woodland" habitat, as described in Section 3.5, Fish and Wildlife Habitat. The creation, acquisition, restoration and improvement of fish and wildlife habitat included in the alternatives is generally anticipated to be a benefit to traditional cultural practices and educational opportunities. Also, access to sites used for traditional cultural practices and educational opportunities are affected by frequency/severity of flooding. Natural aquatic and floodplain habitats resemble the conditions under which traditional cultural practices were developed.

3.20.2 Environmental Consequences

Each of the human considerations sections in this chapter has documented the potential effects of MRRMP-EIS alternatives on Tribal interests, to the extent applicable. This section documents other potential effects on Tribal interests that have not been addressed in the other sections. These specific Tribal interests include subsistence hunting, fishing, and gathering, as well as traditional cultural practices and educational opportunities.

3.20.2.1 Impacts Assessment Methodology

Alternative means of achieving species objectives are evaluated for their effects on these Tribal interests. Some effects are specific to reservations, while some effects occur on other parts of the Missouri River but are relevant to Tribes nonetheless. The impacts to these specific Tribal interests are evaluated using the OSE account. The accounts framework enables consideration of non-monetary values and interests that are expressed as important to Tribes. The following section provides a brief overview of the methodology for evaluating impacts to Tribal interests.

Other Social Effects

Changes in the physical conditions of the Missouri River and its floodplain have a potential to affect Tribal communities and/or individual Tribal members by affecting the ability of Tribal members to use the floodplain for subsistence hunting and gathering, to access the river and Mainstem reservoirs for subsistence fishing, to access the river and its environment for traditional cultural practices, and to access the river for educational opportunities. All of these potential effects are assessed qualitatively.

The assessment of subsistence hunting and fishing draws upon the analysis that can be found in the environmental consequences discussion in Section 3.16, Recreation, particularly the "Tribal Resources" subsection. When Tribal members have better opportunities to hunt or fish for the purpose of recreation, they will also have better opportunities to hunt or fish for the purpose of subsistence.

The assessment of subsistence gathering draws upon the analysis that can be found in the environmental consequences discussion in Section 3.5, Fish and Wildlife Habitat. The ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants is subject to the quantity of habitat where plant species collected for subsistence gathering typically occur, including scrub shrub wetland, riparian woodland/forested wetland, forest, and upland grassland.

The assessments of traditional cultural practices and educational opportunities also draw upon the analysis found in the environmental consequences discussion in Section 3.5, Fish and Wildlife Habitat and the assessment of Ecosystem Services provided in Section 3.23. Opportunities for both traditional cultural practices and education are benefited when the river and its floodplain more closely resemble habitats that occurred under the conditions that traditional cultural practices developed. Given the importance of cottonwood trees in Tribal culture, the riparian woodland /forested wetland habitat class is of particular importance in assessing opportunities for traditional cultural practices.

Analysis Assumptions

The following assumptions were used for the impacts analysis for Tribal interests:

- Effects on subsistence hunting and fishing on or near reservations will generally be proportional with effects on recreational value for the applicable reach, identified in the recreation analysis.
- Effects on subsistence gathering on or near reservations will generally be proportional with effects on trends in upland grassland habitat in the applicable reach, identified in the fish and wildlife analysis.
- Effects on traditional cultural practices and educational opportunities will generally be proportional with the level of habitat creation (via flows and/or land acquisition and construction), and (particularly) riparian woodland/forested wetland.

Importantly, the fish and wildlife habitat analysis does not provide absolute change in habitat classes. Because of modeling constraints, the maximum number of days a habitat class could tolerate inundation was assumed for modeling purposes. A habitat class could be inundated no more than its defined number of days to meet its definition. For example, in the Garrison to Oahe Reach, modeling assumed upland grassland is represented by areas with no more than one day of inundation; forest is represented by areas with no more than 16 days of inundation; riparian woodland/forested wetland is represented by no more than 36 days of inundation; scrub shrub wetland is represented by no more than 52 days of inundation; emergent wetland is represented by no more than 159 days of inundation; and open water is represented by no more than 365 days of inundation. The modeling produces the change in the acreage of upland grassland inundated at no more than one day, for instance, rather than the change in acreage of the upland grassland category as a whole. The analysis is useful for comparing trends between alternatives (e.g., trending toward wetter or drier habitats), but should not be used as an indicator of absolute changes or shifts in habitat classes. The impacts analysis assumes that changes in specific day inundation regimes are representative of the trends that would occur under each alternative.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under the Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, the Alternative 1 does not reflect actual past or future conditions but serve as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

3.20.2.2 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under Alternative 1, System operations would be the same as current operations.

Other Social Effects

Changes in cultural practices and educational opportunities would generally be proportional with the level of habitat creation (via flows and/or land acquisition and construction), particularly the proportion that are riparian woodland/forested wetland habitat. Alternative 1 includes ESH construction in the upper river, construction of an additional 3,999 acres of SWH, a spawning cue release, and an additional 7,046 acres of land acquisition and habitat development and management on MRRP lands. As modeled, Alternative 1 would over time result in 22,606 acres of riparian woodland/forested wetland habitat (i.e., the habitat class most suitable for cottonwood trees) in the upper river and 2,662 acres of riparian woodland/forested wetland habitat in the lower river under typical hydrologic conditions for the POR. While a variety of physical conditions are required for recruitment and establishment of cottonwoods, the presence of habitat could be beneficial to the abundance of species important for traditional cultural practices, including cottonwoods.

The ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants under Alternative 1 is affected by the quantity of scrub shrub wetland, riparian woodland/forested wetland, forest, and upland grassland habitat, particularly in areas on or near reservations. As modeled under Alternative 1 for the POR, management actions would result in 148,329 combined acres of habitat suitable for subsistence gathering across all upper river reaches, as well as 6,137 acres in the Gavins to Rulo reach and 8,792 acres in the Rulo to Kansas River reach. Further details on the acres of habitat types are located in Section 3.5, Fish and Wildlife Habitat.

The ability of Tribal members to use the river and reservoirs for subsistence fishing and to use the floodplain for subsistence hunting are highly correlated with the ability to access similar areas for recreation. This is particularly true for recreation areas on or near reservations. Therefore, the relevant reaches from the recreation analysis include the upper three reservoirs, the lower three reservoirs, the inter-reservoir river reaches, and the lower river. Under Alternative 1, flows would remain stable maintaining subsistence fishing opportunities. Habitat acquisition, creation, and improvement would result in some temporary adverse impacts during construction, but would provide long term benefits for subsistence hunting and fishing by improving river and riparian habitat.

Conclusion

Alternative 1 represents the continuation of current System operation including MRRP implementation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. However, the management actions that comprise Alternative 1 would continue to provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species and the habitat upon which they depend. These habitat improvements would continue to provide long term opportunities for subsistence hunting, fishing, and gathering and for traditional practices and educational opportunities. Alternative 1 is not anticipated to have significant adverse impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities.

3.20.2.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Other Social Effects

Compared to Alternative 1, actions under Alternative 2 would result in a decreasing trend in the riparian woodland/forested wetland habitat type in the upper river. The decreasing trend could mean slightly worse conditions for species in that area important for traditional cultural practices, such as cottonwoods. However, opportunities for traditional cultural practices and education in the lower river could be somewhat better under Alternative 2 based on fish and wildlife habitat modeling, as compared to Alternative 1, as the riparian woodland/forested wetland habitat type under Alternative 2 would have an increasing trend. The largest increasing trend (relative to Alternative 1) in riparian woodland/forested wetland habitat in the lower river would occur in the Kansas to Grand River reach, which could mean much better conditions for species important for traditional cultural practices and education.

In the upper river, the opportunities for Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants could be less under Alternative 2 than under Alternative 1, as habitat modeling indicates a general decreasing trend in scrub shrub wetland and riparian woodland/forested wetland. Most of the decrease would occur in the Fort Peck to Garrison and Fort Randall to Gavins Point reaches.

In addition, there would be an overall decreasing trend in habitat suitable for subsistence gathering in all of the lower river reaches. However, based on fish and wildlife habitat modeling, under Alternative 2, it is likely that the general decreases in these habitat types would be offset by considerably more habitat creation and land acquisition and land management on MRRP lands.

The ability of Tribal members to use the upper three reservoirs for subsistence fishing and hunting would be slightly less under Alternative 2 than under Alternative 1, given that the recreation analysis shows a 0.3 percent decrease in recreation value at the upper three reservoirs under Alternative 2 associated with reservoir elevations in the year or years following the spawning cue release. However, the ability to use the inter-reservoir river reaches and lower river for subsistence fishing and hunting would be better under Alternative 2 than under Alternative 1, as the recreation analysis shows a 2.4 and 6.0 percent increase for the lower river and the inter-reservoir river reaches, primarily due to the increased prevalence of habitat developed in these reaches. There would likely be little to no effect on subsistence fishing and hunting on the lower three reservoirs, given that the recreation analysis indicates that Alternative 2 would have little to no effect on those areas.

Conclusion

The management actions that comprise Alternative 2 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species. Because of flow management actions, the amount of additional land acquired for restoration, and habitat development as compared to Alternative 1, Alternative 2 would provide overall benefits to subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities. Therefore, Alternative 2 is not anticipated to have significant adverse impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities.

3.20.2.4 Alternative 3 – Mechanical Construction Only

Other Social Effects

Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 3 would have a decreasing trend as modeled. The largest decreasing trend (relative to Alternative 1) in the upper river would be for riparian woodland/forested wetland habitat in the Fort Peck to Garrison reach, which could mean slightly worse conditions for species important for traditional cultural practices. There is little difference between Alternative 1 and Alternative 3 in terms of flow releases, therefore the changes in riparian woodland/forested wetland in the upper river are likely due to flow events in the period of record outside of the Management Plan alternatives.

Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 3 would result in an increasing trend in the lower river, based on fish and wildlife habitat modeling. The largest increasing trend for riparian woodland/forested wetland habitat in the lower river would occur in the Kansas River to Grand River reach, which could mean better conditions for species important to cultural practices. The amount of land acquisition and habitat construction under Alternative 3 would be less than Alternative 1, providing a smaller benefit to cultural practices and educational opportunities.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants would be somewhat better under Alternative 3 than under Alternative 1, as fish and wildlife habitat modeling indicates an increasing trend in scrub shrub wetland, forest, and upland grassland. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in the Gavins Point to Rulo reach, the Rulo to Kansas River reach, the Grand to Osage River reach, and the Rulo to the mouth reach and no meaningful change in habitat suitable for subsistence gathering in the Kansas to Grand River reach.

Alternative 3 would likely have little impact on the ability of Tribal members to use the river, reservoirs, or floodplain for subsistence fishing and hunting in any reach, given that the recreation analysis indicates that (relative to Alternative 1) Alternative 3 would not increase or decrease recreation value by more than 0.2 percent in the upper three reservoirs, lower three reservoirs, inter-reservoir reach, and lower river reaches.

Conclusion

As assessed, Alternative 3 could result in a small decrease in opportunities for traditional cultural practices in the upper and lower river compared to Alternative 1, based on the results of fish and wildlife habitat modeling. There would be an increasing trend in suitable habitat for subsistence gathering in both the upper and lower river compared to Alternative 1. The management actions that comprise Alternative 3 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species. Alternative 3 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities because the impacts would be relatively small.

3.20.2.5 Alternative 4 – Spring ESH Creating Release

Other Social Effects

Opportunities for traditional cultural practices and education in the upper river under Alternative 4 would be somewhat better compared to Alternative 1, based on fish and wildlife habitat modeling. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 4 would have an increasing trend. The largest increasing trend in the upper river in riparian woodland/forested wetland habitat would occur in the Fort Peck to Garrison reach, which could mean better conditions for species important for traditional cultural practices in that area.

Opportunities for traditional cultural practices and education in the lower river under Alternative 4 would be very similar to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 4 would have an increasing trend. The largest increasing trend would occur in the lower river in riparian woodland/forested wetland habitat in the Kansas River to Grand River reach, which could mean better conditions for species important for traditional cultural practices. The amount of land acquisition and habitat construction under Alternative 4 would be less than Alternative 1, providing a smaller benefit to cultural practices and educational opportunities than Alternative 1.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants would be higher under Alternative 4 than under Alternative 1, as modeling suggests an increasing trend in scrub shrub wetland, riparian woodland/forested wetland, and upland grassland. Most of the increase would occur in the Fort Randall to Gavins Point reach. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in all reaches.

The ability of Tribal members to use the upper three reservoirs for subsistence fishing and hunting would likely be slightly less under Alternative 4 than under Alternative 1, given that the recreation analysis shows a 1.5 percent decrease in recreation value at the upper three reservoirs under Alternative 4. Alternative 4 would likely have little impact on subsistence fishing and hunting in the other locations, given that the recreation analysis indicates that (relative to Alternative 1) Alternative 4 would not increase or decrease recreation value by more or less than 0.4 percent at the lower three reservoirs, the inter-reservoir river reaches, or the lower river.

Conclusion

As assessed, Alternative 4 would provide more opportunities for traditional cultural practices in the upper river and for subsistence gathering in both the upper and lower river as compared to Alternative 1 with small benefits to OSE. The management actions that comprise Alternative 4 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species. Alternative 4 is not anticipated to have significant adverse impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities because the impacts would be overall beneficial.

3.20.2.6 Alternative 5 – Fall ESH Creating Release

Other Social Effects

Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 5 would have a decreasing trend, based on fish and wildlife habitat modeling. The largest decreasing trend (relative to Alternative 1) in the upper river for riparian woodland/forested wetland habitat would occur in the Garrison to Oahe reach, which could mean slightly worse conditions for species important for traditional cultural practices.

Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 5 would have an increasing trend in the lower river. The largest increasing trend in the lower river in riparian woodland/forested wetland habitat would occur in the Kansas River to Grand River reach, which could mean better conditions for species important for traditional cultural practice, including cottonwoods. The amount of land acquisition and habitat construction under Alternative 5 would be less than Alternative 1, providing an overall smaller benefit to cultural practices and educational opportunities than Alternative 1.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants could be somewhat better in the upper river under Alternative 5, due to an increasing trend in scrub shrub wetland, forest, and upland grassland, as modeled. Most of the increase would occur in the Fort Randall to Gavins Point river reach. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in all reaches with the exception of the Kansas to Grand River reach that has a slight overall decrease in habitat classes.

Alternative 5 would likely have little effect (relative to Alternative 1) on subsistence fishing and hunting. The recreation analysis showed only a 0.1 percent decrease in recreation value at the upper three reservoirs, a 0.2 percent decrease in recreation value in the lower river, a 0.1 percent increase in the inter-reservoir river reaches, and no change in recreation value on the lower three reservoirs.

Conclusion

As assessed, Alternative 5 could result in a small decrease in opportunities for traditional cultural practices in the upper and lower river compared to Alternative 1, based on fish and wildlife habitat modeling. There would be an increasing trend in suitable habitat for subsistence gathering in both the upper and lower river compared to Alternative 1. The management actions that comprise Alternative 5 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species. Overall, Alternative 5 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities because the impacts to OSE would be relatively small.

3.20.2.7 Alternative 6 – Pallid Sturgeon Spawning Cue

Other Social Effects

Opportunities for traditional cultural practices and education in the upper river would likely be somewhat better under Alternative 6, as compared to Alternative 1. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 6 would have an increasing trend. The largest increasing trend (relative to Alternative 1) in the upper river in riparian woodland/forested wetland habitat would occur in the Garrison to Oahe reach, which could mean much better conditions for species important for traditional cultural practices, including cottonwoods, in that area.

Opportunities for traditional cultural practices and education in the lower river would be less but similar to Alternative 1, based on fish and wildlife habitat modeling. Compared to Alternative 1, the riparian woodland/forested wetland habitat type under Alternative 6 would have an increasing trend. The largest increasing trend (relative to Alternative 1) in the lower river in riparian woodland/forested wetland habitat would occur in the Kansas River to Grand River reach, which could mean much better conditions for species important for traditional cultural practices. The amount of land acquisition and habitat construction under Alternative 6 would be less than Alternative 1, providing a smaller benefit to cultural practices and educational opportunities than Alternative 1.

In the upper river, the ability of Tribal members to use the floodplain for the gathering of berries, flowers, and medicinal plants could be less under Alternative 6, due to a decreasing trend in scrub shrub wetland, forest, and upland grassland in the upper river reaches. Most of the decrease would occur in the Garrison to Oahe reach. In the lower river reaches where current Tribal lands occur, there would be an overall increasing trend in habitat suitable for subsistence gathering. In the lower river, there would be an increasing trend in habitat suitable for subsistence gathering in all of the reaches.

The ability of Tribal members to use the upper three reservoirs for subsistence fishing and hunting would likely be slightly less under Alternative 6 than under Alternative 1, given that the recreation analysis shows a 1.2 percent decrease in recreation value at the upper three reservoirs under Alternative 6. There would likely be little effect on subsistence fishing and hunting in the other reaches, given that the recreation analysis shows increases or decreases in recreation benefits of 0.2 percent or less for the lower three reservoirs, the inter-reservoir reaches, and the lower river.

Conclusion

Based on fish and wildlife habitat modeling, Alternative 6 would have a small increase in opportunities for traditional cultural practices in the upper river and a decrease in the lower river as compared to Alternative 1. There would be a decreasing trend in suitable habitat for subsistence gathering in the upper river and an increasing trend in the lower river as compared to Alternative 1. Alternative 6 would have a small increase in benefits as overall these habitat classes would increase. The management actions that comprise Alternative 6 would provide benefits to endangered species with ancillary benefits to other associated fish and wildlife species. Alternative 6 is not anticipated to have significant impacts on subsistence hunting, fishing, and gathering, or traditional Tribal practices and educational opportunities because the impacts would be relatively small.

3.20.2.8 Climate Change

As described in Section 3.5, Fish and Wildlife Habitat, climate change could have a beneficial or an adverse effect on wetter habitat classes (i.e., open water, emergent wetland, scrub shrub wetland, and riparian habitat) that are more suitable for traditional cultural practices, depending on whether climate change has a greater effect on drought conditions or the frequency of spring flood events. Climate change could also have some effect on the ability of Tribal members to use the floodplain for subsistence gathering; however, habitats most suitable for subsistence gathering are a mixture of wetter (i.e., scrub shrub wetland and riparian) and drier (i.e., forest and upland grassland) habitat classes, so the overall effect on subsistence gathering is less clear.

The effects of climate change on subsistence hunting and fishing would parallel the effects of climate change described in Section 3.16, Recreation. Earlier snowmelt could lead to more frequent spring pulses under Alternative 1, followed by more frequent low reservoir elevations, decreasing access to the reservoirs for subsistence fishing. Climate change could also negatively affect access for subsistence fishing under Alternatives 2–6, due to increased frequency of prolonged drought periods, which also decrease reservoir elevations. These impacts could be exacerbated by spring or fall releases under Alternatives 2, 4, 5, and 6. Climate change may also increase the number of partial-release events under Alternatives 2, 4, 5, and 6, which would have a mixed effect on subsistence hunting and fishing.

3.20.2.9 Cumulative Impacts

Tribes in the Missouri River basin have experienced direct impacts as a result of changes made in the river from past Missouri River Mainstem Reservoir System construction and operation and the Bank Stabilization and Navigation Project past construction and operation. Subsistence hunting, fishing, and gathering, along with Traditional Cultural Practices were largely affected for all Tribes along the river, as well as those Tribal members that have historical ties to the river. For Tribes in the reservoir reaches, large areas of land were covered by reservoirs, while in the lower reaches, the river channelization changed the floodplain environment. Along with the changing landscape, access to remaining traditional sites became limited in certain areas. The decrease, or in some cases loss, of the many berries, flowers, medicinal, and sacred plants disrupted the traditional cultural activities that are intrinsic to the identity of the Tribes. Consequently, these losses created a decrease in opportunities to educate future Tribal members about these traditional cultural activities. Eroding embankments due to changes in flows threaten areas that may be used in ceremony or contain cottonwood trees that are important to many of the Tribes. Access continues to be an issue as it is often in competition with the different Authorized Purposes, such as recreation. Subsistence hunting and fishing was changed, impacting the culture and the economy. Similarly, the flooding of land from the reservoirs impacted many of the Tribes that historically used these lands for farming.

Past, present, and reasonably foreseeable future projects and actions that create, develop, and/or manage fish and wildlife habitat have benefited or may benefit fish and wildlife species and would be anticipated to have a positive impact on Tribal interests. These actions include USACE Continuing Authority Programs with the purpose of ecosystem restoration, USFWS National Wildlife Refuge System Lands Management, USFWS Partners for Fish and Wildlife Program, NRCS Easement Programs, NRCS Technical and Financial Assistance Programs, EPA Section 319 Non-Point Source Grant Program, and Tribal programs and actions. These actions are expected to have long-term beneficial impacts to Tribal interests related to fish and wildlife and their habitat.

Reasonably foreseeable future actions which may adversely impact fish and wildlife and their habitat include future transportation and utility corridor development, oil and gas development, conversion of habitat for agriculture and other land uses, and water table depletion due to withdrawals from the Missouri River and are the same for all of the Alternatives (1–6). These actions may result in continued loss, degradation, or fragmentation of habitat within the Missouri River basin. Impacts of these reasonably foreseeable future actions would depend on the timing and location of specific actions. These actions are expected to result in a long-term small adverse impact to fish and wildlife and their habitat and would therefore also impact Tribal interests. As a result of sediment deposited in the upper ends of the reservoirs, the river channel downstream of the dams deepen (degrades) as sediment that erodes from the channel floor is not replenished with sediment from upstream sources (USACE 2014e). Sand and aggregate mining in the lower Missouri River between Rulo, Nebraska and the confluence with the Mississippi River in St. Louis also contribute to degradation. In some stretches of the river, the degradation rates have decreased substantially since reservoir construction, while in other stretches degradation continues to shape the river as it seeks its dynamic equilibrium. Degradation has led to increased erosion of streambanks and the riverbed, aquatic habitat degradation, lowering of the groundwater table in the floodplain, potential conversion of some wetland to upland, and reduced fish access up some of the affected tributaries. As described as part of the year 0 and year 15 analyses (Section 3.2.2.3, Impacts on Hydrology from the Alternatives) degradation and the effects on fish and wildlife and habitat would continue because of the sediment trapping behind dams as well as by continued sand and gravel aggregate mining downstream of Rulo, Nebraska, which lowers the riverbed and the stage of the river over time. Future degradation trends have a similar effect on all of the alternatives and modeling indicates that the action alternatives would not substantially contribute to degradation.

The management actions that comprise Alternative 1 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts that have occurred combined with adverse actions that may occur in the future. The incremental impact of Alternative 1 when added to other past, present, and reasonably foreseeable actions would be negligible. Large impacts to subsistence hunting, fishing, gathering and opportunities for traditional cultural practices and educational opportunities have occurred and continue to occur.

Under Alternative 2, modeled conditions would be somewhat better overall for traditional and cultural practices in both the upper and lower basin under Alternative 2. Traditional and educational opportunities would be somewhat better in the lower river under Alternative 2, than Alternative 1. Based upon the recreation analysis, which shows little change between Alternative 2 and 1, subsistence hunting and fishing appears to have little change between Alternative 1 and Alternative 2. When combined with past, present, and reasonably foreseeable future actions, large impacts to subsistence hunting, fishing, gathering and opportunities for traditional cultural practices and educational opportunities would continue to occur. Although Alternative 2 would provide additional benefit in comparison to Alternative 1, the incremental impact of Alternative 2 would be negligible.

Under Alternative 3 modeled conditions and associated impacts would be somewhat better for traditional cultural practices and education in the upper river under Alternative 3, as compared to Alternative 1, although some small adverse impacts to subsistence gathering could occur. Although Alternative 3 would provide additional benefit in comparison to Alternative 1, when added to other past, present, and reasonably foreseeable future actions the cumulative impacts of Alternative 3 would be large and adverse to subsistence hunting, fishing, gathering and opportunities for traditional cultural practices and educational opportunities. The management actions that comprise Alternative 3 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts.

Under Alternative 4, in both the upper and lower rivers, the opportunities for traditional cultural practices and education would be very similar to Alternative 1. Recreation opportunities would be slightly less under Alternative 4, than Alternative 1, by approximately 2.1 percent in the upper three reservoirs, so it may be assumed that this will be similar for subsistence hunting and fishing. The lower three reservoirs and lower river reaches show little change between the two alternatives. When combined with other past, present, and reasonably foreseeable future action, the cumulative impacts of Alternative 4 would be large and adverse; however, the contribution of Alternative 4 would be negligible.

Under Alternative 5, the slight increase of habitat types associated with traditional and cultural practices could provide a slightly better opportunity for the ability to either continue or bring back traditional cultural activities and provide educational opportunities as compared to Alternative 1. The largest increase may occur in both the Fort Randall to Gavins Point and Rulo to Kansas River riverine reach. Alternative 5 would provide a similar benefit in comparison to Alternative 1. When combined with other past, present, and reasonably foreseeable future action, the cumulative impacts of Alternative 5 would be large and adverse; however, the contribution of Alternative 5 would be negligible. The management actions that comprise Alternative 5 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts that have occurred combined with adverse actions that may occur in the future.

While Alternative 6 would likely result in a slightly better opportunity for traditional cultural practices and educational opportunities compared to Alternative 1 in both the upper and lower river reaches, the acreage inundated at 1 day (upland grassland) was notably less in the upper river. Alternative 6 would provide a similar benefit in comparison to Alternative 1. When combined with other past, present, and reasonably foreseeable future actions, the cumulative impacts of Alternative 6 would be large and adverse; however, the contribution of Alternative 6 would be negligible. The management actions that comprise Alternative 6 would have beneficial impacts to fish and wildlife and their habitats, but these would be negligible in comparison to cumulative impacts that have occurred combined with adverse actions that may occur in the future.

3.21 Human Health and Safety

3.21.1 Affected Environment

For the purposes of the MRRMP- EIS, human health and safety is characterized in terms of risks to human life, injury, or the introduction or spread of disease as a result of implementing any of the alternatives considered. The alternatives analyzed in this EIS may have the potential to affect the health and safety of USACE employees and contractors as well as residents of communities along the Missouri River. More traditional human health and safety issues associated with the use of construction equipment and other occupational hazards involved in ESH creation and SWH construction were discussed and adverse impacts were found not to be significant in previous USACE NEPA documents (USACE 2011a). Further, once site-specific actions are identified, USACE will review the potential impacts to Human Health and Safety and mitigate those impacts as appropriate. Although this section focuses on Human Health and Safety, other sections describe risks to human health and safety associated with river flows, specifically Section 3.12, Flood Risk Management and Interior Drainage.

However, USACE received public comment that the alternatives being evaluated could result in increases in mosquito-borne diseases. Specifically, concern was raised about the potential spread of the Zika virus. Therefore, this section focuses on the potential for increased risk of mosquito-borne diseases as a consequence of implementing any of the MRRMP-EIS alternatives.

Mosquitoes are serious nuisance pests due to their persistent biting behavior and are responsible for affecting the health and well-being of humans, companion animals, livestock, and wildlife (Rolston and Johnson 2012). Accordingly, human health and safety could be affected by the implementation of the alternatives analyzed in this EIS if they result in changes in the availability of mosquito breeding habitat along the Mainstem Missouri River that lead to the potential for increased risk of transmission of disease.

3.21.1.1 Arboviral Diseases of Concern in Mainstem Missouri River States

In the United States, mosquitoes transmit a variety of arboviruses (arthropod-borne viruses). The most common arboviral disease within the Missouri River Basin, and in the United States as a whole, is West Nile Virus. Other arboviral diseases known to occur within the Mainstem Missouri River states include St. Louis encephalitis, western equine encephalitis, and LaCrosse encephalitis. The Zika virus, while not yet known to be transmitted within the Missouri River Basin, represents an emerging threat to human health and safety in states along the Mainstem Missouri River and throughout the country.

West Nile Virus

West Nile virus was first reported in the U.S. in 1999 and is presently the most common mosquito-borne disease in the seven Mainstem Missouri River states as well as in the U.S. (KDOH 2016; Rolston and Johnson 2012; MDHSS 2016). West Nile virus has been detected in a number of mosquito species; however, *Culex* mosquito species act as the primary vector for West Nile virus in the United States (Zurek and Broce 2002; IDPH 2014; KDOH 2016; Rolston and Johnson 2012). Certain birds, particularly crows, jays, robins, and other passerine birds, play an important role in the amplification of the West Nile virus in the environment. These amplifying hosts develop high concentrations of virus in their bodies, making them a source of disease for feeding mosquitoes, which then transmit the disease to humans.

St. Louis Encephalitis

Encephalitis refers to inflammation of the brain. St. Louis encephalitis virus, like West Nile virus, is a member of the genus *Flavivirus*, and similar to West Nile virus, mosquitoes (primarily *Culex* species) become infected with St. Louis encephalitis virus by feeding on birds infected with the virus (CDC 2016a). Infected mosquitoes then transmit the virus to humans and animals during the feeding process. St. Louis encephalitis virus grows in both infected birds and mosquitoes, but does not make either one sick. In the United States, the majority of St. Louis encephalitis virus cases have occurred in eastern and central states, where episodic urban-centered outbreaks have recurred since the 1930s.

Western Equine Encephalitis

Western equine encephalitis has been recognized for nearly 50 years as a disease not only of horses but also of humans in the central and western United States (Andre 1981). Western equine encephalitis is normally maintained between *Culex* mosquito species and birds. People and horses are bitten by *Culex* mosquitoes that have previously fed on infected birds during the late summer months (mid-July through early September). Horses and humans are often referred to as "dead-end" hosts for Western equine encephalitis, as the virus does not build to high enough levels in horse or human blood to infect other mosquitoes (MNDH 2018).

LaCrosse Encephalitis

La Crosse encephalitis is a rare disease typically transmitted to humans by the treehole mosquito (*Aedes triseriatus*). La Crosse encephalitis is not transmitted directly from person to person. Many people infected with La Crosse encephalitis have no apparent symptoms, and similar to other types of mosquito-borne encephalitis, most cases of La Crosse encephalitis likely go unreported. Historically, most cases of La Crosse encephalitis neuroinvasive disease were reported from the upper Midwestern states (Minnesota, Wisconsin, Iowa, Illinois, Indiana, and Ohio). Recently, more cases have been reported from mid-Atlantic and southeastern states (West Virginia, Virginia, Kentucky, North Carolina, and Tennessee). La Crosse encephalitis is relatively rare in the Mainstem Missouri River states. Between 2004 and 2013, one case of La Crosse encephalitis was reported in Missouri and four cases were reported in Iowa. No cases of La Crosse encephalitis were reported in the other Mainstem Missouri River states during this period (CDC 2016c).

Zika Virus

Zika virus disease is caused by the Zika virus, which is spread to people primarily through the bite of an infected *Aedes* species mosquito. *Aedes aegypti* and *Aedes albopictus* are the principal vectors of Zika virus. These species are native to Africa and Asia, respectively, but have been transported globally throughout the tropical, subtropical, and temperate world through shipping activities. Of the two species, *Aedes aegypti* mosquitoes are more likely to spread Zika virus (CDC 2016c).

Prevalence of Mosquito-Borne Diseases in Mainstem Missouri River States

All of the states along the Mainstem Missouri River maintain surveillance programs that track the incidence of mosquito-borne diseases. This information is then shared with the Centers for Disease Control (CDC). As shown in Table 3-266, West Nile virus is by far the most prevalent mosquito-transmitted disease in the seven states along the Mainstem Missouri River.

Table 3-266. Incidence of West Nile Virus, St. Louis Encephalitis Virus, and Zika Virus in Mainstem Missouri River States

		West Nile Virus [a]						St. Louis Encephalitis Virus						Zika Virus [b]
		2010	2011	2012	2013	2014	Total	2010	2011	2012	2013	2014	Total	2015–2016
Montana	Reported Cases	0	1	6	38	5	**50**	0	0	0	0	0	**0**	**1**
	Fatalities	0	0	1	2	0	**3**	0	0	0	0	0	**0**	**0**
North Dakota	Reported Cases	9	4	89	125	23	**250**	0	0	0	0	0	**0**	**0**
	Fatalities	0	0	1	2	2	**5**	0	0	0	0	0	**0**	**0**
South Dakota	Reported Cases	20	2	203	149	57	**431**	0	0	0	0	0	**0**	**0**
	Fatalities	0	0	3	3	0	**6**	0	0	0	0	0	**0**	**0**
Iowa	Reported Cases	9	9	31	44	15	**108**	0	0	0	0	0	**0**	**7**
	Fatalities	2	0	0	0	0	**2**	0	0	0	0	0	**0**	**0**
Nebraska	Reported Cases	39	29	193	226	142	**629**	0	0	0	0	0	**0**	**2**
	Fatalities	2	0	4	5	1	**12**	0	0	0	0	0	**0**	**0**
Kansas	Reported Cases	19	4	56	91	54	**224**	0	0	0	0	0	**0**	**2**
	Fatalities	0	1	3	7	0	**11**	0	0	0	0	0	**0**	**0**
Missouri	Reported Cases	3	10	20	29	13	**75**	1	1	0	0	0	**2**	**4**
	Fatalities	0	0	3	2	2	**7**	0	0	0	0	0	**0**	**0**

Source: CDC 2016f, CDC 2016g, CDC 2016h, USGS 2016a.

Notes: No cases of Western equine encephalitis have been reported in the Mainstem Missouri River states since at least 2003. No cases of La Crosse encephalitis virus have been reported since prior to 2010.

a CDC information on reported cases of West Nile virus and St. Louis encephalitis virus only available through 2014.

b Travel-related Zika cases acquired outside of the United States.

During the 5-year period from 2010 to 2014, a total of 1,767 cases of West Nile virus were reported within the seven states, and 46 fatalities were documented (CDC 2016f). In contrast, only two cases of St. Louis encephalitis have been documented over the same 5-year period, both in Missouri (CDC 2016h; USGS 2016a). No human cases of Western equine encephalitis or La Crosse encephalitis have been documented in the seven Mainstem Missouri River states since at least 2003 (USGS 2016a).

The number of confirmed Zika infections in the United States has been growing at a rapid rate, considering that the virus has only recently been documented in the western hemisphere. As shown in Table 3-266, a total of 16 laboratory-confirmed cases of Zika have been documented within the seven Mainstem Missouri River states as of June 8, 2016.A total of 691 cases have been confirmed within the United States as a whole. Most of the documented cases of Zika virus in the United States have been travel-related, wherein the patient acquired the disease outside of the United States in an area experiencing an outbreak of Zika virus (CDC 2016h); however, local transmission of Zika virus by *Aedes aegypti* mosquitoes was documented in south Florida in July 2016 (CDC 2016j). There has been no documentation to date of local transmission among people via mosquito vectors within the Mainstem Missouri River states, although cases of person-to-person transmission via sexual contact have been confirmed (CDC 2017). It is expected that Zika virus transmission will increase throughout the western hemisphere and, therefore, it is possible that infected travelers visiting or returning to parts of the United States with established populations of *Aedes aegypti* or *Aedes albopictus* mosquitoes, including several of the Mainstem Missouri River states, could increase the potential for local transmission (CDC 2016c, 2016e).

3.21.1.2 Vector Mosquito Species in Mainstem Missouri River States and their Breeding Habitat Requirements

There are between 35 and nearly 60 mosquito species known to be present within each state along the Mainstem Missouri River. In general, the number of species present increases as one moves from northwest to southeast along the length of the river (McCauley et al. 2000; Waddington and Hayes 1976; NDDOH 2016; SDSU Extension 2013; Rolston and Johnson 2012). Each mosquito species has its own unique ecology and life history, but all share a few biological similarities. All mosquito species require water for three of the four stages of their lifecycle. Only female mosquitoes bite. Male mosquitoes feed on plant nectars and sugars and are not equipped with a proboscis or stinger. Female mosquitoes of most species, but not all, require protein from blood in order to lay viable eggs. Some prefer mammalian hosts, some avian ones, some reptilian, and some have no preference, but are opportunistic biters of any available host. Some mosquito species are potential disease vectors and some are not (McCauley et al. 2000).

The most common nuisance mosquitoes in all of the Mainstem Missouri River states include *Aedes vexans* and several different species within the *Culex* genus. As discussed above, *Culex* species are the most common vector species for transmission of West Nile virus, St. Louis encephalitis virus, and Western equine encephalitis from infected birds to humans (NDDOH 2016; Zurek and Broce 2002; Marcelli 2012; CDC 2016a; KDOH 2016; MDHSS 2016; Andre 1981). *Aedes vexans* prefers to feed on large animals such as cattle, deer, horses, and rarely feeds on birds; therefore, while it is a considerable nuisance to humans, there is uncertainty regarding the extent of its potential role in West Nile virus transmission (Larsen et al. 2010) and it is generally not considered to be a significant vector for the mosquito-borne diseases discussed above (Rolston and Johnson 2012). Other vector species known or believed to be present in portions of the Mainstem Missouri River states include *Aedes triseriatus*, or eastern treehole mosquito, which is the main vector for La Crosse encephalitis (CDC 2016c) and *Aedes aegypti* and *Aedes albopictus,* which would be the most likely potential vector species for local transmission of Zika virus in the United States (CDC 2016c). The range inhabited by *Aedes triseriatus* includes Iowa, Kansas, Missouri, and Nebraska, but does not include Montana, North Dakota, or South Dakota (Farajollahi and Price 2013). The estimated range of *Aedes albopictus* in the United States includes Iowa, Kansas, Missouri, and Nebraska, while the estimated range of *Aedes aegypti*, which has higher vectorial capacity than *Aedes albopictus*, includes southwestern Missouri and southeastern Kansas (CDC 2016f).

Among the mosquito species that are known to act as vectors for the arboviral diseases described above, the majority lay their eggs on the surface of standing and often stagnant water with poor circulation, high temperatures, and high organic content. These species use both natural and man-made breeding habitats that include tree holes, standing pools in agricultural fields, roadside ditches, cans, buckets, birdbaths, discarded tires, and clogged gutters (Cofrancesco 1990; Dom et al. 2013; Farajollahi and Price 2013; Houseman 2011). *Aedes aegypti* in particular has been shown to thrive in human-made breeding habitats in urban areas, including water storage containers, discarded tires, tin cans, flower pots, and roof gutters (Dom et al. 2013; Philbert and Ijumba 2013). *Aedes vexans*, on the other hand, is known as a floodwater mosquito. It typically lays its eggs on moist soil in vegetated areas just above the waterline in floodplains and pothole depressions. *Aedes vexans* eggs can withstand drought, cold, and rain for up to 4 years. It is only when eggs are inundated by flooding that they hatch into larvae (Houseman 2011; McCauley et al. 2000; Cofrancesco 1990).

3.21.2 Environmental Consequences

For the analysis of impacts to human health and safety, this section considers the potential for actions included in each alternative to affect the availability of mosquito breeding habitat, which could in turn affect the transmission of the mosquito-borne arboviruses discussed above in the Affected Environment section.

3.21.2.1 Impacts Assessment Methodology

Analysis of the potential impacts to human health and safety is based on review of available scientific literature discussing the breeding habitat requirements for mosquito species that commonly act as vectors for disease, and assessment of the potential for actions included in each of the alternatives to create conditions that meet these breeding habitat requirements. For comparison, this analysis also discusses the potential for the creation of additional breeding habitat for *Aedes vexans*, which is one of the most common nuisance mosquito species in the Mainstem Missouri River states, but rarely acts as a vector for human diseases.

For the analysis of impacts to human health and safety, it is assumed that the vector species of greatest concern for transmission of mosquito-borne disease discussed in the Affected Environment section would remain the same under all of the alternatives and would not be supplanted by other species with substantially different life histories. It is also assumed that, as opposed to rural areas, there is generally less floodplain habitat in more heavily populated urban areas along the Missouri River that could potentially be inundated as a result of actions associated with the alternatives. Additionally, it is assumed that actions associated with the alternatives would be more likely to take place in areas that are not close to urban areas.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under the Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

3.21.2.2 Summary of Environmental Consequences

The management actions common to all of the alternatives considered in this MRRMP-EIS, as well as the actions that would be specific to each of the individual alternatives considered, are anticipated to have no adverse impacts on human health and safety with respect to their potential to contribute to the spread of mosquito-borne diseases. Table 3-267 summarizes the impacts of each alternative to human health and safety.

Table 3-267. Environmental Consequences Relative to Human Health and Safety

Alternative	Impacts to Human Health and Safety
Management Actions Common to All Alternatives	Vegetation management, predator management, human restriction measures, and pallid sturgeon propagation and augmentation would have no impacts on human health and safety, because none of these actions would be expected to result in the creation of mosquito breeding habitat. Channel reconfiguration for pallid sturgeon spawning habitat and habitat development and land management on Missouri River Recovery Program (MRRP) lands would each have some potential to create breeding habitat for *Aedes vexans* mosquitoes, which are not common vectors for human disease, but would have no potential to create habitat for common vector mosquito species. As a result, these actions would be expected to have no adverse impacts on human health and safety.
Alternatives 1–6	Although each alternative has the potential to create breeding habitat for *Aedes vexans* mosquitoes, they would have no potential to create habitat for common vector mosquito species. As a result, these alternatives would be expected to have no adverse impacts on human health and safety.

3.21.2.3 Impacts from Management Actions Common to All Alternatives

Vegetation management would maintain bare sand conditions in ESH habitat, which as described above, would not be expected to provide mosquito-breeding habitat. Predator management and human restriction measures would not result in any manipulation of physical habitat and, therefore, would not create mosquito-breeding habitat. As a result, these actions would not contribute to the increased spread of mosquito-borne diseases and, therefore, would have no impact on human health and safety.

Pallid sturgeon propagation and augmentation efforts involve supplementing the pallid sturgeon population with additional live pallid sturgeon and do not involve any manipulation of physical habitat. As a result, this action would not create mosquito-breeding habitat, would not contribute to the increased spread of mosquito-borne diseases, and, therefore, would have no impact on human health and safety.

The establishment of native vegetation, creation of wetlands, and restoration of riparian buffer habitat on MRRP lands along the Missouri River floodplain would not be expected to lead to the creation of areas where the stagnant conditions preferred by common vector species would have an opportunity to develop. These actions could have the potential to enhance habitat types that provide breeding opportunities for *Aedes vexans* in floodplains along the Missouri River; however, the restoration of natural components of floodplain ecosystems would also create habitat for mosquito predators. For example, mosquitoes in wetlands provide a food source for many invertebrates, birds, bats, amphibians, and fish species. These natural predators make wetlands less than ideal mosquito breeding sites (NRCS 2008). In addition, wetlands having good connectivity with the Mainstem river allow additional mosquito predators to enter the wetlands during high flows (Cofrancesco 1990). Although the magnitude of implementation of this action varies under each alternative, none of the potential scenarios would be expected to create sufficient breeding habitat for *Aedes vexans* to substantially increase the abundance of these mosquitoes. As a result, actions associated habitat development and land management on MRRP lands are not expected to measurably affect the spread of mosquito-borne diseases and would likely result in no adverse impacts on human health and safety.

3.21.2.4 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

In addition to the management actions common to all alternatives described above, Alternative 1 would involve the mechanical construction of approximately 164 acres per year of emergent sandbar habitat (ESH), on average. Since this action would involve the construction of in-river bird habitat consisting of bare sand substrate, it would not be expected to create any opportunities for standing, stagnant pools of water to develop, and, therefore, would not create breeding habitat for the mosquito species that would be expected to act as disease vectors in the Mainstem Missouri River states. Alternative 1 would furthermore involve the construction of approximately 3,999 acres of shallow-water early life stage habitat for pallid sturgeon. This action would create side channels, chutes, and widened river sections, increasing the abundance of areas of shallow, slower-moving, relatively warmer water throughout the Mainstem Missouri River. While the typical river flow velocity in some of these areas may be near zero, they would nonetheless be unlikely to provide the stagnant conditions that common vector species prefer as breeding habitat because these areas would retain connectivity with the river. Additionally, mosquito larvae that may hatch in these areas would be subject to predation by fish and other predators. It is possible that channel reconfiguration and shallow water habitat creation could lead to the longer-term development of additional riparian wetland areas where the adjacent upland soil and vegetation may provide attractive sites for *Aedes vexans* to lay its eggs. Larvae in these areas would be subject to predation by fish and other predators, making these areas less effective as breeding habitat. It is unlikely that this scenario would result in a meaningful level of increase in *Aedes vexans* breeding habitat beyond the amount that currently exists within proximity to the Missouri River. Further, as noted above, *Aedes vexans* is not a common vector for human disease. Alternative 1 would also include the continuation of a spring plenary pulse, which would include downstream flow limits. Inundation of floodplain areas could result during years when this pulse is implemented, which would not be expected to create opportunities for stagnant pools and associated breeding habitat for common vector mosquitoes to develop; however, it may help to maintain breeding habitat for *Aedes vexans*. For reasons similar to those described under the discussion of habitat development and land management on MRRP lands, the inundation of floodplain areas resulting from the spring pulse would not be expected to add a substantial amount of mosquito breeding habitat or related opportunities for the spread of mosquito-borne disease. Overall, based on the above, Alternative 1 would be expected to result in no adverse impacts to human health and safety.

Conclusion

Alternative 1 represents the continuation of current System operation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. Alternative 1 would not have the potential to create habitat for common vector mosquito species, thus continuation of current System operation and MRRP implementation actions are not anticipated to cause significant impacts to human health and safety.

3.21.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

In addition to the management actions common to all alternatives described above, Alternative 2 would include approximately 1,331 acres per year of ESH construction. As discussed under Alternative 1, this action would not create breeding habitat for mosquito species that would be expected to act as disease vectors in the Mainstem Missouri River states. Alternative 2 would also involve the construction of 10,758 acres of pallid sturgeon early life stage habitat. While this is substantially more than the amount that would be created under Alternative 1, it is not expected to result in the creation of breeding habitat for vector mosquito species, for reasons discussed for Alternative 1. It is also not expected to result in a meaningful increase in breeding habitat for *Aedes vexans* relative to that which currently exists throughout the Mainstem Missouri River states. Finally, Alternative 2 would implement a spring pulse combined with a summer low flow that would create conditions of periodic inundation of floodplain areas, thereby creating conditions that may be favorable to the *Aedes vexans* life cycle by helping to maintain breeding opportunities in floodplain habitats. As a result, the impacts of the spring pulse and summer low flow would likely be similar to those described for the spring plenary pulse under Alternative 1. Overall, Alternative 2 is not expected to contribute measurably to the availability of mosquito breeding habitat and, therefore, this alternative would likely result in no adverse impacts to human health and safety.

Conclusion

Alternative 2 has the potential to result in some floodplain inundation due to habitat creating flow releases, but would be temporary and would not have the potential to create habitat for common vector mosquito species, thus it is not anticipated to cause significant impacts to human health and safety.

3.21.2.6 Alternative 3 – Mechanical Construction Only

Under Alternative 3, the use of mechanical construction for implementing restoration actions would result in impacts similar to those described for each of the management actions common to all alternatives. The construction of ESH would not provide any opportunities for stagnant pools to develop, and the IRC habitat concept is limited to creation of flowing aquatic habitat rather than areas of standing water and would not be expected to create any additional mosquito-breeding habitat.

The one-time spawning cue test release would have the potential to result in some level of floodplain inundation that would have impacts similar to those described under Alternatives 1 and 2, because periodic floodplain inundation could create breeding opportunities for *Aedes vexans*. The one-time spawning cue test release would not be expected to contribute to the development of breeding habitat for common vector mosquito species, nor would it contribute measurably to breeding habitat for *Aedes vexans* relative to the amount of habitat that currently exists in the Mainstem Missouri River states. Therefore, the one-time spawning cue test release would be expected to have no adverse impacts on human health and safety.

Overall, Alternative 3 is not expected to contribute measurably to the availability of mosquito breeding habitat and, therefore, Alternative 3 would likely result in no adverse impacts to human health and safety.

Conclusion

The one-time spawning cue test release has the potential to result in some floodplain inundation due to the flow release, but would be temporary and would have no potential to create habitat for common vector mosquito species. Thus, Alternative 3 is not anticipated to cause significant impacts to human health and safety.

3.21.2.7 Alternatives 4, 5, and 6 – Spring ESH Creating Release, Fall ESH Creating Release, and Pallid Sturgeon Spawning Cue – Mechanical Construction Only

In addition to the impacts associated with the management actions common to all alternatives described above, Alternatives 4, 5, and 6 would involve the construction of slightly fewer acres of pallid sturgeon early life stage habitat and a slightly greater acreage of ESH than Alternative 1, with resulting impacts similar to those described for Alternative 1. Alternatives 4, 5, and 6 would each have the potential to result in some level of floodplain inundation that would have impacts similar to those described under Alternatives 1 and 2, because periodic floodplain inundation under each of these alternatives could create breeding opportunities for *Aedes vexans*. Alternatives 4, 5, and 6 would not be expected to contribute to the development of breeding habitat for common vector mosquito species, nor would they be expected to contribute measurably to breeding habitat for *Aedes vexans* relative to the amount of habitat that currently exists in the Mainstem Missouri River states. Therefore, Alternatives 4, 5, and 6 would each be expected to have no adverse impacts on human health and safety.

Conclusion

Alternatives 4, 5, and 6 have the potential to result in some floodplain inundation due to habitat creating flow releases, but would be temporary and would have no potential to create habitat for common vector mosquito species, thus it is not anticipated to cause significant impacts to human health and safety.

3.21.2.8 Tribal Resources

Under all of the alternatives, the impacts to human health and safety would be identical whether management actions take place on Tribal or non-Tribal lands. Since all of the alternatives would have no adverse impacts related to the creation of breeding habitat for vector mosquito species, Tribes would not be disproportionately impacted under any of the alternatives.

3.21.2.9 Climate Change

While climate change by itself could affect the spread of mosquito-borne diseases, Alternatives 1–6 would not create breeding habitat for mosquitoes that are common vectors for human disease. Therefore, even when considering changes in climate, Alternatives 1–6 would not be expected to contribute to impacts on human health and safety.

3.21.2.10 Cumulative Impacts

Cumulative actions considered in this impact analysis were identified in terms of their potential contribution to breeding habitat for mosquitoes that could increase the prevalence of mosquito-borne diseases. All past, present, and future management actions that result in the enhancement of wetland habitat, including construction and management of native fish and wildlife habitat areas, NRCS easement and technical/financial assistance programs, Tribal programs, and NPS Missouri National Recreation River Management Actions could contribute beneficial impacts. Wetland restoration can decrease mosquito populations in two ways: by providing proper habitat for mosquito predators, and by reducing flood risk in areas that are not normally wet and thus may support mosquitoes but not their predators (NRCS 2008). The acreage of wetlands that would be restored along the Mainstem Missouri River is expected to be relatively small compared to the total acreage of wetland habitat existing throughout the Mainstem Missouri River states. Therefore, the beneficial impacts that these wetlands provide as habitat for mosquito predators are not anticipated to be measurable, and actions that enhance wetland habitat along the Mainstem Missouri River likely contribute negligible beneficial impacts to human health and safety.

Conversion of floodplain land to urban uses or agricultural uses such as crop production and livestock grazing could potentially contribute adverse impacts on human health and safety, since these uses can provide opportunities for standing pools of water to develop. The larvae of the *Culex* mosquito species that are the primary vectors for human disease within the Missouri River Basin prefer to live in stagnant, still, often polluted pools of water, which may collect in places such as rain barrels, discarded tires, clogged gutters, ditches, ruts from automobile and tractor tires, low-lying areas of agricultural fields, and similar places where standing water may collect (McCauley et al. 2000; Cofrancesco 1990; Dom et al. 2013; Farajollahi and Price 2013; Houseman 2011). Similarly, *Aedes aegypti*, which is the most common vector species for the Zika virus, has been shown to thrive in human-made breeding habitats in urban areas, including water storage containers, discarded tires, tin cans, flower pots, and roof gutters (Dom et al. 2013; Philbert and Ijumba 2013). The contribution to vector mosquito breeding habitat by converted floodplain lands that are now in urban and agricultural uses is likely minimal relative to the aggregate amount of land within the Mainstem Missouri River states that has been converted to these uses. As a result, while conversion of floodplain land to urban and agricultural uses may contribute to conditions that have adverse impacts on human health and safety, it is likely that the overall contribution to adverse impacts is negligible.

Overall cumulative impacts of Alternatives 1–6 are expected to be negligible on human health and safety. As detailed in the analysis of environmental consequences of the alternatives, each of the six alternatives would not be expected to contribute to the cumulative impacts to human health and safety.

3.22 Environmental Justice

3.22.1 Affected Environment

Executive Order 12898, issued in 1994, directs federal agencies to incorporate environmental justice (EJ) as part of their mission by identifying and addressing the effects of programs, policies, and activities on minority and low-income populations. The fundamental principles of Executive Order 12898 are as follows:

- Ensure full and fair participation by potentially affected communities in the decision-making process.
- Prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority or low-income populations.
- Avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.
- Encourage meaningful community representation in the NEPA process through the use of effective public participation strategies and special efforts to reach out to minority and low-income populations.
- Identify mitigation measures that address the needs of the affected low-income and minority populations.

An environmental justice assessment requires an analysis of whether minority and low-income populations (i.e., "populations of concern") would be disproportionately adversely affected by a proposed federal action. Of primary concern is whether adverse impacts fall disproportionately on minority and/or low-income members of the community compared to the larger community and, if so, whether they meet the threshold of "disproportionately high and adverse." If disproportionately high and adverse effects are evident, then EPA guidance advises that it should initiate consideration of alternatives and mitigation actions in coordination with extensive community outreach efforts (EPA 1998).

EPA defines a community with potential environmental justice populations as one that has a greater percentage of minority and/or low-income populations than does an identified reference area. Areas can be determined to have a high proportion of minority residents if either (1) 50 percent or more of the population identifies themselves as a minority; or (2) there a significantly greater minority population than the reference area (EPA 1998). Individuals are considered to be of a minority if they are identified as a race other than Non-Hispanic White Alone. Low-income populations are defined as those families living below the poverty line, as defined by the U.S. Census Bureau.

The project team took a conservation approach (number 2 above) in evaluating areas with potential minority and low-income populations. Because EPA does not specify any percentage of the population characterized as "significant" in order to identify the presence of minority populations in an area, the project team assumed that if the affected area has a minority population more than ten percentage points higher than the reference area, then a potential minority environmental justice population exists. For this analysis, the state and/or county in which the block group is located were used as the reference area. Therefore, census block groups whose minority population is ten percentage points higher than the state or county average in which it is located are identified as environmental justice populations. According to the U.S. Census Bureau, guidelines for a poverty area consist of 20 percent of the population living below the poverty level (U.S. Census Bureau 2016). Thus, block groups with more than 20 percent of their families living below the poverty level were identified as a potential environmental justice poverty area.

U.S. Census block groups containing a portion of land within the floodplain were included in the analysis. Block group data from the U.S. Census Bureau American Community Survey, 5-year averages from 2006 to 2010, were used to identify the percentages of families in poverty and minority populations. While the identification of potential environmental justice populations focused on areas within the floodplain of the Missouri River, there were other minority populations that are dependent on resources from the river but not physically located within the floodplain. These groups, including Tribal populations, were considered in the evaluation of impacts to environmental justice populations. Additional discussion about Tribal interests is included in Section 3.20. This section describes the locations of potential environmental justice populations within the floodplain of each state along the Mainstem of the Missouri River.

Table 3-268 summarizes the racial and ethnic composition for each state along the Missouri River.

Table 3-269 summarizes the poverty levels for the states located along the Missouri River. Environmental justice block groups are summarized by state.

Table 3-268. Missouri River Basin States Racial Composition and Minority Presence, 2006–2010 5-year Estimates

	State						
Race and Ethnicity	**Iowa**	**Kansas**	**Missouri**	**Montana**	**Nebraska**	**North Dakota**	**South Dakota**
Non-Hispanic, White Alone	89.4%	79%	81.3%	88%	83%	89.4%	85.4%
Black or African American Alone	2.7%	5.6%	11.3%	0.4%	4.2%	1.0%	1.0%
American Indian and Alaskan Native Alone	0.3%	0.7%	0.3%	6.0%	0.7%	5.2%	8.3%
Asian Alone	1.6%	2.3%	1.5%	0.6%	1.6%	0.9%	0.9%
Native Hawaiian and Other Pacific Islander Alone	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%
Two or More Races Alone	1.3%	2.2%	1.8%	2.0%	1.7%	1.4%	1.7%
Some Other Race	0.2%	0.4%	0.4%	0.2%	0.3%	0.1%	0.2%
Total	3,016,267	2,809,329	5,922,314	973,739	1,799,125	659,858	799,462
Minority [a]	10.6%	21.0%	18.7%	12.0%	17.0%	10.6%	14.6%
Hispanic Origin [b]	4.5%	9.8%	3.3%	2.7%	8.4%	1.9%	2.5%

Source: U.S. Census Bureau 2012.

a "Minority" population includes all individuals who identify as being of a race other than "Non-Hispanic, White Alone" in addition to those of Hispanic origin.

b "Hispanic Origin" includes all individuals who identify as being of Hispanic or Latino decent and is thus not considered an exclusive race category.

Table 3-269. Missouri River Basin States Poverty Levels, 2006–2010 5-year Estimates

Geography	State Population	Total Families	Percent of Families Below the Poverty Line
Montana	973,739	256,130	9.7%
North Dakota	659,858	170,477	7.2%
South Dakota	799,462	205,879	8.7%
Nebraska	1,799,125	467,250	7.9%
Iowa	3,016,267	793,842	7.4%
Kansas	2,809,329	730,945	8.4%
Missouri	5,922,314	1,546,509	10.0%

Source: U.S. Census Bureau 2012.
Note: This information is available from the 2006–2010 American Community Survey 5-Year Estimates.

Six hundred census block groups intersect the Missouri River floodplain, of which 186 contain potential environmental justice populations. Table 3-270 summarizes total populations and environmental justice populations for the block groups that intersect the floodplain for all of the states. The vast majority of the environmental justice populations are located in the block groups within the states of Nebraska and Missouri, with approximately 150,084 affected residents located in identified environmental justice communities in both states. The following section provides further detail regarding environmental justice populations and their locations within each of the states.

Table 3-270. Missouri River Populations and Environmental Justice Populations, 2006–2010 5-year Estimates

State	Total Populations of All Block Groups that Intersect the Floodplain	Total Population of All Environmental Justice Block Groups that Intersect the Floodplain	Percent Environmental Justice Populations
Montana	80,575	28,717	35.6%
North Dakota	79,019	14,433	18.3%
South Dakota	80,615	23,841	29.6%
Nebraska	131,320	62,162	47.3%
Iowa	98,432	24,540	24.9%
Kansas	36,462	12,829	35.2%
Missouri	255,021	57,131	22.4%
Total	**751,444**	**223,653**	**29.4%**

Source: U.S. Census Bureau 2012.

Montana

Twenty-nine census block groups in the Montana portion of the study area demonstrate high concentrations of minority and/or low-income populations, with a majority located within the Fort Peck Reservation. Poverty and minority populations are both drivers for environmental justice status in Montana. Environmental justice populations for the block groups that intersect the Missouri River floodplain in Montana are described in Table 3-271.

Table 3-271. Environmental Justice Populations Located in Missouri River Floodplain in Montana, 2006–2010 5-year Estimates

Type of Population	Number of Block Groups	Population
All Block Groups in Montana	75	80,575
Minority Block Groups	11	12,035
Poverty Block Groups	10	9,243
Both Minority and Poverty Block Groups	8	7,439
All Environmental Justice Block Groups	**29**	**28,717**

Source: U.S. Census Bureau 2012.

North Dakota

Twelve census block groups that intersect the Missouri River floodplain in North Dakota comprise potential environmental justice populations. These block groups are concentrated in the Bismarck, North Dakota, metropolitan area and Sioux County and exhibit high concentrations of minority populations. These environmental justice populations are likely associated with the Three Affiliated and Standing Rock Sioux Tribal nations. Eight block groups have high concentrations of people that identify as both minority and low-income populations. The percentage of families living below the poverty line in these block groups ranges from 22 percent to 44 percent, and the percent minority population ranges from 80 percent to 96 percent of total population. Environmental justice populations located in the Missouri River floodplain in North Dakota are described in Table 3-272.

Table 3-272. Environmental Justice Populations Located in Missouri River Floodplain in North Dakota, 2006–2010 5-year Estimates

Type of Population	Number of Block Groups	Population
All Block Groups in the North Dakota	60	79,019
Minority Block Groups	1	1,047
Poverty Block Groups	3	4,335
Both Minority and Poverty Block Groups	8	9,051
All Environmental Justice Block Groups	12	14,433

Source: U.S. Census Bureau 2012.

South Dakota

Twenty-three block groups that intersect the Missouri River floodplain in South Dakota are identified as containing potential environmental justice populations. Twenty are located in rural counties. Nine block groups are located within the city boundaries of Pierre and Fort Pierre, South Dakota. Ten block groups have minority and low-income environmental justice populations. All of the 13 block groups on Tribal lands have high concentrations of people that identify as both low-income and high-minority populations. Of the block groups located off Tribal lands, 5 are identified as minority, low-income populations. Environmental justice populations for this study area are described in Table 3-273.

Table 3-273. Environmental Justice Populations Located in Missouri River Floodplain in South Dakota, 2006–2010 5-year Estimates

Type of Population	Number of Block Groups	Population
All Block Groups in South Dakota	42	80,615
Poverty Block Groups	4	2,716
Minority Block Groups	9	11,468
Both Poverty and Minority Block Groups	10	9,665
All Environmental Justice Block Groups	23	23,841

Source: U.S. Census Bureau 2012.

Iowa

Twenty-six census block groups located in the Missouri River floodplain in Iowa are identified as having potential environmental justice populations. Of these, four have high concentrations of people that identify as both low-income and minority populations. All but one of the environmental justice block groups in Iowa are located within the Sioux City or Omaha-Council Bluffs metropolitan areas. Environmental justice populations in the Missouri River floodplain in Iowa are described in Table 3-274.

Table 3-274. Environmental Justice Populations Located in Missouri River Floodplain in Iowa, 2006–2010 5-year Estimates

Type of Population	Number of Block Groups	Population
All Block Groups in Iowa	101	98,462
Poverty Block Groups	10	9,755
Minority Block Groups	12	11,410
Both Poverty and Minority Block Groups	4	3,375
All Environmental Justice Block Groups	**26**	**24,540**

Source: U.S. Census Bureau 2012.

Nebraska

Fifty-seven census block groups located in the Missouri River floodplain in Nebraska are identified as having potential environmental justice populations. These are located either in rural counties on Tribal lands associated with the Winnebago, Santee Sioux, or Omaha Tribes or within the Omaha-Council Bluffs metropolitan area. Of the ten highest-poverty Nebraska block groups, eight are located within the Omaha-Council Bluffs metropolitan area. These eight block groups have minority populations ranging from 68 percent to 100 percent of their total populations. Environmental justice populations located in the Missouri River floodplain in Nebraska are described in Table 3-275.

Table 3-275. Environmental Justice Populations Located in Missouri River Floodplain in Nebraska, 2006–2010 5-year Estimates

Type of Population	Number of Block Groups	Population
All Block Groups in Nebraska	109	131,320
Poverty Block Groups	5	4,973
Minority Block Groups	21	25,125
Both Poverty and Minority Block Groups	31	32,064
All Environmental Justice Block Groups	**57**	**62,162**

Source: U.S. Census Bureau 2012.

Kansas

Eleven census block groups located in the Missouri River floodplain in Kansas are identified as having potential environmental justice populations, most of which are in urban areas of Kansas City and Atchison, Kansas. Two block groups are associated with rural counties. Of the six block groups that are located in Kansas City, all have high concentrations of people that identify as both minority and low-income populations. The majority of potential environmental justice block groups in the Atchison area are low-income populations. Environmental justice populations are described in Table 3-276.

Table 3-276. Environmental Justice Populations Located in Missouri River Floodplain in Kansas, 2006–2010 5-year Estimates

Type of Population	Number of Block Groups	Population
All Block Groups in Kansas	34	36,462
Poverty Block Groups	1	1,337
Minority Block Groups	4	7,421
Both Poverty and Minority Block Groups	6	4,064
All Environmental Justice Block Groups	**11**	**12,829**

Source: U.S. Census Bureau 2012.

Missouri

Thirty-nine census block groups located in the Missouri River floodplain in Missouri are identified as having potential environmental justice populations. Twenty-eight of these are located in the urban areas of Kansas City, St. Louis, St. Joseph, and Jefferson City, Missouri, while 11 block groups are associated with rural counties. Of the 18 that are located in Kansas City, 10 block groups have high concentrations of people that identify as both minority and low-income populations. The majority of potential environmental justice block groups in the St. Joseph, and Jefferson City areas are low-income populations, while the majority of environmental justice block groups in the St. Louis metropolitan area have high concentrations of minority populations. Environmental justice populations are described in Table 3-277.

Table 3-277. Environmental Justice Populations Located in Missouri River Floodplain in Missouri, 2006–2010 5-year Estimates

Type of Population	Number of Block Groups	Population
All Block Groups in Missouri	197	255,021
Poverty Block Groups	11	10,004
Minority Block Groups	17	33,054
Both Poverty and Minority Block Groups	11	14,073
All Environmental Justice Block Groups	**39**	**57,131**

Source: U.S. Census Bureau 2012.

3.22.2 Environmental Consequences

Alternative means of achieving species objectives are evaluated for their effects on environmental justice. The alternatives evaluated include management actions with potential to affect river flows, channel form, river stage, land cover, and land ownership. The impact analysis focuses on determining if any of the management actions described under the alternatives would have disproportionate impacts on environmental justice populations, and if so, what level of impact would be expected. This section presents the results of the assessment.

3.22.2.1 Impacts Assessment Methodology

An environmental justice assessment requires an analysis of whether minority and low-income populations (i.e., "populations of concern") would be disproportionately affected[22] by a proposed federal action and if so the severity of the adverse impacts from the proposed action. The environmental justice assessment for the MRRMP-EIS first evaluated the nature and extent of impacts evaluated under the other resource areas addressed in the EIS (including flood risk management, water supply, thermal power, hydropower, land acquisition, irrigation, recreation, navigation, and water quality) and then qualitatively evaluated whether these impacts would fall disproportionately on potential environmental justice populations that live within the floodplain. A separate environmental justice analysis that was completed for flood risk management and hydropower is included in Section 3.12, Flood Risk Management and Interior Drainage, and Section 3.13, Hydropower.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

[22] The Council of Environmental Quality in *Environmental Justice, Guidance Under the National Environmental Policy Act*, defined disproportionate environmental impacts as "…environmental impacts are significant (as employed by NEPA) and are or may be having an adverse impact on minority population, low-income population, or Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group." (CEQ 1997).

3.22.2.2 Summary of Environmental Consequences

Table 3-278 summarizes the environmental consequences relative to EJ populations.

Table 3-278. Environmental Consequences to Environmental Justice Populations

Alternative	Impacts to Environmental Justice Populations
Management Actions Common to All Alternatives	Not expected to cause impacts to EJ populations.
Alternatives 1–6	Not expected to have disproportionate adverse impacts on any potential EJ populations.

3.22.2.3 Impacts from Management Actions Common to All Alternatives

The MRRMP-EIS considers a number of management actions that are common to all alternatives, including pallid sturgeon propagation and augmentation, predator management, vegetative management, and human restrictions measures. These actions are expected to cause negligible to small, temporary adverse impacts to the other resource areas being evaluated; however, none of these impacts are expected to fall disproportionately on EJ populations. Therefore, management actions common to all alternatives would not result in impacts to environmental justice.

3.22.2.4 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under Alternative 1, the MRRP would continue to be implemented as it is currently. Management actions that could affect EJ populations under Alternative 1 include creation of both SWH and ESH habitat and a spring plenary pulse or a bi-modal spring plenary pulse. ESH habitat creation would be focused in the Garrison and Gavins Point reaches for early life stage habitat for pallid sturgeon between Ponca and the mouth of the river near St. Louis.

Construction activities under Alternative 1 could have adverse impacts on EJ populations although these impacts would be negligible to small and not disproportionate. In the lower river, most of the identified EJ populations are located within or near urban areas. It is expected that the management actions, especially related to habitat creation under Alternative 1, would be in rural areas away from urban corridors and thus would not be located near potential EJ populations. The spring plenary pulse is expected to have negligible impacts on EJ populations.

Conclusion

Impacts under Alternative 1 are expected to be small, short-term, adverse impacts to the resources evaluated; although in some years there may be somewhat higher adverse impacts. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Alternative 1 is not expected to have significant disproportionate impacts on potential EJ populations; therefore, environmental justice issues are unlikely.

3.22.2.5 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under adaptive management. Actions included under this alternative that may have impacts to EJ populations include a spawning cue release; low summer flow; and mechanical construction of SWH and ESH habitat.

Relative to Alternative 1, Alternative 2 would cause relatively small, short-term, adverse and beneficial impacts on average per year to other resources evaluated, although in some years there may be somewhat higher adverse impacts. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Many of the thermal power plants would experience relatively large adverse impacts under Alternative 2. For example, the adverse impacts to thermal power plants in the lower river would be relatively large and adverse for the summers when low summer flow events occur, causing energy values to increase from 17 to 40 percent during these periods. This would lead to considerably greater reduction in power generation on average and under the worst-case years. The potential for relatively large short-term, adverse impacts to grid stability and power reliability could increase under Alternative 2, leading to an increased potential for brownouts and black-outs and an increase in electricity rates. These impacts have implications for EJ and non-EJ populations in the region and are not expected to fall disproportionately on potential EJ populations.

Conclusion

Relative to Alternative 1, Alternative 2 would cause relatively small, short-term, adverse and beneficial impacts on average per year to other resources; although in some years there may be somewhat higher adverse impacts. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Alternative 2 is not expected to have significant disproportionate impacts on potential EJ populations and therefore is not expected to result in environmental justice issues.

3.22.2.6 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include those that focus on the creation of ESH and IRC habitat through mechanical means. Additional ESH habitat would be created in the Garrison, Fort Randall, and Gavins Point reaches and IRC creation would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. This alternative would result in relatively small, beneficial impacts on several of the resources evaluated (e.g., water supply, irrigation, thermal power, recreation). This alternative would not be expected to have any impacts to potential EJ populations.

One-time Spawning Cue Test: The one-time spawning cue test (Level 2) release that may be implemented under Alternative 3 was not included in the hydrologic modeling for the alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Flows equivalent to the one-time spawning cue test were modeled for multiple years in the POR under Alternative 6. Because Alternative 6 modeling results show small adverse impacts to several resources over the POR, the one-time implementation of the pulse would likely cause small temporary impacts to these resources in the year the pulse is implemented and 1 to 2 years following the pulse when the reservoir levels are recovering. Impacts to RED and OSE would likely be negligible because the pulse would only be run once under Alternative 3. The one-time spawning cue test is expected to have negligible impacts to environmental justice populations.

Conclusion

Alternative 3 is not expected to have any impacts on potential EJ populations, therefore would not result in environmental justice issues.

3.22.2.7 Alternative 4 – Spring ESH Creating Release

Alternative 4 focuses on developing ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Additional ESH habitat would be created in the Garrison, Fort Randall, and Gavins Point reaches and IRC creation would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Relative to Alternative 1, Alternative 4 would cause relatively small, short-term, adverse impacts on average per year to other resources evaluated, although in some years there may be somewhat higher adverse impacts. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

In the upper basin, relatively large and temporary adverse impacts to thermal power plants would be expected under Alternative 4 relative to Alternative 1. In the lower river there could be some benefits to power generation under Alternative 4. Impacts to power generation would be expected to impact all populations (minority and non-minority; low-income and non-low income) and not cause a disproportionate impact to potential EJ populations.

Conclusion

Relative to Alternative 1, Alternative 4 would have a relatively small, adverse impact on several of the resources evaluated. While these impacts would likely affect populations in both rural and urban areas, these impacts are not expected to fall disproportionately on any potential EJ populations.

Alternative 4 is not expected to have significant disproportionate impacts on potential EJ populations, and therefore would not result in environmental justice issues.

3.22.2.8 Alternative 5 – Fall ESH Creating Release

Alternative 5 would focus on developing ESH habitat through both mechanical and reservoir releases that would occur during the fall months. Additional ESH habitat would be created in the Garrison, Fort Randall, and Gavins Point reaches and IRC creation would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Alternative 5 would have a relatively small, adverse impact on water supply intakes and thermal power plants and relatively small or negligible, adverse impacts to recreational resources and irrigation intakes. These impacts would not be expected to fall disproportionately on potential EJ populations.

Conclusion

Alternative 5 would have a relatively small, adverse impact on water supply intakes and thermal power plants and relatively small or negligible, adverse impacts to recreational resources and irrigation intakes. These impacts would not be expected to fall disproportionately on potential EJ populations.

Alternative 5 is not expected to have significant disproportionate impacts on potential EJ populations and therefore would not result in any environmental justice issues.

3.22.2.9 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes actions that would develop ESH habitat through mechanical means and a spawning cue flow that would be mimicked through bi-modal pulses that would occur in March and May. Alternative 6 would have relatively small, temporary adverse impacts on water supply and irrigation intakes and recreational resources. Overall, there would be relatively small adverse impacts to thermal power generation and energy values under Alternative 6. These impacts would not fall disproportionately on potential EJ populations.

Conclusion

Alternative 6 would have relatively small, temporary adverse impacts on water supply and irrigation intakes and recreational resources. In addition, there would be relatively small benefits to power plant generation and energy values under Alternative 6. These impacts would not fall disproportionately on potential EJ populations.

Alternative 6 is not expected to have significant disproportionate impacts on potential EJ populations and therefore would not result in any environmental justice issues.

3.22.2.10 Climate Change

Natural climatic conditions that result in flooding or droughts can have direct and indirect adverse impacts on environmental justice populations, especially when weather events are extreme. For example, the POR is characterized by substantial variability in hydrologic conditions which includes periods of drought (i.e., 1930s) and high runoff (i.e., 1997, 2011). This variation results in substantial variability in impacts to EJ and non-EJ populations. These impacts would not represent a disproportional impact. For a detailed discussion of projected climate change see Section 3.2. The forecasted effects of climate change are not expected to change the effects to environmental justice populations described previously for Alternatives 1–6 and are not expected to lead to more disproportionate impacts on environmental justice populations.

3.22.2.11 Cumulative Impacts

Since none of the alternatives would result in environmental justice issues as described above, there would be no contribution to cumulative impacts from implementation of any of the alternatives.

3.23 Ecosystem Services

3.23.1 Affected Environment

The Missouri River and related terrestrial areas create a complex and biologically productive aquatic ecosystem. Although areas of the Missouri River have been modified, the Missouri River ecosystem continues to provide a steady flow of environmental benefits that sustain life and provide values for humans. These benefits include tangible goods and intangible services that are often collectively referred to as ecosystem services. Ecosystem services are defined as *socially valued aspects or outputs of ecosystems that depend on self-regulating or managed ecosystem structures and processes* (Murray et al. 2013).

Ecosystem services provided by the Missouri River, and its related terrestrial lands, support economic activity and contribute to regional quality of life. These environmental goods and services contribute to human well-being in ways that may or may not be considered in market transactions or economic activity. Some of the notable ecosystem services provided by the Missouri River include[23]:

- **Natural Resource Goods**: The provision of food (e.g., fish, mushrooms, venison) and sediment.
- **Water Supply**: The retention, storage, and availability of fresh water.
- **Water Quality, Waste Assimilation, and Nutrient Regulation**: Role of biota, vegetation, and ecological processes in recycling nutrients and removal of nutrients, pollutants, and compounds.
- **Water Regulation and Flood Attenuation**: Role of floodplain connectivity and land cover in regulating runoff and river discharge; wetlands can provide flood attenuation during peak flows.
- **Climate Regulation and Carbon Sequestration**: Influence of land cover and biological mediated processes on climate resources, which affect the ability to store and absorb carbon.
- **Recreation**: The provision of habitat supports hunting, fishing, bird-watching, and other recreational opportunities; river and floodplain landscapes also provide recreational amenities.
- **Land Values**: Real estate and land values can be affected by surrounding amenities such as aesthetically pleasing habitat, diversity of habitats, and visual resources.
- **Other Cultural Services**: May include aesthetic, cultural, artistic, spiritual, historic, and scientific and educational functions.
- **Non-Use Values**: The intrinsic value of the environment or resource, which is derived from a desire to preserve or improve a resource as a social or public good, for future use, or for enjoyment by future generations.

Benefits can be derived from these ecosystem services through their direct and indirect uses or through their intrinsic values (not tied to uses). For example, cold-water fisheries along the

[23] The term “ecosystem services” refers to human benefits from ecological conditions and natural processes and does not include benefits from human-engineered infrastructure (i.e., flood protection benefits associated with dams and levees).

Missouri River provide direct use benefits to anglers who visit the area, and indirect benefits to people who may enjoy watching fishing programs or competitions at home. Other values for ecosystem services provided by the Missouri River and its related terrestrial lands stem from people's desire to preserve and/or improve the river, floodplain, species, and/or habitat as a social or public good, and are unrelated to the *use* of the ecosystem.

This section describes notable ecosystem services provided by the Missouri River, and the benefits people derive from these services. Many of these ecosystem services are further described in other sections of the document, including recreation, water supply, wastewater, flood risk management, cultural resources, and Tribal Resources.

3.23.1.1 Natural Resource Goods

The Missouri River and its floodplain produce a variety of natural products that can be harvested for subsistence and commercial uses, including fish, wild game, vegetation, and sediment. The river and its floodplain are fertile lands that grow crops, edible plants, and fungi, and serve as feeding/foraging, resting, breeding/spawning, and nesting grounds for fish, birds, and wild game. Commercial fishing along the river is primarily for non-game species (e.g., Asian carp, common carp), and commercial fishing regulations vary by state. In addition to food products, the Missouri River provides sediment, which allows permitted companies to remove sand and gravel for resale purposes.

3.23.1.2 Water Supply

Water provided by the Missouri River provides benefits for residents and businesses by supporting municipal water supplies, electric power generation, agricultural production, and other business operations. Missouri River water is used to provide potable water to residences, businesses, industrial establishments, Tribal reservations, cities and towns, and water districts or associations.[24] In addition, numerous private and public entities withdraw water from the Missouri River for irrigation purposes. Six Bureau of Reclamation units that withdraw water from the Missouri River for irrigation purposes. Twenty-two thermal power plants withdraw water for cooling purposes or to recirculate in cooling systems. Some municipal, industrial, commercial, and irrigation water supply facilities also withdraw water from aquifers. The recharging of groundwater aquifers can be affected by infiltration of precipitation or seepage from the Missouri River and other tributary streams.

3.23.1.3 Water Quality, Waste Assimilation and Nutrient Regulation

Wetlands are an integral component of inland aquatic ecosystems, filtering nutrients, organic compounds, metals, and components of organic matter as water passes through them. They have a high capacity to absorb and process excess nutrients as well as to destroy bacteria, reducing levels of nitrogen, phosphorus, bacteria such as fecal coliform, and other pollutants. Water that flows through wetland areas is considerably cleaner once filtered through wetlands, improving water quality for drinking, recreation, and agricultural and industrial purposes (Millennium Ecosystem Assessment 2003; Hansen et al. 2018). In addition, floodplain connectivity and shallow water habitat features facilitate the filtering of water, providing benefits for water quality and regulating nutrients.

[24]. There are additional water supplies for domestic, public, fish and wildlife, and agricultural uses.

There are 37 major wastewater facilities and 22 thermal power plants that discharge wastewater into the Missouri River between Fort Peck Dam and the confluence with the Mississippi River. Each of these facilities has a National Pollutant Discharge Elimination System permit that specifies effluent limits to meet water quality standards. In many cases these facilities rely on the river to dilute pollutants to acceptable levels. The natural filtering of nutrients and other pollutants and improved water quality can reduce water treatment requirements for wastewater dischargers. The provision of clean water is an important service that also could affect many of the other ecosystem services provided by the Missouri River.

3.23.1.4 Water Regulation and Flood Attenuation

Although the operations and infrastructure (i.e., dams, levees, bank stabilization, and engineered channel) of the Missouri River system reduces flood risks to urban and rural areas, the ecological structure and processes of the river and its floodplain can also mitigate downstream flooding and lessen damage from floods. One acre of wetland adjacent to a river typically stores about three acre-feet of water or one million gallons (NRCS n.d.), and trees and other wetland vegetation can slow the flow of floodwaters. Wetland features, channel widening, backwaters, chutes, and other river-floodplain connectivity can increase storage capacity for flood waters, attenuating flood risks for people and property downstream (Jacobson et al. 2015c; Galat et al. 1998; Hey et al. 2004; Opperman and Buss 2008). Flood hydrograph attenuation occurs in rivers as a flood wave as it migrates downstream.

The ability of the Missouri River ecosystem to regulate and attenuate flood waters is affected by the physical characteristics of the Missouri River and its floodplain including river flow and associated stages, river channel dimensions, vegetation and roughness, floodplain connectivity, and flow impedance. Although the regulation of drainage and flood attenuation through a river system is complex and depends on existing conditions, several general factors likely contribute positively to this ecosystem service including the transition of riparian land to natural habitats, creation or restoration of wetland habitats, and an increase in floodplain connectivity.

3.23.1.5 Climate Regulation and Carbon Sequestration

Carbon dioxide is naturally present in the atmosphere as part of the earth’s carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals) and is also one of the greenhouse gasses emitted through human activities. In 2014, carbon dioxide accounted for about 81 percent of all U.S. greenhouse gas emissions from human activities according to EPA (EPA 2015b). Although the main human activity attributed with emitting carbon dioxide is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, many industrial processes and land-use changes can affect the carbon cycle and the ability of soils and plants to sequester carbon. Carbon sequestration refers to the ability of vegetation to convert carbon dioxide into sugar, cellulose, and other carbon-containing carbohydrates through photosynthesis, and store it for long periods in their woody tissues, the soil, or both.

Herbaceous wetlands store large quantities of carbon in the soil while forested wetlands store carbon in both soil and woody tissue. Wetlands are eutrophic systems that are able to process large quantities of nitrogen and phosphorous and rapidly sequester carbon. Ecosystems regulate the earth’s climate by removing greenhouse gases such as carbon dioxide from the atmosphere. In fact, forests, grasslands, peat swamps, and other terrestrial ecosystems collectively store carbon. By storing this carbon in wood, other biomass, and soil, ecosystems keep carbon dioxide out of the atmosphere, potentially mitigating the effects of climate change.

Changes in land use, vegetation, the quality of wetlands and soils, ecosystem disturbances, and geomorphic processes impact the amount of carbon sequestered from the atmosphere. Shifting land from cultivated uses to a more natural state often results in replenishment of carbon stocks and the capture and storage of carbon. A number of studies have analyzed changes in land use, restoring wetlands, and conversion of croplands and the associated change in carbon sequestration rates. Some studies have noted the following:

- Conversion of croplands to restored grasslands results in a range of 0.22 to 0.45 tons of carbon sequestered per acre per year (NRCS 2012; Follett et al. 2001).
- Every acre of replanted floodplain forests will sequester 2.5 tons of carbon each year (NRCS n.d.; Birdsey 1996).
- Restored wetlands have been shown to recover lost carbon at up to 5 metric tons per hectare per year (2.02 tons/acre/year) (Gleason et al. 2009; University of North Dakota Energy and Environment Research Center 2008).

3.23.1.6 Recreation

Many outdoor recreational activities, like fishing, hunting, wildlife watching, and boating are attributed to the natural processes, vegetation, and natural features of the Missouri River and its associated terrestrial areas. These recreational activities, in addition to others, such as site seeing, picnicking, camping, and hiking benefit from varied landscapes and viewscapes, improving the recreational experience. Changes in natural features within the river, such as floodplain connectivity, SWH, and ESH, can contribute to variations in viewscapes and benefit visual resources for recreators. These opportunities can provide a greater recreational experience, a sense of place, and provide quality of life and amenities for residents and visitors, increasing the value of recreational opportunities, and support visitor spending in local economies.

3.23.1.7 Land Values

Proximity of a property to open space land and/or natural habitats, especially those that consist mainly of preserved natural land such as a national wildlife refuge or national forest, has been shown to increase the value of adjacent property (Southwick Associates 2011; Ham et al. 2015). The values of properties closer to open space land have been shown to be slightly higher than those farther away (Southwick Associates 2011; Ham et al. 2015). The studies show that there are distinctions between types and quality of open space in terms of the impact on property value. Property values near a national wildlife refuge were higher than values near other types of open space such as conservation land or a recreation park (Southwick Associates 2011). Other studies show an increase in property values for residential parcels near natural parks (e.g., those preserved in natural vegetation) (Crompton 2005; Lutzenhiser and Netusil 2001; Southwick Associates 2011) and that values for parcels in proximity to a national forest were higher than property values close to other land uses such as military installations (Ham et al. 2015). Land values are affected by many factors and amenities, such as location, school district, land size and condition, and many others; studies show that the increased property values associated with proximity to natural habitats is a relatively small contribution to property values (Crompton 2005).

3.23.1.8 Other Cultural Services

Natural landscapes along the Missouri River can provide aesthetic enjoyment, educational opportunities, artistic and spiritual inspiration, and emotional comfort. Natural landscapes offer a refuge from the modern world, a place where people can reconnect with nature and escape the stresses of everyday life (de Groot et al. 2005).

3.23.1.9 Non-Use Values

Many natural ecosystems, endangered species, environmental components, and natural amenities are often appreciated by people but may not be directly or indirectly used by humans. Non-use values, also referred to as “passive use” values, are values that are not associated with actual use, nor are they directly valued in the market. Non-use values stem from a desire to preserve or improve a resource (e.g., natural landscape, restored ecosystem, endangered species) as a social or public good (existence value), for future use (option value), or for enjoyment by future generations (bequest value) (Sanders et al. 1990; Brown et al. 2007). Since these values or benefits are not associated with behavior or use, their valuation must rely on people stating their preferences for these goods, and/or services.

The preservation of endangered species has been shown to have important value to individuals and to society in general (Richardson and Loomis 2009). Although threatened and endangered species are not commodities that can be bought and sold in traditional markets, they are widely regarded as valuable for biological, educational, scientific, recreational, historical, and cultural purposes. The existence of the ESA, WRDA, and many other environmental protection and enhancement laws and regulations show strong support for these passive-use societal values. Non-use values for threatened and endangered species reflect the personal satisfaction people obtain from knowing that the species exist, sustaining biological systems, maintaining genetic information of species that may be useful for medicinal and genetic engineering applications, or from knowing that preservation today will allow future generations to enjoy these species (Loomis and White, 1996). Providing and maintaining habitat along the Missouri River for threatened and endangered species benefit their populations and the values that society holds for their preservation.

3.23.2 Environmental Consequences

This section provides a description and analysis of how management actions under the MRRMP-EIS alternatives could affect socially valued aspects of ecosystems provided by the Missouri River ecosystem structures and processes.

3.23.2.1 Impacts Assessment Methodology

The analysis of potential impacts to ecosystem goods and services focuses on how changes in the structure and function of the Missouri River ecosystem may affect future provisions of these goods and services. Although there may be short-term impacts to the various ecosystem services from construction activities, this assessment only focuses on the long-term impacts of the management actions under the MRRMP-EIS, particularly the long-term benefits from federal land acquisition for habitat development, which provides a transition to natural habitat. Relevant studies, reports, and information were reviewed to qualitatively evaluate how management actions under the MRRMP-EIS alternatives could affect pertinent ecosystem services.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

3.23.2.2 Summary of Environmental Consequences

Table 3-279 provides a summary of the impacts to ecosystem services associated with the MRRMP-EIS alternatives.

Table 3-279. Environmental Consequences for Ecosystem Services

Resource	Alternative	Impacts to Ecosystem Services
All Ecosystem Services	Management Actions Common to All Alternatives	Negligible long-term beneficial impacts to ecosystem services from vegetation management, predator management, and human restriction actions.
Natural Resource Goods	Alternative 1	Habitat construction and establishment of natural habitats would provide long-term, beneficial impacts to some types of wildlife and aquatic habitats, increasing the prevalence of fish and wildlife for subsistence, recreation, and potentially commercial harvesting. The provision of sediment would continue as a long-term benefit.
	Alternative 2	Relatively higher long-term benefits to some fish and wildlife compared to Alternative 1 from substantially more land acquisition and management and early life stage habitat compared to Alternative 1. There would be no to negligible changes to the impacts to commercial fishing unless state commercial fishing regulations were revised. There would be negligible changes to the provision of sediment relative to Alternative 1.
	Alternatives 3–6	There would be negligible changes to the impacts relative to Alternative 1.
Water Supply	Alternative 1	No impacts to the quantity of water for water supply.
	Alternative 2	Small, long-term, beneficial impacts would result from changes to groundwater recharge compared to Alternative 1. Negligible impacts to surface water quantities for water supply compared to Alternative 1.
	Alternatives 3–6	Negligible impacts to surface water quantities and groundwater recharge for water supply compared to Alternative 1.
Water Quality, Waste Assimilation, and Nutrient Regulation	Alternative 1	Alternative 1 would have long-term, beneficial impacts from reduced sediment and turbidity, nutrients, and pollutants. Management actions under Alternative 1 would result in negligible impacts to waste assimilation and nutrient regulation.
	Alternative 2	Beneficial impact on water quality, waste assimilation, and nutrient regulation resulting from increased pollutant and nutrient filtration from the creation, restoration, or improvement of habitats that filter pollutants and nutrients compared to Alternative 1. These long-term impacts are anticipated to be negligible to small due to the relatively small amount of habitat created in proportion to all lands along the Missouri River.
	Alternatives 3–6	The impacts are similar to those described under Alternative 1. Compared to Alternative 1, the impacts would be negligible.

Resource	Alternative	Impacts to Ecosystem Services
Water Regulation and Flood Attenuation	Alternative 1	The creation of early life stage habitat under Alternative 1 would result in beneficial impacts to water regulation and flood attenuation through added conveyance that may slightly decrease river stage locally.
	Alternative 2	Relatively higher long-term benefits to water regulation and flood attenuation compared to Alternative 1 with considerably more early life stage habitat and added conveyance that may slightly decrease river stage locally.
	Alternatives 3–6	Negligible changes in impacts compared to Alternative 1.
Carbon Sequestration and Climate Regulation	Alternative 1	Beneficial impact on carbon sequestration capacities from natural habitat creation and restoration.
	Alternative 2	Relatively higher long-term benefits to carbon sequestration capacities compared to Alternative 1. All long-term changes would be negligible due to the extensive size of the river basin and relatively small habitat class changes.
	Alternatives 3–6	Negligible change from Alternative 1.
Recreation	Alternative 1	Long-term, benefits would result from habitat construction and the establishment of natural habitats, which are expected to increase the value of recreational experiences and opportunities.
	Alternative 2	The increased prevalence of habitat would have long-term, negligible to small benefits compared to Alternative 1.
	Alternatives 3–6	There would be negligible changes to the impacts relative to Alternative 1.
Land Values	Alternative 1	Properties near habitat areas could realize an increase in land and property values resulting in long-term, beneficial impact.
	Alternative 2	Long-term, negligible to small beneficial impacts to the value of property and land located near habitat areas from additional federal land acquisition and habitat creation compared to Alternative 1.
	Alternatives 3–6	There would be negligible changes to the impacts relative to Alternative 1.
Other Cultural Services	Alternative 1	Early life stage habitat for the pallid sturgeon and ESH would provide beneficial impacts to other cultural services on the river and its related terrestrial lands.
	Alternative 2	Relatively small benefits to other cultural services from substantially more early life stage habitat and ESH compared to Alternative 1.
	Alternatives 3–6	There would be negligible changes to the impacts relative to Alternative 1.
Non-Use Values	Alternative 1	Alternative 1 may have a reduced likelihood of meeting the species objectives compared to the action alternatives, with potential adverse impacts to non-use values.
	Alternative 2	Relatively higher non-use values compared to other alternatives from substantially more ESH and IRC habitat creation, indirectly improving habitat quality for other species and enhancing ecological functions.
	Alternatives 3–6	Management actions to meet the species objectives, including IRC and ESH creation, would result in relatively higher non-use values compared to Alternative 1.

3.23.2.3 Impacts from Management Actions Common to All Alternatives

Aspects of the MRRMP-EIS alternatives, including vegetation and predator management, population propagation and augmentation, and human restrictions measures would provide beneficial impacts to the pallid sturgeon, piping plover, and least tern. Under all of the MRRMP-EIS alternatives, these management actions would support non-use values associated with protecting and supporting these species populations, with long-term beneficial impacts to these societal non-use values.

3.23.2.4 Natural Resources Goods

Under all alternatives, the construction of ESH for the piping plover and the least tern and early life stage habitat for pallid sturgeon and associated land acquisition and habitat management would create or improve aquatic and riparian habitats. These habitat construction actions would result in changes to the types and amounts of habitat present along the river by transitioning some terrestrial areas of the floodplain into aquatic habitats. Chutes, side channels, backwater areas, slack water habitats, wetlands, bottomland forest, and native prairie would be created and native vegetation would be restored. Alternative 2 would result in considerably more habitat, with approximately 1,167 acres more per year of ESH construction, 10,758 acres more of early life stage pallid sturgeon habitat, and 33,648 acres more lands acquired for habitat development and land management compared to Alternative 1.

The creation, acquisition, restoration, and improvement of wetlands, riparian areas, floodplains, and other natural habitats would result in long-term, beneficial impacts to fish, wildlife, and vegetation that use the river for feeding, spawning, and growing. Long-term, beneficial impacts on fish and wildlife could occur if the hydrology in the constructed and restored areas result in the development of early successional plant communities including wetland habitat. Creation of fish and wildlife habitat would result in a long-term, net increase in native vegetation and fish and wildlife habitat in localized areas. The increased prevalence of fish, wildlife, and vegetation could indirectly benefit the provision of natural products for subsistence and commercial uses. However, as described in Section 3.5, Fish and Wildlife Habitat, the benefits would be negligible under all alternatives to commercial fishing because it is not anticipated that the management actions would lead state agencies to revise existing commercial fishing regulations over the implementation timeframe. Compared to Alternative 1, Alternative 2 would have greater beneficial impacts because of the larger amount of land acquisition and management and habitat development. Overall, the long-term, beneficial impacts to the provision of fish, wild game, and vegetation would be relatively large because of the large increase in benefits to fish and wildlife. Please refer to Section 3.23.2.9 for additional information on how the MRRMP-EIS alternatives would affect recreation as an ecosystem service. Additional details of changes to the types and amounts of habitat present along the river are provided in Section 3.5, Fish and Wildlife Habitat and in the “Fish and Wildlife Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Although sediment is trapped in the upper river by the reservoirs, the Missouri River continues to be a large source of sediment to the lower Missouri River and Mississippi River. Sediment is an integral part of geomorphological processes and important for building and sustaining habitats in a river system. Sediment is transported by the river either as suspended sediment in the water column or as bedload on the channel floor. Sediment, specifically sand and gravel, has been dredged from the Missouri River in the state of Missouri since the 1930s. Commercial sand and gravel dredged from the lower Missouri River are used primarily in the construction industry, including road and highway construction. Under all of the alternatives, there would be a negligible change in the sediment accumulation rate, and Missouri River sediment would continue to be provided by the ecosystem. Additional analysis is provided in Section 3.11, Commercial Sand and Gravel Dredging and in the “Commercial Sand and Gravel Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

3.23.2.5 Water Supply

Under all alternatives, construction of early life stage habitat for the pallid sturgeon and associated land acquisition and habitat management would occur, resulting in increased capacity for stormwater infiltration and inundation by river water and improved recharge of groundwater, benefiting water supplies that use aquifers. Alternative 2 would result in the largest amount of habitat development resulting in a larger amount of inundated areas, with larger beneficial impacts to groundwater recharge compared to the other alternatives. Therefore, Alternative 2 would have small, long-term, beneficial impacts and Alternatives 3–6 would have negligible impacts compared to Alternative 1. Under all alternatives, there would be no impact to the quantity of surface water that is available for water supply. Section 3.18, Water Supply, provides details on the impacts of water supplies relative to intake infrastructure, and Section 3.7, Water Quality also provides additional information.

3.23.2.6 Water Quality, Waste Assimilation, and Nutrient Regulation

Impacts to water quality, waste assimilation, and nutrient regulation associated with the construction and establishment of natural habitats would provide the filtration of nutrients and pollutants and nutrient recycling in addition to providing water quality conditions appropriate for aquatic wildlife and vegetation, water supply, recreation, and cultural services. Creation of early life stage habitat for pallid sturgeon would create or improve aquatic habitats. Habitat development actions would establish native vegetation areas; create chutes, side channels, backwater areas, slack water habitats, wetlands, bottomland forest, and native prairie; and restore other habitats. Habitat creation or development would require land acquisition, which would transfer land from other land uses, most prominently croplands, and reestablish natural vegetation covers, and preserve it in natural form. The creation, acquisition, restoration, or improvement of wetlands, riparian buffers, and other aquatic habitats that function as pollutant filters or nutrient sinks would result in long-term, beneficial impacts on water quality from recycling of nutrients and removal of nutrients, sediment and turbidity, and other pollutants. Compared to Alternative 1, Alternative 2 would have greater beneficial impacts because of the larger amount of federal land acquisition and habitat development. Overall, the long-term, beneficial impacts from pollutant removal and filtration functions would be small because of the localized nature of the filtration and the relatively small amount of habitat created on the System. Additional details are provided in Section 3.7, Water Quality.

3.23.2.7 Water Regulation and Flood Attenuation

Construction of early life stage habitat for the pallid sturgeon under all of the alternatives may locally decrease the river stage slightly due to added conveyance (i.e., added flow area). However, projects for early life stage habitat for the pallid sturgeon are not specifically designed to provide river stage reduction, and it is unlikely that significant project vicinity river stage reduction would occur based on past project performance. The amount of added conveyance during construction is small compared to the total river flow area during extreme events. In addition, some of the added area may not effectively reduce downstream peak flows due to factors such as channel geometry and timing of tributary inflows. Further, the added conveyance may be offset by the management of project acquired lands associated with project construction which may result in higher hydraulic roughness for overbank flows due to a change in vegetative cover (e.g., grass or cropland [smoother] to heavy riparian vegetation [rougher]). Each habitat project would be designed to avoid adverse impacts and would be evaluated fully during design to ensure stage increases do not occur.

Alternative 2 would result in the largest amount of added conveyance, which may result in slight decreases in river stages near project sites, due to considerably more construction of early life stage habitat for the pallid sturgeon (10,758 acres more compared to Alternative 1). Therefore, Alternative 2 likely has the largest potential to benefit water regulation and flood attenuation. However, the amount of added conveyance and/or decrease in river stage at each location would be site specific and downstream benefits would depend on a number of factors (e.g., habitat geometry, tributary inflows, peak flow locations, and others). Generally, Alternatives 3–6 would result in a negligible change in flood attenuation and reduced flood risk associated with early life stage habitat compared to Alternative 1 because the channel changes would be similar to those under Alternative 1.

The construction of additional ESH habitat is expected to have negligible impacts on water regulation and flood attenuation because ESH is designed to balance conveyance within the same river section to avoid a net impact on river stage.

The hydraulic analysis determined that there are reductions in flood risk and associated flood damages at the reach-level under Alternative 2, depending on the location of the habitat creation, river dynamics, water conveyance, and other factors. For instance, under Alternative 2, the Booneville and Hermann reaches would experience a beneficial impact from reduced flood damages in a number of years. Changes in flow releases from Gavins Point Dam for the spawning cue and low summer flow events, the natural hydrologic cycles and variability, and other factors from year to year under Alternative 2 would also affect the System's ability to reduce flood risks. As simulated under Alternative 2, there would be a reduction in flood risks and damages in the following years in the downstream reaches of the lower river: 1984, 1993, 2010, and 2011. Overall, Alternative 2 would result in small benefits to flood attenuation in the lower river from Gavins Point Dam release changes and more early life stage habitat constructed in the lower river compared to Alternative 1. Additional details are provided in Section 3.12, Flood Risk Management and Interior Drainage.

3.23.2.8 Carbon Sequestration and Climate Regulation

Under all alternatives, the creation of habitat to support the early life stage requirements of the pallid sturgeon and associated land acquisition and habitat management would reestablish natural vegetation covers, soils, and biological processes. Land acquired for habitat creation would transition some of the acquired land from farmland to a more undisturbed state and would reduce disturbance, enrich soil life, restore soil organic matter, and increase localized terrestrial carbon pools (Bouchard et al. 2011; NRCS 2012). Inundated and connected floodplains are very productive habitats and provide a large carbon sink in the form of short-lived algal material to long-lived trees (D'Elia et al. 2017). The magnitude and direction of carbon sequestration depends on many factors including the existing land use and land cover, soil conditions and properties, and climate (University of North Dakota Energy and Environment Research Center n.d.). Generally, the increase in undisturbed habitats from early life stage habitat construction and the acquisition of lands for habitat development could result in long-term benefits to carbon sequestration and climate regulation through increases in vegetation and soil carbon storage. The Missouri River drainage basin is approximately 3.4 million acres in area, and the habitat changes under the management alternatives comprise a very small portion of this total.

Additionally, approximately 8 billion metric tons of CO_2 must be removed from the atmosphere to reduce global atmospheric CO_2 by 1 part per million (CDIAC 2012). Alternative 2 would result in substantially more habitat with the potential ability to sequester carbon and larger localized long-term benefits from the establishment of stable and improved soils and natural vegetation compared to Alternative 1. However, there would be a small amount of acreage acquired within the region and relatively small changes in habitat classes, resulting in negligible changes in carbon sequestration compared to Alternative 1. Alternatives 3–6 would result in negligible changes compared to Alternative 1. Therefore, the management actions under all alternatives are anticipated to result in no long-term net impacts on carbon stocks and sequestration capacity across the floodplain.

3.23.2.9 Recreation

An increased prevalence of ESH and early life stage habitat for the pallid sturgeon and associated land acquisition and habitat management would benefit fish and wildlife species diversity and abundance along the Missouri River, provide additional primitive areas for recreation outside of nesting season, and enhance the topography and visual aesthetics of the river. The greater prevalence of early life stage habitat and ESH, and associated diversity and abundance of wildlife and aquatic life it supports, would have benefits for residents and visitors who live near and/or recreate on the river, improving the visitor experience and quality of life amenities. Alternative 2 would result in considerably more habitat, with approximately 1,167 acres more per year of ESH construction, 10,758 acres more of early life stage pallid sturgeon habitat, and 33,648 acres more acquired for habitat development and land management compared to Alternative 1. These benefits would be more pronounced with the greater amount of habitat constructed under Alternative 2 compared to the other alternatives. In general, Alternative 2 could have long-term, negligible to small beneficial impacts on the recreation NED benefits compared to Alternative 1 due to higher-valued recreational experiences derived from the additional habitat. Alternatives 3–6 would have negligible changes in recreational experiences compared to Alternative 1 because the quantity of developed habitats is similar across these alternatives.

The increased value of the recreational experience associated with the prevalence of habitat is monetized in the NED evaluation; detailed discussion of the NED evaluation is provided in in the Final EIS Section 3.16.2.5, Recreation and in the “Recreation Environmental Consequences Analysis Technical Report.”

3.23.2.10 Land Values

The construction of early life stage habitat for pallid sturgeon would in some cases require the acquisition of land to accommodate the habitat construction and provide a buffer between the project and adjacent lands. Lands acquired for habitat construction would be converted from existing uses to a more undisturbed state with diverse landscape of natural habitats. Properties adjacent to or in proximity to these new habitat areas could experience increases in land values resulting in long-term, negligible to small beneficial impacts. Compared to Alternative 1, Alternative 2 would have a much greater amount of federal land acquisition and habitat development. Therefore, the beneficial impacts to land values that would result would be relatively larger under Alternative 2 compared to the other alternatives. Overall, Alternative 2 would have small localized, beneficial impacts due to the limited number of properties that would be affected and the small change in property values associated with adjacent natural landscapes. Alternatives 3–6 would result in similar amount of early life stage habitat developed compared to Alternative 1, with negligible localized changes in land values.

3.23.2.11 Other Cultural Services

Under Alternative 1, the continued acquisition of lands and creation and restoration of early life stage habitat for the pallid sturgeon as well as the creation of ESH would enhance visual aesthetics along the river, with potential benefits to other cultural services, including benefits to emotional well-being; a sense of belonging and identity within communities; the cultivation of stronger emotional bonds with the natural environment; and educational and scientific opportunities. Because there would be considerably more acres acquired for early life stage habitat for the pallid sturgeon and ESH created under Alternative 2 compared to target acreages under Alternative 1, habitat areas would provide relatively small local benefits for other cultural services relative to those under Alternative 1. Because there would be a similar number of lands acquired for pallid sturgeon early life stage habitat under Alternatives 3–6 compared to Alternative 1, beneficial impacts to other cultural services under Alternatives 3–6 would be similar to those under Alternative 1.

3.23.2.12 Non-Use Values

All MRRMP-EIS alternatives include management actions that would improve ecological function of the Missouri River floodplain and benefit the least tern, piping plover, and pallid sturgeon and would continue to support non-use benefits associated with these populations and improved ecosystem functioning. It is anticipated that management actions under Alternatives 2–6 have a higher likelihood of meeting the species objectives. In doing so, these alternatives would provide relatively greater beneficial impacts to societal non-use values associated with threatened and endangered species and improved ecological function compared to Alternative 1.

3.23.2.13 Conclusion

In general, all alternatives would have negligible to small long-term net impacts because the amount of habitat is relatively small in the large Missouri River basin and most of the benefits would be localized, although some impacts could be larger on a localized or reach-level scale. Because ecosystem services are based on environmental benefits provided by or obtained from the natural functioning of the Missouri River ecosystem, the beneficial impacts to ecosystem services would tend to be larger when more natural habitats are developed or supported, with improved ecological functions of the ecosystem. Compared to Alternative 1, Alternative 2 would have considerably more federal land acquisition and habitat development, resulting in relatively more beneficial impacts to many of ecosystem services discussed in this section. Alternatives 3–6 would result in negligible to small beneficial impacts to ecosystem services, with a negligible change compared to Alternative 1.

No significant adverse impacts to ecosystem services are anticipated under any of the alternatives because habitat developed under all alternatives would benefit ecosystem services.

3.23.2.14 Tribal Resources

Tribal resources would be affected by the changes to ecosystem services as described in the above-noted sections.

3.23.2.15 Climate Change

The main future climate trends in the Missouri River Basin will likely consist of increased air temperatures and precipitation (USACE 2016h). The primary ecosystem services impacts (beneficial and adverse) are associated with habitat construction, land acquisition and restoration, and flow releases. It is not anticipated that the effects of climate change would impact the location, amount, or types of habitat construction or land acquisition and restoration under the alternatives. Increases in temperature and precipitation could result in changes to the frequency and duration of flow events under the Alternatives; however, it is not anticipated that climate change would change the direct and indirect impacts of the Alternatives on ecosystem services from as previously described.

3.23.2.16 Cumulative Impacts

Past, present, and reasonably foreseeable future actions have both temporary and long-term impacts on ecosystem services. Activities along the river including those associated with the continued operation of the Mainstem Reservoir System, the BSNP, levee construction, oil and natural gas production, and other development actions would have temporary adverse impacts from disturbances to vegetation and wildlife, water and air quality, carbon storage, aesthetics, and access limitations. The development activities would also result in long-term adverse impacts to natural resource goods, water quality, climate regulation and carbon sequestration, property values, other cultural services, and non-use values from alteration of habitat and other natural resources.

The actions of continued management of recreation, wildlife, and natural areas by USFWS, NPS, and other agencies that manage these resources at the federal, state, and local level generally benefit many types of ecosystem services because they promote conservation and restoration of natural habitats and focus on safeguarding and enhancing wildlife and vegetation, recreation, and cultural resources. Therefore, past, present, or reasonably foreseeable future actions that provide, protect, create, and restore habitat would result in long-term benefits for ecosystem services. In addition to the cumulative actions, variability in natural hydrologic conditions (e.g., precipitation, snowmelt, periods of drought and high runoff) and geomorphic processes and trends over time and by location can have adverse or beneficial impacts on the ecosystem and ecosystem functions, with varying impacts on ecosystem services.

The management actions of developed ESH and early life stage habitat for the pallid sturgeon under Alternatives 1–6 would have long-term beneficial impacts to ecosystem services. Compared to Alternative 1, Alternative 2 would have considerably more natural habitat developed resulting in relatively larger beneficial impacts to most ecosystem services. Alternatives 3–6 would result in negligible to small beneficial impacts to ecosystem services, with a negligible change compared to Alternative 1.

When combined with other past, present, and reasonably foreseeable future actions, Alternatives 1–6 would result in adverse and beneficial long-term cumulative impacts. In general, when compared to Alternative 1, Alternative 2 would provide a larger contribution to the beneficial cumulative impacts because it encompasses a larger part of the project area and provides for more habitat development. Overall, the impacts of Alternatives 1–6 would have a negligible to small contribution to the cumulative impacts because of the localized scale of the habitat development and widespread beneficial and adverse impacts associated with cumulative actions throughout the basin.

3.24 Mississippi River Impacts

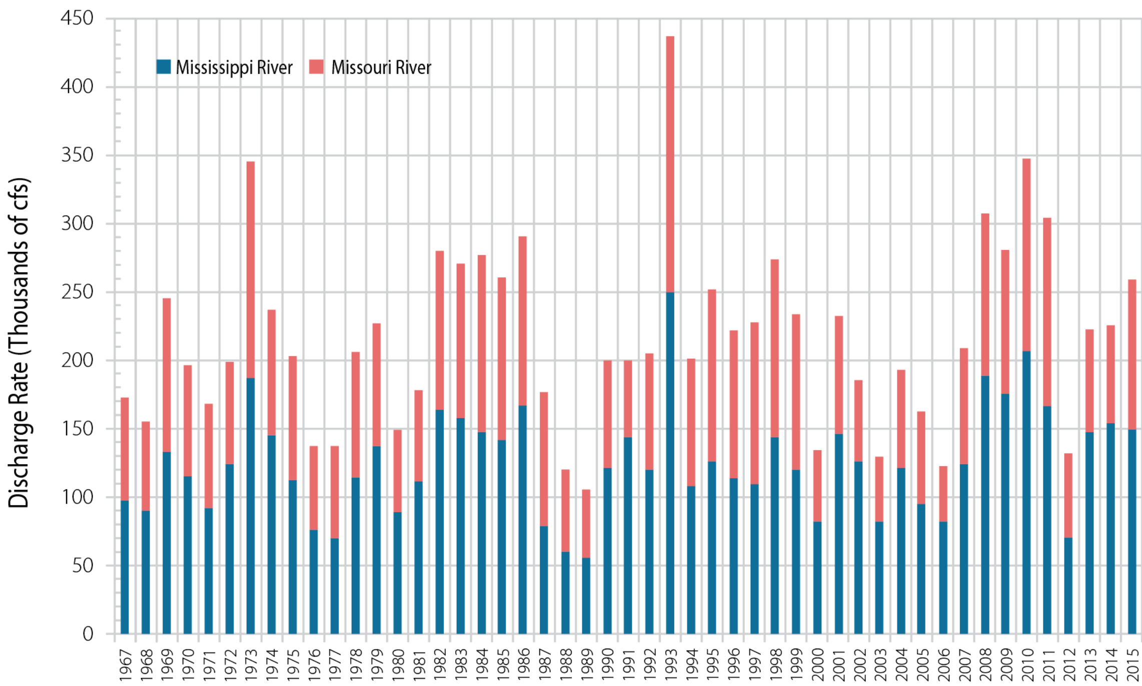
This section describes resources in the Middle Mississippi River that could be potentially affected by the alternatives. The Middle Mississippi River is the portion of the Mississippi River that lies between the confluence with the Missouri River and the confluence with the Ohio River. Counting of river miles on the Middle Mississippi River begins at mile 0 at the Ohio River confluence near Cairo, Illinois and ends at mile 195 at the Missouri River confluence north of St. Louis, Missouri.

Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or "baseline" for comparing the impacts of the action alternatives on resources.

3.24.1 Riverine Infrastructure and Hydrologic Processes

3.24.1.1 Affected Environment

The Missouri River contributes almost half of the flow in the Middle Mississippi River. Between 1967 through 2015, the mean annual discharge rate of the Missouri River at Hermann, Missouri, was 91,800 cfs, whereas the rate for the Mississippi River below the confluence in St. Louis was 217,300 cfs (USGS 2016b). The mean annual discharge contribution of the Missouri River to the Mississippi River between 1967 and 2015 was 42 percent, ranging between 30 and 55 percent (Figure 3-68). On a monthly basis, discharge contributions by the Missouri River between 1967 and 2015 ranged from a low of 20 percent (May 2014) to a high of 73 percent (September 1996). The Missouri River contributes approximately 75 to 95 percent of the suspended sediment load in the Mississippi River (Davinroy 2006).

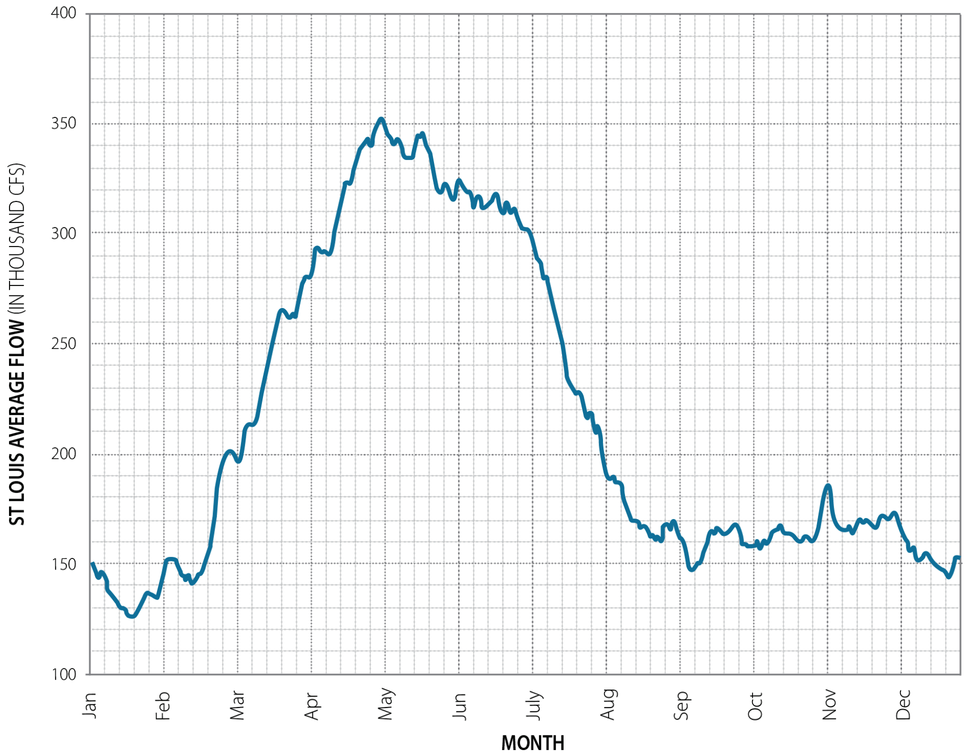


Note: The combined total represents the flow in the Mississippi River at the St. Louis stage.

Figure 3-68. Mean Annual Discharge Rates for the Missouri River and Mississippi River at their Confluence in St Louis, Missouri

Other tributaries to the Middle Mississippi River include the Meramec River at RM 160, the Kaskaskia River at RM 117, and the Big Muddy River at RM 75. These tributaries are small compared to the Missouri River; they contribute mean flows of approximately 3,200 cfs, 3,800 cfs, and 1,900 cfs, respectively (WEST 2000).

The highest flows and stages on the Middle Mississippi River typically occur in April and May and the lowest flows and stages tend to be in December and January (Figure 3-69). The mean stage and corresponding flow for flood stage, approximate elevation of the top of river training structures and the Annual Exceedance Probability for the Mississippi River at St. Louis, Missouri are listed in Table 3-280.



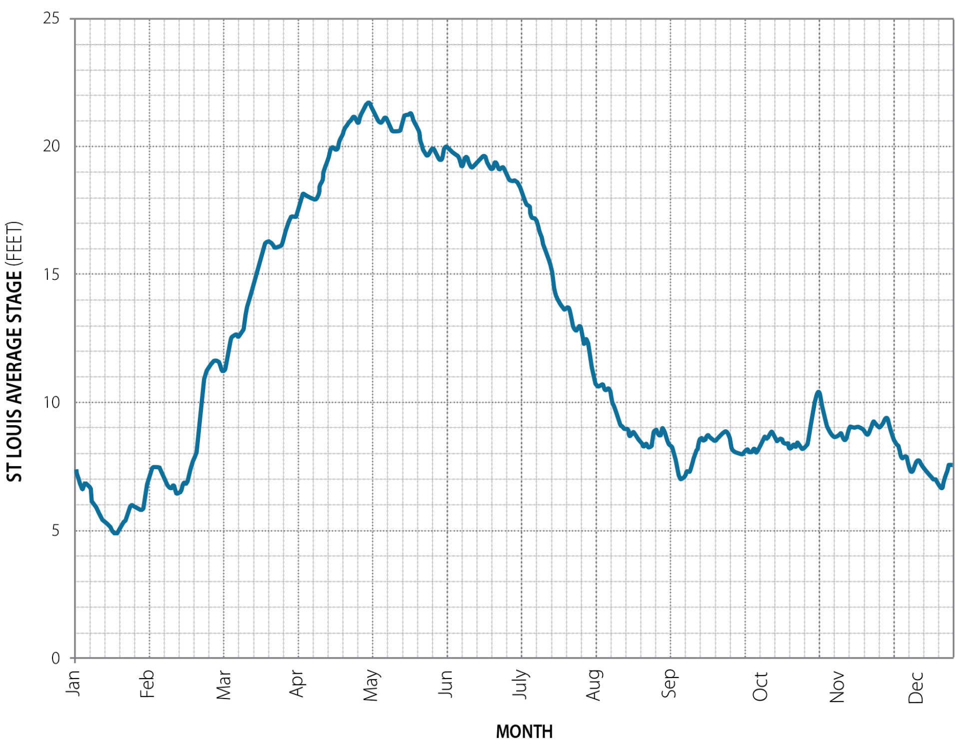


Figure 3-69. Daily Average Middle Mississippi River Flows and Stages at St. Louis over the Period 1967 to 2015

Table 3-280. Annual Exceedance Probability: Mississippi River at St. Louis, Missouri

Annual Exceedance Probability: Mississippi River at St. Louis, Missouri	Stage (ft)	Flow (cfs)
Structure Top Elevation	15.00	247,000
0.50 (2 – year)	29.96	450,000
Flood Stage	30.00	510,000
0.20 (5 – year)	35.76	590,000
0.10 (10 – year)	38.46	670,000
0.04 (25 – year)	41.96	780,000
0.02 (50 – year)	44.06	850,000
0.01 (100 – year)	46.06	910,000
0.005 (200 – year)	47.86	1,000,000
0.002 (500 – year)	50.56	1,120,000

An analysis of changes in river planform[25] in the Middle Mississippi River was recently conducted by the St Louis District, using 10 years for which available survey data were available (1817, 1881, 1908, 1928, 1956, 1968, 1976, 1986, 2003, and 2011) (Brauer et al. 2005; Brauer et al. 2013). The analysis demonstrates that the Middle Mississippi River went through a period of planform widening in the mid-nineteenth century followed by a period of planform narrowing from the end of the nineteenth century through the mid-twentieth century (Figure 3-70). These trends were observed throughout the Middle Mississippi River. The period of narrowing corresponded to the widespread use of river training structures and bank protection for navigation improvements. The increase in planform and channel width in 1881 found between RM 110.3 and RM 120.0 was the result of the channel cutoff that occurred on the Mississippi River when it captured the Kaskaskia River.

The first training structures were mainly permeable wooden structures, which focused the river's energy into the main channel by reducing the velocities between the structures, causing sediment to deposit in channel border areas. This deposited sediment narrowed the channel. Since 1968, however, the channel width appears to have reached dynamic equilibrium with very little change. In the 1960s, USACE began constructing impermeable dikes primarily out of stone. The use of impermeable dikes reduced the rate of deposition between the structures when compared to the previously used permeable structures. Another change was the reduction of the design elevation of dike fields. In the historical case during the establishment of the navigation channel (early 1900s to the 1970s), sediment was deposited between the structures. That sediment was initially not covered in vegetation, and the deposition zone was dynamic with sediment being added and subtracted. Over time, as structures were extended and new structures added, those deposited sediments became vegetated and the channel width was thereby constructed to the current navigation channel geometry. In the present case minor amounts of sediment are deposited between the structures with much of the sediment sluiced downstream. The surfaces between the structures are relatively stable, are increasingly anchored by vegetation, and are stable parts of the floodplain. In addition, the construction of the upstream Mainstem dams in the mid-twentieth century drastically altered the river flows and available sediment load. The result is a channel that is narrower and capable of transporting

[25] The planform is the view of river from above. For example, meandering channels are sinuous single channels with a series of point bars, deep pools, and eroding meander bends.

sediment downstream such that the navigation channel is self-scouring and normal maintenance dredging is not required. By design, the occurrence of channel islands and bars is reduced compared to historic conditions in the current navigation channel. In the 43 years between 1968 and 2011, the average planform width remained relatively steady with a net reduction in average planform width of 167 feet. This was the result of the changes in structure material, structure elevation, and bank protection.

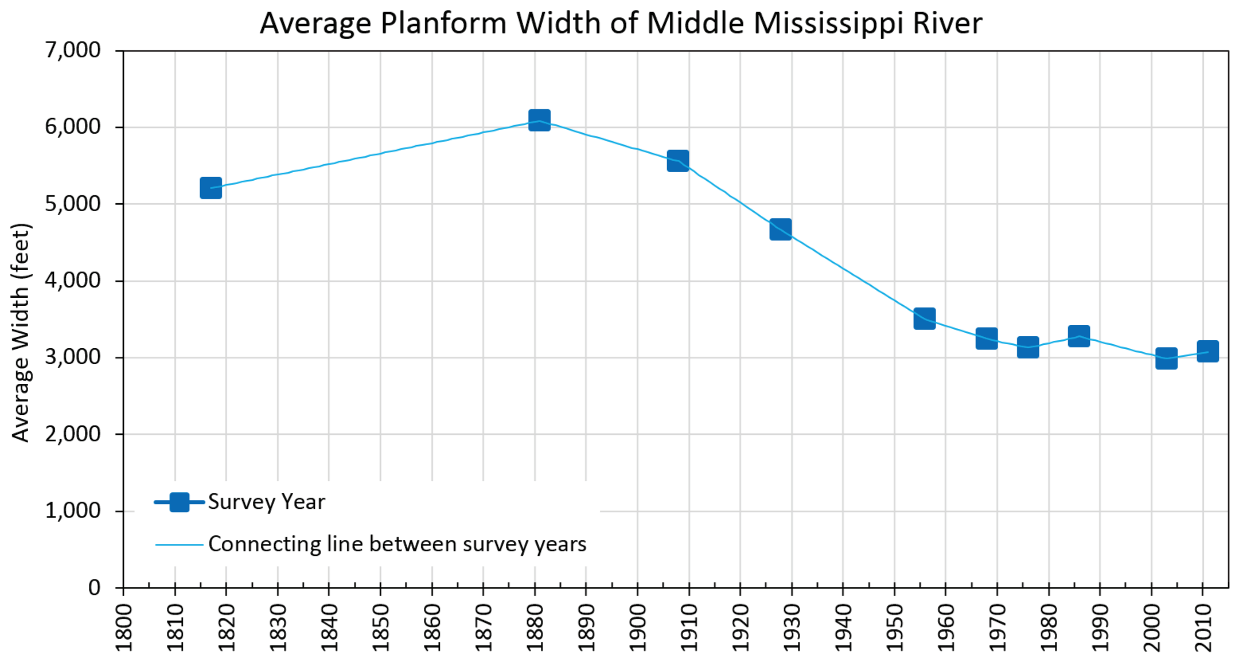


Figure 3-70. Average Planform Width of the Middle Mississippi River from 1817 to 2011

3.24.1.2 Environmental Consequences

Impact Assessment Methodology

The methodology for the analysis of the impacts on the hydrology in the Middle Mississippi River from the alternatives was similar to the methodology used for analyzing the impacts for the Missouri River. Specifically, the analysis of the flow alterations under the six alternatives was largely based on HEC-ResSim and HEC-RAS modeling for the POR, as described in Section 3.1. General hydrologic conditions in the river were analyzed using the statistical 90th percentile (wet period conditions), 50th percentile (average conditions), and 10th percentile (dry period conditions) of the POR.

In addition, flow alterations were assessed for individual years throughout the POR to assess potential impacts on the Middle Mississippi River for specific action alternatives. Examples of individual years shown graphically include the same as the individual years analyzed for the Missouri River (see Section 3.2.2) to show the effect of these altered flows as they travel through the Missouri River into the Mississippi River. These example years were compared to Alternative 1:

- 1963: Representing March and May spawning cue release and low summer flow under Alternative 2 (2003 BiOp Projected Actions), representing spring habitat-forming flow releases under Alternative 4, and representing pallid sturgeon spawning cue releases under Alternative 6. Release for all of these three alternatives would have occurred in 1963, allowing comparisons between alternatives.
- 1966: Representing fall habitat-forming flow releases under Alternative 5.

These years were selected because they are considered fairly typical in their responses to flow alterations under the various alternatives. Ultimately, there would be considerable variability from year to year in response to individual flow alterations, driven by the specific meteorological conditions in the large Missouri River watershed in that year and years prior.

The impact analysis considered both flow (measured in cubic feet per second [cfs]) and stage (measured in feet). Flow is relevant as it affects erosion and deposition rates in the river. Stage affects flooding and navigation (refer to Table 3-281).

Table 3-281. Stages with Action Levels for Navigation at St. Louis, Missouri

Trigger Reading	Description
15 feet	Normal Operations
5 feet	Normal Operations with Advisory
0 foot	Low Water (channel narrows in various conditions)
−3 feet	Extreme Low Water (channel continues to narrow and channel depth decreases)
−5 feet	Minimum Navigation (in many areas of the zone, channel is at best 300-feet wide by 9-feet deep)
−6 feet	Below Minimum Navigation
−7 feet	Historic Low Water

Source: USCG 2012

Summary of Environmental Consequences

The environmental consequences relative to river infrastructure and hydrologic processes are summarized in Table 3-282.

Table 3-282. Environmental Consequences for River Infrastructure and Hydrologic Processes

Alternative	Impacts on River Infrastructure and Hydrologic Processes
Management Actions Common to All Alternatives	• The flow in the Middle Mississippi River at St. Louis would be nearly identical for all alternatives throughout the year for the 90th, 50th, and 10th percentile conditions, as well as for maximum high and low flow conditions. • As modeled the volume of sediment supplied by the Missouri River to the Middle Mississippi River would change very little. Combined with the impacts on flow alterations the impacts on geomorphology and river infrastructure would be negligible. • Impacts on groundwater elevations in the Middle Mississippi River would be temporary, adverse, and negligible to small from adverse negligible to small impacts on hydrology in the Middle Mississippi River.
Alternative 1	• Existing hydrologic conditions in the Middle Mississippi River would continue and the spawning cue release pulses would be mostly attenuated by the time they reach the Middle Mississippi River and would not cause impacts.

Alternative	Impacts on River Infrastructure and Hydrologic Processes
Alternative 2	• The spawning cue releases and summer low flows may affect the stage by lowering it for up to one to two feet for short periods in the Middle Mississippi River in July and August.
Alternative 3	• No impacts would occur to flows or stage of the Middle Mississippi River.
Alternative 4	• Flows would mostly be attenuated before they reach the Middle Mississippi River, but releases would increase the stage by 1 to 3 feet and the flow in the Middle Mississippi River and long-term adverse impacts would be negligible to small.
Alternative 5	• Flows would mostly be attenuated before they reach the Middle Mississippi River, but releases would increase the stage by 1 to 3 feet and the flow in the Middle Mississippi River. These impacts on stage and flow would be negligible.
Alternative 6	• The spawning cue release would be largely attenuated by the time it reaches the Middle Mississippi River, but releases would increase the stage up to 2 feet and flow in the Middle Mississippi River. These impacts on stage and flow would be negligible to small.

Hydrology

Impacts from Management Actions Common to All Plan Alternatives: The flow in the Middle Mississippi River at St. Louis simulated for the POR would be nearly identical for each of the six alternatives throughout the year for 90th, 50th and 10th percentile conditions, as well as for maximum high and low flow conditions.

Alternative 1 – No Action (Current System Operation and Current MRRP Implementation): Existing hydrologic conditions in the Mississippi River would continue. The spawning cue release pulses in March and May would be almost entirely attenuated in the Missouri River by the time they reach the Mississippi River (Figure 3-71) and thus would not impact the hydrology in the Middle Mississippi River.

Alternative 2 – USFWS 2003 Biological Opinion Projected Actions: The spring pallid sturgeon flow releases and summer low flows under Alternative 2 may for short periods affect the stage in the Mississippi River by up to one or two feet, based on the hydrology simulated for individual years of the POR. For example, for hydrologic condition of year 1963, the spawning cue release would be attenuated considerably by the time it reached Hermann, Missouri; the summer low flow would still be recognizable (Figure 3-71). Both flows would be further attenuated at St. Louis, although the summer low flow would result in a lower stage of approximately 2 feet in July and August.

There would be a few years, as simulated over the POR, with the stage decreasing at St. Louis to below 0 foot due to Alternative 2. These occasions would reflect the hydrologic conditions from two weeks in November 1963 when the stage of +1 foot decreased to −1 foot under Alternative 2, and a week in October 2006 when the stage of −1 foot decreased to −2 feet. On the other hand, Alternative 2 would result in increased stages at other times compared to Alternative 1. This would occur under hydrologic conditions represented by a few weeks in November 1963 when the stage as low as −2 increased to +1 (Figure 3-71), a few days in December 1999 when the stage of −2 feet increased to +1 foot, November 2002 when the stage of between −2 and 0 feet increased to between 0 and +2 feet, and a few days in November 2003 when the stage of −2 feet increased to 0 foot. As illustrated by these modeled years, overall, long-term adverse impacts to stage and flows in the Mississippi River under Alternative 2 would be negligible to small.

Alternative 3 – Mechanical Construction Only: There would be no impacts to the flows or stages of the Middle Mississippi River under Alternative 3 as the absence of Alternative 1 spawning cue release would not have a noticeable effect.

Alternative 4 – Spring ESH Creating Release: Although the flow releases under Alternative 4 would be partially attenuated by the time they reach Hermann, Missouri, the releases would still increase the stage (on the order of 1 to 3 feet) and flow in the Mississippi River at St. Louis compared to Alternative 1, as shown, for example, by hydrologic conditions simulated for year 1963 (Figure 3-72). In one of the simulated POR years with flow releases, flows in the Middle Mississippi River decreased slightly in late fall; specifically, a decrease below the stage of 0 at St. Louis would have occurred for about one week in October 1963 when the stage of 0 foot decreased to -1 foot under Alternative 4 (Figure 3-71). Overall the long-term adverse impacts on stage and flow in the Middle Mississippi River would be negligible to small.

Alternative 5 – Fall ESH Creating Release: Similar to flow releases under Alternative 4, flow releases under Alternative 5 would be partially attenuated by the time they reach Hermann, Missouri. However, the releases would still increase the stage (on the order of 1 to 3 feet) and flow in the Mississippi River at St. Louis compared to Alternative 1, as shown for example by hydrologic conditions simulated for year 1966 (Figure 3-73). None of the flow releases would lower the stage in St. Louis to below Stage 0 compared to Alternative 1. Therefore, overall impacts on stage and flow in the Middle Mississippi River would be negligible.

Alternative 6 – Pallid Sturgeon Spawning Cue: The spawning cue releases simulated over the POR under Alternative 6 would often be largely attenuated by the time it reaches Hermann, Missouri, but some of the spawning cue releases would still increase the stage (by up to 2 feet) and flow in the Middle Mississippi River at St. Louis compared to Alternative 1, as shown for example for hydrologic conditions in year 1963 (Figure 3-74). In some of the POR years with spawning cue releases, flows at St. Louis decreased slightly in late fall. A decrease below the stage of 0 at St. Louis occurred for a few days in November 1964 when the stage of 0 foot decreased to −2 feet, and in October 2006 when the stage of −1 foot decreased to −2 feet. Considering the long POR, these occurrences would be comparatively infrequent, thus overall impacts on stage and flow in the Middle Mississippi River would be negligible to small.

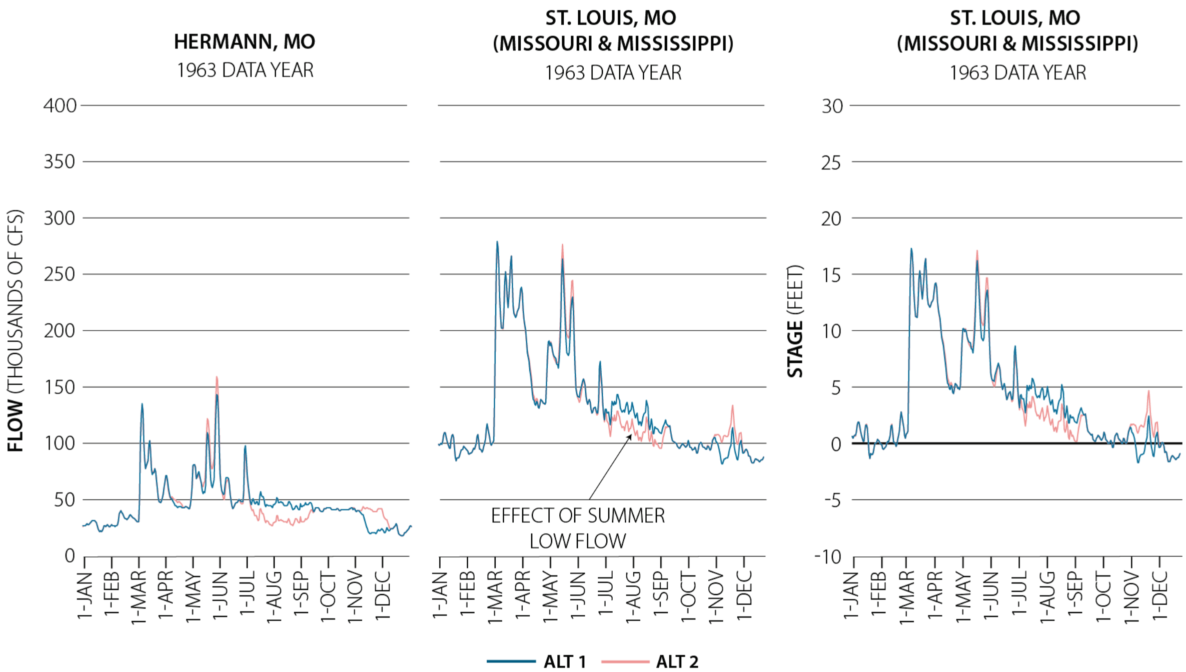


Figure 3-71. Flows of Missouri River at Hermann, MO, and flows and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 2, simulated based on hydrologic conditions in year 1963

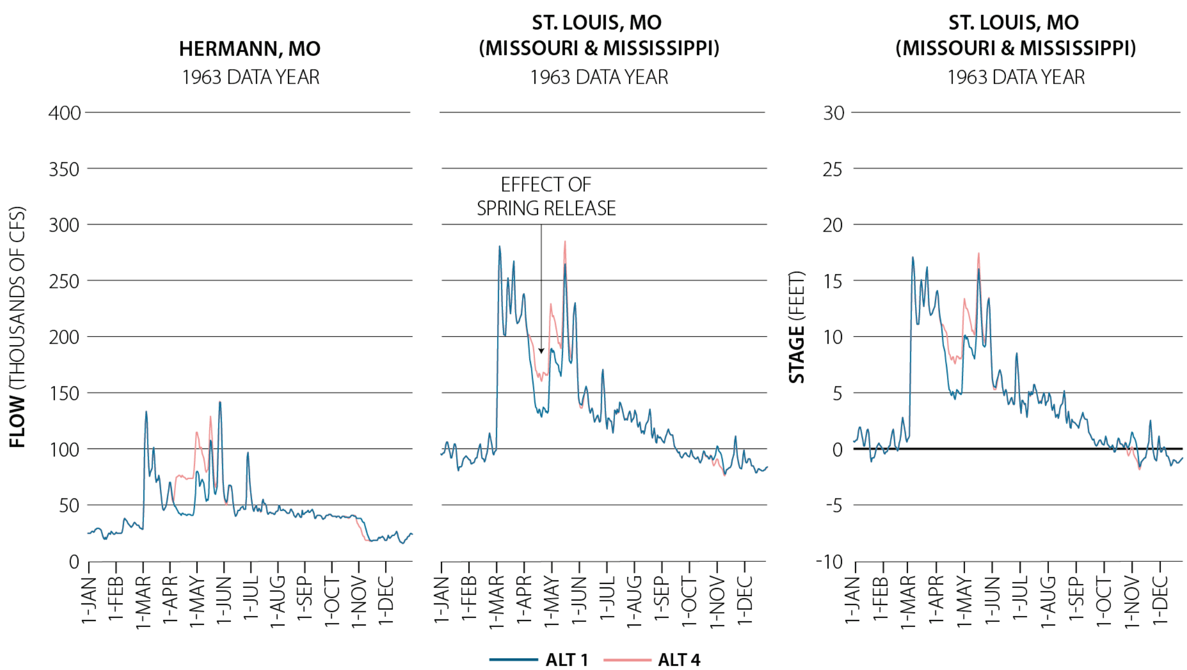


Figure 3-72. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 4, simulated based on hydrologic conditions in year 1963

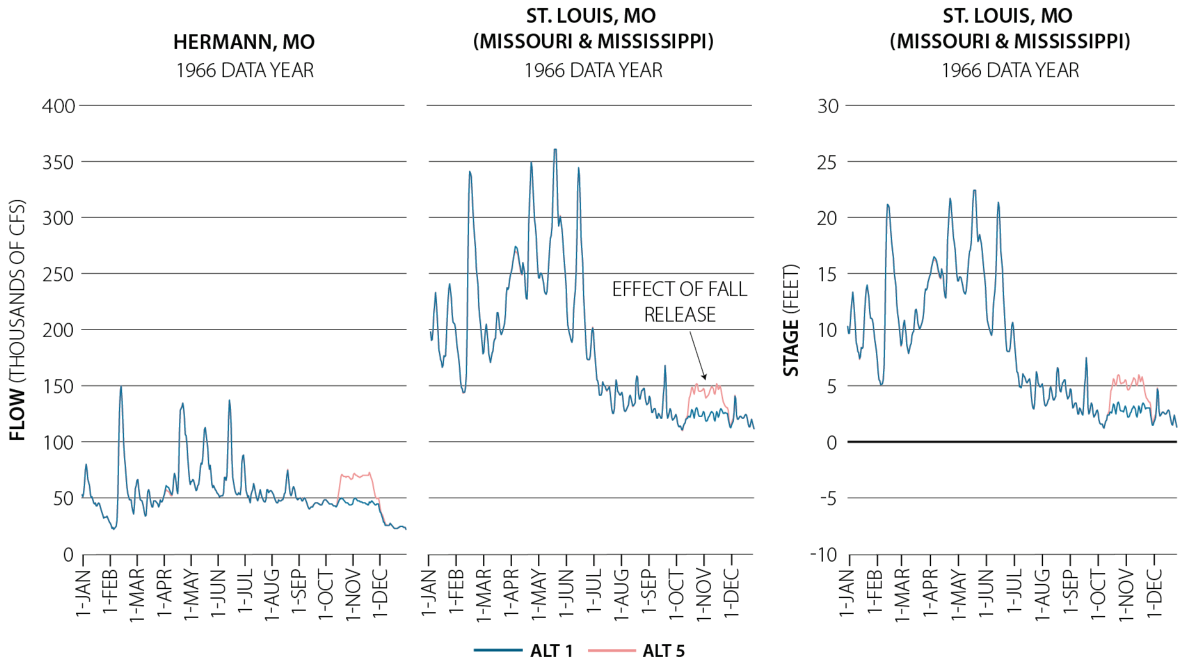


Figure 3-73. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 5, simulated based on hydrologic conditions in year 1966

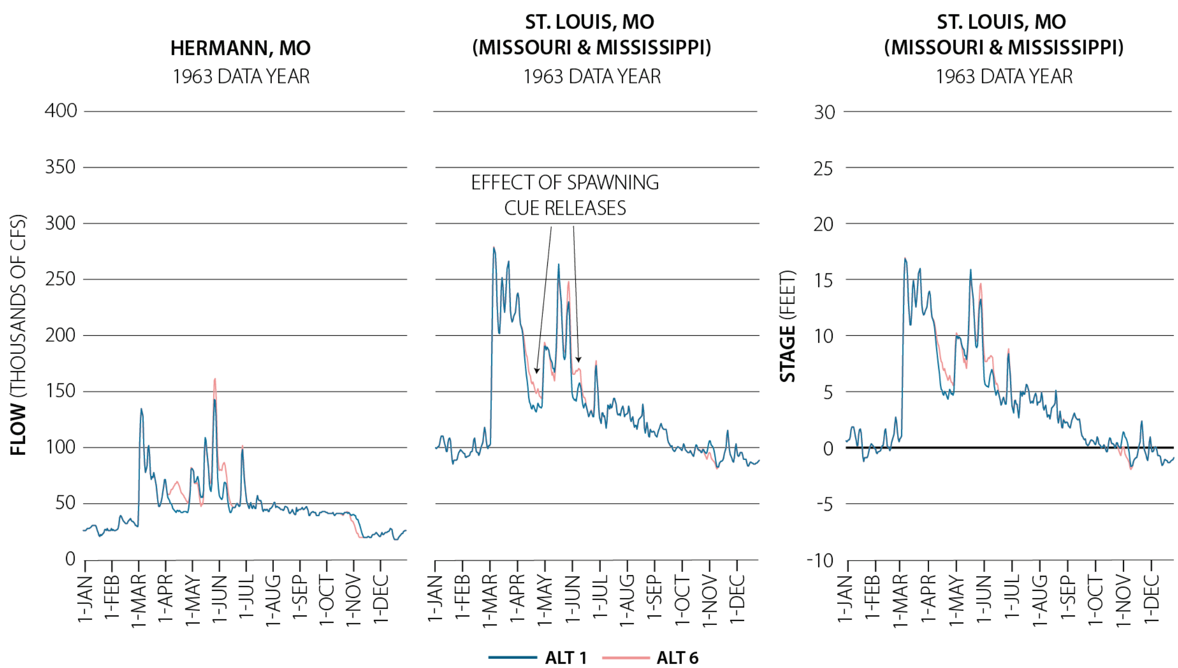


Figure 3-74. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 6, simulated based on hydrologic conditions in year 1963

Geomorphology and Riverine Infrastructures (all Alternatives)

Modeling has shown that sediment transport in the Kansas City reach of the Missouri River would change very little under the action alternatives compared to Alternative 1, indicating that the volume of sediment supplied by the Missouri River to the Middle Mississippi River by the action alternatives would also change very little. Therefore, combined with relatively small to negligible flow alterations under the action alternatives, there would be negligible impacts on the geomorphology in the Middle Mississippi River from the action alternatives. Similarly, there would be negligible impacts on riverine infrastructure in the Middle Mississippi River.

Groundwater (all Alternatives)

Considering that any changes from flow alterations under the action alternatives on the stage in the Middle Mississippi River would be at most comparatively small and also of short duration, there would be negligible to small adverse impacts to groundwater elevations along the Middle Mississippi River.

Conclusion

Given the negligible to small change in hydrology, geomorphology, groundwater, and river infrastructure, no significant impacts are anticipated from any of the alternatives.

3.24.2 Biological Resources

3.24.2.1 Affected Environment

Biological resources associated with the Middle Mississippi River have been shaped over time by a variety of actions, including urbanization, agriculture, levee construction, dam construction, and river training structure placement. Many of the changes in the Middle Mississippi River which have led to its current condition are due to improvements made for navigation including river training structure placement and resulting sedimentation patterns.

A variety of habitat types are found in the Middle Mississippi River, including main channel, main-channel border unstructured, main-channel border wing-dike, and side-channel. Unstructured main-channel border areas provide preferred habitat for fish species that require flowing water throughout all or most of their life cycle and generally consist of moderate depths of flowing water over a sandy substrate. Main channel border wing dike areas produce pockets of still, freshwater habitat in the form of flow refugia and plunge pools, providing habitat often used by macrohabitat generalists, adaptable fish species which live in highly diverse habitat types. The side channel areas provide an important habitat type in the Middle Mississippi River, as it creates lateral connectivity and is likely used as a surrogate for floodplain and backwater habitat by many species. Side channel habitats are known to support a greater abundance of macrohabitat generalists compared to other macrohabitat types (Simmons 2015), presumably due to shallow, low-velocity habitat they provide at certain river stages.

Side channels typically provide a well-defined gradient between flowing to non-flowing water depending on their level of connectivity to the main channel. The level of connectivity affects substrates, water quality conditions (Crites et al. 2012), bottom dwelling macroinvertebrate communities, and fish communities (Barko and Herzog 2003; Barko et al. 2004). Flowing side channels, those connected to the main channel, generally have course bottom substrates (i.e., sand and gravel) and support large-river aquatic species (suckers, minnows, and darters) tolerant of current and/or turbidity. This diversity of habitat provides important feeding, spawning, nursery, and overwintering habitat for fish, and habitat for other environmentally sensitive macroinvertebrates, fish, and wildlife (Barko and Herzog 2003). As such, side channels are important to the health of the river ecosystem as a whole, and are even more important in the Middle Mississippi River because of the loss of hydraulic connectivity to the floodplain.

Fish species associated with side channels include channel catfish (*Ictalurus punctatus),* channel shiner (*Notropis wickliffi*), emerald shiner (*Notropis atherinoides*), red shiner (*Cyprinella lutrensis*), and sauger (*Stizostedion canadense*). A number of other adult and juvenile fish species also use side channels for various stages of their life history, however, little information is available on the role or importance of side channels to riverine fish assemblages (i.e., production or nursery habitat) (Barko and Herzog 2003). Lack of connectivity of side channels with the main channel adversely affects the reproduction and recruitment of species such as bowfin (*Amia clava*), paddlefish (*Polyodon spathula*), and freshwater drum (*Aplodinotus grunniens*) (Barko et al. 2004). Additionally, loss of side channel habitats may affect reproduction and recruitment of the pallid sturgeon and sturgeon chub (*Macrhybopsis gelida*) (Barko and Herzog 2003).

The Middle Mississippi River side channel habitat is represented by three side channels in this analysis; Mosenthein, Moro, and Boston which cover the upper, middle, and lower reaches of the Middle Mississippi River, respectively. The connectivity of these side channels in relation to the main channel is dependent on the stage of the river. Decreases and increases in river stage can alter this relationship and cause changes in side channel connectivity. The river stage at which a side channel becomes disconnected from the main channel is called the choke point elevation. For the purposes of this EIS, the choke point elevation identified for Mosenthein, Moro, and Boston side channels is the one that is the most limiting among the upstream and downstream choke points for each of the side channels. It is assumed that side channel habitat conditions and benefits are maximized or fully functional when both the upstream and downstream connection points with the main channel are flowing.

Table 3-283 describes the median monthly stage at Mosenthein, Moro, and Boston side channels during 2014, choke point stage, and connectivity status (i.e., connected to main channel or disconnected from main channel) (USACE: Unpublished data from St. Louis District). The year 2014 is the most current data representing the current configuration of the river channel as it relates to the height and elevation of the chokepoints of these specific side channels. This most current data was used to establish the baseline or current condition to compare connectivity under the action alternatives. Past data was available but channel configuration and chokepoint elevation changes over time, therefore, the most current data was used.

Table 3-283. Median Monthly Stage (feet) in 2014 and Chokepoint Elevations for Each of the Three Side Channels

Side Channel	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Chokepoint Elevation
Mosenthein	7.6	9.9	15.5	19.9	21.1	19.2	15.6	10.8	9.7	9.5	10.0	8.7	9.8
Moro	8.7	10.8	16.3	20.7	21.9	20.0	16.4	11.7	10.5	10.4	10.8	9.7	9.2
Boston	15.9	19.7	25.4	26.4	23.7	19.3	14.3	9.5	8.2	8.2	10.0	13.4	16.5

Source: USACE Unpublished data, St. Louis District

Note: Cells highlighted in red note that the side channel was disconnected from the main channel at that stage.

3.24.2.2 Environmental Consequences

Impact Assessment Methodology

The anticipated impacts to biological resources in the Middle Mississippi River as a result of the alternatives are described below. Impacts were qualitatively analyzed based on stage and flow simulated for each alternative by modeling the alternative operation over the POR ("Missouri River Recovery Management Plan Time Series Data Development for Hydrologic Modeling" report available online at www.moriverrecovery.org). Impacts to the three representative side channels; Mosenthein, Moro, and Boston are quantitatively discussed in terms of how changes in stage may potentially alter or impact side channel habitat through altering connectivity with the main channel. It is assumed that changes in stage can alter or impact the condition and accessibility of side channel habitat. It is assumed that the changes in stage modeled under each alternative at the St. Louis gage is representative of the Middle Mississippi River and each of the representative side channels. Changes in stage of the Middle Mississippi River directly impact the connectivity of the three side channels. If a side channel is disconnected and the stage rises to the choke point stage, the channel will become connected to the main channel, providing habitat to native aquatic species. The St. Louis gage was used to obtain water level stages for the analysis. None of the analyzed side channels have their own gages to obtain stages.

Known limiting choke point elevations based on 2014 data at the Mosenthein, Moro, and Boston side channels were used to assess the impact from each of the alternatives on the connectivity of each of the representative side channels. Known choke point elevations were assumed to mean the side channel was flowing and thus provide habitat to native aquatic species and is considered a beneficial condition. If stages at the St. Louis gage were less than the known choke point elevation, the side channel was assumed not to be flowing and not providing habitat to native aquatic species. Current condition choke points for the side channels were defined by mean monthly choke point elevation for the three side channels from the most current data set (2014). The analysis and comparison were then performed for each of the alternatives to compare changes in connectivity and to assess impacts from the alternatives. Average monthly 10th, 50th, and 90th percentile stages at the St. Louis gage for each of the modeled alternatives were compared to those modeled under Alternative 1. Connectivity status was evaluated for each of the side channels under each of the alternatives in order to report potential impacts.

Summary of Environmental Consequences

The environmental consequences relative to biological resources are summarized in Table 3-284.

Table 3-284. Environmental Consequences Relative to Biological Resources

Alternative	Impacts on Biological Resources
Alternative 1	• The periods of connection and disconnection of the side channels would be a result of natural cycles experienced with the natural variability of hydrologic conditions in the basin and impacts rather than caused by management actions.
Alternatives 2 and 4	• No changes would occur in connectivity or flow status of the three evaluated side channels in the Middle Mississippi River compared to Alternative 1.
Alternative 3	• No impacts would occur to side channel habitat condition or accessibility because flow and stage would not be impacted in the Middle Mississippi River.
Alternatives 5 and 6	• No change or a small beneficial change in connectivity and flow status would occur in the Middle Mississippi River compared to Alternative 1.

Impacts from Management Actions Common to All Alternatives

It is anticipated that there would be no impacts to biological resources in the Middle Mississippi River from management actions common to all alternatives. These actions would not involve any flow actions or actions that would impact flow or stage. If stage is not impacted on the Middle Mississippi River by these actions, connectivity of these side channels to the main channel will not be changed or impacted.

Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 would result in periods of connection and disconnection to the main channel river for the Mosenthein, Moro, and Boston side channels (Table 3-285). The 10th percentile modeled stages resulted in disconnection of all three side channels from the main river for the entire year. The 50th percentile modeled stages resulted in Mosenthein and Moro flowing or connected in the spring and summer months while disconnected in the fall and winter months and with Boston disconnected the entire year except for May. Modeled average monthly stages in the 90th percentile resulted in the Mosenthein and Moro side channels flowing all year round and Boston only flowing during late spring and summer. Given that the spawning cue releases from Gavins Point Dam under Alternative 1 would be largely attenuated by the time they reach the Mississippi River, the periods of connection and disconnection would be attributed to natural hydrologic cycles observed over the POR rather than the spawning cue release.

It is anticipated that there would be no adverse impacts to biological resources in the Middle Mississippi River from mechanical ESH construction, channel reconfiguration for construction of pallid sturgeon early life stage habitat, or habitat development and land management on MRRP lands. These activities would occur on the Missouri River and would not adversely impact the stage or flow on the Middle Mississippi River and would therefore not impact, disturb, or alter biological resources in the Middle Mississippi River.

Conclusion

Given the spawning cue release from Gavins Point Dam would be largely attenuated by the time it reaches the Mississippi River, the periods of connection and disconnection of the side channels that were analyzed would be a result of natural cycles experienced with the natural variability of hydrologic conditions in the basin rather than caused by management actions associated with Alternative 1. None of the potential impacts from Alternative 1 would be significant for biological resources in the Middle Mississippi River.

Table 3-285. Alternative 1 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels

Side Channel	Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mosenthein (choke point 9.8 ft)	10th	−1.1	−0.4	3.3	7.7	6.8	7.0	4.1	1.0	0.4	−0.2	−0.1	−0.9
	50th	4.3	6.5	12.3	16.0	16.6	14.7	12.0	6.4	5.9	5.2	5.5	4.3
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3
Moro (choke point 9.2 ft)	10th	−1.1	−0.4	3.3	7.7	6.8	7.0	4.1	1.0	0.4	−0.2	−0.1	−0.9
	50th	4.3	6.5	12.3	16.1	16.6	14.7	12.0	6.4	5.8	5.2	5.6	4.3
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.1	11.3
Boston (choke point 16.5 ft)	10th	−1.1	−0.4	3.3	7.9	7.4	7.0	3.4	0.9	0.4	−0.3	−0.1	−0.9
	50th	4.3	6.5	12.3	16.2	16.8	14.7	12.0	6.4	5.8	5.2	5.6	4.3
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.1	12.0	13.3	16.1	11.2

Note: Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 would result in no change in impacts to the biological resources in the Middle Mississippi River (Table 3-286) compared to Alternative 1. There would be no change in connectivity for Mosenthein, Moro, or Boston side channels under Alternative 2 when compared to Alternative 1, thus there would be no additional adverse impacts to biological resources in Middle Mississippi River from this alternative.

Table 3-286. Alternative 2 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels

Side Channel	Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mosenthein (choke point 9.8 ft)	10th	−1.1	−0.5	3.3	7.9	7.5	7.6	3.3	0.9	0.4	−0.4	0.0	−0.9
	50th	4.1	6.5	12.3	16.2	16.9	14.9	12.1	6.2	6.0	5.3	5.6	4.2
	90th	13.1	13.2	20.9	26.5	27.5	27.5	20.8	13.1	12.0	13.4	16.0	11.2
Moro (choke point 9.2 ft)	10th	−1.1	−0.5	3.3	7.9	7.5	7.6	3.3	0.9	0.4	−0.4	0.0	−0.9
	50th	4.1	6.5	12.3	16.2	16.9	14.9	12.1	6.2	6.0	5.3	5.6	4.2
	90th	13.1	13.2	20.9	26.5	27.5	27.5	20.8	13.1	12.0	13.4	16.0	11.2
Boston (choke point 16.5 ft)	10th	−1.1	−0.5	3.3	7.6	6.7	7.6	3.4	1.0	0.4	−0.3	0.0	−0.9
	50th	4.1	6.5	12.3	16.0	16.6	14.9	12.1	6.4	6.0	5.3	5.6	4.2
	90th	13.1	13.2	20.9	26.5	27.5	27.5	20.8	13.3	11.8	13.3	16.0	11.3

Note: Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 2. Connectivity analysis based on the choke points as described in the Affected Environment section.

Impacts from mechanical ESH construction, channel reconfiguration for construction of early life stage habitat, and habitat development and land management on MRRP lands would be the same as what is discussed under Alternative 1.

Conclusion

There would be no changes in connectivity or flow status of the three evaluated side channels from Alternative 2. Impacts from management actions under Alternative 2 would not be significant for biological resources in the Middle Mississippi River.

Alternative 3 – Mechanical Construction Only

There would be no change in connectivity for Mosenthein and Moro side channels under Alternative 3 when compared to Alternative 1 (Table 3-287). There would be a temporary, relatively small benefit to the Boston side channel under Alternative 3 when compared to Alternative 1. In the 50th percentile, the Boston side channel would be flowing or connected under Alternative 3 and would be disconnected under Alternative 1 in the month of April, representing an improvement in condition.

There would be no changes in connectivity or flow status for Mosenthein and Moro side channels, and a relatively small increase in time the Boston side channel is flowing. There would be no impact to biological resources in the Middle Mississippi River from mechanical habitat construction. These activities will occur on the Missouri River and would not impact the stage or flow on the Middle Mississippi River.

Table 3-287. Alternative 3 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels

Side Channel	Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mosenthein (choke point 9.8 ft)	10th	−1.1	−0.4	3.3	7.6	6.6	7.0	4.1	1.0	0.4	−0.2	0.0	−0.9
	50th	4.3	6.5	12.3	16.4	16.6	14.7	12.0	6.4	5.9	5.2	5.6	4.4
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3
Moro (choke point 9.2 ft)	10th	−1.1	−0.4	3.3	7.6	6.6	7.0	4.1	1.0	0.4	−0.2	0.0	−0.9
	50th	4.3	6.5	12.3	16.4	16.6	14.7	12.0	6.4	5.9	5.2	5.6	4.4
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3
Boston (choke point 16.5 ft)	10th	−1.1	−0.4	3.3	8.0	7.1	7.0	4.1	1.0	0.4	−0.3	−0.1	−0.9
	50th	4.3	6.5	12.3	16.9	16.8	14.7	12.0	6.4	5.9	5.2	5.6	4.4
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3

Note: Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 3. Cells highlighted in green note a shift in connectivity status from non-flowing to flowing when compared to Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

Conclusion

Alternative 3 would not impact flow or stage in the Middle Mississippi River, thus resulting in no impacts to side channel habitat condition or accessibility. There would be no significant impacts to biological resources in the Middle Mississippi River under Alternative 3.

Alternative 4 – Spring ESH Creating Release

Alternative 4 would have no impact to the biological resources in the Middle Mississippi River. There would be no change in connectivity for Mosenthein, Moro, or Boston side channels under Alternative 4 when compared to Alternative 1 (Table 3-288), thus there would be no impacts to biological resources in Middle Mississippi River from this alternative.

There would be no impact to biological resources in the Middle Mississippi River from mechanical habitat construction. These activities will occur on the Missouri River and would not impact the stage or flow on the Middle Mississippi River.

Conclusion

There would be no changes in connectivity or flow status of the three evaluated side channels from Alternative 1, indicating there would be no significant impacts to biological resources under Alternative 4.

Table 3-288. Alternative 4 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels

Side Channel	Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mosenthein (choke point 9.8 ft)	10th	−1.1	−0.4	3.3	8.0	7.1	7.0	4.1	1.0	0.4	−0.4	−0.1	−0.9
	50th	4.4	6.5	12.3	16.7	16.8	14.7	12.0	6.4	5.9	5.1	5.5	4.3
	90th	13.3	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3
Moro (choke point 9.2 ft)	10th	−1.1	−0.4	3.3	8.0	7.1	7.0	4.1	1.0	0.4	−0.4	−0.1	−0.9
	50th	4.4	6.5	12.3	16.7	16.8	14.7	12.0	6.4	5.9	5.1	5.5	4.3
	90th	13.3	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3
Boston (choke point 16.5 ft)	10th	−1.1	−0.4	3.3	7.6	6.6	7.0	4.1	1.0	0.4	−0.3	0.0	−0.9
	50th	4.4	6.5	12.3	16.0	16.6	14.7	12.0	6.4	5.9	5.1	5.5	4.3
	90th	13.3	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3

Note: Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 4. Connectivity analysis based on the choke points as described in the Affected Environment.

Alternative 5 – Fall ESH Creating Release

Alternative 5 would have no impacts to small beneficial impacts to the biological resources in the Middle Mississippi River. There would be no change in connectivity for Mosenthein and Moro side channels under Alternative 5 when compared to Alternative 1 (Table 3-289). There would be a temporary relatively small benefit to the Boston side channel under Alternative 5 when compared to Alternative 1. In the 50th percentile, Boston side channel would be flowing under Alternative 5 and would be disconnected under Alternative 1 in the month of April representing an improvement in condition.

There would be no changes in connectivity or flow status for Mosenthein and Moro side channels, and a relatively small increase in time the Boston side channel is flowing.

Conclusion

There would be either no change or a small beneficial change in connectivity and flow status compared to Alternative 1. There would be no significant impacts to biological resources in the Middle Mississippi River under Alternative 5.

Table 3-289. Alternative 5 Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels

Side Channel	Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mosenthein (choke point 9.8 ft)	10th	−1.1	−0.4	3.3	7.6	6.6	7.0	4.1	1.0	0.4	−0.2	0.0	−0.9
	50th	4.3	6.5	12.3	16.0	16.6	14.7	12.0	6.4	5.9	5.4	5.3	4.3
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3
Moro (choke point 9.2 ft)	10th	−1.1	−0.4	3.3	7.6	6.6	7.0	4.1	1.0	0.4	−0.2	0.0	−0.9
	50th	4.3	6.5	12.3	16.0	16.6	14.7	12.0	6.4	5.9	5.4	5.3	4.3
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3
Boston (choke point 16.5 ft)	10th	−1.1	−0.4	3.3	8.0	6.7	7.0	4.1	1.0	0.4	−0.3	0.0	−0.9
	50th	4.3	6.5	12.4	16.8	16.6	14.7	12.0	6.4	5.9	5.4	5.3	4.3
	90th	13.4	13.2	20.9	26.5	27.5	27.4	20.7	13.3	11.7	13.3	16.0	11.3

Note: Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 5. Cells highlighted in green note a shift in connectivity status from non-flowing to flowing when compared to Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 would have no impacts to small beneficial impacts to the biological resources in the Middle Mississippi River. There would be no change in connectivity for Mosenthein and Moro side channels under Alternative 6 when compared to Alternative 1 (Table 3-290). There would be a temporary, relatively small benefit to the Boston side channel under Alternative 6 when compared to Alternative 1. In the 50th percentile, Boston side channel would be flowing under Alternative 6 and would be disconnected under Alternative 1 in the months of April and June, representing an increase in connectivity. There would be no changes in connectivity or flow status for Mosenthein and Moro side channels, and a relatively small increase in time the Boston side channel is flowing.

Table 3-290. Alternative 6 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels

Side Channel	Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mosenthein (choke point 9.8 ft)	10th	−0.5	0.5	3.6	8.5	7.0	7.5	4.7	3.1	2.0	1.3	1.0	−0.6
	50th	6.0	7.6	12.4	17.9	20.2	15.7	12.4	6.3	5.7	5.3	5.6	4.9
	90th	13.4	13.7	21.2	26.6	28.2	27.4	20.7	13.5	12.3	14.8	16.2	11.7
Moro (choke point 9.2 ft)	10th	−0.5	0.5	3.6	8.5	7.0	7.5	4.7	3.1	2.0	1.3	1.0	−0.6
	50th	6.0	7.6	12.4	17.9	20.2	15.7	12.4	6.3	5.7	5.3	5.6	4.9
	90th	13.4	13.7	21.2	26.6	28.2	27.4	20.7	13.5	12.3	14.8	16.2	11.7
Boston (choke point 16.5 ft)	10th	1.1	2.4	5.8	10.6	6.9	7.5	4.5	3.0	1.9	1.1	0.6	0.9
	50th	6.9	9.1	15.2	20.0	22.4	17.2	13.5	6.7	6.9	5.4	7.1	6.7
	90th	14.5	14.4	22.6	29.1	28.6	28.7	24.2	13.6	11.7	16.4	16.2	13.4

Note: Cells highlighted in gray note the side channel is disconnected or not flowing during that month for Alternative 5. Cells highlighted in green note a shift in connectivity status from non-flowing to flowing when compared to Alternative 1. Connectivity analysis based on the choke points as described in the Affected Environment.

Conclusion

None of the potential and anticipated impacts from Alternative 6 would be significant for biological resources in the Middle Mississippi River. There would be no change or a small beneficial change in connectivity and flow status compared to Alternative 1. None of the other proposed management actions under Alternative 6 would impact flow or stage in the Middle Mississippi River.

3.24.3 Flood Risk Management

3.24.3.1 Affected Environment

Given the more-detailed hydrology and hydraulics modeling from the confluence of the Missouri River to St. Louis, the affected environment and assessment of impacts was broken out into two regions: upstream of St. Louis and downstream of St. Louis to Thebes, Illinois.

Upstream of St. Louis

Approximately 17,621 people are at risk of flooding in the Middle Mississippi River reach upstream of St. Louis. Residential and nonresidential structures located in areas along the Mississippi River are subject to flood risk. There are 7,091 residential and 883 nonresidential structures identified in the floodplain (defined as bluff to bluff). Total estimated value of these structures and their contents is over $5.7 billion. Table 3-291 presents the estimated population, number of structures and value (in thousands) located in the floodplain and susceptible to flooding.

In addition to structures, the total land area subject to flooding in the Middle Mississippi River upstream of St. Louis is 131,259 acres with 58,135 acres in agricultural production, predominately corn and soybeans. Table 3-292 summarizes the crop acreage and patterns. Critical and public infrastructure in the Middle Mississippi River floodplain upstream of St. Louis is displayed in Table 3-293.

Table 3-291. Population and Estimated Property Value of the Middle Mississippi River Floodplain

Reach	Population at Risk	Residential Property		Nonresidential Property		All Property	
		Number	Value ($000s)	Number	Value ($000s)	Number	Value ($000s)
Middle Mississippi River (upstream of St. Louis)	17,621	7,091	$3,099,674	883	$2,615,543	7,974	$5,715,217

Source: National Structure Inventory (NSI) 2010
Note: All values are in the FY 2018 price level

Table 3-292. Percent of Agriculture Acreage by Crop in the Middle Mississippi River

Reach	Total Floodplain Acres	Agricultural Acres	Crop Type, as Percent of Total Agricultural Acres		
			Corn	Soybeans	All Other Crops
Middle Mississippi River (upstream of St. Louis)	131,259	58,135	48.7%	50.3%	0.9%

Source: USDA NASS Cropland Data Layer, 2014

Table 3-293. Critical Infrastructure in the Middle Mississippi River Floodplain (upstream of St. Louis)

Critical Infrastructure	Number
Public Utilities	
Energy Producing Plants	5
Propane Locations and Substations	14
Wastewater Treatment Plants	2
Public Facilities	
Emergency Services	9
Law Enforcement	7
Education	7
Public Venues	9
Transportation Infrastructure	
Interstate Miles	4
Highway Miles	118
Local Primary Road Miles	60
Railroad Miles	123
Road and Railroad Bridges	71
Public Use Airports	5
Ports	44

Source: Homeland Security Infrastructure (HSIP) Gold Database 2012, U.S. Census Bureau, Geography Division 2015 TIGER/Line Shapefiles

St. Louis, Missouri to Thebes, Illinois

Within the Middle Mississippi River floodplain between St. Louis and Thebes, Illinois, a majority of the area is leveed. A total of 13 levee systems comprised of 20 levee districts reduce flood risk for over 310,000 acres of floodplain. Nineteen of these levees were federally constructed. Additional flood risk reduction is provided through flood storage in the many reservoirs in the Missouri, Upper Mississippi, and Kaskaskia River basins. This series of levee systems is very robust. Since they were completed, only four of the federal systems have been overtopped and breached, which occurred during the record-breaking flood of 1993.

3.24.3.2 Environmental Consequences

The environmental consequences for flood risk management was described for two geographic regions, the river reach upstream of St. Louis, and the river reach downstream of St. Louis to Thebes, Illinois. A general methodology of the NED analysis including data sources and assumptions can be found in the “Flood Risk Management Environmental Consequences Analysis Technical Report” available online (www.moriverrecovery.org).

Impact Assessment Methodology

The impact analysis focuses on determining if changes in river conditions associated with each of the MRRMP-EIS alternatives could result in an impact to flood risk management along the Middle Mississippi River. Given the more-detailed hydrology and hydraulics modeling from the confluence of the Missouri River to St. Louis, the assessment of impacts upstream of St. Louis follows the impacts assessment for the Missouri River more closely than downstream of St. Louis where detailed channel cross-sections were not available. Downstream of St. Louis the analysis was conducted through comparison of change in flood flow frequency curves at St. Louis.

The impacts to flood risk management were evaluated using two of the four accounts (NED and OSE). The following section provides a brief overview of the overall methodology for evaluating impacts to flood risk as well as the approach for each account.

Physical characteristics of the Mississippi River and its floodplain that are particularly important to flood risk include river flow and associated stages, water storage in the Missouri River Mainstem System, river channel dimensions, and flow impedance. Changes in these characteristics can result in changes in the patterns of flooding (beneficially or adversely), such as the frequency of flooding, depths of inundation, and extent and duration of flooding. Alterations in the patterns of flooding potentially increase or reduce the risks inherent in flooding to people in the floodplain, land, property (both urban and rural), and infrastructure. The analysis used outputs from the HEC-RAS and HEC-ResSim models to simulate river operations over the POR.

Since the hydraulic modeling ended at the St. Louis gage, an analysis at the St. Louis gage was used to infer the potential for flood risk management impacts along the Middle Mississippi River downstream of St. Louis. This analysis was conducted through a comparison of change in flood flow frequency curves at St. Louis and the associated stage differences. Data for this analysis was obtained from hydraulic modeling conducted as part of this study. Flow frequency curves were calculated with a procedure matching that used in the “Upper Mississippi River Flow Frequency Study” (USACE 2004c). Peak annual discharges from the POR for each alternative were converted from regulated to unregulated flows using the curve found in Appendix D of the

"Upper Mississippi River Flow Frequency Study." Frequency curves were then computed using the unregulated discharges. The resulting curves were then converted back to regulated discharges using the same regulated to unregulated relationship. A comparison of the MRRMP-EIS alternative curves was conducted against the curve of Alternative 1. These flow differences were then converted to stage differences using the current rating curve for the St. Louis gage.

National Economic Development: NED effects are defined as changes in the net value of the national output of goods and services. In the case of flood risk management, the conceptual basis for the NED impacts analysis is an increase or decrease in risk of physical and non-physical damage from flooding. The Hydrologic Engineering Center Flood Impact Analysis (HEC-FIA) model was used to compute property damages and impacts to critical infrastructure for every year in the POR under each alternative for the region upstream of St. Louis. The model evaluated damages to crops either related to a loss of a crop in the ground, the inability to plant a crop due to flooding, or to planting a crop later in the season due to flooding at planting time. The model also evaluated changes directly related to damages sustained by structures, contents, and vehicles.

In addition to the tangible damages to businesses, homes, and other physical property items caused by flood inundation or exposure, the costs of flooding include emergency costs and disaster relief costs. Other costs of flooding can encompass savings related to a wide range of flooding impacts, including emergency personnel costs, flood fighting costs (sandbagging, for example), avoidance costs (raising or evacuation of property), temporary food and housing, debris cleanup, and damage to infrastructure items not otherwise included in the damage analysis such as sewer lines. Based on an analysis of approved USACE projects, it was assumed that these costs are equivalent to a maximum of 9 percent of physical flood damages (USACE 2014f).

Other Social Effects: Changes in flood risk have a potential to cause other types of effects on individuals and communities in terms of individual and community safety, health, and well-being. A measure used to assess the safety of the population in the floodplain is population at risk. This measure was computed quantitatively in HEC-FIA. Inputs necessary for determining impacts to OSE were census block level data and the outputs of the NED flood risk management evaluation, which provide a sense of the magnitude of the impacts to the Nation or to the regional area. Census block data was imported into the model with populations distributed to structures based on their occupancy type. The total population at risk is estimated as the number of people associated with the structures that would be inundated as evaluated in the HEC-FIA model.

Environmental Consequences Results – Upstream of St. Louis

Summary of Environmental Consequences

The environmental consequences relative to flood risk management are summarized in Table 3-294. Table 3-295 summarizes the NED analysis for each of the alternatives for flood risk management upstream of St. Louis. Table 3-296 summarizes the population at risk under each of the alternatives upstream of St. Louis as the largest annual increase and decrease in population at risk relative to Alternative 1.

Table 3-294. Environmental Consequences for Flood Risk Management

Alternative	NED Impacts	OSE Impacts
Management Actions Common to All Alternatives	No NED impacts.	No OSE impacts.
Alternative 1	Average annual damages: $13,894,231	Average Annual PAR: 196
Alternatives 2–6	Relatively small, adverse impacts compared to Alternative 1. (Range of annual differences: $11,898,375 decrease to $6,345,357 increase)	Negligible changes in OSE compared to Alternative 1.

Table 3-295. Summary of National Economic Development Analysis

River Reach	Average Annual Property Damages	Average Annual Other Costs of Flooding	Average Annual Agricultural Losses	Total Average Annual NED Damages	Change in Average Annual Damages from Alternative 1	% Change from Alternative 1
Alternative 1	$10,797,768	$971,799	$2,124,663	$13,894,231	N/A	N/A
Alternative 2	$10,888,871	$979,998	$2,139,857	$14,008,727	$114,496	0.8%
Alternative 3	$10,827,043	$974,434	$2,133,916	$13,935,393	$41,162	0.3%
Alternative 4	$10,934,032	$984,063	$2,136,904	$14,054,999	$160,768	1.2%
Alternative 5	$10,821,073	$973,897	$2,132,374	$13,927,343	$33,112	0.2%
Alternative 6	$10,848,264	$976,344	$2,130,207	$13,954,815	$60,584	0.4%

Note: All damage totals are average annual at the FY 2018 price level. Negative numbers indicate a decrease in damages relative to Alternative 1.

Table 3-296. Summary of Population at Risk

River Reach	Maximum PAR under Largest Modeled Flood Event in POR	Average Annual PAR	Greatest Increase Relative to Alternative 1	Greatest Decrease Relative to Alternative 1
Alternative 1	3,232	196	N/A	N/A
Alternative 2	3,213	199	145	-22
Alternative 3	3,231	197	92	-21
Alternative 4	3,231	199	169	-66
Alternative 5	3,231	196	92	-21
Alternative 6	3,231	197	92	-66

Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives would not have any impacts on flood risk management along the Mississippi River. The management actions common to all alternatives would occur in the Missouri River and would not impact flow or stage in the Middle Mississippi River.

Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

NED Analysis: Under Alternative 1, the Middle Mississippi River floodplain upstream of St. Louis would experience measurable flood impacts during large flood events. The magnitude of these impacts would vary considerably from year to year depending on the river stages associated with the year. Across the POR as modeled under Alternative 1, average annual flood damages would be $13,894,231, approximately 0.2 percent of all property values in the floodplain. The spring pulse under Alternative 1 would result in a negligible contribution to these effects because of the small volume of water released from Gavins Point (less than 7,000 cfs) and the attenuation by the time it reaches the Mississippi River.

Other Social Effects: Changes in flood risk have a potential to cause other types of effects on individuals and communities in terms of individual and community health, safety, and economic vitality. HEC-FIA estimates the number and location of people within the inundated area exposed to the flood hazard. This estimate is referred to as the population at risk and it includes people permanently residing in the area, as well as temporary residents. The average annual population at risk under Alternative 1 would be 196 people. Flooding impacts under Alternative 1 are expected to have negligible OSE impacts.

Conclusion

Alternative 1 represents the continuation of current System operation on the Missouri River. It primarily serves as a reference condition allowing for a comparison of the action alternatives. NED and OSE results indicate flood risk management in the Middle Mississippi River would have the potential to be impacted under Alternative 1 during those modeled years when the largest flood events occur as a result of the natural hydrologic cycles and not from the management actions that are part of Alternative 1. The magnitude of these impacts would vary considerably from year to year depending on precipitation and river stages. Management actions under Alternative 1 would have negligible NED and OSE effects as the spawning cue release in March or May would be almost entirely attenuated in the Missouri River by the time it reached the Mississippi River and thus would not impact the hydrology in the Middle Mississippi River and are not anticipated to be significant under Alternative 1.

Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

NED Analysis: When evaluating the impacts of each MRRMP-EIS alternative, annual impacts as well as those that occur on average over the POR were examined. Alternative 2 would result in a small adverse impact to flood risk management, with an average annual increase of $114,496 in damages along the Mississippi River floodplain upstream of St. Louis compared to Alternative 1. This represents an overall increase in NED impacts in relation to Alternative 1 of 0.8 percent. For Alternative 2, the modeled years with the largest beneficial and adverse change in NED damages relative to Alternative 1 were 1993 and 1943, respectively. The modeled results in 1993 under Alternative 2 would result in a decrease in flood damages of $11,898,375 (-4.6 percent), while the modeled year in 1943 would result in an increase of flood damages of $6,345,357 (14.2 percent).

Other Social Effects: For Alternative 2, there would be a small increase in the average annual PAR of 3 people. Under Alternative 2, the greatest increase in PAR would be 145 additional people at risk compared to Alternative 1, while the greatest decrease in PAR would be 22 fewer people at risk compared to Alternative 1. Overall, Alternative 2 is expected to have a negligible OSE impact.

Conclusion

Under Alternative 2, there would be small adverse impacts to average annual flood damages (0.8 percent) and a 3 person increase in the average annual PAR in the Middle Mississippi River compared to Alternative 1. The spring flow releases and summer low flows under Alternative 2 may for short periods affect the stage in the Mississippi River by up to one or two feet, based on the hydrology simulated for individual years of the POR. However, even in the largest increase in damage year of $6.3 million, flood damages would account for less than 0.1 percent of all property value in the floodplain. Overall, long-term adverse impacts to flood risk management in the Mississippi River under Alternative 2 would be negligible to small and are not anticipated to be significant under Alternative 2.

Alternative 3 – Mechanical Construction Only

NED Analysis: The absence of the spawning cue release under Alternative 3 would not have a noticeable effect on flows or stages of the Middle Mississippi River. Alternative 3 as modeled shows a small adverse impact in the Middle Mississippi River. On an average annual basis, the damages in the Middle Mississippi River would increase by $41,162 under Alternative 3 compared to Alternative 1. This represents an overall increase in damages in relation to Alternative 1 of 0.3 percent.

For Alternative 3, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1943, respectively. The 1993 event under Alternative 3 displayed a decrease in damages of $3,162,987 (-4.6 percent), while the 1943 event saw the damages rise by $1,467,952 (14.2 percent) over Alternative 1.

Other Social Effects: For Alternative 3, there was a one person increase in the modeled average annual PAR. The greatest modeled flood event increase in PAR was 92, while the greatest modeled flood event decrease was 21. Overall, there would be negligible OSE impacts under Alternative 3.

Gavins Point One-Time Spawning Cue Test: The one-time spawning cue test release that may be implemented under Alternative 3 was not included in the hydrologic modeling for the alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Flows equivalent to the one-time spawning cue test were modeled for multiple years in the period of record under Alternative 6. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

NED flood risk management impacts under Alternative 6 were described on average as relatively small and adverse. OSE impacts were estimated to be negligible under Alternative 6 compared to Alternative 1. Because Alternative 6 modeling results show adverse impacts under full releases, the one-time implementation of the pulse would likely cause temporary adverse impacts in the year the pulse is implemented. Impacts to RED and OSE would likely be negligible because the pulse would only be run once under Alternative 3.

Conclusion

Under Alternative 3, NED and OSE results indicate flood risk management in the Middle Mississippi River would have the potential to be adversely impacted when compared to Alternative 1. The percent change in average annual damage increase above Alternative 1 was

0.8, thus impacts to flood risk management in the Middle Mississippi River are not anticipated to be significant under Alternative 3.

Alternative 4 – Spring ESH Creating Release

NED Analysis: Although the flow releases under Alternative 4 would be partially attenuated by the time they reach Hermann, Missouri, the releases still would increase the stage (on the order of 1 to 3 feet) and flow in the Mississippi River at St. Louis compared to Alternative 1. Overall, Alternative 4 as modeled shows a small adverse impact in the Middle Mississippi River. On an average annual basis, the damages in the Middle Mississippi River would increase by $160,768 under Alternative 4 compared to Alternative 1. This represents an overall increase in damages in relation to Alternative 1 of 1.2 percent.

For Alternative 4, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 2002, respectively. The 1993 event under Alternative 4 displayed a decrease in impacts of $3,219,229 (-1.2 percent), while the 2002 event saw the damages rise by $4,969,173 (18.8 percent)

Other Social Effects: For Alternative 4, there was a three person increase in the modeled average annual PAR. The greatest modeled flood event increase in PAR was 169, while the greatest modeled flood event decrease was 66. Alternative 4 is expected to have negligible OSE impacts.

Conclusion

Under Alternative 4, NED and OSE results indicate flood risk management in the Middle Mississippi River would have the potential to be adversely impacted when compared to Alternative 1. The percent change in average annual damage increase above Alternative 1 was 1.2, thus the long-term adverse impacts on flood risk management in the Middle Mississippi River would be negligible to small and are not anticipated to be significant under Alternative 4.

Alternative 5 – Fall ESH Creating Release

NED Analysis: Similar to flow releases under Alternative 4, flow releases under Alternative 5 would be partially attenuated by the time they reach Hermann, Missouri. However, the releases would still increase the stage (on the order of 1 to 3 feet) and flow in the Mississippi River at St. Louis compared to Alternative 1. Alternative 5 as modeled shows a small adverse impact in the Middle Mississippi River. On an average annual basis, the damages in the Middle Mississippi River would increase by $33,112 under Alternative 5 compared to Alternative 1. This represents an overall increase in damages in relation to Alternative 1 of 0.2 percent.

For Alternative 5, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1943, respectively. The 1993 event under Alternative 5 displayed a decrease in damages of $3,230,834 (-1.3 percent), while the 1943 event saw the impacts rise by $1,467,952 (3.3 percent).

Other Social Effects: For Alternative 5, there was no change in the modeled average annual PAR. The greatest modeled flood event increase in PAR was 92, while the greatest modeled flood event decrease was 21. OSE impacts would be negligible under Alternative 5.

Conclusion

Under Alternative 5, NED and OSE results indicate flood risk management in the Middle Mississippi River would have the potential to be adversely impacted when compared to Alternative 1. The percent change in average annual damage increase above Alternative 1 was 0.2, therefore, overall impacts on flood risk management in the Middle Mississippi River would be negligible and are not anticipated to be significant under Alternative 5.

Alternative 6 – Pallid Sturgeon Spawning Cue

NED Analysis: The spawning cue releases simulated over the POR under Alternative 6 would often be largely attenuated by the time it reaches Hermann, Missouri, but some of the spawning cue releases would still increase the stage (by up to 2 feet) and flow in the Middle Mississippi River at St. Louis compared to Alternative 1. Alternative 6 as modeled shows a small adverse impact in the Middle Mississippi River. On an average annual basis, the damages in the Middle Mississippi River would increase by $60,584 under Alternative 6 compared to Alternative 1. This represents an overall increase in damages in relation to Alternative 1 of 0.4 percent.

For Alternative 6, the modeled years with the largest beneficial and adverse change in NED impact relative to Alternative 1 were 1993 and 1947, respectively. The 1993 event under Alternative 6 displayed a decrease in damages of $3,171,455 (-1.2 percent), while the 1947 event saw the impacts rise by $2,608,912 (11.9 percent).

Other Social Effects: For Alternative 6, there was a one person increase in the modeled average annual PAR. The greatest modeled flood event increase in PAR was 92, while the greatest modeled flood event decrease was 66. OSE impacts are expected to be negligible under Alternative 6.

Conclusion

Under Alternative 6, NED and OSE results indicate flood risk management in the Middle Mississippi River would have the potential to be adversely impacted when compared to Alternative 1. The percent change in average annual damage increase above Alternative 1 was 0.4, thus overall impacts on flood risk management in the Middle Mississippi River would be negligible to small and are not anticipated to be significant under Alternative 6.

3.24.3.3 Environmental Consequences Results – Downstream of St. Louis

Results from this analysis downstream of St. Louis are summarized in Table 3-297. The values in this table represent relative differences between alternatives and may not represent the absolute change that would be expected in the river. All values for the MRRMP-EIS alternatives were within 0.13 feet of the values of Alternative 1. Alternatives 2 and 4 would result in increases for most flood frequencies. Minimal changes would occur under Alternatives 3 and 5 for all flow frequencies compared to Alternative 1. Minor reductions in rare floods and increases in frequent floods were seen with Alternative 6.

Table 3-297. Change in Stage at St. Louis Gage from Alternative 1

Annual Chance Exceedance	Published Stage at St. Louis Gage (ft)	Difference (ft)				
		Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
1/500	50.56	0.10	0.01	0.13	0.00	-0.09
1/200	47.86	0.09	0.00	0.12	-0.01	-0.08
1/100	46.06	0.09	0.00	0.11	-0.01	-0.07
1/50	44.06	0.07	0.00	0.09	-0.01	-0.05
1/20	41.06	0.04	0.00	0.05	-0.01	-0.03
1/10	38.46	0.05	0.00	0.05	-0.01	-0.02
1/5	35.76	0.04	-0.01	0.03	-0.01	-0.01
1/2	29.96	0.03	-0.01	0.02	-0.02	0.00
1/1.25	22.87*	0.02	-0.01	0.00	-0.02	0.01
1/1.11	19.97*	0.01	-0.01	0.00	-0.02	0.02
1/1.05	17.66*	0.01	-0.01	-0.01	-0.02	0.02
1/1.01	13.66*	0.00	-0.01	-0.01	-0.02	0.03

*No official value exists at this ACE, so this value was taken from the model results.

Conclusion

Alternative 1 represents the continuation of current System operation. It primarily serves as a reference condition allowing for a comparison of the action alternatives. Impacts under Alternatives 2–6 would be negligible to small when compared to Alternative 1; thus, it is anticipated that none of the alternatives would result in significant impacts in the Middle Mississippi River downstream of St. Louis. Additional hydraulic analyses would be required to quantify the magnitude of flood risk changes due to these differences.

The POR modeling includes a limited number of flow change years for the various alternatives. Other inflow combinations may be possible that could alter the assessment of potential flood risk changes. Prior to adopting any alternative or adaptive management plan that alters reservoir operations including the one-time spawning cue test, a comprehensive flood risk evaluation would be conducted.

3.24.4 Navigation

3.24.4.1 Affected Environment

This section describes the current navigation characteristics in the Middle Mississippi River that could potentially be affected by the alternatives. The Middle Mississippi River is the section of the Mississippi River between the confluence of the Missouri River and the Ohio River. This section discusses the characteristics of the vessels traveling on the waterway, the amount and type of commodities moving on the waterway, and the main origins and destinations of the movements on the Middle Mississippi River.

Vessels Traveling on the Middle Mississippi River

While the size, horsepower, and barge configurations of waterborne commerce vessels can vary, some generalizations of traffic can be made. The towboats traveling on the Mississippi River upstream of the Ohio River, which includes the Middle Mississippi River, are usually 160-foot towboats with 3,000 to 5,000 horsepower. Towboats on the lower Mississippi River, from the confluence with the Ohio River to New Orleans, can reach 180 ft in length and have an engine with 8,000 to 10,000 horsepower. The barge sizes measure 35 feet wide by 195 feet long, and are consistent with typical barges traveling on other navigable waterways. Additionally, the average tow configuration on the lower Mississippi River can consist of between 30 to 35 barges. The Middle Mississippi River can accommodate these larger arrangements (up to 36 barges) for much of its 195 miles, but typically averages around 25 barges per tow (Heroff pers. comm. 2017).

Amount and Type of Commodities Moving on Middle Mississippi River

As shown in Figure 3-75, over the last 15 years, the total tons traveling on the Middle Mississippi River ranged between 89.6 million tons (2013) to 121.6 million tons (2000) with a 15-year average of 105.6 million tons. Navigation restrictions in 2013 resulted in a decreased amount of tonnage shipped on the Middle Mississippi River in that year.

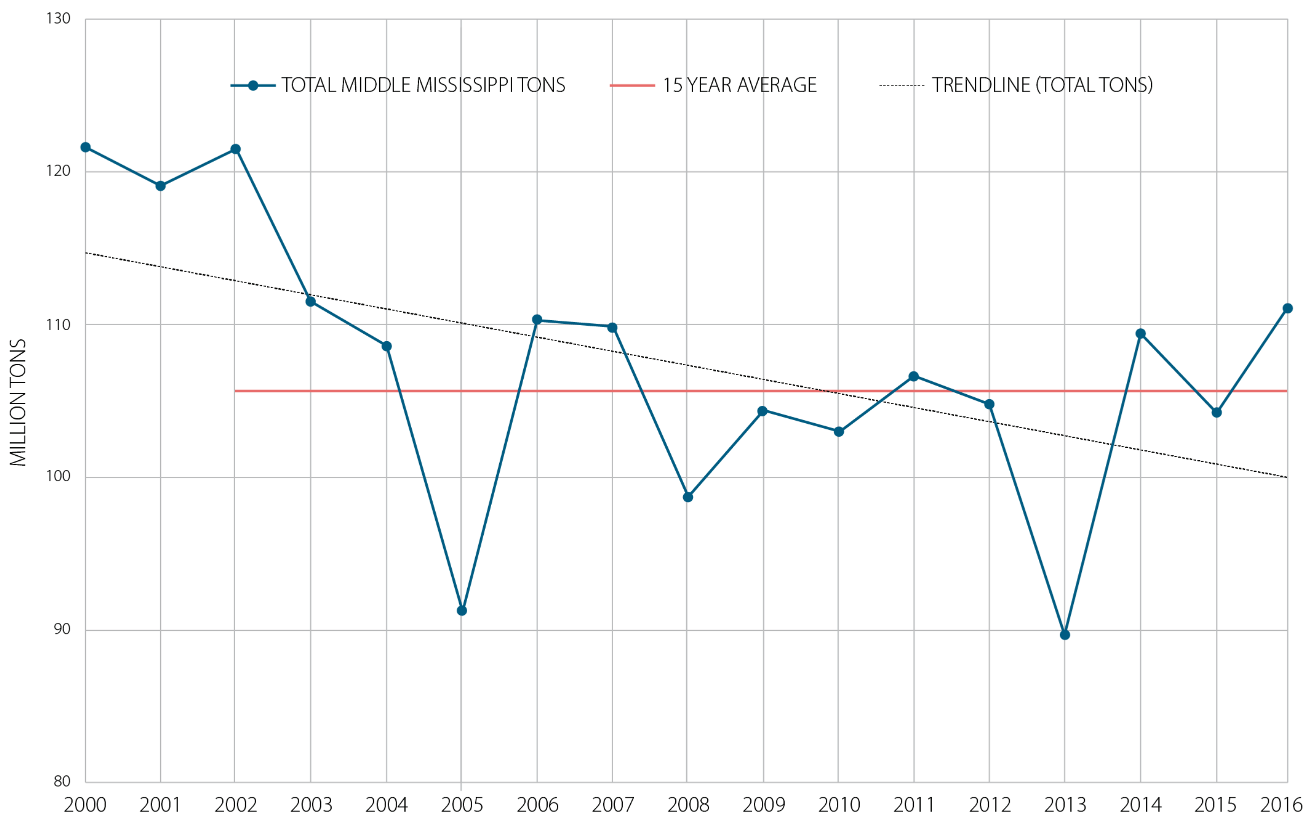


Figure 3-75. Total Annual Tons Shipped and 15-Year Average on the Middle Mississippi River

The data for the Middle Mississippi analysis was obtained from the Waterborne Commerce Statistics Center database. The data is presented for nine broad categories of commodities shipped on the Middle Mississippi River. Table 3-298 summarizes the annual tonnage for each of the nine categories shipped on the Middle Mississippi River, which includes any movements that touch the Middle Mississippi River. The following noticeable trends have occurred among the nine commodity categories.

- The shipments of crude petroleum have increased over the last 12 years. Crude petroleum shipments were 15 thousand tons in 2005. However, in 2013 crude petroleum increased to 5.7 million tons before dropping to 1.4 million tons in 2016.
- Over the last 10 years, the amount of grain and grain products traveling on the Middle Mississippi River averaged 38.5 million tons. However, in 2012 and 2013, grain and grain products decreased to 33.8 million tons and 23.1 million tons, respectively. Drought conditions starting in summer 2012 and stretching into winter of 2013 restricted traffic on the Middle Mississippi River to one way for a period of time in 2013 (Fears 2013). Further navigation restrictions on the Middle Mississippi River occurred during flooding conditions later in 2013.
- The shipments of chemicals have experienced a 64 percent increase (5.1 million tons) and aggregates have seen a 65 percent increase (4.5 million tons) since 2005.
- The amount of coal traveling on the Middle Mississippi River has decreased since 2009, from 27.1 million tons shipped to 8.6 million tons shipped in 2016. This trend is related to the changes in U.S. coal export market over the last 10 years.

Table 3-298. Middle Mississippi River Waterborne Tonnage by Commodity and Year (in thousands of tons)

Year	Coal	Petroleum products	Crude petroleum	Aggregates	Grains and grain products	Chemicals	Non-metallic ores and minerals	Iron ore, iron and steel products	Others	Total
2005	15,416	7,256	15	6,959	37,570	8,032	3,497	6,640	5,877	91,261
2006	26,340	8,284	103	10,338	40,567	7,417	3,577	6,687	6,956	110,268
2007	26,428	8,493	375	9,738	41,676	9,205	3,130	5,037	5,752	109,833
2008	26,228	7,197	725	8,701	32,527	8,638	4,874	4,927	4,848	98,665
2009	27,127	7,339	677	8,428	40,010	8,575	4,797	3,205	4,157	104,315
2010	22,264	6,990	891	8,340	41,522	10,369	2,811	3,310	6,471	102,968
2011	25,589	7,069	3,229	7,952	36,264	11,591	3,581	3,987	7,368	106,630
2012	22,408	7,785	4,827	9,785	33,822	11,156	2,564	4,241	8,183	104,772
2013	17,348	8,233	5,751	10,900	23,113	10,378	2,665	3,429	7,849	89,666
2014	15,539	9,353	4,796	11,486	38,040	12,389	4,880	4,547	8,345	109,375
2015	11,671	8,614	2,655	9,467	42,812	12,272	3,873	4,227	8,196	103,788
2016	8,576	8,828	1,366	8,951	54,871	13,183	3,059	3,713	8,494	111,042
Last 10 Years (avg)	20,318	7,990	2,529	9,375	38,466	10,776	3,623	4,062	6,966	104,105
Last 5 Years (avg)	15,108	8,562	3,879	10,118	38,532	11,876	3,408	4,032	8,213	103,728

Source: USACE 2018.

The monthly tonnage moved on the Middle Mississippi River for the most recent year available (2016) is provided in Table 3-299. The largest amount of tonnage moved on the Middle Mississippi River generally occurs in the summer months, while the smallest amount of tonnage shipped on the Middle Mississippi River generally occurs in January.

Table 3-299. 2016 Tonnage Shipped on the Middle Mississippi River by Month

Month	Tonnage Moved on the Middle Mississippi River
January	6,744,701
February	8,039,676
March	8,231,710
April	8,746,267
May	9,207,767
June	9,635,169
July	10,663,397
August	11,734,766
September	9,733,558
October	8,478,214
November	10,205,438
December	9,621,200
TOTAL	**111,041,863**

Origin and Destination of Commodities Moving on Middle Mississippi River

Along with examining the amount and type of commodities traveling on the Middle Mississippi River, it is useful to examine the origin and destination of the commodity movements. Figure 3-76 shows the states that shipped or received commodities that touched the Middle Mississippi River. Between 2007 and 2016, the top three receiving states were (1) Louisiana (56.9 million tons); (2) Illinois (14.7 million tons); and (3) Tennessee (5.9 million tons) and the top shipping states were (1) Illinois (49.7 million tons); (2) Missouri (22.5 million tons); and (3) Louisiana (14.9 million tons).

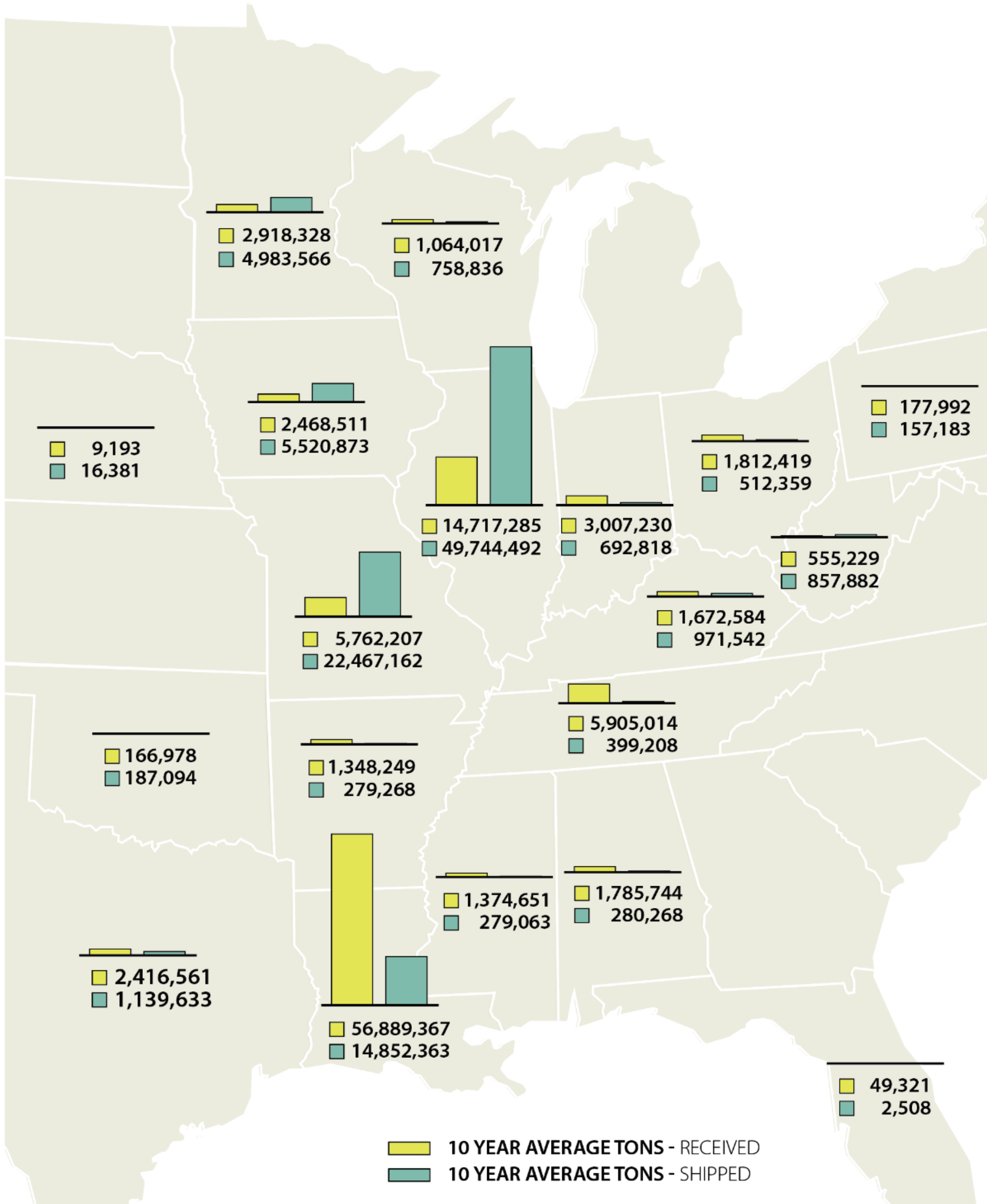


Figure 3-76. Average Tons Received and Shipped by State for Commodities Traveling on Middle Mississippi River

Over the last 10 years, 43 percent of the Middle Mississippi River traffic has been traveling between Illinois and Louisiana. As shown in Table 3-300, the top five commodities being shipped on the Middle Mississippi River between Illinois and Louisiana are maize, coal, soybeans, petroleum, and flours and meals of oil seeds or oleaginous fruits. The second most popular origin and destination pair (12 percent) over the last 10 years is Missouri and Louisiana. The Port of Metropolitan St. Louis plays a key role in the bulk transportation for the Midwest and was the third largest inland port in the U.S. by tonnage in 2014 (USACE 2018).

Table 3-300. Top Three Origin and Destination Pairs for Commodities Traveling on the Middle Mississippi

Shipping State	Receiving State	Top Commodities Moving Between States	5-Year Average (2012 to 2016)	10-Year Average (2005 to 2016)
Illinois	Louisiana	1) Maize, 2) Coal, 3) Soy Beans, 4) Petroleum, and 5) Flour	34.6 million tons	34.5 million tons
Missouri	Louisiana	1) Coal, 2) Maize, 3) Crushed Stone, 4) Soya Beans	14.2 million tons	12.2 million tons
Louisiana	Illinois	1) Sodium Chloride, 2) Pig Iron	8.6 million tons	8.6 million tons
		Total for Middle Mississippi River	103.7 million tons	104.1 million tons

Source: USACE 2018.

Since changes in flow releases on the Missouri River have the potential to impact the river flow and stage of the Middle Mississippi River, Table 3-301 provides the 10-year average tons shipped by drafts traveling on the Middle Mississippi River. The vast majority (77 percent) of tonnage is shipped on barges with a draft of 8 to 9 feet. During favorable river conditions, barges can be loaded in excess of a 9-foot draft, resulting in fewer trips and a lower shipping cost. Between 2007 and 2016, 17 percent of total tonnage was loaded in barges with a draft of 10 feet or greater.

Table 3-301. Ten-Year Average (2007 to 2016) of Middle Mississippi River Commodity Tonnages by Draft Depth (in thousands of tons)

Draft (feet)	Coal	Petroleum Products and Crude Petroleum	Aggregates	Grains and Grain Products	Chemicals	Non-Metallic Ores and Minerals	Iron Ore, Iron, and Steel Products	Others	Total	% of Total
<5	72	91	7	47	605	212	61	111	1,207	1%
6	53	104	13	390	194	83	17	65	919	1%
7	335	409	20	760	897	476	113	280	3,289	3%
8	3,450	1,342	226	2,708	14,415	5,329	1,759	1,821	31,049	32%
9	14,340	4,049	1,258	3,931	14,463	3,486	932	1,474	43,933	45%
10	932	1,485	603	897	2,354	634	258	119	7,282	7%
≥11	1,135	509	403	643	5,538	555	484	192	9,460	10%
All drafts	20,318	7,990	2,529	9,375	38,466	10,776	3,623	4,062	97,139	100%

Source: USACE 2018.

3.24.4.2 Environmental Consequences

The Middle Mississippi River navigation impact analysis focuses on determining if changes in river and reservoir conditions associated with each of the MRRMP-EIS alternatives could affect commodities transported on the Middle Mississippi River. This section summarizes the Middle Mississippi River navigation impact assessment methods and presents the results of the assessment.

Impacts Assessment Methodology

Navigators on the Middle Mississippi River can be affected by lower river stages and flows, which can require using a different sized tow, changing their tow configuration (i.e., number of barges), and light-loading the barges, resulting in higher operating costs for navigators. Information for the analysis was obtained from interviews with Middle Mississippi River experts, including the USACE St. Louis District, industry experts, and the Mississippi River and Tributaries Waterways Action Plan (US Coast Guard 2017). HEC-RAS data was used to assess changes in river stages at the St. Louis gage for each of the MRRMP-EIS alternatives. Tonnage from the USACE Waterborne Commerce Statistics Center for 2016 was used as the reference year tonnage. The following assumptions were used for the evaluation:

- During relatively lower river flows, Middle Mississippi River navigation would continue but could result in a change in navigation operations, including light loading and a lower barge per tow ratio. When river stages are below −2, the barge to tow configuration is assumed to be 20 barges per tow; when river stages are between 0 and −2, the barge to tow configuration is assumed to be 25 barges per tow; when river stages are above 0, the barge to tow configuration is 36 barges per tow (Heroff pers. comm. 2017). It is assumed that all tonnage would be moved by these tow configurations; at relatively lower river stages, additional trips would be needed to transport the tonnage because of the need to light load barges and reduce the tow configuration.

- When river stages are −3, a 9-foot navigation channel would allow for vessels to draft to eight feet. The river stage-channel-draft relationship is assumed to increase and decrease linearly (i.e., when river stages are −2, there would be a 10-foot navigation channel, etc.). These characteristics were used to estimate the load draft relationships for the barges (Campbell Transportation Co. 2018).

- The Middle Mississippi River is approximately 195 miles long. When smaller tows are used during lower river stages, the usual practice is to reconfigure to larger tows below the Ohio River, with a more efficient configuration (Heroff pers. comm. 2017). Although it is possible that the smaller tows would move tonnages in both directions, to be conservative, it was assumed that each trip would require double the distance of the Middle Mississippi River when river stages are below 0 (assumes the need to round-trip on the Middle Mississippi River).

- It was assumed that smaller horsepower tows would be used when river stages are below 0 (approximately 4,000 horsepower) with a cost of $16,000 per day and larger 10,000 horsepower tows would be used when river stages are above 0, with a cost of $22,000 per day. The average speed for the tows was estimated to be 7.5 miles per hour during normal conditions and 5.5 miles per hour during extreme drought conditions (below −3 river stage) (Heroff pers. comm. 2017). The operating costs include labor and fuel costs. Tows were assumed to be operating 24 hours a day.

Estimating the Middle Mississippi River NED impacts involved the following steps. First, the HEC RAS data was converted from daily stage values to percentages of time within a month within one-foot river stage categories. For example, in July, 2012, 68 percent of the days were associated with river stages between −1 and −2 and 32 percent of the days were associated with river stages between 0 and −1. Second, the affected tonnage was calculated by multiplying the stage percentages by the reference year 2016 monthly tonnages. The year 2016 was chosen as the base year tonnage since it was the most recent data available and experienced the highest tonnage moved on the Middle Mississippi River since 2003. This results in the tonnage affected at each river stage category. After calculating the affected tonnage for each month within the POR, the third step estimated the number of barges by dividing the affected tonnage by the tonnage per barge, which was based on the load draft relationships provided by Campbell Transportation (Campbell 2018).

The fourth step estimated the number of tows needed per month. The number of barges was divided by the number of barges per tow within each one-foot stage category for each month within the POR based on data from industry experts. If for example, October 2012 experienced 273,500 tons at a −3 to −4 stage category, the number of tows needed would be estimated to be 11 (273,500 tons / 1,300 tons per barge / 20 barges per tow).

The final step was to estimate the operating costs. The unit operating costs per tow per day were provided by an industry expert (Heroff pers. comm. 2017) as described above. These costs were divided by 24 hours to estimate an operating cost per tow per hour. The time to travel the Middle Mississippi River per hour was estimated by dividing the speed for tows in normal and drought conditions (in miles per hour) by the distance traveled (390 miles for round-trip transportation). Then the operating costs per tow per hour were multiplied by the number of hours in each one-stage category, which was then multiplied by the number of tows in each stage category for every month over the POR. The result was an estimate of the operating costs for each month and each one-stage category over the POR.

Summary of Environmental Consequences

An overview of the navigation environmental consequences is provided in Table 3-302.

Table 3-302. Summary of Environmental Consequences for Mississippi Navigation

Alternative	Environmental Consequences to Navigation Operating Costs	Construction Impacts
Management Actions Common to All Alternatives	No impacts to navigation on the Middle Mississippi River because actions would not occur on the Mississippi River and would not affect flows or stages on the Mississippi River.	NA
Alternative 1	Average annual operating costs would be $43.8 million, annually ranging from a low of $34.5 million during relatively higher river flows to a high of $155.1 million during the drought conditions of the 1930s. The spring plenary pulse would have a negligible impact on operating costs because of the small amount of System storage affected by the plenary pulse, with negligible to small impacts on river flows in the Mississippi River following the pulses.	Mechanical habitat construction would not result in impacts to Middle Mississippi River navigation because there would be no construction in the Middle Mississippi River and the habitat would have negligible impacts on river flows and stages in the Middle Mississippi River.
Alternative 2	Average annual operating costs would increase by $13,942 (0.03%), a negligible change from Alternative 1. There would be years with both small increases and decreases in navigation operating costs from the low summer flow event and spawning cue releases increasing and decreasing river flows in the Middle Mississippi River.	Same as Alternative 1

Alternative	Environmental Consequences to Navigation Operating Costs	Construction Impacts
Alternative 3	Average annual operating costs would result in a negligible decrease of $14,900 (−0.03%) associated with the elimination of the spring plenary pulse under Alternative 3, which would slightly increase System storage in some fall and winter months, with negligible benefits to navigation operating costs.	Same as Alternative 1
Alternative 3: Gavins Point One-Time Spawning Cue Test	Negligible temporary adverse impacts to operating costs from the potential of the spawning cue release reducing river flows in the year of or the year following a release, although impacts would only occur for a few days.	No habitat construction.
Alternative 4	Alternative 4 would result in a negligible to small adverse impact to Middle Mississippi River navigation on average ($153,000 or 0.3%) and in most months and years over the POR. In a small number of years, there could be temporary and large adverse impacts to operating costs from lower river stages in the fall and winter months caused by reduced System storage following the spring release.	Same as Alternative 1
Alternative 5	Alternative 5 would result in an average annual decrease in operating costs of $7,900 (−0.02 percent) over the POR compared to Alternative 1. In some years, there would be small adverse impacts associated with the fall releases reducing System storage and river stages in the subsequent fall months and small beneficial impacts from the elimination of the spring plenary pulse under Alternative 5 increasing System storage and river stages compared to Alternative 1.	Same as Alternative 1
Alternative 6	Alternative 6 would result in a negligible to small adverse impact to Middle Mississippi River navigation on average ($197,000 or 0.3%) and in most months and years over the POR. In a small number of years, there could be temporary and large adverse impacts to operating costs from lower river stages in the fall and winter months from reduced System storage following the spawning cue release.	Same as Alternative 1

Additional details on the environmental consequences relative to Middle Mississippi River navigation are summarized in Table 3-303 and Table 3-304. Table 3-304 summarizes affected tonnage when river stages are below 0 over the POR. Under current management conditions and as simulated by the HEC-RAS models under Alternative 1, an average of 82,300 tons would be transported per month over the POR when river stages are below 0. Under Alternative 1, there would be more tonnage transported in November and December when river stages are below 0 and less tonnage in April and May. In general, Alternative 4 and 6 would result in more days when river stages are below 0 at the St. Louis gage, with more tonnage transported under these conditions in the summer, fall, and winter. On average, 124,000 and 166,000 more tons would be transported under Alternatives 4 and 6, respectively, when river conditions are below a river stage of 0 when compared with Alternative 1. In the average of the 8 largest change years compared to Alternative 1, Alternatives 4 and 6 would result in approximately 1.3 million and 1.6 million additional tons, respectively, when river stages fall below 0 at the St. Louis gage compared to Alternative 1. These impacts usually occur in the fall in the year of the release or the years following the release when river stages are lower as the reservoir System rebalances.

There would be very little changes in river stages under Alternative 3 and 5 compared to Alternative 1. On average, Alternative 2 would result in fewer days when river stages would decrease below 0 and less affected tonnage transported when river stages are less than 0. In general, under Alternative 2, river flows would be higher than a river stage of zero in November and December, with a decrease in affected tonnage (benefit) compared to Alternative 1. However, Alternative 2 also shows that in some months of the year, including July and August, there would be a greater amount of tonnage affected, with more days when river stages fall below a river stage of 0. The lower river stages in the summer would occur from the low summer flow events, which would increase operating costs during these months. These impacts in the summer would be offset with higher river stages and flows in November and December because System storage would be slightly higher than under Alternative 1, with benefits to Middle Mississippi River navigation.

Table 3-303. Difference in Average Tonnage Affected Below 0 River Stage in the Middle Mississippi River Between Alternative 1 and Action Alternatives

Month	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
	Average Monthly Affected Tonnage over POR	Average Monthly Tonnage, Difference from Alternative 1				
January	127,921	5,243	0	5,243	0	0
February	119,910	6,800	0	0	0	0
March	37,431	0	0	0	0	0
April	2,810	0	−3,513	−3,513	−3,513	−3,513
May	9,304	0	3,579	3,579	3,579	0
June	14,704	0	0	0	0	0
July	31,083	33,155	0	16,577	4,144	0
August	108,545	82,093	4,561	27,364	4,561	9,121
September	93,427	3,909	0	7,818	0	7,818
October	110,055	29,656	−6,590	52,721	3,295	56,016
November	160,664	−180,337	−8,197	65,577	−12,296	98,366
December	172,381	−33,654	0	11,218	0	14,957
Average Monthly Tonnage	82,353	−4,428	−847	15,549	−19	15,231
Average Annual Tonnage	1,488,888	−84,509	−10,284	124,455	−232	166,416
Percent Change in Average Annual Tonnage	NA	−5.7%	−0.7%	8.4%	0.0%	11.2%
Ave of 8 Largest Change Years from Alternative 1	NA	911,505	52,612	1,297,299	191,178	1,630,431
Ave of 8 Smallest Change Years from Alternative 1	NA	−2,020,322	−158,027	−76,709	−193,560	−63,639

Note: Positive changes from Alternative 1 indicate more tonnage moved when river stages are below 0 at the St. Louis gage (adverse impacts), while negative values indicated less tonnage moved when river stages are below 0 compared to Alternative 1 (beneficial impacts).

Table 3-304 summarizes the average monthly navigation operating costs for all tonnage that is transported on the Middle Mississippi River as simulated in the HEC-RAS model, the average annual operating costs, and the average of the 8 largest and smallest difference years compared to Alternative 1. Alternatives 4 and 6 would result in increases in operating costs from an increase in the number of days when river stages fall below 0 primarily in October and November in the year of or years following the releases. In the average of the 8 largest difference years, Alternatives 4 and 6 would result in an increase in operating costs of $1.5 million and $1.8 million, respectively, compared to Alternative 1. Although there is a higher percent change in the affected tonnage transported when river stages are below 0 for Alternatives 4 and 6 (8.4 and 11.2 percent, respectively), the change in operating costs would increase only slightly, by 0.3 and 0.4 percent, respectively, for all tonnage being shipped on the Middle Mississippi River. This is due to the very small changes in river stages and tow configurations; operating costs are not very sensitive to these slight changes in river stages.

Alternatives 3 and 5 would result in very little changes in operating costs across the POR compared to Alternative 1 because of the minor change in river flows and stages. Alternative 2 would result in increases in operating costs in the summer months from low summer flow events (with more tonnage affected below river stage of 0), although in the fall months following the low summer flow events, river flows would be relatively higher with reductions in operating costs (with less tonnage affected below river stages of 0) when compared to Alternative 1. Average annual operating costs for Alternative 2 would result in very little change from Alternative 1.

Table 3-304. Average Monthly and Annual Operating Costs for All Tonnage Transported on the Middle Mississippi River

Month	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
	Average Monthly Costs	Difference in Monthly Costs from Alternative 1				
January	$3,419,428	$15,247	$1,783	$7,733	$2,242	$20,209
February	$3,631,668	$8,245	−$1,143	$1,184	$1,184	$2,875
March	$2,938,401	$0	$280	$280	$280	$280
April	$2,732,813	$0	−$1,442	−$1,442	−$1,442	−$1,442
May	$2,906,666	$0	$1,469	$1,469	$1,469	$0
June	$3,084,891	$1,324	$0	$0	$0	$0
July	$3,668,798	$13,976	$0	$6,806	$1,702	−$363
August	$4,503,351	$75,739	$712	$11,674	$712	$2,984
September	$3,781,502	$6,302	−$343	$3,895	−$343	$3,895
October	$3,809,624	$36,713	−$9,710	$82,358	−$5,651	$90,994
November	$4,892,136	−$91,077	−$6,599	$64,678	−$8,282	$73,968
December	$4,783,054	−$38,897	$0	$8,097	$0	$11,567
Average Annual Costs	**$43,801,407**	**$43,815,349**	**$43,786,508**	**$43,954,679**	**$43,793,469**	**$43,998,435**
Change in Ave Annual from Alternative 1		$13,942	−$14,899	$153,272	−$7,939	$197,028
Average Annual Percent Change from Alternative 1		0.0%	0.0%	0.3%	0.0%	0.4%
Average Annual Change in 8 Worst Years Relative to Alternative 1	NA	$1,052,110	$48,502	$1,531,819	$111,281	$1,842,871
Average Annual Change in 8 Best Years Relative to Alternative 1	NA	−$1,118,457	−$193,767	−$41,120	−$192,652	−$46,086

Note: Positive changes from Alternative 1 indicate higher operating costs, while negative values indicate lower operating costs compared to Alternative 1.

Impacts from Management Actions Common to All Plan Alternatives

A number of actions are common to all alternatives including vegetation management, predator management, and human restriction measures. These actions occur upstream of Gavins Point Dam and would not affect navigation in the Middle Mississippi River. Pallid sturgeon propagation and augmentation is also common to all alternatives, but would have no impact on navigation in the Middle Mississippi River.

Mechanical habitat construction under all alternatives would not result in impacts to Middle Mississippi River navigation because there would be no construction in the Middle Mississippi River and the habitat would have no to negligible impacts on river flows and stages in the Middle Mississippi River.

Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 represents the continuation of current System operation on the Missouri River and primarily serves as a reference condition allowing for a comparison with the action alternatives. Table 3-305 summarizes the tonnage estimated to be transported and the operating costs when river stages are below 0 in the Middle Mississippi River. On average over the POR, there would be 32 days per year when river stages are below 0 feet at the St. Louis gage, with an estimated 1.5 million tons transported under these conditions. Average annual operating costs to transport commodities on the Middle Mississippi River is estimated to be $43.8 million. River stages are the lowest over the POR between October and February, with on average between 4 and 6 days per month when river stages are below 0. As simulated in the drought of the 1930s and early 1940s, there would be many months with relatively lower river flows, even in the summer and fall months. On average, April, May, and June would not have many days below river stages of 0.

When river stages are below 0, navigators would need to reconfigure tows to a smaller barge to tow ratio and light load their barges. To transport 1.5 million tons of commodities at river stages below 0, it would cost $12.5 million on average annually. The largest average monthly operating costs would occur in November of $4.9 million. The highest monthly operating cost would occur in November of $34.4 million, as simulated in 1934. The largest operating costs are simulated to occur during the drought of the 1930s when there is a greater number of days below river stages of 0. For example, in 1934, there would be 269 days below a river stage of 0. The spring plenary pulse would have a negligible contribution to these higher operating costs because of the minor change in System storage and river stages in the Middle Mississippi River following the plenary pulse.

Table 3-305. Average Monthly Tonnage and Operating Costs for Movements when River Stages are Below 0 on the Middle Mississippi River under Alternative 1

Month	Total Number of Days over the POR with River Stages Below 0	Average Number of Days over the POR with River Stages Below 0	Average Monthly Tonnage Transported when River Stages are Below 0 (tons)	Average Operating Costs for Tonnage Moving Below 0	Largest Operating Cost for Tonnage Moving Below 0 over the POR
January	488	6.0	127,921	$3,419,428	$19,542,223
February	351	4.3	119,910	$3,631,668	$15,352,869
March	117	1.4	37,431	$2,938,401	$15,448,868
April	8	0.1	2,810	$2,732,813	$1,588,925

Month	Total Number of Days over the POR with River Stages Below 0	Average Number of Days over the POR with River Stages Below 0	Average Monthly Tonnage Transported when River Stages are Below 0 (tons)	Average Operating Costs for Tonnage Moving Below 0	Largest Operating Cost for Tonnage Moving Below 0 over the POR
May	26	0.3	9,304	$2,906,666	$5,784,885
June	38	0.5	14,704	$3,084,891	$8,358,592
July	75	0.9	31,083	$3,668,798	$24,672,994
August	238	2.9	108,545	$4,503,351	$31,486,946
September	239	2.9	93,427	$3,781,502	$26,623,435
October	334	4.1	110,055	$3,809,624	$27,522,484
November	392	4.8	160,664	$4,892,136	$34,394,075
December	461	5.6	172,381	$4,783,054	$25,782,375
Average Monthly	NA	2.8	82,353	$3,419,428	NA
Average Annual	NA	32	1,488,888	$43,815,349	NA

Conclusion

Alternative 1 represents the continuation of current System operation on the Missouri River and primarily serves as a reference condition allowing for a comparison with the action alternatives. Lower river flows would occur over the POR associated with the drought and drier periods with the natural variability in the hydrology of the region. During low river stage conditions, navigators need to reduce their tow configuration and light load their barges, which increases operating costs during these conditions. An estimated 1.5 million tons on average per year would be transported on the Middle Mississippi River when river stages at the St. Louis gage are below 0, with estimated average annual operating costs to transport this tonnage of $43.8 million. The largest costs would occur in November and December with lower river flows in the fall and winter months. The spring plenary pulse would have a negligible impact on operating costs because of the small amount of System storage affected by the plenary pulse, with negligible to small impacts on river flows in the Mississippi River following the pulses. Mechanical habitat construction would not impact navigation on the Middle Mississippi River. Management actions under Alternative 1 would not result in significant impacts to navigation on the Middle Mississippi River.

Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

The results associated with Alternative 2 are summarized in Table 3-306. On average, Alternative 2 would result in fewer tons shipped (84,500) when river stages are below 0 compared to Alternative 1, a decrease of 5.7 percent. On average, there would be very little change in annual operating costs over the POR, a decrease of $13,900 (0.03 percent) relative to Alternative 1. The average of the 8 years with the largest increase in operating cost would result in higher operating costs of $1.1 million, while the average of the 8 years with the largest decreases in costs would result in lower operating costs of $1.1 million.

Table 3-306. Number of Days, Affected Tonnage, and Operating Costs under Alternative 2 Compared to Alternative 1

Month	Total Number of Days over the POR with River Stages Below 0, Difference from Alternative 1	Average Monthly and Annual Tonnage Transported When River Stages are Below 0		Average Operating Costs for All Tonnage Transported	
		Change from Alternative 1 (tons)	% Change from Alternative 1	Change from Alternative 1 (FY 18 $)	% Change from Alternative 1
January	2	5,243	4.1%	$15,247	0.4%
February	2	6,800	5.7%	$8,245	0.2%
March	0	0	0.0%	$0	0.0%
April	0	0	0.0%	$0	0.0%
May	0	0	0.0%	$0	0.0%
June	0	0	0.0%	$1,324	0.0%
July	8	33,155	106.7%	$13,976	0.4%
August	18	82,093	75.6%	$75,739	1.7%
September	1	3,909	4.2%	$6,302	0.2%
October	9	29,656	26.9%	$36,713	1.0%
November	−44	−180,337	−112.2%	−$91,077	−1.9%
December	−9	−33,654	−19.5%	−$38,897	−0.8%
Change in Average Annual	**−0.3**	**−84,509**	**NA**	**$13,942**	**NA**
Percent Change in Average Annual	**−0.8%**	**−5.7%**	**NA**	**0.03%**	**NA**
Ave of 8 Largest Change Years	**3**	**911,505**	**NA**	**$1,052,110**	**NA**
Ave of 8 Smallest Change Years	**6**	**−2,020,322**	**NA**	**−$1,118,457**	**NA**

Note: Positive changes from Alternative 1 indicate more tonnage being transported when river stages are below 0 (adverse effect) and higher operating costs, while negative values indicated a reduction in affected tonnage being transported when river stages are below 0 (beneficial effect) and lower operating costs.

The low summer flow events, as simulated under Alternative 2 would decrease river stages in the summer during these events, but would be offset by higher stages in the fall months following the events, with benefits to Middle Mississippi River navigation. Of the six low summer flow events simulated to occur over the POR, the largest increase in operating costs compared to Alternative 1 would occur in conditions similar to 2003 with a $2.4 million (4.5 percent) increase in costs resulting from lower river stages. During August of 2003, as simulated, there would be five additional days when river stages were below −3 under Alternative 2, compared with no days under Alternative 1.

In the months following the low summer flow events primarily in November and December, there would be higher river flows because of relatively more System storage compared to Alternative 1. The largest reduction in operating costs relative to Alternative 1 following the low summer flow events was simulated to occur in 2002 (following a low summer flow event in the summer of 2002), with a decrease in operating costs of $4.3 million. Because the low summer flow events increase System storage in the fall months following the events, there would be small increases in river flows in the Mississippi River relative to Alternative 1, with reduced operating costs.

The months and years following the spawning cue releases can result in some adverse impacts to Middle Mississippi River navigation usually in the fall and winter months. For example, a spawning cue release occurs as simulated in 1931, which causes river stages to decrease in October of 1932 compared to Alternative 1, as the reservoirs rebalance after the release. Operating costs would increase by $2.6 million compared to Alternative 1 in 1932. Because of the shifting in river flows and stages associated with the spawning cue releases and low summer flows, there are shifts in the impacts to Middle Mississippi River navigation but with very little change in operating costs on average over the POR. In general, there would be small adverse impacts to navigation in some months (summer and fall), although there would be beneficial impacts to navigation in other months (fall and winter). On average, the change in operating costs under Alternative 2 compared to Alternative 1 would be negligible and adverse (0.3 percent).

Conclusion

On average, there would be negligible impacts under Alternative 2 to Middle Mississippi River navigation compared to Alternative 1, with an average annual increase in operating costs of $13,942 (0.03 percent). A shift in the timing of the low river flows would generally cause some increases in operating costs in the summer months during low summer flow events. However, reductions in operating costs would occur in the fall and winter months because the low summer flow events would increase subsequent System storage with small increases in river flows after these events. Mechanical habitat construction would not impact navigation on the Middle Mississippi River. The impacts to navigation would not be significant because adverse impacts would be temporary and would be offset by months with beneficial impacts.

Alternative 3 – Mechanical Construction Only

The results associated with Alternative 3 are summarized in Table 3-307. The elimination of the spring plenary pulse under Alternative 3 would result in slightly higher System storage, with slight increases in river flows in the Middle Mississippi River resulting in very small decreases in navigation operating costs. On average, there would be a decrease in annual operating costs of $14,900 (−0.03 percent) associated with slight increases in river flows and negligible changes in benefits to navigation in the Middle Mississippi River relative to Alternative 1. In the average of the 8 years with the largest decreases in operating costs, costs would decrease by $194,000, a very small decrease in operating costs.

Table 3-307. Number of Days, Affected Tonnage, and Operating Costs under Alternative 3 Compared to Alternative 1

Month	Total Number of Days over the POR with River Stages Below 0, Difference from Alternative 1	Average Monthly and Annual Tonnage Transported When River Stages are Below 0		Average Operating Costs for All Tonnage Transported	
		Change from Alternative 1 (tons)	Percent Change from Alternative 1	Change from Alternative 1 (FY 18 $)	Percent Change from Alternative 1
January	0	0	0.0%	$1,783	0.1%
February	0	0	0.0%	−$1,143	0.0%
March	0	0	0.0%	$280	0.0%
April	−1	−3,513	−125.0%	−$1,442	−0.1%
May	1	3,579	38.5%	$1,469	0.1%
June	0	0	0.0%	$0	0.0%
July	0	0	0.0%	$0	0.0%
August	1	4,561	4.2%	$712	0.0%
September	0	0	0.0%	−$343	0.0%
October	−2	−6,590	−6.0%	−$9,710	−0.3%
November	−2	−8,197	−5.1%	−$6,599	−0.1%
December	0	0	0.0%	$0	0.0%
Change in Average Annual	**−0.04**	**−10,284**		**−$14,899**	
Percent Change in Average Annual	**−0.1%**	**−0.7%**		**−0.03%**	
Ave of 8 Largest Difference Years	**0**	**52,612**		**$48,502**	
Ave. of the 8 Smallest Difference Years	**−1**	**−158,027**		**−$193,767**	

Note: Positive changes from Alternative 1 indicate more tonnage being transported when river stages are below 0 (adverse effect) and higher operating costs, while negative values indicated a reduction in affected tonnage being transported when river stages are below 0 (beneficial effect) and lower operating costs.

Gavins Point One-Time Spawning Cue Test: The one-time spawning cue test (Level 2) release that might be implemented under Alternative 3 was not included in the hydrologic modeling for this alternative because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

Alternative 6 would result in negligible to small adverse impacts to navigation on average ($197,028 or 0.4 percent) and in most years over the POR. However, in a small number of fall months in the years of or following the spawning cue release, there could be temporary and large adverse impacts to operating costs from lower river stages in the fall and winter months from reduced System storage following the release. Because the spawning cue would be implemented as a one-time event, there would likely be relatively negligible impacts because changes in river stages would be temporary (lasting for a few days at most) and USACE would notify the industry and the Coast Guard of the test flow which would allow the navigators to plan around the event, minimizing or changing the timing of shipments in the affected fall seasons to reduce the impacts to operating costs.

Conclusion

Alternative 3 would result in negligible changes in navigation operating costs in the Middle Mississippi River when compared to Alternative 1, with a decrease in average annual operating costs of $14,900 (−0.03 percent). The elimination of the spring plenary pulse under Alternative 3 would slightly increase System storage in some fall and winter months, with negligible benefits to navigation operating costs. Mechanical habitat construction would not impact navigation on the Middle Mississippi River. The one-time spawning cue test would likely result in negligible to small adverse impacts in the fall following the release from lower System storage and river flows as the System rebalances. The impacts to navigation would not be significant because changes in navigation impacts would be negligible to small.

Alternative 4 – Spring ESH Creating Release

The results associated with Alternative 4 are summarized in Table 3-308. Alternative 4 would result in an average annual increase in operating costs of $153,000 (0.3 percent) over the POR compared to Alternative 1 from lower river flows in the Middle Mississippi River following the spring release. Over the POR, there would be negligible to very small differences in operating costs compared to Alternative 1 in most months, with on average less than a day more below a river stage of 0 compared to Alternative 1. However, in some fall months, there would be a large increase in operating costs following the spring release, when System storage would be lower than under Alternative 1, resulting in lower river flows in the Middle Mississippi River. These lower flows would affect navigation operations requiring light loading and changes in the tow configuration, which would increase navigation operating costs.

The months that would be most affected are October (average monthly increase of $82,000) and November (average monthly increase of $65,000). These fall months would occur in the year of or year following a spring release. During the 8 years with the largest increase in operating costs compared to Alternative 1, operating costs would increase by $1.5 million. The largest increase in operating costs would occur, as simulated, in 1964, with an increase in operating costs of $3.7 million (8 percent) compared to Alternative 1 in that year. A spring release would be simulated to occur in conditions reflecting 1963, resulting in lower System storage following the release and lower river flows in the Middle Mississippi River in November of 1964. In November of 1964, there would be seven more days when river stages at the St. Louis gage would be below 0 when compared to Alternative 1, and five more days when river stages would be below −3 under Alternative 4 compared to Alternative 1.

Table 3-308. Number of Days, Affected Tonnage, and Operating Costs under Alternative 4 Compared to Alternative 1

Month	Total Number of Days over the POR with River Stages Below 0, Difference from Alternative 1	Average Monthly and Annual Tonnage Transported When River Stages are Below 0		Average Operating Costs for All Tonnage Transported	
		Change from Alternative 1 (tons)	Percent Change from Alternative 1	Change from Alternative 1 (FY 18 $)	Percent Change from Alternative 1
January	2	5,243	4.1%	$7,733	0.2%
February	0	0	0.0%	$1,184	0.0%
March	0	0	0.0%	$280	0.0%
April	−1	−3,513	−125.0%	−$1,442	−0.1%
May	1	3,579	38.5%	$1,469	0.1%
June	0	0	0.0%	$0	0.0%
July	4	16,577	53.3%	$6,806	0.2%
August	6	27,364	25.2%	$11,674	0.3%
September	2	7,818	8.4%	$3,895	0.1%
October	16	52,721	47.9%	$82,358	2.2%
November	16	65,577	40.8%	$64,678	1.3%
December	3	11,218	6.5%	$8,097	0.2%
Change in Average Annual	**0.4**	**124,455**		**$153,272**	
Percent Change in Average Annual	**1.2%**	**8.4%**		**0.3%**	
Ave of 8 Largest Change Years	**4**	**1,297,299**		**$1,531,819**	
Ave of 8 Smallest Change Years	**0**	**−76,709**		**−$41,120**	

Note: Positive changes from Alternative 1 indicate more tonnage being transported when river stages are below 0 (adverse effect) and higher operating costs, while negative values indicated a reduction in affected tonnage being transported when river stages are below 0 (beneficial effect) and lower operating costs.

Conclusion

Alternative 4 would result in negligible to small adverse impacts to navigation on average ($153,000 or 0.3 percent) and in most years over the POR. However, in a small number of fall months in the years of or following the spring release, there could be temporary and large adverse impacts to operating costs from lower river stages in the fall and winter months from reduced System storage following the spring release. Mechanical habitat construction would not impact navigation on the Middle Mississippi River. Impacts to navigation in the Middle Mississippi River would not be significant under Alternative 4 because in most years, there would be negligible to small impacts and any large impacts would be temporary.

Alternative 5 – Fall ESH Creating Release

Table 3-309 summarizes the results for Alternative 5. Alternative 5 would result in an average annual decrease in operating costs of $7,900 (−0.02 percent) over the POR compared to Alternative 1. Over the POR, there would be negligible to very small changes in operating costs compared to Alternative 1 in most years. Even in the years with the largest change in operating costs, the changes would represent less than 1 percent compared to Alternative 1.

The years following the fall releases could result in lower river stages in the Middle Mississippi River in a few years. For example, as simulated in 1984, there would be higher operating costs of $225,000 associated with a fall release in 1982 (partial release) and 1983 (full release). The flow releases would slightly reduce System storage and river flows in the Middle Mississippi River in the fall months, as simulated in 1984, with small adverse impacts to navigation operating costs.

The elimination of the spring plenary pulse under Alternative 5 would reduce operating costs in a few years over the POR, from small increases in System storage and river flows in fall months when compared to Alternative 1. For example, in conditions similar to 1963, there would be slightly higher river flows in the fall from the elimination of the spring plenary pulse under Alternative 5 compared to Alternative 1, with a decrease in operating costs of $458,000. On average over the POR, the benefits to navigation in the Middle Mississippi River from the elimination of the spring plenary pulse outweigh the adverse impacts from low river flows following the fall releases, with very little change in operating costs when compared to Alternative 1 overall.

Table 3-309. Number of Days, Affected Tonnage, and Operating Costs under Alternative 5 Compared to Alternative 1

Month	Total Number of Days over the POR with River Stages Below 0, Difference from Alternative 1	Average Monthly and Annual Tonnage Transported When River Stages are Below 0		Average Operating Costs for All Tonnage Transported	
		Change from Alternative 1 (tons)	Percent Change from Alternative 1	Change from Alternative 1 (FY 18 $)	Percent Change from Alternative 1
January	0	0	0.0%	$2,242	0.1%
February	0	0	0.0%	$1,184	0.0%
March	0	0	0.0%	$280	0.0%
April	−1	−3,513	−125.0%	−$1,442	−0.1%
May	1	3,579	38.5%	$1,469	0.1%
June	0	0	0.0%	$0	0.0%
July	1	4,144	13.3%	$1,702	0.0%
August	1	4,561	4.2%	$712	0.0%
September	0	0	0.0%	−$343	0.0%
October	1	3,295	3.0%	−$5,651	−0.1%
November	−3	−12,296	−7.7%	−$8,282	−0.2%
December	0	0	0.0%	$0	0.0%
Change in Average Annual	**0.00**	**−232**		**−$7,939**	
Percent Change in Average Annual	**0.00%**	**−0.02%**		**−0.02%**	
Ave of 8 Largest Change Years	**1**	**191,178**		**$111,281**	
Ave of 8 Smallest Change Years	**−1**	**−193,560**		**−$192,652**	

Note: Positive changes from Alternative 1 indicate more tonnage being transported when river stages are below 0 (adverse effect) and higher operating costs, while negative values indicated a reduction in affected tonnage being transported when river stages are below 0 (beneficial effect) and lower operating costs.

Conclusion

On average, Alternative 5 would result in negligible changes to navigation operating costs in the Middle Mississippi River when compared to Alternative 1. In some years, there would be small adverse and beneficial impacts associated with the fall releases reducing System storage and river stages in the subsequent fall months (adverse impacts) and the elimination of the spring plenary pulse under Alternative 5 increasing System storage and river stages (beneficial impacts). Mechanical habitat construction would not impact navigation on the Middle Mississippi River. Impacts to navigation in the Middle Mississippi River would not be significant under Alternative 5 because there is negligible change in navigation operations in most years and adverse impacts in some years are small.

Alternative 6 – Pallid Sturgeon Spawning Cue

The results associated with Alternative 6 are summarized in Table 3-310. Alternative 6 would result in an average annual increase in operating costs of $197,000 (0.3 percent) over the POR compared to Alternative 1 from lower river flows in the Middle Mississippi River following the spawning cue release. Over the POR, there would be negligible to very small differences in operating costs compared to Alternative 1 in most months, with on average less than a day more below a river stage of 0 compared to Alternative 1. However, in some fall months, there would be a large increase in operating costs following the spawning cue release, when System storage would be lower than under Alternative 1, resulting in lower river flows in the Middle Mississippi River. These lower flows would affect navigation operations requiring light loading and changes in the tow configuration, which would increase navigation operating costs.

The months that would be most affected are October (average monthly increase of $56,000) and November (average monthly increase of $98,000). These fall months would occur in the year of or year following a spawning cue release. During the 8 years with the largest increase in costs compared to Alternative 1, operating costs would increase by $1.8 million. The largest percent increase in operating costs would occur, as simulated, in 1964, with an increase in of $3.8 million (8.0 percent) compared to Alternative 1. A spawning cue release would be simulated to occur in 1963, resulting in lower System storage in the fall of the year following the release (1964) and lower river flows in the Middle Mississippi River. In November of 1964, there would be seven more days when river stages at the St. Louis gage would be below 0 when compared to Alternative 1, and five more days when river stages would be below −3 under Alternative 6 compared to Alternative 1.

Table 3-310. Number of Days, Affected Tonnage, and Operating Costs under Alternative 6 Compared to Alternative 1

Month	Total Number of Days over the POR with River Stages Below 0, Difference from Alternative 1	Average Monthly and Annual Tonnage Transported When River Stages are Below 0		Average Operating Costs for All Tonnage Transported	
		Change from Alternative 1 (tons)	Percent Change from Alternative 1	Change from Alternative 1 (FY 18 $)	Percent Change from Alternative 1
January	0	0	0.0%	$20,209	0.6%
February	0	0	0.0%	$2,875	0.1%
March	0	0	0.0%	$280	0.0%
April	−1	−3,513	−125.0%	−$1,442	−0.1%
May	0	0	0.0%	$0	0.0%
June	0	0	0.0%	$0	0.0%
July	0	0	0.0%	−$363	0.0%
August	2	9,121	8.4%	$2,984	0.1%
September	2	7,818	8.4%	$3,895	0.1%
October	17	56,016	50.9%	$90,994	2.4%
November	24	98,366	61.2%	$73,968	1.5%
December	4	14,957	8.7%	$11,567	0.2%
Change in Average Annual	**0.5**	**166,416**		**$197,028**	
Percent Change in Average Annual	**1.6%**	**11.2%**		**0.4%**	
Ave of 8 Largest Change Years	**5**	**1,630,431**		**$1,842,871**	
Ave of 8 Smallest Change Years	**0**	**−63,639**		**−$46,086**	

Note: Positive changes from Alternative 1 indicate more tonnage being transported when river stages are below 0 (adverse effect) and higher operating costs, while negative values indicated a reduction in affected tonnage being transported when river stages are below 0 (beneficial effect) and lower operating costs.

Conclusion

Alternative 6 would result in negligible to small adverse impacts to navigation on average ($197,028 or 0.4 percent) and in most years over the POR. However, in a small number of fall months in the years of or following the spawning cue release, there could be temporary and large adverse impacts to operating costs from lower river stages in the fall and winter months from reduced System storage following the release. Mechanical habitat construction would not impact navigation on the Middle Mississippi River. Impacts to navigation in the Middle Mississippi River would not be significant under Alternative 6 because in most years, there would be negligible to small impacts and any large impacts would be temporary.

3.24.5 Water Intakes

3.24.5.1 Affected Environment

Water is withdrawn from the Mississippi River for multiple purposes including municipal, industrial, and commercial water supply as well as for cooling purposes for power plants. There are four thermal power plants or generating stations and three permanent/fixed water supply intakes located along Middle Mississippi River between St. Louis, Missouri to Cairo, Illinois.

There is one power plant, one power-generating unit as part of an industrial facility, and one municipal water supply facility located in St. Louis. The Ameren Rush Island power plant is located south of St. Louis in Festus, Illinois. About 30 miles downstream of Festus, the City of Chester Municipal intake and water treatment plant is located in Illinois. The Grand Tower Energy Center is located in Wittenberg, Illinois about 20 miles downstream of Chester, Illinois. The southern-most facility is the City of Cape Girardeau water plant, although the primary sources for water supply for this facility are groundwater wells located near the Mississippi River. The city does maintain an intake on the Mississippi River for emergency purposes only.

Two of these power plants use conventional steam coal; one plant uses a mixture of coal, petroleum liquids, and natural gas-fired combustion; and the fourth plant is a natural gas-fired combined cycle plant. At least three of the thermal power plants in this river reach access Mississippi River water for once-through cooling. All of the power plants discharge wastewater into the river and have National Pollutant Discharge Elimination System (NPDES) permits that guide the effluent and temperature requirements based on state water quality standards. The thermal plants along the Middle Mississippi River have a nameplate capacity of 2,303 megawatts (MW).[26]

The water supply intakes using Mississippi River water as the primary source of water supply service a population of 164,382 (Illinois EPA 2016; Missouri Department of Natural Resources 2016b). Most municipalities located on the river have limited or no alternative sources of water other than the Mississippi River. The exception is the City of Cape Girardeau, which uses groundwater as the primary source of water. Table 3-311 summarizes the location, capacities, and population served for the power plants and water supply intakes located along the Middle Mississippi River. In addition, the critical thresholds from the Master Manual were used in the evaluation (USACE 1998, Appendix C).

[26] Nameplate capacity is the maximum rated output of a generator or power production equipment under specific conditions designated by the manufacturer (EIA 2016a).

Table 3-311. Thermal Plants and Water Supply Intakes along the Middle Mississippi River

Name	River Mile	County	State	Nameplate Capacity (MW)[a]	Cooling System[a]	Critical Threshold and Gage Referenced[d]
Middle Mississippi (St. Louis to Cairo): Thermal Power Facilities						
Anheuser Busch Inc.	177	St. Louis	Missouri	26	NA	NA
Ameren – Meramec	161	St. Louis	Missouri	1041	ON	−3 St. Louis
Ameren - Rush Island	140.5	Festus	Illinois	621	ON	−4.6 St. Louis
Mainline Generation LLC - Grand Tower Energy Center	81.9	Jackson	Illinois	641	ON	−6 Chester
Middle Mississippi (St. Louis to Cairo): Water Supply Facilities						
Name	**River Mile**	**County**	**State**	**Intake Type**	**Population Served[b,c]**	**Critical Threshold and Gage Referenced[d]**
Illinois American Water	180.8	St. Clair	Illinois	Municipal	155,382	−5 St. Louis
City of Chester Water Plant	110	Randolph	Illinois	Municipal Public	8,702	−10 (Chester) −8 (Chester)
City of Cape Girardeau Water Plant[e]	54	Cape Girardeau	Missouri	Municipal	38,800	−1 Cape Girardeau

Source:

a Report EIA-860 (2015) provides an estimate or nameplate capacity from 2014; ON – Once through cooling (without cooling system or pond(s))

b Illinois EPA Public Drinking Water (2016)

c Missouri Department of Natural Resources Public Water Supply (2016b);

d USACE Master Manual Volume 13 Mississippi River Studies (1998)

e The source of the City of Girardeau water is from groundwater wells. The City does maintain an intake on the Mississippi, which is for emergency purposes only.

3.24.5.2 Environmental Consequences

The impact analysis focuses on determining if changes in river conditions associated with each of the MRRMP-EIS alternatives could result in an impact to water supply intakes and thermal power plants along the Middle Mississippi River. This section summarizes the impact assessment methodology and presents the results of the assessment.

Impact Assessment Methodology

As river flows or stages fall below minimum operating requirements, water can no longer be accessed through intakes, resulting in adverse impacts to municipalities, commercial operations, and power plants. This in turn can drive changes in costs to operate intakes and replace power, and possibly affect capital costs to address water access issues. In addition, relatively lower river flows in the summer can affect operational efficiencies of power plants that use once through cooling and affect the ability of the plants to meet NPDES requirements.

The analysis used two approaches to describe the potential impacts to water supply facilities and power plants along the Middle Mississippi River. To assess the impacts of the facilities or plants when river stages fall below critical operating elevations, the river stage thresholds, shown in the right-hand column of Table 3-311, were used from the USACE Master Manual Mississippi River Studies Volume 13 (USACE 1998, Appendix C) for the three gage locations (St. Louis, Cape Girardeau, and Chester). The analysis used these critical stages along with the outputs from the HEC-RAS Missouri River models of simulated river flows at the confluence of the Missouri and Mississippi Rivers in St. Louis at river mile 180. Because only data for the St. Louis gage on the Mississippi River was available from the HEC RAS model, input from the USACE St. Louis district was used to estimate how the critical stages at Chester could be evaluated with stages at the St. Louis gage (Duncan pers. comm. 2016). The City of Cape Girardeau was not evaluated because it uses ground water as its primary source of water.

Based on expert input from the St. Louis District, a Low Water Reference Plane method was used to estimate the critical stage levels that would occur at the Chester gage of −6 (critical threshold at Grand Tower Energy Center). The Low Water Reference Plane method uses the low water stages at St. Louis and compares them with the Chester gage to estimate the river flow and stage that would translate to the critical threshold at the Chester gage. A threshold of −6 at Chester would be associated with a stage of −8.8 at the St. Louis gage using the Low Water Reference Plane method. Since this stage threshold was very low, an additional method using rating curves was also used. A stage value of −6 on the Chester gage equates to a flow of 38 kcfs, which is associated with a river stage at St. Louis of −7.15. Since this stage is higher (a more conservative threshold) than −8.8, it was used as the critical threshold at Chester (for the Grand Tower Energy Plant). Because river stages would not fall below −7.4 at the St. Louis gage, there would not be impacts to the City of Chester Water Plant across any of the alternatives.

Output from the HEC-RAS model at St. Louis was used to estimate impacts on intakes located in St. Louis and Chester. The project team used the threshold stages to estimate the number of days when water surface levels in the Middle Mississippi River would fall below critical intake operating thresholds under each of the alternatives. This analysis was the basis for the impact analysis provided below.

In addition, power plants can also be affected by river temperature with higher temperatures during the peak summer months causing reduced operating efficiencies and difficulties in meeting NPDES permit requirements. As a result, power plants may need to reduce their power generation. Because a river temperature model is not available for the Mississippi River, the evaluation uses the river flow data in the summer at St. Louis under the MRRMP-EIS alternatives, the river temperature differences under the MRRMP-EIS alternatives in the lower Missouri River, and the temperature impacts to plants on the lower Missouri River to qualitatively evaluate the potential impacts to the Middle Mississippi River plants associated with possibly higher river temperatures under the MRRMP-EIS alternatives.

Summary of Environmental Consequences

The environmental consequences relative to water supply and thermal power are summarized in Table 3-312.

Table 3-312. Environmental Consequences Relative to Water Supply and Thermal Power

Alternative	Impacts to Water Intakes
Management Actions Common to All Alternatives	No Impacts as management actions would not result in any changes in flow.
Alternative 1	Small to negligible temporary adverse impacts from river stages falling below critical thresholds; however, management actions (spring plenary pulse) would not contribute to these adverse effects.
Alternative 2	Relatively small to negligible and temporary adverse impacts to water intakes from a very small increase in days below critical thresholds compared to Alternative 1. Small temporary adverse effects to power plants could occur from river temperatures during low summer flow events.
Alternative 3	No to negligible impacts to water intakes compared to Alternative 1 from minor change in flows and river temperatures. No impacts to power plants from river temperatures are anticipated because of the small to negligible change in flows during the summer period compared to Alternative 1.
Alternative 3: Gavins Point One-Time Spawning Cue Test	Temporary adverse impacts could occur in the years following the one-time spawning cue test from river stages falling below critical thresholds usually in the fall and winter; no impacts to power plants from river temperatures are anticipated because of the small to negligible change in flows during the summer period compared to Alternative 1.
Alternative 4	Small to negligible temporary adverse impacts from river stages falling below critical thresholds compared to Alternative 1. No impacts to power plants from river temperatures are anticipated because of the small to negligible change in flows during the summer period compared to Alternative 1.
Alternative 5	No to negligible impacts to water intakes compared to Alternative 1 from minor change in flows and river temperatures. No impacts to power plants from river temperatures are anticipated because of the small to negligible change in flows during the summer period compared to Alternative 1.
Alternative 6	Small to negligible temporary adverse impacts from river stages falling below critical thresholds compared to Alternative 1. No impacts to power plants from river temperatures are anticipated because of the small to negligible change in flows during the summer period compared to Alternative 1.

Impacts from Management Actions Common to All Alternatives

Management actions common to all alternatives include pallid sturgeon propagation and augmentation, predator management, vegetative management, human restrictions measures. These actions occur on the Missouri River and do not impact stage; thus, they are not expected to have any impacts on water intakes along the Mississippi River.

Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. Impacts of Alternative 1 to the critical thresholds to water supply and thermal power plants are summarized in Table 3-313. These facilities would realize between 320 and 840 days over the period of record and 0 and 10 days on average when water surface elevations are below critical operating thresholds. This represents a relatively small percentage of time (1 to 3 percent) when intakes would be impacted under Alternative 1. Lowest river flows and stages usually occur in the fall and winter seasons, with small, temporary adverse impacts to water supply intakes and thermal power generation. However, the spring plenary pulse under

Alternative 1 would have negligible contribution to these impacts because it is largely attenuated when it reaches the Mississippi River.

Table 3-313. Impacts of Alternative 1 on Water Supply and Thermal Power Intakes

Facility	Critical Threshold	Total Number of Days Below Threshold over Period of Record	Average Annual Number of Days Below Threshold	Percentage of Days Below Thresholds
Facility 1 (St. Louis)	−5	324	4.0	1.1%
Power Plant 1 (St. Louis)	−4.6	429	5.2	1.4%
Power Plant 2 (St. Louis)	−3	835	10.2	2.8%
Power Plant (Chester)	−7.15	1	0.0	0.0%

The thermal power evaluation (Section 3.17) for the Missouri River power plants indicates that power generation would be reduced under Alternative 1 for the lower Missouri River plants with some of the impacts occurring to the plants in the summer peak power period during drought conditions. On average, the river flows in the Mississippi are two to three times higher than in the lower Missouri River. Under Alternative 1, the impacts to Missouri River water power plants could be temporary, large, and adverse during drought or relatively drier conditions; however, the spring plenary pulse would have a negligible contribution to these impacts. It is possible that there would be small, temporary adverse impacts to Mississippi River plants associated with reduced power generation from higher temperatures under Alternative 1, which are likely to occur during drought conditions when there are relatively lower river flows and higher ambient air temperatures. The spring plenary pulse would not noticeably affect river temperatures in the Mississippi River under Alternative 1 because lower river flows after the pulse is implemented as the reservoir System re-balance would be in the fall and winter when river temperatures do not affect power plants.

Conclusion

Alternative 1 represents the continuation of current System operation on the Missouri River. Impacts to the Mississippi River intakes would occur a relatively small percentage of time (1 to 3 percent) and would be temporary. These impacts are considered to be a result of natural hydrologic variability in the System rather than from the spring plenary pulse that is part of Alternative 1 because the pulse is almost entirely attenuated by the St. Louis gage. The spring plenary pulse would not noticeably affect river temperatures in the Mississippi River under Alternative 1 because lower river flows after the pulse is implemented as the reservoir System re-balance would be in the fall and winter when river temperatures do not affect power plants. Impacts to water intakes in the Middle Mississippi River would not be significant under Alternative 1.

Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

The management actions under Alternative 2 would result in relatively small and temporary adverse impacts, with up to 11 more days below the critical threshold compared to Alternative 1 over the period of record (Table 3-314). These low flows as simulated under Alternative 2 in the POR would occur in years that reflect the 1930s during drought years when river stages in St. Louis and Chester were affected in the fall season. Although Alternative 2 shows adverse impacts, these impacts would be relatively small and temporary, in the year of or years following the spawning cue release.

Table 3-314. Impacts of Alternative 2 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in St. Louis

Facility	Critical Threshold	Difference in Number of days Over POR Below Threshold from Alternative 1	Difference in Average Annual Number of days Below Threshold from Alternative 1	Percentage Change from Alternative 1
Facility 1 (St. Louis)	−5	8	0.1	2.5%
Power Plant 1 (St. Louis)	−4.6	7	0.1	1.6%
Power Plant 2 (St. Louis)	−3	11	0.1	1.3%
Power Plant (Chester)	−7.15	3	0.0	300%

Under Alternative 2, the low summer flow as simulated in the ERDC temperature model in 2002 and 2003 in the lower Missouri River (river mile 57) could result in river temperatures up to 2°F higher than under Alternative 1 during peak summer river temperatures.[27] The thermal power evaluation for the Missouri River power plants under Alternative 2 shows that power generation would be reduced for the lower Missouri River plants during the low summer flow events due to relatively higher river temperatures, resulting in relatively large adverse impacts to thermal power compared to Alternative 1 during these events. The relatively lower flows during the higher temperature summer periods in the Missouri River may have some adverse impacts to Mississippi River temperatures, resulting in reduced operational efficiencies for the plants along the Mississippi River. However, the impacts from river temperatures in the summer are likely to be small because the Mississippi River has considerably more water volume than the Missouri River which will assimilate the temperature.

Conclusion

Alternative 2 has the potential to have negligible to small adverse impacts to water intakes in the Middle Mississippi River when compared to Alternative 1 from an increase in the number of days below critical thresholds, with 3–11 more days over the POR for all of the evaluated facilities compared to Alternative 1. If water temperatures are affected in the Middle Mississippi River during low summer flow events, power plants could be affected through reduced operational efficiencies and possibly power generation. It is not anticipated that these impacts to water intakes would be significant under Alternative 2.

Alternative 3 – Mechanical Construction Only

Alternative 3 would have negligible to no impacts to water supply facilities or power plant in the Middle Mississippi River; the impacts of Alternative 3 are shown in Table 3-315. The elimination of the spring plenary pulse under Alternative 3 would have a small increase in days at one plant in St. Louis. River temperatures are not anticipated to be affected under Alternative 3 compared to Alternative 1 because of the minor change flows.

[27] As part of the effort for the MRRMP-EIS, ERDC conducted a water temperature model for the Missouri River (USACE ERDC 2017). It is available as a technical report as supplemental information for the Final EIS and online at missourirecovery.org.

Table 3-315. Impacts of Alternative 3 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in Middle Mississippi River

Facility	Critical Threshold	Difference in Number of days over the POR below critical thresholds from Alternative 1	Difference in Average Annual Number of days below critical thresholds from Alternative 1	Percentage Change from Alternative 1
Facility 1 (St. Louis)	−5	0	0.0	0.0%
Power Plant 1 (St. Louis)	−4.6	0	0.0	0.0%
Power Plant 2 (St. Louis)	−3	−1	0.0	−0.1%
Power Plant (Chester)	−7.15	0	0.0	0.0%

Gavins Point One-Time Spawning Cue Test

Temporary adverse impacts could occur in the years following the one-time spawning cue test from river stages falling below critical thresholds usually in the fall and winter; however, it is likely the number of days that the intakes would be affected would be very small. No impacts to river temperatures are anticipated in the summer months because of the small change in river flows during this season.

Conclusion

Alternative 3 would result in negligible to no impacts to water intakes in the Middle Mississippi River because of the small change in river flows; impacts are not anticipated to be significant.

Alternative 4 – Spring ESH Creating Release

Small adverse impacts would occur under Alternative 4 with up to 17 more days below the critical threshold at the power plant in St. Louis over the period of record compared to Alternative 1, with less than a change in one day on average annually, as shown in Table 3-316. Alternative 4 would result in negligible impacts to power plants because water temperatures in the Middle Mississippi River would not be noticeable during the summer period because of the small change in river flows.

Table 3-316. Impacts of Alternative 4 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in Middle Mississippi River

Facility	Critical Threshold	Difference in Number of Days below Thresholds over the POR from Alternative 1	Difference in number of days below critical thresholds over the POR from Alternative 1	Percentage Change from Alternative 1
Facility 1 (St. Louis)	−5	10	0.1	3.1%
Power Plant 1 (St. Louis)	−4.6	11	0.1	2.6%
Power Plant 2 (St. Louis)	−3	17	0.2	2.0%
Power Plant (Chester)	−7.15	0	0.0	0.0%

Conclusion

Temporary adverse impacts could occur under Alternative 4 relative to Alternative 1 from river stages falling below critical thresholds. The percent changes in number of days below critical thresholds from Alternative 1 is small (−0 to 3 percent) for all of the evaluated facilities. No impacts to river temperatures in the summer are anticipated. Impacts to water intakes in the Middle Mississippi River would not be significant under Alternative 4.

Alternative 5 – Fall ESH Creating Release

Alternative 5 would have negligible to no impacts to water supply facilities or power plants in the Middle Mississippi River, as shown in Table 3-317. Alternative 5 would result in negligible impacts to power plants because water temperatures in the Middle Mississippi River would not be noticeable during the summer period because of the small change in river flows.

Table 3-317. Impacts of Alternative 5 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in Middle Mississippi River

Facility	Critical Threshold	Difference in Number of Days below Thresholds over the POR from Alternative 1	Difference in Average Annual Number of Days below Thresholds from Alternative 1	Percentage Change from Alternative 1
Facility 1 (St. Louis)	−5	0	0	0.0%
Power Plant 1 (St. Louis)	−4.6	0	0	0.0%
Power Plant 2 (St. Louis)	−3	−1	0	−0.1%
Power Plant (Chester)	−7.15	0	0	0.0%

Conclusion

Alternative 5 would result in negligible or no impacts relative to Alternative 1 from river stages falling below critical thresholds. No impacts to river temperatures in the summer are anticipated. Impacts to water intakes in the Middle Mississippi River are not anticipated to be significant.

Alternative 6 – Pallid Sturgeon Spawning Cue

Small adverse impacts would occur under Alternative 6 with up to 17 more days below the critical threshold at the power plant in St. Louis over the period of record compared to Alternative 1, with less than a change in one day on average annually (Table 3-318). The number of days below critical thresholds for the power plant in Chester would be 4 days under Alternative 6 and one day under Alternative 1 over the period of record, with a large percent increase but very low number of affected days. Alternative 6 would result in negligible impacts to power plants because water temperatures in the Middle Mississippi River would not be noticeable during the summer period because of the small change in river flows.

Table 3-318. Impacts of Alternative 6 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in Middle Mississippi River

Facility	Critical Threshold	Difference in Number of Days below Thresholds over the POR from Alternative 1	Difference in Average Annual Number of Days below Thresholds from Alternative 1	Percentage Change from Alternative 1
Facility 1 (St. Louis)	−5	11	0.1	3.4%
Power Plant 1 (St. Louis)	−4.6	12	0.1	2.8%
Power Plant 2 (St. Louis)	−3	17	0.2	2.0%
Power Plant (Chester)	−7.15	3	0.0	300.0%

Conclusion

Temporary adverse impacts could occur under Alternative 6 relative to Alternative 1 from river stages falling below critical thresholds. Negligible changes in river temperatures would occur. Impacts to water intakes in the Middle Mississippi River are not anticipated to be significant under Alternative 6.

3.24.6 Climate Change

A discussion on the influence of climate change to alternative operations is included in Section 3.2 River Infrastructure under Climate Change. The northern plains are expected to experience changes similar to the Missouri River Basin with more rainfall and less snowpack accumulating during winter months resulting in earlier peaks in seasonal plains runoff patterns. As a result, the influence of climate change on the hydrology of the Mississippi River is expected to be similar to the impacts of the management actions described for the Missouri River. Annual rainfall amounts will increase during the summer months, but rainfall events will become sporadic. Large rain events will be more frequent and interspersed by longer relatively dry periods. Extremes in climate will likely magnify periods of wet or dry weather, resulting in longer, more severe droughts, and larger more extensive flooding. Increased air temperatures could also have impacts on water temperatures and water quality, which could exacerbate impacts of alternatives to the Middle Mississippi River.

Higher natural annual flows and a higher number of peak flow events could result in higher sediment erosion rates, an increase in adverse impacts (i.e., erosion, wear and tear from frequent overtopping, burial) on river infrastructure, and greater variability in groundwater elevations throughout the year in the floodplain and land adjacent to the Middle Mississippi River. More frequent and longer flow releases could result in an incremental increase in geomorphological adverse impacts and less frequent and shorter flow releases could result in an incremental decrease in geomorphological adverse impacts. Higher air temperatures and higher sporadic flood flows could also adversely affect ice dynamics, resulting in altered flooding patterns from ice dams.

It is anticipated that climate change could influence operation of both the Missouri River and Mississippi River in the future and potentially the timing and duration of side channel connectivity. During periods of low water, similar to those conditions modeled in the average monthly 10th percentile stages, side channels could remain disconnected from the main channel for the entire year or longer. If more intense storms cause high water or flooding, similar to those conditions modeled in the average monthly 90th percentile stage, side channels could become connected to the main channel and could be flowing much longer throughout the year. Both dry and wet periods could impact biological resources on the Middle Mississippi River by causing transitions from one habitat type to another. These impacts are dynamic and related to up-river operations and activities on the Mississippi River that are not accounted for in this modeling effort. Given the nature of side channels and that they are maximizing benefits when flowing, impacts could be exacerbated in the future if dry periods increase and stages dropped below the choke point and the side channel was not flowing. However, these impacts would result from changing patterns of climate rather than actions from the alternatives.

It is anticipated that climate change could influence the flows on the Middle Mississippi River by increasing the severity, length, and frequency of extreme flow events. Changes in these variables would impact the stage and frequency of water elevations potentially affecting water intakes and dropping below the critical water intake thresholds. Extended drought conditions from climate change could result in greater impacts to water intakes in times of very low water.

Overall, the influence of climate change is not expected to change conditions to the point that it would change impacts from the alternatives considered.

3.24.7 Cumulative Impacts Associated with all Alternatives

Past construction and operation of the Missouri River Mainstem System has affected the hydrology in the Middle Mississippi River because the Missouri River contributes almost half of the flow at its confluence with the Mississippi River (Meade and Moody 2010). Additionally, the Missouri River contributes approximately 75 to 95 percent of the suspended sediment load to the Middle Mississippi River (Davinroy 2006). Reduced suspended sediment in the Missouri River from construction of the Missouri River Mainstem dams has affected the sediment load to the Middle Mississippi River. In addition to past, present, and continuing effects on hydrology, the Mississippi River basin has been shaped over time by a variety of actions, including urbanization, agriculture, levee construction, and dam construction. Many of the changes in the Middle Mississippi River which have led to its current condition are due to improvements made for navigation including river training structure placement and associated changes sedimentation patterns. Navigation improvements to the Middle Mississippi River were achieved and maintained through the continuing Regulating Works Project. These alterations in hydrology, structure and condition have large past, present, and continuing effects on Middle Mississippi River resources and functions, such as flood-risk management, navigation, biological resources, and water supply intakes.

Individually, all six alternatives would have long term, negligible to small adverse impacts to the Middle Mississippi River from releases. When combined with past, present, and reasonably foreseeable future actions, the cumulative impacts are large; however, the contribution by any of the alternatives to these impacts in context of other actions would be small to negligible and not significant. These conditions would apply equally in year 0 and in year 15, since modeled flows and stages in the Mississippi River at St. Louis are near-identical for the two model years.

3.25 Regional Economic Effect of Program Expenditures

Program expenditures were used to evaluate the regional economic benefits of the MRRMP-EIS alternatives. Many types of MRRP program actions and activities associated with the MRRMP-EIS alternatives were included in the list of costs, including habitat construction; program management, integration, and coordination; MRRIC; among many others. Detailed costs categories can be found in Appendix F: Missouri River Recovery Management Plan-EIS Alternatives – Cost Estimates. This section describes the methodology and provides the results of the RED analysis of program expenditures for the MRRMP-EIS alternatives.

3.25.1.1 Regional Economic Development Impact Methodology

The analysis used the IMPLAN® Pro data and modeling system to estimate the change in regional economic activity (jobs, income, and sales) as a result of USACE spending on program expenditures. Program costs were grouped based on the time period in which they are anticipated to be incurred. Two periods were associated with the timing of the activities and associated costs: short-term program activities, incurred in years 1 to year 15; and long-term program activities, incurred in year 16 to year 50. Short-term costs include costs such as habitat construction and shallow water habitat refurbishment while long-term costs include program coordination, vegetation management, and propagation and augmentation costs, among other long-term costs.

The costs for each year over 50 years were obtained for each cost category, and annualized using the Fiscal Year 2018 federal interest rate of 2.75 percent. The cost categories were assigned to appropriate industry sectors in IMPLAN® Pro with information from Appendix F: Missouri River Recovery Management Plan-EIS Alternatives – Cost Estimates, “USACE Resource Guide for Work Activities and Spending Profiles for the Regional ECONomic System for Federal Spending Appendix” (USACE 2016i), and the Census Bureau North American Industry Classification System descriptions. USACE staff familiar with implementation of projects under MRRP identified two regions where spending was likely to occur: the upper river, including the states of Montana, North Dakota, and South Dakota; and the lower river, including Iowa, Missouri, Kansas, and Nebraska. To present the economic impacts of the program expenditures, the jobs and income supported in the short term are shown separately from the jobs and income supported in the long term. The regional economic benefits of the MRRMP-EIS alternatives are described below.

3.25.1.2 Summary of Environmental Consequences

Table 3-319 provides a summary of the RED environmental consequences for MRRP program expenditures and the MRRMP-EIS alternatives.

Table 3-319. RED Environmental Consequences for Program Expenditures

Alternative	RED Impacts
Alternative 1	Program expenditures would support 1,282 annual jobs and $70.5 million in labor income on average in the short term and 495 annual jobs and $28.0 million in the long term; vast majority of the regional benefits would be experienced in the lower river. These impacts would be small and beneficial in the context of the communities and counties in the lower river, but could be important in some rural areas.
Alternative 2	An increase of 1,951 annual jobs and $102.4 million in labor income in the short term and an increase of 666 annual jobs and $33.8 million in labor income in the long term; regional benefits would increase in the lower river and upper river relative to Alternative 1.

Alternative	RED Impacts
Alternative 3	A decrease of 577 annual jobs and $31.2 million in labor income in the short term and a decrease of 110 annual jobs and $5.9 million in labor income in the long term; regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.
Alternative 4	A decrease of 631 annual jobs and $33.8 million in labor income in the short term and a decrease of 164 annual jobs and $8.6 million in labor income in the long term; regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.
Alternative 5	A decrease of 617 annual jobs and $33.1 million in labor income in the short term and a decrease of 150 annual jobs and $7.9 million in labor income in the long term; regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.
Alternative 6	A decrease of 347 annual jobs and $18.6 million in labor income in the short term and a decrease of 151 annual jobs and $8.0 million in labor income in the long term; regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.

3.25.1.3 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Alternative 1 represents current System operations including a number of management actions associated with MRRP implementation. Management actions under Alternative 1 include construction of early life stage habitat for the pallid sturgeon and ESH. Total program expenditures over the 50-year program management period under this alternative would equal approximately $3.3 billion. Program expenditures for MRRP along with management actions under Alternative 1 would support 1,282 annual jobs in the short term and 495 jobs in the long term. The bulk of the jobs created under Alternative 1 would be supported by this spending in the lower river and are associated with activities that would occur in the short term, including construction of early life stage habitat for pallid sturgeon (Table 3-320). The main types of jobs supported by these program expenditures include habitat construction and maintenance, vegetation management, environmental research and scientific activities and consulting, and federal government jobs. During the short term, annual labor income would be approximately $70.5 million; and in the long term, annual labor income would be about $28.1 million. Alternative 1 would result in small, long term, beneficial impacts to regional economic conditions in the large economic context of the cities and communities along the river, especially in the lower river. In smaller rural communities, these impacts could be notable.

Table 3-320. Annual Economic Benefits of Program Expenditures – Alternative 1

Impact Type	Expenditure Period	Upper River	Lower River	Total
Direct, Indirect and Induced Jobs	Short term (years 1–15)	123	1,159	1,282
	Long term (years 16–50)	93	402	495
Direct, Indirect, and Induced Labor Income	Short term (years 1–15)	$7,650,000	$62,836,000	$70,486,000
	Long term (years 16–50)	$5,906,000	$22,154,000	$28,060,000
Direct, Indirect, and Induced Sales	Short term (years 1–15)	$14,774,000	$147,171,000	$161,945,000
	Long term (years 16–50)	$11,509,000	$50,374,000	$61,883,000

3.25.1.4 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under an adaptive management plan. Actions in this alternative include a spawning cue release, low summer flow, and the construction of considerably more ESH and early life stage habitat for pallid sturgeon than under Alternative 1.

Under Alternative 2, the largest increases in total program expenditures over the entire 50-year program management period (relative to Alternative 1) include construction projects for early life stage habitat for pallid sturgeon and mechanical ESH construction, which would increase by $1.9 billion and $4.3 billion, respectively. Total program expenditures over the 50-year period under this alternative would equal approximately $11.5 billion, an increase of approximately 350 percent compared to Alternative 1. Program expenditures under Alternative 2 would support 3,234 jobs annually during the short term, and 1,161 jobs in the long term, with most of the jobs supported in the lower river (Table 3-321). Under Alternative 2, the total number of jobs supported annually in the short term would increase by 1,951, relative to Alternative 1, while the number of jobs supported in the long term would increase by 666 annually relative to Alternative 1. Additional jobs under Alternative 2 would be primarily habitat construction and maintenance jobs as Alternative 2 would require more funding for ESH and early life stage habitat construction relative to Alternative 1. Annual labor income and sales would also experience considerable increases compared to Alternative 1.

Table 3-321. Annual Economic Benefits of Program Expenditures – Alternative 2

Impact Type	Expenditure Period	Impact	Upper River	Lower River	Total
Direct, Indirect, and Induced Jobs	Short term (years 1–15)	Annual Impact	351	2,882	3,234
		Change in annual impact relative to Alternative 1	228	1,723	1,951
	Long term (years 16–50)	Annual Impact	322	840	1,161
		Change in annual impact relative to Alternative 1	228	438	666
Direct, Indirect, and Induced Labor Income	Short term (years 1–15)	Annual Impact	$18,914,000	$153,980,000	$172,894,000
		Change in annual impact relative to Alternative 1	$11,264,000	$91,144,000	$102,408,000
	Long term (years 16–50)	Annual Impact	$17,170,000	$44,700,000	$61,870,000
		Change in annual impact relative to Alternative 1	$11,264,000	$22,546,000	$33,810,000
Direct, Indirect, and Induced Sales	Short term (years 1–15)	Annual Impact	$43,939,000	$370,335,000	$414,274,000
		Change in annual impact relative to Alternative 1	$29,165,000	$223,164,000	$252,329,000
	Long term (years 16–50)	Annual Impact	$40,674,000	$106,250,000	$146,924,000
		Change in annual impact relative to Alternative 1	$29,165,000	$55,876,000	$85,041,000

3.25.1.5 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include the construction of ESH and early life stage habitat for pallid sturgeon through mechanical means. Additional acres of ESH would be constructed annually, in years when constructed, in the Garrison, Fort Randall, and Gavins Point reaches compared to Alternative 1. Early life stage habitat for pallid sturgeon would be constructed in the riverine areas between Ponca, Nebraska, and the mouth of the river near St. Louis. In addition, a one-time spawning cue test may be implemented.

The largest change in total program expenditures (over the entire 50-year program management period), relative to Alternative 1, would be reductions in costs for construction of early life stage habitat for the pallid sturgeon of approximately $800 million, and over $125 million in additional expenditures for mechanical ESH construction. Total expenditures over the 50-year period under this alternative would equal approximately $1.8 billion, a decrease of approximately 56 percent relative to Alternative 1. Under Alternative 3, the number of annual jobs supported in the short term would decrease by 577 relative to Alternative 1. In the long term, the number of jobs supported annually would decrease by 110 relative to Alternative 1 (Table 3-322). Labor income and sales follow the same pattern, with decreases in the short term and long term relative to Alternative 1. The types of jobs supported under Alternative 3 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and increase in the upper river relative to Alternative 1.

Table 3-322. Annual Economic Benefits of Program Expenditures – Alternative 3

Impact Type	Expenditure Period	Scenario	Upper River	Lower River	Total
Direct, Indirect, and Induced Jobs	Short term (years 1–15)	Annual Impact	147	558	706
		Change in annual impact relative to Alternative 1	24	−601	−577
	Long term (years 16–50)	Annual Impact	98	287	386
		Change in annual impact relative to Alternative 1	5	−115	−110
Direct, Indirect, and Induced Labor Income	Short term (years 1–15)	Annual Impact	$8,782,000	$30,548,000	$39,330,000
		Change in annual impact relative to Alternative 1	$1,132,000	−$32,288,000	−$31,156,000
	Long term (years 16–50)	Annual Impact	$6,113,000	$16,001,000	$22,114,000
		Change in annual impact relative to Alternative 1	$207,000	−$6,153,000	−$5,946,000
Direct, Indirect, and Induced Sales	Short term (years 1–15)	Annual Impact	$17,923,000	$69,355,000	$87,278,000
		Change in annual impact relative to Alternative 1	$3,149,000	−$77,816,000	−$74,667,000
	Long term (years 16–50)	Annual Impact	$12,168,000	$35,727,000	$47,895,000
		Change in annual impact relative to Alternative 1	$659,000	−$14,647,000	−$13,988,000

3.25.1.6 Alternative 4 – Spring ESH Creating Release

Management actions under Alternative 4 would include the construction of ESH and early life stage habitat for pallid sturgeon. Early life stage habitat for pallid sturgeon would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. ESH habitat would be constructed annually, in years when construction is needed, in the Garrison, Fort Randall, and Gavins Point reaches. In addition, a spring release would be implemented to create ESH habitat.

The largest change in total program expenditures (over the entire 50-year program management period), relative to Alternative 1, would be reductions in costs for construction of early life stage habitat for the pallid sturgeon of approximately $800 million, and a reduction of more than $70 million in spending for mechanical ESH construction. Total expenditures over the 50-year period under this alternative would equal approximately $1.6 billion, a decrease of approximately 50 percent relative to Alternative 1. Relative to Alternative 1, Alternative 4 would result in 631 fewer annual jobs in the short term, while in the long term, there would be 164 fewer annual jobs (Table 3-323). Annual labor income and sales would also be lower in the short and long term, relative to Alternative 1. The types of jobs supported under Alternative 4 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and the upper river relative to Alternative 1.

Table 3-323. Annual Economic Benefits of Program Expenditures – Alternative 4

Impact Type	Expenditure Period	Scenario	Upper River	Lower River	Total
Direct, Indirect, and Induced Jobs	Short term (years 1–15)	Annual Impact	117	535	652
		Change in annual impact relative to Alternative 1	−6	−624	−631
	Long term (years 16–50)	Annual Impact	68	264	332
		Change in annual impact relative to Alternative 1	−26	−138	−164
Direct, Indirect, and Induced Labor Income	Short term (years 1–15)	Annual Impact	$7,291,000	$29,383,000	$36,674,000
		Change in annual impact relative to Alternative 1	−$359,000	−$33,453,000	−$33,812,000
	Long term (years 16–50)	Annual Impact	$4,622,000	$14,836,000	$19,458,000
		Change in annual impact relative to Alternative 1	−$1,284,000	−$7,318,000	−$8,602,000
Direct, Indirect, and Induced Sales	Short term (years 1–15)	Annual Impact	$14,063,000	$66,334,000	$80,397,000
		Change in annual impact relative to Alternative 1	−$711,000	−$80,837,000	−$81,548,000
	Long term (years 16–50)	Annual Impact	$8,308,000	$32,706,000	$41,014,000
		Change in annual impact relative to Alternative 1	−$3,201,000	−$17,668,000	−$20,869,000

3.25.1.7 Alternative 5 – Fall ESH Creating Release

Management actions under Alternative 5 would include the construction of ESH and early life stage habitat for pallid sturgeon. Early life stage habitat for pallid sturgeon would be constructed in the riverine areas between Ponca and the mouth of the river near St. Louis, and ESH habitat would be constructed annually, when construction is needed, in the Garrison, Fort Randall, and Gavins Point reaches. Alternative 5 would also include a fall release to create ESH.

The largest change in project expenditures (over the entire 50-year program management period), relative to Alternative 1, would be reductions in costs for construction of early life stage habitat for the pallid sturgeon of approximately $800 million, and a reduction of $24 million in spending for mechanical ESH construction. Total expenditures over 50 years under this alternative would equal approximately $1.7 billion, a decrease of approximately 51 percent relative to Alternative 1. Under Alternative 5, annual jobs supported in the short term would decrease by 617, relative to Alternative 1, while the number of jobs supported in the long term would decrease by 150 annually relative to Alternative 1 (Table 3-324). Annual labor income and sales would also decrease relative to Alternative 1 in the short and long term. The types of jobs supported under Alternative 5 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and the upper river relative to Alternative 1.

Table 3-324. Annual Economic Benefits of Program Expenditures – Alternative 5

Impact Type	Expenditure Period	Scenario	Upper River	Lower River	Total
Direct, Indirect, and Induced Jobs	Short term (years 1–15)	Annual Impact	125	541	665
		Change in annual impact relative to Alternative 1	1	−618	−617
	Long term (years 16–50)	Annual Impact	76	270	345
		Change in annual impact relative to Alternative 1	−18	−132	−150
Direct, Indirect, and Induced Labor Income	Short term (years 1–15)	Annual Impact	$7,667,000	$29,676,000	$37,343,000
		Change in annual impact relative to Alternative 1	$17,000	−$33,160,000	−$33,143,000
	Long term (years 16–50)	Annual Impact	$4,998,000	$15,129,000	$20,127,000
		Change in annual impact relative to Alternative 1	−$908,000	−$7,025,000	−$7,933,000
Direct, Indirect, and Induced Sales	Short term (years 1–15)	Annual Impact	$15,034,000	$67,095,000	$82,129,000
		Change in annual impact relative to Alternative 1	$260,000	−$80,076,000	−$79,816,000
	Long term (years 16–50)	Annual Impact	$9,279,000	$33,467,000	$42,746,000
		Change in annual impact relative to Alternative 1	−$2,230,000	−$16,907,000	−$19,137,000

3.25.1.8 Alternative 6 – Pallid Sturgeon Spawning Cue

Management actions under Alternative 6 would include the construction of ESH and early life stage habitat for pallid sturgeon through mechanical means. Construction of early life stage habitat for pallid sturgeon would be focused in the riverine areas between Ponca and the mouth of the river near St. Louis. Additional ESH habitat would be constructed annually, in years when constructed, in the Garrison, Fort Randall, and Gavins Point reaches. A bi-modal spawning cue release would also occur in the spring for the pallid sturgeon.

The largest change in total project expenditures (over the entire 50-year program management period) relative to Alternative 1 would be reductions in costs for construction of early life stage habitat for the pallid sturgeon of approximately $800 million, and approximately $26 million in reductions in spending for mechanical ESH construction. Total expenditures over the entire 50-year period under this alternative would equal approximately $1.7 billion, a decrease of approximately 51 percent relative to Alternative 1. Under Alternative 6, the number of jobs supported annually in the short term would decrease by 347, relative to Alternative 1, while the number of jobs supported in the long term would decrease by 151 annually relative to Alternative 1 (Table 3-325). Annual labor income and sales would also experience a decrease in the short and long term, relative to Alternative 1. The types of jobs supported under Alternative 6 would be similar to those described under Alternative 1. Regional benefits would decrease in the lower river and the upper river relative to Alternative 1.

Table 3-325. Annual Economic Benefits of Program Expenditures – Alternative 6

Impact Type	Expenditure Period	Scenario	Upper River	Lower River	Total
Direct, Indirect, and Induced Jobs	Short term (year 1–15)	Annual Impact	124	811	935
		Change in annual impact relative to Alternative 1	1	−348	−347
	Long term (year 16–50)	Annual Impact	75	269	345
		Change in annual impact relative to Alternative 1	−18	−133	−151
Direct, Indirect, and Induced Labor Income	Short term (year 1–15)	Annual Impact	$7,646,000	$44,208,000	$51,854,000
		Change in annual impact relative to Alternative 1	−$4,000	−$18,628,000	−$18,632,000
	Long term (year 16–50)	Annual Impact	$4,977,000	$15,114,000	$20,091,000
		Change in annual impact relative to Alternative 1	−$929,000	−$7,040,000	−$7,969,000
Direct, Indirect, and Induced Sales	Short term (year 1–15)	Annual Impact	$14,982,000	$100,682,000	$115,664,000
		Change in annual impact relative to Alternative 1	$208,000	−$46,489,000	−$46,281,000
	Long term (year 16–50)	Annual Impact	$9,227,000	$33,426,000	$42,653,000
		Change in annual impact relative to Alternative 1	−$2,282,000	−$16,948,000	-$19,230,000

3.26 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those impacts that cannot be avoided or fully mitigated should the alternatives be implemented. Although many adverse impacts could be avoided, minimized, or mitigated by the measures described under each resource topic, Table 3-326 describes those types of impacts which may not be fully avoided, as required by CEQ regulations (40 CFR 1502.16). Location and intensity of unavoidable impacts would vary by alternative. Full descriptions of impacts are provided under each resource topic previously in this chapter. Most unavoidable adverse impacts that would occur from implementing the preferred alternative would be short-term in nature and restricted to habitat treatment and construction periods. USACE would take steps to minimize the adverse impacts, but certain disturbances associated with the construction would still occur (e.g., temporary fish and wildlife avoidance of active treatment and construction areas). Overall these types of unavoidable impacts will be negligible to small in magnitude. Changes in river flows associated with any of the alternatives that propose reservoir releases would have somewhat larger impacts that would occur over a longer period. It is unlikely that all impacts could be avoided, however, USACE would carefully consider precipitation forecasts and resulting downstream tributary inflow in order to plan releases to avoid flooding potential downstream. As described in Chapter 5 of the Adaptive Management Plan, USACE would engage in assessing any site-specific human consideration concerns at proposed future sites including monitoring of impacts to seek to minimize those that are adverse.

Table 3-326. Unavoidable Adverse Impacts to Resources

Resource	Unavoidable Adverse Impacts
River Infrastructure and Hydrologic Processes	Channel reconfiguration could result in alteration of geomorphological processes (degradation and bank erosion and ice dynamics) and groundwater elevations at various localized river locations, depending on the selected alternative. Alternatives 2, 4, 5 and 6 would cause changes in reservoir levels, shoreline erosion and degradation and aggradation in inter-reservoir reaches from ESH creating releases or spawning cue flows.
Pallid Sturgeon	Habitat construction would result in temporary displacement of, or disturbance to, pallid sturgeon that would be common to all alternatives.
Piping Plover and Least Tern	Alternatives that included a spring flow release could impact nesting plovers and terns below the reservoirs although these impacts would be minimized through coordination between USACE and USFWS and use of steady-release, flow-to-target.
Fish and Wildlife Habitat	Management actions associated with mechanical ESH construction and construction of early life stage habitat for pallid sturgeon or vegetation and predator management may temporarily disturb or displace wildlife during construction. Predator management, if lethal, would remove individuals from a local species population.
Other Special-Status Species	Management actions associated with ESH construction and construction of early life stage habitat for pallid sturgeon may temporarily disturb or displace some special status species during construction.

Resource	Unavoidable Adverse Impacts
Water Quality	ESH construction and construction of early life stage habitat for pallid sturgeon would result in temporary increases in turbidity and mobilization of nutrients and pollutants for all alternatives with Alternative 2 having the most localized impacts given the amount of ESH created. Changes in river flow, channel form, or river stage under Alternatives 2, 4, 5, and 6 could result in short-term adverse impacts to water quality including increases in turbidity, mobilization of nutrients and pollutants, changes in dissolved oxygen concentration, or changes in water temperature.
Air Quality	Emissions from vehicles and equipment would result in short-term localized adverse impacts on air quality during mechanical ESH construction and construction of early life stage habitat for pallid sturgeon. Alternative 2 would likely have the highest impacts as it would construct the most habitat.
Cultural Resources	Cultural resources located along reservoirs and river banks would be at risk of adverse impacts due to erosion, vandalism, or looting, depending on water levels under all the alternatives. ESH construction and construction of early life stage habitat for pallid sturgeon could result in adverse impacts to cultural resources if inadvertently disturbed during construction activities.
Land Ownership	Federal land acquisitions could result in loss of jobs, labor income, and property tax revenue. Alternative 2 would have the largest adverse impacts to jobs, labor income, and property taxes given the large amount of land proposed for acquisition.
Commercial Sand and Gravel Dredging	Changes in flow regime and sediment conditions, due to construction of early life stage habitat for pallid sturgeon, would result in negligible adverse impacts to commercial sand and gravel dredging. However, there is no perceived difference among alternatives.
Flood Risk Management and Interior Drainage	Changes in river flow or river stage could result in adverse impacts for flood risk management, especially for Alternative 6, which would have increase in annual costs for flood risk management compared to Alternative 1. Changes in flow regime could result in adverse impacts to jobs and labor income under Alternative 6. Changes in river flow or river stage could result in adverse impacts for interior drainage, though the differences from Alternative 1 would be minimal. Changes in river flow under Alternatives 2, 4, 5, and 6 would increase the days of channel capacity exceedance in the Fort Randall and Garrison reaches.
Hydropower	Changes in river flows, water elevations, and reservoir System storage under the Alternatives 2, 4, 5 and 6 could result in adverse impacts to hydropower production and reduced revenue generation. Alternative 4 would have the highest decrease in revenue. Replacement of hydropower with thermal power would result in adverse impacts to greenhouse gas emissions, with the highest contributions of greenhouse gas emissions from Alternative 4.
Irrigation	Changes in river flows and reservoir elevations from flow changes may result in adverse impacts to irrigation if intakes become inoperable if they are not submerged. Decreases in average annual net income would be largest for Alternative 6. Loss of irrigation water supply could result in loss of jobs and income in the agricultural sector with the largest decrease for Alternative 6.

Resource	Unavoidable Adverse Impacts
Navigation	Changes in river flows and river stage under the alternatives could adversely affect navigation service level, reliability, and season length. Reduced navigation opportunities would result in loss of jobs and income, especially Alternative 4, which would result in the largest decrease in jobs and average annual labor income.
Recreation	Mechanical construction of ESH habitat would result in temporary localized loss of recreational opportunities with Alternative 2 resulting in the largest impacts given the amount of ESH that would be created. Changes in river flows and reservoir elevations and associated changes in abundance of habitat classes could result in changes in quantity and quality of recreational experiences. There could be adverse effect in the upper three reservoirs due to releases under Alternatives 2, 4 and 6. Changes in visitation could result in reduced jobs and revenue in recreation and tourism industries, especially for Alternative 4 which could see a reduction of 21 jobs and $585,000 in labor income.
Thermal Power	Changes in river flows, reservoir conditions (including temperature) and river stages under the alternatives could result in reduced power generation, grid stability, and electrical reliability, which could result in increased retail electricity rates, especially in Alternative 2 which would result in the highest increases in costs and reductions in value.
Water Supply	Changes in water supply conditions could result in increased operation costs and water utility rates. These changes in costs would be small across Alternatives 2, 4, 5, and 6, with Alternative 4 having the highest change in costs.
Wastewater Facilities	Construction of early life stage habitat and ESH could result in small adverse impacts to wastewater facilities. Alternative 2 could have the largest impact compared to the other action alternatives given the amount of proposed habitat construction.
Tribal Resources	Altered abundance of terrestrial and aquatic habitat classes could result in small adverse impacts for subsistence hunting, fishing, or gathering opportunities, especially for Alternative 2, though there would be some level of unavoidable adverse effects from all alternatives.
Human Health and Safety	Management actions associated with each alternative would not create additional habitat for common vector mosquito species; thus, no unavoidable impacts would occur to human health and safety.
Environmental Justice	None of the alternatives are expected to result in unavoidable adverse impacts to environmental justice.
Ecosystem Services	Unavoidable adverse impacts to ecosystem services would only occur if the jeopardy avoidance objective is not met, resulting in reduced non-use values.
Mississippi River Impacts	Each of the alternatives, with the exception of Alternative 3, are expected to result in negligible to small adverse impacts to the Mississippi River as any releases would be largely attenuated before they reached the Mississippi River.
Regional Economic Effect of Program Expenditures	Alternatives 3–6 could result in adverse impacts to Regional Economic Effects of Program Expenditures in terms of decreases in jobs and labor income.

3.27 Relationship between Short-Term Uses and Long-Term Productivity

To facilitate comparison of the alternatives, NEPA requires that an EIS consider the proposed short-term uses of environmental resources compared with the long-term productivity of the environment. This section discusses whether the short-term uses of environmental resources proposed by the alternatives would impact, either adversely or beneficially, the long-term productivity of the environment.

Short-term uses of environmental resources necessary to carry out the action alternatives would include any actions associated with the construction of pallid sturgeon, least tern, or piping plover habitat either through flow actions or mechanical habitat construction. Impacts of these short-term uses are generally the same as the short-term impacts described for each resource in this EIS. These impacts would include disturbance or alteration of aquatic and terrestrial habitats, water quality impacts associated with increased turbidity, air quality impacts associated with emissions from construction equipment, disruptions to hydropower or thermal power operations, disruptions to water supplies and wastewater treatment facilities, temporary loss of recreational opportunities, and all associated economic impacts.

Productivity can be broadly grouped into three categories: ecosystem (biological) productivity, hydrologic productivity (water resources), and land use productivity. Overall, short-term uses of environmental resources necessary to carry out the action alternatives would benefit long-term productivity. Creation of habitat for pallid sturgeon, least terns, and piping plover would benefit these species. The acquisition of lands and management of habitats associated with the alternatives would benefit ecosystem productivity throughout the geographic scope of the EIS. Protection of acquired lands from future development or other land use practices would also benefit hydrologic productivity by preventing loss of wetlands and expansion of impervious cover. Water supply intakes could be impacted both adversely and beneficially over the long-term due to hydrologic changes associated with flow actions and channel reconfiguration under the alternatives. Agriculture is the dominant land use type within the Missouri River basin. Land acquisition associated with the alternatives may reduce agricultural production over the long term due to the development and management of wildlife habitat on lands that would otherwise be used for agriculture. Although there could be short-term decreases in hydrologic and land use productivity associated with human considerations, environmental productivity would be enhanced under all action alternatives.

3.28 Irreversible and Irretrievable Commitment of Resources

An irreversible or irretrievable commitment of resources refers to impacts on or losses to resources that cannot be recovered or reversed. Irreversible and irretrievable resource commitments associated with the alternatives would include the loss of funds, labor, energy (including by not limited to the burning of fossil fuels), and materials required to plan, conduct, and monitor various components of the proposed action. The acquisition of land would not represent an irreversible or irretrievable commitment of resources because the land could be returned to its previous use in the future. Similarly, alteration or conversion of habitat types resulting from flow actions or habitat construction would not represent an irreversible or irretrievable commitment of resources because these changes could potentially be reversed, allowing habitats to revert to their previous conditions. The use of water resources associated with flow actions under the alternatives would not represent an irreversible or irretrievable commitment of resources because it is assumed that water resources would be restored during the winter months as part of the annual precipitation cycle. In the event of drought conditions, it may take several years for water resources to be restored.

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Chapter 4 Implementation of the Preferred Alternative under the Science and Adaptive Management Plan

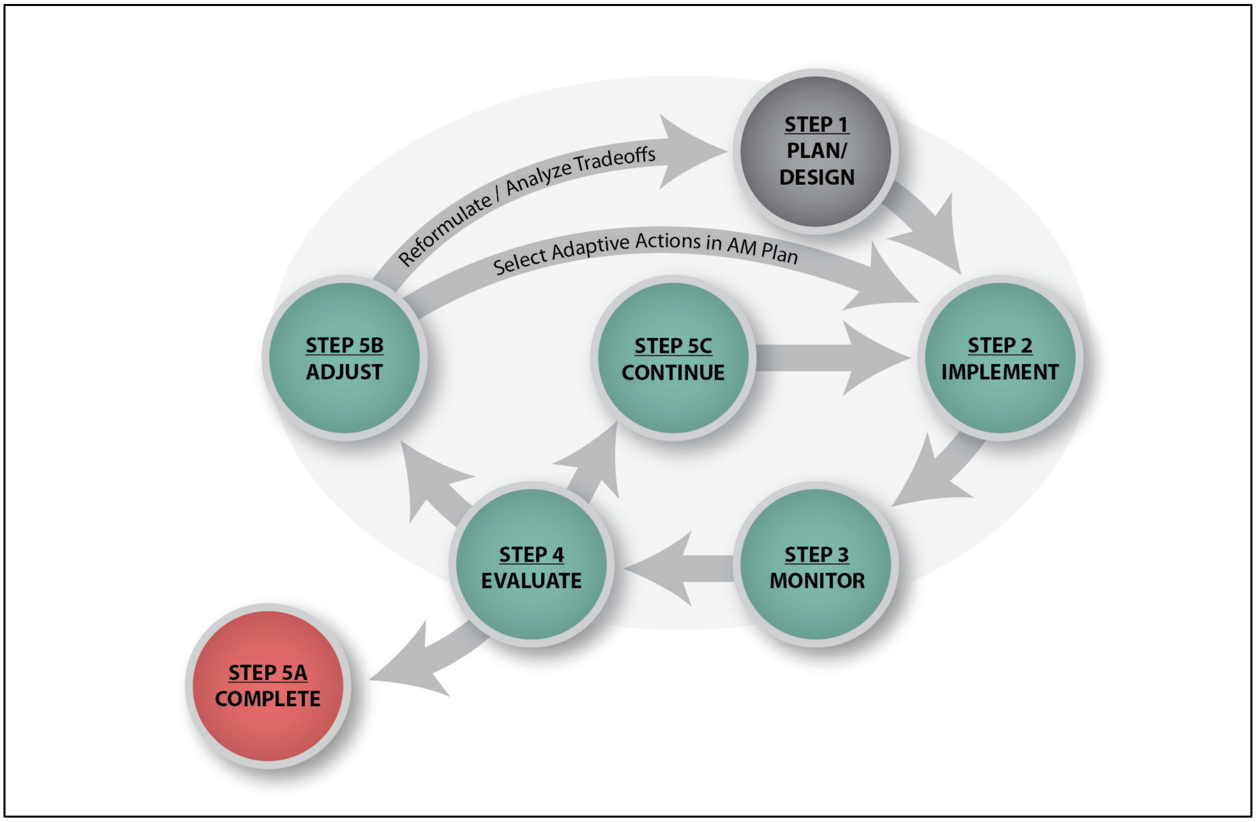
4.1 Introduction

This chapter summarizes how the U.S. Army Corps of Engineers (USACE) would implement the preferred alternative under the Missouri River Recovery Program Science and Adaptive Management Plan (SAMP). In addition to providing a brief summary of the main parts of the SAMP, this chapter also provides locations in the SAMP of more-detailed information related to each subject. The SAMP is a companion document to the Missouri River Recovery Management Plan – Environmental Impact Statement (MRRMP-EIS) and the implementation plan for the preferred alternative. The SAMP identifies the process and criteria to implement the initial actions, assess hypotheses, and introduce new actions should they become necessary. The process described in the SAMP is consistent with the National Environmental Policy Act (NEPA) goal of informed decision-making and takes the process further in addressing uncertainties and data gaps that may be revealed during implementation of the preferred alternative. This allows decision makers to make corrections based on new information while observing project performance, thus enabling transition from the planning and designing efforts associated with this MRRMP-EIS to implementation of the selected management actions using adaptive management (AM).

The SAMP is a living document that can be changed as new information is learned from monitoring of actual performance and processed through a governance structure. This chapter describes the governance approach and decision-making processes which would be used to assess, plan and design, implement, evaluate, and finally make adjustments based on new information. This chapter also discusses estimated implementation costs of the preferred alternative and how this EIS may be supplemented in the future to address actions not considered during this NEPA process.

4.2 Overview and Context of Missouri River Recovery Program Science and Adaptive Management Plan

AM can be characterized as a cycle of assessing the state of knowledge about species needs and management effectiveness; identifying uncertainties; careful planning and designing of actions to reduce these uncertainties; implementing the planned actions; monitoring and evaluating the results; and finally, adjusting based on what is learned (Figure 4-1).



Source: SAMP (Fischenich et al. 2016)

Figure 4-1. Simplified Depiction of the Adaptive Management Process

The SAMP is designed to guide the MRRP implementation process and help meet Endangered Species Act (ESA) requirements while avoiding and/or minimizing impacts to human considerations (HC), which include the authorized purposes of the Missouri River as well as the many other services afforded by the river system.

The SAMP provides detailed information on the strategy for addressing uncertainties for each species, provides a governance structure for the program, defines the roles and responsibilities of the participants, and describes both how data are managed and how program actions and results will be communicated and reported.

Primary components of the SAMP include the following:

1. A summary of the effects analysis, particularly the decision trees, critical uncertainties, and hypotheses that underlie the proposed research and actions for the listed species.
2. Monitoring program associated with the management actions and broader river system;
3. Research and study activities including those to address hypotheses for which specific management actions have not yet been identified;
4. Assessment methods and processes to evaluate the effectiveness of actions implemented under the preferred alternative;
5. Decision criteria used to determine if actions are effective, and whether changes to the preferred alternative are necessary;

6. Contingency plans; and
7. Governance approach to be used in collaboration with stakeholders, states, and Tribes to make decisions.

4.3 The Preferred Alternative

As described in Section 2.10 of this EIS, the preferred alternative includes the initial suite of management actions, research, and monitoring USACE would implement after approval of the record of decision (ROD) aimed at achieving objectives for the pallid sturgeon, piping plover, and interior least tern. The initial set of actions were chosen after careful consideration of species needs, remaining critical management uncertainties, anticipated impacts to authorized purposes and other socioeconomic impacts, and existing impediments to implementation of management actions contained within the other alternatives. The SAMP serves as the repository of knowledge related to management hypotheses, associated management actions, and remaining uncertainties. It is possible that in the future, the AM process will conclude that actions which were not part of the preferred alternative may be warranted and feasible. The ability to incorporate and adjust to new information is a central concept for successful adaptive management; therefore, if these activities lead to an adjustment in the implementation strategy laid out in the preferred alternative, a supplemental NEPA process may be necessary prior to the end of the 15-year period.

4.4 Adaptive Management Plan for Pallid Sturgeon

Management for pallid sturgeon will rely upon research conducted in conjunction with the implementation, monitoring, and adjustments more commonly associated with AM. This is because the uncertainties associated with pallid sturgeon ecology are both extensive and fundamental to the ability to plan and design effective actions over time. Pallid sturgeon actions are designed to build the necessary science information upwards from fundamental Level-1 research to full scale implementation of management actions intended to ensure persistence and ultimately support recovery of the species. Timing and coordination among studies, along with sound experimental designs that facilitate feedback from data to decisions, will be critical to success.

The SAMP for pallid sturgeon in the upper and lower river segments includes a 4-level framework to guide delivery of research and implementation of different management actions. Level 1 in this framework is associated with actions that do not change the system (e.g., laboratory or mesocosm experiments, observational studies across gradients in conditions, modeling, other research). Level 2 is associated with in-river testing of management actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon or surrogate species, or a related habitat response, but not at a level expected to produce a population response. Level 3 is associated with a magnitude of the in-river management action that is expected to produce a population-level response. Level 4 implements a management action at the ultimate level required to remove a limiting factor from the population. Uncertainties are further expressed as “Big Questions” and management hypotheses related to potential management actions with underlying uncertainties.

Big Questions in the upper river include:

1. Spawning Cues: Can spring pulsed flows from Fort Peck synchronize reproductive fish, increase chances of reproduction and recruitment?

2. Food and Forage: Can naturalization of the flow regime from Fort Peck contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?

3. Temperature Control: Can water-temperature manipulations at Fort Peck contribute significantly to increased chance of reproduction and recruitment?

4. Sediment Augmentation: Can sediment bypass at Fort Peck contribute significantly to increased chance of reproduction and recruitment?

5. Drift Dynamics: Can combinations of flow-manipulation from Fort Peck, drawdown of Lake Sakakawea, and fish passage at Intake Dam on the Yellowstone River increase probability of successful dispersal of free embryos and retention of exogenously feeding larvae?

6. Population Augmentation: Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?

Big Questions in the lower river include:

1. Spawning Cues: Can spring pulsed flows synchronize reproductive fish, increase chances of reproduction and recruitment?

2. Temperature Control: Can water-temperature manipulations at Fort Randall and/or Gavins Point contribute significantly to increased chance of reproduction and recruitment?

3. Food and Forage: Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to increased food production, foraging habitat, and survival of age-0 sturgeon?

4. Drift Dynamics: Can naturalization of the flow regime or channel reconfiguration (alone or in combination) contribute to decreased direct mortality and increased interception of free embryos into supporting habitats?

5. Spawning Habitat: Can channel reconfiguration and spawning substrate construction increase probability of survival of eggs through fertilization, incubation, and hatch?

6. Population Augmentation: Can population augmentation (stocking) processes be enhanced to increase survival and genetic fitness of stocked fish?

7. Fish Condition: Are there combinations of management actions (flow alteration, channel re-configuration, population augmentation, water quality management, or management of other fish species) which could improve the condition of pallid sturgeon within key segments of the lower Missouri River, resulting in population stability or growth?

The Big Questions and associated management hypotheses are described in-detail in Chapter 4 of the SAMP.

4.4.1.1 Pallid Sturgeon Framework

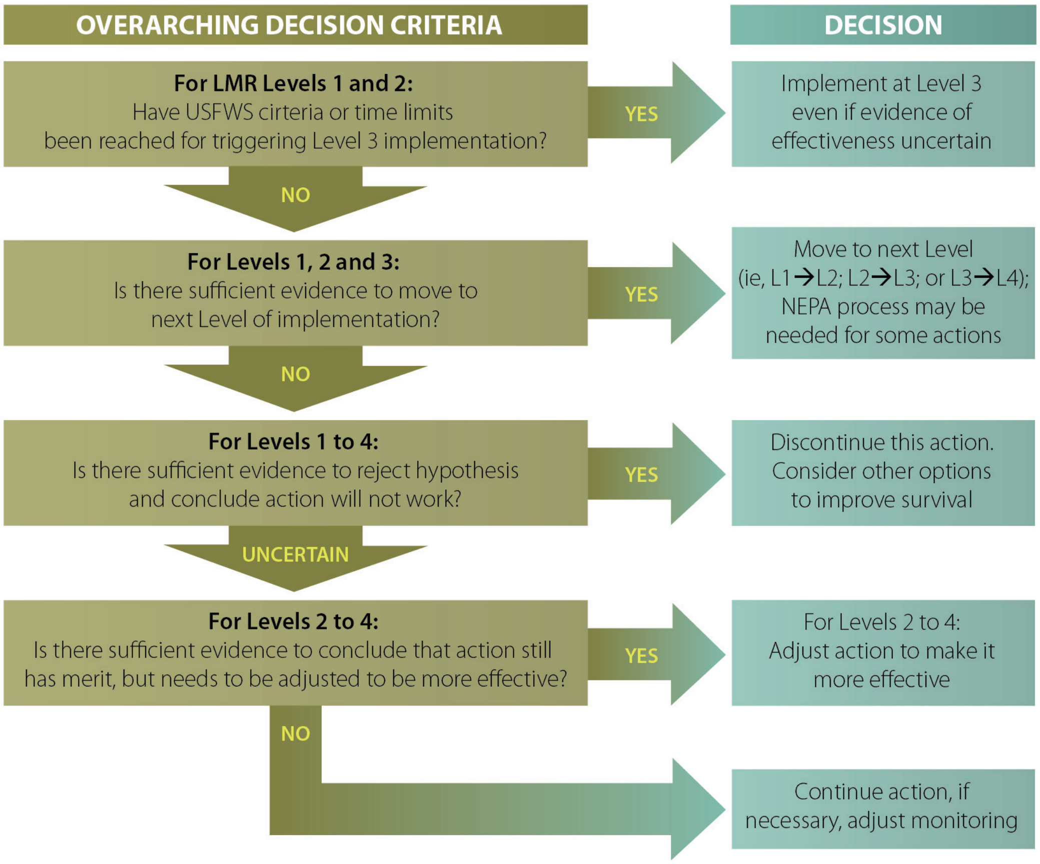
Under the SAMP, actions related to hypotheses would be explored, evaluated, and implemented with increasing intensity using the four-level framework. Under this framework, Level 1 and 2 studies are directly tied to uncertainties and management hypotheses that emerged from the effects analysis. As these uncertainties are reduced or resolved with work at Levels 1 and 2, management actions may be discontinued, adjusted, or expanded to Levels 3 or 4 where a population level response is expected which, if resolved, could significantly affect the implementation of management actions intended to address the objectives (Figure 4-2).

<table>
<tr><td>Level 1: Research</td><td rowspan="2">Population Level Biological Response IS NOT Expected</td><td>Studies without changes to the system (Laboratory studies or field studies under ambient conditions)</td></tr>
<tr><td>Level 2: In-river Testing</td><td>Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.</td></tr>
<tr><td>Level 3: Scaled Implementation</td><td rowspan="2">Population Level Biological Response IS Expected</td><td>In terms of reproduction, numbers, or distribution, initial implementation should occur at a level sufficient to expect a meaningful population response progressing to implementation at levels which result in improvements in the population. The range of actions within this level is not expected to achieve full success (i.e., Level 4).</td></tr>
<tr><td>Level 4: Ultimate Required Scale of Implementation</td><td>Implementation to the ultimate level required to remove as a limiting factor.</td></tr>
</table>

Figure 4-2. Four-Level Pallid Sturgeon Framework

Under the preferred alternative, population augmentation will be implemented at Level 3 in both the upper and lower river. The lower river includes two additional actions that were assessed at Level 3: creation of interception and rearing complexes (which will include both new habitat and rehabilitation of previously constructed habitat); and creation of spawning habitat. Although these actions could eventually be implemented at Level 3, Level 1 and Level 2 learning actions are also being carried out prior to or concurrently to address continuing uncertainties.

Specific criteria will guide decisions about whether to move from Level 1 to 2, Level 2 to 3, and Level 3 to 4. The general decision process is summarized in Figure 4-3, with more detailed decision criteria included in Chapter 4 of the SAMP for each action at each level.



Source: SAMP (Fischenich et al. 2018)

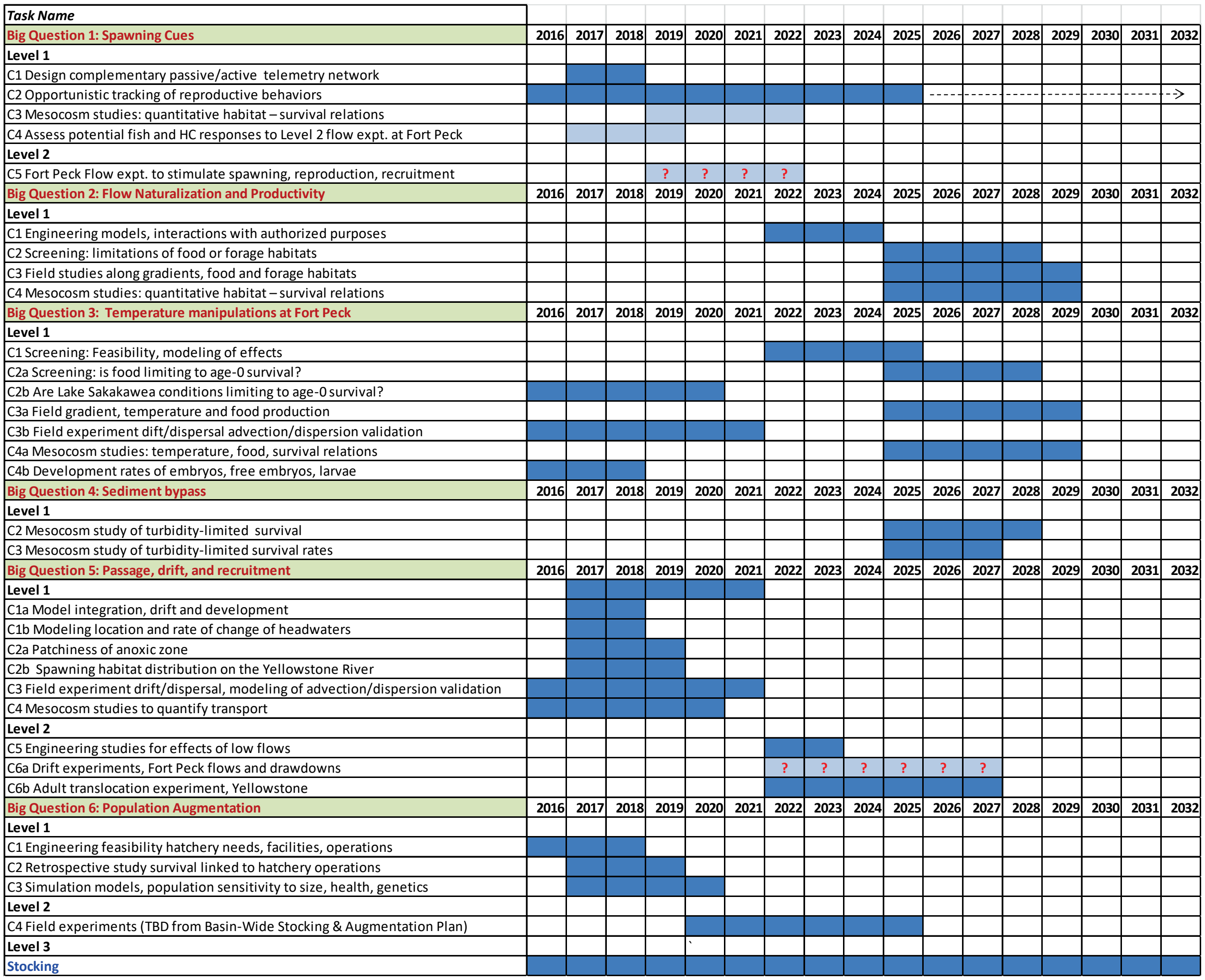
Figure 4-3. Overview of Decision Criteria for Various Decisions in the Pallid Sturgeon Framework

4.4.2 Implementation of Actions for Pallid Sturgeon

This section provides the current schedule for implementation of Level 1, 2, and 3 actions for pallid sturgeon associated with the preferred alternative (Figure 4-4 and Figure 4-5).

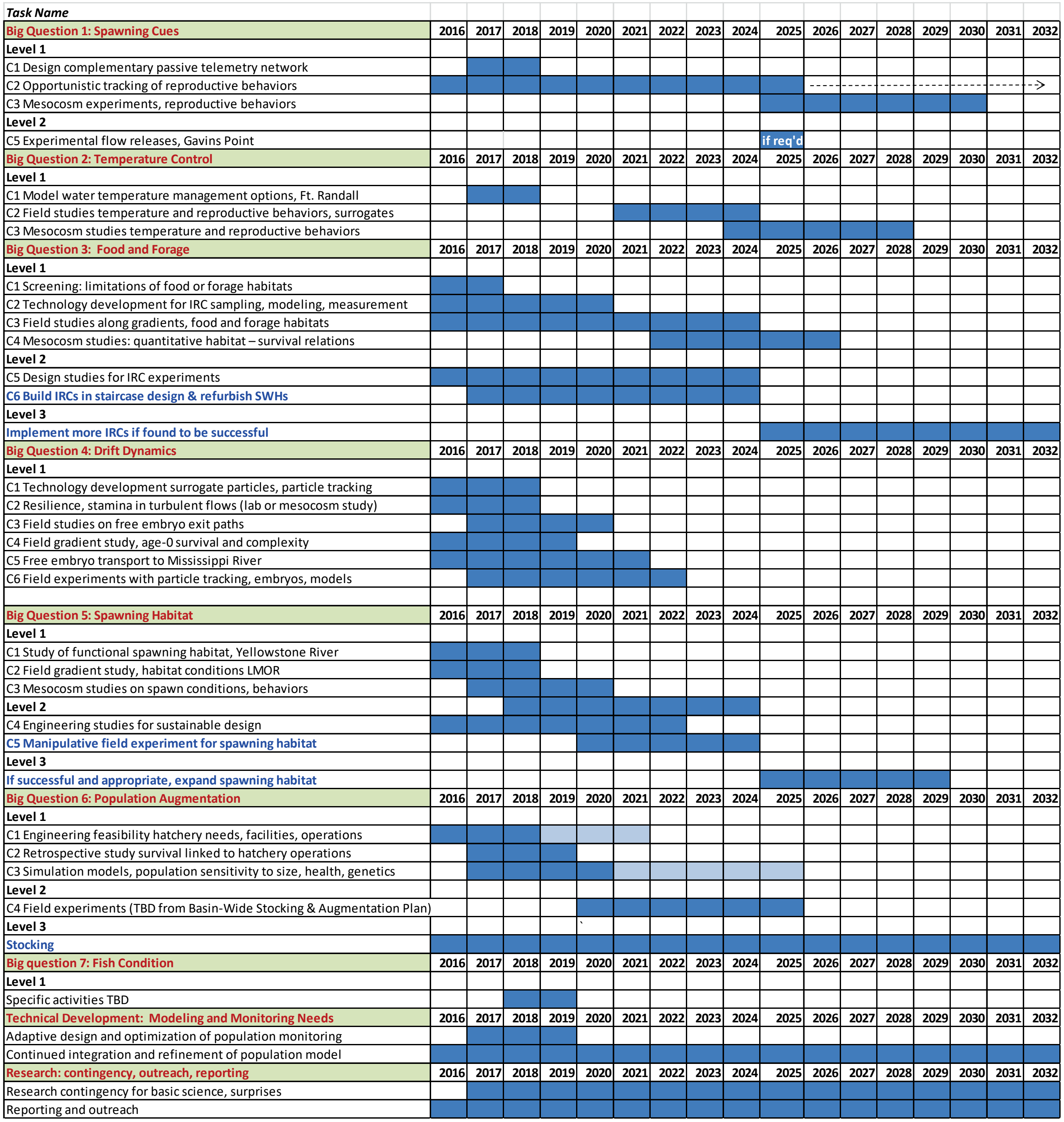
The SAMP actively seeks to accelerate the pace of learning and implementation to maximize benefits for pallid sturgeon by implementing multiple Level 1 components concurrently, or nearly concurrently, rather than sequentially. Concurrent implementation will require a substantial investment in early and carefully planned research. As such, Level 1 science components will jointly provide complementary lines of evidence that cumulatively affect decisions to implement field experiments at Level 2.

Based on agreement between USACE and the U.S. Fish and Wildlife Service (USFWS), implementation of management actions at Level 3 for each hypothesis would be required within a specified timeframe ranging from immediate to 9 years post-ROD, provided the hypotheses associated with the action are not rejected by that time. The implementation time limits range from “Immediate” for population augmentation to 9 years for spawning cue flows if none of the flow events that occur during the first 9 years is sufficient to evaluate the spawning cue management hypothesis.



Source: SAMP (Fischenich et al. 2018)

Figure 4-4. Proposed Schedule for Implementation of Actions in Upper Missouri River



Source: SAMP (Fischenich et al. 2018)

Figure 4-5. Proposed Schedule for Implementation of Actions in Lower Missouri River

At any time during implementation of the framework, it may become apparent that: (1) a particular action is not needed, (2) a proposed action requires modification to be effective, or (3) some new action not previously evaluated is required. In addition to modification of actions, the timeframe for implementation may be adjusted as knowledge is gained from Level 1, 2 and 3 actions, hypotheses are tested, and the likelihood of biological benefits becomes clearer. Moreover, budget allocations may also affect the timing of actions or a suite of actions. A detailed description of Level 1 and 2 science components for pallid sturgeon is provided in Appendix C of the SAMP, and a more-detailed schedule and prioritization of Level 1 and 2 components are provided in Appendix F of the SAMP. A detailed description of management actions associated with the Preferred Alternative is provided in Chapter 2 of this EIS.

4.4.3 Pallid Sturgeon Monitoring

There are three types of monitoring related to pallid sturgeon that will be conducted as the SAMP proceeds:

- Implementation monitoring: did the action get successfully completed as intended?
- Action effectiveness monitoring: is there a biological and/or habitat response that has the potential to increase survival or appropriately inform the next level of implementation towards achieving increased survival?
- Population monitoring: is age 1 recruitment occurring, the population growing, and attaining the right size?

Foundational research is required at Level 1 to support all three forms of monitoring, including the design of new protocols, the establishment of monitoring hardware such as stationary telemetry networks, as well as the development of models and power analyses to test monitoring protocols and experimental designs. Monitoring for pallid sturgeon is described in-detail in Chapter 4 of the SAMP, Appendix D of the SAMP describes proposed revisions to current protocols for population monitoring, and Appendix E of the SAMP contains references to the proposed design for monitoring the effectiveness of actions. A brief summary of the implementation, action effectiveness, and population monitoring associated with Level 2 and 3 Actions is provided in Table 4-1.

Table 4-1. Sample Metrics for Implementation, Action Effectiveness and Population Monitoring for Level 2 and Level 3 Actions

Note: Management hypotheses listed in first column (e.g., H8, H9) are those most relevant to the action, as discussed in the SAMP.

Level 2 / 3 Action	Implementation Monitoring	Effectiveness Monitoring	Population Monitoring
Augmentation [H8, H9] [H20, H21]	• Finalization of implementation monitoring awaits the 2018 release of the Rangewide Stocking and Augmentation Plan	• Finalization of effectiveness monitoring awaits the 2018 release of the Rangewide Stocking and Augmentation Plan	• Estimated survival probabilities of hatchery fish to age 1, 2, and 3 by stocked size, age, hatchery of origin, release location • Modeled long-term change in population based on survival probabilities of hatchery origin fish (e.g., probability of quasi extinction, population growth rates) • Effective population size • Finalization of population monitoring awaits the 2018 release of the Rangewide Stocking and Augmentation Plan
IRC Habitat [H17, H18, H19]	• “Effective acreage” (acre-days of available IRC habitat/year)	• Habitat metrics based on measures of depths, velocities, substrate, habitat complexity • Trends in % area of shallow water habitat (SWH) with suitable habitat after refurbishment to IRCs • Catch per unit effort (CPUE) and apparent presence at meso-habitat and project level; • Production of food/area • Fish condition (% empty/full stomachs; genetics; lipid content; length frequency distribution of age-0 fish) and bioenergetics modeling	• Survival of hatchery-reared first-feeding pallid sturgeon larvae in IRCs, refurbished SWH, thalweg, and to age-1 • Population size structure analysis (length-frequency distributions of age-1+ fish)

Level 2 / 3 Action	Implementation Monitoring	Effectiveness Monitoring	Population Monitoring
Spawning Habitat [H16]	• Number and area of spawning sites created with suitable characteristics (depth, velocity, substrate, and derivative hydraulic variables)	• Confirmation of site quality • Telemetry data showing relative selection of created spawning sites vs. control sites • Attraction/specificity of adults to different spawning substrates; site confirmation that eggs are not buried • Confirmation of spawning (see row below on spawning cue flows)	• Modeled long-term change in population based on estimated proportional increase in successful spawning due to creation of high quality spawning habitat (if such an increase occurs) • Field monitoring of recruitment to age-1, -2, -3
Spawning Cue Flows [H11]	• Level 1- Ambient flow monitoring to record timing, magnitude, and longitudinal spatial distribution • Level 2- Flow monitoring to check whether spawning cue flow had expected timing, magnitude, and longitudinal spatial distribution	• Movement and aggregation of spawning males and females in response to spawning cue flow • Multi-receiver, 3D telemetry and acoustic video to confirm egg release events • Male: female ratios in spawning aggregations • Confirmation of female spawning through captured downstream eggs and embryos, and recapture of spawned females	• Mesocosm and field-inferred benefit of achieved pulse • Modeled long-term change in population based on estimated proportional increase in successful spawning due to spawning cue (if such an increase occurs) • Field monitoring of recruitment to age-1, -2, -3 (delayed metric reflecting the cumulative effect of all actions, other stressors and natural variability)

Source: SAMP (Fischenich et al. 2018)

4.4.4 Evaluation

The methods used to evaluate the effectiveness of various actions are directly tied to the metrics selected for monitoring. Specific analytical procedures that may be used to address each question are generally based on procedures developed and that have undergone some form of peer review from previous research and monitoring work on the Missouri River or pallid sturgeon. However, in some cases for Level 2 and 3 Implementation, analytical methods for evaluation are dependent on development of methods during their respective Level 1 phase. Tables 64 through 68 in Chapter 4 of the SAMP describe the proposed methods to evaluate the effectiveness of various actions using the more specific and testable hypotheses that are described in Appendix E of the SAMP.

4.4.5 Adjustment Decisions

The pallid sturgeon framework provides a suite of five questions to guide decisions on moving to Level 3 implementation (Table 4-2). Work at Level 1 will help to answer questions 1, 2, 3, and 5. Level 3 implementation will be triggered if all five questions are marked “Yes”, but a 2-year time limit for implementation will be triggered if 4 of 5 are marked “Yes” and either questions 1 or 2 is marked “Uncertain.” As knowledge is gained from Level 1, 2 and 3 actions the timeframe for implementation may be adjusted, targets may be changed, management actions may be refined, and hypotheses may be dismissed. The “rules” by which these decisions will be made are outlined in the decision criteria for the respective management hypotheses, subject to the overarching governance and decision process laid out in Chapter 2 of the SAMP.

Table 4-2. Supplemental Lines of Evidence Strategy for Triggering Level 3 Implementation

	Question	**Y**	**U**	**N**
1	Is this factor limiting pallid sturgeon reproductive and/or recruitment success?			
2	Are pallid sturgeon needs sufficiently understood with respect to this limiting factor?			
3	Do one or more management action(s) exist that could, in theory, address these needs?			
4	Has it been demonstrated that at least one kind of management action has a sufficient probability of satisfying the biological need?			
5	Have other biological, legal, and socioeconomic considerations been sufficiently addressed to determine whether or how to implement management actions to Level 3?			
Criteria for Level 3 implementation				
1: A "Yes" to all five questions triggers Level 3 implementation 2: A "Yes" to four of five, with an "Uncertain" for either #1 or #2 triggers a 2-year clock to either reject the hypothesis or implement at Level 3				

Source: SAMP (Fischenich et al. 2018)

On a broader level, there are four major categories of decisions for pallid sturgeon management:

A. Is there enough evidence at Level 1 to proceed with an action at Level 2?

B. Is there enough evidence at Level 1 and Level 2 to proceed with and action at Level 3?

C. Have time limits been reached for implementation of Level 3 actions?

D. Is there enough evidence at Level 3 to proceed with an action at Level 4?

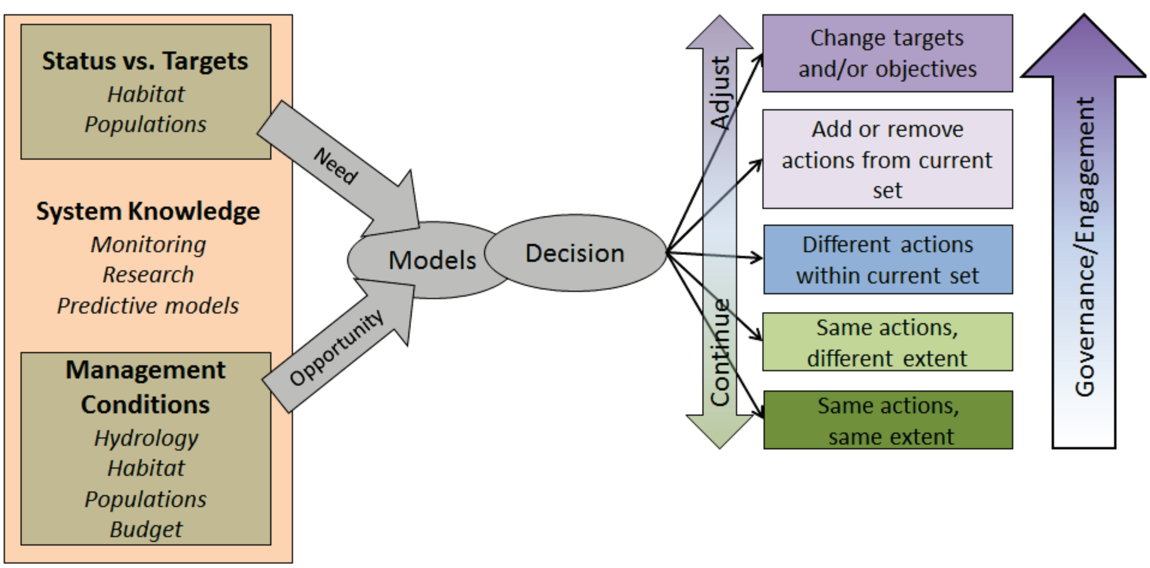
The evidence that is used to inform these decisions includes metrics and decision criteria specific to a single action as well as the accumulating evidence of the relative amount of support for multiple actions. An overview of decision criteria is provided in Chapter 4 of the SAMP in Figure 54. Metrics and decision criteria pertaining to a single action can be found in Appendix C of the SAMP, as well as in Tables 44 and 45 of Chapter 4 of the SAMP for decisions in category A (moving from Level 1 to Level 2) and category B (moving from Level 2 to Level 3). Decisions related to singe actions for categories B and C are discussed in the sub-sections on Metrics and Decision Criteria in Sections 4.25 and 4.2.6 of the SAMP. For evidence on the relative amount of support for multiple actions, this chapter also includes decision trees for recruitment in the upper Missouri River, recruitment in the lower Missouri River, and spawning habitat. The collaborative population model (described in Appendix D of the SAMP) will be used to integrate information from Level 1 through 3 studies to provide estimates of the relative benefits of different actions in helping with the recovery of pallid sturgeon.

4.5 Adaptive Management Plan for Piping Plovers and Interior Least Terns

Managing for piping plovers and interior least terns largely involves ensuring sufficient availability of emergent sandbar habitat (ESH) to support nesting and foraging for the birds, while also accounting for any benefits to bird populations from use of reservoir shorelines. The focus of these efforts is on nesting habitat for plovers; provided those needs are met, habitat needs for terns are likely also met. Habitat and population models developed for the plovers provide a powerful planning tool, but uncertainty about parameter estimates in the habitat models, coupled with observation errors and uncertainty about dispersal, demographic rates, and their trends in the population models provide significant opportunities for improvements. The greatest source of uncertainty is in estimating future flows, which drive the availability of ESH. Managers will be required to make decisions about how much ESH to create annually by construction or vegetation management with consideration of the risks that the habitat may fall short of targets. AM will likely revolve around the above issues, but opportunities exist for meaningful improvements to ESH construction methods, vegetation management, predator management, and foraging habitat, among other aspects.

4.5.1.1 Piping Plover and Interior Least Tern Framework

The key decision-making information and range of decisions are illustrated in Figure 4-6. The information needed to make decisions is provided by system status relative to targets, together with the management conditions that allow for actions to be implemented. That information is interpreted in the context of the current understanding of the system, as synthesized by models, to make decisions. Decisions range from continuing the current activities exactly, to continuing actions while adjusting them, to changing the actions that are implemented, to adjusting fundamental components of the program when necessary based upon new information. As the breadth and significance of decisions increases, the level of governance and engagement with stakeholders, states, and Tribes increases accordingly.



Source: SAMP (Fischenich et al. 2016)

Figure 4-6. Factors Affecting Adaptive Management Decisions for Birds and the Nature of those Decisions

The variability of the Missouri River and the need to balance multiple, and sometimes competing, species and human considerations objectives support a toolbox approach to managing for plovers and terns. The approach consists of having multiple management actions and options available to ensure effective management in a context of natural variability and socioeconomic uncertainty. As the AM program is implemented, learning about the actions in the toolbox is applied to use them more effectively. Importantly, learning may also result in changes to the actions that are included and the bounds and conditions under which they are applied, or the addition or removal of management actions. Decisions to make changes are evidence-based and made in collaboration with stakeholders, states, and Tribes when human considerations may be affected.

4.5.2 Implementation of Actions for Piping Plovers and Least Terns

Management actions for birds fall into three general categories: (1) those that create habitat, (2) those that improve habitat quality or availability, and (3) those that directly protect nests, chicks, and/or adults to improve survival. Section 3.2.4 of the SAMP details implementation plans for each management action listed below.

The following is a summary of the actions to be taken for the piping plover and least tern under the preferred alternative.

Emergent Sandbar Habitat Mechanical Construction: This would include implementation of mechanical ESH creation in the Garrison, Fort Randall, and Gavins Point reaches to meet plover population persistence targets specified by USFWS. Based on hydrology and hydraulics modeling coupled with population models this would result in constructing an average of 332 acres of ESH per year in years where construction is needed, although vegetation management may reduce the amount that needs to be constructed from year to year. Construction was estimated to occur in 61 percent of the years modeled (Table 4-3). In real-time, the existing population and ESH status would be assessed, as described in the SAMP, to determine actual construction needs based on trends in the population and ESH. The rate of construction in a given year is calculated by aiming for the plover persistence probability. ESH targets are a means objective for implementation planning on the 5-year time frame.

Table 4-3. Summary of Modeled Construction for the Preferred Alternative

Average ESH Construction in Build Years*	2.5 percentile ESH Construction	Median ESH Construction	97.5 percentile ESH Construction
332 acres	14 acres	271 acres	928 acres

* 61% of years were modeled to need construction to meet population persistence targets.

As described in Section 3 of the SAMP, habitat and demographic targets have been specified by USFWS (USFWS 2015; Buenau 2015). Acres of ESH are calculated in two ways:

- Standardized ESH: The area above water when releases from Gavins Point Dam are 31.6 kcfs, Fort Randall Dam are 30.5 kcfs, and Garrison Dam are 23.9 kcfs. Estimating ESH acreage at constant flows each year allows for the detection of changes in sandbar structure due to erosion, deposition, construction, or mechanical modification.
- Available ESH: The area above water during maximum July release for a specified year. This is an estimate of usable habitat for the birds during the nesting season. It is

reported as the acreage of available ESH exceeded during a percentage of years (e.g., 10, 25, 50, or 75 percent).

Median standardized ESH targets (450 acres in the Northern Region; 1,180 acres in the Southern Region) are to be met 3 out of 4 years (Table 4-4). This frequency was calculated based on the proportion of time standardized ESH was above target in the model runs used to calculate the target values. A moving window of 12 years is used for median available ESH. This allows for calculation of the exceedance probabilities over a meaningful time frame, long enough to accommodate naturally occurring periods of drought and high runoff that affect ESH quantities.

Table 4-4. Standardized and Available ESH Targets for the Northern and Southern Regions

		Acres of Emergent Sandbar Habitat					
		Northern Region			Southern Region		
		2.5 percentile	Median	97.5 percentile	2.5 percentile	Median	97.5 percentile
Standardized ESH Acres		190	450	2160	330	1180	4720
Available ESH Acres Exceeded for Percentage of Years	75%	170	270	555	300	430	720
	50%	420	680	1295	500	740	1550
	25%	960	1920	2670	750	1410	3075
	10%	1965	3000	5165	1125	2240	4945

- **Reduced Nesting-Season Flow Releases within Capability Provided in Current Master Manual**: Flexibility under the existing Master Manual to allow reduction in releases when there is no navigation traffic scheduled is included as an option. This management action would continue to be an option to extend the life of ESH for nesting terns and plovers under the preferred alternative as conditions permit.
- **Flow Management to Reduce Take**: The steady release flow-to-target operation under the existing water control manual during the nesting season would continue as described in Chapter 2. This involves setting initial releases high enough early in the year to discourage birds from nesting on low-elevation sandbars that may get flooded later in the year and releasing less water when possible to avoid flooding tern and plover nests below the dams. Regular communication between USFWS and reservoir control staff currently occur for this purpose and would continue.
- **Predator Management and Human Restriction Measures**: Predator management and human restriction measures would continue on constructed and naturally created sandbars. Proposed management actions in the plan include the use of exclusion cages and exclusion fending to protect nests and hazing of predators in combination with audio or visual frightening devices to deter predators away from nesting sites. Lethal and non-lethal removal of individual target predators that have the greatest impact on least tern and piping plover nests and chicks, particularly raccoons, coyotes, mink, and great horned owls, would also occur. Human restriction measures include fencing of nesting areas or signage to alert people of the presence of nesting birds.

- **Vegetation Management**: The primary method of vegetation removal from smaller sandbars would be spraying from an all-terrain vehicle or hand spraying for smaller areas with less vegetation. In areas that are large and/or densely vegetated aerial spraying from a helicopter would be conducted. USACE would continue to use an imazapyr-based (e.g., Habitat) and/or a glyphosate-based (e.g., Rodeo) herbicide approved by the U.S. Environmental Protection Agency (EPA) for aquatic use. Additional vegetation removal activities may include cutting, mulching, disking, mowing, raking, and removing vegetation from sandbars. The ESH Project Delivery Team (PDT) would continue to meet annually to discuss locations on the river where vegetation treatment could be conducted in an effort to maintain as much ESH as possible.
- **Monitoring**: Annual productivity monitoring of least tern and piping plover populations on the reservoir and river reaches of the Missouri River Mainstem would continue. The current monitoring focuses on an adult census, measurement of fledge ratios, and documentation of incidental take if applicable. ESH habitat monitoring and assessment of management actions to determine their effectiveness would also occur.
- **Research and Modeling**: Modeling and research would also occur related to ESH construction, habitat-creating flow releases, lowered nesting season flow releases, flow releases to reduce take, sandbar augmentation and modification, vegetation management, predation control, human restriction measures, and reservoir water-level management. In addition, focused research projects on various aspects of piping plover demographics and habitat use would be implemented based on the prioritization process developed for the SAMP. A detailed listing of the associated management questions and study summaries can be found in Chapter 3 of the SAMP.

4.5.3 Monitoring for Piping Plovers and Least Terns

Annual monitoring of habitat and species performance metrics, and as-needed monitoring of action effectiveness and of unusual events will be required to adaptively manage decisions for the birds. Monitoring is necessary for tracking program performance relative to targets and identifying trends that indicate a need for changes to management. It also provides some of the information needed to develop and maintain accurate models (e.g., fledgling production relative to habitat availability and changes in ESH availability as a function of river flow). Monitoring requires flexibility and responsiveness to ensure timely and consistent data collection in a highly variable system. As habitat and populations on the Missouri River have the potential to change rapidly, monitoring for performance metrics must occur annually. Information needs that are not addressed through the monitoring program can be addressed through focused research.

The following metrics will be used to support hypotheses testing and management decisions:

- Habitat metrics
  - Standardized ESH (acres)
  - Available ESH (acres)
  - Available shoreline (feet)
  - Inundation during the nesting season (feet)

- Species metrics
  - Population size
  - Population growth rate
  - Fledge ratio
- Metrics of management conditions
  - Standardized ESH (acres) and distribution
  - Vegetated habitat (acres)
  - Storage in reservoirs (million acre-feet) and planned releases (cubic feet per second [cfs])
  - Tributary flows (cfs) and downstream stage (elevation)
  - Bird population density (adults/acre)
  - Budget ($)

Some of these metrics have historically been collected under the Tern and Plover Monitoring Program. Revisions to the monitoring program, which are under development, will be used to collect information related to the remaining metrics. A detailed description of tern and plover monitoring is provided in Section 3.3 of the SAMP.

4.5.4 Evaluation

The evaluation process includes assessing ESH and population status, management needs, hypotheses, and the updating and validation of predictive models. Assessment of ESH status involves the use of the models, along with remotely sensed imagery, to determine both standardized and available habitat during nesting and fledging seasons. ESH acreage relative to median and 95 percent confidence intervals for targets, along with trends, are evaluated for planning ESH creation needs. Evaluating population requires assessment of population resiliency under current management conditions through modeling and assessment of observed fledge ratios and population growth and their trends.

Section 3.5 of the SAMP provides guidance for the overall evaluation of status and management needs. Figure 4-7 categorizes ESH and species status and communicates a recommended management pathway (e.g., continue, increase, or decrease current rates of habitat creation). An evaluation of management conditions including System storage, snowpack, ESH condition, vegetation and predator status, budget, and the pallid sturgeon research and management needs provides understanding of how the decision space may be constrained. Chapter 3 of the SAMP also discusses the evaluations needed to address new information, evaluate key relationships, hypotheses and science questions, update and validate models, deal with ancillary information, and assess unexpected outcomes.

POPULATION STATUS	EMERGENT SANDBAR HABITAT STATUS			
	Acreage < Lower Bound	Lower Bound < Acreage < Median	Median < Acreage < Upper Bound	Upper Bound < Acreage
Growing Population FR and λ > target	On track to meet objectives **Status**: Small population OR density dependence less than expected **Need**: Continue pace of habitat creation	Meeting objectives **Status**: Moderate population, not habitat limited **Need**: Continue habitat creation at current or slower pace	Meeting objectives **Status**: Moderate population, not habitat limited **Need**: Maintain existing acreage and quality	Exceeding objectives **Status**: More birds and much more habitat than needed **Need**: Maintain habitat quality
Stable Population FR and λ ≈ target	Unlikely to meet objectives **Status**: Small to moderate population, becoming habitat limited **Need**: Increase rate of habitat creation	Meeting objectives **Status**: Moderate population, habitat may become limiting **Need**: Continue pace of habitat creation	Meeting objectives **Status**: Moderate to large population **Need**: Maintain existing acreage and quality	Exceeding objectives **Status**: More birds and more habitat than needed **Need**: Maintain habitat quality
Declining Population FR and λ < target	Will not meet objectives **Status**: Small to large population, very habitat limited **Need**: Rapidly increase rate of habitat creation	Unlikely to meet objectives **Status**: Moderate to large population habitat limited **Need**: Increase pace of habitat creation	Potential reversal **Status**: Large population returning towards equilibrium **Need**: Continue pace of habitat creation and maintain habitat	Reversal **Status**: Large population returning towards equilibrium OR density dependence much higher than expected **Need**: Maintain habitat quality, consider maintaining acreage

Note: FR = fledge ratio (number of fledglings observed/[number of breeding adults/2]); λ= lambda (population size in current year/population size in previous year)

Figure 4-7. Matrix for Characterizing Status and Needs for ESH Acreage and Bird Population

4.6 Governance of the AM Program

The term "governance" refers to the approach for decision-making and includes a description of what decisions need to be made, who is involved in the decision process, how decisions are made, and when they are required. Effective systems of governance contribute to trust-building, knowledge generation, collaborative learning, development of priority action listing, and conflict resolution. The governance structure and process for the MRRP is intended to achieve the above aims and to promote collaboration among the lead agencies and stakeholders, including the Missouri River Recovery Implementation Committee (MRRIC), while maintaining the statutory decision responsibilities of USACE and USFWS. A detailed description of proposed program governance can be found in Chapter 2 of the SAMP.

Governance under the MRRP would involve making decisions about topics ranging from highly technical considerations, such as the selection of monitoring sites and sample sizes, to policy- and value-laden issues, such as whether to adjust reservoir operations criteria. Major policy decisions would be made by the USACE Division and District Commanders—subject to their authorities and appropriations—with input from USFWS, Tribes, MRRIC, and the public. Some decision-making would be a joint USACE and USFWS function (e.g., changes to targets, decision criteria, or management actions). MRRIC would work closely with USACE and USFWS (agency) leaders and may provide consensus recommendations.

As currently proposed, governance starts with interagency teams working together, with support of a technical team to interpret what has been learned to date and apply that knowledge to future decisions. The bird, fish, and HC teams would interact with component MRRIC work groups that may provide expertise and perspective, while serving to keep the full MRRIC aware of the teams' activities and deliberations. The management team and implementation teams (the latter consisting of the bird, fish, and HC teams), together with the technical team and agency leadership, would provide the governance structure for the MRRP (Figure 4-8).

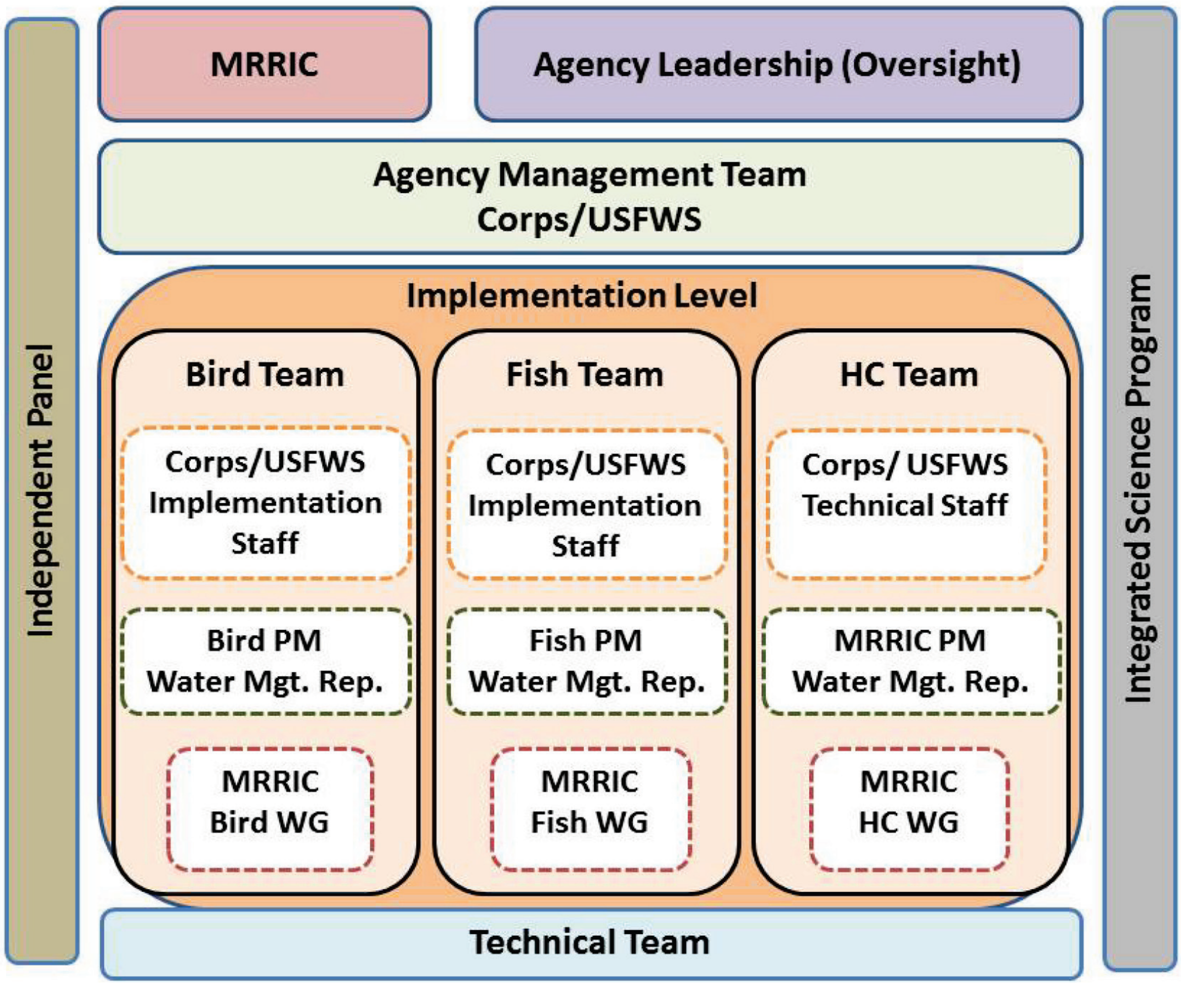


Figure 4-8. Proposed Governance Structure for Adaptive Management of the Missouri River Recovery Program

The MRRP would also maintain an independent review panel along with several internal and external peer review processes to assess the program, monitoring and study plans and reports, project designs, and other program products. Ensuring that the products used for decision-making are of the highest quality and meet standards of good practice is essential to trust-building and program success.

The SAMP includes numerous decision criteria that indicate which actions would be taken based on performance of preceding actions, the status of the system, species populations, or the results of hypotheses testing. Occasionally, new information or understanding would dictate adjustments to these criteria or to the targets program objectives, or scope. The governance process for the MRRP would include procedures for making these changes, as well as for adjusting the program's governance structure and process itself.

Chapter 2 of the SAMP includes a more-detailed description of the AM Governance including a calendar of key engagements with stakeholders and Tribes, development of MRRP work plans and reporting and communication of AM process results.

4.7 Human Considerations

The purpose of the MRRP is to fulfill the requirements of the ESA while minimizing the impacts to Human Considerations (HCs). The SAMP is designed to guide the MRRP implementation process and help achieve the MRRP's purpose. Chapter 5 of the SAMP discusses how HCs were programmatically addressed during the MRRMP-EIS and how they will be considered and adaptively managed during implementation of the MRRMP. Chapter 5 also:

- summarizes the range of HCs that may be directly affected by the MRRMP;
- presents planning context related to USACE's Missouri River responsibilities and authorities;
- discusses how the specific actions in the preferred alternative could potentially affect HCs, and how USACE plans to avoid or minimize adverse impacts to the HCs, while fulfilling the requirements of the ESA; and
- discusses issues concerning the adaptive management of the HCs such as: SAMP governance and HCs, responding to new situations or concerns that arise while implementing the preferred alternative, screening and prioritizing HC monitoring, and tradeoffs involving HCs.

In practice, steps taken to minimize HCs occur at varying levels of planning, design, construction, and maintenance. The degree to which USACE can minimize impacts to HCs is informed by the basis for and limits of these responsibilities and authorities. Because all impacts may not be avoidable, and more than one HC has the potential to be impacted, there may be tradeoffs to consider in the future.

4.8 Implementation Costs and Authorities

The authorized scope and estimated costs pursuant the Water Resources Development Act (WRDA) 1986, 1999, and 2007 (described in Section 1.1 of this EIS) are anticipated to be sufficient to implement the preferred alternative. The preferred alternative would be implemented under existing USACE MRRP authorities provided under WRDA 1986, WRDA 1999, and WRDA 2007. WRDA expanded the project from a mitigation project in four states to a mitigation and ESA project in eight states. Reservoir unbalancing provisions and the existing spring pulse criteria would be removed from the Master Manual under the preferred alternative. If necessary, the one-time flow test within the preferred alternative would likely be implemented through a one-time Master Manual deviation request that would be coordinated through the Annual Operating Plan Process (AOP) which involves public meetings and review. Each habitat construction project would involve site-specific environmental compliance activities including a tiered NEPA process which includes public meetings and public review of a draft NEPA document.

The total estimated cost of the preferred alternative if it were to be implemented over a 50-year timeframe is approximately $1.84 billion and the annual cost in years 1–9 was estimated to be approximately $56.3 million. This estimate includes program management, integration, and coordination, costs for MRRIC engagement, upper and lower river pallid sturgeon habitat construction, operations, and maintenance, piping plover and least tern habitat construction, operation, and maintenance, real estate acquisition, habitat development and land management, and monitoring/studies costs. The MRRP receives annual construction general funding for implementation, and a smaller amount of annual operations and maintenance (O&M)

funding. Table 4-5 includes total and annual costs for each management action and the number of years each would be implemented for the preferred alternative. The below estimates display the estimated costs of the preferred alternative over the standard 50-year planning horizon used in USACE planning studies. More-detailed annual budgets are developed by the MRRP in collaboration with MRRIC as described in Chapter 2 of the SAMP. Annual costs for the various MRRP actions, and the annual cost for the overall Program will likely vary over time based on changing system conditions and other new information. For example, the preliminary estimates of pallid sturgeon spawning habitat acreages are based on similar types of projects in other systems targeting different species, and the amount of ESH construction needed in a given timeframe will vary based on the amount of ESH on the system and status of bird metrics, and the amount of operation and maintenance funding will vary based on the condition and performance of habitat structures over time.

Table 4-5. Estimated Cost for the Preferred Alternative over the 50-year Planning Horizon

Management Actions	Annual Cost (Average)	Years Implemented	Total
Program Management, Integration, and Coordination	$6,011,659	1–50	$300,582,950
MRRIC	$1,897,000	1–50	$94,850,000
Subtotal			**$395,432,950**
ISP			
Propagation and Augmentation Program	$479,552	1–50	$23,977,600
Pallid Sturgeon Population Assessment Project	$2,587,669	1–50	$129,383,450
Habitat Assessment Monitoring Program	$1,925,570	1–15	$28,883,550
Lower Pallid Sturgeon Monitoring, Evaluation, and Research Level 1 and 2 Studies	$1,498,361	1–19	$28,468,859
Upper Pallid Sturgeon Monitoring, Evaluation, and Research Level 1 and 2 Studies	$983,012	1–15	$14,745,180
Bird Monitoring	$1,267,837	1–50	$63,391,850
Bird Level 2 Studies/Projects	$1,918,325	1–15	$28,774,875
Subtotal			**$317,625,364**
Pallid Sturgeon Habitat			
Spawning Habitat Construction	$125,270	1–9	$1,127,430
Spawning Habitat Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRRR)	$25,054	1–50	$1,252,700
SWH Refurbishment			
Omaha Reaches	$1,613,553	1–15	$24,203,295
Kansas City Reaches	$1,613,553	1–15	$24,203,295
Existing SWH Operations and Maintenance	$7,853,061	1–50	$392,653,050
Omaha Reaches Early Life Stage Habitat Construction	$2,289,017	1–15	$34,335,255

Management Actions	Annual Cost (Average)	Years Implemented	Total
Omaha Reaches O&M	$522,997	2–15	
	$1,045,995	16–50	
		2–50	$43,931,783
Kansas City Reaches Early Life Stage Habitat Construction	$16,326,112	1–15	$244,891,680
Kansas City Reaches O&M	$1,536,298	2–15	
	$3,023,525	16–50	
		2–50	$127,331,547
Real Estate Acquisition	$1,054,108	1–10	$10,541,080
Habitat Development	$146,648	1–15	$2,199,720
Land Management	$23,130	2 –15	
	$46,260	16–50	
		2–50	$1,942,920
Subtotals			
Construction			**$343,444,675**
OMRRR			**$565,169,080**
Bird Habitat			
Mechanical ESH Creation	$4,302,266	1–50	$215,113,300
Vegetation Management	$300,000	1–50	$300,000
Predator Management	$21,000	1–50	$1,050,000
Human Restrictions Measures	$5,200	1–50	$260,000
Subtotal			**$216,723,300**
Totals (All Year Total Cost, Annual Construction General Total, Annual O&M Total)			**$1,838,395,369**
Total Annual Costs (average, without discounting)	$56,339,635	1–9	
	$54,955,416	10–15	
	$30,364,439	16–19	
	$28,866,078	20–50	
Total Average-Annual MRRP Implementation (NED) Cost (using FY18 federal discount rate: 2.75%)	**$40,863,033**	**1–50**	

4.9 Future NEPA and Other Environmental Compliance Requirements

The programmatic MRRMP-EIS is USACE's strategic approach to meeting its NEPA responsibilities in implementing the recovery program in a cost effective and streamlined manner. To achieve these goals, it is important that the EIS be developed in a way that considers how it will be used as well as how future projects will be considered and evaluated. A programmatic approach is well suited for the MRRP, as it integrates the management actions being implemented and the adaptive management framework that will be used to assess performance and make adjustments based on new learning. By addressing uncertainties and potential impacts associated with potential future management actions as part of this EIS process, the need to supplement or prepare additional NEPA documents will be reduced. The MRRMP-EIS establishes a SAMP that is flexible and should allow many of the management actions specified within the preferred alternative to proceed without additional NEPA analysis or with site-specific NEPA analysis. Information gathered through the adaptive management process will be used to adjust actions within the range of the impacts analyzed in this EIS.

Because the adaptive management process may ultimately indicate the need for actions that address hypotheses outside the scope of the preferred alternative, these potential actions are identified in the SAMP. Several options are available for future NEPA documentation: (1) tiering from this EIS (2) supplemental EISs or environmental assessments, or (3) standalone NEPA documentation. Figure 4-9 illustrates the NEPA and environmental review process.

4.9.1 Tiering

Implementation of the management actions articulated in the EIS may require subsequent analysis for site-specific actions that can be tiered from the programmatic EIS. NEPA regulations encourage the use of tiering in order to focus on issues ripe for decision making (40 CFR 1502.20.) Using a "tiering" approach allows more general matters to be addressed in this programmatic EIS, with subsequent tiered EISs or environmental assessments to focus site-specific actions and associated environmental analyses. The tiered EIS or environmental assessment would reference the general discussion from this programmatic EIS while focusing on the project-specific impacts important to USACE decision-makers. This programmatic EIS will enable USACE to tier future project proposals from the overarching programmatic EIS analysis, helping to streamline future environmental reviews.

4.9.2 Supplemental NEPA Documentation

NEPA requires agencies to prepare supplements to their draft or final EISs under two circumstances: (1) "the agency makes substantial changes to the proposed action that are relevant to environmental concerns, or" (2) "if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts" (40 CFR 1502.9(c)). If adaptive management provides significant new information affecting selection of the preferred alternative and the actions and potential impacts are not within the range of impacts and alternatives considered in this MRRMP-EIS, supplemental NEPA analysis would be required. The approach used to address this situation was to develop alternatives that would be initially implemented (over roughly a 15-year timeframe) to begin the adaptive management process. At the end of this timeframe, and potentially sooner, another NEPA process may be necessary to assess any proposed changes, due to adaptive management. These would be addressed in supplemental NEPA documentation required to augment the MRRMP-EIS. If there are no substantial changes to the proposed action relevant to environmental concerns, or no new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts, then implementation could proceed without modifications to this EIS.

4.9.3 Standalone NEPA Documentation

Implementation of actions not contemplated in this EIS, or based on a decision not to supplement the EIS, would require a separate NEPA process. This process would be initiated and conducted according to appropriate Council on Environmental Quality and USACE regulations and policies associated with NEPA.

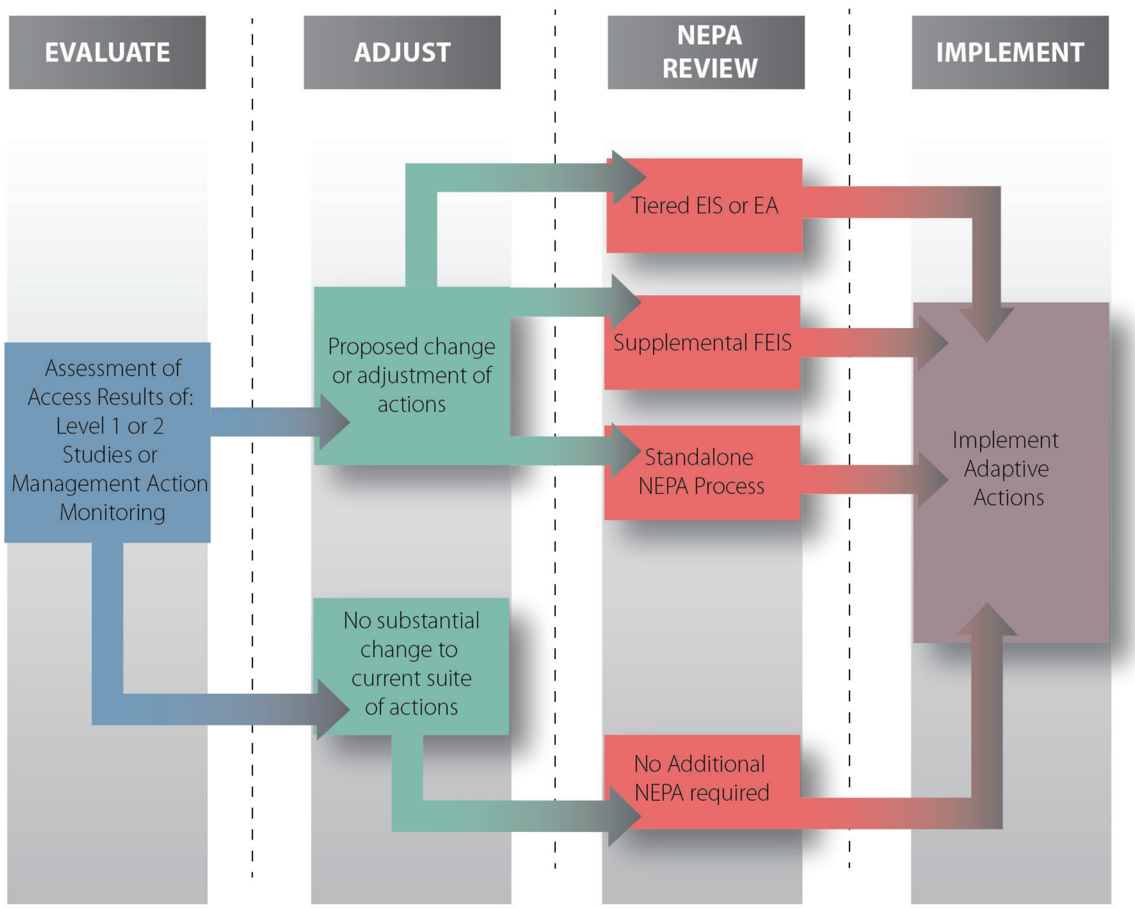


Figure 4-9. Integration of the National Environmental Policy Act and Environmental Compliance Process in the Adaptive Management Framework

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Chapter 5 Tribal, Agency, and Public Involvement

This chapter describes Tribal and agency involvement as well as the coordination and public engagement activities that have been conducted as part of the Missouri River Recovery Management Plan – Environmental Impact Statement (MRRMP-EIS).

5.1 Missouri River Recovery Implementation Committee

The Missouri River Recovery Implementation Committee (MRRIC) is an interdisciplinary group charged by Congress with making recommendations and providing guidance on a long-term study of the Missouri River and its tributaries and on the existing Missouri River recovery and mitigation plan. MRRIC recommendation letters related to the MRRMP-EIS process can be found in Appendix G. The committee was established by the Secretary of the Army in 2008, as authorized by Section 5018 of the 2007 Water Resources Development Act (WRDA). The committee is intended to help guide the prioritization, implementation, monitoring, evaluation, and adaptation of recovery actions, while providing representation for a broad array of interests. MRRIC is comprised of nearly 70 members representing Tribal, local, state, and federal interests throughout the Missouri River Basin. MRRIC coordination and collaboration is additional to consultation required by other laws. A list of MRRIC members can be found at www.mrric.org. More information on Tribal representation at MRRIC can be found at www.mrric.org and in Appendix H.

MRRIC has made several substantive recommendations related to the Management Plan process. In August of 2012, MRRIC made a consensus recommendation to the U.S. Army Corps of Engineers (USACE), which was based upon the Missouri River Independent Science Advisory Panel (ISAP) report entitled: Final Report on Spring Pulses and Adaptive Management (ISAP 2011). These documents are available at www.mrric.org. ISAP's report and MRRIC recommendations led to development of the effects analysis, the Science and Adaptive Management Plan (SAMP), and the EIS process for their implementation. MRRIC's recommendation included seven proposed actions:

1. An effects analysis should be developed that incorporates new knowledge that has accrued since the 2003 Amended Biological Opinion. As part of this analysis:
    - The effects of the Missouri and Kansas River Operations on the listed species should be reviewed and analyzed in the context of other stressors on the listed species;
    - The quantitative effects of potential management actions on the listed species should be documented to the extent possible; and
    - These potential management actions should be incorporated into the conceptual ecological models (CEMs).
2. CEMs should be developed for each of the three listed species and these models should articulate the effects of stressors and mitigative actions (including but not limited to flow management, habitat restoration actions, and artificial propagation) on species performance.
3. Other managed flow programs and adaptive management (AM) plans should be evaluated as guidance in development of the CEMs and AM strategy for the Missouri River Recovery Program.

4. An overarching AM strategy should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction, and this strategy should be used to guide future management actions, monitoring, research, and assessment activities within the context of regulatory and legal constraints.
5. Monitoring programs along the Missouri River should be designed so as to determine if hypothesized outcomes are occurring and the extent to which they are attributable to specific management actions.
6. The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
7. Aspects of how the entire hydrograph influences the three listed species should be evaluated when assessing the range of potential management actions.

In August 2014, MRRIC made a consensus recommendation to USACE regarding human considerations (HC) objectives and performance metrics which is available on the MRRIC website (www.mrric.org). This recommendation established criteria to ensure that adequate consideration is given to the possible interactions of management actions with human uses and interests on the river, and that these criteria are used to evaluate the impacts of alternatives in the MRRMP-EIS. HC objectives and metrics are evaluated in this EIS and include:

- Fish and wildlife
- Cultural resources
- Agriculture
- Commercial sand dredging
- Flood risk management
- Hydropower
- Irrigation
- Navigation
- Recreation
- Thermal power
- Wastewater
- Water supply
- Ecosystem services
- Tribal interests (in addition to those associated with the above categories)

These interests and associated objectives and metrics were key considerations in analyzing and comparing the effects of different alternatives in this EIS. The analysis is documented in Chapter 3, Affected Environment and Environmental Consequences.

In November 2016, MRRIC developed process recommendations to structure MRRIC's engagement in the AM governance process and a related substantive recommendation asking USACE to modify the SAMP that it reflects the evolving understanding of the relationship between MRRIC and the lead agencies in implementation of the SAMP (text of the recommendation available at www.MRRIC.org).

In November 2017, MRRIC provided a consensus recommendation on "Common Ground Recommendations for USACE" that included two recommendations related to the EIS from an initial list of ten proposed recommendations:

- When using the word "channel" in the Final MRRMP-EIS and SAMP, there should be clarification of its definition in the context that it was used.

- MRRIC affirms and supports USACE's commitment to conduct the supplemental flood risk modeling recommended by the IEPR in Panel Comment 39.

USACE has coordinated with MRRIC throughout the development of the MRRMP-EIS in addition to receiving the formal consensus recommendations. Coordination includes quarterly 3-day in-person plenary meetings, and numerous webinars, in-person and virtual meetings with MRRIC work groups, and collaboration on the preparation and review of multiple technical reports and documents, including the effects analysis and iterations of the SAMP. MRRIC has established individual work groups consisting of MRRIC members, alternates, agency staff, and others, which meet one to three times per month on average. The purpose of the work groups is to allow MRRIC members to better understand the actions at hand and work directly with the agencies to make recommendations aimed at maximizing the effectiveness of the Missouri River Recovery Program (MRRP), while ensuring stakeholder, other agency, and Tribal values are sufficiently incorporated into the plans. The work groups include ad hoc groups which are intended to address specific issues and disband upon completion of their work. A brief summary of each work group is provided below:

- **Agenda Work Group**: The Agenda Work Group collaborates with the MRRIC Chair and agency staff to develop the agenda for each MRRIC plenary meeting.
- **Common Ground Ad Hoc Group**: This group's purpose is to identify and discuss topics concerning the proposed assessment and implementation actions related to the Draft MRRMP-EIS and SAMP to identify where there may be common ground for potential MRRIC consensus recommendations.
- **Fish Work Group**: The purpose of this group is to understand the science and technical issues that relate to the pallid sturgeon and to track progress toward fish objectives presented in the EIS and SAMP.
- **Bird Work Group**: The purpose of this group is to understand the science and technical issues that relate to the piping plover and closely monitor activities underway intended to achieve the bird objectives presented in the EIS and SAMP.
- **Human Considerations Work Group**: The purpose of this group is to understand the technical aspects of AM that relate to human uses of the Missouri River System and how HCs are being accounted for in AM.
- **Plover Habitat Ad Hoc Group**: The purpose of this group is to explore methods to identify potential alternative piping plover habitat sites and to ultimately determine if alternative habitat types can be integrated into the MRRP efforts.
- **Adaptive Management Governance Planning Ad Hoc Group**: The purpose of this group is to build on MRRIC's AM governance recommendation from November 2016 to

discuss the governance aspects of the SAMP and develop recommendations regarding how MRRIC should engage in efforts to implement the SAMP.

- **Communications Work Group**: The Communications Work Group is responsible for developing communication materials including press releases, newsletters, reports surveys, and meeting materials such as PowerPoint presentations and other technologies.
- **Science and Adaptive Management Work Group**: The Science and Adaptive Management Work Group collaborates with the ISAP to provide guidance and recommendations to MRRIC regarding implementation, monitoring, and evaluation of actions associated with the MRRMP. This group has now sunsetted, but had a high level of involvement in the MRRMP-EIS and SAMP development. Species related activities will continue via the Fish and Bird Work Groups and Plover Habitat Ad Hoc Group moving forward.
- **Tribal Interests Work Group**: The Tribal Interests Work Group advises MRRIC on Tribal-related issues to ensure that Tribal concerns are sufficiently considered, and works to improve Tribal participation in MRRIC.
- **Adaptive Management Ad Hoc Group**: The Adaptive Management Ad Hoc Group was established to help evaluate and make recommendations to MRRIC on how MRRIC, the Independent Science Advisory Panel, and the Independent Socio-Economic Technical Review (ISETR) should engage with the lead agencies in implementation of the SAMP, including development of the AM governance approach. MRRIC sunsetted the AM Ad Hoc Group in August 2017.
- **Human Considerations Ad Hoc Group**: The Human Considerations Ad Hoc Group provides recommendations to MRRIC to ensure that adequate consideration is given to the possible interactions of management actions with human uses and interests on the river, specifically as they pertain to the evaluation of alternatives in the MRRMP-EIS.
- **Membership, Process and Procedures Ad Hoc Group**: The Membership, Process and Procedures Ad Hoc Group addresses process and procedures related to the operations of MRRIC and assists the lead agencies (USACE and U.S. Fish and Wildlife Service (USFWS)) with aspects of membership on MRRIC.

5.2 Tribal Coordination and Consultation

In August 2013, USACE held a series of six Tribal scoping meetings for the MRRMP-EIS at various locations across five states. Beyond fulfilling USACE's responsibilities under the National Environmental Policy Act (NEPA), the purpose of the Tribal scoping was to inform the tribes about the proposed action and possible alternatives and provide meaningful opportunity for comment and participation in the process. Tribal scoping also allowed the tribes to help identify the scope of issues to be addressed and to identify potentially significant issues related to the MRRMP-EIS. Letters of invitation were distributed to all 29 tribes in the Missouri River Basin in mid-July 2013. The letters included a description of the project and a complete schedule of the Tribal scoping meetings. Meetings were held in Fort Peck and Billings, Montana; Bismarck, North Dakota; Vermillion, South Dakota; Pawhuska, Oklahoma; and Lawrence, Kansas. Members of the tribes were invited to submit comments in person at the Tribal scoping meetings, by mail, email, or online via NPS's Planning, Environment and Public Comment (PEPC) system. The scoping period was initiated with the publication of a Notice of Intent in the Federal Register on August 9, 2013, and closed on November 4, 2013. The content of these comments can be found in the MRRMP-EIS Scoping Summary Report (available at www.moriverrecovery.org).

Tribal members have also provided guidance and input throughout the Management Plan process through their participation in MRRIC plenary meetings and their involvement in work groups including the Tribal Interests Work Group. USACE has also held regional and small-group meetings with the Tribes separate from the regular MRRIC process to exchange information and address emerging questions and concerns related to Management Plan development. A description of these engagements is included in Appendix H.

Government-to-Government Tribal consultation for the purposes of the MRRMP-EIS is the responsibility of both USACE and USFWS. All federally recognized Tribes geographically located within the Missouri River basin or that have historical ties within the basin have been identified as potential consulting Tribes. The intent of Government-to-Government consultation is to provide for identification and resolution of issues related to the alternatives being evaluated in the EIS. An invitation for Government-to-Government consultation was sent in a letter to the Tribes dated October 20, 2016. In December, 2016 a separate letter was sent to all basin Tribes offering National Historic Preservation Act (NHPA) Section 106 consultation. In response to the invitation, the Standing Rock Sioux, Osage, Sac and Fox, Iowa Tribe of Kansas and Nebraska, and Prairie Band of Potowatomie Tribes requested formal consultation with USACE and USFWS. Consultation meetings were held with the Standing Rock Tribe on February 28, 2018, Osage Tribe in July 2018, and Sac and Fox, Iowa, and Prairie Band of Potowatomie on April 4, 2018.

In addition to consultation on the EIS and BiOp, USACE also consulted with lower basin tribes on the development of a new programmatic agreement for NHPA Section 106 procedures that would be followed during site-specific project implementation. The lower river PA was pending signature at the time of printing of the Final MRRMP-EIS and is not appended; however, the document will be made available on the MRRP website (www.moriverrecovery.org) concurrent with the signed ROD.

Coordination and communication with the Tribes will continue throughout the AM implementation process and will comply with NHPA Section 106 and Tribal Trust responsibilities.

5.3 Agency Coordination, Public Scoping, and Public Involvement

5.3.1 Cooperating Agencies

The USFWS; Bureau of Reclamation; National Park Service (NPS); Western Area Power Administration (WAPA); and States of Nebraska, South Dakota, and Wyoming are cooperating agencies in the Management Plan process. All of the cooperating agencies are also members of MRRIC. Given their MRRIC membership and the high degree of MRRIC involvement in the Management Plan process, much of the cooperating agency involvement in the Management Plan process has occurred in the MRRIC forum. In addition to their participation in MRRIC, USFWS has provided their technical input and expertise to the process through a series of planning aid letters to USACE. USACE and USFWS coordinated closely in developing the MRRMP-EIS and the accompanying SAMP. Correspondence between USFWS and USACE are provided in Appendix B (Fish and Wildlife Coordination Act Correspondence) and Appendix I (Endangered Species Act Correspondence). Close coordination during this effort ultimately lead to meeting the fundamental objective of developing a plan that avoids jeopardy for the piping plover, least tern, and pallid sturgeon.

WAPA, NPS, Bureau of Reclamation, and States of Wyoming, South Dakota, and Nebraska provided their technical expertise and input on Draft Management Plan products and provided technical information for the analysis. USACE worked with WAPA to determine reasonable estimates for the financial impact of the alternatives to WAPA and the RED impact to hydropower. WAPA provided information about their hourly preference customer and pumping load in the Southwestern Power Pool (SPP) footprint and their deliveries external to SPP for 2016. WAPA provided a way to compare generation data from the alternatives to an estimate of actual demand on the System and value those comparisons. WAPA also identified 2012 as a normal generation year in the existing condition and so this year was used as a point of comparison for the alternatives. The Bureau of Reclamation provided information and data on water supply intakes under their purview and the states have provided needed data especially related to the recreation analysis. NPS and USACE continue to discuss the manner in which emergent sandbar habitat (ESH) construction would be conducted in the Missouri River National Recreational River reaches where NPS has responsibilities under the Wild and Scenic Rivers Act. USACE and NPS will continue to co-manage this reach as directed by the enabling legislation for the Missouri River National Recreational River.

5.3.2 Public and Agency Scoping

To solicit public input in the MRRMP-EIS process, USACE conducted public scoping webinars on September 11 and 18, 2013, which were broadcast live via internet from the Omaha District Office. Members of the public were invited to participate online, or attend a broadcast of the webinars in real time at one of several host sites. The dates and times of the public scoping webinars and the host site locations were announced in the Notice of Intent, published in the Federal Register on August 9, 2013, via a press release from the Kansas City District Public Affairs Office on August 28, through social media, and in mass emails. At least one host site location was offered in each of eight states throughout the Missouri River Basin. Additionally, one of the webinars was recorded, archived, and made available on the Management Plan webpage for members of the public who were unable to attend the live broadcast via internet or at a host site.

Members of the public were invited to submit questions and comments during the live webinar broadcasts, by mail, email, or online via NPS's PEPC system. Host sites managed questions and comments received verbally during the webinars by submitting attendees' questions and comments through the webinar chat function. The comment period was open from August 9 to November 4, 2013, during which 70 correspondences were received. The content of comments received is summarized in MRRMP-EIS Scoping Summary Report (available at www.moriverrecovery.org).

5.3.3 Public and Agency Involvement on the Environmental Impact Statement

This document has undergone standard USACE planning internal review processes (District Quality Control and Agency Technical Review on the Draft EIS in 2016 and 2017 and on the Final EIS in 2018) and was also reviewed by a panel of external experts (Independent External Peer Review on the Draft EIS in 2017). On December 16, 2016, USACE, Kansas City and Omaha Districts, released the Draft MRRMP-EIS for public review and comment. A Notice of Availability (NOA) of the Draft MRRMP-EIS was published in the Federal Register on December

23, 2016. Members of the public also received notice of the availability of the Draft MRRMP-EIS through a news release published following the publication of the NOA in the Federal Register.

NEPA requires a minimum 45-day public review and comment period for all draft EISs. USACE initiated a 60-day public review and comment period in December of 2016. Based on requests from MRRIC members, Tribes, and the public the Draft EIS review and comment period was ultimately extended to a total of 122 days that ended on April 24, 2017. This public comment period was announced on the USACE website (http://moriverrecovery.usace.army.mil/), posted at 10 libraries located in towns along the Missouri River, and announced through press releases. The Draft MRRMP-EIS was made available through several outlets, including USACE's website, NPS's Planning, Environment, and Public Comment (PEPC) website at http://parkplanning.nps.gov/MRRMP, and on the U.S. Environmental Protection Agency (EPA) EIS database website. During the comment period, six public meetings, which contained a formal hearing portion, were held in February 2017 throughout the region. These meetings provided the public an opportunity to ask questions, make statements (with a court reporter on hand to record their comments for the official record), and encourage public involvement and community feedback on the Draft MRRMP-EIS. All six of the public meetings were held during the public comment period as follows:

February 7, 2017: Fort Peck Interpretive Center, Fort Peck, Montana

February 8, 2017: Bismarck State College-National Energy Center of Excellence, Bismarck, North Dakota

February 9, 2017: Ramkota Hotel and Conference Center, Pierre, South Dakota

February 14, 2017: Thompson Alumni Center-Bootstrapper Hall, Omaha, Nebraska

February 15, 2017: Hilton-Kansas City Airport, Kansas City, Missouri

February 16, 2017: Double Tree by Hilton Hotel, Chesterfield, Missouri

The public was encouraged to submit comments regarding the Draft MRRMP-EIS online at http://parkplanning.nps.gov/MRRMP. The public was also able to submit comments by mailing letters and comment forms to the USACE Omaha District, 1616 Capitol Avenue, Omaha, Nebraska, 68102. Public comments from the public meetings were recorded and collected by court reporters. All of the comments received were entered into PEPC in order to organize and analyze each comment.

USACE considered the comments received (Appendix K) in the preparation of the Final MRRMP-EIS. Comments on the Draft MRRMP-EIS varied with some supportive of managed flow pulses, habitat construction, land acquisition, and other management actions for the listed species while some are opposed. The public comment and review process resulted in improvements in the impacts analysis, but did not result in any significant changes to the alternatives or the conclusions. The comments received during the review of the Draft MRRMP-EIS in 2016–2017 are included in Appendix K, along with corresponding responses. Comments are addressed throughout the Final MRRMP-EIS, appendices, and supporting documents. In addition, this Final MRRMP-EIS was made available for final review from August 31 to October 8, 2018. A record of decision is anticipated to be issued in October, 2018.

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Chapter 6 Compliance with Other Environmental Laws

This section addresses federal statutes, implementing regulations, and executive orders potentially applicable to the programmatic Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS). Applicable requirements are summarized below. For site-specific projects, a tiered analysis would be conducted to ensure compliance with any associated laws prior to implementation.

6.1 Threatened and Endangered Species

6.1.1 Endangered Species Act

The Endangered Species Act (ESA) (16 USC 1531 et seq.) established a program to promote the conservation and facilitate recovery of imperiled species and the habitats in which they are found. As such, ESA prohibits “take” of any species listed as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS), where “take” is defined as to, “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect,” any species listed under ESA. Section 7 of the ESA requires federal agencies to ensure that any actions authorized, funded, or carried out by the agency do not jeopardize the continued existence of a federally listed threatened or endangered species, or result in the destruction or adverse modification of the designated critical habitat of a federally listed species. ESA correspondence associated with the MRRMP-EIS is provided in Appendix I.

Following consideration of public, agency, Tribal, and stakeholder review of this Draft MRRMP-EIS, the USACE identified a “proposed action” and prepared a biological assessment (BA) of the effects of that action on the pallid sturgeon, interior least tern, and piping plover. The BA was transmitted to the USFWS to initiate formal consultation under Section 7 of the ESA. The USFWS prepared a Biological Opinion (BO) which included a finding that the proposed action would not likely jeopardize the continued existence of the listed species. The BO also includes “incidental take statements” which include “reasonable and prudent measures” (RPMs) which are thought to be necessary to minimize potential incidental take of the listed species. The BA and BiOp are provided as accompanying documents to the MRRMP-EIS and are available at www.moriverrecovery.org.

Any site-specific action carried out under the recommended plan that has the potential to adversely impact threatened or endangered species or associated habitat would not be implemented without site-specific surveys and assessments to ensure that no threatened or endangered species would be adversely impacted by U.S. Army Corps of Engineers (USACE) actions. When necessary, at specific sites, USACE will complete tiered National Environmental Policy Act (NEPA) and coordination with USFWS to ensure compliance with ESA. All construction timing constraints related to specific listed species within the project area will be observed in order to avoid impacts to federally listed species. Furthermore, USFWS is a cooperating agency for the MRRMP-EIS and has submitted planning guidance to USACE throughout the process (Appendix B).

6.1.2 Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (16 USC §§ 668a–668d) prohibits the take, possession, or sale of bald and golden eagles, with limited exceptions for the scientific or exhibition purposes, for religious purposes of Indian Tribes, or for the protection of wildlife and agriculture or for preservation of the species. In 2009, USFWS created a permit program for non-purposeful take of eagles and their nests. The MRRMP-EIS has analyzed the potential impacts of the considered alternatives and has determined that the alternatives are not likely to result in the take of bald or golden eagles. As part of each site-specific project, USACE would coordinate with USFWS and the appropriate state agencies to avoid incidental take of bald or golden eagles during the implementation of any management action. If a bald or golden eagle were to be found near or on a project site, the appropriate USFWS office would be contacted and USFWS National Bald Eagle Management Guidelines would be implemented in coordination with USFWS.

6.2 Fish and Wildlife Conservation

6.2.1 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) (16 USC 661 et seq.) requires federal agencies to coordinate with USFWS or the National Marine Fisheries Service and appropriate state wildlife agencies to avoid or minimize adverse impacts of federal actions that propose to modify any stream or water body. Modification of a stream or water body includes impoundment, diversion, and deepening of channels. While USACE is not proposing such modifications as part of this effort, USACE has coordinated with USFWS and various state wildlife agencies throughout the development of the Draft MRRMP-EIS and has received and incorporated planning aid letters (Appendix B) into the development of the MRRMP-EIS. Preliminary draft chapters of the Draft MRRMP-EIS were also shared with the USFWS and state resource agencies for their review and comment. A final FWCA report is included in Appendix B. Coordination will also continue to occur during implementation of the recommended plan.

6.2.2 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (16 USC § 703(a)), originally implemented in 1918, prohibits the take, possession, or sale of migratory birds. No significant impacts to migratory birds are anticipated under any of the MRRMP-EIS alternatives. Migratory birds are addressed in Section 3.5, Fish and Wildlife Habitat, and Section 3.6, Other Special-Status Species. USACE coordinates with USFWS and appropriate state agencies prior to construction occurring at site-specific projects. Clearing of vegetation normally is scheduled to occur outside of the primary nesting season further reducing the risk to migratory birds.

6.3 Water Resources and Wetlands Conservation

6.3.1 Clean Water Act

The objective of the Clean Water Act (CWA) (33 USC 1251 et seq.), as amended, is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. USACE regulates discharges of dredge or fill material into waters of the United States pursuant to Section 404 of the CWA. The selection of disposal sites for dredged or fill material is done in accordance with the Section 404(b)(1) guidelines, which were developed by the U.S. Environmental Protection Agency (EPA) (40 CFR Part 230). Section 401 of the CWA allows certain states or the EPA to grant or deny water quality certification for any activity that results in a discharge into waters of the United States and requires a federal permit or license. Certification requires a finding by the affected states or EPA that the activities permitted would comply with all water quality standards individually or cumulatively over the term of the permit.

Section 401 water quality certifications would be obtained for site-specific management actions, as required, prior to construction. Section 402 of the CWA also established the National Pollutant Discharge Elimination System (NPDES) for permitting point-source discharges to waters of the United States. A tiered NEPA process will be associated with each site-specific project under the alternative ultimately selected for implementation. Each process will include compliance with Sections 401, 402, and 404 of the CWA through site-specific analysis and coordination.

6.3.2 Executive Order 11988 Flood Plain Management

Executive Order 11988 requires federal agencies to evaluate the potential effects of their actions on floodplains and to consider alternatives to avoid or minimize impacts. This requirement applies to the following actions: (1) acquiring, managing, and disposing of federal lands and facilities; (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. Implementation of the preferred alternative will avoid, to the extent possible, long- and short-term adverse impacts to the floodplain. It will also avoid direct and indirect support of development or growth (construction of structure/or facilities, habitable or otherwise) in the base floodplain. Site-specific designs will be developed to ensure that the project complies with Executive Order 11988 through technical analysis and coordination with local floodplain management authorities. Potential impacts to the Missouri River floodplain are described in Section 3.2, River Infrastructure and Hydrologic Processes.

6.4 Cultural Resources and Heritage

6.4.1 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (54 USC 306108) requires federal agencies to evaluate the effects of federal undertakings on historical, archeological, and cultural resources. To do this, USACE must identify any district, site, building, structure, or object that is located in or near the project area, and is included in or eligible for inclusion in the National Register of Historic Places. In addition to ongoing coordination, the USACE Omaha District has developed a programmatic agreement (PA) in consultation with Tribes, Tribal Historic Preservation Officers (THPOs), State Historic Preservation Officers (SHPOs), agencies, and interested parties to address cultural and historic resource impacts involved with the ongoing operation and maintenance of the Missouri River System. A separate PA has been developed, in collaboration with Tribes, THPOs, Advisory Council on Historic Preservation, and SHPOs for Missouri River Recovery Program (MRRP) actions in the lower river such as interception and rearing complex (IRC) construction. The lower river PA was pending signature at the time of printing of the final MRRMP-EIS and is not appended; however, the document will be made available on the MRRP website (www.moriverrecovery.org) concurrent with the signed ROD. Consultation requirements under Section 106 of the NHPA will be met for all projects and the PAs will be utilized as appropriate. The NHPA System operations PA is included in Appendix J. More information regarding cultural resources identification and potential impacts to cultural resources are described in Section 3.9, Cultural Resources.

6.4.2 Archaeological Resources Protection Act

The Archeological Resources Protection Act (16 USC 470aa–470mm) provides for the protection of archeological sites located on public and Tribal lands; establishes permit requirements for the excavation or removal of cultural properties from public or Tribal lands; and establishes civil and criminal penalties for the unauthorized appropriation, alteration, exchange, or other handling of cultural properties. USACE is authorized to issue permits for archeological surveys and exploration and would ensure that all permit requirements are met if excavation of archaeological sites was required. Potential impacts to archaeological resources are described in Section 3.9, Cultural Resources.

6.4.3 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 USC 3001 et seq.) addresses the discovery, identification, treatment, and repatriation of Native American human remains and cultural items. This Act also establishes penalties for the sale, use, and transport thereof. In recognition of the sensitivity and cultural importance of human remains, funerary objects, sacred objects, or objects of cultural patrimony, each USACE District has developed a standard operating procedure to provide guidance to assure respectful and responsive treatment of human skeletal remains inadvertently discovered on federal lands managed by the district. USACE does not have NAGPRA jurisdiction over human remains or other NAGPRA related collections recovered from private and non-Tribal lands. This is also true if remains are recovered during a federal undertaking on private lands. Under those circumstances, specific state unmarked burial laws would take precedence. Management actions described in the MRRMP-EIS would make the appropriate efforts to avoid adverse impacts to Tribal sites as described in Section 3.9, Cultural Resources.

6.4.4 American Indian Religious Freedom Act

The American Indian Religious Freedom Act (AIRFA) of 1978 (42 USC 1996) provides for the protection and preservation of American Indian rights of freedom of belief, expression, and exercise of traditional religions. Courts have interpreted AIRFA to mean that federal agencies must consider American Indian interests before undertaking actions that might cause unnecessary interference with those traditional practices. USACE recognizes its responsibilities with respect to AIRFA and will coordinate with Tribes in carrying out the requirements of the AIRFA for any actions described in the MRRMP-EIS.

6.4.5 Executive Order 13007 Indian Sacred Sites

Executive Order 13007 requires federal agencies to accommodate access to, and ceremonial use of, American Indian sacred sites by Tribal religious practitioners. The order requires federal agencies to avoid adverse impacts to Tribal sacred sites and maintain the confidentiality of information pertaining to Tribal sacred sites. Tiered environmental analyses will be prepared for site-specific management actions and USACE will coordinate with appropriate Tribes to ensure that all actions comply with Executive Order 13007.

6.5 Water Rights

Modifying the operation of the Missouri River Mainstem Reservoir System for purposes other than endangered species compliance is outside the scope of this analysis. The alternatives that do propose such changes in the MRRMP-EIS do not establish, regulate, determine, quantify, or impact consumptive water rights for any State, Tribe, or individual.

USACE operates the Mainstem System in accordance with federal legislation that Congress has enacted. In accordance with Congressional intent, USACE endeavors to operate its projects for their authorized purposes in a manner that does not interfere with lawful uses pursuant to State and Tribal water right authorities. USACE develops water control plans and manuals through a public process, affording all interested parties the opportunity to present information regarding uses that may be affected by USACE operations for authorized purposes of its projects. USACE would consider modifications to System operation, in accordance with pertinent legal requirements, as State or Tribal water rights are exercised in accordance with applicable law. The Winters Doctrine, developed by the Supreme Court in *Winters v. United States*, 207 U.S. 564 (1908), maintains that sufficient water was reserved by implication to fulfill the purposes of the Tribal Reservation at the time the Reservation was established. Case law supports the premise that American Indian reserved water rights cannot be lost, whether or not those rights are exercised.

6.6 Environmental Justice

Executive Order 12898 Federal Actions to Address Environmental Justice in Minority and Low-Income Populations

Executive Order 12898, passed in 1994, requires federal agencies to make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States. Executive Order 12898 calls for federal agencies to provide opportunities for stakeholders to obtain information and provide comment on federal actions. One additional way USACE is complying with this executive order is by engaging with MRRIC and providing regular and accessible means for stakeholders in the Missouri River Basin to obtain information and provide comments to USACE related the MRRMP-EIS and its potential effects to their resource or use of concern. A more detailed description of the level of engagement USACE has had with MRRIC is included in Section 5.1, Missouri River Recovery Implementation Committee. In addition to regularly engaging with MRRIC, and seeking input from the general public, USACE has conducted additional meetings throughout the Missouri River Basin in an effort to specifically provide information and seek input from minority and low-income populations. Impacts to environmental justice populations are addressed in Section 3.22, Environmental Justice. USACE would take all appropriate measures to ensure that management actions described in the MRRMP-EIS would not disproportionately adversely impact minority or low-income communities.

6.7 Farmland Protection

Farmland Protection Policy Act

The Farmland Protection Policy Act (7 USC 4201, et seq.) requires federal agencies to coordinate with the USDA to develop criteria for identifying the effects of federal programs on the conversion of farmland to non-agricultural uses. USACE will coordinate with USDA before implementation of site-specific projects where Management Plan actions have the potential to convert farmland to non-agricultural uses. More information regarding the potential impacts from conversion of farmland are described in Section 3.10, Land Ownership.

6.8 Air Quality

Clean Air Act

The Clean Air Act (42 USC 7401 et seq.), amended in 1977 and 1990, was established “to protect and enhance the quality of the Nation's air resources so as to promote public health and welfare and the productive capacity of its population.” The Clean Air Act authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. The Clean Air Act establishes emission standards for stationary sources, volatile organic compound emissions, hazardous air pollutants, and vehicles and other mobile sources. USACE does not anticipate impacts to air quality from implementation of actions under the Management Plan. If a site-specific project presents potential for impacts to air quality to occur from a USACE action, it will comply with EPA standards and operations. Potential impacts to air quality from the alternatives are described in Section 3.8, Air Quality.

6.9 Navigation

Rivers and Harbors Act

The Rivers and Harbors Appropriation Act of 1899 (33 USC 1344) prohibits obstruction or alteration of any navigable water of the United States. The purpose of the act was to preserve the public right of navigation and prevent interference with interstate and foreign commerce unless authorized by Congress and approved by the Chief of Engineers and Secretary of the Army. The Missouri River is designated a navigable water under the Rivers and Harbor Act. Actions implemented as part of the Management Plan are focused on habitat projects which are designed, constructed, implemented, and monitored to avoid and minimize negative impacts to the System’s authorized purposes including navigation. Prior to any site-specific construction project, a NEPA analysis will be completed and monitoring will be conducted to detect any issues such as shoaling in the navigation channel. If issues are detected then adjustments will be made to restore the authorized 9-foot-deep by 300-foot-wide navigation channel. All site-specific projects will comply with requirements of Section 10 of the Rivers and Harbors Act. Potential impacts to navigation are addressed in Section 3.15, Navigation.

6.10 Recreation

Federal Water Project Recreation Act

The Federal Water Project Recreation Act (16 USC 4612 et seq.) requires federal agencies to give full consideration to outdoor recreation and fish and wildlife enhancement in the investigating and planning of any federal navigation, flood control, reclamation, hydroelectric, or multipurpose water resource project, whenever any such project can reasonably serve either or both purposes consistently. Projects must be constructed, maintained, and operated to provide recreational opportunities, consistent with the purposes of the project. Potential impacts to recreation are addressed in Section 3.16, Recreation.

6.11 Wild and Scenic Rivers Act

6.11.1 Missouri National Recreational River

Some of the proposed actions in the preferred alternative would take place within the Missouri National Recreational River, river reaches designated under the Wild and Scenic Rivers Act (16 USC 1271 et seq.) and managed as a unit of the National Park System. The Missouri National Recreational River is managed by the National Park Service (NPS), which is a cooperating agency in the development of the MRRMP-EIS. Under the Wild and Scenic Rivers Act, a federal agency may not carry out actions that would have a direct and adverse effect on the free-flowing, scenic, and natural values of a federally designated wild or scenic river.

The Missouri National Recreational River was established by Congress in 1978 and expanded in 1991 to preserve the Outstandingly Remarkable Values (ORVs) of two free-flowing sections of the Missouri River on the border of South Dakota and Nebraska. In total, the Missouri National Recreational River includes 98 miles of Missouri River, 20 miles of the lower Niobrara River to its Missouri River confluence, and 8 miles of Verdigre Creek to its Niobrara River confluence. The protected values of the Missouri National Recreational River, as determined in a 2011 Missouri National Recreational River ORV workshop and further defined by the 2012 Missouri National Recreational River ORV report, are free-flowing condition, water quality, and the following ORVs: cultural, ecological, fish and wildlife, geological, recreational, and scenic.

The primary focus for the management of the Missouri National Recreational River segments is to “protect and enhance” the ORVs for which the segments were designated. Outstandingly remarkable values are defined by the Wild and Scenic Rivers Act as the characteristics that make a river worthy of protection. As a fish and wildlife value, the Missouri National Recreational River is very important to the piping plover and least tern. Both stretches are designated critical habitat for the piping plover because of the presence of emergent sandbar habitat (ESH). Critical habitat is a term defined and used in the ESA that refers to specific geographic areas that contain features essential to the conservation of an endangered or threatened species and that may require special management and protection. These species were included in the pre-listing document for the 9-mile segment. In addition to being protected under the ESA the birds are “values” for which the river was designated within the “fish and wildlife” general value.

Pursuant to its responsibilities under the ESA, Wild and Scenic Rivers Act, and NPS Organic Act, the NPS has evaluated the preferred alternative management actions that would occur in the Missouri National Recreational River. The NPS found that ESH program activities would not be compatible with ORV protection goals in some specifically identified river reaches, because according to the NPS assessment they may have a direct and adverse effect on river values.

As the adaptive management component of the MRRMP is implemented, the NPS will assess and review each project within the Missouri National Recreational River on a case by case basis and may issue individual Section 7(a) determinations for each action when specific project details are made available.

The NPS has expressed a commitment to continued coordination and conversation regarding the ESH program within Missouri National Recreational River with the USACE, USFWS, and other ESH Project Development Team (PDT) partners, to ensure that river values are protected while meeting the objectives of the MRRMP-EIS.

Chapter 7 References

Anders, P. J., and L. G. Beckman. 1993. Location and timing of white sturgeon spawning in three Columbia River impoundments. Report B. Pages 47–59 in R. C. Beamesderfer and A. A. Nigro. Volume 1: Status and habitat requirements of the white sturgeon populations in the Columbia River downstream from McNary Dam. Final Report to Bonneville Power Administration, Portland, OR.

Andre, R.G. 1981. The Vector Competence of Selected Species of Iowa Mosquitoes for Three Strains of Western Equine Encephalomyelitis Virus. Doctoral Dissertation. Entomology, Iowa State University. Ames, Iowa.

Anteau, M.J., M.H. Sherfy, and M.T. Wiltermuth. 2012a. Selection Indicates Preference in Diverse Habitats: A Ground-nesting Bird (*Charadrius melodus*) Using Reservoir Shoreline. Plos One 7(1). Doi.e3034710.1371/journal.pone.0030347.

Anteau, MJ, TL Shaffer, MH Sherfy, MA Sovada, JH Stucker, and MT Wiltermuth. 2012. "Nest Survival of Piping Plovers at a Dynamic Reservoir Indicates an Ecological Trap for a Threatened Population," *Oecologia*, 170(4):1167-1179. doi:10.1007/s00442-012-2384-y.

Anteau, M.J., M.T. Wiltermuth, M.H. Sherfy, and T.L. Shaffer. 2014. "Measuring and Predicting Abundance and Dynamics of Habitat for Piping Plovers on a Large Reservoir," *Ecological Modelling*, 272(0):16-27. doi:http://dx.doi.org/10.1016/j.ecolmodel.2013.08.020.

AWRA (American Water Works Association) n.d. “Buried No Longer: Confronting America’s Water Infrastructure Challenge.” Available at: http://www.awwa.org/Portals/0/files/legreg/documents/BuriedNoLonger.pdf

Backes, K.M., W.M. Gardner, D. Scarnecchia, and P.A. Stewart. 1994. Lower Yellowstone River Pallid Sturgeon Study IV and Missouri River Creel Survey. Montana Department of Fish, Wildlife and Parks, Fisheries Division, Miles City, Montana.

Barko, V.A., M. W. Palmer, D.P. Herzog, and B.S. Ickes. 2004. Influential Environmental Gradients and Spatiotermporal Patterns of Fish Assemblages in the Unimpounded Upper Mississippi River. American Midland Naturalist., V(152) No. 2: 369-385.

Barko, V.A., and D.P. Herzog. 2003. Relationship among side channels, fish assemblages, and environmental gradients in the unimpounded Upper Mississippi River. Journal of Freshwater Ecology. 18: 377-382.

Birdsey, R.A. 1996. Carbon Storage for Major Forest Types and Regions in the Coterminous United States. In: Sampson, N.; Hair, D., (Eds.). Forests and Global Change. Forest Management Opportunities for Mitigating Carbon Emissions. Washington, D.C. *American Forests*. (2) 1-25, Appendixes 2-4.

Blevins, D.W., and J. Fairchild. 2001. Applicability of NASQAN data for ecosystem assessments on the Missouri River. *Hydrologic Processes*. 15:1347-1362.

Blevins, D.W., D.H. Wilkison, and S.L. Niesen. 2014. Pre- and Post-Impoundment Nitrogen in the Lower Missouri River. *Hydrological Processes*. 28(4):2535-2549.

Bouchard, M., D. Butman, T. Hawbaker, Z. Li, J. Liu, S. Liu, C. McDonald, R. Reker, K. Sayler, B. Sleeter, T. Sohl, S. Stackpoole, A. Wein, and Z. Zhu (ed). 2011. Baseline and projected future carbon storage and greenhouse-gas fluxes in the Great Plains region of the United States. U.S. Geological Survey, Professional Paper 1787. Available at: https://pubs.usgs.gov/pp/1787/p1787.pdf.

Bragg, T.B., and A.K. Tatschl. 1977. Changes in flood-plain vegetation and land use along the Missouri River &om 1826 to 1972. Environmental Management I(4): 343-348.

Braaten, P.J., C.M. Elliott, J.C. Rhoten, D.B. Fuller, B.J. McElroy. 2015. Migrations and swimming capabilities of endangered pallid sturgeon (*Scaphirhynchus albus*) to guide passage designs in the fragmented Yellowstone River. Restoration Ecology 23(2): 186-195.

Braaten, P.J., D.B. Fuller, L.D. Holte, R.D. Lott, W. Viste, T.F. Brandt, and R.G. Legare. 2008. Drift Dynamics of Larval Pallid Sturgeon and Shovelnose Sturgeon in a Natural Side Channel of the Upper Missouri River, Montana. *North American Journal of Fisheries Management*. 28(3):808–826.

Braaten, P.J., D.B. Fuller, R.D. Lott, and G.R. Jordan. 2009. An estimate of the historic population size of adult pallid sturgeon in the upper Missouri River Basin, Montana and North Dakota. Journal of Applied Ichthyology 25(s2): 2-7.

Braaten P.J., D.B. Fuller, R.D. Lott, M.P. Ruggles, and R.J. Holm. 2010. Spatial Distribution of Drifting Pallid Sturgeon Larval in the Missouri River Inferred from Two Net Designs and Multiple Sampling Locations. North American Journal of Fisheries Management 30:1062-1074

Braaten, P.J., D.B. Fuller, R.D. Lott, M.P. Ruggles, T.F. Brandt, R.G. Legare, and R.J. Holm. 2012. An Experimental Test and Models of Drift and Dispersal Process of Pallid Sturgeon (*Scaphirhynchus albus*) Free Embryos in the Missouri River. Environmental Biology of Fishes 93:377-392.

Bramblett, R.G. 1996. Habitat and Movements of Pallid and Shovelnose Sturgeon in the Yellowstone and Missouri Rivers, Montana and North Dakota. Ph.D. Dissertation. Bozeman, Montana: Montana State University. p. 210.

Bramblett, R.G., and R.G. White. 2001. Habitat Use and Movements of Pallid and Shovelnose Sturgeon in the Yellowstone and Missouri Rivers in Montana and North Dakota. Transactions of the American Fisheries Society 13 0: 1 006-1 025.

Brauer, E.J., D.R. Busse, C. Strauser, R.D. Davinroy, D.C. Gordon, J.L. Brown, J.E. Myers, A.M. Rhoads, and D. Lamm. 2005. Geomorphology study of the Middle Mississippi River. U.S. Army Corps of Engineers, St. Louis District, Applied River Engineering Center, St. Louis, Missouri.

Brauer, E.J., R.D. Davinroy, L. Briggs, and D. Fisher. 2013. Draft supplement to Geomorphology study of the Middle Mississippi River (2005). U.S. Army Corps of Engineers, St. Louis District, Applied River Engineering Center, St. Louis, Missouri.

Bringolf, R.B., W.G. Cope, S. Mosher, M.C. Barnhart, and D. Shea. 2007. Contaminant sensitivity of freshwater mussels: Acute and chronic toxicity of glyphosate compounds to glochidia and juveniles of Lampsislis siliquoidea (Unionidae). Environmental Toxicology and Chemistry 26(10):2094-2100.

Brown, T.C., J.C. Bergstrom, and J.B. Loomis. 2007. Defining, Valuing and Providing Ecosystem Goods and Services. *Natural Resource Journal*. 47(2):329-376.

Buckler, J. 2011. Persistent Organic Pollutant Effect on Middle Mississippi River Scaphirhynchus Sturgeon Reproduction and Early Life Stages. Columbia, Mo. University of Missouri-Columbia. M.S. Thesis. p.154.

Buehler, D.A. 2000. Bald Eagle (*Haliaeetus leucocephalus*), The Birds of North America Online. A. Poole (Ed.). Ithaca: Cornell Lab of Ornithology. Retrieved June 2016, from http://bna.birds.cornell.edu/bna/species/506 doi:10.2173/bna.506.

Buenau, K., C. Aron, V. Cullinan, C. Huber, J. Ledwin, C. Smith, T. Swannack, C. Vernon. 2014a. *Draft Narrative of Conceptual Ecological Models for Interior Least Terns and Piping Plovers on the Missouri River,* Pacific Northwest National Laboratory.

Buenau, K., V. Cullinan, C. Huber, and C. Vernon. 2014b. *Draft Interim Effects Analysis Integrated Report,* Pacific Northwest National Laboratory.

Buenau, K.E., T.L. Hiller, and A.J. Tyre. 2014c. Modeling the Effects of River Flow on Population Dynamics of 22 Piping Plovers (*Charadrius melodus*) and Least Terns (*Sternula antillarum*) nesting on the Missouri 23 River, River Research and Applications, 30, pages 964–975, doi: 10.1002/rra.2694

Buenau, K.E., C.J. Huber, V. Cullinan, C. Vernon, C. Aron, C. Smith, J. Ledwin, R. Fischer, and T. Swannack. 2014d. Draft Hypotheses for Emergent Sandbar Habitat, Piping Plovers, and Least Terns.

Buenau, K. 2015. *Modeling to Support the Development of Habitat Targets for Piping Plovers on the Missouri River,* Pacific Northwest National Laboratory.

Buenau K.E., C.J. Huber, V.I. Cullinan, C.A. Smith, C.R. Vernon. 2016a. Conceptual Ecological Models and Hypotheses for Piping Plovers and Interior Least Terns on the Missouri River. prepared for the U.S. Army Corps of Engineers, Omaha District, Omaha, Nebraska by the Pacific Northwest National Laboratory, Richland, Washington.

Buenau K.E., C.J. Huber, V.I. Cullinan, C.R. Vernon. 2016b. Final Interim Missouri River Effects Analysis Integrated Report: Piping Plovers and Least Terns. prepared for the U.S. Army Corps of Engineers, Omaha District, Omaha, Nebraska by the Pacific Northwest National Laboratory, Richland, Washington.

Bureau of Reclamation (U.S. Bureau of Reclamation). 2003. Canyon Ferry Reservoir Resource Management Plan/environmental Assessment. United States Department of the Interior. p. 375.

Bureau of Reclamation and USACE. 2016a. National Large Wood Manual. Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure. 628p.

Bureau of Reclamation and USACE. 2016b. Draft Environmental Impact Statement for the Intake Diversion Dam Fish Passage Project, Dawson County, Montana.

Burton, M., and L. Bray. 2016. Missouri River Water-Compelled Railroad Rates: Review and Qualitative Update, July 2016.

Caceres, M.C., and M.J. Pybus. 1997. Status of the Northern Long-Eared Bat (*Myotis septentrionalis*) in Alberta. Alberta Environmental Protection, Wildlife Management Division. Wildlife Status Report No. 3, Edmonton, AB. p. 19.

Cairns, W.E. 1982. Biology and breeding behavior of breeding Piping Plovers. Wilson Bulletin. 94: 531-545.

Campbell Transportation Company, Inc. 2018. Barge Draft Tables. Available: http://www.barges.us/barge-draft-tables/Accessed: January 20, 2018.

Catlin, D.H. 2009. Population dynamics of piping plovers (*Charadrius melodus*) on the Missouri River. PhD Dissertation. Virginia Institute of Technology. Blacksburg. 106 pp.

Catlin, D.H., and J.D. Fraser 2006. Factors affecting piping plover nesting density and population numbers on the Missouri River, on created and natural bars. Field Operations Report 2006. Virginia Tech. Blacksburg, VA. 13 pp.

Catlin, D.H., and J.D. Fraser 2007. Factors affecting piping plover nesting density and population numbers on the Missouri River, on created and natural bars, field operations report 2007. Department of Fisheries and Wildlife, Virginia Polytechnic Institute and State University. Unpublished document.

Catlin, D.H., J.D. Fraser, J.H. Felio, and J.B. Cohen. 2011. Piping plover habitat selection and nest success on natural, managed, and engineered sandbars. The Journal of Wildlife Management, 75: 305–310. doi:10.1002/jwmg.46.

Catlin, D.H., J.H. Felio, and J.D. Fraser. 2013. Effects of water discharge on fledging times, growth, and survival of piping plovers on the Missouri River. Journal of Wildlife Management, 77: 525–533.

Catlin, D.H., J.D. Fraser, and J.H. Felio. 2015. Demographic Responses of Piping Plovers to Habitat Creation on the Missouri River. *Wildlife Monographs*. 192:1-42.

CDC (Centers for Disease Control). 2016a. St. Louis Encephalitis Technical Fact Sheet. Retrieved June 6, 2016, from http://www.cdc.gov/sle/technical/fact.html.

CDC. 2016b. LaCrosse Encephalitis. Retrieved June 3, 2016, from http://www.cdc.gov/lac.

CDC. 2016c. Surveillance and Control of Aedes Aegypti and Aedes Albopictus in the United States. Retrieved June 7, 2016, from http://www.cdc.gov/chikungunya/resources/vector-control.html.

CDC. 2016e. West Nile Virus: Final Annual Maps & Data for 1999-2014. Information on reported West Nile Virus and fatalities in mainstem Missouri River states. Retrieved June 7, 2016, from http://www.cdc.gov/westnile/statsmaps/finalmapsdata/index.html.

CDC. 2016f. Zika Virus Disease in the United States. 2015–2016. Retrieved June 9, 2016, from http://www.cdc.gov/zika/geo/united-states.html.

CDC. 2016g. Key Messages – Zika Virus Disease. Updated June 2016. Retrieved June 23, 2016, from http://www.cdc.gov/zika/pdfs/zika-key-messages.pdf.

CDC. 2016h. CDC. 2017. Zika cases in the US: 2017 case counts in the US. Retrieved February 27, 2018, from https://www.cdc.gov/zika/reporting/2017-case-counts.html

CDC. 2016i. St. Louis Encephalitis – Epidemiology and Geographic Distribution. Retrieved June 9, from http://www.cdc.gov/sle/resources/SLEbyYear_2004-2013.pdf.

CDC. 2016j. Florida investigation links four recent Zika cases to local mosquito-borne virus transmission. CDC press release, July 29, 2016. Obtained from CDC website, accessed August 4, 2016 at http://www.cdc.gov/media/releases/2016/p0729-florida-zika-cases.html

CDC. 2017. Zika cases in the US: 2017 case counts in the US. Retrieved February 27, 2018, from https://www.cdc.gov/zika/reporting/2017-case-counts.html

CDIAC (Carbon Dioxide Information Analysais Center). 2012. Conversion Tables. Available at: http://cdiac.ess-dive.lbl.gov/pns/convert#2.

CEQ (Council on Environmental Quality). 1997. Considering Cumulative Effects Under the National Environmental Policy Act. Executive Office of the President. January 1997.

CEQ. 2014a. Memorandum for Heads of Federal Departments and Agencies on Effective Use of Programmatic NEPA Reviews. December 18, 2014.

CEQ. 2014. Revised Draft Guidance for Federal Department and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change. NEPA Reviews. Federal Register. 79:247. December 24, 2014. Retrieved May 20, 2016 from, http://energy.gov/nepa/downloads/revised-draft-guidance-consideration-greenhouse-gas-emissions-and-climate-change-nepa.

Chapman, F.A., and S.H. Carr. 1995. Implications of early life stages in the natural history of the Gulf of Mexico sturgeon, Acipenser oxyrinchus desotoi. Environmental Biology of Fishes 43:407–413.

Cofrancesco, Jr., A.F. 1990. Evaluation of Mosquito Breeding on Corps of Engineers Properties Adjacent to Williston, North Dakota. US Department of the Army, Corps of Engineers.

Conover, G., R. Simmonds, and M. Whalen (eds). 2007. Management and control plan for bighead, black, grass, and silver carps in the United States. Asian Carp Working Group, Aquatic Nuisance Species Task Force, Washington, D.C. 223 pp.

Cook, B.I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains Science Advances. 12 Feb 2015: Vol. 1, no. 1, e1400082.

Crites, J.W., Q.E. Phelps, K.N.S. McCain, D.P. Herzog, and R.A. Hrabik. 2012. An investigation of fish community and water quality compositions in an isolated side channel of the upper Mississippi River, Journal of Freshwater Ecology, 27:1, 19-29, DOI: 10.1080/02705060.2011.599988

Crompton, J.L. 2005. The Impact of Parks on Property Values: Empirical Evidence from the Past Two Decades in the United States. Managing Leisure 10:203-218. Available at: http://agrilifecdn.tamu.edu/cromptonrpts/files/2011/06/4_1_6.pdf.

CWS and USFWS (Canadian Wildlife Service and U.S. Fish and Wildlife Service). 2007. International Recovery Plan for the Whooping Crane. Ottawa: Recovery of Nationally Endangered Wildlife (RENEW), and U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 162 pp.

Davinroy, R. 2006. Sedimentation in the Upper Mississippi River Basin. U.S. Army Corps of Engineers.

D'Elia, A.H., G.C. Liles, J.H. Viers, and D.R. Smart. 2017. Deep carbon storage potential of buried floodplain soils. Scientific Reports 7(8181). Distributed under a Commons Attribution 4.0 International License. Available at: http://www.nature.com/articles/s41598-017-06494-4.

de Groot, R.P.S., A. van de Berg, and B. Amelung. 2005. Ecosystems and Human Well-Being: Current State and Trends: Findings of the Condition and Trends Working Group. *Cultural and Amenity Services*. 1:455.

DeLonay, A.J., K.A. Chojnacki, J.D.A. Faulkner, J.S. Candrl, and D.K. Combs. 2015. Comparative studies of the initiation of drift behavior by three sturgeon species in an experimental stream [abs.]: Oshkosh, Wis., North American Sturgeon and Paddlefish Association. Also available at http://www.nasps-sturgeon.org/media/33336/NASPS%202015%20Abstracts%20in%20Alphabetical%20Order.pdf.

DeLonay, A.J., K.A. Chojnacki, R.B. Jacobson, J.L. Albers, J.P. Braaten, E.A. Bulliner, C.M. Elliott, S.O. Erwin, D.B. Fuller, J.D. Haas, H.L.A. Ladd, G.E. Mestl, D.M. Papoulias, and M.L. Wildhaber. 2016. Ecological Requirements for Pallid Sturgeon Reproduction and Recruitment in the Missouri River: A Synthesis of Science, 2005-2012: U.S. Geological Survey, Scientific Investigations Report 2015-5145, 224 p. https://pubs.er.usgs.gov/publication/sir20155145

DeLonay, A.J., R.B. Jacobson, M.L. Annis, P.J. Braaten, K.A. Chojnacki, C.M. Elliott, D.B. Fuller, J.D. Haas, T.M. Haddix, B.J. McElroy, G.E. Mestl, D.M. Papoulias, J.C. Rhoten, and M.L. Wildhaber. 2014. Ecological requirements for pallid sturgeon reproduction and recruitment in the Missouri River: Annual report 2011. USGS Open File Report 2014–1106. 96 p.

DeLonay, A.J., R.B. Jacobson, D.M. Papoulias, D.G. Simpkins, M.L. Wildhaber, J.M. Reuter, T.W. Bonnot, K.A. Chojnacki, C.E. Korschgen, G.E. Mestl, and M.J. Mac. 2009. Ecological Requirements for Pallid Sturgeon Reproduction and Recruitment in the Lower Missouri River: A Research Synthesis 2005–08. *U.S. Geological Survey, Scientific Investigations Report 2009–5201*. p. 59.

Deng, D.F., S. Koshio, S. Yokoyama, S.C. Bai, Q.J. Shao, Y.B. Cui, and S.S.O. Hung. 2003. Effects of Feeding Rate on Growth Performance of White Sturgeon (*Acipenser transmontanus*) Larvae. Aquaculture 217:589–598.

Dettlaff, T.A., A.S. Ginsburg, and O.I. Schmalhausen. 1993. Sturgeon Fishes—Developmental Biology and Aquaculture. Berlin, Springer-Verlag, 300 p.

DeVoto, B. 1997. The Journals of Lewis and Clark. Mariner Books. 576p.

Dom, N.C., A.H. Ahmad, and R. Ismail. 2013. Habitat Characterization of Aedes Sp. Breeding in Urban Hotspot Areas. ASEAN Conference on Environment-Behaviour Studies, Hanoi Architectural University. Hanoi, Vietnam. pp. 19-22.

Doyle, M., D. Murphy, S. Bartell, A. Farmer, C. Guy, M. Palmer, and R. Turner. 2011. Missouri River Recovery Program Independent Science Advisory Panel—Final Report on Spring Pulses and Adaptive Management. Prepared for the U.S. Institute for Environmental Conflict Resolution and Missouri River Recovery Implementation Committee, 11–STRI–1482.

Dryer, M.P., and A.J. Sandvol. 1993. Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*): U.S. Fish and Wildlife Service, 55 p.

Duffy, W.G., C.R. Berry, and K.D. Keenlyne. 1996. The Pallid Sturgeon—Biology and Annotated Bibliography through 1994. South Dakota Cooperative Fish and Wildlife Research Unit, 32 p.

Duncan, D. 2016. Personal communication with Kara Reeves, USACE regarding the effects to water supply intakes on the Mississippi River, July 12, 2016.

Dunn, J. 2015. Personal Communication between H. Bender and L. McDonald, Pinyon Environmental, and J. Dunn, U.S. EPA Region 7 NPDES Specialist Regarding the Missouri River Management Plan, Proxy Results, and an Approach to Estimate Impacts for Missouri River Facilities. December 14.

Dunn, J. 2016. Personal Communication between J. Dunn, Environmental Protection Agency, and H. Bender, Pinyon Environmental, Regarding Wastewater Facilities and Low Flow Criteria. January 6, 2016.

Dunn, R.A. 1996. Impacts to Historic Properties in Drawdown Zones at Corps of Engineers Reserviors. Technical Report EL-96-7, US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Earth Economics. 2010. Gaining Ground. Wetlands, Hurricanes and the Economy: The Value of Restoring the Mississippi River Delta.

Echols, K.R., W.G. Brumbaugh, C.E. Orazio, T.W. May, B.C. Poulton, and P.H. Peterman. 2008. Distribution of Pesticides, PAHs, PCBs, and Bioavailable Metals in Depositional Sediments of the Lower Missouri River, USA. *Archives of Environmental Contamination and Toxicology.* 55(2):161-172.

EIA (U.S. Energy Information Administration). 2014. Extended Midwest Reliability Organization Region States. Retrieved 2014 from http://www.eia.gov/state/.

EIA. 2015. Form EIA-860. Retrieved April 2015, from https://www.eia.gov/electricity/data/eia860/. and retrieved October 2015, from https://www.eia.gov/electricity/data/eia860.

EIA. 2016a. Nameplate capacity-glossary. Retrieved April 2016, from https://www.eia.gov/tools/glossary/index.cfm?id=N.

EIA. 2016b. 2014 Average Monthly Bill- Residential. Retrieved March 2016, from http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf.

EIA. 2016c. EIA-923 Monthly Generation Unit Net Generation Time Series. Files 2012-2015. Retrieved March 2016, from https://www.eia.gov/electricity/data/eia923/.

EIA. 2017. Annual Energy Outlook 2017. Posted January 5, 2017. Accessed January 2018. https://www.eia.gov/outlooks/archive/aeo17/

Elliot, C., and R.B. Jacobson. 2006. Geomorphic Classification and Assessment of Channel Dynamics in the Missouri River National Recreational River, South Dakota and Nebraska. Reston, Virginia.

Elliott-Smith, E., and S.M. Haig. 2004. Piping plover (*Charadrius melodus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. Available on line http://bna.birds.cornell.edu/bna/species/002 (Accessed January 19, 2011).

EPA (U. S. Environmental Protection Agency). 1993. Reregistration Eligibility Decision (RED) for Glyphosate. EPA-738-F-93-011.

EPA. 1998. Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analysis. Retrieved August 25, 2011, from http://www.epa.gov/environmentaljustice/resources/policy/ej_guidance_nepa_epa0498.pdf.

EPA. 2004. Drinking Water Treatment. Fact Sheet EPA 816-F-04-034. Retrieved from http://water.epa.gov/lawsregs/guidance/sdwa/upload/2009_08_28_sdwa_fs_30ann_treatment_web.pdf.

EPA. 2005a. "National Management Measures to Control Nonpoint Source Pollution from Forestry." EPA 841-B-05-001. May 2005. Available at: http://www.epa.gov/sites/production/files/2015-10/documents/ch3g.pdf.

EPA. 2005b. Reregistration Eligibility Decision (RED) for Imazapyr. List C. Case Number 3078. Prevention, Pesticides and Toxic Substances (7508C). EPA 738-R-06-007 2006. OPP-2005-0495.

EPA. 2014. Air Emissions Inventories by Source Sector, National Emissions Inventory V 1. Accessed: https://www3.epa.gov/cgi-bin/broker?polchoice=CO&_debug=0&_service=data&_program=dataprog.national_1.sas. Accessed January 12, 2018.

EPA. 2015a. National Ambient Air Quality Standards (NAAQS). United States Environmental Protection Agency. Air and Radiation Home Page. Retrieved June 11, 2015, from http://www.epa.gov/air/criteria.html.

EPA. 2015b. Overview of Greenhouse Gases. Retrieved from https://www3.epa.gov/climatechange/ghgemissions/gases/co2.html.

EPA. 2015c. A compilation of Cost Data Associated with the Impacts and Control of Nutrient Pollution. https://www.epa.gov/sites/production/files/2015-04/documents/nutrient-economics-report-2015.pdf

EPA. 2015d. 2014 Greenhouse Gas Emissions from Onshore Petroleum and Natural gas Production. EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT). Retrieved August 4, 2016, from https://ghgdata.epa.gov/ghgp/main.do.

EPA. 2015e. Clean Water Rule: Definition of “Waters of the United States.” https://www.federalregister.gov/documents/2015/06/29/2015-13435/clean-water-rule-definition-of-waters-of-the-united-states

EPA. 2016a. Green Book Nonattainment Areas. National Area and County-Level Multi-Pollutant Information, Nonattainment/Maintenance Area Status for Each County by Year for All Criteria Pollutants. Retrieved from https://www3.epa.gov/airquality/greenbook/anayo_mo.html.

EPA. 2016b. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. August 2016. Available online at: https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf. Last Accessed: February 28, 2018.

EPA. 2016c. eGRID2014v2 Summary Tables: GHG Annual Output Emission Rates. Available online at: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid. Last Accessed: February 28, 2018.

EPA. 2016d. eGRID2014_Data_v2. Available online at: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid. Last Accessed: February 28, 2018.

EPA. 2017. Air Emissions Inventories. Air Emission Sources. June 2nd. Access March 5th, 2018. [Data file] Retrieved from https://www.epa.gov/air-emissions-inventories/air-emissions-sources.

ERDC (Engineer Research and Development Center). 2008. Evaluating Potential Entrainment of Pallid Sturgeon during Sand Mining Operations, Summary of Field Study. ERDC-WES-EL, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Erwin, S.O., E.A. Bulliner, C.J. Fischenich, R.B. Jacobson, P.J. Braaten, A.J. DeLonay. in press, Evaluating Flow Management as a Strategy to Recover an Endangered Sturgeon Species in the Upper Missouri River, USA; River Research and Applications.

Espie, R.H.M., P.C. James, and R.M. Brigham. 1998. The Effects of Flooding on Piping Plover Charadrius Melodus Reproductive Success at Lake Diefenbaker, Saskatchewan, Canada. *Biological Conservation*. 86(2):215-222. doi:10.1016/s0006-3207(98)00001-9.

Farajollahi, A., and D.C. Price. 2013. A Rapid Identification Guide for Larvae of the Most Common North American Container-Inhabiting Aedes Species of Medical Importance. *Journal of the American Mosquito Control Association*. 29(3):203–221.

Fears, D. 2013. Drought threatens to halt critical barge traffic on Mississippi River. The Washington Post. January 6.

Felio, J.H., D.H. Catlin, and J.D. Fraser. 2009. Great Plains plover project 2008: Evaluating piping plover population dynamics and engineered sandbar habitat: Field operations report 2008. Department of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Felio, J.H., D.H. Catlin, and J.D. Fraser. 2010a. Great Plains plover project 2009: evaluating piping plover population dynamics and engineered sandbar habitat field operations report 2009. Department of Fisheries and Wildlife, Virginia Tech. Blacksburg, VA. 16a.

Felio, J.H., D.H. Catlin, and J.D. Fraser. 2010b. Great Plains plover project 2010: evaluating piping plover population dynamics and engineered sandbar habitat field operations report 2010. Department of Fisheries and Wildlife, Virginia Tech. Blacksburg, VA. 10 pp.

FEMA (Federal Emergency Management Agency). 2006. Multi-hazard loss estimation methodology, flood model, HAZUS, technical manual, developed by the Department of Homeland Security, Emergency Preparedness and Response Directorate, FEMA, Mitigation Division, Washington, D.C., under a contract with the National Institute of Building Sciences, Washington, D.C.

Fischenich, J.C. 2018 Hydrologic, Hydraulic, and Geomorphic Models and Analyses to Support the Missouri River Effects Analysis. ERDC Technical Report TR-16-X. Engineer and Development Center Environmental Laboratory. Vicksburg, MS.

Fischenich, J., J. Tripe, D. Meier, D. Pridal, S. Givson, J. Hickey, and T. Econopouly. 2014. Models, Data and Literature to Support Habitat Analyses for the Missouri River Effects Analysis. U.S. Army Corps of Engineers, Vicksburg, Mississippi. 80 pp.

Fischenich, J.C., R. McComas, D. Meier, J. Tripe, D. Pridal, P. Boyd, S. Gibson, J. Hickey, T. Econopouly, and L. Strong. 2014. Habitat Analyses for the Missouri River Effects Analysis – Geomorphic Team Integrative Report.

Fischenich et al. 2017. Habitat Assessments in Support of the Missouri River Recovery Program Effects Analysis; Hydrogeomorphic Team Integrative Report. ERDC Technical Report EL TR-17-XX. Vicksburg, MS: US Army Engineer Research and Development Center.

Fletcher, S. 2012. Personal communication. Wildlife Conservation Officer, Department of Wildlife, Fish and Recreation, Lower Brule Sioux Tribe. Information provided to Elizabeth Peake by telephone July 13, 2012, regarding fishing and hunting activities by Tribal members and recreation facilities that have been recently built or are damaged/nonfunctional.

Follett, R.F., E.G. Pruessner, S.E. Samson-Liebig, J.M. Kimble, and S.W. Waltman. 2001. Carbon Sequestration under the Conservation Reserve Program in the Historic Grassland Soils of the United States of America. I R. Lal (Ed.). Carbon Sequestration and Greenhouse Effect. *Soil Science Society of America Special Publication*. No. 57. pp 27 – 40.

French, W.E. 2010. Predation Vulnerability and Trophic Interactions of Pallid Sturgeon *Scaphirhynchus albus*. South Dakota State University, Brookings, South Dakota, 59 p.

Fryda, D. 2016. Email correspondence between Holly Bender at Pinyon Environmental and Dave Fryda, North Dakota Game and Fish regarding visitation at Lake Sakakawea. Sept. 8.

Fuller, D.B., and P.J. Braaten. 2012. For Peck Flow Modification Biological Collection Plan compendium; a summary of 2001 - 2009 activities. Report prepared for the U.S. Geological Survey.

Fuller, D.B., M.E. Jaeger, and M. Webb. 2008. Spawning and Associated Movement Patterns of Pallid Sturgeon in the Lower Yellowstone River: U.S. Army Corps of Engineers, 22 p.

Funk, J.L., and J.W. Robinson. 1974. Changes in the Channel of the Lower Missouri River and Effects on Fish and Wildlife. Missouri Department of Conservation. p. 52.

Galat, D.L, L.H. Fredrickson, D.D. Humburg, K.J. Bataille, J.R. Bodie, J. Dohrenwend, G.T. Gelwicks, J.E. Havel, D.L. Helmers, J.B. Hooker, J.R. Jones, M.F. Knowlton, J. Kubisiak, J. Mazourek, A.C. McColpin, R.B. Renken, and R.D. Semlitsch. 1998. Flooding to Restore Connectivity of Regulated, Large-River Wetlands: Natural and Controlling Flooding as Complementary Processes Along the Lower Missouri River. *BioScience*. 48(9) 721-733.

Galat, D.L., and R. Lipkin. 2000. Restoring Ecological Integrity of Great Rivers—Historical Hydrographs Aid in Defining Reference Conditions for the Missouri River: Hydrobiologia. 422(0): 29–48.

Galat, D.L., M.L. Wildhaber, and D.J. Dieterman. 2001. Spatial Patterns of Physical Habitat. Volume 2. Population Structure and Habitat Use of Benthic Fishes along the Missouri and Lower Yellowstone Rivers. U.S. Geological Survey. Cooperative Research Units. University of Missouri.

Galat, D.L., G.W. Whitledge, and G.T. Gelwicks. 2004. Influence of Lateral Connectivity on Larval Fish Assemblage Structure and Habitat Use in Lower Missouri River Floodplain Water Bodies. Final Report to Missouri Department of Conservation. U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri, Columbia.

Galat, D.L., C.R. Berry, Jr., E.J. Peters, and R.G. White. 2005a. Missouri River Basin. In Benke, A.C. and Cushing, C.E. (Eds.). *Rivers of North America*. Elsevier, Oxford, UK. pp. 427-480.

Galat, D.L., C.R. Berry, W.M. Gardner, J.C. Hendrickson, G.E. Mestl, G.J. Power, Stone, Clifton, and Winston, M.R. 2005b. Spatiotemporal Patterns and Changes in Missouri River Fishes. *American Fisheries Society Symposium*. 45:249–291.

Garvey, J.E., E.J. Heist, R.C. Brooks, D.P. Herzog, R.A. Hrabik, K.J. Kilgore, J.J. Hoover, and C.E. Murphy. 2009. Current Status of the Pallid Sturgeon (*Scaphirhynchus albus*) in the Middle Mississippi River—Habitat, Movement, and Demographics. U.S. Army Corps of Engineers, 353 p.

Gemeinhardt T.R., N.J.C. Gosch, D.M. Morris, M.L. Miller, T.L. Welker, and J.L. Bonneau. 2016. Is Shallow Water a Suitable Surrogate for Assessing Efforts to Address Pallid Sturgeon Population Declines? *River Research and Applications* 32:734-743.

Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, T.C. Richmond, K. Reckhow, K. White, and D. Yates. 2014. Ch. 3: Water Resources. Climate Change Impacts in the United States: The Third National Climate Assessment, J.M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, 69-112. Available at: http://nca2014.globalchange.gov/report/sectors/water.

Gerrity, P.C., C.S. Guy, and W.M. Gardner. 2006. Juvenile Pallid Sturgeon are Piscivorous—A Call for Conserving Native Cyprinids. Transactions of the American Fisheries Society 135: 604–609.

Giuseppe, F., M. Pavan, M. Gramek, P. Kafarski, and J. Lipok. 2006. Biochemical Bases for a Widespread Tolerance of Cyanobacteria to the Phosphonate Herbicide Glyphosate. *Plant and Cell Physiology* 49:443-456.

Gleason, R.A., B.A. Tangen, B.A. Browneb, and N.H. Euliss, Jr. 2009. Greenhouse Gas Flux from Cropland and Restored Wetlands in the Prairie Pothole Region. *Soil Biology & Biochemistry.* 41:2501–7.

Goodman B.J., C.S. Guy, S.L. Camp, W.M. Gardner, K.M. Kappenman, M.A.H. Webb. 2012. Shovelnose sturgeon spawning in relation to varying discharge treatments in a Missouri River tributary. River Research and Applications 29:1009–1015.

Gosch, N.J., D.M. Morris, T.R. Gemeinhardt, and J.L. Bonneau. 2013. Pre- and Post-Construction Assessment of Nutrient Concentrations at Shallow Water Habitat Restoration Sites on the Lower Missouri River. *Journal of Water Resource and Protection.* 5:249-258.

Gosch, N.J.C., M.L. Miller, T.R. Gemeinhardt, S.J. Sampson, and J.L. Bonneau. 2015. Age-0 Sturgeon Accessibility to Constructed and Modified Chutes in the Lower Missouri River. *North American Journal of Fisheries Management*. 35:75-85.

Gosch, N.J.C., T.R. Gemeinhardt, W.W. Bouska, M.L. Miller, T.L. Brown, and J.L. Bonneau. 2016. Age-0 Sturgeon and Shallow Water: Assessing Catch and Habitat Use to Inform Adaptive Management Efforts in the Lower Missouri River. U.S. Army Corps of Engineers 2014-2015 Habitat Assessment and Monitoring Program Report.

Gosch, N.J.C., T.R. Gemeinhardt, W.W. Bouska, M.L. Miller, T.L. Brown, and J.L. Bonneau. 2017. Age-0 Sturgeon and Shallow Water: A Local- and Reach-Scale Assessment. River Research and Application. DOI: 10.1002/rra.3195

Gratto-Trevor, C., D. Amirault-Langlais, D. Catlin, F. Cuthbert, J. Fraser, S. Maddock, E. Roche, and F. Shaffer. 2012. "Connectivity in Piping Plovers: Do Breeding Populations Have Distinct Winter Distributions?" *Journal of Wildlife Management*. 76(2):348-355. doi:10.1002/jwmg.261.

Grohs, K.L., R.A. Klumb, S.R. Chipps, and G.A. Wanner. 2009. Ontogenetic Patterns in Prey Use by Pallid Sturgeon in the Missouri River, South Dakota and Nebraska. *Journal of Applied Ichthyology*. 25:48–53.

Gutreuter, S., A.D. Bartels, K. Irons, and M.B. Sandheinrich. 1999. Evaluation of the Flood-Pulse Concept Based on Statistical Model of Growth of Selected Fishes of the Upper Mississippi River System. Canadian Journal of Fisheries and Aquatic Sciences 56:2282–2291.

Guy, C.S., H.B. Treanor, K.M. Kappenman, E.A. Scholl, J.E. Ilgen, and M.A.H Webb. 2015. Broadening the Regulated-River Management Paradigm— A Case Study of the Forgotten Dead Zone Hindering Pallid Sturgeon Recovery. *Fisheries.* 40(1):6–14. [available at http://dx.doi.org/10.1080/03632415.2014.987236.]

Hadley, G.L., and J.J. Rotella. 2009. Upper Basin Pallid Sturgeon Survival Estimation Project: Final Report. Montana State University. Bozeman, Montana. pp. 34.

Haig. 1992. Piping plover. *In* The Birds of North America, No. 2 (A. Poole, P. Stettenheim, and F. Gill, eds). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union. 17 pp.

Haig, S.M., and L.W. Oring 1988. Mate, site, and territory fidelity in piping plovers. The Auk. 105(2): 268-277.

Hallberg, G.R., J.M. Harbaugh, and P.M. Witinok. 1979. Changes in the Channel Area of the Missouri River in Iowa, 1879–1976. *Iowa Geological Survey*. p. 32.

Ham, C., J.B. Loomis, and P.A. Champ. 2015. Relative Economic Values of Open Space Provided by National Forest and Military Lands to Surrounding Communities. Growth and Change 46(1):81-96. Available at: https://www.fs.fed.us/rm/pubs_journals/2015/rmrs_2015_ham_c001.pdf.

Hansen, A.T., C.L. Dolph, E. Foufoula-Georgiou, and J.C. Finlay. Contribution of wetlands to nitrate removal at the watershed scale. *Nature Geoscience* 11, 127-132.

Haring, H.J., K.A. Blocksom, M.E. Smith, T. Angradi, M.C. Wratschko, B. Armstrong, D. Bolgrien, and J.M. Lazorchak. 2010. Sediment Toxicity in Mid-Continent Great Rivers (USA). *Archives of Environmental Contamination and Toxicology*. 60(1):57-67.

Haroldson, M. 2015. Personal Communication between H. Bender, Pinyon Environmental, and M. Haroldson, NPDES Program Manager, Division of Water Quality for the North Dakota Department of Health Regarding How Effluent Limits are Estimated for North Dakota Facilities that Discharge to the Missouri River. June 18.

Harrison, A.B., W.T. Slack, and K.J. Killgore. 2014. Feeding Habitats of Young-of-Year River Sturgeon *Scaphirhynchus* spp. in the Lower Mississippi River. *The American Midland Naturalist* 171:54–67.

Havel, J.E., K.A. Medley, K.D. Dickerson, T.R. Angradi, D.W. Bolgrien, P.A. Bukaveckas, and T.M. Jicha. 2009. Effect of Main-Stem Dams on Zooplankton Communities of the Missouri River (USA). *Hydrobiologia*. 628:121-135.

Helfrich, L.A., C. Liston, S. Heibert, M. Albers, and Frazer, K. 1999. Influence of Low-Head Diversion Dams on Fish Passage, Community Composition, and Abundance in the Yellowstone River, Montana. Rivers 7:21-32.

Heroff, B. Archer Daniels Midland Co. 2017. Personal communication with Holly Bender, Natural Resource Economist, Pinyon Environmental, Chris Bouquot, USACE Navigation Economist and Kara Reeves, Economist, USACE Omaha District to discuss Middle Mississippi River navigation. December 29, 2017.

Hesse, L.W., and W. Sheets. 1993. The Missouri River Hydrosystem. *Fisheries*. 18(5):5–14.

Hesse, L.W., G.E. Mestl, P.P. Sensenbaugh, P.A. Tornblom, R.J. Hollis, T.L. Nuttlemann, and J.A. Vaughn. 1992. Recreational Use Survey of the Missouri River in Nebraska – Summer. Draft Report, Federal Aid in Fish Restoration, Dingell-Johnson Project F-75-R. Nebraska Game and Parks Commission, Lincoln, Nebraska. October 1992. 29 pages plus 76 tables and 1 appendix.

Hesse, L.W., G.E. Mestl, P.P. Sensenbaugh, P.A. Tornblom, R.J. Hollis, T.L. Nuttlemann, J.A. Vaughn, and J.A. Harrison. 1993. Recreational Use Survey of the Missouri River in Nebraska. Federal Aid in Fish Restoration, Dingell-Johnson Project F-75-R-10. Performance Report Study I. Nebraska Game and Parks Commission, Lincoln, Nebraska. March 1993. 212 pages.

Hesse, L.W., C.W. Wolfe, and N.K. Cole. 1988. Some Aspects of Energy Flow in the Missouri River Ecosystem and a Rationale for Recovery. Benson, N.G. (Ed.). The Missouri River—The Resources their Uses and Values: North Central Division of the American Fisheries Society Special Publication 8. pp. 13–20.

Hey, D.L., D.L. Montgomery, L.S. Urban, T. Prato, A. Forbes, M. Martell, J. Pollack, Y. Steele, and R. Zarwell. 2004. Flood Damage Reduction in the Upper Mississippi River Basin: An Ecological Alternative. The Wetlands Institute.

Hoover, J.J., K.J. Killgore, D.G. Clarke, H. Smith, A. Turnage, and J. Beard. 2005. Paddlefish and Sturgeon Entrainment by Dredges: Swimming Performance as an Indicator of Risk. DOER Technical Notes Collection, ERDC TN-DOER-E22, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Houseman, R. 2011. Flooding, Mosquitoes and West Nile Virus: What You Need to Know. University of Missouri Extension.

HSIP (Homeland Security Infrastructure Program) Gold. 2012. (NGA (National Geospatial-Intelligence Agency) and Homeland Infrastructure Foundation-Level Data (HIFLD) Working Group, HSIP Gold 2012.

Hupfeld, R.N., Q.E. Phelps, M.K. Flammang, and G.W. Whitledge. 2015. Assessment of the Effects of High Summer Water Temperatures on Shovelnose Sturgeon and Potential Implications of Climate Change. *River Research Applications* 31:1195-1201.

Hydropower Analysis Center. 2015. Personal Communication between H. Bender, Pinyon Environmental and M. Parrish and M. Ryan, Hydropower Specialists Regarding Energy and Capacity Values. Multiple conversations and email correspondence.

Hydropower Analysis Center. 2018. Personal Communication between Holly Bender, Pinyon Environmental, Chris Dixon, Louis Berger, and Margaret Ryan, USACE Hydropower Analysis Center regarding energy and capacity values. February 5.

IA DNR (Iowa Department of Natural Resources). 2010a. Lake Manawa State Park. Accessed May 24, 2010, at the following Web site: http://www.iowadnr.gov/parks/state_park_list/lake_manawa.html

IA DNR. 2010b. Lewis and Clark State Park. Accessed May 24, 2010, at the following Web site: http://www.iowadnr.gov/parks/state_park_list/lewis_clark.html.

IA DNR. 2010c. Wilson Island State Recreation Area. Accessed February 23, 2010, at the Web site: http://www.iowadnr.gov/parks/state_park_list/wilson_island.html.

IDPH (Iowa Department of Public Health). 2014. Vector-Borne Diseases 2014 Final Report. Des Moines, IA. Iowa Department of Public Health Center for Acute Disease Epidemiology.

Illinois Environmental Protection Agency. 2016. Drinking Water Watch. Retrieved July 2016, from http://water.epa.state.il.us/dww/index.jsp.

Ireland, S.C., R.C.P., Beamesderfer, V.L. Paragamiam, and J.T. Siple. 2002. Success of Hatchery-Reared Juvenile White Sturgeon (*Acipenser transmontanus*) Following Release in the Kootenai River, Idaho, U.S.A. Journal of Applied Ichthyology 18:642–650.

ISAP. 2015. Evaluation of the Draft Bird Adaptive Management Cycle Example.

Jacobson, R.B., and D.L. Galat. 2006. Flow and Form in Rehabilitation of Large-River Ecosystems—An Example from the Lower Missouri River. *Geomorphology*. 77(3–4): 249–269.

Jacobson, R.B., and D.L. Galat. 2008. Design of a Naturalized Flow Regime — An Example from the Lower Missouri River, USA: Ecohydrology, v. 1, no. 2, p. 81–104. [Also available at http://dx.doi.org/10.1002/eco.9.]

Jacobson, R.B., D.W. Blevins, and C.J. Bitner. 2009. Sediment Regime Constraints on River Restoration—An Example from the Lower Missouri River. *The Geological Society of America Special Paper*. v. 451.

Jacobson, R.B., M.J. Parsley, M.L. Annis, M.E. Colvin, T.L. Welker, and D.A. James. 2015a. Science Information to Support Missouri River *Scaphirhynchus albus* (pallid sturgeon) Effects Analysis: *U.S. Geological Survey Open-File Report* 2015–1226, 78 p., http://dx.doi.org/10.3133/ofr20151226.

Jacobson, R.B., M.J. Parsley, M.L. Annis, M.E. Colvin, T.L. Welker, and D.A. James. 2015b. Development of Conceptual Ecological Models Linking Management of the Missouri River to Pallid Sturgeon Population Dynamics: *U.S. Geological Survey Open-File Report* 2015-1038, 47 p., http://dx.doi.org/10.3133/ofr20151038.

Jacobson, R.B, G. Lindner, and C. Bitner. 2015c. The Role of Floodplain Restoration in Mitigating Flood Risk, Lower Missouri River, USA. Chapter in Geomorphic Approaches to Integrated Floodplain Management of Lowland Fluvial Systems in North America and Europe. Springer New York. pp. 203-243.

Jacobson, R.B., M.J. Parsley, M.L. Annis, M.E. Colvin, T.L. Welker, and D.A. James. 2015d. Missouri River Pallid Sturgeon Effects Analysis Integrative Report 2015. U.S. Geological Survey. *Scientific Investigations Report*.

Jacobson, R.B., M.J. Parsley, M.L. Annis, M.E. Colvin, T.L. Welker, and D.A. James. 2016a. Development of Working Hypotheses Linking Management of the Missouri River to Population Dynamics of *Scaphirhynchus albus* (pallid sturgeon): U.S. Geological Survey Open-File Report 2015–1236, 33 p., http://dx.doi.org/10.3133/ofr20151236.

Jacobson, R.B., M.L. Annis, M.E. Colvin, D.A. James, T.L. Welker, and M.J. Parsley. 2016b. Missouri River *Scaphirhynchus albus* (pallid sturgeon) Effects Analysis—Integrative Report 2016: U.S. Geological Survey Scientific Investigations Report 2016–5064, 154 p., http://dx.doi.org/10.3133/sir20165064.

Jaeger, M., A. Ankrum, T.M. Watson, G.L. Hadley, J. Rotella, G. Jordan, R. Wilson, S.L. Camp, T. Thatcher, and K. Boyd. 2009. Pallid Sturgeon Management and Recovery in the Yellowstone River, 2008 Annual Report. Montana Fish, Wildlife and Parks, Glendive, Montana, p. 311.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The Flood Pulse Concept in River-Floodplain Systems. Canadian Special Publication of Fisheries and Aquatic Sciences. 106:110–127.

Kappenman, K.M., W.C. Fraser, M. Toner, J. Dean, and M.A.H. Webb. 2009. Effect of Temperature on Growth, Condition, and Survival of Juvenile Shovelnose Sturgeon. Transactions of the American Fisheries Society 138:927-937.

Keenlyne, K.D., and L.G. Jenkins. 1993. Age at Sexual Maturity of the Pallid Sturgeon. Transactions of the American Fisheries Society 122:393–396.

Kieffer, M.C., and B. Kynard. 1996. Spawning of shortnose sturgeon in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 125:179–186.

KDOH (Kansas Department of Health). 2016. Arboviral Disease Surveillance in Kansas. Retrieved June 7, 2016, from http://www.kdheks.gov/epi/arboviral_disease.htm.

Korman pers. comm. 2015. Personal Communication between B. Korman, NPS Missouri National Recreation River, and J. Dobb, Pinyon Environmental, regarding activities along the Missouri River. December 21.

Kynard, B., E. Parker, D. Push, and T. Parker. 2007. Use of Laboratory Studies to Develop a Dispersal Model for Missouri River Pallid Sturgeon Early Life History Intervals. Journal of Applied Ichthyology 23:365-374.

LaPointe, D. Jr. 2012. Personal communication. Parks and Wildlife Director, Santee Sioux Nation. Information provided to Elizabeth Peake by telephone June 22, 2012, regarding hunting, fishing, and recreational activities by Santee Sioux Nation members.

Larsen, S., J.P. DeGroote, L.C. Bartholomay, and R. Suguraman. 2010. Ecological Niche Modeling of Potential West Nile Virus Vector Mosquito Species in Iowa. *Journal of Insect Science*. 10:110.

Lavers, J.L., C. Wilcox, and C.J. Donlan. 2010. "Bird Demographic Responses to Predator Removal Programs," *Biological Invasions*, 12(11):3839-3859. doi:10.1007/s10530-010-9776-x.

Le Fer, D. 2006. Piping Plover (*Charadrius melodus*) Foraging Ecology in the Great Plains. Ph.D. Dissertation. Virginia Polytechnic Institute and State University.

Lehman, W. "National Structure Inventory." *Advances in Hydrologic Engineering* (Mar. 2015): 10-11. Print.

Lenihan, D.J., T.L. Carrell, S. Fosberg, L. Murphy, S.L. Rayl, and J.A. Ware. 1981. The Final Report of the National Reservoir Inundation Study Vol. I. United States Department of the Interior. National Park Service Southwest Cultural Resources Center. Santa Fe, New Mexico.

Little Swallow, L. 2012. Personal communication. Natural Resource Department, Three Affiliated Tribes. Information provided to Elizabeth Peake by telephone July 17, 2012, regarding Tribal recreation activities and favorite recreation sites.

Long, G. 2014. Lower Missouri River Pallid Sturgeon Structured Expert Judgment Elicitation Workshop. Prepared by Compass Resource Management.

Longhenry, C. 2016. Email correspondence between Holly Bender at Pinyon Environmental and Chris Longhenry, South Dakota Game, Fish, and Parks. Regarding visitation at the reservoirs. Aug 10, August 19, and September 23.

Loomis, J.B., and D.S. White. 1996. Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis. *Ecological Economics*. 18(3). pp. 197-206.

Lott, C.A., R.L. Wiley, R.A. Fischer, P.D. Hartfield, and J.M. Scott. 2013. Interior Least Tern (*Sternula antillarum*) Breeding Distribution and Ecology: Implications for Population-Level Studies and the Evaluation of Alternative Management Strategies on Large, Regulated Rivers. *Ecology and Evolution*. 3(10):3613-3627. doi:10.1002/ece3.726.

Love, S.A., Q.E. Phelps, S.J. Tripp, and D.P. Herzog. 2017. The Importance of Shallow-Low Velocity Habitats to Juvenile Fish in the Middle Mississippi River. *River Research and Applications*. 33:321–327.

Lutzenhiser, M., and N.R. Netusil. 2001. The Effect of Open Spaces on a Home’s Sale Price. Contemporary Economic Policy 19(3):291-298. Available at: http://www.greenstogreen.org/pdfs/resources/resources-openspaces-homesaleprices.pdf.

Magnan, R. 2009. Personal communication. Director, Fish and Game Department, Fort Peck Tribes. Information provided to Elizabeth Peake by telephone July 10, 2009, regarding characteristics of hunting, fishing, trapping, and other recreational activities by Tribal members and non-members along the Missouri River adjacent to the Fort Peck Reservation

Marcelli, J.W. 2012. Investigation of West Nile Virus Infection Rates in Culex Tarsalis at Medicine Lake Wildlife Refuge and Ninepipe Wildlife Refuge 2011. Honors Thesis, Carroll College. Department of Natural Sciences. Helena, Montana.

Marotz, B.L., and M.S. Lorang. Pallid sturgeon larvae: The drift dispersion hypothesis. J Appl Ichthyol. 2017;00:1-9. https://doi.org/10.1111/jai.13569

McCauley, B., M. Ritter, and L. Schaughnessy. 2000. A Synopsis of the Mosquitoes of Missouri and their Importance from a Health Perspective Compiled from literature on the subject.

Mcgowan, C.P., D.H. Catlin, T.L. Shaffer, C.L. Gratto-Trevor, and C. Aron. 2014. Establishing Endangered Species Recovery Criteria Using Predictive Simulation Modeling. Biological Conservation. 177(0):220-229. doi:http://dx.doi.org/10.1016/j.biocon.2014.06.018.

MDHSS (Missouri Department of Health and Senior Services). 2016. West Nile virus data and statistical reports obtained from MDHSS website. Retrieved June 1, 2016, fromhttp://health.mo.gov/living/healthcondiseases/communicable/westnilevirus/reports.php.

Meade, R.H., and J.A. Moody. 2010. Causes for the decline of suspended-sediment discharge in the Mississippi River System, 1940–2007. Hydrol. Process. 24, 35–49 (2010). www.interscience.wiley.com.

Millenium Ecosystem Assessment. 2003. Ecosystems and Human Well-being: A Framework for Assessment. Retrieved from http://www.millenniumassessment.org/documents/document.356.aspx.pdf.

MISO (Midcontinent Independent System Operator). 2014. MISO 2013 Annual Market Assessment Report. Information Delivery and Market Analysis. June 2014. Available online at: https://www.misoenergy.org/Library/Repository/Report/Annual%20Market%20Report/2013%20Annual%20Market%20Assessment%20Report.pdf. Last Accessed: July 20th, 2016.

MISO. 2016. Reserves Tighten in the MISO Region. June 10, 2016. MISO Media: 317-432-4507. Retrieved August 5, 2016, from https://www.misoenergy.org/AboutUs/MediaCenter/PressReleases/Pages/ReservesTighteninthMISORegion.aspx.

Missouri Department of Conservation. 2011. Missouri Department of Conservation Regions and Areas. Accessed January 14, 2011, at the Web site: http://mdc.mo.gov.

Missouri Department of Conservation. 2012a. Site Map and Site Regulations accessed July 25, 2012 at the MDC information overlay on GoogleEarth for all MDC River Access areas.

Missouri Department of Conservation. 2012b. Missouri Department of Conservation Rules 3 CSR 10-11.140. Accessed January 30, 2012 to determine at which MDC areas boaters were allowed to beach their boats and camp overnight near the boat.

Missouri Department of Natural Resources. 2010a. Missouri State Parks and Historic Sites: Big Lake State Park. Accessed May 18, 2010, at the Web site: http://mostateparks.com/biglake.htm.

Missouri Department of Natural Resources. 2010b. Missouri State Parks and Historic Sites: Clark's Hill/Norton State Historic Site. Accessed May 18, 2010, at: http://mostateparks.com/clarkshill.htm.

Missouri Department of Natural Resources. 2010c. Missouri State Parks and Historic Sites: Edward "Ted" and Pat Jones-Confluence Point State Park. Accessed May 18, 2010, at the Web site: http://mostateparks.com/confluence.htm.

Missouri Department of Natural Resources. 2010d. Missouri State Parks and Historic Sites: Lewis and Clark State Park. Accessed May 18, 2010, at the Web site: http://mostateparks.com/lewisandclark.htm.

Missouri Department of Natural Resources. 2010e. Missouri State Parks and Historic Sites: Van Meter State Park. Accessed May 18, 2010, at the Web site: http://mostateparks.com/vanmeter.htm.

Missouri Department of Natural Resources. 2010f. Missouri State Parks and Historic Sites: Weston Bend State Park. Accessed May 18, 2010, at the Web site: http://mostateparks.com/westonbend.htm.

Missouri Department of Natural Resources. 2010g. Missouri State Parks and Historic Sites: Arrow Rock State Historic Site. Accessed November 29, 2010, at: http://mostateparks.com/arrowrock.htm.

Missouri Department of Natural Resources. 2010h. Missouri State Parks and Historic Sites: Battle of Lexington State Historic Site. Viewed November 29, 2010, at the Web site: http://mostateparks.com/lexington.htm.

Missouri Department of Natural Resources. 2010i. Missouri State Parks and Historic Sites: First Missouri State Capitol State Historic Site. Accessed November 29, 2010, at the Web site: http://mostateparks.com/firstcapitol.htm.

Missouri Department of Natural Resources. 2010j. Missouri State Parks and Historic Sites: Jefferson Landing State Historic Site. Accessed November 29, 2010, at the Web site: http://mostateparks.com/jeffersonland.htm.

Missouri Department of Natural Resources. 2010k. Missouri State Parks and Historic Sites: Katy Trail State Park. Accessed November 29, 2010, at: http://mostateparks.com/katytrail.htm.

Missouri Department of Natural Resources. 2010l. Missouri State Parks and Historic Sites: Recreation Directory. Accessed November 29, 2010 at: http://mostateparks.com/directory.htm.

Missouri Department of Natural Resources. 2016a. Proposed 2016 Section 303(d) Listed Waters. Retrieved April 26, 2016, from http://dnr.mo.gov/env/wpp/waterquality/303d/303d.htm.

Missouri Department of Natural Resources. 2016b. Water system search by Public Water Supply System. Retrieved July 2016, from https://www.dnr.mo.gov/DWW/indexSearchDNR.jsp.

MNDH (Minnesota Department of Health). 2018. Western Equine Encephalitis Fact Sheet. Revised May 2005. Retrieved July 19, 2018, fromhttp://www.health.state.mn.us/divs/idepc/diseases/weencephalitis/wee.pdf.

Montana Department of Natural Resources & Conservation. 2016. Water Rights. http://wr.msl.mt.gov/default.aspx

MRRP (Missouri River Recovery Program). 2008. Bald Eagles and Cottonwood Trees: a Dynamic Duo.

MTFWP (Montana Fish, Wildlife and Parks). 2005. Montana's Comprehensive Fish and Wildlife Conservation Strategy. Montana Fish, Wildlife & Parks. Helena, Montana.

Murphy, D.D., and P.S. Weiland. 2011. The Route to Best Science in Implementation of the Endangered Species Act's Consultation Mandate: The Benefits of Structured Effects Analysis. Environmental Management 47: 161. doi:10.1007/s00267-010-9597-9.

Murray, E., J. Cushing, L. Wagner, and D.J. Tazik. 2013. Incorporating Ecosystem Goods and Services in Environmental Planning- Definitions, Classifications, and Operational Approaches. ERDC TN-EMRRP-EP-18.

NASS (National Agricultural Statistics Service). 2016. United States Department of Agriculture, National Agricultural Statistics Service. 2012 Census of Agriculture. Retrieved from http://www.nass.usda.gov/index.php.

National Climatic Data Center, National Oceanic and Atmospheric Administration. 2016. 2014 Annual Summary. Retrieved from http://www.ncdc.noaa.gov/cdo-web/.

NatureServe. 2009. Possible Vegetation Alliances and Associations in the Missouri River Valley. Arlington, VA.

NDDH (North Dakota Department of Health). 2015. North Dakota 2014 Integrated Section 305(b) Water Quality Assessment Report and Section 303(d) List of Waters Needing Total Maximum Daily Loads. Approved February 12, 2015. Retrieved fromhttps://www.ndhealth.gov/wq/sw/Z7_Publications/IntegratedReports/2014_North_Dakota_Integrated_Report_Final_20150428.pdf.

NDDH. 2016. Mosquito Information. Retrieved June 7, 2016, from http://www.ndhealth.gov/WNV/Mosquito/Default.html.

NDGFD (North Dakota Game and Fish Department). 2009. North Dakota Paddlefish Snagging Season: Annual Phone Survey Results and Summary Information, 1992-2008. Word table 2 pages long emailed to Elizabeth Peake March 3, 2009, by Northwest District Fisheries Biologist Fred Ryckman, NDGFD, Williston, ND.

Nebraska Department of Natural Resources. 2016. Surface Water Rights. http://www.dnr.ne.gov/surface-water-rights

NEDEQ (Nebraska Department of Environmental Quality). 2016. Water Quality Integrated Report. Retrieved April 26, 2016, from http://deq.ne.gov/Publica.nsf/Pages/WAT234.

NEPA (National Environmental Policy Act) Task Force. 2003. Modernizing NEPA Implementation. Report to the Council on Environmental Quality.

National Geospatial-Intelligence Agency (NGA) and Homeland Infrastructure Foundation-Level Data (HIFLD) Working Group, Homeland Security Infrastructure Program (HSIP), HSIP Gold 2012.

NGPC (Nebraska Game and Parks Commission). 2009a. Niobrara State Park. Accessed March 2, 2009, at the Web site: http://www.ngpc.state.ne.us/parks/guides/parksearch/showpark.asp?Area_No=126.

NGPC. 2009b. Ponca State Park. Accessed March 2, 2009, at the Web site: http://www.ngpc.state.ne.us/parks/guides/parksearch/showpark.asp?Area_No=143.

NGPC. 2010a. Brownville State Recreation Area. Accessed May 4, 2010, at the Web site: http://www.ngpc.state.ne.us/parks/guides/parksearch/printpark.asp?Area_No=36.

NGPC. 2010b. Indian Cave State Park. Accessed May 4, 2010, on the Web at: http://www.ngpc.state.ne.us/parks/guides/parksearch/printpark.asp?Area_No=91.

NGPC. 2010c. Lewis and Clark State Recreation Area. Accessed May 4, 2010, at the Web site: http://www.ngpc.state.ne.us/parks/guides/parksearch/printpark.asp?Area_No=101.

NGPC. 2010d. Pelican Point State Recreation Area. Accessed May 4, 2010, at the Web site: http://www.ngpc.state.ne.us/parks/guides/parksearch/printpark.asp?Area_No=223.

NGPC. 2010e. Riverview Marina State Recreation Area. Accessed May 4, 2010, at the Web site: http://www.ngpc.state.ne.us/parks/guides/parksearch/printpark.asp?Area_No=151.

Nico, L., and P. Fuller. 2010. Hypophthalmichthys nobilis. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Accessed online, November 8, 2010. Available: http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=551 Revision Date: 3/13/2009.

Niswonger pers. comm. 2016. Personal Communication between D. Niswonger, Missouri Department of Conservation and H. Bender, Pinyon Environmental, regarding angler activities on the Missouri River. January 6.

Nixon, R. 2013. Farm Subsidies Leading to More Water Use. The New York Times. http://www.nytimes.com/2013/06/07/us/irrigation-subsidies-leading-to-more-water-use.html.

North American Electric Reliability Corporation. 2012. Regional Entities. Retrieved June 19, 2012, from http://www.nerc.com/page.php?cid=1|9|119.

North Dakota State Water Commission. 2016. Water Permits. http://www.swc.nd.gov/info_edu/map_data_resources/waterpermits/

NPS (National Park Service). 2003. Missouri River: Missouri National Recreational River, Nebraska/South Dakota. Brochure with map. Publication GPO: 2003-496-196/40662.

NPS. 2009. Monthly vehicle counts for Mulberry Bend Overlook and Niobrara State Park Overlook in Nebraska and Standing Bear Bridge Overlook in South Dakota. Provided to Elizabeth Peake by email from Stephen K. Wilson, Resource Management/GIS Specialist, NPS, Yankton, SD, February 26, 2009.

NPS. 2010a. 39-Mile Reach Guide. Accessed July 28, 2010, at the Web site: http://www.nps.gov/mnrr/39guide.htm.

NPS. 2010b. 59-Mile Reach Guide. Accessed July 28, 2010, at the Web site: http://www.nps.gov/mnrr/59guide.htm.

NRC (National Research Council). 2002. The Missouri River Ecosystem. Exploring the Prospects for Recovery. Committee on Missouri River Ecosystem Science, Water Science and Technology Board, Division of Earth Science and Life Studies. Washington, D.C. National Academy Press.

NRC. 2004. Adaptive Management for Water Resources Project Planning. Panel on Adaptive Management for Resource Stewardship, Water Science and Technology Board, Division on Earth and Life Studies. Washington, D.C.

NRC. 2010. Missouri River Planning: Recognizing and Incorporating Sediment Management. Committee on Missouri River Recovery and Associated Sediment Management Issues. National Academy Press, Washington, D.C.

NRC. 2011. Missouri River Planning: Recognizing and Incorporating Sediment Management. Committee on Missouri River Recovery and Associated Sediment Management Issues. National Academy Press, Washington, D.C. 165 p.

NRCS (National Resources Conservation Service). (n.d.) Restoring America's Wetlands: A Private Lands Conservation Success Story. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1045079.pdf.

NRCS. 2008. Biology Technical Note: Wetlands, Mosquitoes, and West Nile Virus. NRCS Indiana Office.

NRCS. 2012. Conserving Prairie Pothole Wetlands: Evaluating their Effects on Carbon Sequestration in Soils and Vegetation. CEAP Science Note. Retrieved from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1080434.pdf.

NRCS. 2015. Natural Resources Inventory Summary Report. August. Available: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd396218.pdf. Accessed March 23, 2018.

NRCS. 2016. GHG and Carbon Sequestration Ranking Tool. NRCS Practice Standards for Greenhouse Gas Emission Reduction and Carbon Sequestration. Retrieved June 15, 2016, from http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/air/?cid=stelprdb1044982.

NRCS. 2017. Soil survey manual. C. Ditzler, K. Scheffe, and H.C. Monger (eds.). USDA Handbook 18. Government Printing Office, Washington, D.C. available: https://www.nrcs.usda.gov/

NRCS. 2017. Soil Survey Geographic (SSURGO) Database. USA Soils Farmland Class, ArcGIS Imagery Service. Available online: http://www.arcgis.com/home/item.html?id=9708ede640c640aca1de362589e60f46. Accessed October, 2017.

NSI (National Structure Inventory). 2010. https://maps.crrel.usace.army.mil/apex/nsi_dev.cm2.map

Oldenburg, E.W., B.J. Goodman, J.W. Boyd, and T.P. Hanrahan. 2010. Pallid Sturgeon Population Assessment Project and Associated Fish Community Monitoring for the Missouri River. Missouri River Recovery—Integrated Science Program, U.S. Army Corps of Engineers, 20 p.

Opperman, J., and L. Buss. 2008. Projects Restore Floodplain Ecosystems while Reducing Flood Risk. The Corps Environment.

PAD-US (Protected Areas Database of the United States). 2012. Retrieved May 20, 2016, from http://gapanalysis.usgs.gov/padus/.

Palmer, R.S. 1967. Piping plover. *The shorebirds of North America. Viking Press, New York*, pp.168-169.

Papoulias, D.M., A.J. DeLonay, M.L. Annis, M.L. Wildhaber, and D.E. Tillitt. 2011. Characterization of Environmental Cues for Initiation of Reproductive Cycling and Spawning in Shovelnose Sturgeon *Scaphirhynchus platorynchus* in the Lower Missouri River, U.S.A. Journal of Applied Ichthyology 27:335–342.

Paragamian V. L., and V. D. Wakkinen. 2002. The effects of flow and temperature on the spawning of Kootenai River white sturgeon. Journal of Applied Ichthyology 18:608−616.

Parker, P.L., and King, T.F. 1998. Guidelines for the Evaluation and Documentation of Traditional Cultural Properties. United States Department of the Interior, National Park Service, National Register of Historic Places, Washington: District of Columbia.

Pear, R. 2012. After Three Decades, Tax Credit for Ethanol Expires. The New York Times. http://www.nytimes.com/2012/01/02/business/energy-environment/after-three-decades-federal-tax-credit-for-ethanol-expires.html.

Persoon, R. 2011. Personal communication. District Supervisor, South Dakota Game, Fish and Parks (SDGFP) Department. Information provided by telephone to Justin Brewer January 13, 2011, regarding facilities at various Lake Oahe sites owned and/or managed by SDGFP.

Peters, E.J., and J.E. Parham. 2008. Ecology and Management of Sturgeon in the Lower Platte River, Nebraska. (Nebraska Technical Series No. 18.) Nebraska Game and Parks Commission, Lincoln, NE.

Petersen, M.S. 1997. Chapter 2: Planning for Canalization, Engineering and Design - Monograph Prepared by M. Petersen on Inland Navigation and Canalization. EP 1110-2-14. Washington, D.C.: CECW-EH, November 30. Available at: http://140.194.76.129/publications/eng-pamphlets/EP_1110-2-14/toc.htm

Phelps, Q.E., S.J. Tripp, J.E. Garvey, D.P. Herzog, D.E. Ostendorf, J.W. Ridings, J.W. Crites, and R.A. Hrabik. 2010. Habitat Use During Early Life History Infers Recovery Needs for Shovelnose Sturgeon and Pallid Sturgeon in the Middle Mississippi River. *Transactions of the American Fisheries Society*. 139:1060-1068.

Philbert, A., and J.N. Ijumba 2013. Preferred Breeding Habitats of Aedes Aegypti Mosquito and its Public Health Implications in Dares Salaam, Tanzania. *Journal of Environmental Research and Management.* 4(10). pp. 344-351.

PNNL (Pacific Northwest National Laboratory). (2018). Effects Analysis Integrated Report for Least Tern and Piping Plover. Prepared for the U.S. Department of Energy.

Poff N.L., J.D. Allan, M.B. Bain, J. R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47: pp. 769–784.

Ponca Tribe of Nebraska. 2012. Overview of Office Locations. Retrieved July 15, 2012, from Ponca Tribe of Nebraska: http://www.poncatribe-ne.org/office_locations.php.

Porreca, A.P., W.D. Hintz, G.W. Whitledge, N.P. Rude, E.J. Heist, and J.E. Garvey. 2015. Establishing ecologically relevant management boundaries: linking movement ecology with the conservation of Scaphirhynchus sturgeon. Canadian Journal of Fisheries and Aquatic Sciences 73:877-884.

Port of Kansas City. 2017. Port KC Progress. December. Accessed: http://myemail.constantcontact.com/Port-KC-Progress-December-2017.html?soid=1110781875637&aid=RTjy7sbILB8 on February 28, 2018.

Poulton, B., M. Wildhaber, C. Charbonneau, J. Fairchild, B. Mueller, and C. Schmitt. 2003. A longitudinal assessment of the aquatic macroinvertebrate community in the channelized Lower Missouri River. Environmental Monitoring and Assessment 85:23-53.

Poulton, B.C., A.L. Allert, K.R. Echols, and W.G. Brumbaugh. 2005. Validation of Aquatic Macroinvertebrate Community Endpoints for Assessment of Biological Conditions in the Lower Missouri River. United States Geological Survey, Columbia Environmental Research Center. Columbia, Missouri. p. 197.

Pracheil, B.M., D.D. Snow, and M.A. Pegg. 2010. Distribution of Selenium, Mercury and Methylmercury in Surficial Missouri River Sediments. *Bulletin of Environmental Contamination and Toxicology*. 84:331–335.

Prater, A.J., J.H. Marchant, and J. Vuorinen. 1977. Guide to the identification and ageing of 89 holarctic waders. British Trust for Ornithology Guide #17. Maund and Irvine Ltd., Tring, Herts, England. 168 pp.

Prindiville-Gaines, E.M., and M.R. Ryan. 1998. Piping plover habitat use and reproductive success in North Dakota. Journal of Wildlife Management 52: 266-273.

Rhoads, B.L., D. Wilson, M. Urban, and E.E. Herricks. 1999. Interaction between Scientists and Nonscientists in Community-Based Watershed Management—Emergence of the concept of stream naturalization: Environmental Management, v. 24, no. 3, p. 297–308. [Also available at http://dx.doi.org/10.1007/s002679900234.]

Richards, R.R., C.S. Guy, M.A. Webb, W.M. Gardner, and C.B. Jensen. 2014. Spawning related movement of shovelnose sturgeon in the Missouri River above Fort Peck Reservoir, Montana. Journal of Applied Ichthyology 30:1-13.

Richardson, L., and J. Loomis. 2009. The Total Economic value of threatened, Endangered and Rare Species: An Updated Meta-Analysis. Ecological Economics 68(5): 1535-1548.

Ridenour C.J., W.J. Doyle, and T.D. Hill. 2010. Habitat Assessment and Monitoring Program 2010 Pilot Study: A Comparison of HAMP Bends to “End State” Habitats. Final Report to the U.S. Army Corps of Engineers.

Ridenour, C.J., W.J. Doyle, and T.D. Hill. 2011. Habitats of Age-0 Sturgeon in the Lower Missouri River. Transactions of the American Fisheries Society 140:1351–1358.

Ridenour, C.J., C.J. Wrasse, H.A. Meyer, W.J. Doyle, T.D. Hill. 2012. 2011 Contingency Sampling Report- Variation in Fish Assemblages Among four Habitat Complexes during a Summer Flood: Implications for Flow Refuge. Report to the U.S. Army Corps of Engineers. U.S. Fish and Wildlife Service, Columbia, Missouri. 39p.

Robinson, J. W. 2001. Missouri's Commercial Fishing Harvest, 1999. Missouri Department of Conservation, Non Federal Aid Project, Final Report. 39 pp. as cited in Tripp. S. D. Herzog, S. Reinagel, and J. McMullen. 2012. Final Report. Missouri Commercial Fish Harvest 2000-2012, Missouri Department of Conservation.

Rolston, M., and G. Johnson. 2012. Biology and Impact of Mosquitoes in Montana. Montana State University Extension.

Rotella, J. 2012. Upper Basin Pallid Sturgeon Survival Estimation Project—2010 Update. Report submitted to the Upper Basin Pallid Sturgeon Work Group, 64 p.

Rousseau, D. 2012. Personal communication. Game, Fish and Parks Director, Cheyenne River Sioux Tribe. Information provided by telephone June 13, 2012, regarding current and future facilities and activities at Tribal-operated recreation areas along Lake Oahe.

RTO Insider. 2017. “UPDATE: Capacity Survey Shows MISO in the Black”. RTOInsider.com. Available online at: https://www.rtoinsider.com/oms-miso-resource-adequacy-survey-44404/. Last Accessed: March 26, 2018.

Sanders, L.D., R.G. Walsh, and J.B. Loomis. 1990. Toward Empirical Estimation of the Total Value of Protecting Rivers. *Water Resources Research*. 26(7):1345-1358.

Sanders, R.M., D.G. Huggins, and F.B. Cross. 1993. The Kansas River system and its biota. Pages 295-326 in Restoration planning for the rivers of the Mississippi River ecosystem, L.W. Hesse, C.B. Stalnaker, N.G. Benson, and J.R. Zuboy, editors. U.S. Dept. of the Interior, National Biological Survey, Biological Report 19.

Schapaugh A., T.L. Hiller, and A.J. Tyre. 2010. The Pallid Sturgeon Habitat Assessment and Monitoring Program 2007-2009. University of Nebraska-Lincoln School of Natural Resources.

Schmulbach, J.C., L.W. Hesse, and J.E. Bush. 1992. The Missouri River-Great Plains Thread of Life. In: Becker, C.D. and Nietzel, D.A. (Eds.) *Water Quality in North American River Systems*. Columbus, Ohio. Batelle Press. pp. 137–158.

Schneiders, R.K. 1999. Unruly River: Two Centuries of Change along the Missouri. University Press of Kansas. Lawrence, Kansas. p. 314.

Schuckman, J. 2009a. Personal communication. Fisheries Specialist, Nebraska (NE) Game and Parks Commission, Norfolk, NE. Information provided to Elizabeth Peake during an interview February 10, 2009, regarding boating, waterfowl hunting, and angling use at the boat ramps and near sandbars in the Islands reach of the Lewis and Clark Lake Segment of the Missouri River.

Schwalbach, M.J., K.F. Higgins, J. Dinan, B.J. Dirks, and C.D. Kruse. 1993. Effects of Water Levels on Interior Least Terns and Piping Plover Nesting along the Missouri River in South Dakota. In Higgins, K.F. and Brashier, M.R. (Eds). *Proceedings of the Missouri River and its Tributaries: Piping Plover and Least Tern Symposium/Workshop*. South Dakota State University, Brookings. Pages 75-81.

SDDENR (South Dakota Department of Environment and Natural Resources). 2014. South Dakota Integrated Report for Surface Water Quality Assessment. Retrieved fromhttp://denr.sd.gov/documents/14irfinal.pdf.

Sechler, D.R. 2010. Effects of Abiotic and Biotic Factors on Diet Composition of Age-0 Sturgeon (*Scaphirhynchus spp.*) in the Middle Mississippi River. Southern Illinois University, Carbondale, Illinois, 79 p.

Sechler, D.R., Q.E. Phelps, S.J. Tripp, J.E. Garvey, D.P. Herzog, D.E. Ostendorf, J.W. Ridings, J.W. Crites, and R.A. Hrabik. 2012. Habitat for Age-0 Shovelnose Sturgeon and Pallid Sturgeon in a Large River: Interactions among Abiotic Factors, Food, and Energy Intake. North American Journal of Fisheries Management 32:24–31.

Sechler, D.R., Q.E. Phelps, S.J. Tripp, J.E. Garvey, D.P. Herzog, D.E. Ostendorf, J.W. Ridings, J.W. Crites, and R.A. Hrabik. 2013. Effects of River Stage Height and Water Temperature on Diet Composition of Year-0 Sturgeon (*Scaphirhynchus spp.*): A Multi-Year Study. Journal of Applied Ichthyology 29:44–50.

Secretary of War. 1881. Letter from the Secretary of War in relation to the improvement of the navigation of the Missouri River. Submitted to the House of Representatives, February 17, 1881.

Shafer, L. 2009. Personal communication. Water Quality Specialist/Biologist, Fort Peck Tribes-Office of Environmental Protection. Information provided to Elizabeth Peake by email February 27, 2009, regarding boat ramps used by Fort Peck Tribal members to access the Missouri River.

Shaffer, T.L., M.H. Sherfy, M.J. Anteau, J.H. Stucker, M.A. Sovada, E. Roche, M.T. Wiltermuth, D.A. Buhl, and C.M. Dovichin. 2013. Accuracy of Missouri River Least Tern and Piping Plover Monitoring Program: 24 Considerations for the Future, U.S. Geological Survey, prepared in cooperation with the U.S. Army 25 Corps of Engineers U.S.G. Survey, Reston, VA.

Shelley, J. and P. Bailey. 2018. The Cross Section Viewer: A Tool for Automating Geomorphic Analysis Using Cross Section Data. ERDC/TN RSM- 18-3. Vicksburg, MS: U.S. Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/26284.

Sherfy, M.H., J.H. Stucker, and D.A. Buhl. 2012. "Selection of Nest-Site Habitat by Interior Least Terns in Relation to Sandbar Construction," *Journal of Wildlife Management*, 76(2):363-371. doi:10.1002/jwmg.301.

Sheriff, S.L. 2015. Personal Communication between Steve Sheriff and Holly Bender, Pinyon Environmental regarding the lower river visitation estimates. January 5.

Sheriff, S.L., R.B. Renken, and T. Treiman. 2011. Missouri River Public Use Assessment: Final Report. Results from the 2004 Survey of River Users. Missouri Department of Conservation – Resource Science Division. Columbia, Missouri.

Simmons S.M. 2015. A comparison of fish communities between the main channel and side channels of the Middle Mississippi River. Unpublished M.S. Thesis. Southeast Missouri State University.

Skalak, K.J, A.J. Benthem, E.R. Schenk, C.R. Hupp, J.M. Galloway, R.A. Nustad, and G.J. Wiche. 2013. Large dams and alluvial rivers in the Anthropocene: The impacts of the Garrison and Oahe Dams on the Upper Missouri River: Anthropocene 2 (2013): 51-64. http://dx.doi.org/10.1016/j.ancene.2013.10.002

Sorenson, J. 2017. Personal communications between J. Sorenson (North Dakota State Water Commission) and A. Heller (Louis Berger) via email with records drawn from Water Permit Database.

Sorenson, J. 2018. Personal communications between J. Sorenson (North Dakota State Water Commission) and A. Heller (Louis Berger) via email with records drawn from Water Permit Database.

South Dakota Department of Environment & Natural Resources. 2016. Water Rights. http://denr.sd.gov/des/wr/dbwrsearch.aspx

South Dakota Game Fish and Parks. 2016. Annual Fish Population and Angler Use, Harvest, and Preference Surveys on Lake Oahe, 2015. Annual Report 16-03.

South Dakota State University Extension. 2013. Know Your Mosquitoes to Protect Yourself. July 15, 2013. Retrieved June 7, 2016, from http://igrow.org/gardens/home-and-garden-pests/know-your-mosquitoes-to-protect-yourself/.

Southwick Associates. 2011. The Economics Associated with Outdoor Recreation, Natural Resources Conservation and Historic Preservation in the United States. Available at: https://www.fws.gov/refuges/news/pdfs/TheEconomicValueofOutdoorRecreation%5B1%5D.pdf.

Spangler, A. 2015. Email Communication between H. Bender, Louis Berger, and A. Spangler Regarding How Effluent Limits Are Estimated for South Dakota Facilities that Discharge to the Missouri River. April 30, 2015.

Sparks, R.E., J.C. Nelson, and Y. Yin. 1998. Naturalization of the Flood Regime in Regulated Rivers. *Bioscience*. 48(9):706–720.

Sparks, R.E. 1995. Need for ecosystem management of large rivers and their floodplains. Bioscience 45(3):168-182.

SPP (Southwest Power Pool). 2015. 2014 State of the Market. SPP Market Monitoring Unit. August 24th, 2015. Available online at: http://www.spp.org/documents/29399/2014%20state%20of%20the%20market%20report.pdf. Last Accessed: July 20, 2016.

SPP. 2016. Personal Communication Regarding RED and OSE Impacts Due to Potential Changes in the Management of the Missouri River. June 16, 2016.

SPP. 2018. Personal Communication. Meeting with Casey Cathey, Manager, Operations Engineering Analysis and Support; Bruce Rew, VP, Operations; CJ Brown, Director, Systems Operations; Richard Dillon, Technical Director, Market Policy; Charles Hendrix, Manager, Compliance and Advanced Studies; and Derek Hawkins, Supervisor, Real Time and Current Day Engineering; Holly Bender, Pinyon Environmental; Chris Dixon, Louis Berger; Kara Reeves, USACE Omaha District; Drew Minert Kansas City District to discuss the implications of the thermal power modeling results for the RTO. Feb 13.

State of Nebraska. 2016a. Administrative Code Title 117. Ch. 4. Retrieved May 23, 2016, from http://www.sos.ne.gov/rules-and-regs/regsearch/Rules/Environmental_Quality_Dept_of/Title-117/Chapter-4.pdf.

Steffensen, K.D., L.A. Powell, and J.D. Koch. 2010. Assessment of Hatchery-Reared Pallid Sturgeon Survival in the Lower Missouri River. North American Journal of Fisheries Management 30:671–678.

Steffensen, K.D. 2012. Population Characteristics, Development of a Predictive Population Viability Model, and Catch Dynamics for Pallid Sturgeon in the Lower Missouri River. Master's thesis, University of Nebraska. Lincoln, Nebraska. 120 pp.

Steffensen, K.D., M.A. Pegg, and G. Mestl. 2013. Population Prediction and Viability Model for Pallid Sturgeon (Scaphirynchus albus (Forbes & Richardson)) in the Lower Missouri River. *Journal of Applied Ichthyology*. 29:984-989.

Steffensen K.D., S. Stukel, and D.A. Shuman. 2014. The status of fishes in the Missouri River, Nebraska: Shovelnose Sturgeon (Scaphirhynchus platorynchus). Transactions of the Nebraska Academy of Sciences and Affiliated Societies. Paper 466.

Storms, D., F. Davis, B. Griffith, S. Henke, L. Maguire, V. Meretsky, J.M. Scott, D. Goble, J. Vaughn, S. Yaffee. 2008. Initial Implementation of the State Wildlife Action Plans: Conservation Impacts, Challenges and Enabling Mechanisms. Final Report to the National Council for Science and the Environment's Wildlife Habitat Policy Research Program. Seminar Report. July 16, 2008.

Stucker, J.H., and M.H. Sherfy. 2007. *A Muddy Question: Assessing Human Recreation and Research Disturbance on Missouri River Sandbars Managed for Endangered Birds*, Jamestown, ND.

Stucker, J.H., D.A. Buhl, and M.H. Sherfy. 2012. "Emergent Sandbar Construction for Least Terns on the Missouri River: Effects on Forage Fishes in Shallow-Water Habitats," *River Research and Applications*, 28(8):1254-1265. doi:10.1002/rra.1525.

StuckerJ.H., D.A. Buhl, and M.H. Sherfy. 2013. "Consequences of Least Tern (Sternula Antillarum) Microhabitat Nest-Site Selection on Natural and Mechanically Constructed Sandbars in the Missouri River," *The Auk*, 130(4):753-763. doi:10.1525/auk.2013.13048.

Sundsted, J. 2011. Personal Communication with J. Sundsted, Western Area Administration Official. October 6, 2011.

Tern and Plover Conservation Partnership n.d. http://ternandplover.unl.edu/.

Texas A & M University. Texas Transportation Institute. 2012. Retrieved http://www.marad.dot.gov/resources/maritime-publication.

Three Legs, P. 2012. Personal communication. Game and Fish Department, Standing Rock Sioux Tribe. Information provided to Elizabeth Peake by telephone July 20, 2012, regarding recreational activities of Tribal members and the recreational sites that are used.

Tockner, K., F. Malard, and J.V. Ward. 2000. An extension of the Flood Pulse Concept. Hydrological Processes. 14(16–17):2861–2883.

Tripp. S., D. Herzog, S. Reinagel, and J. McMullen. 2012. Final Report. Missouri Commercial Fish Harvest 2000-2012, Missouri Department of Conservation.

Tu, M., C. Hurd, and J.M. Randall. 2001. Weed Control Methods Handbook: Tools & Techniques for Use in Natural Areas. The Nature Conservancy. http://tncweeds.ucdavis.edu

University of North Dakota Energy and Environment Research Center 2008. Fact Sheet No. 5: Wetland Carbon Sinks in the Glaciated North American Prairie. Conducted by the Plains CO2 Reduction (PCOR) Partnership with US Geological Survey and Ducks Unlimited Canada. Available: https://www.undeerc.org/pcor/NewsAndPubs/pdf/FS5-Wetland-Carbon-Sinks-in-Prairies.pdf

Urbanek, R.P., and J.C. Lewis. 2015. Whooping Crane (Grus americana). The Birds of North America Online (A. Poole, ed.). Available at: http://bna.birds.cornell.edu/bna/species/153doi:10.2173/bna.153. Accessed July 28, 2016. Cornell Lab of Ornithology, Ithaca, NY.

U.S. Bureau of Economic Analysis. 2016. CA25N Total Full-Time and Part-Time Employment by NAICS Industry. https://bea.gov/itable/iTable.cfm?ReqID=70&step=1#reqid=70&step=1&isuri=1

US Bureau of Labor Statistics. 2018. Producer Prices Index for Inland Water Freight Transportation, 2002-2016. Accessed February 12, 2018.

U.S. Census Bureau. 2004. American Community Survey, 5-year Averages. Accessed on 9.24.2017. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

U.S. Census Bureau. 2009. American Community Survey, 5-year Averages. Accessed on 9.24.2017. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

U.S. Census Bureau. 2012. American Community Survey, 5-year Averages. Accessed on 9.24.2017. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

U.S. Census Bureau. 2015. American Community Survey, 5-year Averages. Accessed on September 24, 2017. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml; American Community Survey, 5-year Estimates. Employment by Industry: Civilian Employment Population. Available: https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

U.S. Census Bureau. 2016. Poverty Definitions. Retrieved from https://www.census.gov/hhes/www/poverty/methods/definitions.html.

U.S. Census Bureau. Geography Division. 2015. TIGER/Line Shapefiles.

U.S. Department of the Interior. 2012. Frequently Asked Questions. Retrieved from Bureau of Indian Affairs: http://www.bia.gov/FAQs/index.htm

U.S. Department of the Interior. 2018. Payments in Lieu of Taxes. Accessed: https://www.doi.gov/pilt. Accessed February 26, 2018.

U.S. Interagency Advisory Committee on Water Data. 1982. Guidelines for determining flood flow frequency. Reston, VA. USGS. Office of Water Data Coordination, Hydrology Committee Bulletin 17B.

U.S. Water Resources Council. 1983. Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation Studies.

USACE (U.S. Army Corps of Engineers). (n.d.a) RCC Annual Operating Plan (AOP) US Army Corps of Engineers – Northwestern Division. Missouri River Basin Water Management Division. [http://www.nwd-mr.usace.army.mil/rcc/aop.html].

USACE. (n.d.b) Planning Guidance Notebook (ER 1105-2-100).

USACE. 1981. Missouri River Bank Stabilization and Navigation Project Final Feasibility Report and Final EIS for the Fish and Wildlife Mitigation Plan. U.S. Army Corps of Engineers. Omaha District and Kansas City District.

USACE. 1985. Hydropower Engineer Manual. 1110-2-1701.

USACE. 1989. Additional information report submitted to U.S. Fish and Wildlife Service on the operation of the Missouri River main stem system for interior least terns and piping plovers. Missouri River Division. Omaha, Nebraska.

USACE. 1994. Missouri River Master Water Control Manual Review and Update, Volume 6C: Recreation Economics. Recreation Economics Technical Report Appendix D: Recreation Economic Benefit Analysis for Missouri River Mainstem and Reservoir Projects. July.

USACE. 1998a. Volume 6F: Economic studies—Flood Control (revised), Interior Drainage, and Groundwater. Missouri River Master Water Control Manual Review and Update Study. U.S. Army Corps of Engineers, Northwestern Division, Missouri River Region, Omaha, Nebraska.

USACE. 1998b. Volume 11: Interior Drainage Study, Master Water Control Manual, Northwest Division, August 1998.

USACE. 1998c. Northwestern Division. Missouri River Basin Water Management Division (ND-MRBWMD). Missouri River Master Water Control Manual. Vol. 6A-R. Economic Studies Navigation Economics (Rev.). Navigation Economics Technical Report.

USACE. 1998d. Missouri River Master Water Control Manual. Vol. 13: Mississippi River Studies.

USACE. 2002. Transportation Rate Analysis: Missouri River Master Manual Review. Prepared by the Tennessee Valley Authority, Navigation and Hydraulic Engineering. March.

USACE. 2003a. Missouri River Fish and Wildlife Mitigation Project, Final Supplemental Environmental Impact Statement. Kansas City and Omaha Districts.

USACE. 2003b. Big Bend Dam/Lake Sharpe Master Plan. Missouri River, South Dakota. Update of Design Memorandum MB-90. United States Army Corps of Engineers, Omaha District.

USACE. 2003c. Gavins Point Dam/Lewis and Clark Lake Master Plan.

USACE. 2004a. Missouri River Master Water Control Manual Review and Update. Final Environmental Impact Statement. U.S. Army Corps of Engineers Northwest Division, Omaha District. Retrieved from http://www.nwd-mr.usace.army.mil/mmanual/feis/Index.htm.

USACE. 2004b. Gavins Point Dam/Lewis and Clark Lake Master Plan. Missouri River, Nebraska and South Dakota. Update of Design Memorandum MG-123, December 2004. USACE, Omaha District, Omaha, Nebraska.

USACE. 2004c. Upper Mississippi River Flow Frequency Study Final Report, U.S. Army Corps of Engineers, 2004.

USACE. 2006a. Missouri River Mainstem Reservoir System - Master Water Control Manual. Missouri River Basin. Reservoir Control Center. U.S. Army Corps of Engineers, Northwestern Division – Missouri River Basin. Omaha, Nebraska. Retrieved from http://www.nwd-mr.usace.army.mil/rcc/reports/mmanual/MasterManual.pdf.

USACE. 2006b. Water Quality Conditions Monitored at the Corps' Garrison Project in North Dakota during the 3-Year Period 2003 through 2005. Prepared by the Water Quality Unit. Water Control and Water Quality Section. Hydrologic Engineering Branch, Engineering Division, Omaha District.

USACE. 2006c. *Kansas River Interior Least Term and Piping Plover Productivity Report*.

USACE. 2007a. Water Quality Conditions Monitored at the Corps' Fort Peck Project in Montana During the 3-Year Period 2004 through 2006. Prepared by the Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division. Omaha District.

USACE. 2007b. Waterborne Commerce Statistics Center (WCSC). Missouri River Fort Benton, Montana to the Mouth. 2008-2012. Retrieved June 5, 2015, from http://www.navigationdatacenter.us/wcsc/webpub12/Part2_WWYs_tonsbyTT_Dr_Yr_commCY2012-2008.HTM.

USACE. 2007c. Garrison Dam/Lake Sakakawea Master Plan with Integrated Programmatic Environmental Assessment. Missouri River, North Dakota. Update of Design Memorandum MGR-107D. United States Army Corps of Engineers. Omaha District. p. 817.

USACE. 2007d. Department of the Army Permit Evaluation and Decision Document, August 2007. Accessed March 30, 2018, http://www.nwk.usace.army.mil/Portals/29/docs/regulatory/modredging/2007/CDD_Aug2007.pdf

USACE. 2008. Fort Peck Dam/Fort Peck Lake Master Plan. Missouri River, Montana. Update of Design Memorandum MFP-105D, August 2008. USACE, Omaha District, Omaha, Nebraska.

USACE. 2009a. Predator Management Plan.

USACE. 2009b. Fort Peck Temperature Control Device Reconnaissance Study, Fort Peck, Montana. Final Report, Prepared by Tetra Tech for USACE Omaha District. 116p.

USACE. 2009c. Missouri River Bed Degradation Study. Greater Kansas City Post Industry Day Education & Training Workshop. (28 January 2009). Available at: www.nwk.usace.army.mil/Missions/Civil.../Civil.../Missouri-River-Bed-Degradation/

USACE. 2009d. Evaluation of Vegetation Removal and Control Methods to Create Emergent Sandbar Habitat on the Upper Missouri River. Missouri River Recovery Program, Integrated Science Program.

USACE. 2009e. Creation of Emergent Sandbar Habitat (ESH) in the Headwaters of Lewis and Clark Lake and the Impacts on Water Quality. U.S. Army Corps of Engineers, Omaha District.

USACE. 2010a. 2009 Annual Report. Water Quality Conditions in the Missouri River Mainstem System. Prepared by the Water Quality Unit, Water Control and Water Quality Section, Hydrologic Engineering Branch, Engineering Division, Omaha District.

USACE. 2010b. Special Situation Report: Low dissolved oxygen levels in summer power plant discharges from Fort Randall Dam. South Dakota. Retrieved fromhttp://cdm16021.contentdm.oclc.org/cdm/ref/collection/p266001coll1/id/2245.

USACE. 2010c. Final Oahe Dam/Lake Oahe Master Plan. Missouri River, South Dakota and North Dakota. Design Memorandum MO-224. United States Army Corps of Engineers. Omaha District. p. 554.

USACE. 2011a. Final Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River. U.S. Army Corps of Engineers, Omaha District, Omaha, Nebraska.

USACE. 2011b. United States Army Corps of Engineers Missouri River Bed Degradation Final Environmental Impact Statement (EIS). Retrieved from http://www.nwk.usace.army.mil/Missions/RegulatoryBranch/MissouriRiverCommercialDredging.aspx.

USACE. 2011c. Missouri River Commercial Dredging Final Environmental Impact Statement (FEIS), Chapter 2, page 2-4, February 2011.

USACE. 2011d. United States Army Corps of Engineers Record of Decision for Authorization of Commercial Sand and Gravel Dredging on the Lower Missouri River. Retrieved from http://www.nwk.usace.army.mil/Missions/RegulatoryBranch/MissouriRiverCommercialDredging.aspx.

USACE. 2012a. Off Channel Emergent Sandbar Habitat Creation Opportunities. U.S. Army Corps of Engineers. August 2012.

USACE. 2012b. Fort Peck Lake Dam Water Temperature Study and Preliminary Design of Submerged Weir. Interim Implementation Report. USACE Omaha District, April 2012.

USACE. 2012c. Missouri River Monthly Project Statistics. Retrieved 2012, from http://www.nwd-mr.usace.army.mil/rcc/projdata/projdata.html.

USACE. 2012d. Missouri River Garrison Project Downstream Channel and Sediment Trends Study. Updated April 2012. Northwestern Division – Omaha District. Sedimentation and Channel Stabilization Section. (Updated by West Consultants).

USACE. 2012e. Missouri River Fort Randall Project Downstream Channel and Sediment Trends Study. Updated June 2012. Northwestern Division – Omaha District. Sedimentation and Channel Stabilization Section. (Updated by West Consultants).

USACE. 2012f Final Special Situation Report: Low Dissolved Oxygen Levels in Discharges from Fort Peck Dam. Omaha District. Retrieved from http://cdm16021.contentdm.oclc.org/cdm/ref/collection/p266001coll1/id/2738.

USACE. 2012g. Hourly Plant Generation.

USACE. 2012h. Operations and Maintenance Business Information Link (OMBIL). Database of Corps visitation data through Fiscal Year 2012 and recreation facility inventories for management areas (including Recreation Areas) at Corps Missouri River mainstem reservoirs. Accessed by Omaha District Operations Division staff in Omaha, Nebraska and at the Project offices.

USACE. 2012i. Reservoir Control Center Intake Data.

USACE. 2013a. Lewis and Clark Lake Sediment Management Study (LCLSMS) Part I: Summary Report on Evaluating Hydraulic Transport of Missouri River Delta Sediments. Prepared by the Omaha District, USACE. http://moriverrecovery.usace.army.mil/mrrp/f?p=136:155:0::NO::PIS_ID:28

USACE. 2013b. Water Quality Sampling Report and Factual Determinations, Results of Sediment Sampling and Elutriate Testing at the Proposed Little Sioux Bend Shallow Water Habitat Project Site. U.S. Army Corps of Engineers, Omaha District.

USACE. 2013c. Real Estate Program Brochure. Retrieved from http://www.moriverrecovery.usace.army.mil/mrrp.

USACE. 2014a. 2013 Annual Report for the Biological Opinion on the Operation of the Missouri River Mainstem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. U.S. Army Corps of Engineers. Omaha and Kansas City Districts.

USACE. 2014b. Draft Study of Potential Least Tern and Piping Plover Habitat Enhancement on the Reservoirs of the Missouri River Main Stem Reservoir System. USACE Omaha District.

USACE. 2014c. Habitat Analysis for the Missouri River Effects Analysis. Missouri River Effects Analysis. Hydrogeomorphic Team Integrative Report (Draft). U.S. Army Corps of Engineers.

USACE. 2014d. Missouri River Gavins Point Dam Degradation Trends Study. Updated March 2014. Northwestern Division – Omaha District. Sedimentation and Channel Stabilization Section. Updated by West Consultants. M.R.B Sediment Memorandum 24a.

USACE. 2014e. Investigation of Channel Degradation. Missouri River Gavins Point Dam to the Platte River Confluence. Northwestern Division – Omaha District. Sedimentation and Channel Stabilization Section. (Updated by West Consultants).

USACE. 2014f. Final Independent External Peer Review Report Cache la Poudre River at Greeley, Colorado General Investigations Study.

USACE. 2015a. Missouri River Mainstem Reservoir System: Summary of Actual 2014 Regulation. US Army Corps of Engineers Northwestern Division. Retrieved from http://www.nwd-mr.usace.army.mil/rcc/reports/pdfs/rcc2014summary.pdf.

USACE. 2015b. 2014 Annual Report Biological Opinion on the Operation of the Missouri River Mainstem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. Prepared by the Omaha and Kansas City Districts for the U.S. Fish and Wildlife Service.

USACE. 2015c. Missouri River Mainstem Reservoir System: Summary of Actual 2015 Regulation. US Army Corps of Engineers Northwestern Division. Retrieved from http://www.nwd-mr.usace.army.mil/rcc/reports/pdfs/rcc2015summary.pdf.

USACE. 2015d. United States Army Corps of Engineers Memorandum for Record for the Department of the Army Combined Decision Document for Permit Application. Retrieved from http://www.nwk.usace.army.mil/Portals/29/docs/regulatory/modredging/2016/2015-12-10%20CDD.pdf.

USACE. 2015e. Communication and email from B. Peake, U.S. Army Corps of Engineers, Omaha District to M. Ryan, U.S., Army Corps of Engineers, Kansas City District regarding 2006 Drought Informational Study Data.

USACE. 2015f. Shallow Water Habitat Accounting Report. Kansas City and Omaha District.

USACE. 2015g. Biological Assessment for Commercial Sand and Gravel Dredging on the Lower Missouri River. Kansas City and Omaha Districts. 157 p.

USACE. 2016a. 2014 Report of Water Quality Conditions in the Missouri River Mainstem System. Prepared by the Water Control and Water Quality Section, Hydrologic Engineering Branch. Engineering Division Omaha District.

USACE. 2016b. Long-term, Fixed-station Ambient Monitoring Data from the Mainstem System Reservoirs and Mainstem System Powerplants Data. Omaha District.

USACE. 2016c. Long-term, Fixed-Station Ambient Monitoring Data along the Missouri River from Gavins Point Dam to Rulo, NE Data. Kansas City District.

USACE. 2016d. *Engineering and Construction Bulletin. Guidance for Climate Change Adaptation Engineering Inputs to Inland Hydrology for Civil Works Studies, Designs, and Projects*. USACE Draft, 4 May 2016.

USACE. 2016e. Civil Works Construction Cost Index System, Amendment #8: Tables Revised as of 31 March 2016. Available: http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1304.pdf

USACE. 2016f. NDC. Side Channel stage unpublished Data, St. Louis District.

USACE. 2016g. Navigation Charts: Upper Mississippi. Retrieved July 2016, from http://www.mvr.usace.army.mil/Missions/Navigation/Navigation-Charts/Upper-Mississippi-River/.

USACE. 2016h. Climate Change Assessment – Missouri River Basin.

USACE. 2016i. USACE Resource Guide for Work Activities and Spending Profiles for the Regional ECONomic System for Federal Spending Appendix.

USACE. 2017a. Missouri River Bed Degradation Feasibility Study. Technical Report. Available at: www.marc2.org/assets/environment/mobeddeg/MoRiverBedDegStudy2017.pdf. May 2017.

USACE. 2017b. Economic guidance Memorandum, 18-03, Unit Day Values for Recreation for Fiscal Year 2018. November 20. Available: https://planning.erdc.dren.mil/toolbox/library.cfm?Option=Listing&Type=EGM&Search=Policy&Sort=YearDesc

USACE. 2018. Waterborne Commerce Statistics Center (WCSC) Navigation Movement Database.

USACE and USFWS 2010. 2009 Annual Report for the Biological Opinion on the Operation of the Missouri River Main Stem System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System.

USACE and USFWS. 2012. Operational Draft Adaptive Management Strategy for Creation of Shallow Water Habitat. Version 5.3.

U.S. Coast Guard (USCG). 2012. Mississippi River and Tributaries. Waterways Action Plan. Upper Mississippi River Annex 2012.

USCG. 2017. Mississippi River and Tributaries Waterways Action Plan. Available: http://www.atlanticarea.uscg.mil/Portals/7/Eigth%20District/SectorUMR/UMR%20WAP%202017.pdf. Accessed December 16, 2017.

USDA (U.S. Department of Agriculture). 2012. Census of Agriculture. Table 4: Net Cash Farm Income of the Operations and Operators: 2012 and 2007. Retrieved from https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Montana/st30_2_004_004.pdf. Table 25: Field Crops: 2012 and 2007. https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Colorado/st08_2_025_025.pdf

USDA. 2016. Cooperative Emerald Ash Borer Project. Initial county EAB detections in North America. August 1.

USDA NASS. 2014. Cropland Data Layer. Retrieved from http://nassgeodata.gmu.edu/CropScape/.

USFWS (U.S. Fish and Wildlife Service). 1980. Fish and Wildlife Coordination Act Report, Missouri River Bank Stabilization and Navigation Project. U.S. Fish and Wildlife Service, Division of Ecological Services, Kansas City, Missouri, 77 pp.

USFWS. 1985. Determination of endangered and threatened status for the piping plover. Federal Register 50: 50726-50734.

USFWS. 1988a. Atlantic Coast piping plover recovery plan. Newton Corner, Massachusetts.

USFWS. 1988b. Great Lakes and Northern Great Plains piping plover recovery plan. U.S. Fish and Wildlife Service, Twin Cities, MN. 160 pp.

USFWS. 1990. Interior population of the least tern (*Sterna antillarum*) Recovery Plan.

USFWS. 2000. Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota.

USFWS. 2003. Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota, USA.

USFWS. 2007a. Pallid Sturgeon (*Scaphirhynchus albus*) 5-year review: summary and evaluation. USFWS, Billings, Montana.

USFWS. 2007b. Confirmed Whooping Crane Sightings, Central Flyway of the United States. USFWS Ecological Services, Grand Isle, Nebraska. Available at: https://www.fws.gov/nebraskaes/wind.php. Accessed October 31, 2016.

USFWS. 2007c. Indiana Bat (*Myotis sodalis*) Draft Recovery Plan. Great Lakes-Big Rivers Region – Region 3, Fort Snelling, Minnesota.

USFWS. 2009a. USFWS Western Prairie Fringed Orchid 5-Year Review: Summary and Evaluation.

USFWS. 2009b. “Management Methods: Prescribed Burning, Impacts of Fire Webpage.” Available at: http://www.fws.gov/invasives/staffTrainingModule/methods/burning/impacts.html.

USFWS. 2009c. Piping Plover 5-year review. 206 pp.

USFWS. 2012. USFWS Whooping Crane 5-Year Review: Summary and Evaluation.

USFWS. 2013. Interior Least Tern (*Sternula antillarum*). 5-Year Review Summary and Evaluation. Southeast Region. Mississippi Field Office. Jackson, MS.

USFWS. 2014. Revised Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*). Denver, CO. U.S. Fish and Wildlife Service.

USFWS. 2015a. Planning Aid Letter Regarding Development of the Missouri River Recovery Management Plan/EIS from Casey D. Kruse, USFWS to April Fitzner, USACE. December 4, 2015.

USFWS. 2015b. Letter from Noreen E. Walsk, Regional Director, USFWS to David Ponganis, Director of Programs, USACE Northwestern Division dated March 30 2015.

USFWS. 2015c. Planning Aid Letter regarding the Missouri River Recovery Management Plan Lower Missouri River Pallid Sturgeon Framework, Targets and Decision Criteria from Casey D. Kruse, USFWS, to April Fitzner, USACE. November 2, 2015.

USFWS. 2015d. Northern Long-Eared Bat (Myotis septentrionalis) Fact Sheet.

USFWS. 2015e. Recovery Plan for the Northern Great Plains piping plover (*Charadrius melodus*) in two volumes. Volume I: Draft breeding recovery plan for the Northern Great Plains piping plover (*Charadrius melodus*) 132 pp. and Volume II: Draft revised recovery plan for the wintering range of the Northern Great Plains piping plover (*Charadrius melodus*) and Comprehensive conservation strategy for the piping plover (*Charadrius melodus*) in its coastal migration and wintering range in the continental United States. Denver, Colorado. 166 pp.

USFWS. 2016a. Draft technical note: estimating pallid sturgeon biomass for RPMA #2. Number 1:2016. Bismarck, ND.

USFWS. 2016b. Endangered Species. Indiana Bat (*Myotis sodalis*). Retrieved June 2016, from http://www.fws.gov/midwest/Endangered/mammals/inba/index.html#ch.

USFWS and NMFS (U.S. Fish and Wildlife Service and National Marine Fisheries Service). 1998. Endangered Species Consultation Handbook. U.S. Fish and Wildlife Service and National Marine Fisheries Service. p. 4-19.

USFWS and USACE. 2015. Lower Missouri River Pallid Sturgeon Framework, Targets and Decision 4 Criteria. Nov. 2, 2015. 18 pp.

USFWS and U.S. Census Bureau. 2002. *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.*

USGS (U.S. Geological Survey). 2001. National Land Cover Database (NLCD). Retrieved from http://www.epa.gov/mrlc/nlcd-2001.html.

USGS. 2011. National Wildlife Refuge Visitor Survey 2010/2011: Individual Refuge Results for Charles M. Russell National Wildlife Refuge. By Natalie R. Sexton, Alia M. Dietsch, Andrew W. Don Carlos, Lynne Koontz, Adam N. Solomon and Holly M. Miller.

USGS. 2012a. Gap Analysis Program. Protected Areas Database of the United States (PADUS) Ver. 1.3.

USGS. 2012b. USGS Current Water Data for Missouri. Available at: http://waterdata.usgs.gov/mo/nwis/rthttp://waterdata.usgs.gov/mo/nwis/rt

USGS. 2016a. Information on annually reported cases of arboviral diseases in mainstem Missouri River states. Retrieved June 9, 2016, from http://diseasemaps.usgs.gov/mapviewer/.

USGS. 2016b. USGS Current Water Data for Missouri. Accessed August 9, 2016 at: http://waterdata.usgs.gov/mo/nwis/rthttp://waterdata.usgs.gov/mo/nwis/rt

Waas, M. 2015. The Unintended Consequences of Subsidized Irrigation Conservation. Chicago Policy Review. http://chicagopolicyreview.org/2015/06/25/the-unintended-consequences-of-subsidized-irrigation-conservation/.

Waddington, K.D. and J. Hayes. 1976. Mosquitoes in Kansas: Natural History and Methods of Control. Bulletin of the State Biological Survey of Kansas.

Walsh, R.G. 1986. The Intelligent Manger's Guide to Recreation Economic Decisions. State College, PA: Venture Publishing.

Walters, C. 1986. Adaptive Management of Renewable Resources: New York, Macmillan, 374 p.

WAPA (Western Area Power Administration). 2016. Personal Communication between C. Dixon, Louis Berger and S. Sanders, WAPA to discuss RED and OSE Impacts due to Potential Changes in the Management of the Missouri River. June 2, 2016.

Ward, J.V., and J.A. Stanford. 1983. The Serial Discontinuity Concept of Lotic Ecosystems. In Fontaine, T.D., III and Bartell, S.M. (Eds.). Dynamics of Lotic Ecosystems: Ann Arbor, Michigan. Ann Arbor Science. pp. 29-42.

Welker, T.L., and M.R. Drobish. 2010. Missouri River Standard Operating Procedures for Fish Sampling and Data Collection. U.S. Army Corps of Engineers, Omaha District, V1.5, 214 p.

Wells, J. 2012. Personal communication. Director of the Department of Natural Resources, Crow Creek Sioux Tribe. Information provided to Elizabeth Peake by telephone July 20, 2012, regarding the recreational activities that Tribal members engage in and the recreation sites they use.

WEST Consultants, Inc. 2000. Upper Mississippi River and Illinois Waterway Navigation Feasibility Study - Cumulative Effects Study, Volumes 1–2. Prepared by WEST Consultants, Inc. for the U.S. Army Corps of Engineers, Rock Island District, Rock Island, Illinois.

West Consultants. 2013. Missouri River Bankline Mapping. Gavins Point. Fort Randall and Garrison Reaches. Final Report. Prepared for the U.S. Army Corps of Engineers.

Whyte, A.J. 1985. Breeding ecology of the piping plover (*Charadrius melodus*) in central Saskatchewan. M.S. Thesis, Univ. Saskatchewan, Saskatoon. 126 pp.

Wieberg, C. 2015. Personal Communication between C. Wieberg, Missouri Department of Natural Resources and H. Bender and L. McDonald, Pinyon Environmental Regarding Low Flow Criteria in Wastewater NPDES Permits. June 20, 2015.

Wilcox, 1959. A Twenty-Year Banding Study of the Piping Plover. Auk 76: 129–152.

Wildhaber, M.L., A.J. DeLonay, D.M. Papoulias, D.L. Galat, R.B. Jacobson, D.G. Simpkins, P.J. Braaten, C.E. Korschgen, and M.J. Mac. 2007. A Conceptual Life-History Model for Pallid and Shovelnose Sturgeon: U.S. Geological Survey Circular 1315, 18 p.

Wildhaber, M.L., A.J. DeLonay, D.M. Papoulias, D.L. Galat, R.B. Jacobson, D.G. Simpkins, P.J. Braaten, C.E. Korschgen, and M.J. Mac. 2011. Identifying Structural Elements Needed for Development of a Predictive Life-History Model for Pallid and Shovelnose Sturgeons. Journal of Applied Ichthyology 27:462–469.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, D.C.

Winders, K.R., and K.D. Steffensen. 2014. Population size of pallid sturgeon, Scaphirhynchus albus (Forbes & Richardson, 1905), in the lower Missouri River near Kansas City, Missouri, USA. Journal of Applied Ichthyology 30:1356–1361.

WSDA (Washington State Department of Agriculture). 2003. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, April to December, 2003. Washington State Department of Agriculture Publication 04-03-048.

Zurek, L. and Broce, A. 2002. Mosquitoes and West Nile Virus in Kansas. Department of Medical and Veterinary Entomology, Kansas State University. Kansas Insect Newsletter.

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Chapter 8 Glossary

Accounts – Human Considerations objectives and performance criteria are organized into four accounts that were established to facilitate evaluation and display the effects of alternative plans in accordance with U.S. Army Corps of Engineers Planning Guidelines. The four accounts are:

- Environmental Quality (EQ)
- National Economic Development (NED)
- Regional Economic Development (RED)
- Other Social Effects (OSE)

Active adaptive management – The active form of adaptive management employs management actions in an experimental design aimed primarily at learning to reduce uncertainty; near-term benefits to the resource are secondary.

Adaptive Management (AM) – Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process.

Aggradation (or alluviation) – Increase in land elevation within a river system due to the deposition of sediments; aggradation occurs within river reaches where the supply of sediment is greater than the amount of material the system is able to transport.

Annual Work Plan (AWP) – This document includes real estate actions, habitat creation actions, monitoring of physical and biological responses to actions, and research activities for a particular year within the five-year Strategic Work Plan. It is used by product delivery teams to budget and implement management actions annually.

Baseload power plant – An energy plant devoted to the production of baseload supply.

Benthic – The zone on the bottom under a river or reservoir and the organisms that live there.

Biological Assessment (BA) – A document prepared for the Section 7 process to determine whether a proposed major construction activity under the authority of a Federal action agency is likely to adversely affect listed species, proposed species, or designated critical habitat.

Biological Opinion (BiOp) – Document stating the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) opinion as to whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat. Specifically in the MRRP, the USFWS 2000 Biological Opinion (BiOp) found that the operation of the Missouri River Mainstem Reservoir System and the operation and maintenance of the BSNP, as proposed by the USACE, would likely jeopardize the continued existence of three federally listed species: the piping plover, least tern, and pallid sturgeon. The BiOp was amended in 2003 to note that, with additional actions proposed by the USACE, operation of the System and the operation and maintenance of the BSNP would not likely jeopardize terns and plovers, but would jeopardize pallid sturgeon.

Biological nutrient removal – A process used for treating nitrogen, including ammonia-nitrogen, and phosphorus in wastewater. With the new stringent ammonia standards being implemented by the U.S. EPA and states, more and more wastewater facilities are upgrading their treatment systems to use biological nutrient removal or enhanced nutrient removal; with these types of technologies, changes in low flows are not likely to impact water quality.

Capacity value – Represents the capital, fixed operating and maintenance cost of the displaced thermal resource. Measured in units of dollars per kilowatt-year.

Capacity – The maximum amount of power that a generating unity or power plant can deliver under a specified set of conditions.

Carbon monoxide (CO) – A colorless, odorless, tasteless, and poisonous gas that is formed when carbon in fuel is not completely burned. It is a component of motor vehicle exhaust, which contributes approximately 56 percent of all CO emissions nationwide.

Carbon sink – Ecosystems that absorb and store more carbon dioxide from the atmosphere than they release, which offsets greenhouse gas emissions; e.g., forests and oceans.

Carbon sequestration – The practice of capture and long-term storage of atmospheric carbon dioxide or other forms of carbon.

Channel – The top width of the river at the ordinary high water level.

Conceptual Ecological Models (CEMs) – CEMs are graphical depictions of an ecosystem that are used to communicate the important components of the system and their relationships. They are a representation of the current scientific understanding of how the system works.

Critical uncertainties – Uncertainties that impede the identification of a preferred alternative management action.

Dependable capacity – A measure of the amount of capacity that a project can reliably contribute towards meeting system peak demand.

Decision criteria – Broadly refers to the set of pre-determined criteria used to make AM decisions. Performance metrics, targets, and decision triggers are considered to be different types of decision criteria. They can be qualitative or quantitative based on the nature of the performance metric and the level of information necessary to make a decision.

Decision trigger – Decision triggers are pre-defined commitments (population or habitat metric for a specific objective) that trigger a change in a management action. Decision triggers are addressed in the Evaluate step (Step 4 of the AM process) specifying the metrics and actions that will be taken if monitoring indicates performance metrics are or are not reaching target values. In some cases a decision trigger may be learning a new piece of information that triggers the Continue/Adjust/Complete step (Step 5 of the AM process).

Degradation – A lowering of a fluvial surface, such as a stream bed or floodplain, through erosional processes.

Disease vector – A carrier of disease, e.g. in malaria a mosquito is the vector that carries and transfers the infectious agent.

Dissolved oxygen – Dissolved oxygen concentrations that are too high **or** too low are harmful to aquatic animal life. Water temperature affects dissolved oxygen concentrations with colder water holding more oxygen. Low oxygen levels can result from decomposition of large amounts organic matter following eutrophication and high levels can result from enhanced photosynthesis activity during the over-production of algae.

Early life stage habitat – Riverine habitat that support the early life stages of the pallid sturgeon (e.g., spawning habitat and interception and rearing complexes).

Effects Analysis (EA) – The purpose of this effort is to conceptually and quantifiably make explicit the effects of operations and actions on the listed species by specifically evaluating the effects of hydrologic and fluvial processes on the Missouri River, as well as ongoing Mitigation and Biological Opinion management actions to the status and trends of the listed species (piping plover, interior least tern, and pallid sturgeon) and their habitats.

Effluent – Liquid waste or sewage discharged into a receiving water body such as the Missouri River.

Emergent plants – A plant which grows in water but which pierces the surface so that it is partially in air; collectively, such plants are called emergent vegetation.

Emergent Sandbar Habitat – Habitat for nesting, brood rearing, and foraging for least terns and the Northern Great Plains piping plover that is a complex of side channels and sandbars with the proper mix of habitat characteristics required by the birds.

Energy value – Represents the fuel cost or variable cost of an alternative thermal generation resource that replaces the lost hydropower generation (cost per megawatt-hour).

Energy – The capability of doing work expressed in terms of kilowatt-hours (kWh).

Ephemeral pool – A seasonal body of standing water that typically forms in the spring from melting snow and/or other runoff that dries out completely in the summer; provides an important breeding habitat for many terrestrial and semiaquatic species.

Erosion – The wearing away of rock and soil found along a river bed and banks; involves the breaking down of rock particles being carried downstream by the river.

Eutrophication – Process whereby water bodies, such as lakes, reservoirs, or slow-moving rivers and streams, receive high nutrient concentrations that stimulate excessive plant growth (e.g., algae and nuisance plants weeds).

Formal consultation – The consultation process conducted when a Federal agency determines its action may affect a listed species or its critical habitat, and is used to determine whether the proposed action may jeopardize the continued existence of listed species or adversely modify critical habitat. This determination is stated in the Service's biological opinion.

Firm power – Capacity and energy that is guaranteed to be available at all times. If insufficient generation is available power must be purchased from alternative resources to meet contractual agreements.

Fledge Ratio – The ratio of adult pairs of birds to the number of fledged chicks; applies in the MRRMP-EIS to least terns and piping plovers.

Floodplain – An area of low-lying ground adjacent to a river formed mainly of river sediments and subject to flooding.

Floodplain connectivity – Maintaining a connection (which may be seasonal) between the Missouri River and its associated floodplain habitats.

Fundamental objectives – Fundamental objectives are used to formalize the desired outcome of the program in terms of biological response. They are derived to achieve avoidance of jeopardizing the three species from USACE actions on the Missouri River and articulate the ends the program is trying to achieve.

Greenhouse gas (GHG) – Gases that trap heat within the earth's atmosphere by absorbing energy and slowing the rate at which the energy escapes. GHGs differ in their radiative efficiency (ability to absorb energy) and lifetime (how long they stay in the atmosphere).

Genotype – The genetic constitution of an individual organism.

Hydrograph – A graph showing the rate of flow (discharge) versus time past a specific point in a river (e.g., Missouri River); typically expressed in cubic feet per second.

Human Considerations (HCs) – A set of objectives with associated metrics and proxy metrics that are related to the wide array of uses and stakeholder interests on the Missouri River. They form the basis for some of the monitoring and decision criteria in the AM Plan.

Hydropower – The converting of energy from running water to produce electricity; a renewable energy source.

Hypolimnion – The lower layer of water in a stratified lake or reservoir, typically cooler than the water above and relatively stagnant.

Implement – Implementation of the selected alternative.

Integrated Science Program (ISP) – The component of the MRRP that is responsible for conducting scientific monitoring and investigations. The ISP monitors federally listed species under the Endangered Species Act (ESA), the habitats upon which they depend, and researches and monitors critical uncertainties.

Interception and Rearing Complexes (IRCs) – The physical definitions of IRCs are currently identified as follows: (1) food-producing habitat occurs where velocity is less than 0.08 meters per second (m/s); (2) foraging habitat is defined as areas with 0.5–0.7 m/s velocity and 1–3 m depth; and (3) interception habitat has been qualitatively described as zones of the river where hydraulic conditions allow free embryos to exit the channel thalweg.

Invasive species – A plant or animal species that is not native to a specific location (an introduced species) and which has a tendency to spread to a degree believed to cause damage to the environment, human economy or human health.

Implementation level (or Level) – Refers to one of four classifications of action that could be implemented to assist pallid sturgeon as part of the MRRP (see also *Pallid Sturgeon Framework*). The levels include:

- **Level 1: Research** – Studies without changes to the system (Laboratory studies or field studies under ambient conditions).
- **Level 2: In-river testing** – Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.
- **Level 3: Scaled implementation** – A range of actions not expected to achieve full success, but which yields sufficient results in terms of reproduction, numbers, or distribution to provide a meaningful population response and indicate the level of effort needed for full implementation.
- **Level 4: Ultimate required scale of implementation** – Implementation to the ultimate level required to remove an issue.

Investigations – Research activities that are intended to generate information that will fill the key gaps in understanding and reduce uncertainty associated with implementation of management actions.

Jeopardy – As defined by the Endangered Species Act (ESA), jeopardy occurs when there is an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

Lower Missouri River – The reach of the river downstream of Gavins Point Dam (RM 810) as it pertains to management for pallid sturgeon.

Management actions – Proposed or potential actions to be taken by the USACE to address species needs on the Missouri River. Original management actions were prescribed by the Biological Opinion as Reasonable or Prudent Alternatives or actions outside the BiOp if necessary to achieve species objectives.

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Master Manual – The Missouri River Master Water Control Manual (Master Manual) is the guide used by the U.S. Army Corps of Engineers to operate the system of six dams on the Missouri River Mainstem Reservoir System (System) – Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point.

Mixing zone – A mixing zone is defined generically as a limited area or volume of a receiving water body where the initial dilution of a permitted or authorized discharge occurs. Defined mixing zones are intended to dilute or reduce pollutant concentrations below applicable water quality standards (USEPA 1991). It is important to note that mixing zones are designed to ensure that water quality standards are met in the receiving water body a high percentage of the time. For example, flows in a given river will be higher than a 7Q10 low-flow over 99 percent of the time. Thus, if flows were to drop below the established low-flow criterion, water quality standards are waived.

Monitoring – In the context of the MRRMP-EIS, monitoring is the process of measuring attributes of the ecological, social or economic system. Monitoring has multiple purposes, including: to provide a better understanding of spatial and temporal variability, to confirm the status of a system component, to assess trends in a system component, to improve models, to confirm that an action was implemented as planned, to provide the data used to test a hypothesis or evaluate the effects of a management action, and to provide an understanding of a system attribute which could potentially confound the evaluation of action effectiveness.

National Environmental Policy Act (NEPA) – Requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet NEPA requirements federal agencies may be required to prepare a detailed statement known as an Environmental Impact Statement (EIS).

Naturalization of the flow regime – Naturalization of the flow regime involves incremental changes which move the flow regime towards the hydrological attributes which would exist in the absence of dams and reservoirs, while recognizing social and economic constraints. It does not mean matching the unaltered, historical flow regime. More generally, naturalization refers to the process of using characteristics of the natural ecosystem to guide elements of river restoration, but constrained by social and economic values.

Navigation channel – The navigation channel is congressionally authorized as a 9-feet-deep by 300-feet-wide channel and generally refers to that portion of the Missouri River between Sioux City and the mouth at St. Louis as defined by normal water levels during the navigation support flow season.

Navigation season – The period usually between April and December that the USACE supports navigation on the river from Sioux City, Iowa, to St. Louis, Missouri.

Nitrogen and phosphorus – The inorganic nutrients nitrogen and phosphorus support primary productivity (i.e., the production of energy by plants through photosynthesis) in the river. Excessive nutrients present in the water column foster the growth of plants and algae potentially resulting a state of eutrophication and algae blooms and, then following decomposition, depleted dissolved oxygen. Disturbance to bed sediment has the potential to resuspend nutrients into the Missouri River.

Nitrogen dioxide – Nitrogen dioxide has a strong, harsh odor and is a liquid at room temperature, becoming a reddish-brown gas above 70°F. It is released to the air from the exhaust of motor vehicles, the burning of coal, oil, or natural gas, and during processes such as arc welding, electroplating, engraving, and dynamite blasting.

Non-routine repair, replacement, and rehabilitation (R, R, & R) costs – Costs covered include (1) support for two river field offices including any funds necessary for rescues, funds for repairs of equipment, funds for staff, and funds for other expenses; (2) repair, replacement, and rehabilitation of thousands river structures; (3) emergency dredging that is required for extreme river conditions.

Objectives – Objectives define an endpoint of concern and the direction of change that is preferred. Objectives are concise statements of the interests that could be affected by a decision — the “things that matter” to people. In PrOACT, objectives typically take a simple form such as: Minimize costs, Increase population number, increase habitat availability.

Other pollutants – Other pollutants of concern within the Missouri River system are metals, hydrocarbons, organic toxins, pesticides, and treated wastewater. Pollutants and toxic chemicals may adhere to suspended matter that settles to the bottom of the river or remain in suspension, where they can pose a hazard to native species or affect socioeconomic resources such as water supply, irrigation, wastewater treatment, and recreational uses.

Ozone (O_3) – A gas composed of three oxygen atoms. It is not usually emitted directly into the air, but at ground-level is created by a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight.

Ozone precursor – Oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) which chemically react in the atmosphere producing ground-level ozone (O_3).

Particulate matter – A complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

Passive adaptive management – In passive AM, management actions are intended to achieve resource objectives but and are improved using knowledge gained from monitoring and assessment.

Peak and off-peak power – The daily and seasonal variation of energy cost following system demand.

Peaking power plants – Power plants that are generally run only when there is high demand.

Period of Record – A period of record between 1931 and 2012 used to develop predictive models and assess changes in physical river and reservoir conditions.

Performance metric – A specific metric or quantitative indicator that is monitored and can be used to estimate and report consequences of management alternatives with respect to a particular objective.

Plant factor – The ratio of the actual monthly generation to the maximum possible monthly generation.

Population Augmentation – Stocking to supplement year class structure to the pallid sturgeon population due to lack of natural recruitment in the Missouri River.

Power marketing administrations – A U.S. federal agency within the Department of Energy with the responsibility for marketing hydropower. Western Area Power Administration (WAPA) represents the Mainstem of the Missouri River hydropower plants.

Preferred alternative – The preferred alternative is the alternative which the USACE believes would best fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical, and other factors.

PrOACT decision making model – An organized, structured decision making approach to identifying and evaluating creative options and making choices in complex decision situations. PrOACT is a decision analysis approach currently employed by USACE in the development of the Missouri River Recovery Management Plan. It is a technique used to provide analytical structure and rigor to values-based questions by clarifying the consequences of alternate solutions, including the impacts on multiple objectives. The unifying features of PrOACT analyses are that they involve: 1) clarifying the Problem to be solved, 2) listing Objectives to be considered (usually with associated performance metrics), 3) developing Alternative solutions to the problem as stated, 4) estimating the consequences of each of the alternatives on each of the objectives in terms of the metrics (usually in the form of a consequence table of alternatives versus objectives) and 5) explicitly evaluating the Trade-offs that are revealed to exist between the alternatives, usually in a discursive setting.

Recovery – An improvement in the status of a listed species to the point at which listing is no longer appropriate under the Endangered Species Act.

Riparian – The natural zone located along the bank of a watercourse (e.g., Missouri River), tributary, or reservoir.

River Segment – A term used to designate an area of study or action. The area begins at the base of a dam and proceeds downstream including the area of the separate area of the river channel and the separate area the lake waters with the segment ending at the top of the next downstream dam.

Run-of-River – Flows that are basically uncontrolled, as was experienced before the construction of the Missouri River dams.

Run-of-river hydroelectric plants – A type of hydroelectric generation whereby the natural flow and elevation drop of the river are used to generate electricity.

Section 7 – The section of the Endangered Species Act that requires all Federal agencies, in "consultation" with the Service, to insure that their actions are not likely to jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat.

Selected alternative – The alternative identified in the ROD that the USACE intends to implement.

Sediment and turbidity – Turbidity is a measure of the loss of water clarity due to the presence of suspended particles such as eroded sediment and organic matter in the water column. Although sediment and turbidity maintain natural ecological conditions, turbidity also affects the water temperature, can accumulate in reservoirs, and sediment transport can impact water intake pipes and destabilizing intake structures.

Sediment load – The solid material that is transported by a river within the water column.

Service level – The daily minimum discharge required for the level of navigation service determined from available system storage.

Snowpack – A seasonal accumulation of slow melting packed snow; runoff to the Missouri River system.

Snow water equivalent (SWE) – A measurement for the amount of water contained within a snowpack. Specifically, it is the depth of water that would theoretically result if you melted the entire snowpack instantaneously.

Spawning habitat – Functional spawning habitat produces a successful hatch of embryos. For successful hatch to take place, hydraulics and substrate must be conducive first to attraction and aggregation of reproductive adults, followed by egg and milt release, fertilization, and deposition of eggs in a in a protected environment.

Spawning cue – Either a natural or man-made condition that may prompt fish to spawn.

Stage – The water level above some arbitrary point in the river, often with the zero height being near the river bed.

- *Action Stage at Bismarck, ND (12.5 feet):* Unusually high river stage for this reach of the Missouri River. Residents are encouraged to pay close attention to National Weather Service (NWS) updates, local media, and local emergency management for information concerning why the river is this high and its potential for further rises.
- *Minor Flood Stage at Bismarck, ND (14.5 feet):* Flooding of rural areas begins. Inundation of croplands and the potential closure of local boat ramp access is likely. Riverbank erosion rates increase and cause unstable shorelines. If water levels are the result of an ice jam south of Bismarck, water levels will be relatively higher near the jam and cause concerns for residents south of Fox Island.
- *Moderate Flood Stage at Bismarck, ND (16.0 feet):* Flooding of rural areas begins. Inundation of croplands and the potential closure of local boat ramp access is likely. Riverbank erosion rates increase and cause unstable shorelines. If water levels are the result of an ice jam south of Bismarck, water levels will be relatively higher near the jam and cause concerns for residents south of Fox Island.

Structured Decision Making (SDM) – Organized approach to identifying and evaluating creative options and making choices in complex decision situations. It is used to inform difficult choices, and to make them more transparent and efficient. PrOACT is a specific application of SDM to collaborative problem solving.

Success criteria – A qualitative or (preferably) quantitative description of the conditions for which the parties agree that the objectives have been sufficiently met. Usually expressed in terms of the performance metrics.

Target – Targets are a specific value or range of performance metric that define success. Targets can be quantitative values or overall trends (directional or trajectory).

Trade-offs (also trade-off analysis) – A trade-off is when one alternative performs well on one metric but poorly on another relative to another alternative. Reasonable people may disagree about which is the best alternative because they value the two metrics differently, thus value trade-offs involve making judgments about how much you would give up on one objective in order to achieve gains on another objective. By analyzing trade-offs, the PrOACT process tries to help find the alternative a) that eliminates unnecessary trade-offs and b) that people agree is the ‘best balance’ of trade-offs possible.

Temperature – Shifts in the natural frequency, duration, and timing of temperature conditions can affect biological communities as well as recreation uses and the functioning of and permitting related to thermal power uses. Water temperature can also determine the amount of dissolved oxygen present in the water column.

Transportation savings – The difference in the value of resources required to transport commodities between the waterway and overland.

Trigger – A form of decision criteria serving as a threshold or condition that, when met, initiates some action or decision.

Uncertainty – Circumstances in which information is deficient. Leaning while doing under the adaptive management process provides a framework for reducing program uncertainties over time.

Upper Missouri River – Mainstem of the Missouri River between Fort Peck Dam and the headwaters of Lake Sakakawea, and the Yellowstone River for an unspecified distance upstream of the confluence with the Missouri River.

Understory – The layer of vegetation beneath the main canopy of a floodplain or upland forest.

Vegetation management – Control and removal of vegetation on ESH using application of pre- and/or post emergent herbicides or cutting, mulching, disking, mowing, and raking of vegetation from sandbars to maintain suitable habitat conditions for least tern and Northern Great Plains piping plover nesting.

Work Plan (also Strategic Plan) – A rolling, five-year plan outlining the management actions, monitoring, assessment, research and engagement needs for the MRRP. It includes the details for the current FY and the FY+1 President's Budget, and planned activities for FY+2 through FY+4 for budgeting and other purposes.

Chapter 9 List of Preparers

Name	EIS Responsibility	Education	Agency/Firm
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Kara Reeves	Support for and peer review of Chapter 3, Human Considerations sections	M.S., Economics B.S., Finance	USACE
Clayton Ridenour	Support for Chapter 4 and the Adaptive Management Plan	M.S., Fisheries Ecology B.S., Fisheries and Wildlife	USACE
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Name	EIS Responsibility	Education	Agency/Firm
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Kate Buenau	Adaptive Management Plan; technical input to Chapters 2, 3 and 4; plover and tern modeling	Ph.D., Ecology B.S., Biology	Pacific Northwest National Laboratory
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Name	EIS Responsibility	Education	Agency/Firm
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Name	EIS Responsibility	Education	Agency/Firm
Mary Kenner	Administrative Record	B.S., Interdisciplinary Studies	Louis Berger
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Tom St. Clair	NEPA Compliance	Ph.D., Environmental Management M.S., Environmental Health Sciences B.S., Biology	Louis Berger
Laura Totten	Project manager for contractor support; NEPA compliance; Chapter 3, Fish and Wildlife and Mississippi River Biological Resources sections; Chapter 4 and coordination of cost estimating for EIS	M.S., Biological Sciences B.S., Biological Sciences	Louis Berger

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