APPENDIX A

NEW INFORMATION SINCE THE 2000 BIOP

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BIOLOGICAL ASSESSMENT ON THE MISSOURI RIVER MAINSTEM RESERVOIR SYSTEM, THE LOWER MISSOURI RIVER, AND THE KANSAS RIVER

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APPENDIX A

NEW INFORMATION SINCE THE 2000 BIOP

Since the U.S. Fish and Wildlife Service (USFWS) completed the 2000 Biological Opinion (BiOp), considerable new information has become available to both the U.S. Army Corps of Engineers (Corps) and the USFWS. This information includes: 1) completion of a report by the National Academy of Sciences' National Research Council (NRC) entitled "The Missouri River: Exploring the Prospects for Recovery", 2) further analyses of the recommended changes in System releases included in the 2000 BiOp Reasonable and Prudent Alternative (RPA), 3) continued monitoring and study of listed species, 4) development of a new model to better analyze use of reservoir habitat by the least tern and piping plover, and 5) the USFWS designation of critical habitat on the Missouri River for the piping plover that became effective on October 11, 2002. This appendix of the Biological Assessment (BA) discusses this new information. Finally, additional information has been provided to the Corps and USFWS by various entities and individuals since the 2000 BiOp was completed.

Two of the categories of new information listed above are broken down further in this section. Discussion of the analyses of the recommended changes in System releases included in the 2000 BiOp RPA is very detailed. It is broken down into subsections on the analyses of the effects of the releases on 1) the natural processes and tern and plover habitat, 2) connectivity to the floodplain, 3) shallow water habitat for river fish, and 4) spawning cue in the Lower River. The continued monitoring discussion focuses on 1) existing shallow water habitat on the Lower River, 2) results of Fort Peck monitoring, 3) the pallid sturgeon in the Fort Peck reach and 4) the historic mortality of least terns and plovers.

During the timeframe this new information was being developed and evaluated, the Corps and the USFWS entered into informal Endangered Species Act (ESA) consultation on the Missouri and Kansas River projects in May 2002. During the course of this consultation, the full range of measures to benefit the species were identified and discussed. These measures include proposed flow tests, fish hatchery improvements, accelerated broodstock collection, accelerated shallow water habitat construction, additional research, monitoring, and evaluation, and development of a programmatic approach to adaptive management for species recovery. While the new information since the completion of the 2000 BiOp will be discussed in this section, this informal consultation effort has resulted in the Corps bringing forth new measure that were not considered during the preparation of the 2000 BiOp. Even though these measures are new information, the detailed discussion of these will be included in the next separate section called the "Proposed Action".

NATIONAL RESEARCH COUNCIL'S 2002 REPORT

The National Academy of Sciences' National Research Council (NRC) released a 2002 Report entitled "The Missouri River, Exploring the Prospects for Recovery" in response to a request from the Corps and the U.S. Environmental Protection Agency. These two federal agencies asked the NRC to characterize the historical and current ecological status of the Missouri River, review existing scientific information and prioritize scientific information needs, and recommend policies and institutional arrangements to improve scientific knowledge and promote adaptive management of the Missouri River and floodplain ecosystem.

The NRC recognized the challenges to any plan for improving the ecology of the Missouri River. The report underscores the importance of restoring "natural river processes," and places emphasis on restoring river form and function. Further, the report recognizes that there are key uncertainties regarding how and to what degree the ecosystem will respond to different habitat restoration and river management actions. The NRC proposed that future actions leading to recovery of the ecosystem be framed within an adaptive management approach, which includes broad stakeholder participation. The report states:

> "Restoring some portion of the Missouri River's pre-regulation physical processes is the key to ecological improvements. Movement toward river recovery will necessarily be incremental, and should be framed within an adaptive management approach. Details of the timing and the extent of specific management actions should be established through collaboration among scientists, managers, and the public. Restoration efforts should be implemented within a basinwide framework that recognizes the relationship of tributaries to the mainstem, of upstream areas to downstream areas, and of the river system's main channel and floodplain. The recommendation to cast management actions within a basinwide framework is not meant to imply that all actions should be conducted simultaneously across the basin. On the contrary, a more reasoned approach, consistent with an adaptive management paradigm, would be to first identify and implement management actions that appear to offer substantial ecological improvements with minimal disruptions to people and flood plain infrastructure (the "low hanging fruit"). Management actions that are taken should be conducted in a spatially-coordinated manner that considers mainstem-tributary, upstream-downstream, and main channel floodplain relations through the entire river system."

During the current informal consultation with the USFWS, the Corps recognized that to restore natural river processes, the NRC recommendation of a broader approach to include diverse stakeholder participation was necessary. In the "Proposed Action" section of this BA, and consistent with the NRC recommendation, the Corps proposes a broader unified process that builds upon current stakeholder efforts to develop a program that would ultimately lead to greater success in the survival and recovery of the listed species and the ecosystem upon which they depend. This program involves taking actions in habitat and propagation with known biological improvements, conducting and monitoring tests to reduce the uncertainties of ecological responses to various flows, and having a time certain check-in to reconsider flow changes in response to the scientific information gained.

NATURAL PHYSICAL PROCESSES AND TERN AND PLOVER HABITAT

Natural Alluvial Geomorphologic Processes on the Missouri River

The Missouri River is an alluvial stream, and by definition, transports sediment whenever water is flowing between the high banks. Channel geometry (width, depth, slope, plan form, etc.) is a function of 1) the predominant hydrology, 2) the amount and characteristics of available sediment, and 3) the local/regional geology. All three of these factors are somewhat interdependent, but hydrology and sediment yield are more closely related. When viewed over a long temporal scale the river attempts to reach a state of "dynamic equilibrium", or "natural stability", where the channel geometry is created/maintained by a dominant discharge, or dominant discharge class. The dominant discharge is defined as the discharge (or discharge class) that transports the majority of bed material sediments through a river reach. Major flood events (25-, 50-, 100-year) can transport an enormous amount of sediment in a short period of time, cause severe bed and bank erosion/build up, and create large channel evulsions. Their infrequent occurrence and relative short duration, however, do not allow them to play a major role in determining the natural stability of a river reach. Rather, the natural stability is determined by normal flows and/or smaller floods with a higher return frequency and longer durations. These flows overtop point bars and medial sandbars at a great enough depth and for a sufficient duration to initiate scour. Natural stability does not imply static conditions. Erosion/deposition processes are ongoing. As high banks erode, point bars advance, and medial sandbars migrate downstream. In a naturally stable river reach over a long time period, the sediment transported into the reach will equal the sediment transported out.

Status of Alluvial Processes in the Present Missouri River

The above discussion represents the alluvial processes of the uncontrolled Missouri River. Presently the hydrology and sediment supply of the Missouri River is largely controlled by six large mainstem dams upstream of Yankton, South Dakota (RM 811), and by channelization downstream of Ponca State Park, Nebraska (RM 753).

Dams impact alluvial processes in two ways. First, dams change the hydrology of the river. Peak flows are reduced to provide flood protection, and base flows are increased for water supply, hydropower, etc. Channel evulsions associated with flood events become very rare and the floodplain ceases to contribute to the sediment supply. Flow regulation causes a shift in the dominant discharge class, usually to a lower discharge. Dams further impact the alluvial processes by preventing sediments from the upper basin from entering the reach below the dam, causing a sediment-starved reach below the dam. This leads to degradation of the riverbed and channel widening. The absence of large floods does not allow the river to rebuild high bank land. This process results in lower water surface profiles, flatter slopes, and a general decrease in the dynamic alluvial processes of erosion/deposition. In general, point bars do not advance as rapidly, medial sandbars move slower (some not at all) due to less over topping, and side channels tend to fill and/or drain. The alluvial processes that once took place across the entire floodplain are now confined to the area between the high banks. These slower, less dynamic alluvial processes can lead to vegetation encroachment that can further retard the alluvial processes.

The un-channelized Missouri River was a wide river with multiple channels of varying depths that resulted from erosion, channel evulsions, etc. In contrast, the channelized Missouri River is a single channel characterized by a greater depth-to-width ratio and nearly uniform velocities. Channelization has removed the banks as a source of sediment, leaving only the riverbed and tributary contributions to maintain the alluvial processes. This further exacerbates the degradation process, particularly in the reach above the Platte River. The net result is little or no exposed point bars/sandbars and very little alluvial variability.

Relationship of the Hydrologic and Geomorphic Processes to the Missouri River Ecosystem Form and Function

The Missouri River before man's influence was characterized by a highly variable flow regime both within and between years. This flow regime and the associated sediment it transported drove many of the physical and biological processes thought to be important in maintaining a healthy, functioning ecosystem. The high-flow periods maintained a connection between the river and its floodplain and the constantly moving sediment along with the eroding and filing of the bank line maintained the channel morphology. The resulting channel morphology, in conjunction with the river flow, created the physical habitat template on which endemic Missouri River species are adapted. The distribution and abundance of species associated with a river is highly dependent on this physical habitat structure (Poff and Ward 1990). Naturally variable flows are thought to create and maintain the dynamics of the in-channel and floodplain habitat that are essential to aquatic and riparian species. Important ecological functions are thought to be associated with natural flows (Poff et al 1997). As an example, sediment transport through channels flushes organic matter. Woody debris washed into the channel can help create high quality habitat. Flood flows act to flush organisms and nutrients back to the river.

Poff et al. (1997) thought a river's flow was so important that they concluded it could be considered a "master variable". This conclusion was based on the assumption that stream flow was highly correlated with many critical physical characteristics of a river such as channel geometry and habitat diversity. Richter (1996) further defined the important characteristics of stream flow so that they could be quantified and evaluated. These characteristics include: magnitude, timing, frequency, duration, and rate of change of flow. Each of these characteristics has associated biological relevance. Magnitude refers to the mean of the daily water conditions. It is a measure of the habitat availability and suitability and, thereby, defines the volume of habitat on any given day. Timing, or when a flow event occurs, determines whether critical life cycle requirements can be met. Frequency is a measure of how often the flow event occurs and influences reproduction and mortality. Duration refers to how long the flow event occurs and determines whether life cycle phases can be completed. Rate of change is a measure of how rapidly flow changes and can influence an organism's ability to respond.

Effect of the CWCP and the BiOp RPA on the Alluvial Geomorphologic Processes in Relation to Tern and Plover Habitat

As stated above, the geomorphic processes are a product of the hydrology, sediment availability, and geology. Because the 2000 BiOp RPA does not include a change in sediment availability and the geologic controls are unchanged, those aspects will not be discussed further. It is important to realize that a change in the present alluvial processes will require a change in the dominant discharge class. The dominant discharge is that discharge (or discharge class) that transports the majority of the bed material sediment load. Determining the dominant discharge class requires flow-duration data and an adequate relationship between river discharge and sediment transport. For the reach below Gavins Point Dam, the Sioux City gage is the nearest gage with an adequate sediment discharge record. Although this gage is not in the reach immediately below Gavins Point Dam, it is appropriate for this analysis as the hydrology of this gage is dominated by releases from Gavins Point Dam. To create a change in the alluvial geomorphology of the reach below Gavins Point Dam, the flow duration curve would need to be rotated clockwise sufficiently to change the dominant discharge class to the 55- to 70-thousand cubic feet per second (kcfs) class. Based on survey data, this is the discharge needed to inundate a significant number of medial sandbars to a depth that would initiate scouring.

The first step in determining the impacts of the 2000 BiOp RPA on the alluvial processes required the development of flow duration curves for the current Water Control Plan (CWCP) and the 2000 BiOp RPA System operation recommendation. These curves were developed using the daily flow models and are shown in Figure A-1. Examination of the flow-duration curves shows little change between the CWCP and the 2000 BiOp RPA. The second step was to determine the percent of the average annual sediment for each flow class. This was accomplished by merging the sediment discharge rating curve data from "Suspended Sediment Data Assessment Study, Missouri River at Sioux City, Iowa, MRR Sediment Series Report No. 39a, January 2001" and the flow duration curves, then dividing the sediment yield for each class by the total yield. The results are shown in Figure A-2. Examination of Figure A-2 indicates the distribution of sediment yield by discharge class for the 2000 BiOp RPA is shifted to the left (lower class) rather than to the right. The slight shift in the 55- to 70-kcfs discharge class is not sufficient to scour and maintain high elevation barren sandbars. In fact, the data suggest that, if any changes were to occur, the most likely scenarios would be for existing barren sandbars to convert to islands and channel border fills, with barren sandbars being maintained at a much lower elevation.

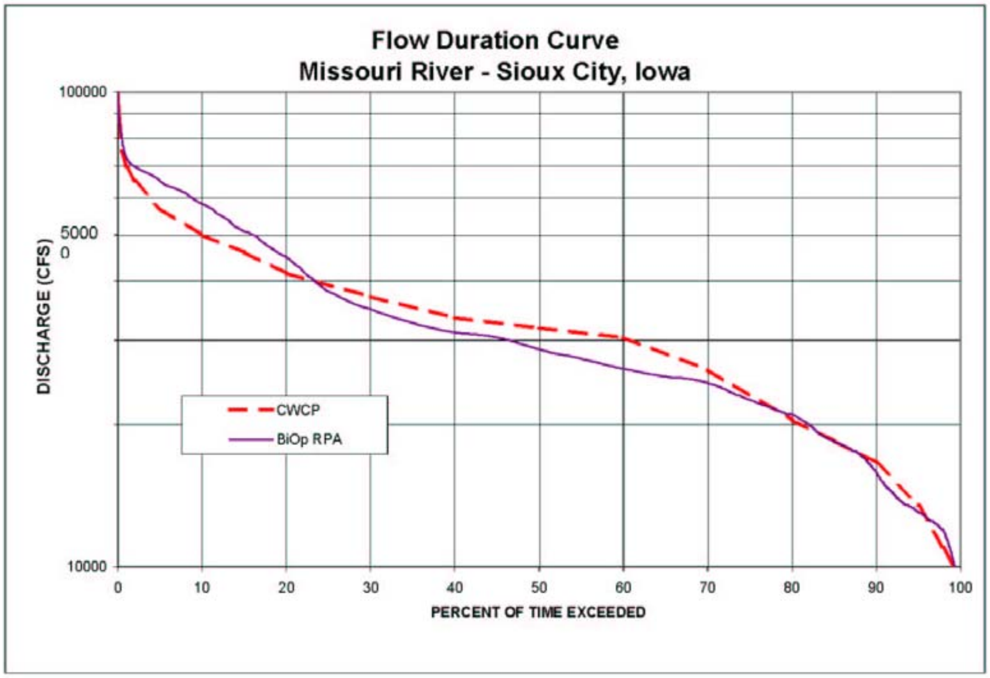

Figure A-1. Flow duration curve at Sioux City, Iowa for the CWCP and 2000 BiOp RPA.

As the distance from Gavins Point Dam increases, the impacts of any changes in the release pattern decreases even further. This is due to the tributary inflow, both water and sediment, as well as the river's attempt to re-establish a new "natural stability". The stabilization and channelization downstream of Sioux City further restricts the natural alluvial processes. In the reach below Sioux City, the alluvial processes will be nearly identical for both the CWCP and the 2000 BiOp RPA.

Additional data were gathered in the fall 2002 concerning the quantity and quality of sandbar habitat in the reach below Gavins Point Dam. Nine randomly selected sandbars were surveyed in an attempt to determine the total amount of available sandbar habitat at various flows. Sandbar area was broken into three categories: 1) total sandbar, 2) potential habitat, and 3) safe habitat. Potential habitat was defined as having less than 25 percent vegetation cover with a beach slope of less than 1:10. Safe habitat was defined as potential habitat that is more than 18 inches above the water surface. The survey data were integrated with rating curves for each site to develop a habitat-discharge relationship for each site. The area from the nine sites was prorated based on 2000 data (last year for which data exist) to estimate the total habitat for the reach below Gavins Point Dam. The results of this investigation are shown in Figure A-1. It is important to note that, in Figure A-3 the Total Emergent Sandbar line approximates the conditions of the reach in 1998 (following 1997 high flows). Lack of a true scouring/sandbar building event has allowed erosion and the vegetation encroachment to reduce the amount of habitat.

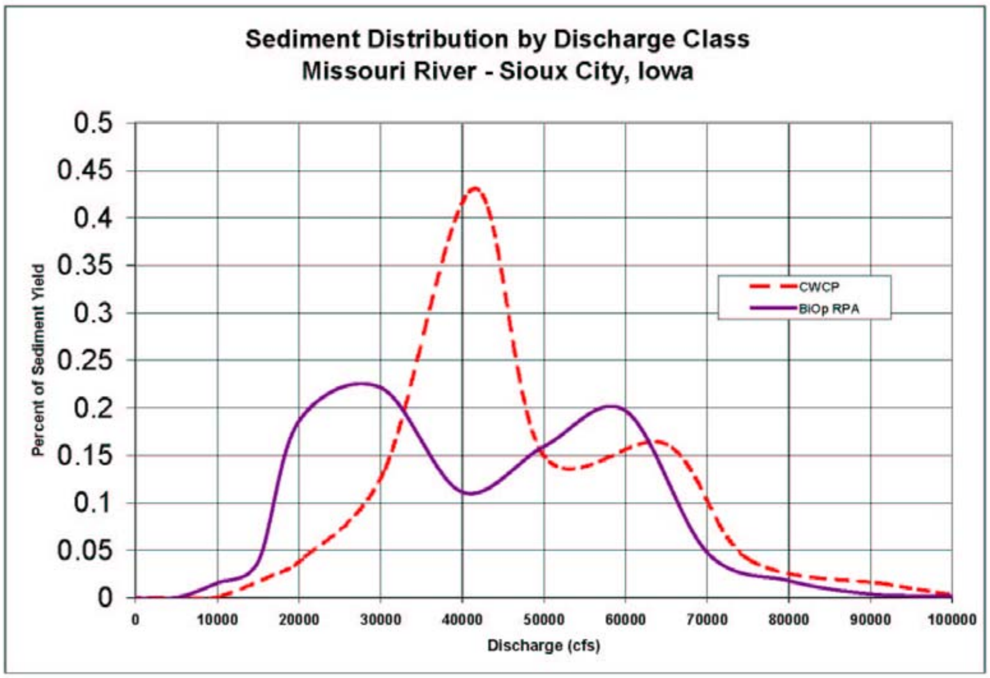

Figure A-2. Sediment distribution by discharge class for the Missouri River at Sioux City for the CWCP and 2000 BiOp RPA.

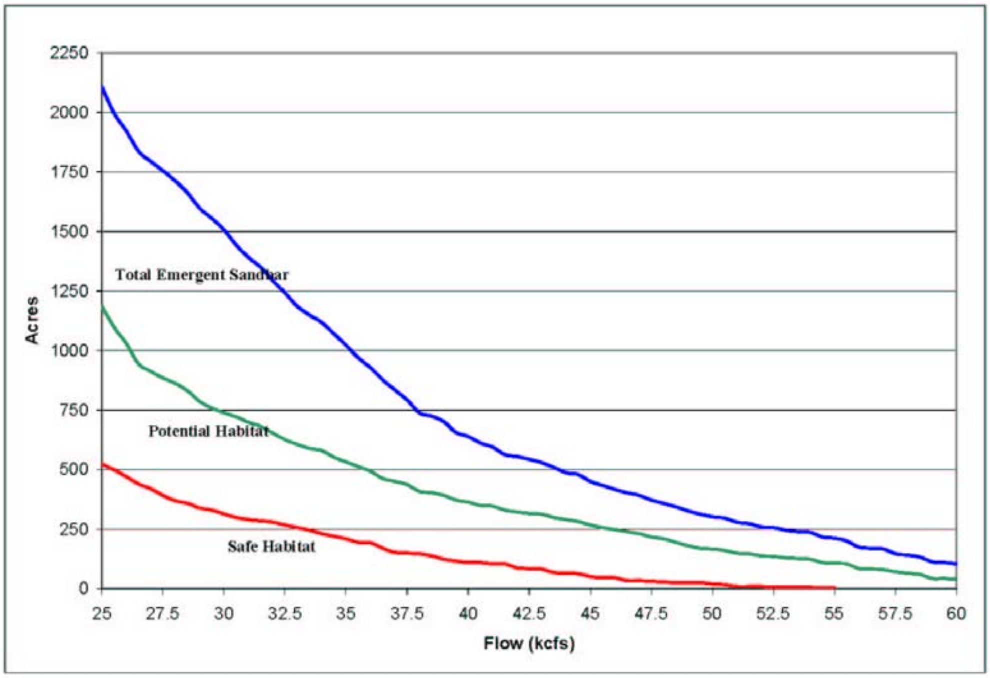

Figure A-3. Relationship between flows (25 to 60 kcfs) and acres of emergent sandbar, potential habitat, and safe habitat on the Missouri River between Gavins Point Dam and Ponca, NE, Fall 2002.

Erosion is a natural process that would take place whenever stages drop to the point that flowing water concentrates in the main channel(s) of the river. This process, however, is likely more pronounced in an incised/degradational reach like the one below Gavins Point Dam. In a natural river setting, this erosion loss would be offset by the presence of a scouring/sandbar building event. The BiOp RPA, with its two low flow periods (summer and winter), would likely accelerate this erosion process beyond that of the CWCP, but it does not provide for a complimentary scouring/sandbar building event. The long-term net result would be less available habitat.

CONNECTIVITY TO LOW-LYING LANDS

As stated in the 2000 BiOp, "Floodplain connectivity refers to the seasonal flooding of areas adjacent to the river. The spring flood pulse often provides connectivity between the floodplain to the river. For native river fish like the pallid sturgeon, this floodplain connectivity, especially during May/June, provided spawning areas for forage species, increased phytoplankton production, and redistributed carbon to the river". This carbon, in the form of detritus scoured off of the floodplain, settled out in the shallow water areas along the river where the microscopic biota grew. As the pallid sturgeon hatched, the larval fish would float down the river until they were able to float into the shallow water areas, where they would reside during their fragile first months of life.

To better understand how much floodplain connectivity may be occurring along the Lower River from Sioux City to the mouth, the Corps estimated the acreage and elevation of the low-lying lands (areas adjacent to oxbow lakes and chutes) that could be inundated by high river flows. The elevations were then converted to river stages for the output nodes of the Daily Routing Model (DRM) hydrologic model used for the Master Manual Study to determine when the spring rises were inundating these areas. The months of May and June, the period when the spring rise was modeled in the DRM simulation runs, were checked to see how many acres were flooded for a varying number of days for the CWCP and 2000 BiOp RPA.

The graphical results of the analyses of connectivity are duration plots of acres inundated versus percent of the time. Duration plots were developed for inundation for at least 2 days up to over 10 days. As the number of days is increased, the amount of acres inundated diminishes, and the curves shift towards the lower left on the plots. The duration plot of the 2-day analysis is shown as Figure A-4. This figure shows that the CWCP and the 2000 BiOp RPA provide similar duration plots of connectivity with the number of acres of connectivity for 2 days sometime during May or June increasing with the addition of a spring rise at Gavins Point Dam. This figure also includes the duration plot for a run-of-river (ROR) scenario to provide a perspective for how often these low-lying lands would have been inundated for 2 days with no flow control. This flow scenario has considerably higher values across the entire range of the plot from near zero percent to near 100 percent.

Table A-1 presents the total values for the 25th percentile (lower quartile) from Figure A-4 with a breakdown among the reaches making up the total reach from Sioux City to the mouth. The 25th percentile was selected for presentation because the BiOp RPA was designed to have spring rises about one-third of the time, and the 25th percentile falls within the range when spring rises may be affecting the amount of connectivity.

The CWCP provides a total of 3,282 acres of connectivity. The 2000 BiOp RPA has only a slightly higher total value (+164 acres) because only two reaches have substantially higher values—the Sioux City and Omaha reaches.

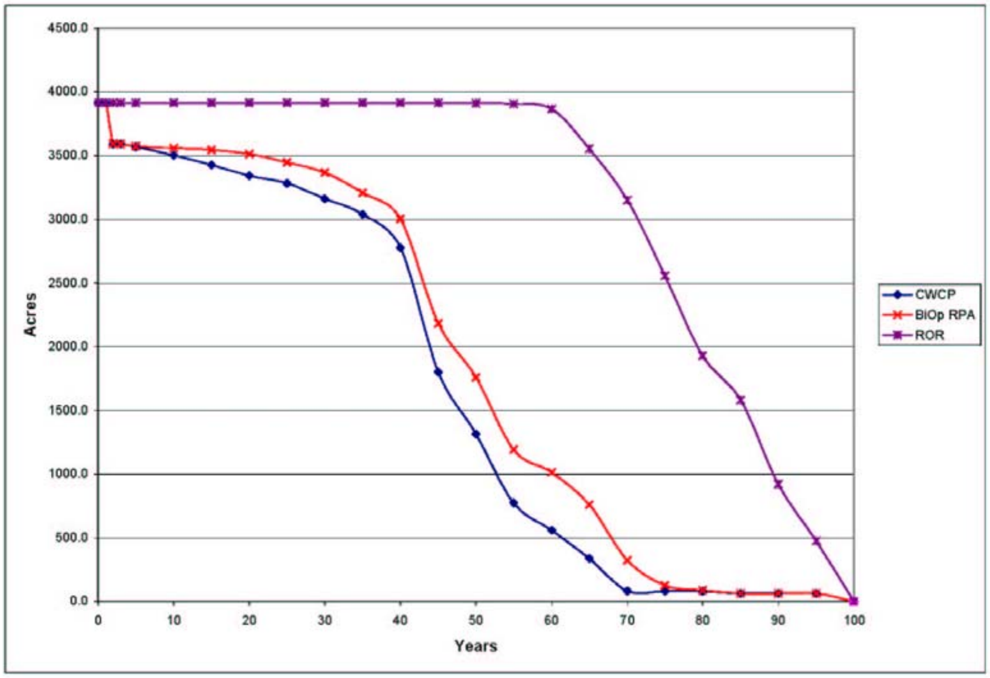

Figure A-4. Acres of connectivity for 2 days in May and June for the CWCP, 2000 BiOp RPA, and ROR scenario.

Table A-1. Connectivity to low-lying lands for 2 days in May and June (acres for the 25th percentile).

River Mile	Reach	CWCP	BiOp RPA
734-648	Sioux City	249	332
648-597	Omaha	270	344
597-497	Nebraska City	136	137
497-374	St Joseph	287	287
374-250	Kansas City	265	272
250-130	Boonville	768	768
130-0	Hermann	1,307	1,307
Total		**3,282**	**3,446**

In conclusion, the gains in connectivity in the low-lying areas with flow increases via spring rises are relatively minor. In fact, there is effectively no increase in value downstream of the Omaha reach. By adding a spring rise of 20 kcfs, the gain in connectivity is only 164 acres. These data indicate that the spring rise should not be added based on the gains in connectivity that could occur with the increased flows.

Another way of looking at the end result of connectivity, or the flushing of detritus into the river, is to think about how this type of material gets into the river. The 2000 BiOp RPA, according to the data presented above, would inundate approximately 3,500 acres of low-lying lands for 2 days during the May through June timeframe. This is approximately 5.5 square miles. A small tributary to the Missouri River is likely to be several times larger than 5.5 square miles, and a rainfall event on the drainage area for each tributary flushes detritus into the tributary, which ultimately gets carried into the Missouri River. There are many thousands of acres that drain into the Missouri River, and many of the tributaries carry heavy sediment loads into the river during major rainfall events. These tributaries are, and will continue to be, the main source of detritus to the Missouri River no matter how the System is operated.

SHALLOW WATER HABITAT ALONG THE LOWER RIVER

In its 2000 BiOp, the USFWS states that shallow water habitat has value to all life stages of native big river fish and other river organisms. As stated in the introductory remarks of the connectivity analysis discussion, shallow water habitat is especially important during the first few months of the life of the larval pallid sturgeon, an endangered species. The Corps and USFWS agreed during the formal consultation for, and the review of, the 2000 BiOp, that 20 to 30 acres of shallow water habitat per mile may provide the habitat necessary for initial recovery of pallid sturgeon. This section focuses on the amount of shallow water habitat occurring in the Lower River for the CWCP and 2000 BiOp RPA.

The analysis of existing shallow water habitat under the various alternatives was conducted using data obtained for the physical habitat model developed by the Corps as one way of assessing impacts of alternatives. As part of the development of that model, cross sections were taken at a representative sub-reach of seven reaches of the Lower River and hydraulically modeled. These data provided a basis for determining the amount of habitat fitting into a variety of depth and velocity classes for each of the seven reaches (habitat per mile times reach length). Shallow water habitat for the purpose of this analysis is habitat that is up to 5 feet deep with a velocity no greater than 2.5 feet per second. The amount of habitat in each depth and velocity class could be determined based on the amount of flow in each river reach. Using these relationships, the Corps developed a model that would provide duration plots of the acres of habitat per mile in each reach for any timeframe of interest. Generally, the Corps looked at individual months; however, the lowest flows for one of the alternatives occur from mid-July to mid-August. Data were computed for this period for the seven Lower River reaches and are presented in Figure A-5. Integration of the area under the duration curve leads to the average daily value per mile for shallow water habitat for each reach. TableA-2 presents these data for all seven sub-reaches modeled. This table also presents historic data (prior to the construction of the navigation channel) to provide some insight into habitat losses due to the construction that has taken place on the river. Figure A-6 shows the acres per mile for the six reaches from Sioux City to the Osage River for the CWCP and BiOp RPA. Data are not presented for the reach downstream from Gavins Point Dam because there is already adequate habitat (63.8 acres per mile for the CWCP) in this reach. Using the acres per mile from Figure A-6 and Table A-2, the total acreage available in each reach of the Lower River from Gavins Point Dam to the Osage River (River Mile 130) can be computed. The data for five reaches are presented in Table A-3 on a reach and total basis (data combined using data from two locations for the Sioux City to Omaha reach) for the CWCP, BiOp RPA, and the ROR scenario (no control of system inflows by the Mainstem Reservoir System).

Table A-2. Expected daily shallow water habitat for representative sub reaches from mid-July to mid-August (acres/mile).

Reach	CWCP	BiOp RPA	ROR	Historic
Gavins Point	63.8	71.6	64.9	106.6
Sioux City	2.2	5.8	3.6	107.0
Omaha	1.9	5.1	3.3	107.0
Nebraska City	4.5	6.0	5.1	103.4
St. Joseph	4.8	7.9	6.2	100.3
Kansas City	1.4	1.7	1.2	-
Boonville	18.3	18.7	17.4	-

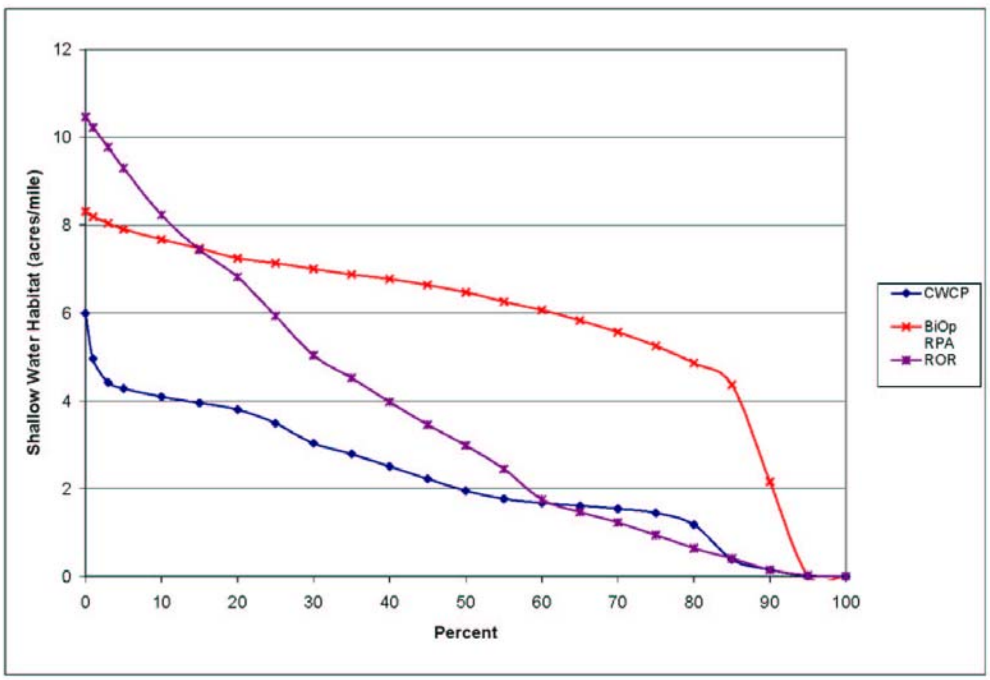

Figure A-5. Duration Plot of Shallow Water Habitat during the mid-July to mid-August Period - Sioux City Reach.

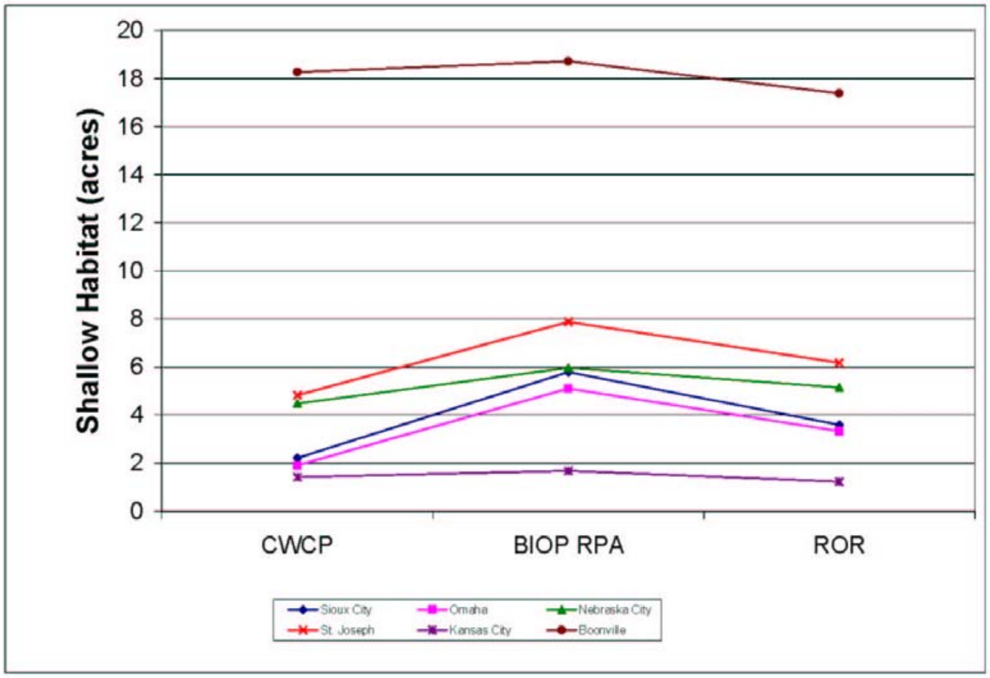

Figure A-6. Expected Daily Shallow Water Habitat for River Fish.

Table A-3. Expected daily shallow water habitat available from mid-July to mid-August (acres).

Reach	CWCP	BiOp RPA	ROR	20 Ac/mile
Sioux City to Omaha	288	757	479	2,740
Omaha to Nebraska City	144	191	165	640
Nebraska City to Kansas City	929	1,513	1,187	3,840
Kansas City to Grand River	164	200	144	2,320
Grand River to Osage River	2,193	2,245	2,086	2,400
Total	**3,717**	**4,906**	**4,061**	**11,940**

The CWCP provides 3,717 acres of shallow water habitat for the five reaches. The greater share of this habitat is provided between the Grand and Osage Rivers in the central part of the State of Missouri: 2,193 acres, or 59.0 percent of the total. Operation with the lower summer split season release of 25/21 kcfs under the BiOp RPA provides an increase of 1,189 acres more than the CWCP. If the flows were to be completely uncontrolled, as they would be under the ROR, the amount of total shallow water habitat would be less than it is for the 2000 BiOp RPA but 344 acres more than for the CWCP.

The shallow water habitat model was modified to create an output file of the average daily habitat values for each year. This data set allowed the creation of Figure A-7. This figure compares the annual values for the CWCP and the 2000 BiOp RPA. Reducing the summer Gavins Point Dam release to 21 kcfs during this mid-summer period, as operations under the BiOp RPA would, results in more shallow water habitat in most years. Both the CWCP and BiOp RPA provide a wide range of habitat from year to year. This results from the year-to-year variability in flows, which indicates that flow should not be relied upon to provide the required amount of shallow water habitat.

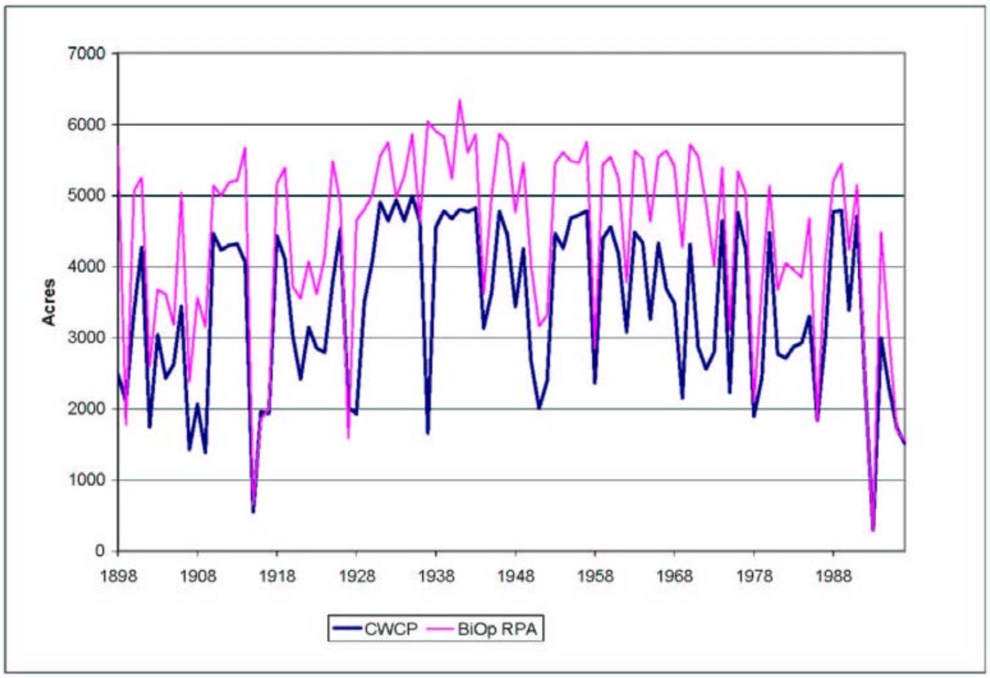

Figure A-7. Annual Average Daily Acres of Shallow Habitat from Sioux City to the Osage River from mid-July to mid-August.

Additional discussion is needed regarding the amount of habitat that exists per mile in the reaches from Sioux City to the Osage River. With the exception of the Grand River to Osage River reach, habitat acreage is well below the minimum of 20 acres per mile that the Corps and USFWS agreed was a necessary attribute for the continued survival of the pallid sturgeon. Even though there are some increases in shallow water habitat (as discussed above and shown in Figure A-6), the gains provided by release changes alone are also not enough to provide, on average, the minimum 20 acres per mile. Because of this, the USFWS included in its 2000 BiOp RPA the recommendation for the Corps to construct additional shallow water habitat. The changes in flow primarily have an impact on the amount of additional habitat that needs to be provided through channel alternation methods. For example, the 2000 BiOp RPA may reduce the amount of required acres to be constructed, on average, by 1,189 acres. This amounts to only 10 percent of the total of 11,940 acres required to meet the 20 acres per mile requirement.

As flows in the Lower River decrease, shallow water habitat associated with the Corps' mitigation, Section 1135 habitat enhancement projects, and other off-channel habitat sites are affected. Figures A-8 through A-10 identify the changes in habitat with flow for the CWCP and BiOp RPA. For the sites in the Sioux City to the Platte River reach (Figure A-8), the BiOp RPA reduces the habitat by about 150 acres at the median value with its 21-kcfs release from Gavins Point Dam in the mid-July to mid-August timeframe. Similarly, habitat is lost in the Platte River to Rulo reach (Figure A-9), with the loss for the 2000 BiOp RPA being about 50 acres at the median value. Finally, the loss at sites further downstream is anticipated to be minimal, as evidenced by the relatively minor loss at the Jameson Island site, which became aquatic habitat resulting from BANP maintenance activities following the 1993 flood and is now part of the USFWS's Big Muddy Refuge (Figure A-10). The total of about 200 acres of lost habitat would reduce the increase in shallow water habitat provided by the flow changes of the 2000 BiOp RPA.

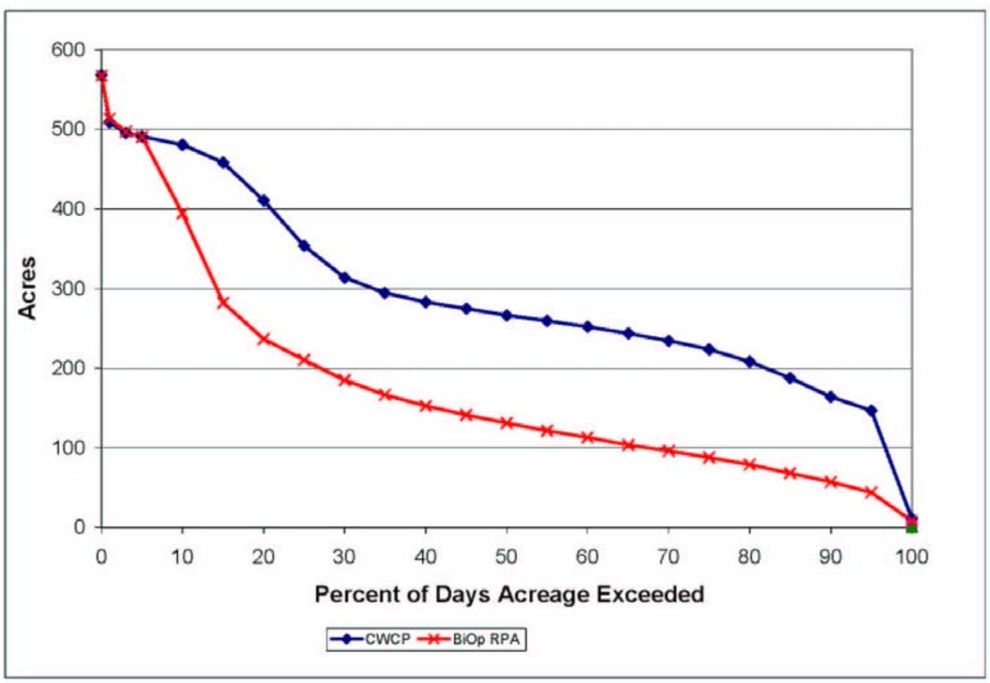

Figure A-8. Impacts on existing mitigation and Section 1135 projects - Missouri River, Sioux City to the Platte River.

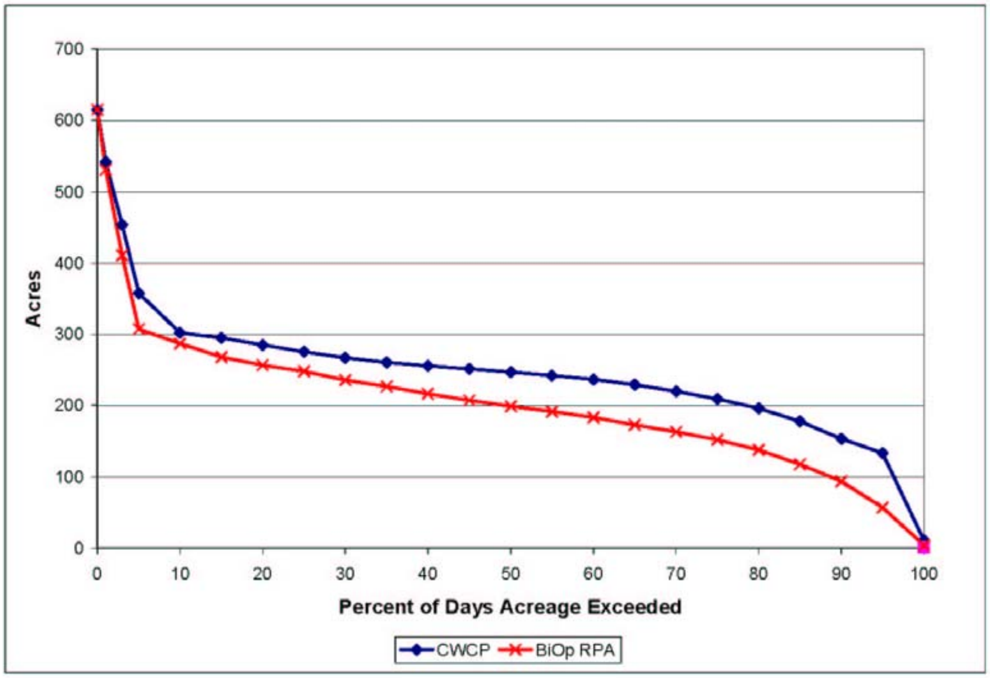

Figure A-9. Impacts on existing mitigation and Section 1135 projects - Missouri River, Platte River to Rulo.

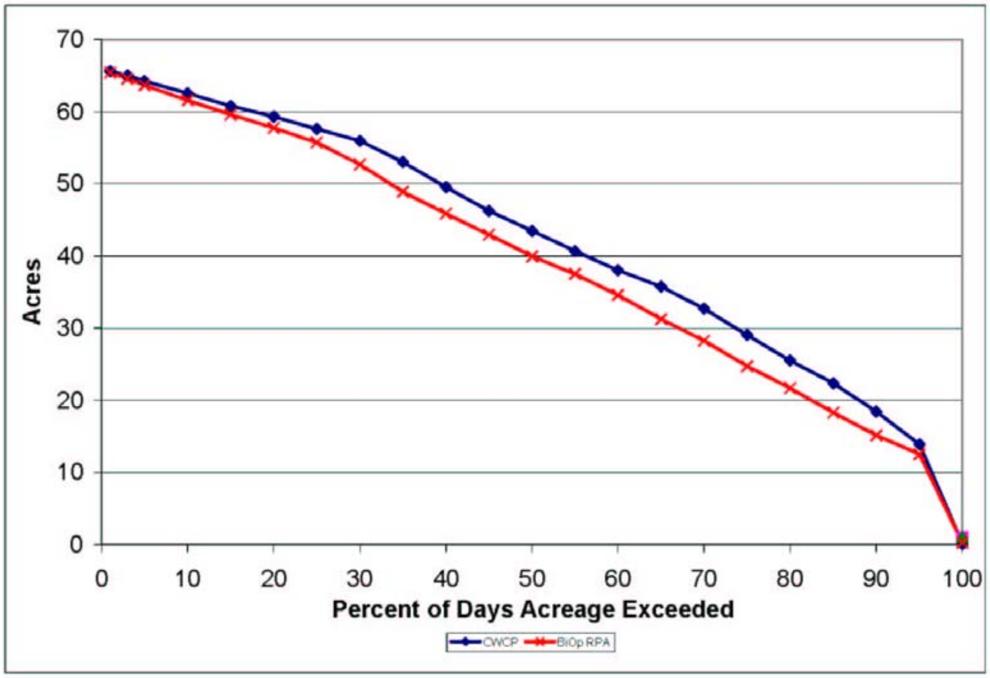

Figure A-10. Impacts on existing mitigation site – Jameson Island.

SPAWNING CUE IN THE LOWER RIVER

The 2000 BiOp RPA recommends a spring rise release from Gavins Point Dam to provide, among other biologically important functions, a spawning cue for native river fish, especially the endangered pallid sturgeon. The 2000 BiOp RPA specifies a modified annual release pattern that has a spring rise above the full navigation service releases of 15 to 20 kcfs. This release is to have a duration of 2 weeks at its peak and a total duration of 4 weeks including the period over which the releases are gradually increased and decreased. Discussions between the USFWS and Corps staff determined that the spawning cue requirements of the pallid sturgeon are basically unknown at this time.

In an e-mail sent to the Corps on January 22, 2001, the USFWS requested the Corps to conduct a set of hydrologic analyses. This set of analyses included a spring rise analysis. The USFWS requested, “For gage sites downstream of Gavins Point, document spring rise spawning cues. Rises should be defined as increases of discharge of at least 20 percent above the mean discharge prevailing for the preceding 15 days, during the period May to July. The rise should take place over three days or less”. The USFWS provided no information on what duration of rise to analyze. This lack of information supported the general understanding between the Corps and USFWS staffs that the required spawning cue is basically unknown at this point in time. Corps staff understood that the aforementioned criteria were hypothetical, and they did not have supporting data, analysis, and documentation of associated spawning success. A discussion of the analysis conducted for evaluating a spawning cue follows.

A model was developed that would access the daily flow data for each DRM node location from Gavins Point Dam to the mouth. A running average of the daily flows for the previous 15 days was conducted using the data starting on May 1 and ending on June 30 of each year. (The likelihood of spawning cues after June 30 is low, so it was not checked.) The flows for May 1, 2, and 3 were checked to determine if the flows over this 3-day period exceeded the prior 15-day average by at least 20 percent. If the flows on one of the days met the 20 percent increase, the model would continue to check the daily average flow until it dropped to less than 20 percent of the flows for the 15 days prior to May 1. The model continued the day by day check of the prior 15 days, computed an average, and counted the number of days the flows continued to be at least 20 percent above that prior 15-day average. This continued up to June 30.

In various years there were some short periods and some longer periods. The model recorded the longest period in terms of days. The longest period was recorded for each year, and then the 100 years of data were analyzed. The 100 annual values were sorted from highest to lowest with the highest value assigned a 1 (for equaled or exceeded 1 percent of the time) and the lowest value was assigned a 100 (for equaled or exceeded 100 percent of the time). A plot of these data is called a duration plot, and Figure A-11 is an example of such a plot for the CWCP. This figure shows the duration plots for the CWCP at all of the gage locations in the DRM simulation output files for the Lower River from Sioux City downstream. A similar plot was completed for the 2000 BiOp RPA. Another set of curves was developed for the ROR scenario (no control of inflows to the mainstem of the Missouri River). Sets of curves were compiled for each gage location using this first set of curves, as shown on Figure A-12. The second set of curves, one for each gage location in the DRM, provides the spawning cues for a full range of days. For example, to determine how often a 20 percent increase in flow occurred for a total of 21 consecutive days, one would go to the point where the 21-day line crosses the duration curves. Next one would slide down and read off the percent of time from the bottom axis of the graph for each curve. In the case of the CWCP curve on the figure, this point is located at 7 percent of the time. Similarly, it is 36 percent of the time for the 2000 BiOp RPA.

Because the USFWS did not specify a length for the spawning cue, a 21-day length was selected for analysis based on the spring rise recommended in the 2000 BiOp RPA. The total rise occurs over a 28-day period. If it takes 3 days to go up 20 percent, there will also be 3 days at the end of the spring rise where the releases will drop below the 20 percent value. This means that the spawning cue lasted 22 days (28 minus 6). Based on this basic consideration, a 3-week, or 21-day, length was evaluated for the spawning cue. Figure A-13 shows a bar plot of the resulting data for all of the gage locations included in the DRM. The bars shown on this plot shift upward for shorter lengths of spawning cues, and vice versa.

Figure A-13 shows that the CWCP and 2000 BiOp RPA have spawning cues that occur for differing percents of time. The values are presented in Table A-4. For example, the Sioux City line on the plot shows that the percent of time increases for the CWCP in a downstream direction, with a 21-day spawning cue occurring 7 percent of the years at Sioux City and a maximum of 38 percent of the years at Hermann. The 2000 BiOp RPA increases the percent of years values for most of the reaches to 33 percent or greater. The exception is for the St. Joseph reach. Generally, for the reaches from Kansas City upstream, the values are higher moving across the figure because of the spring rise included in the 2000 BiOp RPA. Downstream from Kansas City, however, the value for the percent of the time the spawning cue occurs remains relatively constant with the values ranging from 38 to 39 percent. The ROR scenario has more spawning cues because the uncontrolled flows were historically much higher than the modeled spring rises, with the percent values ranging from high on the reaches closest to Sioux City (78 or 79 percent) to the lowest value occurring at Hermann (54 percent).

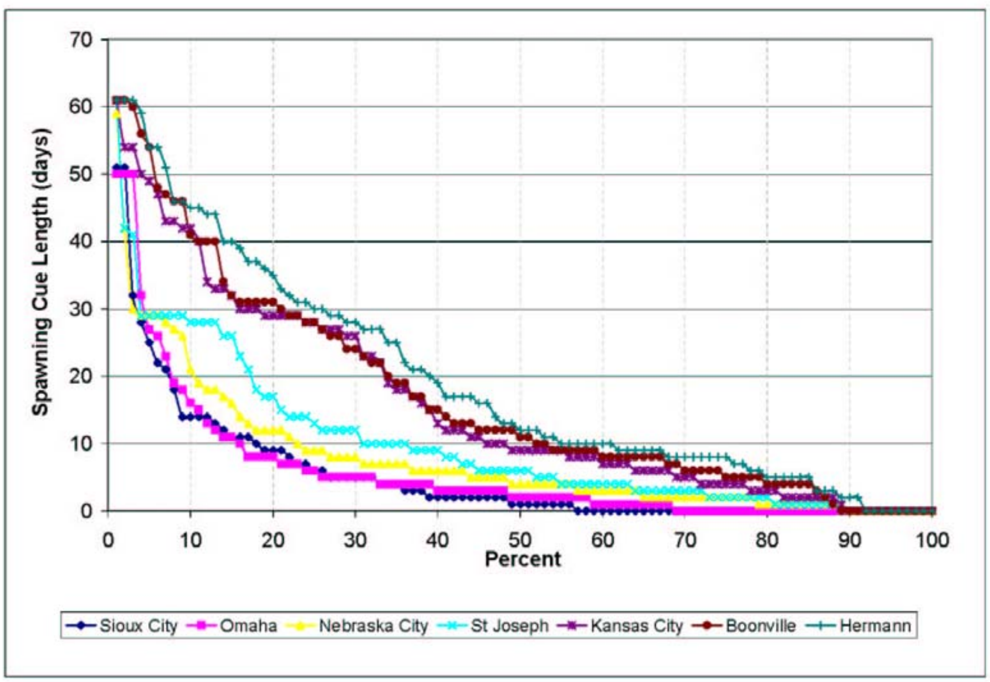

Figure A-11. Duration plot of spawning cue length during May and June for the CWCP.

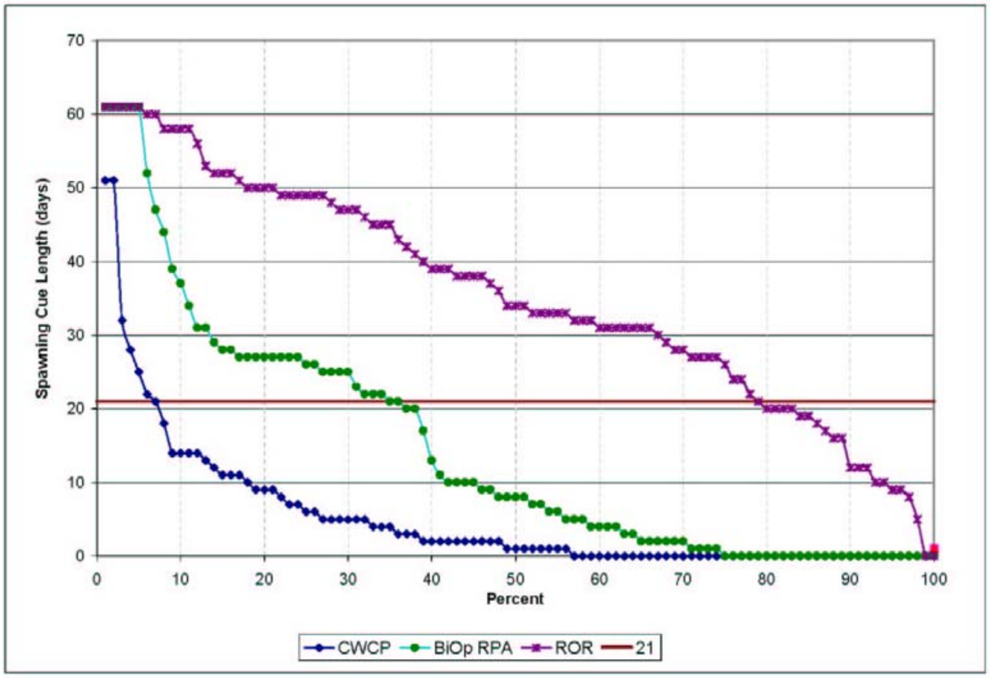

Figure A-12. Duration plot of spawning cue length during May and June at Sioux City.

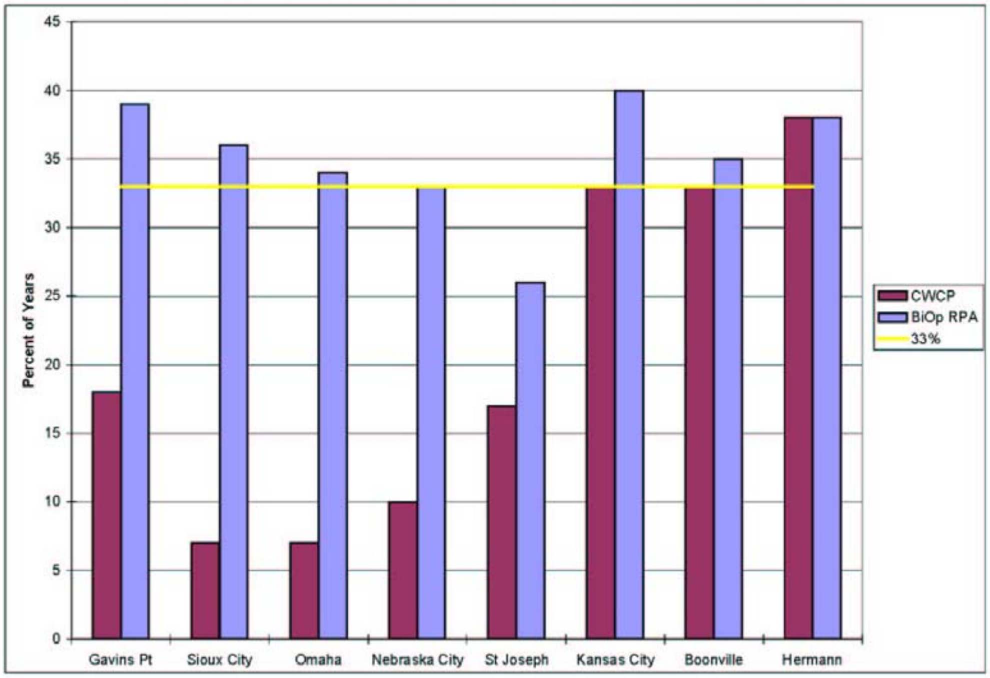

Figure A-13. Percent of years with a 21-day spawning cue at various locations.

Table A-4. Percent of years with a 21-day spawning cue at Lower River gaging stations.

Reach	CWCP	BiOp RPA	ROR
Gavins Point Dam	18	39	78
Sioux City	7	36	79
Omaha	7	34	79
Nebraska City	10	33	68
St Joseph	17	26	63
Kansas City	33	40	62
Boonville	33	35	62
Hermann	38	38	54

To demonstrate what happens when shorter length spawning cues are used in the analysis, a 14-day and 7-day spawning cue lengths were analyzed. As stated earlier, the shorter the spawning cue, the more often it occurs (duration plots shift upward). Figure A-14 shows that this is indeed the case. All of the bars in the graph have shifted upward. For the 7-day spawning cue length (Figure A-15) and the CWCP, the minimum percent of years is over 20 percent, and all of the reaches from Nebraska City to Boonville have this spawning cue length in over 33 percent of the years. The 2000 BiOp RPA has a 7-day spawning cue in 50 percent or more of the years for all of the reaches.

This brief analysis demonstrates how important it is to have a definitive length for a spawning cue. The CWCP comes very close to meeting the one-third requirement for a relatively short spawning cue, and it has a 34.5-kcfs flat release from Gavins Point Dam in many years. This release value is equivalent to a spring rise of about 5 to 6 kcfs in the May timeframe. The Corps' understanding of the primary purpose of the spring rise is to cue the pallid sturgeon to spawn; however, the absolute length and magnitude of the required flow to provide an adequate spawning cue are not known at this time.

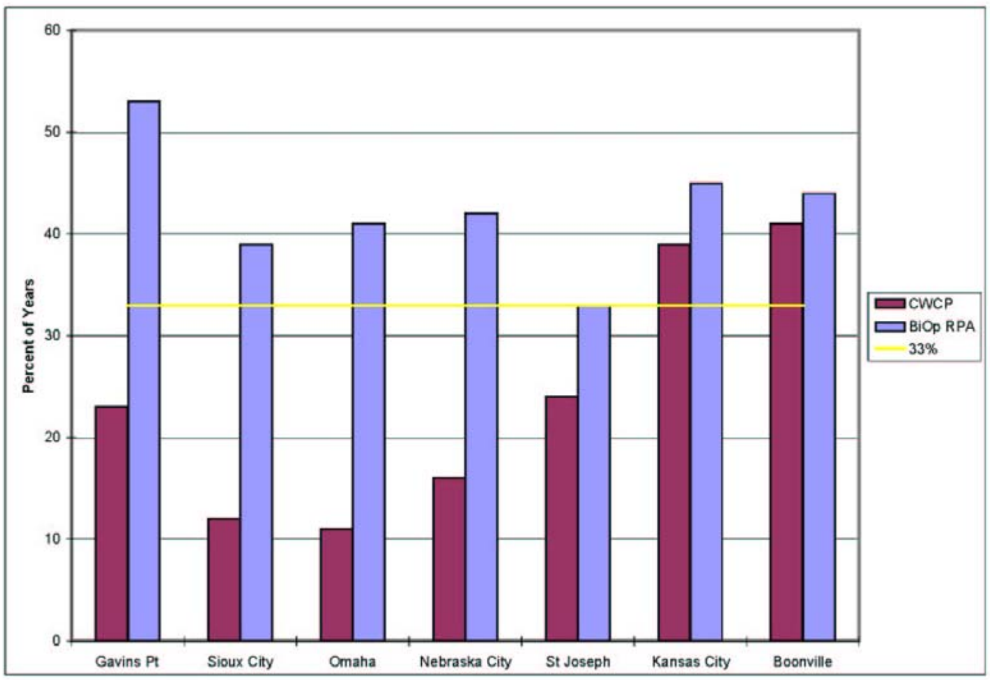

Figure A-14. Percent of years with a 14-day spawning cue.

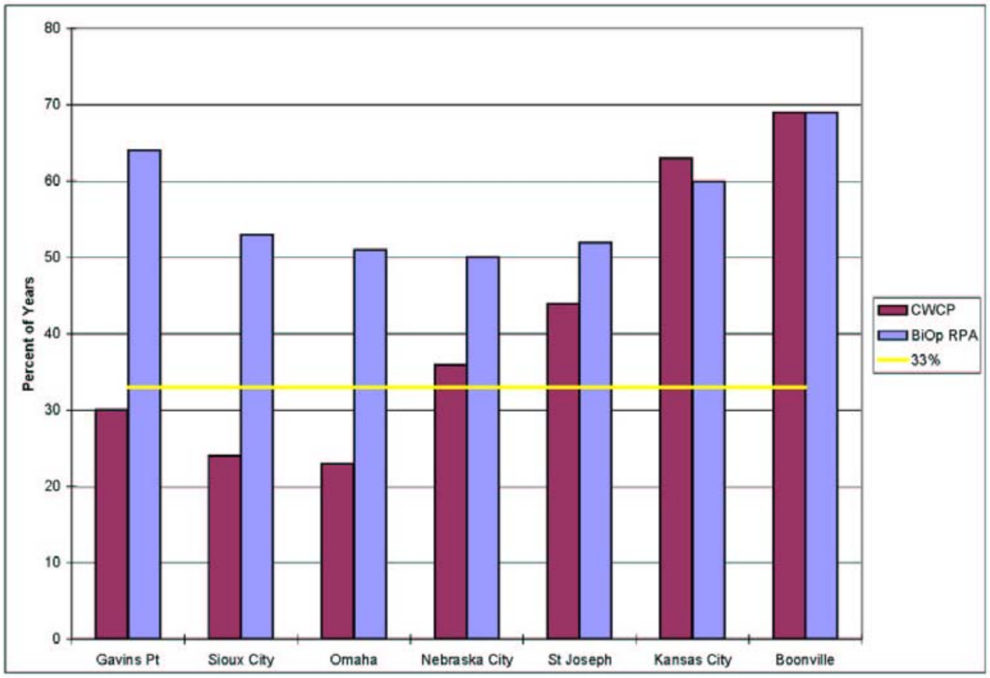

Figure A-15. Percent of years with a 7-day spawning cue.

The criticality of the spawning cue length is also demonstrated using another analysis that provides more insight into the relationship between spawning cues and shallow water habitat. For the pallid sturgeon to receive the greatest potential for future growth in numbers, the larval fish need to have adequate shallow water habitat following the spawn. Figure A-16 shows 2000 BiOp RPA plots of both spawning cue length and shallow water habitat over the period of analysis from 1898 to 1997 for the Sioux City reach. The spawning cue lengths range from zero days up to 61 days, and the shallow water habitat areas range from zero up to 8.0 acres per mile. The spawning cue length is affected by the spring flows, with the higher flows generally resulting in longer cue lengths. Conversely, the shallow water habitat size is affected by the summer flows, with the lower flows resulting in greater amounts of habitat. Because they are driven by different factors, they may not always coincide, as shown in the figure. The Sioux City data were selected for display because of the wider variation between the cue and habitat values.

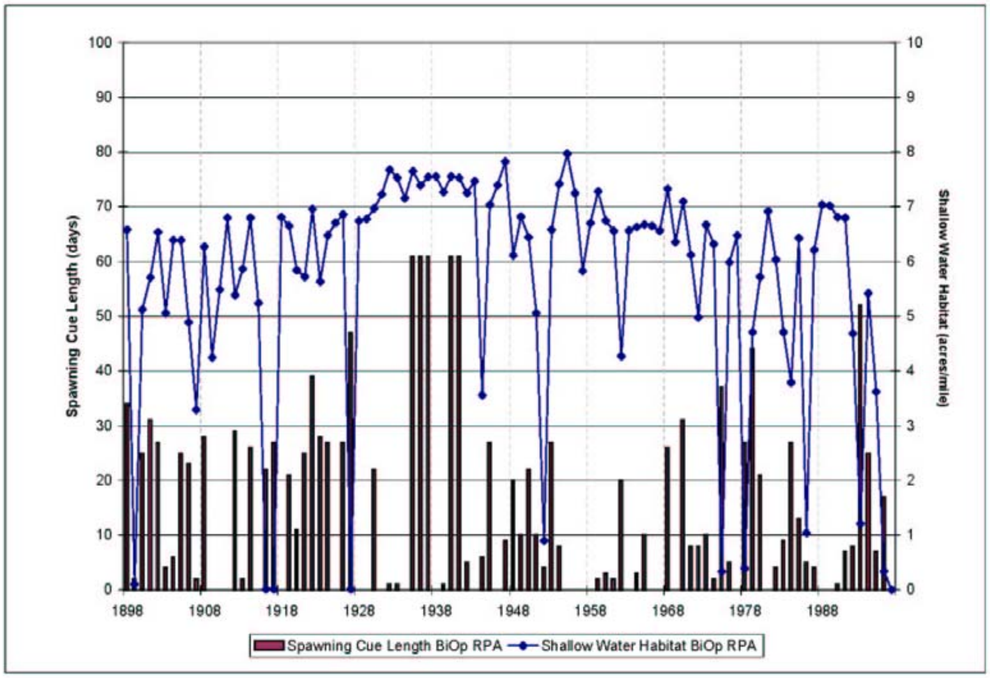

Figure A-16. Annual values for spawning cue length and shallow water habitat at Sioux City for the BiOp RPA.

To assist with the identification of years in which these two values are coincident, an Excel spreadsheet model was developed to identify whether the two are coincident in each year, with the shallow water habitat held constant and the cue length allowed to be variable. Four different cue lengths were run to develop the output for the Sioux City reach. The output file was plotted and is shown on Figure A-17. This figure shows that the percent of the years the shallow water habitat availability and spawning cue coincide increases as the spawning cue length decreases. A considerable percentage increase across the range of spawning cue lengths occurs between the CWCP and the 2000 BiOp RPA. One can also determine the spawning cue length required to have both factors coincide in 33 percent of the years (note 33 percent line on the plot). To have at least 2 acres per mile of shallow water habitat available for the 2000 BiOp RPA, a spawning cue length of at least 14 days has a coincident rate of 33 percent. In conclusion, shorter spawning cues of 14 days have to result in successful spawning to have a spawning cue with at least 2 acres per mile of shallow water habitat in 33 percent of the years. This analysis was based on the spawning cue occurring in May or June and the shallow water habitat being measured in the period from mid-July to mid-August.

Similar analyses were done for the Nebraska City and Boonville reaches. The results are shown on Figure A-18 for at least 3 acres per mile of shallow water habitat in the

Nebraska City reach and on Figure A-19 for at least 15 acres per mile in the Boonville reach. For the Nebraska City reach, the BiOp RPA meets the 33 percent level as long as spawning cues can be as short as 16 days to count as a spawning cue. For the Boonville reach, the spawning cue requirement needs to be no longer than 12 days for the BiOp RPA if there are to be coincidental spawning cues and at least 15 acres of shallow water habitat in the same year for 33 percent of the years. If longer spawning cues are required, smaller habitat requirements are needed. Conversely, if more habitat requirements are needed, an "adequate" spawning cue needs to be shorter.

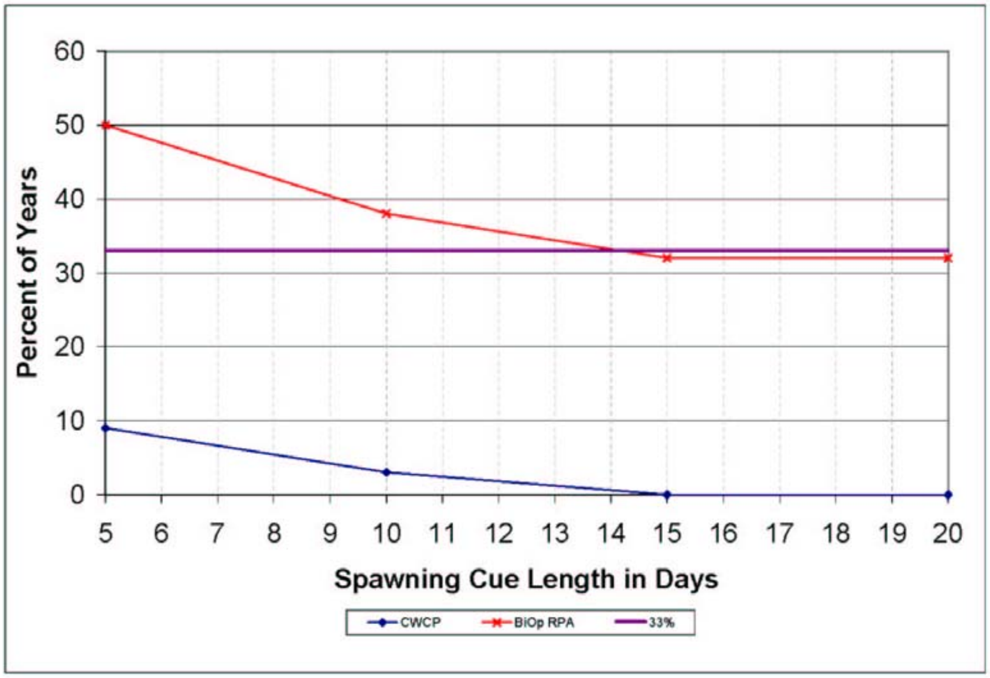

Figure A-17. Percent of years when spawning cue length and shallow water habitat (2 ac/mi) coincide at Sioux City

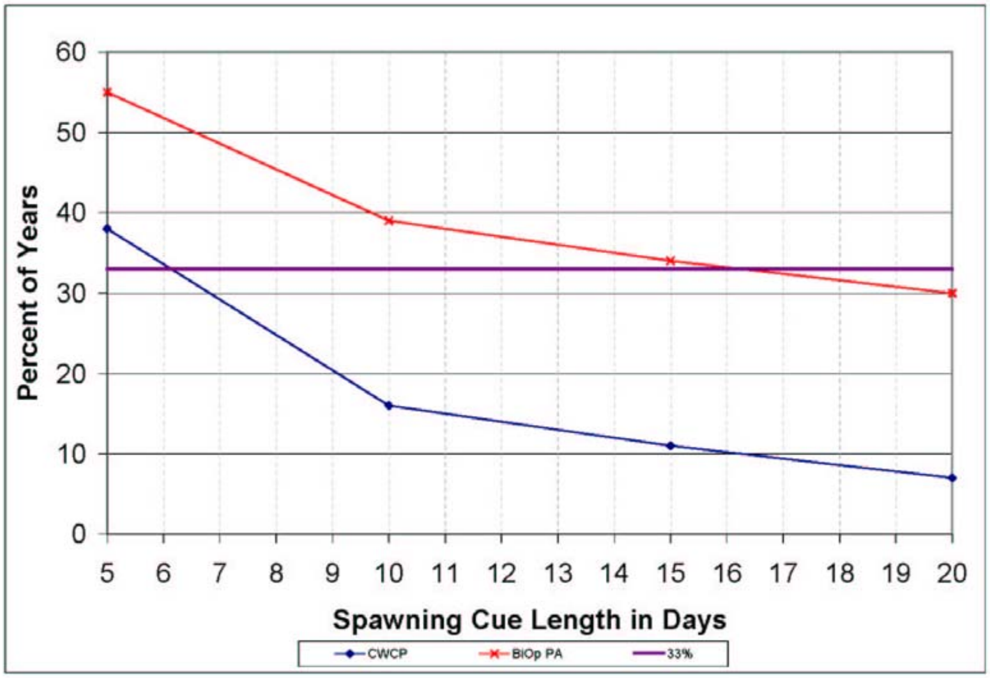

Figure A-18. Percent of years when spawning cue length and shallow water habitat (3 ac/mi) coincide at Nebraska City.

Spawning cues of greater magnitude were also evaluated to determine their frequency at the Lower River gaging stations for the two alternatives. The results are shown in Figure A-20, which shows that the differences between the CWCP and 2000 BiOp RPA diminish in a downstream direction. Also, the percent of years that the specified percent increase in spring flow occurs diminishes as the percent increase gets larger. Finally, this figure shows that the higher spring rises cannot meet the third-of-the-time requirement for even the 2000 BiOp RPA at all sites for magnitudes of rises that are 30-percent or greater. This demonstrates that the necessary magnitude may not be able to meet the desired frequency with any of the alternatives if the spawning cue requirement of the pallid sturgeon is greater than a 30-percent increase in flow.

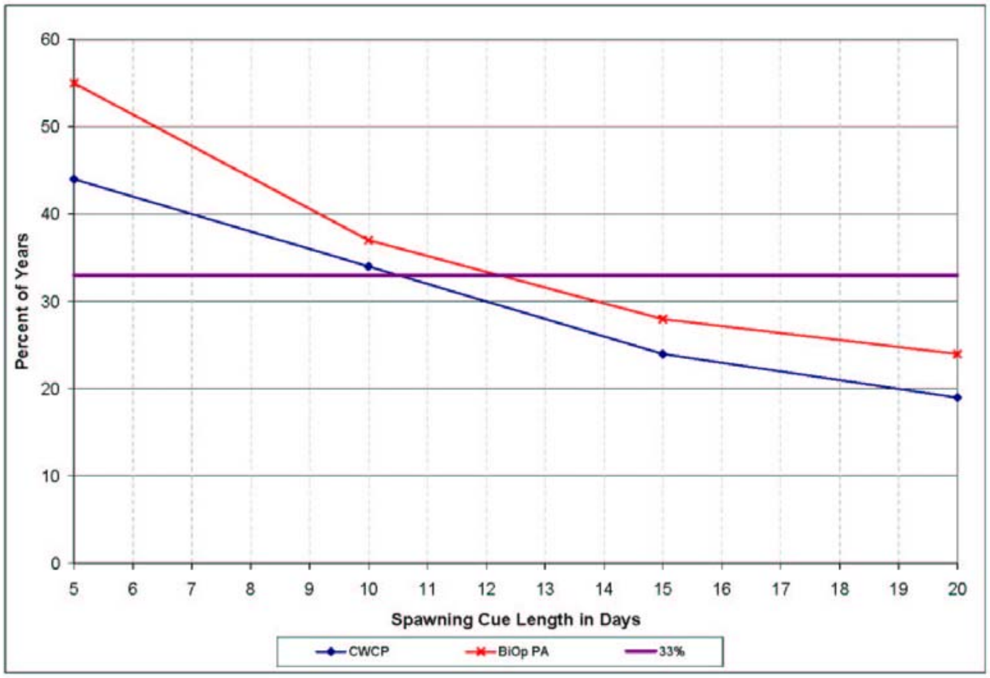

Figure A-19. Percent of years when spawning cue length and shallow water habitat (15 ac/mi) coincide at Boonville.

Water temperature is also an important factor in initiating spawning in sturgeon. The 2000 BiOp stated the shovelnose sturgeon is believed to provide a good indication of the spawning requirements of the pallid sturgeon. Shovelnose sturgeon in the un-channelized Missouri River downstream of Gavins Point Dam were thought to spawn in swift water in or near the main channel (Moos 1978). Moos (1978) studied the spawning timing and duration during 1968 and 1969. He observed that spawning initiation and duration was related to water temperature. In 1968, water temperatures increased steadily during the later part of May and early June to 18 to 19 degrees C, then rose rapidly in July to near the summer maximum. In 1969, water temperatures were more variable over the same time period. The differences he observed between the two years with regard to initiation and duration of spawning correlated with a faster increase in water temperature, subsequent fluctuations in temperature, and higher flow rates in the second year. Spawning in the second year was thought to be less successful because of the variability in these factors. The summer hydrographs for 1968 and 1969 are shown in Figure A-21.

Hurley and Nickum (1984) studied shovelnose sturgeon spawning and early life history on the Mississippi River in the tail waters of Lock and Dam 12 to Pool 13 (downstream from Dubuque, Iowa) during 1983. They concluded sturgeon probably spawned between May 21 and June 28 when water temperatures were between 16 and 24 degrees C. Peak spawning was thought to be in mid-June when water temperatures were 21 to 24 degrees C. Peak catches of males running milt occurred during periods of stable flows and rising water temperatures. Pallid sturgeon spawning is also directly related to water temperature (USFWS 2000). When water temperature increases to 16.7 to 18.3 degrees C, pallid sturgeon initiate spawning. Optimum spawning temperature for pallid sturgeon spawning in hatcheries was determined to be 15.5 to 18.5 degrees C.

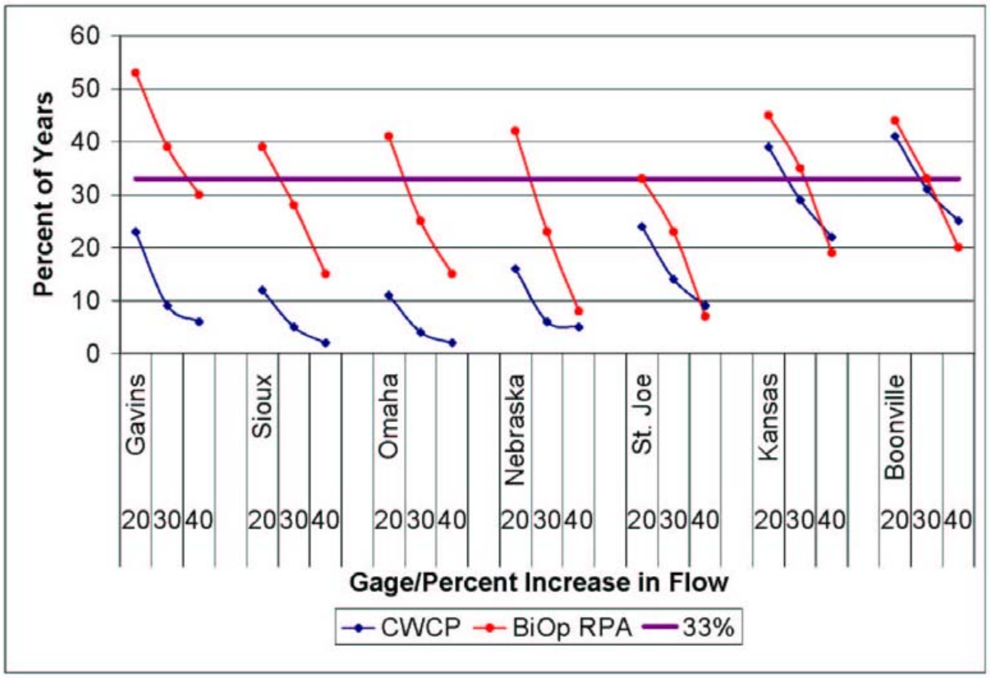

Figure A-20. Percent of years that a 14-day spawning cue is provided for three different magnitudes of spawning cues (20-, 30-, and 40-percent increase in flow).

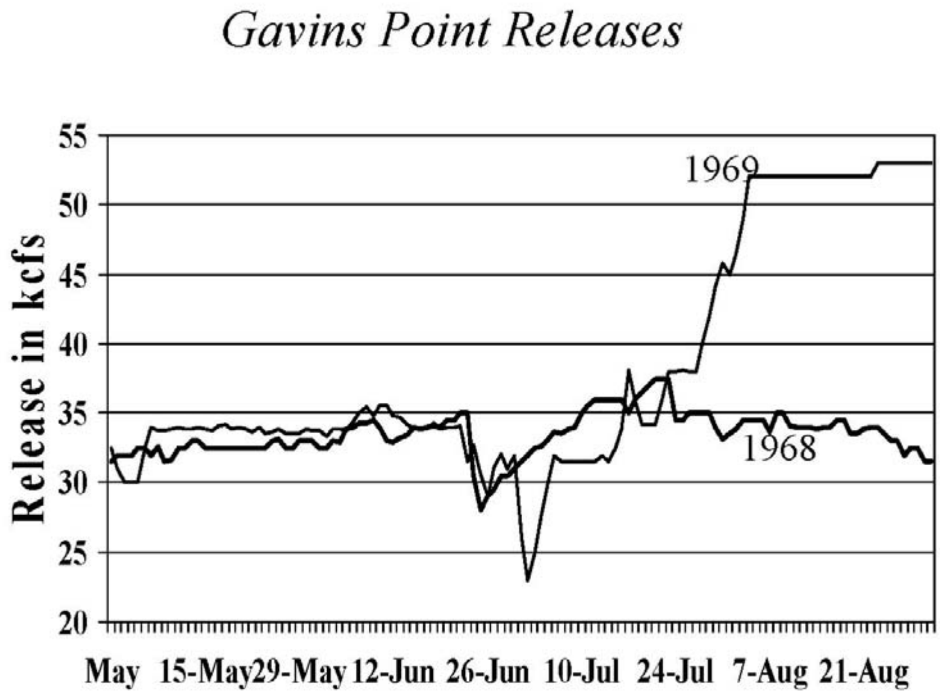

Figure A-21. Hydrograph during shovelnose sturgeon spawning for 1968 and 1969 below Gavins Point Dam (Corps of Engineers unpublished data).

In conclusion, greater knowledge of what constitutes an adequate spawning cue is required. If the primary reason for having a spring rise is to provide an adequate spawning cue for the pallid sturgeon so this species can recover, better definition of an adequate spawning cue is essential. The relationship of water temperature and flow to pallid sturgeon spawning is unknown. A robust Research Monitoring & Evaluation (RM&E) program that examines the multiple factors that may be limiting pallid sturgeon spawning and recruitment will fulfill this need.

FINDING OF RECENT MONITORING EFFORTS

Existing Shallow Water Habitat in the Lower River

It should be noted that Table 22 of the 2000 BiOp states that comparable data of existing SWH was not available for segments 14 and 15. New data provided by the Corps in the Supplemental BA for the 2002-2003 Annual Operating Plan (Corps 2003) shows that the Lower River, from the mouth of the Grand River (RM 250) to the mouth of the Osage River (RM 130), averages 18.3 acres/mile of existing SWH. Due to the local channel geometry and the reach hydrology, it is reasonable to assume that from the mouth of the Osage River (RM 130) to the mouth of the Missouri River (RM 0) the quantity and quality of SWH would be at least equal to that in the Grand to Osage River reach. The fact that 250 miles of the Lower River already averages nearly 20 acres/mile of SWH is very significant as the Corps tries to identify what measures are needed to save the pallid sturgeon.

Results of Fort Peck Monitoring

Monitoring and evaluation on the Missouri River below Fort Peck Dam has been occurring since spring 2001. This monitoring and evaluation was designed to comply with the 2000 BiOp. The monitoring and evaluation plan has multiple components, covers several years of data collection, and can be revised to address new information. The Corps intends to conduct a comprehensive evaluation at the conclusion of the data collection, but evaluation is also occurring throughout the data collection.

Preliminary findings exist which provide additional or new data for consideration. The Corps will continue to monitor and evaluate the new data. Because all of the activities planned for evaluating these finding have not been completed, consideration should be given to the following:

- Two larval pallid sturgeon were sampled in September 2002 in the Missouri River downstream of the confluence with the Yellowstone River. This provided the first documented account of larval pallid sturgeon in the Missouri River reach downstream of Fort Peck Dam and indicates that successful spawning by pallid sturgeon occurred in 2002. The potential spawning timeframe for these larval sturgeon can be estimated based on size and degree of maturity.

- Additional larval drift rate studies were conducted in 2003 to more thoroughly evaluate drift behavior and drift rate of larval sturgeon at higher velocities. These studies were conducted in the laboratory (USGS, Conte Anadromous Fish Research Center; report in preparation) and in a side channel of the Missouri River downstream from Fort Peck Dam (MTFWP, Fort Peck; USGS, Fort Peck; report in preparation). The preliminary indications are that the larva drift at the same rate as the water flows.

- Water temperatures were recorded at Frazer Rapids in 2001 and 2002. The water temperatures at Frazer Rapids were not sustained at 18 degrees C at any time during these two years.

Average historic surface lake temperatures have a high degree of variation from year to year, between 50 and 70 degrees F for the month of June. The Corps is still analyzing surface temperature ranges near the spillway during the summer months. To attain 64 degrees F (18 degrees C) at Frazer Rapids, a surface temperature in excess of 64 degrees F in the lake would be necessary before running the full test.

Estimation of Pallid Sturgeon Extirpation in the Fort Peck Reach

A remnant population of pallid sturgeon exists in the riverine portion of the Missouri River system below Fort Peck Dam (Fort Peck Dam to the headwaters of Lake Sakakawea) including the lower Yellowstone River. This area is recognized as Recovery Priority Management Area #2 (RPMA) of the Pallid Sturgeon Recovery Plan (USFWS 1993). Naturally reproduced young-of-the-year pallid sturgeon were collected during trawling efforts in September 2002 (David Fuller, MTFWP & Patrick Braaten, USGS, personal communication); however, recruitment is lacking as the size structure of this population is void of any smaller pallids. The existing wild population is dominated by large pallids exceeding 50 pounds. This population is declining, and extirpation of this aging population is projected as early as 2016, based on a population estimate conducted using data from 1991 through 2001 (Kapuscinski, 2002). The population estimate for wild pallid sturgeon in this reach of the Missouri River indicates the population to be 178 fish. 95% Confidence Intervals indicate as few as 96 and as many as 351 fish remaining in this population.

Least Tern and Piping Plover Reservoir Habitat Model

The Corps received feedback on the RDEIS regarding the lack of an analysis of the habitat that least terns and piping plovers, particularly piping plovers, were using on Lake Sakakawea and Lake Oahe. Historically, over 98 percent of the least tern and piping plover habitat within the Missouri River have occurred on the two lakes. This situation was discussed with the field biologists that monitor these birds annually to determine if development of such a model could be accomplished. As a result of this inquiry, the Reservoir Habitat Model (RHM) for least terns and piping plovers was developed in 2002. The RHM is a GIS model that combines elevation grids on these two lakes with end-of-month lake water surface elevations to quantify defined habitat type for each year of the 100-year period of record modeled. Modeling was ultimately conducted for approximately 25 percent of the area around each lake.

End-of-May elevations were selected because the majority of piping plovers have arrived on Lake Sakakawea and Lake Oahe by this time and have initiated nesting activities. The majority of least terns arrive shortly thereafter during the first 2 weeks of June. An inundation elevation was also required for the modeling, and the second largest end-of-month elevation in the previous 12 months was used. This was done to ensure a high probability that areas being classified as inundated had actually been inundated for a sufficient length of time during the previous year to reestablish suitable habitat conditions.

Three-dimensional digital representations of the lake floors were developed from pre-dam (1943 Lake Sakakawea, 1947 Lake Oahe) topographic paper maps. A grid of the river channel bottom at the upstream end of each lake was included in the lake elevation grids. A distance attribute was added to the elevation grid with the zero distance located at the upstream end of the model area.

Factors that were included in the modeling effort included slope of the exposed bottom (less than 1:10 was acceptable), years post inundation (amount of suitable habitat diminished as years following inundation increased), and distance from the water (100 meters maximum). The amount of suitable habitat included only areas connected to the main body of each lake. For example, a deep pool in a bay with high ground between it and the main lake pool was not included unless the water surface elevation was high enough to top the high ground and fill the pool. The May end-of-month elevation was used to calculate the miles of river that became exposed during each year. The first four years' data were not "good data" because the period of post inundation had not been fully engaged until the fifth year. All subsequent years had the factor fully engaged and were, therefore, based on all of the same factors.

A primary factor leading to the development of the model was the concern that increased conservation during droughts, which all alternatives undergoing detailed analysis included, would result in less habitat around the lakes. For this reason, the model was developed with the goal of being able to understand relative differences in habitat among the alternatives (versus being able to identify the absolute amount of habitat for a specific alternative). The modeling determined that the increased conservation actually provided an increase in average annual habitat. Also the alternatives with spring rises and lower summer flows had increased levels of habitat, compared to that of the CWCP. Furthermore, any gains in riverine habitat for the alternatives being evaluated at that time would not be offset by losses of habitat around the lakes. Both riverine and lake average annual habitat amounts increased with these alternatives.

Historic Least Tern and Piping Plover Mortality Report

The Corps has compiled and evaluated all available current and historic information from these assessment activities to document natural loss and the impacts of System operations on avoidable and unavoidable take of least tern and piping plover nests, as described in the 2000 BiOp. This analysis evaluated the impacts of take from 1) daily dam operations, including storage and releases; 2) flood control operations; 3) uncontrolled local inflow; and 4) predation, weather, abandonment, human disturbance, livestock, and erosion. The report on this analysis has been provided to the USFWS by separate transmittal.

CRITICAL HABITAT DESIGNATION

The USFWS designated critical habitat for the northern Great Plains population of the piping plover (67 FR 57638) including the Missouri River in September 2002.
In Montana, critical habitat was designated on Fort Peck Lake (77,370 acres (31,310.6 ha.), and 125.4 miles (201.8 km) of the Missouri River below Fort Peck Dam (RM 1712.0 to RM 1586.6). In North Dakota, critical habitat includes 18.6 miles below Fort Peck Dam (RM 1586.6 to RM 1540.0), 179 miles of river on Lake Sakakawea above Garrison Dam (RM 154.0-RM 1389.0), 87 miles of river below Garrison Dam (RM 1389.0-RM 1302.0), and 70 miles of river on Lake Oahe (RM 1302-RM 1232.0). In South Dakota, critical habitat includes 159.7 miles on Lake Oahe (RM1232.0-RM

1072.3); 36 miles (57.9 km) below Fort Randall Dam (RM 880.0- RM 844.0), 32.9 miles (52.9 km) on Lewis and Clark Lake (RM 844.0-RM811.1); and 58.9 miles (94.8 km) below Gavins Point Dam (RM 811.1-752.2). The Kansas River was not designated as critical habitat.

Primary constituent elements of the northern Great Plains population of the piping plover are those habitat processes (biological) and components (physical) essential for the biological needs of courtship, nesting, sheltering, brood rearing, foraging, roosting, intraspecific communication, and migration. The overriding primary constituent element (biological) necessary on all sites is the dynamic ecological processes that create and maintain the physical components of piping plover habitat through dynamic hydrological processes. On rivers, the physical primary constituent elements include sparsely vegetated channel sandbars, sand and gravel beaches on islands, temporary pools on sandbars and islands, and the interface with the river. On reservoirs, the physical primary constituent elements include sparsely vegetated shoreline beaches; peninsulas; islands composed of sand, gravel, or shale; and their interface with the water bodies.

ADDITIONAL INFORMATION SUBMITTED BY OTHERS

Following the 2000 BiOp, additional biological information was provided to the Corps and the USFWS by other entities and individuals. This information has been provided to the Corps by separate transmittal.

CONCLUSION

In light of the new information presented in this BA, the Corps has concluded that the RPA flows at Gavins Point are not reasonable and prudent. The new information was used in the development of the Corps' proposed action and helps support the Corps'conclusions. The Corps believes the new information is significant and substantive, and meets the threshold for reinitiation of consultation between the Corps and the USFWS.