Programmatic Environmental Impact Statement Technical Appendix

Pallid Sturgeon

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<u>Background</u>

Description of Habitat Area

Within the area affected by the alternatives, the pallid sturgeon occurs in the lower Platte River. Most captures and study observations have occurred in the area below the upstream edge of Two Rivers State Park (river mile 41), just above the confluence of the Elkhorn River (river mile 32) to the mouth of the Platte River (U.S. Fish and Wildlife Service 1997, E. Peters, University of Nebraska- Lincoln, personal communication). This section of river can generally be characterized as being considerably more turbid than many developed plains rivers; it contains significant instream structure (e.g. sandbar complexes, large woody debris, islands, and side channels); and although substantially impacted by upstream water development, exhibits some facsimile of the pre-development seasonal hydrograph. These habitat features lend the lower Platte River considerable importance in its habitat value to native plains fishes such as the pallid sturgeon and sturgeon chub (U.S. Fish and Wildlife Service 1997).

Flows in the lower Platte River consist primarily of water from three upstream sub-basins; the upper reaches of the Platte River, the Loup River, and the Elkhorn River. The Shell and Salt Creek watersheds provide smaller, but significant flows to the lower Platte River. The remaining lower Platte River water supply comes from ungaged minor tributaries and groundwater inflow (Nelson 1983).

The Platte River basin above the confluence with the Loup River encompasses 59,300 square miles. The upper Platte basin carries an average of over 1.2 million acre-feet of water each year. The greatest volume of water delivered to the central Platte River comes in the form of snowmelt from the East slope of the Rocky Mountains in Colorado and Wyoming.

The Loup basin encompasses some 15,200 square miles. Much of the basin is fed by seeps and springs draining the Ogallala aquifer underlying the Nebraska sandhills region. The unconsolidated sands and gravels comprising the sandhills absorb some of the runoff, snowmelt and rainfall in the area. This acts to form an underground storage reservoir that slowly releases water into small tributary streams draining into the Loup River. As a result, the natural flow of the Loup River, while it does exhibit seasonal hydrology associated with runoff, it does not experience dramatic year-to-year changes between wet and dry cycles (Nelson 1983).

The Elkhorn River also rises in the sandhills region of Nebraska, and drains approximately 6,000 square miles (McKinley 1935) and carries nearly one million acre-feet of water each year (Grier 1983). In addition to draining part of the sandhills, it also drains a considerable area in the more humid and less permeable loess hills region of northeastern Nebraska. Summer thunderstorms provide localized runoff events in the rolling hills of the Lower Elkhorn watershed, resulting in substantial variability in flows and silt load at Waterloo, Nebraska (Nelson 1983).

The Shell and Salt Creek watersheds drain a physiographic region similar to the loess hills of the Lower Elkhorn basin. Shell Creek enters the Platte River near North Bend, Nebraska, and Salt Creek enters the Platte River just downstream from Ashland, Nebraska.

In addition to upstream development of water in the Platte River basin, a substantial level of municipal and industrial water development effects the habitat area. Currently, the Fremont and Lincoln well fields pump several hundred acre-feet per month and 5,850 acre feet per month respectively. Downstream of the Louisville gauging station, but within the habitat area, the Omaha Metropolitan Utilities District and Allied Chemical Company well fields pump a combined total of 6,760 acre-feet per month. Agricultural uses consume an additional unmeasured quantity of water from the lower Platte River itself.

Sediment transport within the Platte River basin is directly related to instream flow. As a consequence, water development within all areas of the basin directly affects the rate of sediment transport. This in turn affects maintenance of instream habitat such as sand and gravel bars, and also affects turbidity levels that have been linked to pallid sturgeon feeding efficiency (U.S. Fish and Wildlife Service 1993).

Historic Trends

<u>Hydrology</u>

Relatively few records exist of flow in the Platte River basin prior to water development. Nearly-continuous records of flow in the mainstem Platte exist since 1928 for a point above the Salt Creek confluence (near Ashland, Nebraska) and since 1953 for a point about 16.5 miles from the river mouth (near Louisville, Nebraska). Annual peak flows at Ashland are shown in Figure 1, and annual flow volume in Figure 2.

Figure 1. Annual peak flow at Ashland, Nebraska

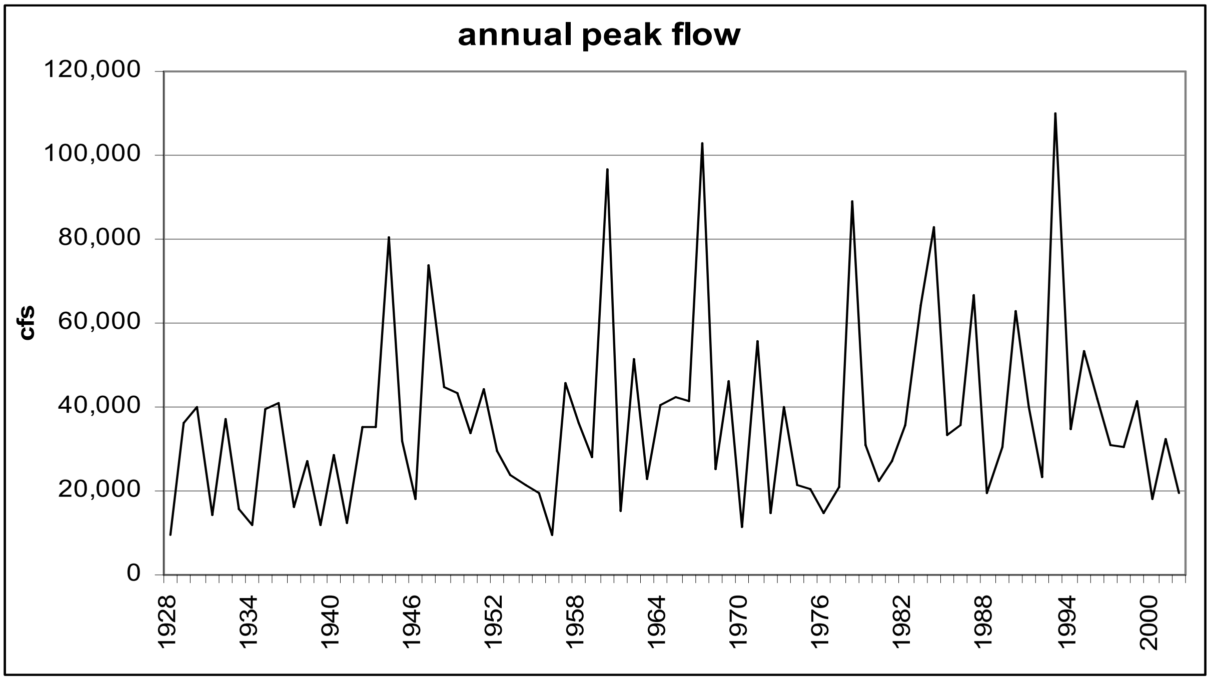
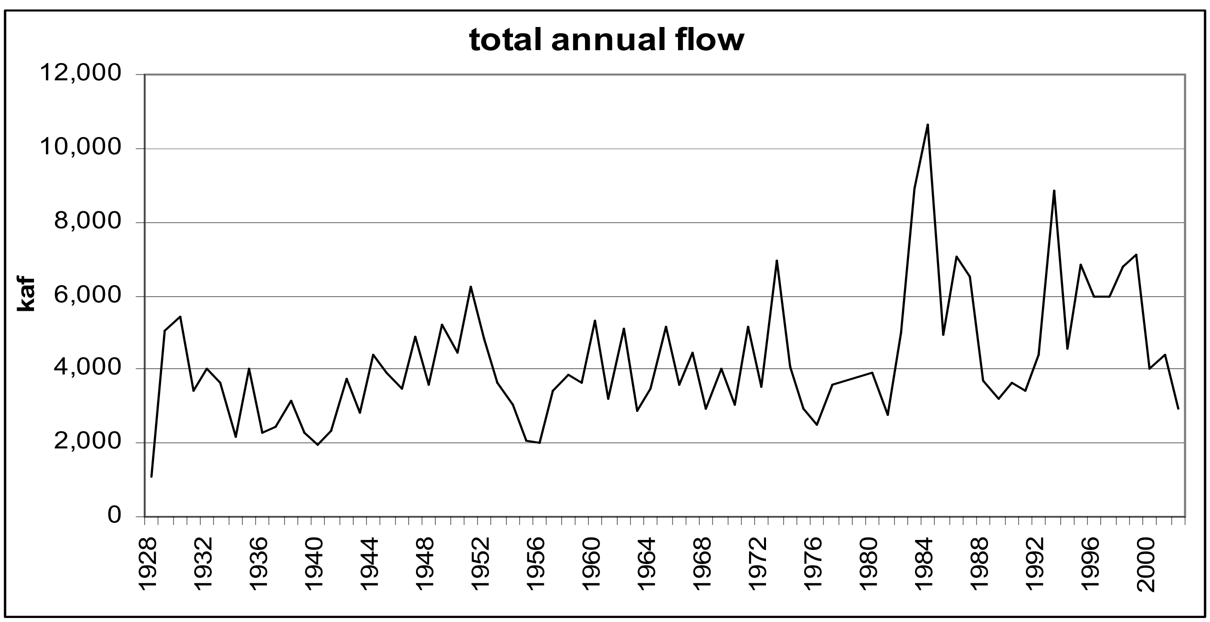


Figure 2. Total annual flow at Ashland, Nebraska



Given the limited term of the period of record available for the lower Platte River, and the fact that records begin after significant water development had already taken place, it is difficult to identify distinct trends in the long-term hydrology of the lower Platte River. The extent of the period of record available do distinctly show that the Platte River basin is subject to wet and dry cycles typical of the Great Plains. In addition, the period of record shows that the 1980's – 1990's wet cycle was wetter than the two previous wet cycles, but a meaningful long term trend cannot be drawn from the limited data.

The USFWS (2003) has estimated the degree to which depletions both above and below the Loup River confluence have affected flows at Louisville from February through September. This information suggests that water development has reduced flow during the February through July timeframe by approximately 35% overall, and during July through September by approximately 30% to 45% overall (Table 1).

Table 1. Estimated depletions to flow at Louisville, Nebraska.

Period	Estimated average depletion to Louisville flows due to water use above Loup confluence	Estimated average depletion to Louisville flows due to water use in entire Platte basin
February-July	At least 25%	~ 35%
July-September	15% to 30%	30% to 45%

Sediment Transport

Yang equations used by Lyons and Randle (1988) show that the relationship between rate of flow and rate of sediment transport is not linear. In essence this means that flows of 10,000 cfs would transport significantly more than ten times the amount of sediment that would be transported by 1,000 cfs. In consequence, the majority of sediment transport occurs during high flow events (Simons 2000). Bedload sediment transport, when coupled with hydrology, is responsible for formation and maintenance of sandbars and sandbar complexes that comporise an important component of pallid sturgeon habitat. In sand-bed rivers, such as the Platte, suspended sediment transport drives turbidity, which is believed to be important to pallid sturgeon foraging efficiency and larval and juvenile pallid sturgeon predator avoidance.

Simons (2000) found that approximately 4.25 million tons of sediment was trapped per year by reservoirs on the North Platte and South Platte rivers. He also found that average annual peak flow in the upper basin as measured at Overton, Nebraska had declined from 16,325 cfs to 7,878 cfs from the pre-1930 period to the 1970-1998 period. The combination of these two effects, coupled with the effects of water diversion into canals operated by the Nebraska water districts, have dramatically reduced the amount of both suspended and bedload sediment transported through the central Platte River to the lower Platte River.

Operations of water development projects in the Loup River basin have had similar if less substantial effects on sediment transport. Two large upstream reservoirs trap an undetermined amount of sediment, and operation of the Loup River Canal and its associated structures trap an additional unquantified, but substantial amount of sediment. The causes of differences in levels of inhibition of sediment transport between the Loup basin and the upper Platte basin lie in two areas. Sherman reservoir is not a main stem reservoir; instead it draws water from a diversion off the Middle Loup River (Bouc 1983), and the limit of the Loup River Canal is 3,000 cfs (G. Pearson, Loup Power District, personal communication). This means that during unusually high flows, which carry a disproportionate share of sediment, transported by the Loup River, considerable flow and sediment bypass these structures. Therefore, while sediment transport in the Loup River basin is substantially impeded, the magnitude of the impedance is considerably smaller than that of the upper Platte River basin.

In contrast, sediment transport in the Elkhorn River system remains primarily unimpaired. While upstream water demands reduce instream flows, the lack of large canal systems and reservoirs allows the majority of sediment transported by the Elkhorn River to reach the lower Platte River.

Although no data are available for the Salt Creek basin, it too supports several reservoirs and a high water demand, and would be expected to exhibit reduced annual flows and sediment transport rates.

Current Conditions

Hydrology

Average annual flow at the Louisville gauge from 1954 through 2003 was 5,106,809 acre-feet. Average annual flow at the Grand Island gage for the same period was 1,215,969 acre-feet.

Nelson (1983) calculated the proportional contribution of different water sources to average annual flow at the Louisville gauge for the period from 1950 to 1980. He determined the approximate contributions of the individual basins, on an average annual basis, to be:

25% Upper Platte basins
41% Loup basin
21% Elkhorn basin
8% Salt Creek basin
6% Shell Creek, groundwater, other tributaries

Sediment Transport

The Sediment and Vegetation Model developed by the Bureau of Reclamation estimates the rate of sediment transport at various points in the central Platte River. While an estimate cannot be made of the exact proportion of sediment transported out of the central Platte River that arrives at the pallid sturgeon and sturgeon chub habitat area in the lower Platte River, this model remains the most powerful tool available to estimate the sediment contribution of the upper Platte basin to the lower Platte basin. The model estimates that from 1947 to 1994, a total of 7,100,460 tons of sediment has been transported past the downstream end of the central Platte River. The bulk of this sediment was transported during high flow periods. This means that an average daily rate of sediment transport for the period was 405 tons per day. Again, the bulk of sediment transport takes place during high peak flows that occur over a relatively short period in a typical year. As a result, this 405 tons per day average does not truly represent a typical day, but is a useful figure for the comparison of alternatives in subsequent sections of this document. The median daily sediment transport for this period was 1,121 tons per day. This more closely represents typical conditions, but is less representative of overall effects on sediment transport. As a result, the mean and median values are used in conjunction to give a more complete picture of the effects of an alternative on sediment transport.

Current rates of sediment transport are not available for the Loup River, Elkhorn River, or Salt Creek. However, as discussed above, the Loup River appears to be substantially less impaired in terms of sediment transport than the central Platte River, and the Elkhorn river appears to be less impaired still. No estimate of current levels of sediment transport can be made for Salt Creek or other tributaries.

Due to this relative lack of data, we cannot determine the level of impairment of sediment transport in the lower Platte River directly caused by water development in the upper Platte River basin.

Water Quality and Daily Hydrograph

As in the central Platte River, high temperature water events have been recorded in the lower Platte River (Yu 1996, Fessel 1996). It is likely that these events are generally of lower magnitude and frequency than those in the central Platte, due to higher relative summer flows in the lower Platte. Unfortunately, unlike in the central Platte River, no large data set is available for water temperatures in the lower Platte River. Fishkills have been reported, and undoubtedly some are due to elevated water temperatures, but a definitive link to high water temperature has not been established. Some indication has been made that many of these fishkills may be linked to rapid change in flow rates (E. Peters, University of Nebraska – Lincoln, personal communication). Operation of water projects in the Loup and lower Platte basins cause frequent and rapid changes in flow rate. These fluctuations occur on a diel basis, resulting in exposure and reflooding of large areas. This has particular importance for sessile taxa and delicate reproductive life stages that cannot move to avoid dewatering (Nebraska Game and Parks Commission 1989). Although this effect is not directly caused by upper basin water development, an incidental benefit of increasing summer flows in the central Platte River would be to moderate this effect. In essence, when base flows are sufficient to wet the majority of the channel width, any fluctuations in flows above that level have a smaller incremental effect on wetted area.

Methods of Analysis

Hydrology and Water Quality Methodology and Assumptions

Analysis of hydrology model runs for the pallid sturgeon is conducted through analysis of changes in river flows at the Louisville gage, which is located roughly in the middle of the habitat area. Monthly flows for present conditions and the Program at Louisville are calculated by the hydrology model (Table 91 in the hydrology model output), then adjusted for transmission loss as determined by the "testing the assumption" (testing) analysis detailed in the model description section. The testing analysis provides a range of transmission loss factors, so that when applied, the output is an anticipated high, low, and median monthly flow value at Louisville for an analyzed alternative. The flow values for present conditions and the flow range for the Program are then ranked in order of exceedance (ranked from highest flow to lowest). In this manner, the range of flows under different scenarios can be displayed in a graphic or tabular fashion for a range of periods (e.g. monthly, yearly, seasonally, etc.), and compared using this common frame of reference.

The data, as organized above, is divided into distinct periods important to the pallid sturgeon and ranked as described above. Within these periods, the ranked data are specifically examined by exceedance intervals. An exceedance interval is a specified percent range of flows for the period of record (e.g., the highest 16.7 percent of flows). Generally for the purpose of this analysis, the 48 year period of record was examined by thirds (wettest third of years in the period of record, middle third, driest third of years) or sixths (following the same pattern as before, but in sixths). These seasonal periods and exceedance intervals are as follows:

1. The April to June period is identified as the critical spawning period for pallid sturgeon. The exceedance intervals specifically examined within this period are the years in the wettest sixth of the dataset, second wettest sixth, and third wettest (0 percent through 16.7 percent, 16.7 percent through 33.3 percent, and 33.3 percent through 50 percent).

   Based on capture records, runoff patterns and water temperature patterns, opportunity for pallid sturgeon to spawn in the Platte River probably occurs between April and June. Initiation of pallid sturgeon spawning migrations has been associated with seasonal spring flow differences in rivers (Peterman 1977, Zakharyan 1972, both cited in Gilbraith et al. 1988). Since 1979, nineteen of the 23 captures of pallid sturgeon in the Platte River or Missouri River near the Platte confluence occurred between April and June. The remaining four captures were in July and September of 1999. Twenty of the 23 captures correspond with years when May-June flows in the lower Platte River were above normal for the recent period (U.S. Fish and Wildlife Service 1997). Pallid sturgeon do not spawn every year (Keenlyne and Jenkins 1993). Intervals between spawning for females are estimated to be three to seven years or more (H. Bollig, U.S. Fish and Wildlife Service, personal communication). Environmental conditions are among the factors believed to play a part in intervals between spawning intervals (U.S. Fish and Wildlife Service 1993). For these reasons, the wettest three sixths of the April to June period of record are considered to be the most critical.

2. The February to July period is identified as the period in which habitat forming and maintenance flows most frequently occur, as well as the primary production period for the prey base for the pallid sturgeon. The exceedance intervals specifically examined within this period are the years in the wettest sixth of the dataset, second wettest sixth, and third wettest for pallid sturgeon habitat formation and maintenance (0 percent through 16.7 percent, 16.7 percent through 33.3 percent, and 33.3 percent through 50 percent), and the wettest third, the middle third, and the driest third for the pallid sturgeon food base (0 percent through 33.3 percent, 33.3 percent through 66.7 percent, and 66.7 percent through 100 percent).

   Studies in the Platte River and elsewhere have found significant pallid sturgeon use of inchannel structure, principally the downstream edges of sand and gravel bars, and submerged dunes (Snook 2000, Bramblett 1996, Hurley 1996). Formation of these inchannel structures occurs primarily at the elevated flow levels most often seen in the February to July period in the lower Platte River. The wetter years would be expected to play a greater role in maintenance and formation of inchannel structure. The diet of the pallid sturgeon is made up of small fish and aquatic invertebrates. Multiple studies have stressed the role of floodplain connectivity in fish and aquatic invertebrate production (Crance 1988, Schlosser 1990, Killgore and Baker 1996, Fisher 1999). This connectivity occurs most often in the February to July period in the lower Platte River. The exceedance intervals examined in this analysis encompass all exceedances. The greatest potential for habitat formation and maintenance occurs at higher flows, and as a result, more focus is placed on the wettest third for this factor. The greatest production of small fish and aquatic invertebrates could be expected with higher flows, but increases in flow rates during the driest years could still be expected to increase the more limited production occurring in those years.

3. The June, July, and August period is identified as the period most impacted by low water and high temperature events. It is important for pallid sturgeon prey base survival, and may be of significant importance in pallid sturgeon young of the year survival. The exceedance intervals specifically examined for this period are the driest sixth, second driest sixth, and third driest sixth (50 percent through 66.7 percent, 66.7 percent through 83.3 percent, and 83.3 percent through 100 percent).

   As has been identified in the current conditions section, high water temperature events, coupled with frequent fluctuations in flows can be moderated by the presence of greater summer base flows. Temperature effects on pallid sturgeon have not been investigated, but adult pallid sturgeon have been located in water with temperatures of up to 34.7˚C, and are quite capable of moving to avoid dewatering under normal circumstances. As a result, direct effects of these fluctuations on adult pallid sturgeon would be expected to be minimal. Effects of these fluctuations on the larval and young of the year pallid sturgeon and foodbase for the pallid sturgeon could be more substantial. Years with the lowest summer flows would be considered the most impacted, and therefore the driest three sixths are considered to be the most important exceedance intervals.

4. The importance of the period from September through January for pallid sturgeon in the Platte River is not well understood. As a result, at this time the September through January period is examined by month, but lower emphasis is placed on the period until such information is available that would warrant otherwise. The intervals specifically examined for the months in this period are each of the driest three sixths, as in the June to August period (as in 4, above).

   Daily fluctuations in flow are still a consideration in the fall months, and opportunity for improvement in baseline habitat flows is available in both fall and winter. As a result, the months in the fall period are analyzed, but would be not be emphasized as highly as the previously discussed periods at this time.

<u>Sediment Transport Methodology and Assumptions</u>

Sediment transport directly affects habitat formation and maintenance in the lower Platte River, along with flow rate. Simply put, both sufficient sediment, and flows sufficient to move and arrange that sediment are necessary to build the macro-bedforms used as habitat by pallid sturgeon in the lower Platte River.

The Sediment and Vegetation model developed by the U.S. Bureau of Reclamation calculates the rate of sediment transport at a number of transects in the central Platte River. At this point in time, the model does not extend to the lower Platte River. As a result, it cannot calculate the amount of central Platte sediment that reaches the habitat area, only the amount that passes the last central Platte transect (river mile 162.2).

The model provides mass of sediment transported per day using hydrologic records from January 1, 1947 to December 31, 1994. The analysis of this data calculated cumulative sediment transport for the period of record, average daily sediment transport for the period of record and median daily sediment transport for the period of record for each alternative.

The majority of sediment is transported during high flow events and as a result, the average daily flow rate becomes to a large extent influenced by and therefore reflective of these high flow events. Given the nature of the seasonal flow patterns in the Platte River, it is difficult to define "typical" river conditions. The median daily sediment transport rate is used by this analysis to represent somewhat more "typical" river conditions. This statistic is less influenced by high flow events than mean sediment transport rate, and is therefore less reflective of them. The two basic statistics must be viewed together to gain an adequate view of sediment leaving the central Platte area.

Results of Analyses

note: A summary of the results of the analyses appears in the FEIS Chapter 5 text. To view the complete hydrology spreadsheets with calculations, please see the associated files:

Pallid Analysis Governance Committee Alternative.xls
Pallid Analysis Full Water Leasing Alternative.xls
Pallid Analysis Wet Meadow Alternative.xls
Pallid Analysis Water Emphasis Alternative.xls

No corresponding spreadsheet is available for the sediment analysis, as the calculations are performed directly on the output of the Sediment and Vegetation Model. This information is provided in the technical appendix for that model.