DOWNSTREAM IMPACTS OF PROGRAM WATER MANAGEMENT

BACKGROUND

During the first increment of the Platte River Recovery Implementation Program (PRRIP or Program), impacts to the pallid sturgeon that are caused by Program activities or by new water related activities covered by the states' or federal depletions plans will be assessed.[1]

The geographic extent for Program and depletion-plan-related activities includes the entirety of the Platte River basin upstream of the Loup River confluence including areas of Nebraska, Wyoming and Colorado. Water activities upstream of the Loup River confluence are expected to influence the volume and timing of flow in the lower Platte River (below the Loup River confluence) to some extent. The Program does not provide coverage for water-related activities below the Loup River confluence and is not responsible for mitigating depletions associated with water-related activities that occur downstream of the Loup River confluence (Figure 1).

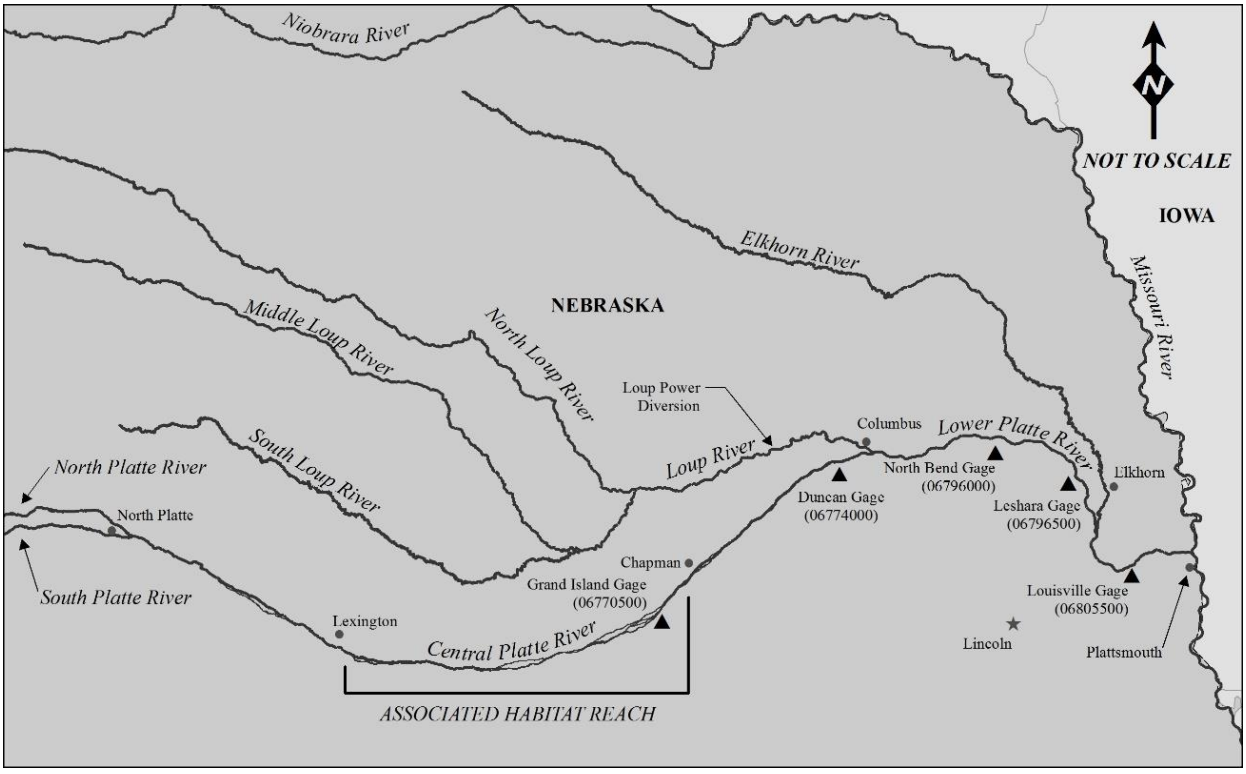

Figure 1. Major tributaries and stream gage locations discussed in this document.

Program water activities and depletions plans activities broadly include:

1) Program water activities

[1] Depletions plans are intended to mitigate the impacts of new water related activities on the occurrence of meeting target flows and on the effectiveness of the Program in reducing shortages to target flows, whether or not the new water related activities are subject to Section 7(a)(2) of the ESA or are intended to mitigate the impacts of other new water related activities.

a. Reduce depletions to United States Fish and Wildlife Service (FWS or Service) target flows from pre 7/1/1997 activities by an average of 130,000-150,000 acre-feet (AF) annually

2) Depletions plans to offset or mitigate new depletions from activities that commenced or will commence after 7/1/1997
   a. Mitigate the adverse impacts of new water related activities on:
      i. the occurrence of FWS target flows
      ii. the effectiveness of the Program in reducing shortages to those flows
   b. Mitigation is not required for new water related activities:
      i. depletions in excess to FWS target flows
      ii. depletion of flow downstream of the Grand Island gage

The FWS calculated average annual shortages to target flows is 417,000 AF using a representative hydrograph from 1947 through 1994 measured at the Grand Island stream gage. 1997 is the GC negotiated hydrologic baseline for the Program. This hydrologic baseline represents the hydrologic record from 1947 to 1994 adjusted to reflect 1997 levels of water development and water demands on the Platte River. The Program's 1st increment water objective is to reduce Service target flows by 130 to 150 kaf at the Grand Island gage. In addition, the federal and state's new depletions plans maintain the 1997 hydrologic baseline by offsetting any new depletions to Service target flows occurring after 1997. With all 1st increment Program water actions in place, shortages to target flows at Grand Island is expected to average 267-287 kaf annually with the 130,000-150,000 AF reduction in target flow shortages and maintenance of the 1997 hydrologic baseline.

PROGRAM-RELATED WATER ACTIVITIES

Program water activities fall into two categories:

1) Retiming of water to reduce deficits
   a. Store river flow at times of excess to target flows and return or release at times of shortage

2) Addition of new water to reduce deficits
   a. Reallocation of existing irrigation (or other) water supplies to instream flows
   b. Reduced consumptive use through modified agricultural practices (conservation projects)

Depletions plans activities fall into the same categories. Most of the Program and depletion-plan water activities are expected to consist of retiming of existing flows (>70%). The remainder will consist almost entirely of reallocation of existing water supplies as no practicable conservation projects have been identified.

WATER ACTIVITY IMPACTS ON CENTRAL PLATTE RIVER HYDROLOGY

By the end of the First Increment Extension in 2032, Program and Nebraska New Depletions Plan activities[2] are expected to influence the hydrology of the Platte River in two ways:

1) Increase in volume of water downstream of the Loup River due to addition of new water to reduce deficits. Average annual volume change is expected to be on the order of 90,000 - 100,000 AF.[3]

[2] The Wyoming, Colorado, and Federal depletions plans are fully operational, all existing new depletions are being mitigated and provisions are in place to mitigate future new depletions.

2) Change in timing of water (hydrograph) downstream of the Loup River due to retiming projects. Timing change is expected to effect on the order of 60,000 – 70,000 AF annually as some retiming projects (like broad scale recharge) require retiming of more water than is credited to the Program.[4]

These two impacts are not mutually exclusive but overlap is generally limited. For example, retiming projects will primarily change when flow reaches the lower Platte River, but may also affect evaporation, seepage and evapotranspiration amounts, which will have a limited impact on flow volume (can be positive or negative). Likewise, reallocation of existing water supplies from surface water irrigation to the Environmental Account may slightly alter return flow patterns during the irrigation season as augmentation plans may not exactly replicate return flows.

The magnitude and timing of central Platte River hydrograph to retiming projects will be dependent upon the availability (magnitude and timing) of excess flows that can be stored, storage capacity, and the magnitude and timing of releases back to the river. Figure 2 provides a general picture of excess flow availability during the period of 1995-2015 based on Program real-time hydrologic condition.[5]

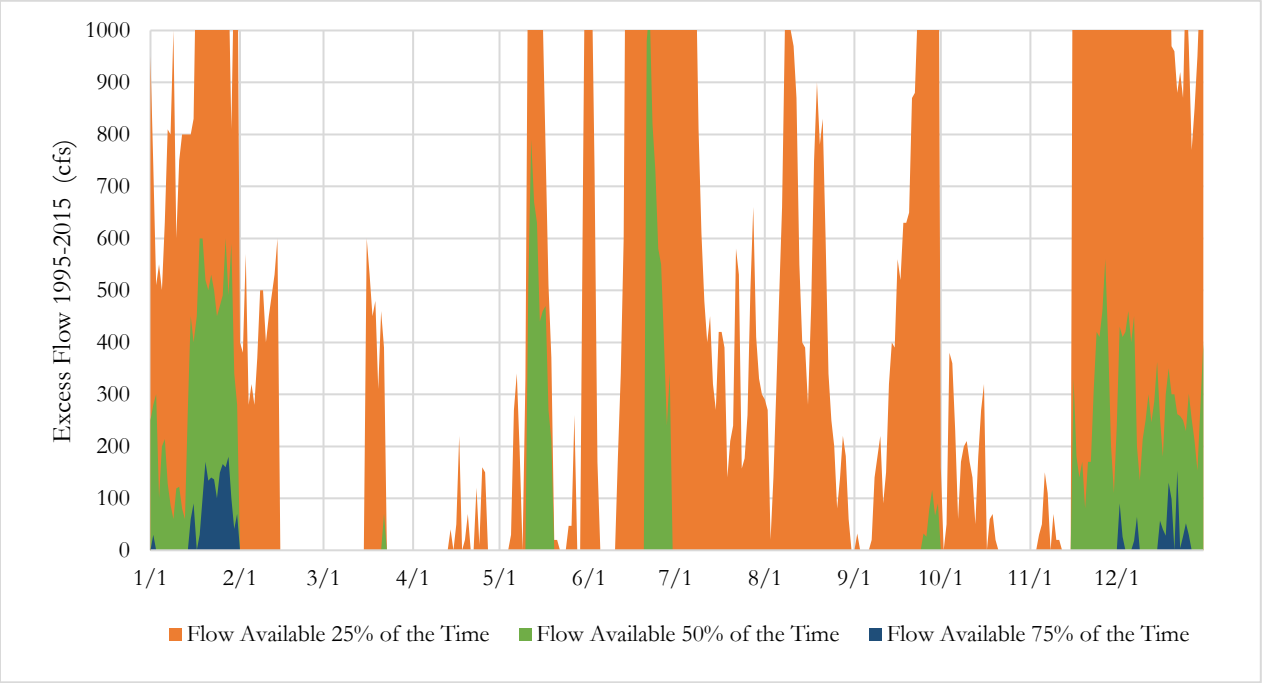

Figure 2. Excess flow availability 25%, 50%, and 75% of the time at the Overton stream gage (1995-2015) based on real-time hydrologic conditions. Excess flows are defined as flows exceeding USFWS species and pulse flow targets. Excesses were capped at 1,000 cfs to correspond with the expected First Increment diversion capacity of 1,000 cfs.

[3] Includes approximately 60,000 AF for Environmental Account and an additional 30,000 - 40,000 AF of water leasing by the PRRIP and State of Nebraska.
[4] For example, groundwater recharge projects result in some water coming back to the river during times of excess. Accordingly, approximately 20%-60% more water has to be retimed than is credited.
[5] Real-time hydrologic conditions were utilized in this analysis as they will most likely be used to define excesses for Program water operations.

As indicated in Figure 2, excesses were frequently available during the period of November 16 through February 1. Excess flows were also available somewhat less frequently during the months of May – August. Excesses were infrequently available during the period of February 15 through May 1.

The amount of excess flow that can be stored via retiming projects will be dependent upon excess volumes, the rate at which flow can be moved into storage, and total storage volume. It is anticipated that First Increment Program and state of Nebraska water projects will have the capacity to divert approximately 1,000 cfs into recharge or storage projects.[6] Accordingly, this is the best estimate of the maximum flow reduction impact associated with Program and Nebraska water activities during the First Increment. Table 1 presents the maximum excess flow volumes that could have been diverted into retiming projects during the period of 1995-2015 given a diversion capacity of 1,000 cfs and unlimited storage capacity. The actual volume of water diverted for retiming is expected to average 60,000 AF due to limited capacity to store flows for retiming.

Table 1. Maximum excess flow volume that could have been routed into retiming projects during the period of 1995-2015 using real-time hydrologic conditions and assuming a maximum diversion rate of 1,000 cfs.

	Excess Flow Volume (ac-ft)	Maximum Volume that Could Have Been Retimed @ 1,000 cfs Diversion Rate (ac-ft)
Average Volume all Years	429,561	194,457
Volume Available in 25% of Years	697,297	324,601
Volume Available in 50% of Years	214,093	115,240
Volume Available in 75% of Years	76,864	73,300

New and retimed water will be released to 1) reduce deficits to target flows and/or 2) implement other flow-management actions such as Short-Duration High Flows (SDHF). Maximum release capacity will depend on the design of future retiming projects but is generally expected to be on the order of 5,000 cfs.[7] It is anticipated that the majority of releases will be lower in magnitude, ranging from 500 – 1,500 cfs for species' flows and up to 2,500 cfs for pulse flow releases.

The Wyoming, Colorado, and Federal depletions plans are fully operational, all existing new depletions to Service target flows are being offset and provisions are in place to offset future new depletions. Nebraska intends to cost share with the Program to offset depletions to target flows since 1997.

FIRST EIGHT YEARS OF PROGRAM OPERATIONS

From 2007 to 2014, the average annual shortage to target flows at Grand Island is 504,696 AF representing eight total years of Program operation. There were six years classified as normal and two years classified as wet. No dry years were represented from 2007 through 2014. From 2007 to 2014, the annual shortages to target flows range from 18,197 AF in 2011 to 731,257 AF in 2013.

[6] This includes approximately 600 cfs diverted into canals for groundwater recharge and 400 cfs diverted or pumped into Program water projects.
[7] This includes approximately 4,000 cfs from existing water projects and an additional 1,000 cfs from future projects.

EA and Tamarack Phase 1 were in place by 2007. Pathfinder Modification and Pathfinder Municipal projects (4,800 AF) were in place by 2012. With the addition of Pathfinder Municipal water, the combined annual reduction to Service target flows is approximately 85,000 AF. Water from both Pathfinder projects are combined with the EA at Lake McConaughy, so releases from all three accounts are tracked through the central Platte River through Grand Island. Contributions from Tamarack Phase 1 are tracked to the Colorado/Nebraska state line only.

Not including contributions from Tamarack Phase 1, Program water delivered to Grand Island averaged 23,774 AF from 2007 through 2014. Of the 23,774 AF of Program water delivered to Grand Island, the average reduction to shortages at Grand Island is 20,130 AF. The range in annual reduction in target flows is 0 AF in 2010 and 2011 to 47,751 AF in 2013. No accounting procedures are currently in place to assess Program's effects average annual volume change to the Lower Platte River approximating 90,000 - 100,000 AF annually.

The following summarizes Program Environmental Account releases from 2007 through 2014:

1. February 15 to March 15 pulse flow time period (1 out of 8 years)
2. March 23 to May 10 spring whooping crane time period (3 out of 8 years)
3. May 11 to September 15 summer time period (3 out of 8 years)
4. Flow routing test/short duration medium flow (2 out of 8 years)
5. Canal recharge (1 out of 8 years)
6. No releases due to limited release opportunities (2 out of 8 years)

	Year Type	Shortages to Target Flows (AF)	Total EA Volume at GI (AF)	EA Reduction to Shortages (AF)
2007	Normal	543,983	24,406	12,965
2008	Normal	547,055	17,834	13,569
2009	Normal	632,802	13,313	8,210
2010	Wet	267,463	0	0
2011	Wet	18,197	0	0
2012	Normal	719,543	40,906	40,906
2013	Normal	731,257	56,101	47,751
2014	Normal	577,270	37,635	37,635
2015	Wet	212,520	NA	NA
2016	Wet	NA	NA	NA

WATER OPERATIONS IMPACTS IN THE LOWER PLATTE

Figure 3 and 4 present median and mean daily discharge at the Grand Island stream gauge in the central Platte River and the North Bend and Louisville gauges in the lower Platte River for the period of 1995-2015. During this period, median discharge was 1,200 cfs at Grand Island, 3,930 cfs at North Bend and 6,800 cfs at Louisville. Average discharge was 1,672 cfs at Grand Island, 4,594 cfs at North Bend and 8,054 cfs at Louisville.

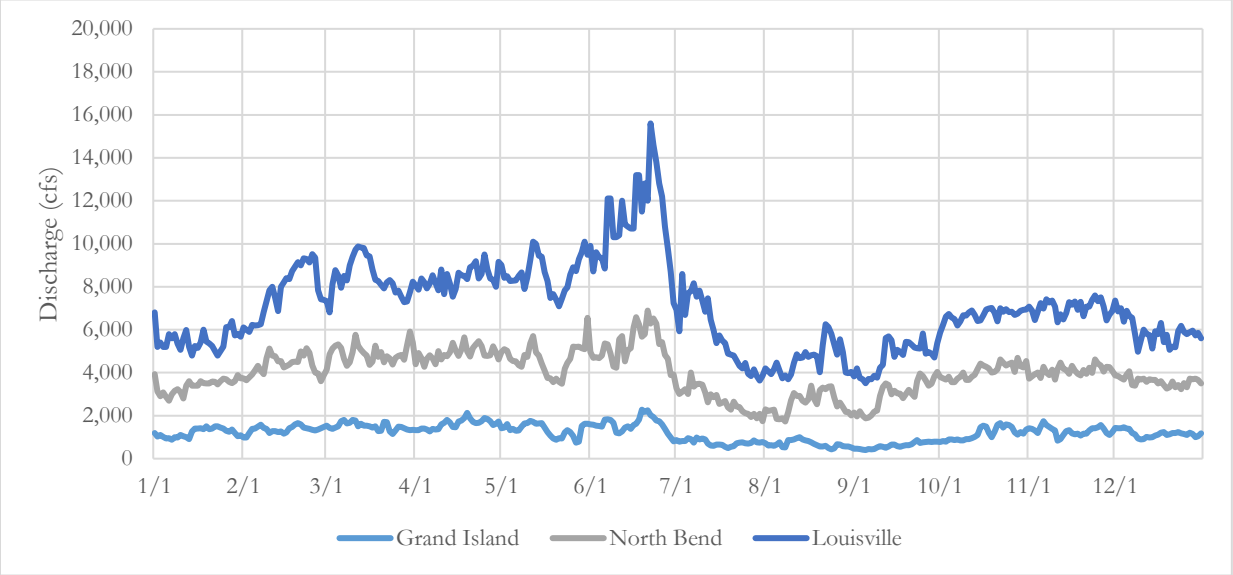

Figure 3. Median daily discharge at Grand Island, North Bend and Louisville stream gauges during the period of 1995-2015. Median discharge at Grand Island was 1,200 cfs, North bend was 3,930 cfs, and Louisville was 6,800 cfs.

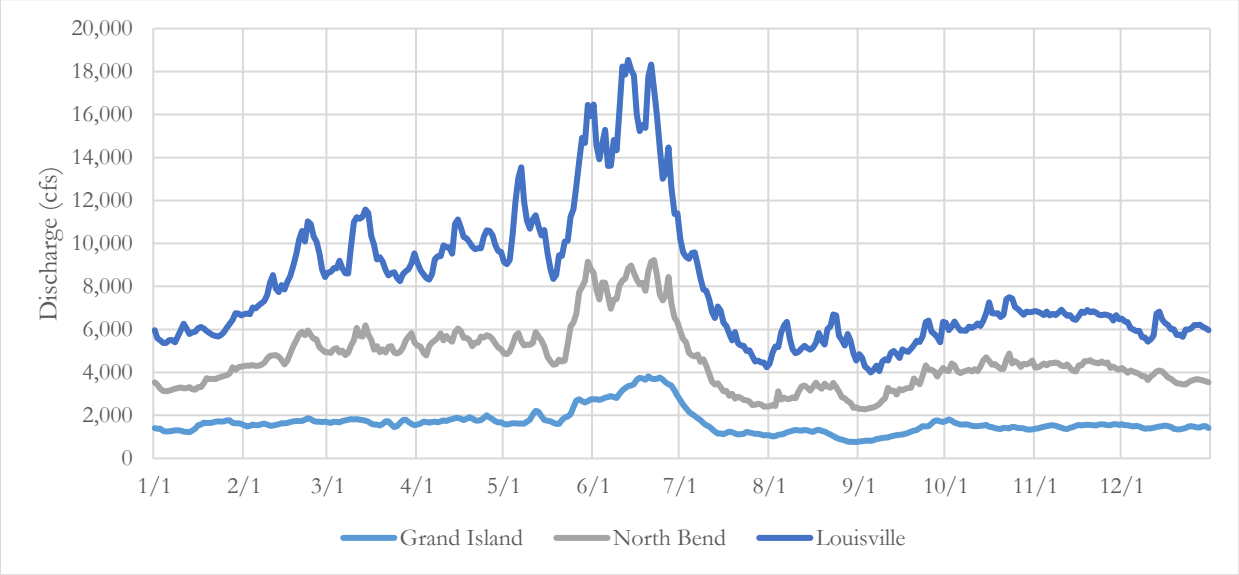

Figure 4. Mean daily discharge at Grand Island, North Bend and Louisville stream gauges during the period of 1995-2015. Average discharge at Grand Island was 1,672 cfs, North Bend was 4,594 cfs, and Louisville was 8,054 cfs.

Peters and Parham (2008) developed pallid sturgeon habitat suitability and channel connectivity relationships for the lower Platte River below the Loup River confluence. Those relationships are reproduced below in Figure 5. Those relationships were used to calculate average daily and monthly habitat suitability and channel connectivity for the North Bend and Louisville gauges during the period of 1954-2016. In addition, Program operations (as described above) were used to develop a conservative estimate of potential impacts to habitat suitability and connectivity at the two lower Platte River gauges.

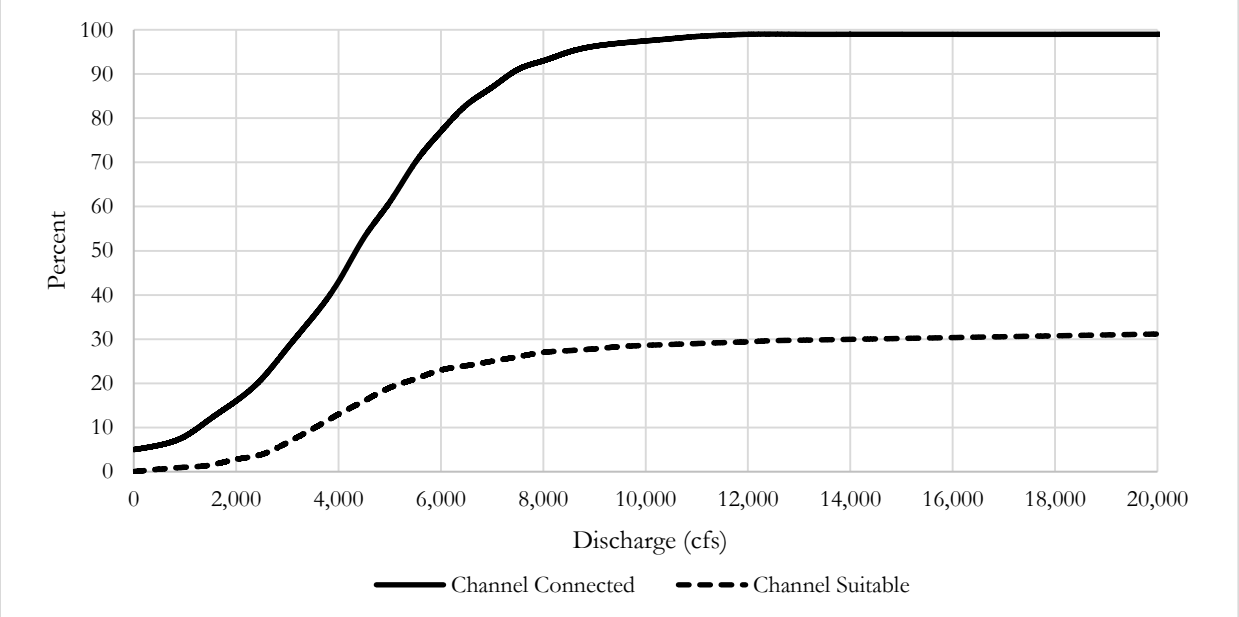

Figure 5. Lower Platte River discharge-connectivity and discharge-habitat-suitability curves for pallid sturgeon from Peters and Parham (2008).[8] The authors developed these relationships using aerial photography from the entirety of the lower Platte River below the Loup River confluence.

IMPACTS OF WITHDRAWALS FOR RETIMING PROJECTS

Withdrawal impacts were calculated for the period of 1954-2016 based on the assumptions that 1) up to 1,000 cfs of flow could be diverted from the river into storage projects during times of excess to species and pulse flow targets, 2) storage capacity was unlimited, 3) all of the flow that was diverted would have reached the lower Platte (no losses), and none of the excess flow is released back to the river. This set of assumptions represents the maximum diversion impact scenario for combinations of projects with up to 1,000 cfs of combined diversion capacity.

Figures 6-9 present comparisons of 10th percentile, median and 90th percentile habitat suitability and channel connectivity by gauge with and without the Program diversion scenario described above. As discussed above, this represents a worst-case scenario for impacts as it assumes the Program has unlimited ability to store all excesses up to 1,000 cfs above target flows and all of that flow would have reached the North Bend and Louisville gauges (i.e., no losses). Each figure includes a rough approximation of the annual spawning window in the lower Platte, which was based on temperature records at the Louisville gage and an assumed spawning temperature range of 16°C to 23°C.

[8] Peters, E. J., and J. E. Parham. 2008. Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska Game and Parks Commission, Nebraska Technical Series No. 18, Lincoln, Nebraska.

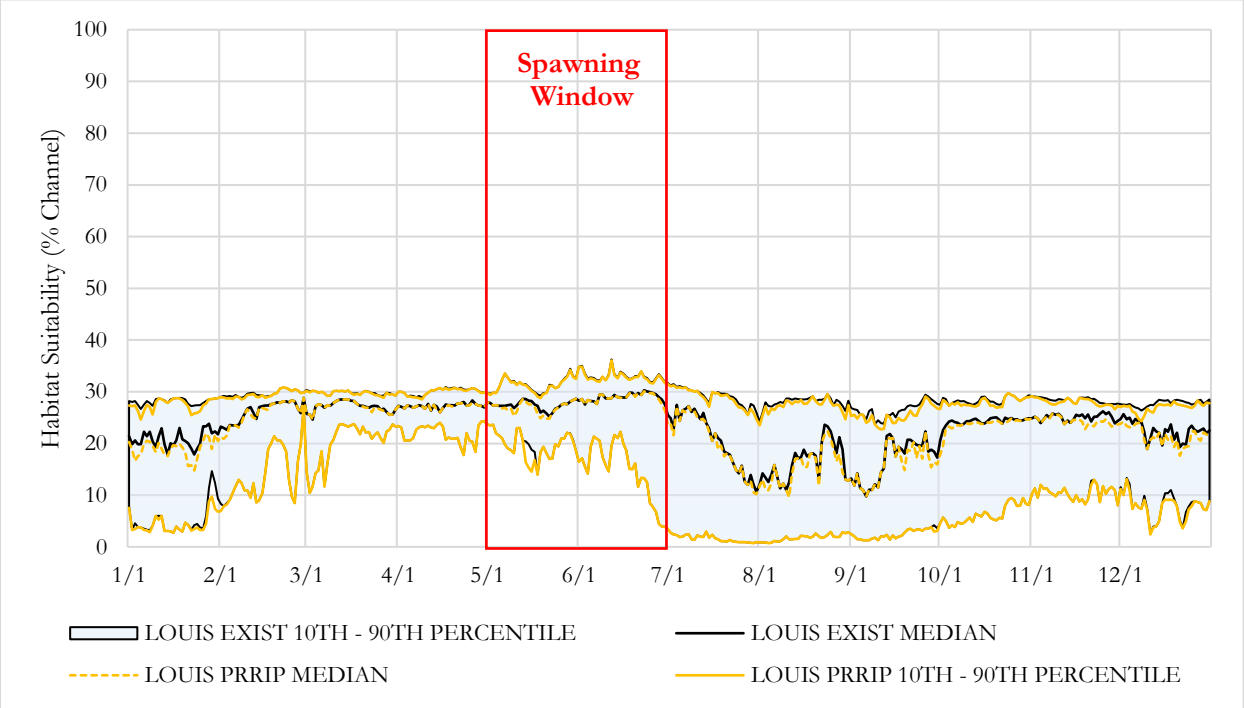

Figure 6. 10th, median, and 90th percentile habitat suitability at the Louisville (LOUIS) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

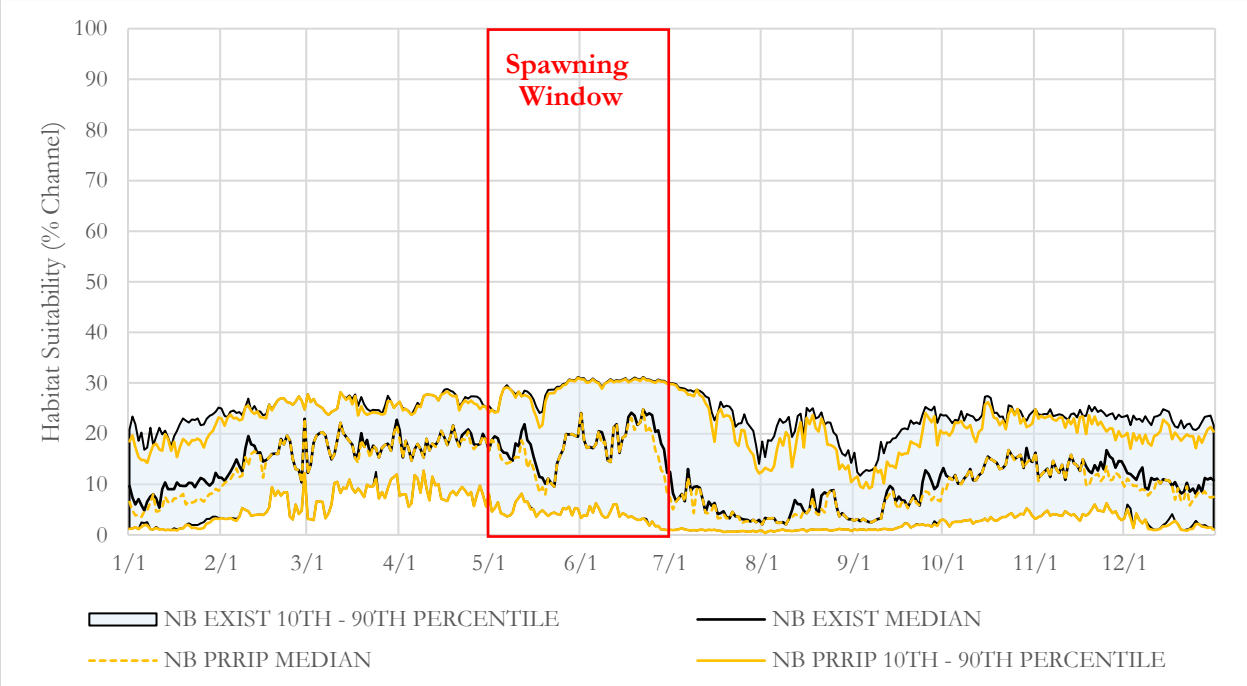

Figure 7. 10th, median, and 90th percentile habitat suitability at the North Bend (NB) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

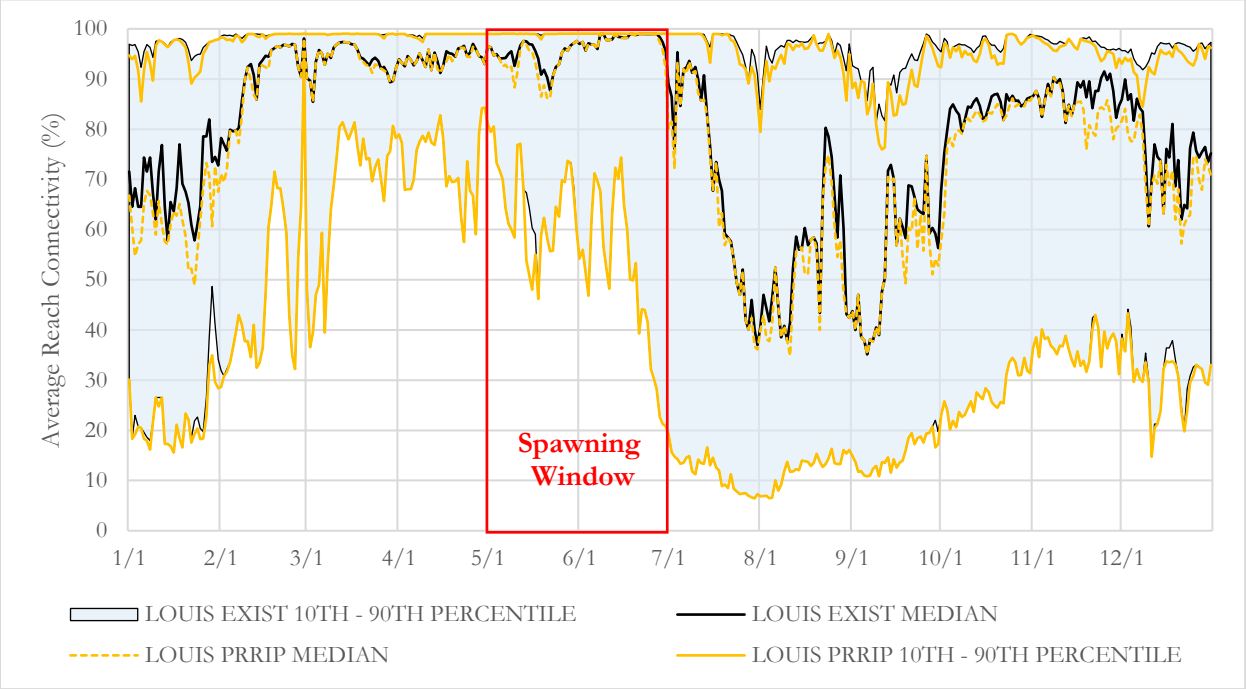

Figure 8. 10th, median, and 90th percentile reach connectivity at the Louisville (LOUIS) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

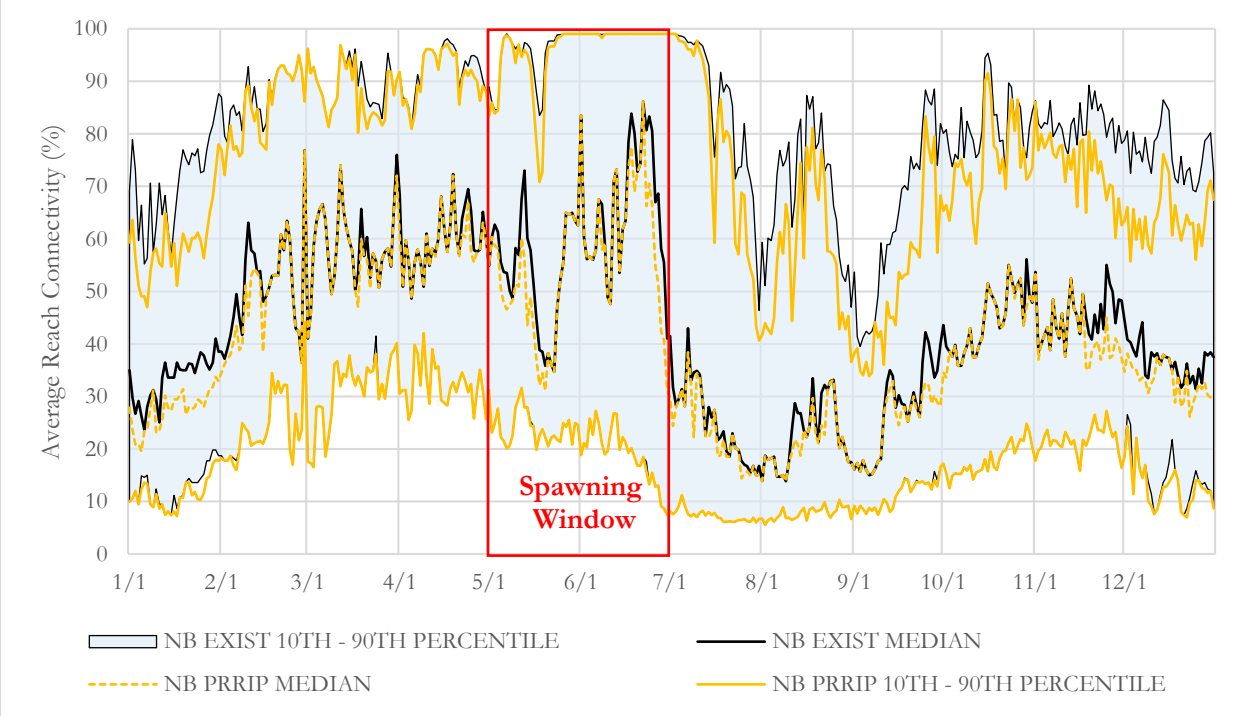

Figure 9. 10th, median, and 90th percentile reach connectivity at the North Bend (NB) gauge with maximum Program diversion scenario (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

IMPACTS OF LATE SPRING PULSE FLOW RELEASE

The late spring pulse is the sole target flow with beneficial effects directly related to the pallid sturgeon.[9] Pulse flow impacts were calculated for the period of 1954-2016 based on the assumptions that 1) sufficient volume and channel capacity was available to implement full, pulse flow releases in all normal and wet years[10] and 2) all of the flow would have reached the lower Platte River (i.e., no losses or attenuation). This set of assumptions represents the maximum release impact scenario. Figures 10-13 present 10th percentile, median and 90th percentile comparisons habitat suitability and channel connectivity by gauge with and without the Program late spring pulse flow release scenario described above. This represents a best-case scenario for impacts as it assumes that the Program has unlimited ability to release flow to achieve the pulse flow target and all of that flow would have reached the North Bend and Louisville gauges without losses or attenuation. Average annual release volume for this scenario in normal and wet years[8] was on the order of 120,000 acre-ft, indicating that this flow release would utilize all of the controllable water that will be developed during the First Increment of the Program.

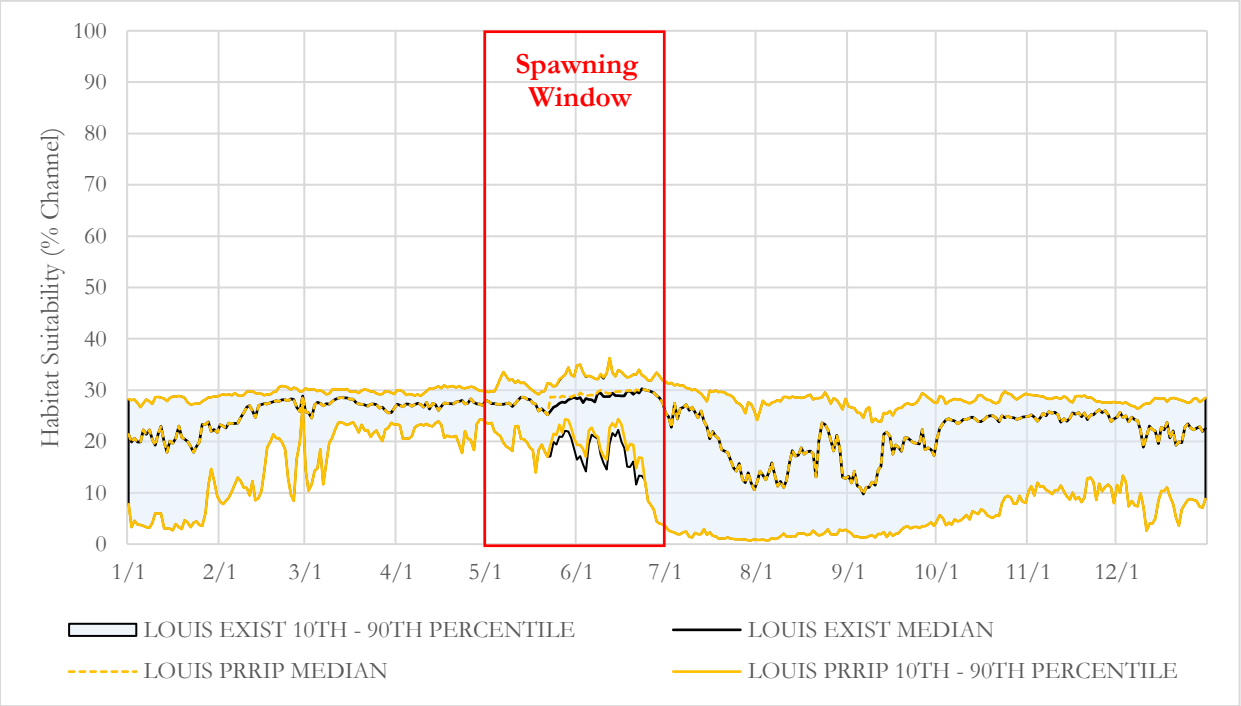

Figure 10. 10th, median, and 90th percentile habitat suitability at the Louisville (LOUIS) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

[9] Necessary effect number three for the late spring pulse is: "Help maintain and rehabilitate aquatic characteristics of large river habitats in the lower Platte River for animals such as the endangered pallid sturgeon."
[10] There is no late spring pulse target or release during dry years.

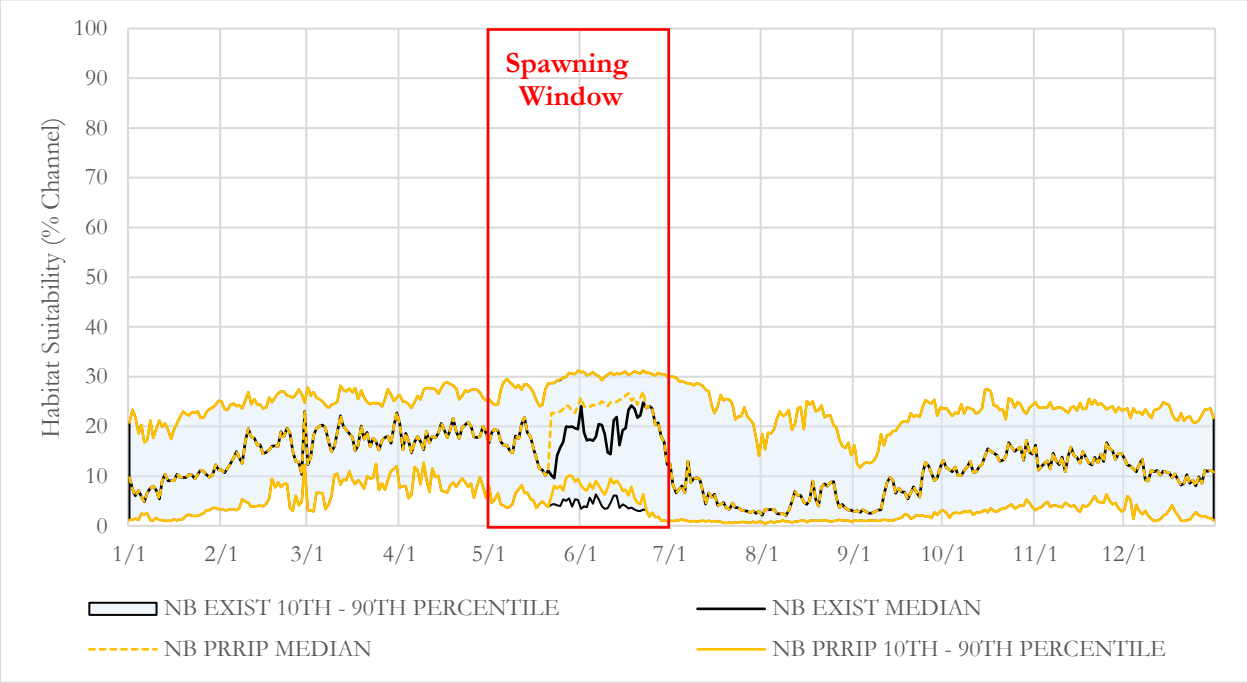

Figure 11. 10th, median, and 90th percentile habitat suitability at the North Bend (NB) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

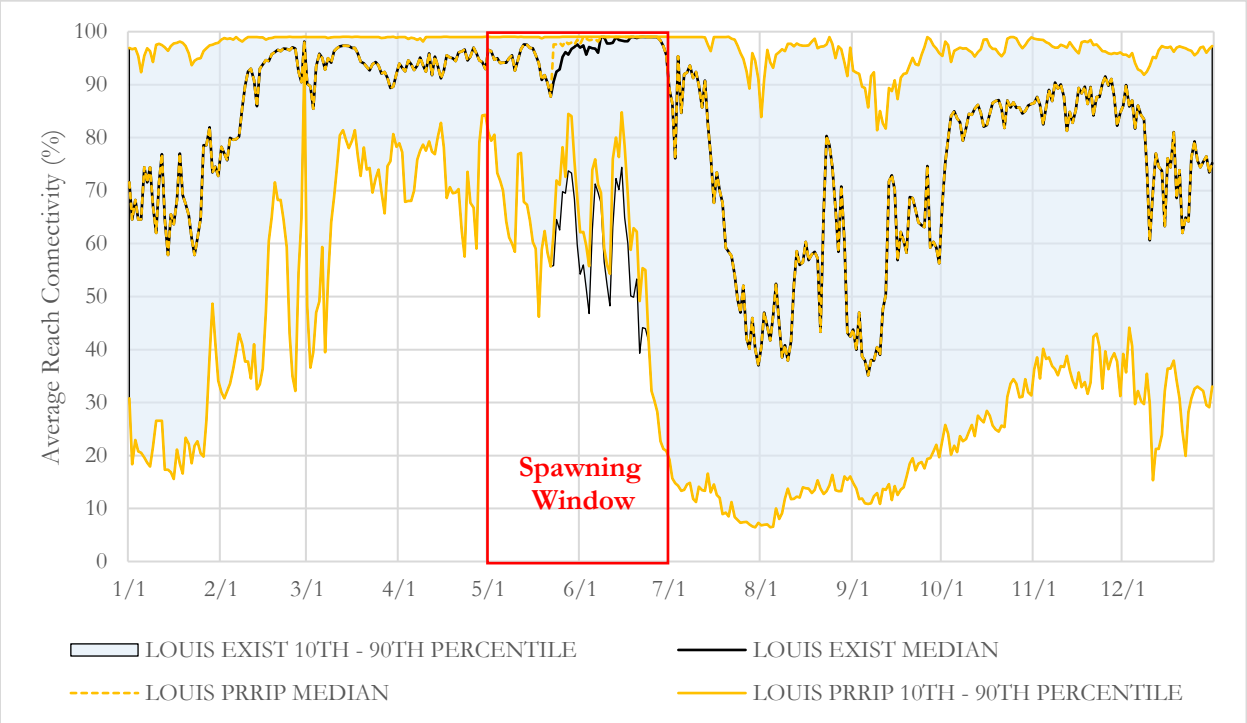

Figure 12. 10th, median, and 90th percentile reach connectivity at the Louisville (LOUIS) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

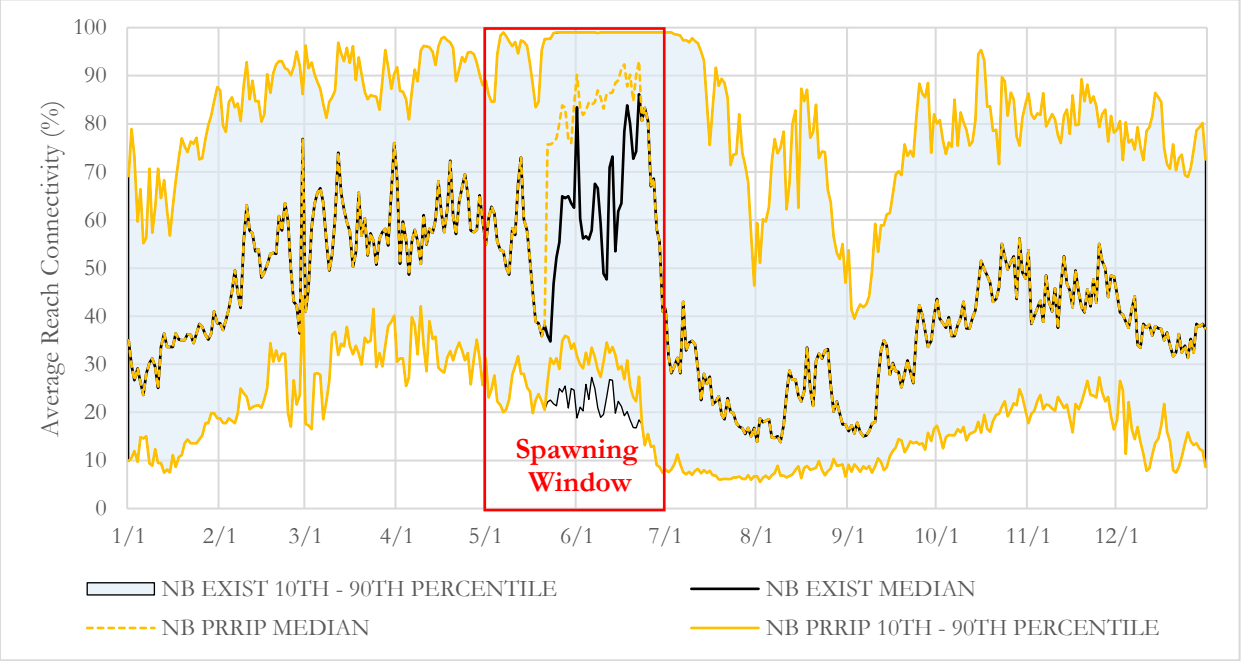

Figure 13. 10th, median, and 90th percentile reach connectivity at the North Bend (NB) gauge with full Program late spring pulse flow implementation (PRRIP) and observed (EXIST) conditions during the period of 1995-2015.

EXTERNAL FACTORS OF INTEREST

External factors will influence the Program's impact on lower Platte River hydrology. Two of these factors are hydrocycling of Loup River flows and future lower Platte River depletions due to ongoing or new consumptive uses. Each of these factors is described briefly below.

LOUP RIVER HYDROCYCLING

The analyses presented above are all based on mean daily flow records at USGS gauges. These records do not capture sub-daily flow and stage variability due to hydrocycling of a portion of Loup River discharge. In many cases, daily hydrocycling fluctuations would be of greater magnitude than changes produced by Program flow releases. Figures 14 and 15 provide an example of the influence of lower Platte River hydrocycling on Program water released during a 2009 flow routing test. Peak release magnitude at the Grand Island gauge was approximately 4,000 cfs, which is slightly greater than the wet year late-spring pulse target of 3,700 cfs.

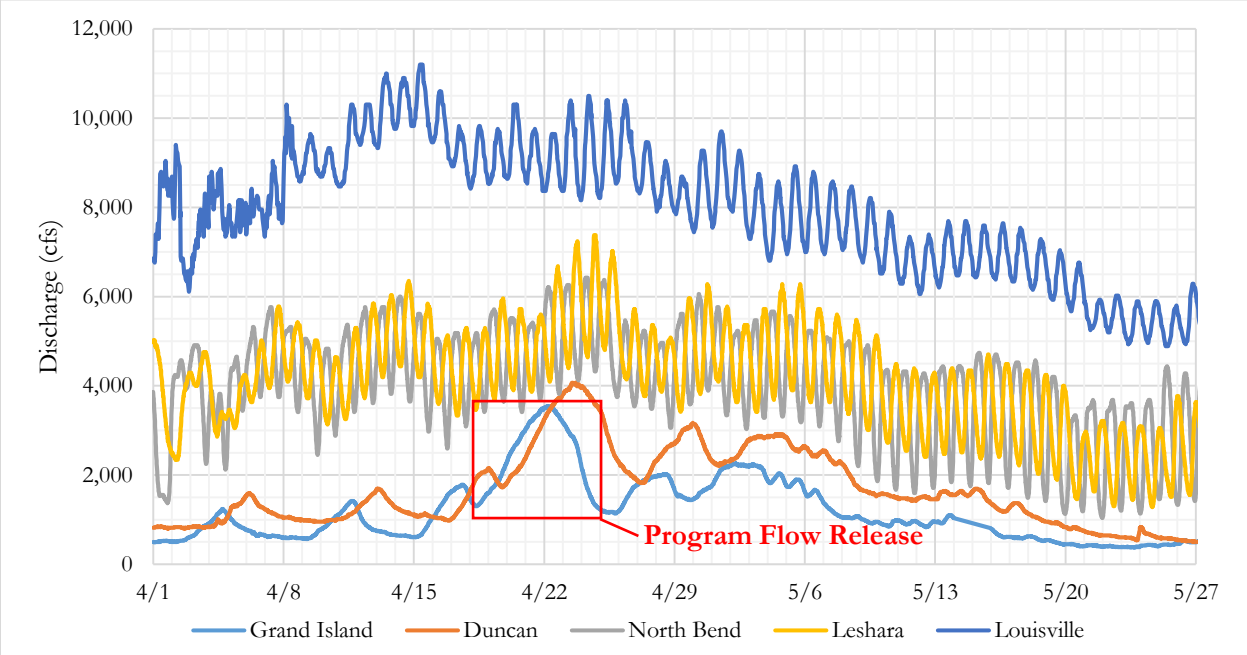

Figure 14. Real time (15 minute) river discharge at the Grand Island, Duncan, North Bend, Leshara and Louisville gauges for the April 2009 Program flow routing test. Hydrocycling-induced flow fluctuations below the Loup River confluence (North Bend, Leshara and Louisville gauges) mask the flow increase associated with the Program flow release.

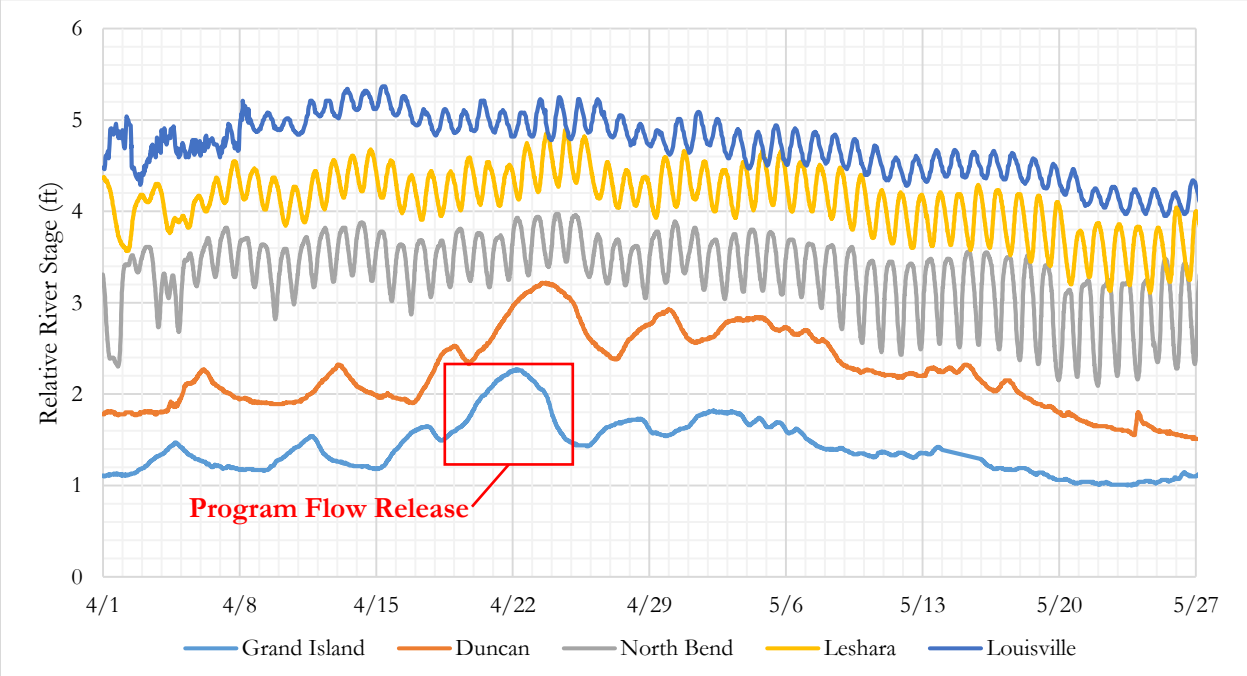

Figure 15. Real time (15 minute) river stage at the Grand Island, Duncan, North Bend, Leshara and Louisville gauges for the April 2009 Program flow routing test. Hydrocycling-induced stage fluctuations below the Loup River confluence (North Bend, Leshara and Louisville gauges) mask the stage change associated with the Program flow release.

FUTURE LOWER PLATTE RIVER DEPLETIONS

The Nebraska Department of Natural Resources (NDNR) 2017 Report on Annual Evaluation of Availability of Hydrologically Connected Water Supplies that describe the expected declines in streamflow for the lower Platte River (Figure 16). In 25 years, the lower Platte River streamflow is expected to decline by 337 cfs at the Louisville gage as a result of lag effects from existing groundwater development. NDNR expects an additional decline in streamflow of 122 cfs in 25 years based on existing trends in new water development which equates to a total decline for the Louisville gage in 25 years of 459 cfs. For the North Bend gage, the anticipated decline as a result of lag effects from existing groundwater development is 35 cfs in 25 years while there is an anticipated decline of 71 cfs from projected new water development. It is recognized that declines in base flow throughout the remainder of the first increment will increase annually, but NDNR did not provide total loss estimates for time increments less than 25 years. Total losses throughout these years would be less than 107 and 459 cfs at the North Bend and Louisville gages, respectively, or average, annual volume reductions of 77,468 AF and 332,316 AF at the North Bend and Louisville gages, respectively.

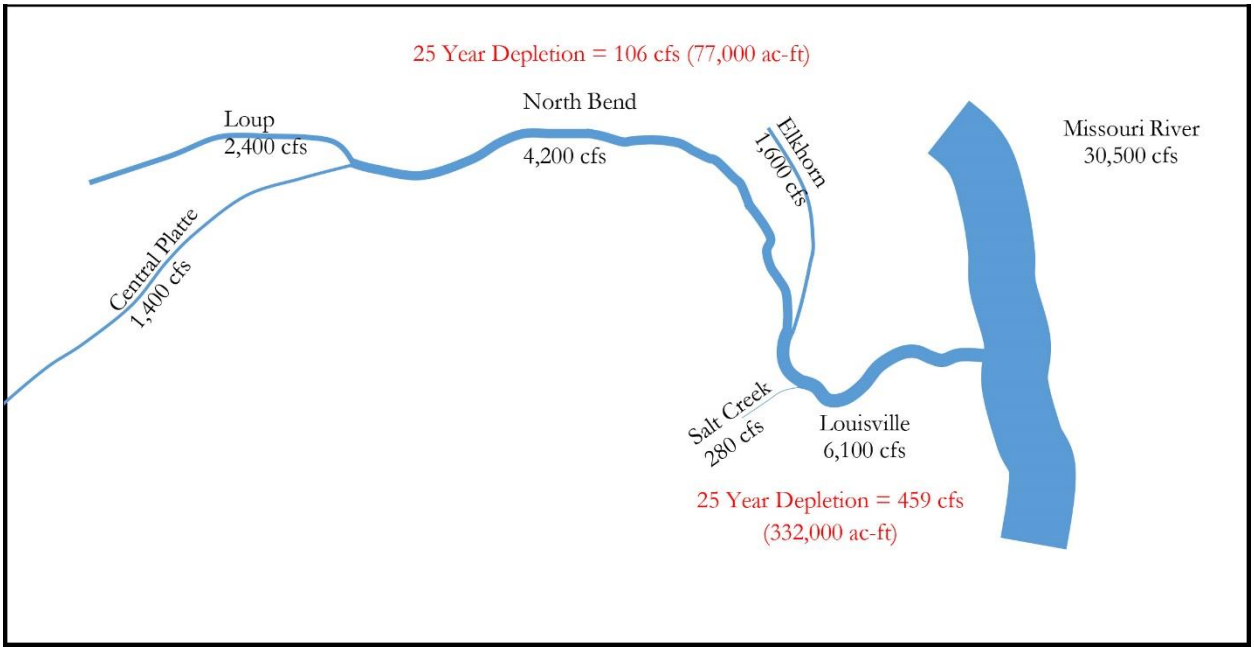

Figure 16. Median discharge during stream gauge periods (Black font) of record with anticipated future lower Platte River depletions (red font) due to ongoing and new consumptive water uses.