TO: Governance Committee (GC)
FROM: Executive Director's Office (EDO)
SUBJECT: 2016 EDO Technical Series
#01 – Predicted Performance of Short-Duration High Flows
DATE: August 31, 2016
CC: Technical Advisory Committee (TAC) and Independent Scientific Advisory Committee (ISAC)

Short Duration High Flows

Short duration high flow (SDHF) is the sole flow management action contemplated in the Platte River Recovery Implementation Program's (PRRIP) Adaptive Management Plan (AMP). The SDHF is defined as a flow of 5,000 to 8,000 cfs magnitude in the habitat reach for a duration of three to five days at Overton on an annual or near-annual basis.[1] SDHF is intended to increase 1.5-year recurrence flood ($Q_{1.5}$) magnitude in the Associated Habitat Reach (AHR) from approximately 4,000 cfs to 5,000 – 8,000 cfs. When implemented in combination with mechanical channel leveling and sediment augmentation,[2] implementation of SDHF is hypothesized to: 1) increase the height of sandbars in the AHR to a height that is suitable for least tern and piping plover nesting, and 2) increase the average width of the vegetation-free channel to a width suitable for whooping crane roosting.[3]

Origins of SDHF

The SDHF management action was developed in the early 2000s by the Technical and Adaptive Management Advisory Committees based on alluvial channel regime theory. Regime theory postulates that a single channel-forming discharge, often referred to as bank-full or effective discharge, controls the dimensions of alluvial river channels. In the case of the AHR, it was assumed that bank-full discharge corresponded to an annual flood recurrence interval of 1.5 years ($Q_{1.5}$).[4] Per regime theory, it was hypothesized that increasing the magnitude of the channel-forming discharge in the AHR would increase sandbar heights and cause the channel to widen.

SDHF in relation to PRRIP water supply and management

The Program's First Increment water objective is to reduce deficits to United States Fish and Wildlife Service (USFWS) target flows by an average of 130,000 – 150,000 acre-ft annually. Although SDHF is not a target flow, the Program document explicitly states that water used to implement SDHF will count as a reduction to target flow deficits.[5] Program water supply projects include manageable supplies like the Lake McConaughy Environmental Account that can be used to implement flow releases as well as projects like Phelps County Canal groundwater recharge that reduce deficits but cannot be actively managed.

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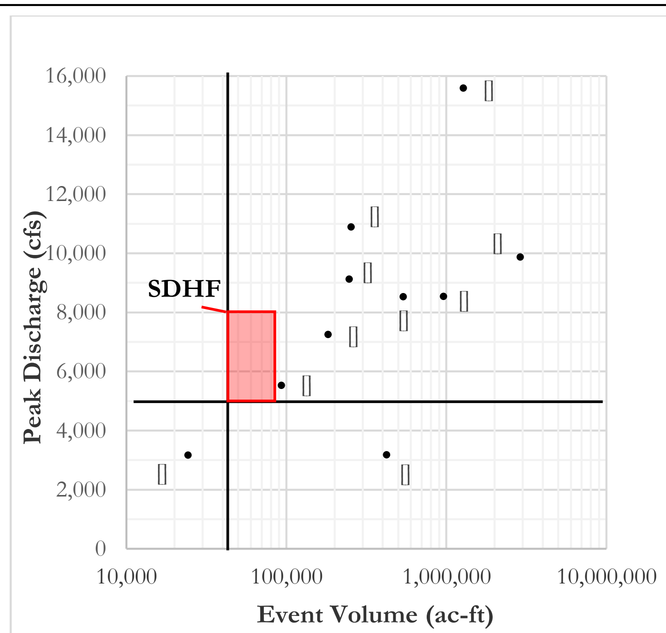
[1] See description of SDHF on pages 3-38 and 3-39 of the PRRIP Final Environmental Impact Statement.
[2] Together, these activities comprise the Flow-Sediment-Mechanical management strategy.
[3] See Physical Process Hypothesis PP-1 on page 16 of the AMP.
[4] This assumption was not verified in the field. Bank-full discharge is likely closer to 8,000 cfs.
[5] Target flows are comprised of species and annual pulse flow recommendations. SDHF is classified as a peak flow. The USFWS also established peak flow recommendations but they are not included in target flow calculations.

The volume of water that accrues to manageable projects varies annually depending on basin hydrologic conditions. Once all First Increment water projects are completed, the average volume of manageable water during dry, normal and wet hydrologic year types will be on the order of 75,000, 85,000 and 105,000 acre-ft respectively. [6] The volume necessary to implement SDHF varies inversely to water supply with more water required during dry years due to lower base flows and higher conveyance losses. During dry and normal years when maintenance of channel width is most necessary, implementation of SDHF will likely require most or all of the Program's manageable water (see table).

Hydrologic Year Type	Manageable Water (acre-ft)	Full SDHF (acre-ft)	Percent of Water
WET	105,000	40,000	38%
NORMAL	85,000	65,000	76%
DRY	75,000	80,000	106%

Predicting SDHF Effectiveness

The Program is currently not able to implement a full-scale SDHF of 8,000 cfs for three days. However, natural peak flow events during the First Increment have provided the data necessary to evaluate physical process relationships and predict the beneficial effects of SDHF with a high degree of confidence. Since 2007, natural peak flow events have exceeded SDHF volume in all but one year and minimum SDHF magnitude in all but two years (see figure). The Program has collected unvegetated channel width data following annual peak flow events in all years and sandbar height data since 2010. Target species use monitoring has also been conducted in all years and habitat selection analyses have been completed to identify channel characteristics that are highly suitable for species use and reproduction (in the case of the least tern and piping plover).



2007-2016 annual peak flow event magnitude and volume in relation to SDHF management action.

Sandbar Height Analyses

Sandbar height analyses were conducted following natural peak flow events in 2010, 2011, 2013, 2014 and 2015. Sandbar height potential in the AHR is on the order of 1.5 feet below peak stage of the formative event assuming that duration at peak is sufficient to scour vegetation and mobilize bed sediment. Increasing the $Q_{1.5}$ discharge from 4,000 cfs to a full SDHF magnitude of 8,000 cfs would increase peak flow stage and associated sandbar heights by

[6] Program hydrologic year types are as follows: Dry = driest 25% of years, Normal = middle 42% of years, Wet = wettest 33% of years.

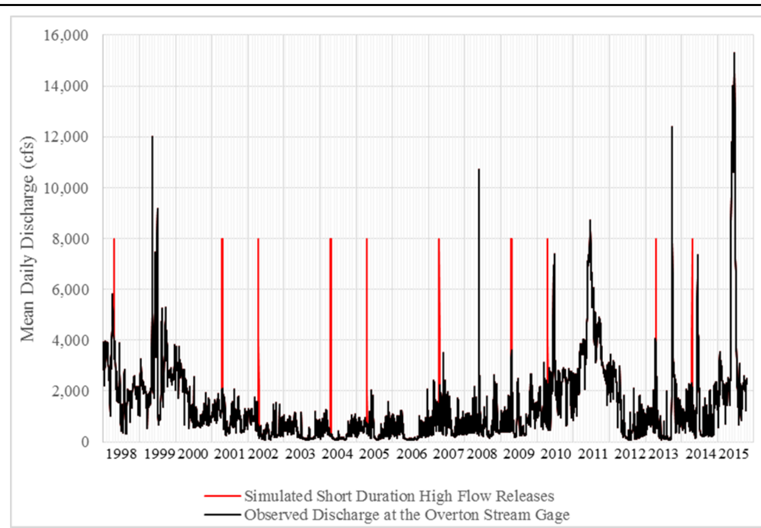
approximately 1.0 ft. However, the sandbars would still be inundated during the tern and plover nesting season in approximately 70% of years.[7]

Sandbar Height Implications for the Least Tern and Piping Plover

In 2015, the Program's Governance Committee officially concluded that sandbars created by SDHF would not be suitably high for nesting given the frequency of inundation and entered into a structured decision making process to adjust management actions to meet least tern and piping plover management objectives.[8] The revised management approach focuses on creation and maintenance off-channel sand and water nesting habitat along with a small amount of mechanically-created in-channel habitat.

Unvegetated Channel Width Analysis

Data collected during the period of 2007-2015 was used to perform an analysis of the influence of hydrologic, geomorphic, and mechanical management variables on total unvegetated channel width and the maximum width of the channel unobstructed by vegetation. Hydrologic metrics included annual peak and minimum discharges, June discharge and growing season discharge. Geomorphic metrics included bank-full channel width, bed material grain size, river mile, and channel slope. Management metrics included herbicide application and channel disking. Multiple regression analyses indicate that unvegetated channel width was best explained by 40-day peak discharge, wetted width of the channel at bank-full discharge, bed material grain size, and the presence or absence of herbicide and disking. For every 1,000 cfs increase in 40-day peak discharge, an average 33 ft increase in unvegetated channel width was predicted. If disking and herbicide were applied, the average increase was 118 ft. Results were similar for unobstructed channel width except that the average increase for peak discharge was lower (18 ft) and the increase for mechanical actions was higher (164 ft).



Simulated SDHF releases during the period of 1998-2015

The regression model was used to predict the performance of SDHF in increasing unvegetated and unobstructed channel width given observed hydrology during the period of 1998-2015. A total of 10 SDHF releases were modeled (see figure) and increased the average predicted unvegetated channel width by a maximum of 22 ft and unobstructed channel width by a maximum of 19 ft. Overall, the analysis strongly supported the assertion of a positive relationship

[7] Inundation frequency varies with channel width. Inundation risk is slightly lower in narrow channels and slightly higher in wide channels.

[8] Peak flow magnitudes of 13,000-15,000 cfs are necessary to increase sandbar height to the Program's minimum height suitability criterion of 1.5 ft above 1,200 cfs stage.

between peak flow magnitude and channel width. It did not, however, support the assertion that SDHF will produce substantive increases in the vegetation-free width of the channel. This is due to the very short duration and low volume of SDHF releases in relation to the 40-day peak discharge duration that is the best hydrologic predictor of width.

Unvegetated Width Implications for the Whooping Crane

Whooping crane resource selection analyses indicated cranes select for unobstructed channel width and distance to riparian forest. Channels with unobstructed widths of 500-700 ft and unforested widths of 1,000 ft are highly suitable for whooping crane roosting. The predicted average maximum increase in unobstructed channel width of 12 ft due to SDHF is minimal during dry periods when average unobstructed width is less than 400 ft.[9] In wetter years when baseline unobstructed width is closer to 500 ft, the much greater duration of natural peak flow events appears to eclipse the limited effect of SDHF. Accordingly, SDHF is predicted to be ineffective in managing for suitable whooping crane roosting habitat, especially during dry periods.

Assessment of SDHF Effectiveness

SDHF was developed based on the hypothesis that changing the magnitude of the assumed AHR channel-forming discharge ($Q_{1.5}$) would cause the channel to adjust, producing suitable habitat for the Program's target species. This concept is generally supported by regime theory of alluvial channels. However, when SDHF was formulated, channel-forming discharge was not field verified and the importance of event duration/volume was not considered. This appears to have led to an overestimation of the beneficial effects of SDHF in relation to the proportion of Program water it would require.

Given First Increment learning, a revised equivalent peak flow management action to create and maintain suitable least tern, piping plover, and whooping crane habitat would likely be a 12,000-15,000 cfs long duration high flow (40 days) in 30-50% of years. The magnitude of 12,000-15,000 cfs would be necessary to create sandbars meeting the minimum height suitability criterion. Maintenance of the flow for 40 days would result in an approximately 50% probability that unobstructed channel width at any given location in the AHR would be highly-suitable for whooping cranes (>500 ft).[10] Peak flows of this magnitude and recurrence interval are consistent with 1993 USFWS pulse flow recommendations for the central Platte River valley. A 40-day duration at peak would be approximately two weeks longer than the 27-day total event duration proposed in 1993.

[9] Unobstructed widths are less than 400 ft in absence of disking. With disking, unobstructed channel width increases by an average of 164 ft, producing suitably wide channels.

[10] This assumes that no mechanical channel maintenance actions are taken.