Upper Colorado River Endangered Fish Recovery Program

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IN REPLY REFER TO:
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Memorandum

To: Mr. Brent Rhees, Regional Director, Upper Colorado Region, Bureau of Reclamation
Ms. Heather Patno, Chair, Flaming Gorge Technical Working Group, Bureau of Reclamation

From: Thomas Chart, Director, Upper Colorado River Endangered Fish Recovery Program

Subject: Recovery Program's Research Request for 2017 Green River Flows

The Upper Colorado River Endangered Fish Recovery Program (Recovery Program) supports the Bureau of Reclamation's (Reclamation) operations at Flaming Gorge Dam in 2017 consistent with the 2005 Biological Opinion (U.S. Fish and Wildlife Service (USFWS) 2005) and 2006 Record of Decision (ROD; U.S. Department of Interior 2006). As in the past five years, an objective of our request this year is to continue to build on past research (Bestgen et al. 2011) and recent success to benefit the razorback sucker (*Xyrauchen texanus*) population throughout the Green River by timing the river-floodplain connection with the presence of wild-produced razorback sucker larvae. Secondly, and similar to 2016, the Recovery Program asks that Reclamation experiment with flexibility identified in the 2006 ROD to provide summer base flows within a range intended to improve survival of age-0 Colorado pikeminnow (*Ptychocheilus lucius*) as described in Bestgen and Hill 2016a. The Recovery Program appreciates Reclamation's willingness to work with the Flaming Gorge Technical Work Group (FGTWG) to address base flows within existing authority under the 2006 ROD. And finally, we ask that Reclamation continue to consider the possibility of experimental spike flow releases in the early summer at some point in the future to negatively affect early life stages of nonnative smallmouth bass (*Micropterus dolomieu*) as described in Bestgen and Hill 2016b (see discussion in Appendix A). (Here, "spike flow" refers to elevated releases over several days that would occur subsequent to the annual peak.)

The Recovery Program is currently evaluating the Green River Flow and Temperature recommendations of Muth et al. 2000 in light of recent findings. A Green River Evaluation and Assessment Team (GREAT) was convened in 2015 to initiate this evaluation The GREAT consists of representatives from Argonne National Laboratory (ANL – co-lead of this evaluation), Colorado State University (co-lead of this evaluation), Reclamation, Western Area Power Administration, National Park Service, USFWS (Program Director's Office and the Utah Ecological Services Field Office), and the State of Utah. The GREAT is reviewing the physical and biological data collected under historical operations (with a focus on post-ROD operations) to determine if the flow recommendations of Muth et al. (2000) should be updated. The GREAT met for an initial workshop in 2015; two workshops in 2016; and another most recently in February 2017. Conference calls / webinars are scheduled bi-weekly. A draft evaluation report is now scheduled for submittal to the Recovery Program technical committees in July 2017.

At this point in that evaluation, we can report that the GREAT report will recognize the importance of larval triggered spring operations (including down ramping rates) and the need to experiment with: a) the range of base flows described by Bestgen and Hill (2016a) as well as the onset of the base flow period, and b) summer spike flows to disrupt nonnative smallmouth bass spawning success (Bestgen and Hill 2016b). As the Recovery Program determined last year, the GREAT's evaluation of Muth et al. (2000) will describe an experimental approach to implement and evaluate of the alternative base flow range and nonnative spike flows. Because the GREAT's evaluation remains a work-in-progress, this Recovery Program 2017 flow request is very similar to our 2016 request. If / when the Recovery Program approves updates to the flow recommendations of Muth et al. (2000), we then expect Reclamation will determine if additional NEPA analysis is necessary. The Recovery Program will work with Reclamation (through this GREAT evaluation and Recovery Program committee review of any revisions to the flow recommendations included in Muth et al. (2000)) to provide information needed to assist Reclamation with that NEPA determination.

<u>THE RECOVERY PROGRAM'S 2017 GREEN RIVER FLOW REQUEST</u>:

The Recovery Program's 2017 Green River Flow Request comprises two components: a Larval Trigger Study Plan (LTSP *ad hoc* committee 2012) spring peak and experimentation with alternative Reach 2 base flow target ranges that should be achieved coincident with the presence of drifting Colorado pikeminnow larvae and maintained through September 30. The Recovery Program believes all aspects of this request are supported by sound science and we understand that achieving both components may not be possible based on water availability and operational considerations. The Recovery Program assumes that our 2017 flow requests will be refined in concert with the FGTWG using the best available flow forecast information.

To assist Reclamation and the FGTWG, should such deliberations be necessary, the Recovery Program prioritizes these flow experiments as follows:

Priority 1 – LTSP spring peak
Priority 2 – New, proposed Reach 2 base flow ranges as per Bestgen and Hill (2016a)

1. Implement the LTSP. The Recovery Program requests that FGTWG match Recovery Program research needs identified in the LTSP with the best available spring flow forecast information to develop a specific middle Green River floodplain connection scenario. Our LTSP study design matrix (Table 1) details the range of experimental conditions we would like to assess with recognition that more than one cell of that matrix could be accomplished in a single year. The Recovery Program Director's office will distribute the pertinent FGTWG recommendation to the Biology and Management committees and Principal Investigators as quickly as possible.

The Recovery Program will provide a real-time assessment of razorback sucker larval presence (i.e., the 'larval trigger') through ongoing monitoring under Recovery Program Project No. 22f. Based on information provided in Bestgen et al. (2011), waiting for this larval trigger will likely cause

Reclamation to make spring releases from Flaming Gorge Dam after the Yampa River has peaked, which may necessitate releases in excess of power plant capacity to meet the flow magnitude thresholds needed for river-floodplain connections. Because of the current snowpack in the upper Green River drainage, it is likely that Reclamation will be at maximum release levels when the larvae are detected this year. As addressed in the LTSP, the Recovery Program is prepared to direct sampling efforts each year to the appropriate floodplain habitats based on hydrologic forecasting and the FGTWG request. The Recovery Program is poised and properly funded to follow through on specific LTSP field investigations again in 2017 (e.g., Project Nos. 22F, 164 and 165[1]). Larval entrainment in 2017 may be lower than previous years because the lower outlet gate is closed for repair and larvae will only be entrained through the upper inlet gates. The lower gate will be repaired prior to the fall draining and evaluation period.

Table 1. The Larval Trigger Study Plan design matrix (refer to App. Fig.2 for a summary of Reach 2 flow conditions achieved to date).

Peak Flow (x) as Measured at Jensen, Utah	Proposed Study Wetlands[a, b]	Number of Days (x) Flow to Be Exceeded and Corresponding Hydrologic Conditions[c]		
		1 ≤ x < 7	7 ≤ x < 14	x ≥14
8,300 ≤ x < 14,000 cfs	Stewart Lake (f), Above Brennan (f), Old Charley Wash (s)[d]	Dry	Moderately dry	Moderately dry and average (below median)
14,000 ≤ x < 18,600 cfs	Same as previous plus Escalante Ranch (f), Bonanza Bridge (f), Johnson Bottom[e] (s), Stirrup (s), Leota 7 (s)	Average (below median)	Average (below median)	Average (below median)
18,600 ≤ x < 20,300 cfs	Same as previous	Average (above median)	Average (above median)	Average (above median)
20,300 ≤ x < 26,400 cfs	Same as previous plus Baeser Bend (s), Wyasket (s), additional Leota units (7a and 4), Sheppard Bottom (s)	Moderately wet	Moderately wet	Moderately wet
x ≥ 26,400 cfs	Same as previous	Wet	Wet	Wet

(a) f = flow-through wetland, s = single-breach wetland

(b) Up to eight wetlands would be sampled in a given year with the three in the lowest flow category being sampled in all years.

(c) Exceedance percentages and peak flow recommendations for each hydrologic condition as described in Muth et al. 2000. Note that the hydrologic conditions presented are the driest that could support a particular combination of peak flow magnitude and duration. For any combination, wetter hydrology could also support an experiment.

(d) Access to the Old Charley Wash floodplain has been denied since 2012.

(e) In 2015, Johnson Bottom was re-contoured and canals were cleaned; this wetland can now entrain larvae when flows are <14,000cfs.

2. An Experimental Base Flow Range. We request that Reclamation exercise the flexibility in the 2006 ROD to achieve the proposed experimental base flow ranges as presented in Bestgen and Hill (2016a) in Reach 2 through September 30 (see Table below). We request that Reclamation experiment with alternative down-ramping rates to achieve the summer base flow target as soon as possible after Colorado pikeminnow larvae are detected in the drift. The Program Director's office will coordinate with Colorado State University, Reclamation, and the FGTWG with predictions of larval presence and communicate real time larval collection information as soon as it is available.

Table 10. Comparison of base flow levels in Muth et al. (2000) and those proposed in this report for the middle and lower Green River, Utah. The higher upper ends of flow ranges in Muth et al. (2000) for the lower Green River reflect uncertainty about tributary inputs, while proposed targets represent preferred ranges.

	Reach 2, Middle Green River flows		Reach 3, Lower Green River flows	
Hydrologic classification	2000 (Muth et al.)	Proposed	2000 (Muth et al.)	Proposed
Dry (10% of years, 0 to 10% exceedance)	26-31 m^3/s (900-1,100 ft^3/s)	48-51 m^3/s (1,700-1,800 ft^3/s)	37-74 m^3/s (1,300-2,600 ft^3/s)	48-57 m^3/s (1,700-2,000 ft^3/s)
Moderately dry (20% of years)	31-43 m^3/s (1,100-1,500 ft^3/s)	51-57 m^3/s (1,800-2,000 ft^3/s)	42-96 m^3/s (1,500-3,400 ft^3/s)	57-65 m^3/s (2,000-2,300 ft^3/s)
Average (40% of years)	43-68 m^3/s (1,500-2,400 ft^3/s)	57-74 m^3/s (2,000-2,600 ft^3/s)	51-119 m^3/s (1,800-4,200 ft^3/s)	65-79 m^3/s (2,300-2,800 ft^3/s)
Moderately wet (20% of years)	68-79 m^3/s (2,400-2,800 ft^3/s)	62-79 m^3/s (2,200-2,800 ft^3/s)	77-133 m^3/s (2,700-4,700 ft^3/s)	74-91 m^3/s (2,600-3,200 ft^3/s)
Wet (10% of years, 90 to 100% exceedance)	79-85 m^3/s (2,800-3,000 ft^3/s)	68-85 m^3/s (2,400-3,000 ft^3/s)	91-133 m^3/s (3,200-4,700 ft^3/s)	79-108 m^3/s (2,800-3,800 ft^3/s)

Excerpted from Bestgen and Hill 2016a

The Recovery Program has two monitoring projects (Project 22f – Larval Monitoring and Project 138 age-0 Colorado pikeminnow fall monitoring) in place and funded to assist in the implementation and evaluation of this experimental base flow operation. These same projects and resulting data are what we rely on each year to assess flow and temperature effects on Colorado pikeminnow reproduction, growth, and survival, and provide the basis for flow recommendations previously described and as outlined in Bestgen and Hill (2016a). Annual drift net sampling begins in late spring each year in the lower Yampa River prior to Colorado pikeminnow reproduction. That daily sampling allows us to determine the onset of reproduction by Colorado pikeminnow, and eventual presence of drifting larvae that disperse from the lower Yampa River spawning areas. Larvae subsequently drift downstream to the low gradient and sand-bedded middle Green River where backwater nursery habitat is abundant. When pikeminnow larvae are first detected in field samples (samples are sorted daily, preliminary identifications will be made in the field, and quickly followed by verification in the laboratory), the FGTWG would be consulted to initiate the onset of the base flow period. This could result in flow release changes from Flaming Gorge Dam, if changes are needed, for the summer base flow period that extends through 30 September. Reclamation would communicate these operations with stakeholders through the Flaming Gorge Work Group process.

This larvae-presence driven approach is similar to the one used in the LTSP to document first presence of razorback sucker larvae in light trap samples in the middle Green River. Drift net sampling will continue throughout the reproductive season for pikeminnow, and typically ends in early to mid-August when no larvae are captured for several consecutive days. Consultation with the FGTWG through the summer growth and survival period is planned so that Flaming Gorge Dam flow releases may be altered to provide recommended flow levels in the middle Green River reaches. Alterations may be needed because Yampa River flows decline through summer such that Flaming Gorge Dam flow rates may occasionally need to be increased.

Annual backwater sampling in the middle and lower Green River reaches would then take place in autumn, following the summer Colorado pikeminnow reproduction and survival period. This long-term and spatially extensive sampling consists of seine hauls made in about 30-40 backwaters throughout each nursery habitat reach and documents density and size of pikeminnow that resulted from summer reproduction. Understanding reproductive effort at spawning sites, resulting recruitment of young-of-year Colorado pikeminnow in autumn, and documenting flow and habitat conditions in nursery habitat reaches, allows us to understand if and why managed flow conditions were successful to produce year-classes of young pikeminnow abundant enough to contribute substantially to adult life stages in several years.

We may also consider additional summer (early August) seine sampling in nursery reach backwaters to obtain an additional measure of pikeminnow survival and growth. This may be useful to provide an early indication of success of flow management and serves as a backup measure of recruitment success should autumn sampling be compromised by unforeseen flow events. There was such an occurrence in 2014, when late summer storms mobilized fine sediment and filled backwaters with deep mud, which compromised sampling efficiency throughout nursery habitat reaches in autumn.

We may also consider an otolith-aging investigation to understand if base flow onset timed with presence of larvae was successful to enhance survival of early hatching fish. This would be accomplished by understanding if early hatching cohorts of larvae survived to autumn, based on comparing hatching dates of fish captured in autumn to presence of larvae in summer (sensu Bestgen et al. 2006). Past analyses have shown that early hatching cohorts are underrepresented in autumn, sometimes by a substantial amount, and apparently survived at lower rates than later hatching cohorts (Bestgen et al. 1997; 2006). Presence and abundance patterns of early hatching cohorts in autumn relative to abundance of larvae in summer, would allow us to understand the importance of using the pikeminnow larvae presence to trigger onset of the base flow period.

In the longer term, the Recovery Program (via the GREAT) is considering a revision to the flow recommendations in Muth et al. (2000) that would formally recognize the science that supports further experimentation with a base flow range. Such a revision would include an experimental implementation plan, including an economic analysis of the impacts of an alternate base flow range, and will also assist Reclamation with its determination of the need for additional NEPA analysis.

We recognize proposed flow revisions may result in greater volumes of water being released from Flaming Gorge Reservoir than under current scenarios. Any increased deliveries may ultimately impact elevations in Lake Powell and, as such, operations pursuant to the 2007 Interim Guidelines.

In closing, the Recovery Program appreciates Reclamation's efforts in the past to achieve the flow and temperature recommendations and assist in recovery of the endangered fishes. We recognize that greater reliance on the LTSP biological trigger (presence of larval razorback sucker) may require greater volumes of water during the spring in some years, but we believe this experiment is consistent with the biological intent of Muth et al. (2000) and this research is essential to the recovery of the endangered fish. The Recovery Program's sampling results from the past four years, and particularly the large number of juvenile razorback suckers collected at Stewart Lake in 2013, 2014, and 2016, clearly demonstrate the effectiveness of the LTSP operations (Appendix B). Similarly, our request for experimentation with base flows within Reclamation's authority under the 2006 ROD would require greater volumes of water released during the summer months.

Thank you for considering these Recovery Program 2017 flow requests.

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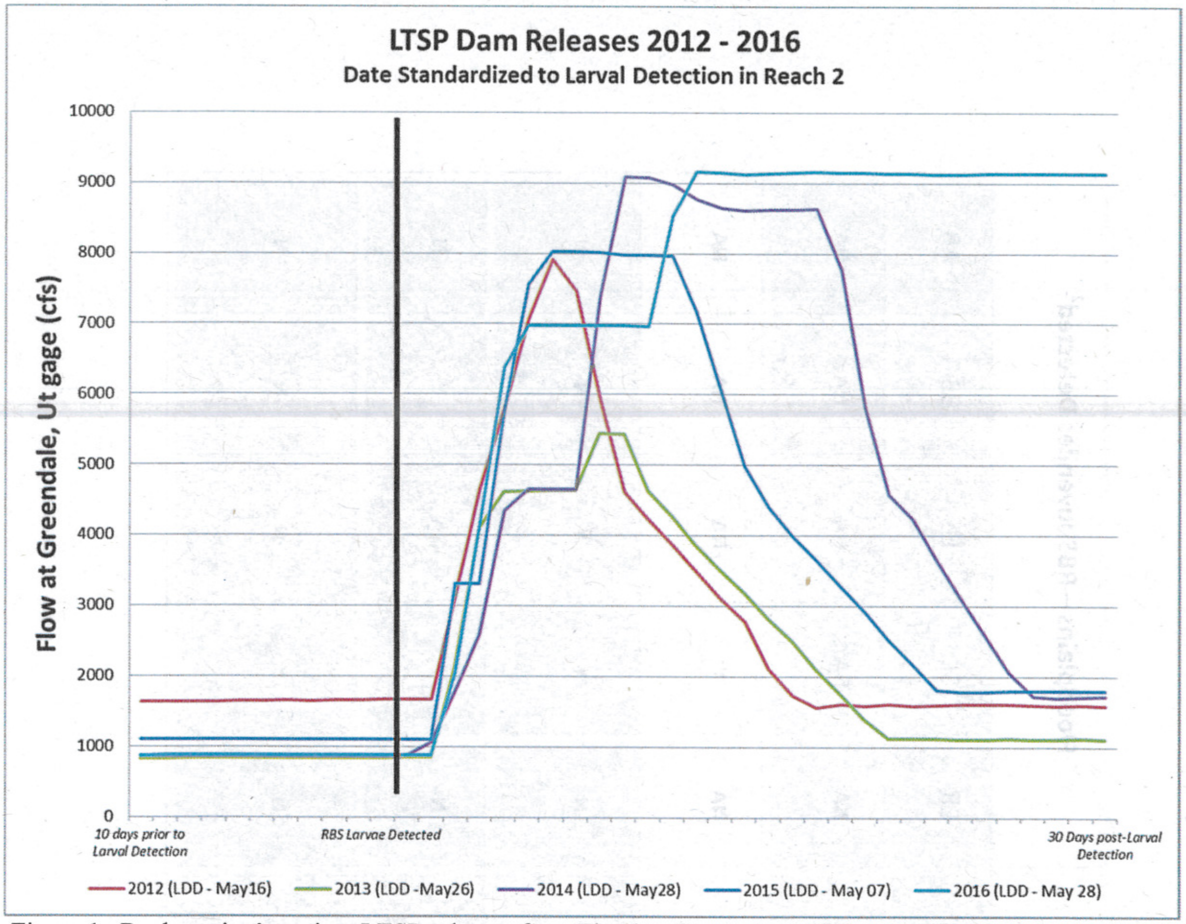
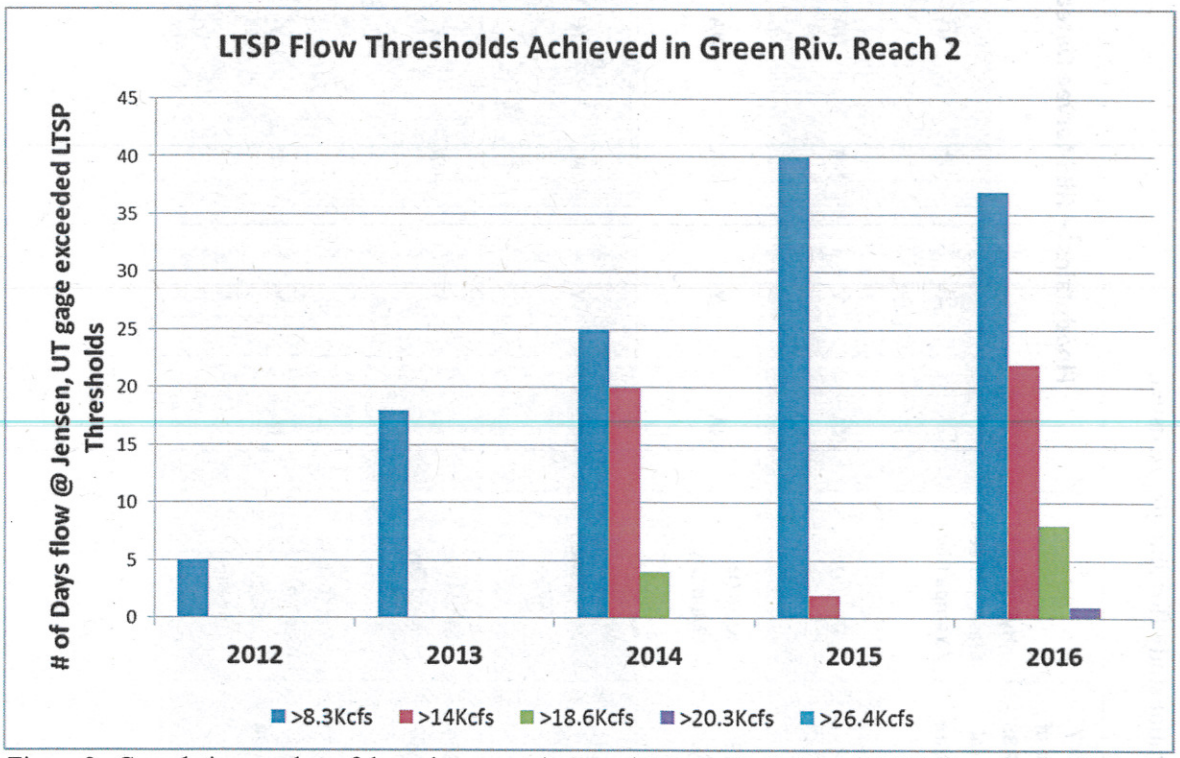
Appendix A. Background Information in Support of the Recovery Program Flow Requests

Spring Flow Request for River / Floodplain Connection - The Recovery Program's spring flow request is based on objectives outlined in our *Study Plan to Examine the Effects of Using Larval Sucker Occurrence in the Green River as a Trigger for Flaming Gorge Dam* (LTSP; Larval Trigger Study Plan Ad Hoc Committee 2012). In the LTSP we describe a desired range of experimental floodplain connection scenarios (post larval detection) and studies we would implement to evaluate those scenarios. Minimally, to complete the experiment, the Recovery Program requests three years with flows < 18,600 cfs and three years with flows $\geq$ 18,600 cfs and with connecting flows in each of these years of at least seven days duration. However, spring peak flow magnitude requests will be driven by hydrologic conditions in the upper Green River Basin and to some extent the Yampa River basin; therefore, it may not be possible to complete the experiment in six consecutive years.

The LTSP experiment began officially in 2012; however, the Recovery Program was able to gather some pre-LTSP related information during 2011. Reclamation's spring operations in 2011 were dictated by flood control concerns, but resulted in significant floodplain connection in Reach 2 after larval razorback sucker were detected in the river. Since 2012, Reclamation's high spring releases (Appendix Figure 1) have been timed specifically to achieve LTSP objectives in Reach 2 (Appendix Figure 2). The resulting Reach 2 flows and preliminary results of biological monitoring in Reach 2 floodplain habitats are summarized in Appendix Table 1 and discussed in greater detail in Appendix B. In each year from 2011 to 2016, floodplain connection was achieved, larval entrainment was documented and age 0 razorback sucker were found in at least one sampled floodplain pond (except for 2012). Stewart Lake and Johnson Bottom have been particularly successful as described in Appendix B, and in Speas et al. (2017). LTSP releases and our evolving floodplain management (as summarized in Speas et al. 2017) are clearly assisting in the recovery of two of our endangered species.



App. Figure 1. Reclamation's spring, LTSP releases from Flaming Gorge Dam 2012 – 2016. Chronology of annual hydrographs has been standardized to 1st larval detection date (LDD). Actual annual LDD's are identified in the legend.



App. Figure 2. Cumulative number of days above certain Larval Trigger Study Plan (LTSP) flow thresholds in the Green River Reach 2 (as measured @ Jensen, UT gage); 2012 – 2016 when razorback sucker larvae were present.

App. Table 1. A summary of biological findings associated with Larval Trigger Study Plan operations and Recovery Program studies. Not all potential study floodplains are listed.

Year / date of 1st RBS larval capture	Hydrologic Class. - Green / Yampa River	Floodplains[2] – RBS Larvae Detected[3]					Floodplains – RBS Juveniles Detected[2]				
		ER	SL	Le	JB	AB	ER	SL	Le	JB	AB
2012 / May16	Dry / Dry	NA	Y	NA	NA	NA	NA	NA	NA	NA	NA
2013 / May26	Mod Dry / Mod Dry	NA	Y	NA	NA	NA	NA	Y	NA	NA	NA
2014 / May28	Avg (Above Med) / Mod Wet	Y	Y	N	N	Y	N	Y	Y	N	N
2015 / May07	Mod Dry / Mod Dry	N	Y	NA	Y	NA	N	Y	NA	Y	N
2016 / May28	Avg (below median) / Avg (above median)	N	Y	N	Y	Y	N	Y	N	N	N

2 ER = Escalante Ranch; SL = Stewart Lk; Le = Leota Bottoms; JB = Johnson Bottom; AB = Above Brennan
3 NA = habitat did not connect - not available; Y, N = yes or no - larvae or juvenile detected in floodplain. Beginning in 2015, juvenile bonytail were also collected in SL and JB.

Request for Experimental Summer Base Flows – Since the ROD was signed, the Recovery Program has made only one specific summer base flow request, in 2008. The objectives of that request were: a) to create more nursery habitat for age-0 Colorado pikeminnow in Reach 2; b) to provide a Reach 2 base flow which was scaled more closely to the observed 2008 spring peak flow; and c) disadvantage nonnative smallmouth bass in Reaches 1 and 2. Beginning in 2009, the USFWS – Utah Field Office has submitted similar base flow requests directly to Reclamation. All the base flow requests submitted to date exercised seasonal flow variability identified in Muth et al. (2000) and relied on preliminary summaries of the long term (1979 – present) age -0 Colorado pikeminnow fall monitoring program that indicated survival of that life stage was higher when base flows in most average and drier hydrology years were higher.

In February 2016, the Recovery Program technical committees (Biology and Water Acquisition) approved a report (Bestgen and Hill 2015a), which provided a formal analysis of the age-0 monitoring data and coupled that with Colorado pikeminnow larval monitoring (1992 – 2012; one year missing). Bestgen and Hill concluded (1 of 19 conclusions in the report):

> *Age-0 Colorado pikeminnow abundance was highest in the middle Green River in moderate flow years (1700-3000 ft3/sec), lower in some low flow years because larvae were fewer (< 1700 ft3/sec), and low in most high flow years (>3000 ft3/sec) because backwater habitat was reduced. Patterns were similar in the lower Green River except higher abundances of age-0 pikeminnow were in slightly higher flows.*

In Table 10 (reproduced on page 4 above) of their report, Bestgen and Hill compare their proposed base flow recommendations for Reaches 2 and 3 with the original Muth et al. (2000) recommendations. Those proposed base flow recommendations in both reaches are encompassed by the full base flow range presented in Muth et al. (2000) established for the full suite of hydrologic conditions. However, the proposed base flow targets in dry and moderately dry years are higher than in Muth et al. (2000) (i.e., they raise the lower end of the range). Considering the status of Colorado pikeminnow in the Green River as discussed in Bestgen and Hill (2016a), the Recovery Program requests that Reclamation strive to meet these proposed base flows on an experimental basis through September 30 of each year. We understand that Reclamation may need to revert to the Muth et al. (2000) base flow ranges after September 30 to manage the reservoir; those changes would be discussed with the FGTWG.

Reclamation's operations during the summer of 2015 and 2016 resulted in Reach 2 flows that were consistent with this new information. Flows at Jensen, Utah averaged 2,118 cfs through the months of August and September in 2015, and 2,150 cfs during the same months in 2016. The Utah Division of Wildlife Resources (UDWR) (Breen et al. 2015) captured 202 age-0 Colorado pikeminnow in their middle Green River fall 2015 monitoring, which was their 3rd highest catch in the past 20 years. Catch of age-0 pikeminnow (n= 6) dropped off in the middle Green River in 2016 (Breen et al. 2016). Bestgen and Jones (2016) reported that abundance of larvae did not appear to explain poor age-0 catch in the autumn. Colorado pikeminnow larval production at the Yampa River spawning bar was average or higher than average. One possible reason for reduced YOY production is that early July flows were high, during a period when about 50% of Colorado pikeminnow larvae were produced. Thus, backwaters may not have been available during that time. Further, newly formed backwater habitat is likely food-poor because invertebrates have not colonized those areas and established populations. Thus, suitable backwater habitat may not have been available until later in July in 2016. Flow pattern as well as magnitude may be very important for production of good year classes of YOY pikeminnow.

Summer base flows in Reach 3 (measured at Green River, UT) averaged 2,328 cfs in August and

September, 2015, and 2,667 cfs for the same months in 2016. UDWR reported above average captures of age-0 Colorado pikeminnow in their lower Green River monitoring in 2015 (n=461) and 2016 (n=426).

As discussed above, Bestgen and Hill (2016a) and Bestgen and Jones (2016) recognized the importance of achieving the proposed base flows in Reach 2 as soon as possible after Colorado pikeminnow larvae were detected in the annual drift monitoring conducted at Echo Park, CO. This incorporates a new 'larval triggered' element for this species, similar to that for razorback sucker in the middle Green River, and for base flow management not specifically discussed in Muth et al. (2000). In some cases, this may require reducing Flaming Gorge releases to as low as 800 cfs then increasing flows in response to declining Yampa flows. The Recovery Program recognizes the utility of providing optimal nursery habitat conditions in Reach 2 as the drifting larvae arrive and then continuing those flows through the summer growth and recruitment period. The Recovery Program will coordinate with Reclamation in documenting real-time presence of larval Colorado pikeminnow captured in Project 22f drift samples that are collected in the lower Yampa River. More detail on monitoring effects of experimental summer base flows on young Colorado pikeminnow abundance and survival are described below. The Recovery Program (via the GREAT) will revise Muth et al (2000) to recognize the science that supports experimentation with a proposed base flow range. Such a revision would include a proposed base flow experimental implementation plan. We expect that implementation plan will define criteria for success, identify a finite time frame and address uncertainties.

> **NOTE:** ***The Recovery Program is not requesting a spike flow in 2017.*** *The Recovery Program (via the GREAT) is in the process of evaluating and revising Muth et al. (2000) flow recommendations. Revisions will include an experimental approach to implementation of spike flows.*

Request for Smallmouth Bass Experimental Spike Flow – (For consideration in future below median years, not a 2017 request). The Recovery Program now considers persistent competition and predation from nonnative predators (smallmouth bass, northern pike (*Esox lucius*), and walleye (*Sander vitreus*) on the native and endangered fish community our greatest remaining threat to recovery. Our nonnative predator control strategy to date consists of: 1) mechanical (primarily boat based electrofishing) removal of these predators from 600+ miles of the Green and Colorado rivers and their tributaries, 2) controlling escapement from reservoir sources (e.g. chemical renovation, screening outlets, incentivized harvests), and 3) changes in sport fish management to utilize species that are considered more compatible with endangered fish recovery. Of these three nonnative predators, smallmouth bass are the most widespread and spawn in main channel habitats. Spawning populations are found in the Yampa River, Green River (Reaches 1, 2, and 3), White River, and in the Colorado River. Adult male smallmouth bass guard shallow shoreline nests where the female deposits eggs and where recently hatched young remain to develop. Fish biologists from other parts of the country have long reported that sudden increases in flow (spikes) and/or increased turbidity can displace the recently hatched young from those protected nests into less favorable habitat, which results in high mortality of the age-0 cohort (see Bestgen and Hill 2016b for a summary of those studies). Such environmental changes may also cause adult male bass to abandon nests, which also increases mortality of young bass. For years, the Recovery Program's Biology Committee (BC) has recognized that induced spike flows could be an important complement to the nonnative fish removal strategy mentioned above because it could influence smallmouth bass spawning success on a reach-wide scale. The BC also recognized that considerable information needed to be gathered on smallmouth bass spawning ecology in our rivers to characterize a meaningful flow manipulation in terms of timing, magnitude, duration, techniques for evaluation. Since 2003, Bestgen and Hill have analyzed otolith microstructure to estimate hatching dates and growth rates of early life stages of smallmouth bass collected in regulated or partially regulated reaches of the Green River, and the free-flowing Yampa River, Colorado and Utah. Bestgen and Hill (2016b) summarized that information and provide the Recovery Program with the basis for a spike flow experiments.

As with alternate base flows, the Recovery Program (via the GREAT) will revise Muth et al. (2000) to incorporate periodic experimental summer spike flows to disrupt smallmouth bass spawning. Such a revision would include an implementation plan that would be based on Reach 1 and 2 hydrology and thermal regimes as well as real-time observations of smallmouth bass spawning behavior. More specifically, Bestgen and Hill (2016b) provide the following general considerations for experimental implementation of a spike flow:

- Smallmouth bass reproduction is most successful during years of drier hydrology (e.g. (below median) to Dry) because spawning occurs early and age-0 growth is adequate for fish to survive their first winter. Therefore spike flows would have the greatest effect in these below median hydrologic year types.
- Smallmouth bass spawning can occur over a multiple (typically four to five) week period. For the reasons mentioned above, a spike flow that targets the early to middle portion of that spawning activity would have the greatest effect. Also targeting the early smallmouth bass spawn reduces possible collateral effects on Colorado pikeminnow reproduction, which occurs later.
- The magnitude of a spike flow is of critical importance. Smallmouth bass have been observed to select spawning sites at the lower end of cutoff side channels. A cursory review of flow / stage relationships indicate that rapidly increasing flows from a low level (e.g. <1500cfs) in Reach 1 up to power plant capacity (~4500cfs) would create flow-through conditions in many side channels habitats both in Lodore Canyon (Reach 1) and in the upper portions of Reach 2 thereby disrupting established spawning sites.
- Timing of the spike flow will be equally important. Timing of releases for disruption of reproduction should be predicted with Bestgen and Hill (2016b) smallmouth bass hatching date distribution, but verified with observations. Although there is a flow magnitude component to the onset of reproduction, Bestgen and Hill (2016b) report that time of smallmouth bass spawn is closely correlated with the onset of a main channel temperature of 16ºC. Ideally, flows in the Yampa River will have dropped to moderate to low levels to maximize the disturbance in downstream Island and Rainbow Parks in the upper portion of Reach 2.
- Duration of the Spike Flow – Flows would have to be sustained for a long-enough period, perhaps 2-3 days in the reaches to be affected, to have the desired impact, and to allow investigators to measure effects.
- Evaluation - Understanding effects of flow disturbances would likely require an assessment of physical effects of increased flows, in addition to a biological assessment. Physical habitat changes during flow increases should focus on those characteristics that may disrupt nesting success (increased velocity over the nests, reconnection of a side channel). A physical effects analysis may involve finding and marking active nests, taking measurements of velocity and depth characteristics around the nest area before and during the flow disruption, and describing macro-habitat features of the site, including whether the nest was located in the downstream end of a secondary channel.

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[illegible] climate base flows, the Recovery Program [illegible] the 2016 SMART [illegible] Mohr et al. [illegible] appropriate periods to experimentally implement spike flows to disrupt smallmouth bass spawning. Such a decision would include an implementation plan that would be based on [illegible] 1 and 2 hydrology and thermal regimes as well as real-time observations of smallmouth bass spawning behavior. More specifically, Bestgen and Hill (2016c) provide the following general considerations for experimental implementation of a spike flow.

- Smallmouth bass reproduction is most successful during years of lower hydrology (e.g., below median) to Dry; because spawning occurs early and early growth is adequate for fish to survive their first winter. Therefore, spike flows would have the greatest effect in these below median hydrologic year types.
- Smallmouth bass spawning can occur over a multi-day (typically four week) [illegible] period. For the reasons mentioned above, a spike flow that targets the early to middle portion of the spawning activity would have the greatest effect. Also, targeting the early smallmouth bass spawn reduces possible unintended effects on Colorado pikeminnow reproduction, which occurs later.
- [illegible] smallmouth bass have been observed [illegible] lower end [illegible] A cursory review of [illegible] rapidly increasing flows from low levels (e.g., Flaming Gorge [illegible] power plant capacity [~4,500 cfs]) would create flow-through conditions in many side channels habitats both in Lodore Canyon (Reach 1) and in the upper portions of Reach 2 likely disrupting established spawning sites.
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- Duration of the Spike Flow – Flows would have to be sustained for a long-enough period, perhaps 2–3 days in the reaches to be affected, to have the desired impact, and to allow investigators to measure effects.
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Appendix B: Discussion of LTSP Related Operations, Physical Conditions in Reach 2 of the Green River and Preliminary Biological Findings

LTSP Operations and Findings: 2012

In 2012, hydrologic classifications for the Yampa River and Upper Green River basins were categorized as 'dry'. The Recovery Program and the Flaming Gorge Technical Work Group (FGTWG) ultimately agreed to focus the 2012 spring flow request on the driest category of experimental conditions outlined in the LTSP, i.e. a peak flow between 8,300 and 14,000 cfs for 1 to 7 days. The Recovery Program detected wild produced razorback sucker larvae on May 16, 2012 (Bestgen et al. 2012). Reclamation ramped up Flaming Gorge releases to a peak of 7,420 cfs, which resulted in a peak flow at Jensen, Utah of 10,200 cfs on May 24, 2012 (Reclamation 2013b). Flows at Jensen, Utah were sustained above 8,300 cfs for 5 days after larvae were detected. Floodplain connection occurred at Stewart Lake and Old Charley Wash. Utah Division of Wildlife Resources (UDWR) crews documented larval entrainment into Stewart Lake and described physical conditions at that floodplain site (Breen and Skorupski 2012). Similarly, USFWS field crews documented larval entrainment into the Old Charley site. Unfortunately, all fish entrained at both locations likely perished, because water quality deteriorated quickly after flows declined. During the spring and summer months of 2012, USFWS crews (Webber and Jones 2012) sampled fish and monitored water quality at a variety of other floodplains that still held water from the extensive period of connection in 2011, but did not connect in 2012.

Personnel from Western Area Power Administration (Western), Argonne National Laboratory (funded by Western), and the Recovery Program surveyed Reach 2 levee breach elevations in Autumn 2012 to better assess connection flows for future LTSP experiments. Those data, in preliminary form, were available for FGTWG discussions in Spring 2013.

LTSP Operations and Findings: 2013

In 2013, the spring hydrologic classification started off 'dry' but turned 'moderately dry'. Reclamation reviewed the FGTWG recommendation and decided to implement the LTSP recommendations for moderately dry hydrologic conditions and to increase releases when larvae were detected (Reclamation 2014; Draft Report). The Recovery Program and the Flaming Gorge Technical Work Group (FGTWG) ultimately agreed to focus the 2013 spring flow request on the moderately dry category of experimental conditions outlined in the LTSP, i.e. a peak flow between 8,300 and 14,000 cfs for 7 to 14 days. The Recovery Program detected wild produced razorback sucker larvae on May 26, 2013 (Bestgen et al. 2013). Flaming Gorge Dam releases were increased to full power plant capacity (~4,500 cfs) on May 29, 2013. Yampa River flows dropped below 4,000 cfs and Flaming Gorge Dam releases were increased 1,000 cfs on June 4th above power plant capacity for a total release of ~5,500 cfs to maintain flows in Reach 2 above 8,300 cfs. Releases returned to power plant capacity on June 5, 2013. The Green River measured at Jensen, Utah reached its peak of 10,700 cfs on June 6, 2013. Flows at Jensen, Utah were above 8,300 cfs for 25 days total and above 8,300 cfs during larval presence for 18 consecutive days. Prior to, during, and after floodplain connection, Stewart Lake proper and the Stewart Lake drain were sampled using an assortment of techniques to monitor the fish community. UDWR biologists documented that razorback sucker larvae were entrained into Stewart Lake and grew quickly (~1mm/day) during the ~2 month inundation period. On July 31, 2013, UDWR began draining Stewart Lake because of declining water quality. A total of 613 age-0 razorback sucker were collected, of which 592 were released alive to the Green River (Skorupski et al. 2013). This was the largest number of juvenile razorback suckers ever documented in the Colorado River Basin, demonstrating the importance of appropriately timed connections between the river and floodplain wetlands. Razorback sucker larvae were not detected in the Escalante Ranch wetland; the only other wetland identified in the LTSP that connected to the Green River in 2013 (Webber and Jones 2013).

LTSP Operations and Findings: 2014

In 2014, Flaming Gorge Reservoir was expected to receive 135 % of average inflow. Observed volume was 118% by September 2, 2014. Reclamation targeted LTSP 'Average' hydrologic conditions (Reclamation 2014; Draft Report). The Recovery Program detected wild produced razorback sucker larvae on May 28, 2014 (Bestgen and Jones 2014). Reclamation began their ramp up to bypass flows on May 30, 2014; ramp down to base flows was initiated 15 days later when Yampa River flows no longer supported meaningful floodplain connection in Reach 2 (see Figure 1 and Table 1).

UDWR and USFWS biologists documented that razorback sucker larvae were entrained into Stewart Lake, Escalante Ranch, the Stirrup, and Above Brennan in 2014 (Schelly et al. 2014; Webber et al. 2014). Larval entrainment at Leota7 was confirmed in the fall via capture of age-0 razorback sucker. UDWR biologists used floodgate structures to control flows and picket weirs to exclude large-bodied nonnative fishes at Stewart Lake. Stewart Lake filled to capacity in 2014 during the larval drift period. Stewart Lake was drained in September, beginning 92 days post-initial connection. A total of 749 razorback suckers were sampled returning to the Green River during drawdown of the wetland. Furthermore, the fish released back to the Green River had a mean length of 97 mm TL, with one fish reaching a length of 168 mm, indicating substantial growth while in Stewart Lake and improving these individuals' chances of overwinter survival when released back to the river. Later in September 2014, researchers collected wild produced age-0 razorback sucker in Green River Reach 2 main channel backwater habitats for the first time since 2000 (Breen et al. 2014). For the second consecutive year, Stewart Lake has demonstrated the enormous potential of managed wetlands for razorback sucker recovery under the Larval Trigger Study Plan.

Escalante Ranch The USFWS set larval light traps in late May through mid-June; wild larval razorback sucker were collected. They also sampled with 18 fyke nets from 24 -28 March to determine overwinter (2013-2014) survival of 989 bonytail (*Gila elegans*) stocked by the Ouray National Fish Hatchery on 19 September 2013. Five individuals (TL=255, 295, 254, 275, 300mm) were captured. The low number of fish caught suggests high winter mortality, which is possibly a result of the low dissolved oxygen levels in this wetland from October until ice-off as revealed by data recorded by a mini-DOT logger. Fall sampling in the Escalante Ranch wetland occurred from 20–22 October and 10 fyke nets were set to determine the relative abundance and recruitment of razorback sucker. Despite collections of larval razorbacks in this wetland in June 2014 only one adult (TL = 503mm) was collected in the fall.

Above Brennan The USFWS set larval light traps in early to mid-June; wild larval razorback sucker were collected. This wetland reset (dried) in 2012. USFWS sampled the wetland in late August for larger sized fish. They caught one razorback sucker (TL=418mm) (in a fyke net) and many nonnatives. These included, in order of abundance, common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), black bullhead (*Ameirus melas*), young-of-year black crappie (*Pomoxis nigromaculatus*), red shiner (*Cyprinella lutrenis*), adult white sucker (*Catostomus commersoni*), and one young-of-year smallmouth bass. The razorback sucker was translocated into the Green River adjacent to the floodplain.

The USFWS returned to Above Brennan in the fall from 27-29 October, their native fish catch consisted of one adult razorback sucker (TL=470mm), which was translocated into the Green River.

Leota The USFWS sampled with larval light traps in late June – native flannelmouth sucker (*Catostomus latipinnis*) were collected, but razorback sucker were not (entrainment confirmed later in the year). Leota **7** reset in 2012 thru 2013 and connected directly to the Green River during 2014 peak flows. USFWS sampled with 10 fyke nets between 14-17 October; five young-of-year individuals (TL 101-152mm) were captured and released to a backwater near the Leota canal outlet at RMI 256. Nonnative fishes caught included common carp, fathead minnow, black bullhead, and green sunfish (*Lepomis cyanellus*), of which almost all were young-of-year. The fact that few adult nonnative fish were observed suggests that razorback larvae can survive and recruit in the presence of similarly sized competitors or predators. The presence of these larger predator species in the other wetlands is likely responsible for the lack of razorback recruitment in those sites. The Leota complex was also very large, with the different sub-units connected through water control structures and canals. It is possible that juvenile razorback sucker were present throughout the complex.

MiniDOT loggers were set in Above Brennan wetland and Leota 7 to monitor water conditions throughout the winter of 2014-2015.

Bonanza Bridge and Stirrup The UDWR conducted fall sampling of naturally functioning wetlands subject to inundation in 2014 to assess Age-0 razorback sucker survival elsewhere in the reach (Schelly et. al. 2014). Nonnative species comprised the entire fall catch at Bonanza Bridge and most of the catch at the Stirrup; 21 bonytail were also collected. Comparison of these results with the success at Stewart Lake suggests that modification of additional wetland breaches through installation of floodgates to control filling and improve water retention—in combination with blocking weirs to exclude adult nonnative fishes—would improve razorback sucker recruitment in these nursery habitats.

LTSP Operations and Findings: 2015

Hydrologic conditions during the Spring 2015 were extremely varied. In early May, both the Yampa and Flaming Gorge Inflow forecasts were classified as 'moderately dry', but then the weather turned cold and wet, which resulted in a wetter April – July runoff. The Recovery Program detected razorback sucker larvae on May 7, 2015; eight days earlier than ever detected before (period of sampling started in 1992). Reclamation and the FGTWG agreed to target LTSP 'moderately dry' conditions, i.e., achieve Reach 2 flows between 8,300 – 14,000cfs for as many days as the Yampa River would support meaningful floodplain connection. Reclamation began their ramp up from 1,100cfs on May 10, 2015 to a peak release of 8,030cfs 5 days later. Ramp down operation commenced on May 21 and was down to base flow on May 31, 2015 (see Figure 1 above). In Reach 2, flows were above 8,300cfs for 40 consecutive days and above 14,000cfs for 2 days post larval detection (see Figure 2 above). The Reach 2 peak of 14,900cfs occurred on May 21, 2015.

Three study floodplains connected in 2015: Stewart Lake, Escalante Ranch, and Johnson Bottom. Larvae were detected in Stewart Lake and Johnson Bottom. Above Brennan connected at the peak with a sheet flow through one of the upstream breeches; not deemed biologically significant (Jones et al. 2015; Schelly and Breen 2015).

Stewart Lake Outlet gates were opened on May 9, 2015 and were closed for the final time on May 28, 2015 with Stewart Lake within 10cm of full pool. Through the summer, continuous loggers revealed dissolved oxygen levels consistently in the range of 6-9 mg/L in open water near the surface and in the middle of the water column, with low dissolved oxygen zones (below 1 mg/L) near the benthos or in dense vegetation. Temperatures ranged from 14-22 °C, and were typically on the upper end of this range in the upper portion of the water column during the latter period of inundation. Stewart Lake outlet gate was opened for draining on 1 September 2015. Draining was completed on 13 September 2015. Whereas in 2014, fish sampling alternated with periods of un-sampled free releases (Schelly et al. 2014), this year sampling continued without interruption even in the absence of 24/7 staffing.

With uninterrupted sampling in 2015, the total estimated number of fishes trapped during 13 days of draining was 371,990 (comprising 371,866 nonnatives and 124 natives). Notably, the relative species composition of the nonnative component shifted dramatically compared to 2014. This was mainly a result of an explosion of green sunfish in 2015, constituting 33% of the total fishes processed at draining (n = 121,501). In striking contrast, green sunfish were a negligible component of the 2014 Stewart Lake sample (n = 329; Schelly et al. 2014). Curiously, fewer (n = 87) Age-0 razorback suckers were sampled during the draining of Stewart Lake in 2015 than in previous years (n = 729 in 2014, n = 579 in 2013). Despite the smaller sample size, the mean total length of the 2015 Stewart Lake razorback sucker class at draining was 107 mm, 10 mm longer than the mean total length in 2014. Some possible explanations include reduced densities of drifting larvae related to the record breaking early date of larval first appearance, or increased predation on larval razorback suckers early in the inundation phase by the extremely high numbers of green sunfish documented in the system this year.

Escalante Ranch Larval light traps were deployed at this floodplain, but razorback sucker larvae were not detected. The existing burden of nonnative fishes in the floodplain likely explained the lack of collections.

Johnson Bottom NOTE: *The Cooperative Recovery Initiative renovation of Johnson Bottom was completed in time for spring flows in 2015. This renovation consisted of re-contouring portions of the wetland to facilitate draining, clearing canals, refurbishing the breech, and retrofitting the water control gate with a large bodied fish exclusion device.* The water control gate at Johnson Bottom was opened on May 11, in anticipation of the Flaming Gorge releases. Flows at the Ouray gage (13 miles downstream) at that time were approximately 10,000 cfs. Razorback sucker larvae were collected in the Johnson Bottom canal when the gate was opened and were collected in the wetland beginning May 19. On May 16, the uncontrolled breach began flooding at ~13,000 cfs at the Ouray gage. CRFP crews installed a net across the breach on May 13, in an attempt to reduce nonnative fish movement into the wetland. The net failed for a variety of reasons periodically, but was repaired daily. Adult carp entered the wetland through the breach. The gate was closed on May 22 because the floodplain pool had equilibrated with river stage - river flows were still over 14,000 cfs but declined soon thereafter. A mid-July sampling rotation yielded 115 age-0 razorback sucker, one age-1 Colorado pikeminnow, and four adult bonytail. Around mid-August, dissolved oxygen levels did approach zero for a few hours each night until photosynthesis increased during the day. There was no evidence of a fish kill during this time, and sampling at the end of summer (see below) yielded many fish of different species and sizes. Wetland water level / quality was freshened with an 8" river pump for 10 days between August 27 and September 11, which increased the wetland depth by six inches.

The wetland was drained starting on October 19. Slotted screens were installed in the drain gate, and the water was run through a fish kettle (easily sampled) before it entered the canal back to the river. During draining, crews captured 38 white sucker, two adult bonytail, one age-0 bluehead sucker (*Catostomus discobolus*), and one age-0 flannelmouth sucker. No razorback sucker or Colorado pikeminnow were captured, only one of the bonytail captured in July was collected during draining. The nonnative fish community was sub-sampled: 71% fathead minnow, 23% red shiner, 5% green sunfish, and small numbers (<1%) of white sucker, brook stickleback (*Culaea inconstans*), black bullhead and carp.

Water levels in the wetland dropped as low as 0.77 meter before pumping commenced. However, the collection of nonnative suckers (in a range of sizes) and other species when the wetland was drained suggests that summertime water quality issues may not have been the primary reason for poor razorback sucker survival. Pelicans and other piscivorous birds were observed at the wetland, sometimes in large numbers, throughout the summer.

LTSP Operations and Findings: 2016

In early May 2016, Reclamation and the Upper Colorado River Basin Forecast Center classified 2016 unregulated runoff into Flaming Gorge Reservoir in the average (below median); Yampa River runoff was categorized as average (above median). Precipitation during the month of May was above normal particularly upstream and Flaming Gorge Reservoir and contributed to extended full bypass releases. The Program detected the first RZB larvae on May 28 at Cliff Creek, when mean daily flow at Jensen, UT was 11,100 cfs and mean water temperature was 13.6°C (Jones et al. 2016). Reclamation began increasing Flaming Gorge releases on May 31, to a peak of around 9,000 cfs on June 9. Releases from Flaming Gorge remained at 8,600 cfs until June 29. The Green River at Jensen peaked at 20,500 cfs on June 1 after two smaller peaks of 15-16,000 cfs in mid-May. These smaller pulses likely began filling some wetlands before the detection of RZB larvae. Sites that were flooded included Escalante Ranch, Stewart Lake, Bonanza Bridge, Stirrup, Above Brennan, Johnson Bottom, Wyasket Lake, and Old Charley.

Argonne National Laboratory (funded by Western), and the Recovery Program surveyed Reach 2 levee breach elevations in Autumn 2012 and 2014 (LaGory et al. 2016a, 2016b) to better assess connection flows for LTSP experiments. Those data were available for FGTWG discussions in Spring 2016.

Stewart Lake (from Schelly et al. 2016) - UDWR crews began backfilling Stewart Larval through the outlet channel on 31 May 2016 after razorback sucker larvae were detected near the outlet gate. Larval light traps were deployed in the wetland from 1-13 June 2016, which resulted in relatively high captures of razorback sucker larvae. As in past years, significant effots was made to exclude large bodied fish from entering the wetland, including specific efforts to erect temporary blocking nets when river flows inundated two breaches along the Stewart Lake levee road. Both inlet and outlet gates were closed on the morning of 14 June 2016, upon achieving near-equilibrium (slight inflow) between river and wetland at the outlet gate and at both levee road breaches. This point represented a maximum wetland depth of 241 cm (7.9 ft) at the outlet gage (newly installed for this season), an above-capacity volume that, once the river dropped, slowly drained back over the breaches until 29 June 2016, on which date an at-capacity fill of 228.6 cm (7.5 ft) was observed.

For the second consecutive year, two Biomark flat plate antennas were deployed on 30 May 2016 in the outlet channel to detect any PIT-tagged fishes attempting to enter the wetland during filling. In 2016 the antennas detected 40 unique PIT tags, compared to 28 unique detections in 2015. Fishes detected attempting to enter the wetland in 2016 included a Colorado Pikeminnow (tagged in 2014) at least 27 razorback suckers (representing year classes from 2004 to 2011, and at least four bonytail stocked in 2016.

Similar to 2014 and 2015, a picket weir and trap box (with 1 cm wire mesh panels and seine attachments to prevent escapement) was installed in the outlet channel to capture fishes exiting the wetland. Wetland draining began on 19 September 2016, several weeks later than in previous years to allow for a full three months of growth by razorback suckers in the wetland. Draining was completed on 18 October 2016, after one month of continuous fish trap operation. The total estimated number of fishes trapped during 30 days of draining was 151,109 (comprising 2,172 natives and 148,937 nonnatives). A record number of YOY razorback suckers was sampled (n = 2,110, with n = 1,767 PIT tagged) This large cohort of wild-spawned razorback suckers emerged from a fish community in which green sunfish were still a major component, perhaps refuting our initial 2015 hypothesis that a green sunfish explosion might be partly responsible for low razorback sucker numbers that year. The mean total length of the 2016 Stewart Lake razorback sucker cohort was 103.3 mm, 6 mm longer than the mean total length in 2014, once again underscoring the importance of each additional week of inundation for maximum growth. Of note: a total of 18 age-1 Colorado pikeminnow, 17 of which were PIT-tagged and released to the river, and for the second consecutive year, hatchery-raised adult bonytail (n = 23) were captured during draining. Bonytail spawned in the wetland in early summer after it was disconnected from the river.

Johnson Bottom (for this wetland and the rest reported here see Jones et al. 2016) - Due to high forecasted flows, FWS crews did not attempt to block fish access from the river through the large, downstream breach, nor did they manage water through the much smaller control structure. As a result, Johnson Bottom was connected to the Green River from approximately May 9 (avg daily flow measured at Ouray, UT = 10,700 cfs) through June 29 (avg daily flow measured at Ouray, UT = 12,100 cfs). Fish sampling during the summer (see below) did not show evidence of RZB presence. FWS did not supplement water (pumping) during the summer, but water depth was still three feet by October.

Ouray national Fish Hatchery personnel released 1,041 bonytail ranging in length from 160-285mm (mean TL=226mm) at the wetland / river interface during the inundation period. Forty-two bonytail were recaptured in the wetland during the rest of the season.

Wetland draining commenced on October 6. Sampling involved pulling seines in the fish kettle, which is isolated between two water control gates. FWS also electrofished within the wetland on October 6, which yielded two adult bonytail. Later, from October 27 through November 2, 46 more bonytail from the fish kettle were collected, consisting of 41 adults and 5 young-of-year. For all 48 bonytail caught in autumn, stocking records indicate 39 of the 43 adults were stocked in May 2016. Two fish did not have tags, but were similar in size to other fish stocked in this group. Two additional fish had tags that were not from the 2016 stocking, and one could be traced back to a stocking event in September 2015 at the Ouray NFH boat ramp across the river. The other was a 370mm adult for which we currently do not have stocking information. The five young-of-year bonytail were confirmed by CSU-LFL based on morphological characteristics, and represent wild spawning within the wetland by stocked adults. The majority of fish captured at Johnson Bottom in autumn were nonnative species consisting of carp, black bullhead, fathead minnow, green sunfish, black crappie, white sucker, red shiner, brook stickleback, channel catfish, and Iowa darter.

Leota Bottom - FWS sampled Leota Bottom, units 7/7a, August 3-5 and Oct. 11-12. During the August sampling, a combination of fyke and baited hoop nets were used. October sampling consisted of only fyke nets. Although this site had wild razorback sucker juveniles in fall 2014 and spring 2015, no native fish were caught during sampling. In August, the fish community consisted of common carp, black bullhead, fathead minnow, green sunfish, white sucker, and channel catfish. Nonnative fish composition in October was 35% black bullhead, 35% fathead minnow, 20% carp, 8% green sunfish, and 2% black crappie.

Above Brennan - This site was first sampled on August 1-3 using baited hoop nets, fyke nets, and seines, which yielded one adult RZB and one adult bonytail. The RZB was stocked in September 2015 at Ouray National Wildlife Refuge. The bonytail was stocked at Rainbow Park in Dinosaur National Monument (59 miles upstream) in August 2015. Both were translocated to the Green River. The remainder of fish caught were nonnative species: black bullhead, red shiner, green sunfish, white sucker, fathead minnow, common carp, and crappie.

FWS returned to this wetland on Oct. 13-14 and sampled with fyke nets. This produced five adult RZB. One RZB was originally tagged in 1999 as a 485mm adult, and had not been encountered since. The other RZBs were stocked between 2013 and 2015. All fish were released in the Green River. Besides these native fish, the rest of the sampling collected 75% black bullhead, 10% crappie, 7.5% fathead minnow, 1.5% green sunfish, 1.5% common carp, 0.5% white sucker, 0.5% Iowa darter, and 0.5% red shiner.

Stirrup – FWS sampled Stirrup August 1-3 using seines, fyke nets, and baited hoop nets. The summer sampling yielded only nonnative fish, including predominantly YOY carp, green sunfish, fathead minnow, black bullhead, and red shiner. A second sampling using only large mesh fyke nets from October 13-14 produced 70% black bullhead, 20% carp, 5% green sunfish, 4% fathead minnow, and an equal proportion of red shiner and white sucker. No native fish were captured at the Stirrup.

Wetland draining commenced on October 6. Sampling involved [illegible] in the fish [illegible], which is isolated between two water control gates. FWS also [illegible] within the wetland on October 6, which yielded two adult Kanyard [illegible] from October 2 through November 2, [illegible] the [illegible] were collected, consisting of 41 adults and [illegible] (Total of 43 [illegible]) [illegible] stocking records indicate [illegible] of the 43 adults were stocked in May 2016, [illegible] but were similar in size to other fish stocked [illegible]. [illegible] from the 2016 stocking and [illegible] could be [illegible] stocked [illegible] October 2017 [illegible] (Gross/KFF) [illegible]. The [illegible] stocking information. The live young-of-year [illegible] morphological characteristics and [illegible] The majority of fish captured at Johnson Bottom in [illegible] were [illegible] of carp, [illegible] minnow, green sunfish, black crappie, white sucker, red shiner, [illegible] channel catfish, and Iowa darter.

Lewis Bottom - FWS sampled Lewis Bottom in August [illegible] and October [illegible]. During the August [illegible] October sampling [illegible] of only [illegible]. Although this [illegible] wild [illegible] stocked [illegible] in fall 2014 and spring 2015 [illegible] during sampling. In August, the fish [illegible] consisted of [illegible] minnow, green sunfish, white sucker, [illegible]. [illegible] October [illegible] and 2% black crappie.

Chow Bottom - [illegible] sampled in August [illegible] using [illegible] nets [illegible] RZB [illegible]. The RZB [illegible] September 2014 [illegible] Park in Oneida National [illegible] August 2015 [illegible] to the [illegible] River. The [illegible] consisted of [illegible] black bullhead, red shiner, green sunfish, white sucker, [illegible] minnow, [illegible] and crappie.

FWS [illegible] wetland [illegible] sampled with fyke nets. This [illegible] RZB [illegible] 1998 [illegible]. The other RZBs were stocked between [illegible] and 2015. All fish were released in the Green River. [illegible] the remaining [illegible] black bullheads [illegible] fathead minnow, 1.5% green sunfish, [illegible] carp, 0.5% white sucker, [illegible] Iowa darter, and 0.5% red shiner.

Stirrup - FWS sampled [illegible] August [illegible] using [illegible] nets and [illegible] nets. The summer sampling [illegible] nonnative fish, including predominantly YOY carp, green sunfish, fathead minnow, black bullhead, and red shiner. A second sampling [illegible] fyke nets from October [illegible] black bullhead, [illegible] green sunfish, [illegible] fathead minnow, and an equal proportion of red shiner and white sucker. [illegible] were captured at the Stirrup.