RECOVERY PROGRAM Recovery Program Project Number: _____
FY 2019-2023 SCOPE OF WORK for:
Green River physical habitat monitoring for experimental flows

Reclamation Agreement number: ____
Reclamation Agreement term: ____

Lead agency: National Park Service
Submitted by: Dusty Perkins

Dusty Perkins
National Park Service
Program Manager, Northern Colorado Plateau Network
Dusty_W_Perkins@NPS.gov
(970) 589-1474

Date Last Modified: 05/24/19

Category:
__ Ongoing project
__ Ongoing-revised project
_x_ Requested new project
__ Unsolicited proposal

Expected Funding Source:
__ Annual funds
__ Capital funds
__ Other *[explain]*

I. Title of Proposal: Green River Monitoring of vegetation and sediment resources in response to flow spike and base flow experiments

II. Relationship to RIPRAP:
General
I.A.4.b.(1). Periodically monitor future channel narrowing and compare to historic rates using aerial or satellite imagery in the Green River (between Yampa and White rivers) [*and other rivers*]
Green River
I. Provide and Protect Instream Flows (Habitat Management)
I.D. Develop Study Plans to Evaluate Flow Recommendations
I.D.2.c. Develop Study Plan to evaluate revised base flows and flow spike.
I.D.2.f. Evaluate effect of base flow variability on backwater maintenance and quality.

III. Study Background/Rationale and Hypotheses:

The Upper Colorado River Endangered Fish Recovery Program is proposing new experimental flow releases from Flaming Gorge Dam for (1) revised 'elevated' summer base flows to promote survival and recruitment of age-0 endangered Colorado pikeminnow (Bestgen and Hill 2016a), and (2) early summer flow spikes to disadvantage spawning invasive smallmouth bass (Bestgen and Hill 2016b, Bestgen 2018). The proposed revised base flows are higher than previous lowest base flows, and restrict the range of preferred base flows both overall, and within most hydrologic categories compared to the Muth et al. (2000) base flow recommendations (Figure 1).

These experimental flows are in addition to the Larval Trigger Study Plan (LTSP), which recommends experimental flows to benefit razorback sucker larval survival by timing peak dam releases with the presence of larvae, which generally occurs later than the peak of the Yampa River. That ongoing study, which began in 2012, may result in reduced magnitude peak flows below the Yampa River, because dam releases are not timed to coincide with the peak of the Yampa River, although the duration of the peak releases may be extended. Reduced peak flows and flow stabilization have contributed to channel narrowing and simplification since Flaming Gorge Dam was constructed. The flow spike and base flow experiments coupled with possible associated reductions in magnitude or duration of peak flows could exacerbate the long-term trend of flow stabilization on the Green River. Flow stabilization has led to proliferation of vegetation including invasive tamarisk along the channel and associated sediment deposition, channel narrowing and channel simplification (Friedman 2018 and citations therein). Also potentially contributing to changes in channel morphology, flow spikes could promote establishment of tamarisk due to its long seed production and germination window and disadvantage the recruitment of native cottonwoods that have a shorter seed production and germination period. Cottonwoods can outcompete tamarisk or at least hold their own when flows closely mimic a natural hydrograph. While both cottonwood and tamarisk seedlings would be scoured away in the zone below the peak of the spike, tamarisk may have greater opportunity to germinate new seedlings on the newly wetted surface due to their longer seed production period, which elevated base flows may allow to persist in dry years, if the seedlings don't dry out (Friedman, 2018). Also, any reduction in peak flow reduces the power of the river to scour sediment and vegetation and re-set the vegetation.

Channel narrowing and simplification threatens persistence and quality of backwater and side channel features needed by endangered fish. Use of high flows to remove unwanted vegetation is constrained by current operational guidance for Flaming Gorge Dam, which attempts to limit spills (i.e., releases greater than 8600 ft^3/s). Therefore, reversing vegetation encroachment with current peak flow maxima is more likely to succeed if implemented while plants are still small and vegetation is sparse. Peak flows in the range described in the 2006 ROD may be sufficient to remove new vegetation if they occur frequently enough, but a series of dry years such as experienced between 2000 and 2004 could allow vegetation to grow large enough to resist scouring. Low base flows in some low water years helps to prevent vegetation establishment by desiccating young plants that can't reach the water table. Elevated base flows in all low water years may not allow this desiccation to take place. However, permanently wetted areas below the elevated base flows will not allow vegetation establishment in that zone, so the zone of potential vegetation establishment is fairly narrow, above the elevated base flows. The proposed annual monitoring of near-channel vegetation and topography will focus on this sensitive zone at selected sites and attempt to describe changes in vegetation as they occur on an annual basis so that changes observed can be attributed to that year's flow. This would enable managers to prescribe a timely response in case the proposed flow experiments lead to vegetation encroachment and habitat degradation (Friedman 2018), or to determine if the proposed experiments have neutral or positive effects on habitat and channel morphology. For example, if results indicated that vegetation was encroaching, in subsequent years it might be more

important to make sure the two rivers combined resulted in a high peak flow than to peak the Green river based on the presence of larval fish. If there are multiple consecutive years where the elevated base flows are predicted to be similar in the upcoming year, it might be worth skipping a year of the elevated base flows for fish to ensure a different base flow that would make vegetation more likely to be scoured, drowned, or desiccated. Alternatively, if several consecutive years of stable elevated base flows are not resulting in vegetation encroachment or loss of backwater habitat, there would be no reason for the experiment not to proceed despite it being predicted to be a similar base flow as previous years.

The Recovery Program Biology Committee approved a flow spike study plan including the timing, magnitude and frequency of 'flow spikes' and the response of the fish community, primarily the targeted smallmouth bass (Bestgen 2018). A base flow study plan including timing, magnitude and frequency of flows and the response of the fish community, primarily Colorado pikeminnow larvae and juveniles, is expected to be finalized in 2019. A channel and vegetation monitoring study plan that can evaluate the physical effects of both flow spikes and revised summer base flows in the context of the present peak flow regime is needed to accompany these experiments. This SOW addresses the needed channel and vegetation monitoring.

Friedman (2018) reviewed and summarized the underlying theories and mechanisms leading to the potential for the experimental flows to lead to continued vegetation encroachment and channel simplification. He also recommended components of a monitoring plan that would track changes through time, potentially allowing for experimental flows to be revised, suspended, or halted if unacceptable impacts are observed. A workshop organized by NPS in April 2019 gleaned additional input on recommended monitoring strategies from various subject matter experts, including technical experts in channel morphology, sediment transport, and riparian vegetation. We recognize that it may be difficult to separate the effects of the flow experiments from ongoing channel simplification, however published research in the Colorado River basin shows that stabilization of flows results in vegetation encroachment. Therefore we think it is warranted to conduct monitoring that is intended to identify if flow related mechanisms lead to vegetation establishment which in turn leads to channel simplification.

The NPS Northern Colorado Plateau Network (NCPN) implemented a monitoring program to track channel and vegetation changes in Dinosaur National Monument (NM) in 2010 and in Canyonlands National Park in 2014 (Perkins et al. 2018). We propose supplementing data collection at those existing monitoring sites and using similar methods outside NPS lands in areas where critical nursery habitat for Colorado pikeminnow occurs.

IV. Study Goals, Objectives, End Product(s):

Goals

1. Establish channel vegetation and channel condition monitoring sites at selected locations
2. Detect changes in channel vegetation and channel form that may lead to simplified channel morphology and degrade backwater habitat from baseflow experiments and any potential reduction in peak flows in Dinosaur NM, and in known areas of Colorado pikeminnow nursery habitat below the Yampa River confluence
3. Determine if flow spike experimental flows are altering the recruitment rates of woody vegetation (cottonwood and tamarisk) in Dinosaur NM.

Objectives

1. Develop monitoring plan
2. Determine thresholds for unacceptable change to river channel characteristics and endangered fish habitat while still considering potential beneficial effects on endangered fish populations
3. Identify potential mitigation strategies, offsetting measures, and experiment cessation points if thresholds are met and a positive fish response is not observed.
4. Implement annual monitoring to evaluate changes to vegetation and channel characteristics
5. Evaluate monitoring data annually and meet with decision-makers to develop recommendations for the prescribed flows, adjustments in experimental flow management, or other measures, which may address concerns about vegetative encroachment, channel simplification, or habitat loss.

End Products

1. Database of measurements
2. Annual reports by due date set by the Recovery Program (mid-November) summarizing results and recommending potential adjustments in experimental flows if needed
3. Periodic summary reports as needed (e.g. after 3 or more consecutive years of similar hydrology and base flows) describing changes in vegetation and channel form at the monitoring sites, evaluating the likely causes, and identifying potential mitigation strategies, offsetting measures, and experiment cessation points if thresholds are met and a positive fish response is not observed

V. Study Area: Three reaches of the Green River from upstream boundary of Dinosaur NM, downstream to confluence with Colorado River in Canyonlands NP. NPS will continue funding for existing monitoring in Dinosaur NM and Canyonlands NP. This SOW addresses additional monitoring to be added in the Dinosaur NM, and the Jensen to Ouray Reach.

1. Dinosaur NM is monitored by NPS (NCPN) as part of on-going "Big-River Program." Dinosaur NM will be the sole focus of measuring the effects of the flow spikes on cottonwood and tamarisk generation, and will be monitored as well for changes resulting from the experimental summer baseflows.

2. Jensen to Ouray – Three to five new sites to be established in this Colorado pikeminnow nursery habitat area. These sites will be used to evaluate the experimental summer base flows and any potential changes in peak flows.
3. Canyonlands NP is monitored by NPS/NCPN as part of on-going Big-River Program. These existing sites will be used to evaluate responses to the experimental flow management and any potential changes in peak flows.

VI. Study Methods/Approach:

A number of direct and indirect metrics may be used to assess changes in channel width and form and the processes that affect these features. Over time, channel width and form are a function of streamflow, sediment supply and transport, and riparian vegetation, and these factors should be measured and monitored to evaluate the processes that may result in changes. The conversion of active-channel surfaces to less active, more stable surfaces is a hallmark of channel narrowing (Graf 2006), often intimately related to the establishment of riparian vegetation. Direct measures of channel narrowing often involve repeated topographic surveys at permanently located channel and floodplain cross-sections over time. Such direct measures can provide detailed and temporally rich information on localized channel change, but often are spatially limited, making it difficult to infer change at larger spatial scales (Moody et al. 1999, Allred and Schmidt 1999). Annual aerial photographs can provide an indirect but spatially integrated quantification of channel change over larger areas as it relates to annual flows, but aerial photography is generally collected with low temporal resolution to provide a more detailed interpretation of floodplain formation and related channel narrowing (Graf 1978, Merritt 1997, Grippo 2017) and can be cost-prohibitive. Some combination of fine- and coarse-scale analyses of channel narrowing can provide a more robust interpretation (Manners et al. 2011, Dean and Schmidt 2011). The NPS Northern Colorado Plateau Network (NCPN) focused its 'Big River' monitoring efforts on hydrologic, geomorphic, and vegetation changes because these provide strong, robust, measurable indications of the channel-narrowing process, and combined both fine and coarse-scaled analyses. Other aridland riparian methods were reviewed, evaluated, and determined to not be of sufficient rigor or repeatable by NCPN. Due to the extensive lengths of rivers in remote settings within NCPN parks and the limited resources available for monitoring, we sought to focus most of our effort on detailed annual monitoring at a select number of sites (sentinel sites) that we hypothesize are sensitive to potential changes in streamflow.

Revised Base Flow Monitoring

Complete channel and floodplain cross-sections with bathymetry are probably the optimal method for measuring geomorphic changes along a river. However, the costs in labor or equipment are cost-prohibitive for these experiments. This proposed geomorphic monitoring will occur at low flow. This allows us to survey 75–90% of the channel, only avoiding the deepest sections due to safety, so complete bathymetry will not be collected. While under optimal conditions we would survey complete cross-sections of the channel and floodplain, we anticipate that changes in the deeper parts of the channel due to river incision (or the progressive disconnection from the floodplain) will be evident on the banks, where we will

sample.

The NCPN sampling protocol outlines a process for establishing long-term sample sites called sentinel sites. Each sentinel site consists of a significant habitat feature such as a side channel or backwater, and surrounding topography and vegetation. Measurements of vegetation, hydrologic, and physical drivers are co-located at each sentinel site and monitored concurrently. The size of a sentinel site is dependent on geomorphic features affected by the river's peak and annual flow, and the constraints (canyons) that allow or restrict the river channel's movement. Currently NCPN has 9 sentinel sites in Dinosaur National Monument (6 on the Green River and 3 on the Yampa) and 9 sites at Canyonlands National Park (6 on the Green and three on the Colorado). The existing sentinel sites on NPS lands were not chosen at random. They were chosen based on logistics, safety, presence of legacy data, significant park resources, and sensitivity to fluvial geomorphic change and subsequent channel narrowing. New sample sites outside of park lands in riverine nursery habitat areas will be chosen with similar criteria, including persistent presence of Colorado pikeminnow nursery habitat backwaters and sidechannels. Annual sampling allows us to detect the effects of annual flows, sediment supply, and other factors within one year after they occur. Sampling of vegetation and geomorphology occurs during summer baseflow, after vegetation has reached peak growth (July– September). Surface water depths will be continuously monitored with transducers at all sites. Information from the transducers will be collected once each year during the physical monitoring trips.

We propose to select 3 to 5 new sites in the Jensen to Ouray reach, and establish baseline and ongoing monitoring of channel features and vegetation including backwater nursery habitat at those sites. At each site, several transects will be established and repeat surveys will take place annually. Survey plots ($1m^2$) will be established along the transects similarly to how sites were established in Canyonlands NP (Perkins et al. 2018), with a focus on establishing the plots at elevations most likely to be affected by the experimental flows. At each plot, total and individual species percent cover area will be determined, as well as sediment grain size. Each plot will also be surveyed with RTK to determine elevation. Air and water transducers will be permanently located to aid in determining the number of days per year of inundation on each plot. A thorough description of methods to establish the transects and survey plots, data collection and storage, and analysis is given in Perkins et al. (2018).

Efforts will be made to select sites that have an existing history of channel morphology, vegetation, and/or habitat monitoring, in order to maximize the value of gathering new information at these locations. Examples of sites that may be selected for this effort in the Jensen-to-Ouray reach of the Green River are shown in Figures 2 through 5. Figure 2 shows sites recently studied as part of a CPM nursery habitat study from 2009 to 2012 (Breen and Jones, 2019) against a background of imagery taken in 2015 (from Google Earth). Not all backwaters were available annually during that study, and not all will be available in 2019 and beyond, as sandbar features move, erode and deposit anew. Final site selection will be done on the first monitoring trip and by consulting historic imagery prior to the trip. During the trip, personnel will also census all available YOY pikeminnow habitat identified by a fish biologist. All habitat will then be photographed, GPS location of the habitat and photo location recorded, and a rapid assessment done so that in future years, observers can determine if these sites are being lost due to vegetation encroachment, and whether the experimental flows are contributing to that change. The new and existing sites will be monitored annually to evaluate

changes in vegetation and channel charactistics that include effects of base flows. The site specific surveys are intended to provide early detection of vegetation encroachment, allowing for timely action to reverse or mitigate the effects on channel complexity and habitat quality.

Repeated digital analysis of historic and more recent aerial photography has revealed channel narrowing and simplification occurring in the Green River over several decades (Grippo 2017, Manners et al. 2011). Comparison with future aerial imagery will allow us to track changes in the future as well, at fairly fine resolution, and perhaps determine if channel simplification continues, ceases, or reverses. A NASA/NPS partnership has developed codes for using remote satellite imagery to track these changes as well. Currently the finest resolution for this method is $100m^2$, which is a coarser-scale analysis than will allow for early detection of vegetation establishment on recently deposited sand surfaces. However, it can show river-wide changes. Worldview satellite may be added in the future, improving resolution to 33 cm making this application useful on a shorter time scale.

For this SOW we propose to partner with the USGS in the use drone technology to capture fine scale imagery of areas including and adjacent to the sentinel sites to capture changes at a larger scale than the transect sites. Chris Holmquist-Johnson of USGS, Fort Collins has the necessary expertise to capture and analyze the imagery to distinguish between bare sand, water, and vegetation, and evaluate changes in sizes, area, and distribution of age 0 CPM habitat. This effort would ideally be conducted annually in conjunction with the physical monitoring trips, but data could be collected periodically (every 3 to 5 years) if funding is not available annually.

We will also pursue the use of WorldView Satellite Imagery. The USGS can request to task these satellites every year within a specified time window of one month free of charge to cover the necessary area. The WorldView product includes panchromatic imagery at a resolution of 33 cm, which is superior to the 1-m resolution of NAIP that had been used in the past by Grippo (2017) for monitoring backwaters. The WorldView product also includes 8-band multispectral imagery at 1 m resolution that could be used to calculate NDVI (Normalized Difference Vegetation Index). This would provide a straightforward annual measurement of vegetation encroachment at the scale of a long reach. Furthermore, for most years NAIP imagery collected during the base-flow period is not available, while the WorldView can be tasked during base flows, which is essential for matching field data to remote sensing data at similar flows.

Flow Spike Monitoring

The primary concern of the flow spike is that it could promote the germination and establishment of non-native tamarisk on bare sand areas at the expense of cottonwoods that have a shorter germination period. The flow spike, which would likely be implemented between late June and the end of July in years where conditions are favorable, is outside of the window for cottonwood germination so it could potentially remove new cottonwood seedlings and allow for new germination sites for tamarisk. In low flow years, this is likely less of an issue as next year's peak flow will likely scour any new seedlings of cottonwood or tamarisk. However if there are multiple low peak flow years and a stabilization of base flows over a number of years, there is the potential for tamarisk to establish and grow larger and then be

able to resist scour from higher peak flows. Conversely, the relatively rapid fall in stage associated with the proposed flow spikes may inhibit the establishment of new vegetation at the affected bank elevations. The primary area of concern for the flow spike is Dinosaur National Monument as we think the effects of the spike flow will attenuate and be minimized farther downstream.

We propose an additional monitoring trip occur after the spring peak but before the spike flow. This pre-spike trip should occur as close to the flow spike as logistics allow. This trip will focus on existing sites at Brown's Park, Echo Park, and Island Park. Additional sites may be needed. At existing sites we will focus on the $1m^2$ plots established at the targeted elevations inundated by discharges between the base flow and approximately 5600 cfs (slightly above the flow spike peak). Crews will only be seeking to collect census data on woody tree species tamarisk and cottonwood. The post-spike flow trip will occur at the same time as the existing base flow monitoring occurs (at the expense of NPS) to evaluate survival and mortality of woody species after the flow spike.

Adaptive Management

An adaptive framework will be developed with the Program Director's office and program partners, Bureau of Land Management (BLM) and the Ouray National Wildlife Refuge that includes measures of success or failure for the fish community, vegetation, and channel morphology. Thresholds should be established that allow the flow experiments to be evaluated both annually and on a longer term basis. Based on these evaluations, NPS will work with the other program partners to recommend adjustments to the proposed flow experiments if needed, and/or other measures as appropriate to address concerns about vegetative encroachment, channel simplification, and habitat loss. NPS will meet with the members of the Flaming Gorge Technical Workgroup (including U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and Western Area Power Administration) to discuss these recommendations. .

Summary of monitoring methods and schedule

<u>Flow spike monitoring</u>

a. Pre-spike survey of cottonwood and tamarisk germination sites: June (dependent on hydrology, post-peak, pre-spike, should be as close to spike as logistics allow). Locations should include Brown's Park, Echo Park, and Island/Rainbow Park at a minimum. Additional sites TBD,
b. Post-spike survey of cottonwood survival – in conjunction with annual NCPN trips (funded by NPS) that will also monitor base flow sampling trips in July/August

<u>Revised base flow monitoring</u>

a. Established NPS monitoring sites will be sampled on current schedule in late July/August (funded by NPS). New monitoring sites will be integrated into the NPS schedule in August or September. Five new sites will be located in the Jensen to Ouray reach as recommended by as this area is known to be important nursery habitat for Colorado pikeminnow (Bestgen 2016a,b). New sites will be selected based on persistent presence of side channels and backwater habitat suitable as nursery habitat for Colorado pikeminnow YOY and potential sensitivity to channel narrowing, as

well as ease of access (secondarily). These methods will primarily detect changes in channel width and simplification which likely correlates to important changes in backwaters. Due to the ephemeral nature of many of these backwaters, we will seek out more persistent sites by analyzing historical images. For an overall assessment it is crucial that this be coupled with an assessment from imagery acquired at low water.

b. In addition to the new sentinel sites, we will do a count or "census" of backwater fish habitats in the Jensen to Ouray Reach that are quick assessments as we travel down the river. A GPS point will be recorded for each habitat. If the sites selected for monitoring are not persistent within or among years, new sites will be chosen near to previous sites if possible, to maintain the same number of sites.

c. High-resolution remote sensing data (natural color and possibly multispectral) will be acquired annually during base flow conditions using drones at each of the sentinel sites, and 'worldview' satellite imagery will be requested at the reach scale level. The high-resolution imagery (sub meter) will be used to assess both local and reach scale channel/habitat change over time. Ideally this would be acquired annually as funding allows, or a minimum of every 3 to 5 years.

VII. Task Description and Schedule:

Task 1. Convene expert group to review draft monitoring plan and develop adaptive management framework (no funding requested)
Task 2. Finalize monitoring plan (no funding requested)
Task 3. Pre-flow spike treatment monitoring trip
Task 4. Group development and finalization of adaptive management plan
Task 5. Post flow spike and baseline base flows monitoring trip
Task 6. Annual report and assessment of impacts
Task 7. Three-year summary report
Task 8. Collect drone imagery

FY19-20	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1			x									
Task 2				X								
Task 3						x						
Task 4				X	X	x	X	x	x	x	x	x
Task 5								x	x			
Task 6											x	
Task 7												
Task 8												

FY20-21	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1												
Task 2												
Task 3						x						
Task 4												
Task 5								x	x			
Task 6											x	
Task 7												
Task 8								x	x			

FY21-22	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1												
Task 2												
Task 3						x						
Task 4												
Task 5								x	x			
Task 6											x	
Task 7												
Task 8								x	x			

FY22-23	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1												
Task 2												
Task 3						x						
Task 4												
Task 5								x	x			
Task 6											x	
Task 7												x
Task 8								x	x			

FY23-24	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1												
Task 2												
Task 3						x						
Task 4												
Task 5								x	x			
Task 6											x	
Task 7												
Task 8								x	x			

VIII. Deliverables, Due Dates, and Budget by Fiscal Year:
FY19 Annual Report due Nov 30, 2019 Pre-study monitoring and site selection

FY20 Annual Report due Nov 30, 2020
FY21 Annual Report due Nov 30, 2021
FY22 Annual Report due Nov 30, 2022
FY23 Annual Report due Nov 30, 2023, Three Year summary report due Dec, 2023
FY24 Annual Report due Nov 30, 2024

IX. Budget Summary:

Cost-Sharing for this project includes $130,000 of internal NPS funding to continue existing monitoring within NPS managed lands, as well as additional staff time to crew the monitoring trips.

Requested funding:
National Park Service – Dusty Perkins, NCPN

Project Name:	Green River physical habitat monitoring for experimental flows					
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
Enter the BEGINNING dates for each year ------>	10/1/2019	9/30/2020	10/1/2021	10/1/2022	10/1/2023	
	Through	Through	Through	Through	Through	
Enter the ENDING dates for each year ------->	9/29/2020	9/30/2021	9/30/2022	9/30/2023	9/29/2024	
DIRECT LABOR AND FRINGE BENEFIT COSTS:	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
Direct Labor - Hourly	$ 27,562.80	$ 25,916.98	$ 31,141.04	$ 26,964.02	$ 31,699.89	$ 143,284.73
Fringe Benefits - Hourly	$ 6,531.64	$ 6,047.09	$ 7,458.75	$ 6,291.39	$ 7,578.28	$ 33,907.16
Subtotal of Direct Labor & Fringe Benefits:	**$ 34,094.44**	**$ 31,964.07**	**$ 38,599.80**	**$ 33,255.41**	**$ 39,278.17**	**$ 177,191.89**
OTHER DIRECT COSTS:	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
Materials and Supplies	$ 13,200.00	$ 5,508.00	$ 5,645.70	$ 5,815.07	$ 6,018.60	$ 36,187.37
Travel Costs	$ 5,577.00	$ 4,700.00	$ 5,597.00	$ 4,700.00	$ 5,597.00	$ 26,171.00
Equipment	$ 24,000.00	$ -	$ -	$ -	$ -	$ 24,000.00
Contractors	$ -	$ -	$ -	$ -	$ -	$ -
Subtotal of Other Direct Costs:	**$ 42,777.00**	**$ 10,208.00**	**$ 11,242.70**	**$ 10,515.07**	**$ 11,615.60**	**$ 86,358.37**
INDIRECT/OVERHEAD COSTS:	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
Subtotal of Labor and Other Direct Costs:	**$ 76,871.44**	**$ 42,172.07**	**$ 49,842.50**	**$ 43,770.48**	**$ 50,893.77**	
Total dollars exempt from indirect/overhead base:	$ 5,000.00	$ 5,100.00	$ 5,200.00	$ 5,300.00	$ 5,400.00	
<Enter Description of Indirect/OH Cost #1>	**** $ -	**** $ -	**** $ -	**** $ -	**** $ -	$ -
Total dollars exempt from indirect/overhead base:	$ -	$ -	$ -	$ -	$ -	
<Enter Description of Indirect/OH Cost #2>	**** $ -	**** $ -	**** $ -	**** $ -	**** $ -	$ -
Subtotal of Indirect/Overhead Costs:	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
GRAND TOTAL:	**$ 76,871.44**	**$ 42,172.07**	**$ 49,842.50**	**$ 43,770.48**	**$ 50,893.77**	**$ 263,550.26**

USGS – Chris Holmquist-Johnson

Project Name: Green River physical habitat monitoring for experimental flows

		YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		TOTAL
Enter the BEGINNING dates for each year ------>		10/1/2019		9/30/2020		10/1/2021		10/1/2022		10/1/2023		
		Through		Through		Through		Through		Through		
Enter the ENDING dates for each year ------->		9/29/2020		9/30/2021		9/30/2022		9/30/2023		9/29/2024		
DIRECT LABOR AND FRINGE BENEFIT COSTS:		YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		TOTAL
Direct Labor - Hourly		$ 33,486.80		$ 36,365.45		$ 33,515.86		$ 35,536.46		$ 33,492.62		$ 172,397.19
Fringe Benefits - Hourly		$ 11,720.38		$ 12,727.91		$ 11,730.55		$ 12,437.76		$ 11,722.42		$ 60,339.01
Subtotal of Direct Labor & Fringe Benefits:		$ 45,207.18		$ 49,093.35		$ 45,246.41		$ 47,974.22		$ 45,215.03		$ 232,736.20
OTHER DIRECT COSTS:		YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		TOTAL
Materials and Supplies		$ 3,500.00		$ 2,500.00		$ 3,500.00		$ 2,500.00		$ 3,500.00		$ 15,500.00
Travel Costs		$ 3,891.00		$ 3,891.00		$ 3,891.00		$ 3,891.00		$ 3,891.00		$ 19,455.00
Equipment		$ 2,000.00		$ -		$ 2,000.00		$ -		$ 2,000.00		$ 6,000.00
Contractors		$ -		$ -		$ -		$ -		$ -		$ -
Subtotal of Other Direct Costs:		$ 9,391.00		$ 6,391.00		$ 9,391.00		$ 6,391.00		$ 9,391.00		$ 40,955.00
INDIRECT/OVERHEAD COSTS:		YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		TOTAL
Subtotal of Labor and Other Direct Costs:		$ 54,598.18		$ 55,484.35		$ 54,637.41		$ 54,365.22		$ 54,606.03		
Total dollars exempt from indirect/overhead base:												
<Enter Description of Indirect/OH Cost #1>	####	$ 18,929.19	####	$ 19,236.43	####	$ 18,942.79	####	$ 18,848.42	####	$ 18,931.91		$ 94,888.74
Total dollars exempt from indirect/overhead base:		$ -		$ -		$ -		$ -		$ -		
<Enter Description of Indirect/OH Cost #2>		$ -	####	$ -	####	$ -	####	$ -	####	$ -		$ -
Subtotal of Indirect/Overhead Costs:		$ 18,929.19		$ 19,236.43		$ 18,942.79		$ 18,848.42		$ 18,931.91		$ 94,888.74
		YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		TOTAL
GRAND TOTAL:		$ 73,527.37		$ 74,720.78		$ 73,580.20		$ 73,213.64		$ 73,537.94		$ 368,579.94

X. Reviewers: *[For new projects or ongoing-revised projects, list name, affiliation, phone, and address of people who have reviewed this proposal.]*

Melissa Trammell
National Park Service
Melissa_trammell@NPS.gov
970-244-3034

Jonathan Friedman
US Geological Survey
3215 Marine Street, Suite E127
Boulder, CO 80303
303-541-3017
Friedmandj@usgs.gov

XI. References:

Allred, T. M., and J.C. Schmidt. 1999. Channel narrowing by vertical accretion along the Green River near Green River, Utah. Geological Society of America Bulletin 111:1757–1772.

Bestgen, K. R., and A. A. Hill. 2016a. Reproduction, abundance, and recruitment dynamics of young Colorado pikeminnow in the Green River Basin, Utah and Colorado, 1979-2012. Final report to the Upper Colorado River Endangered Fish Recovery Program, Project FW BW-Synth, Denver, CO. Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins. Larval Fish Laboratory Contribution 183.

Bestgen, K. R., and A. A. Hill. 2016b. River regulation affects reproduction, early growth, and suppression strategies for invasive smallmouth bass in the upper Colorado River basin. Final report to the Upper Colorado River Endangered Fish Recovery Program, Project FR-115, Denver, CO. Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins. Larval Fish Laboratory Contribution 187.

Bestgen, K.R. 2018. Smallmouth bass flow spike study plan: evaluate effects of flow and water temperature shifts to disrupt reproduction and recruitment of smallmouth bass in the Green River downstream of Flaming Gorge Dam. Report to the Upper Colorado River Recovery Program.

Breen, M. J., and T.M. Jones. 2018. Assessment of Larval Colorado pikeminnow presence and survival in low velocity habtats in the middle Green River: 2009-2012. Draft Final report to the Upper Colorado River Endangered Fish Recovery Program, Project 158, Denver, CO.

Dean, D. J., and J. C. Schmidt. 2011. The role of feedback mechanisms in historic channel changes of the lower Rio Grande in the Big Bend region. Geomorphology 126:333–349.

Friedman, J. M. 2018. Potential effects of elevated base flow and midsummer spike flow experiments on riparian vegetation along the Green River. Natural Resource Report NPS/NRSS/WRD/NRR-20181603. National Park Service. Fort Collins, Colorado.

Graf, W. L. 1978. Fluvial adjustments to the spread of tamarisk in the Colorado Plateau region. Geological Society of America Bulletin 89:1491–1501.

Graf. W. L. 2006. Downstream hydrologic and geomorphic effects of large dams on American rivers. Geomorphology 79: 336–360.

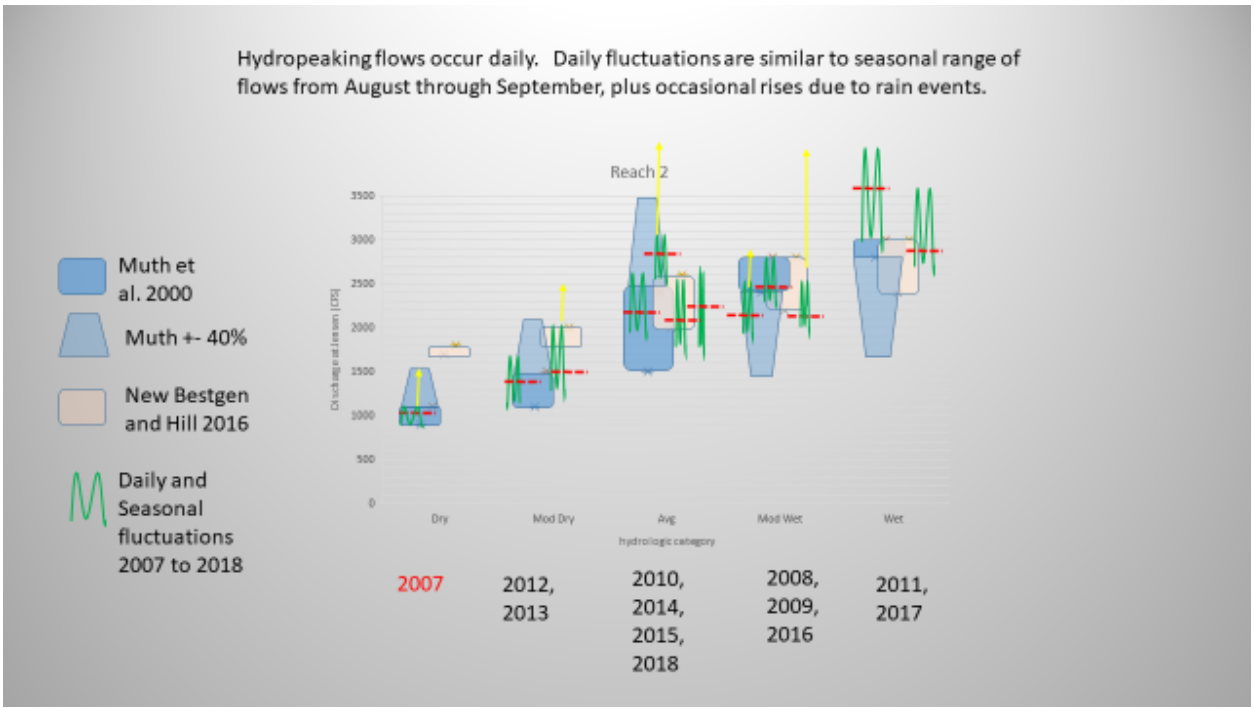
Grippo, M., K.E. LaGory, D. Waterman, J.W. Hayse, L.J. Walston, C.C. Weber, A.K. Magnusson, and X.H. Jiang. 2017. Relationships between Flow and the Physical Characteristics of Colorado Pikeminnow Backwater Nursery Habitats in the Middle Green River, Utah**.** Argonne National Laborary Report, 29 p.

Manners, R. B, J. C. Schmidt, M. L. Scott, J. A. Scott, and C. M. U. Neale. 2011. Investigate floodplain processes and riparian ecosystem linkages on the Yampa River and on the middle Green River in Dinosaur National Monument, Moffatt County, Colorado, and Uintah County, Utah. Final Report for Dinosaur National Monument Cooperative Agreement # H1200-004-0002.

Merritt, D. M. 1997. Riparian vegetation and geomorphic features on regulated and unregulated rivers: Green and Yampa, northwest Colorado. Master's thesis, Colorado State University, Fort Collins. 65 p.

Moody, J. A., J. E. Pizzuto, and R. H. Meade. 1999. Ontogeny of a floodplain. Geological Society of America Bulletin 111:291–303.

Perkins, D. W., M. Scott, G. Auble, M. Wondzell, C. Holmquist-Johnson, E. Wahlig, H. Thomas, and A. Wight. 2018. Big rivers monitoring protocol for park units in the Northern Colorado Plateau Network: Version 1.01. Natural Resource Report NPS/NCPN/NRR— 2018/1707. National Park Service, Fort Collins, Colorado.



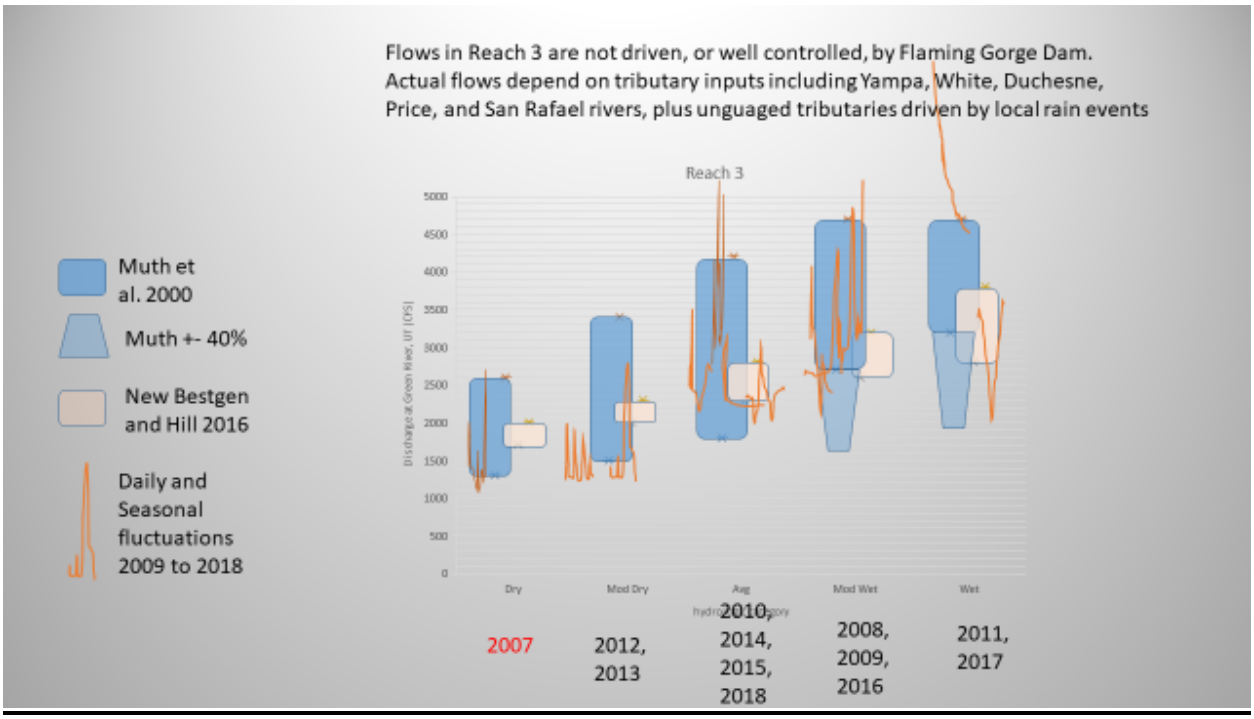


Figure 1. Old (Muth et al. 2000) and new proposed (Bestgen and Hill 2016) base flow recommendations for Reaches 2 and 3, in the Green River, UT. Also shown are the range of the +-40% of flows based on Muth et al. 2000 and ROD in the categories when that additional range of flows may be used to meet the revised recommendations, and the ranges of daily and seasonal fluctuations that have occurred during August and September for the most recent 10 years by hydrologic category. Red dashed lines in Reach 2 indicate mean August to September flows for each year from 2007 to 2018. Reach 2 fluctuations are primarily driven by load-following hydropeaking, and Reach 3 fluctuations are representations of the actual hydrographs from August through September in each year.

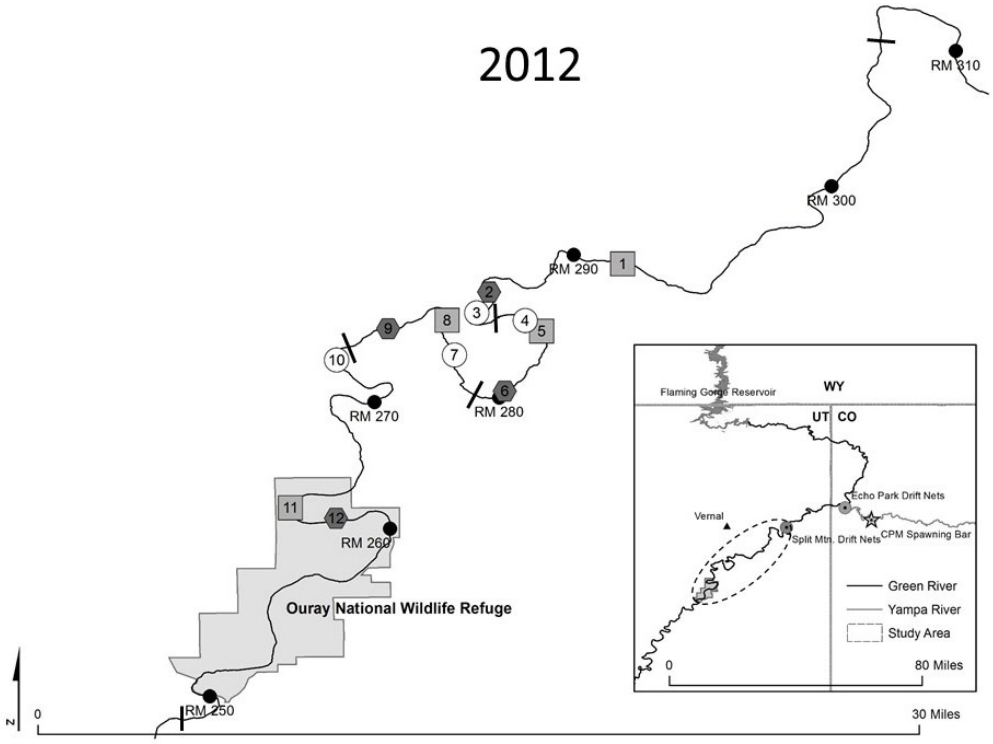


Figure 2. Sample sites shown for Colorado pikeminnow nursery habitat sampled in 2012 from Recovery Program project #158, Figure 3 (Breen and Jones 2018 draft).

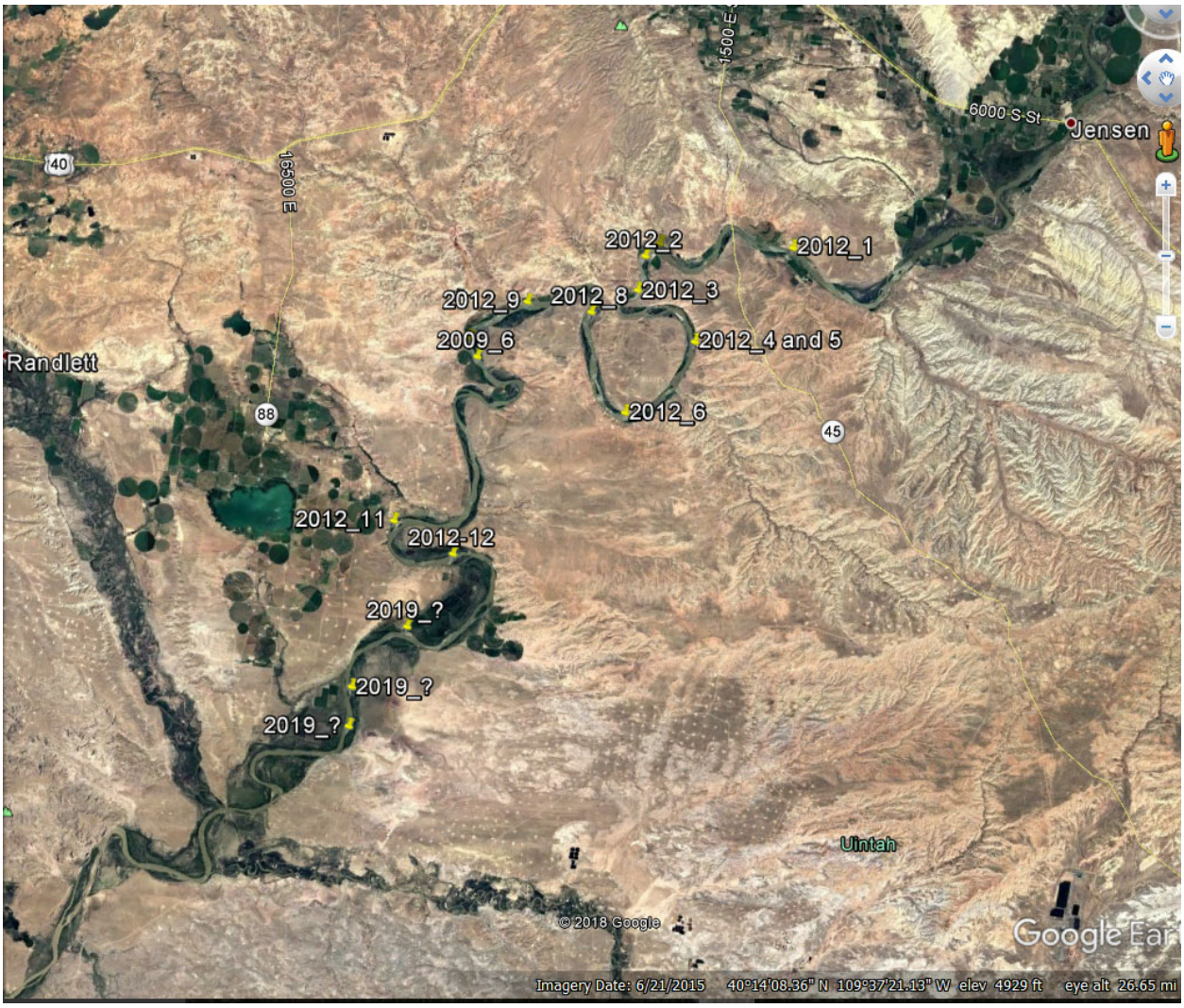


Figure 3. Sites labeled 2012_x and 2009_x were sampled as part of project 158 (Breen, draft 2018) for Colorado pikeminnow nursery habitat study. Those sites, plus sites labeled 2019_? are also potential sites for NCPN monitoring. Image is taken from Google Earth, June 21, 2015 imagery (most recent imagery) at approximately 6700 cfs (USGS gage 09261000 near Jensen, UT).

Figure 4. Close up of area with potential Colorado pikeminnow nursery habitat experimental backwaters (Breen and Jones 2018 draft) on BLM land below Jensen, UT.

Figure 5. Closeup of potential Colorado pikeminnow experimental backwaters on Ouray NWR lands