PROPOSAL

Project Title: Madison River Sediment Mobility Evaluation—Using Flushing Flows to Improve Spawning Habitat

Date: November 2, 2020

Applicability to Project 2188 License Article(s)
This project meets the purposes and intents of Article 419, which requires the coordination and monitoring of flushing flows on the Madison River below Hebgen Dam.

Priority Justification:
Priority 1: 2188 License projects which meet License Article requirements and PM&E for fisheries or wildlife populations or their habitats within the main stem Madison River (Hebgen Reservoir to Three Forks) or Missouri River (Hauser Reservoir to Fort Peck Reservoir).

This project is a ***Priority 1*** effort that evaluates flushing flow relationships to sediment movement and spawning gravel habitats on the mainstem Madison River.

Project Sponsor (submitted by):
Jordan Tollefson and Jon Hanson, NorthWestern Energy

Location of Proposed Project:
Madison River from Quake Lake to Greycliff Fishing Access

TAC Funds (Cost-Share) Requested for Project: $99,570

I. Introduction: Brief statement of project to be completed with pertinent background information

The primary objectives of this proposed study are to assess how flushing flows on the Madison River relate to sediment movement and to use that information to build on current efforts to improve mainstem spawning habitats.

In September 2000, the United States Federal Energy Regulatory Commission (FERC) issued a new license to PPL Montana for the Missouri-Madison Hydroelectric project. This Project No 2188 license regulates nine hydroelectric facilities on the Missouri and Madison Rivers in central Montana. Article 419 of the new license required PPL Montana to file a plan to coordinate and monitor flushing flows in the upper Madison River downstream of Hebgen Dam. The license originally issued to PPL Montana is now owned by NorthWestern Energy (NWE). R2 Resource Consultants prepared a plan in 2003 to coordinate and monitor flushing flows in consultation with agencies (R2, 2018). The plan called for collecting substrate core samples every year, and additional geomorphic and macroinvertebrate data every five years. Data were analyzed and results reviewed to determine flushing flow needs.

The flushing flow currently calls for up to 3,500 cfs at the Kirby gage for a minimum of 3 days in years when both runoff volume forecasts and Hebgen storage triggers are met (NWE, 2016). The flushing flow is restricted to a maximum discharge of 3,500 cfs at Kirby Ranch (USGS #06038800) to limit erosion of the outlet from Quake Lake. Rates of change in flow releases are limited to <10% per day. Since 2003 the 3,500 cfs flow has been exceeded four times at Kirby Ranch (Table 1). The duration of mean daily flow exceedances of 3,500 cfs ranges from 2 days in spring 2020 to seven days in both 2008 and 2011. Flushing flows were not released between 2011 and 2017 due to construction activities at Hebgen Dam.

Table 1. Recorded flows exceeding 3,500 cfs at the Kirby Ranch Gage since 2003.

Date	**Peak Q (cfs)**	**# of days 3,500 cfs exceeded (mean daily flow)**
Sep. 02, 2008	3,680	7 (Sept 2- Sept 8)
June 24, 2011	4,050	7 (June 19-25)
May 27, 2018	3,680	4 (May 26-29)
June 6, 2020*	Not available	2 (June 6-7)

*as of 10/12/2020

In 2018, R2 Resource Consultants summarized data collected between 2013 and 2017 and compared those results to previous data collected from 1994 to 2012 (R2, 2018). Data available for evaluation included:

- **Redd Surveys** - performed in the spring and fall at Kirby Ranch, Ennis Campground, Norris Bridge, and Greycliff Fishing Access.
- **Macroinvertebrate Samples** - collected every summer at Yellowstone National Park, Hebgen Dam, Kirby Ranch, Ennis Campground, Madison Powerhouse, Norris Bridge, and Greycliff Fishing Access.
- **McNeil Gravel Samples** - collected in the fall at Kirby Ranch, Ennis Campground, Norris Bridge, and Greycliff Fishing Access.
- **Scour Chains** - installed in 2014 at Ennis Campground, Norris Bridge, and Greycliff Fishing Access.
- **River Cross-Section Surveys -** performed in 2015 at Kirby Ranch, Ennis Campground, Norris Bridge, and Greycliff Fishing Access.

The monitoring results indicated that, at the upper river sites (Kirby Ranch and Ennis), sediment characteristics are generally good with low concentrations of fine sediment in gravels (R2, 2018). The lower river sites (Norris Bridge and Greycliff Fishing Access) showed higher concentrations of fine sediments in the gravels. Aquatic macroinvertebrate data support the sediment results.

Repeat cross section surveys show little change in channel form between 1995 and 2015. In 2018 NWE proposed the discontinuation of those cross section surveys due to the lack of evidence of any channel change as well as challenges with maintaining survey controls and limiting river access during the survey events.

The data comparison at the four monitoring sites showed the following:

- Net change in streambed elevation of less than 0.1 ft at most transects.
- No measurable scour or fill at scour chains since 2014 (Ennis, Norris Bridge, Greycliff).
- Increasing percent fines and embeddedness at the lower river sites since 2002.
- Longitudinal increase in sediment tolerant macroinvertebrate taxa between Kirby (upper river) and Greycliff (lower river).
- A higher quality of spawning gravels in the upper river versus lower river.

More recently, FWP and NWE conducted additional monitoring to evaluate sediment mobility on the river. The intent of this effort was to evaluate the effects of a flushing flow in depositional areas, side channels, and near local scour elements (e.g. boulders). This monitoring focused on four sites including Pine Butte, Varney, Norris Bridge, and Greycliff Fishing Access. The 2019 MadTAC monitoring report also describes sediment sampling results from these known spawning areas. Conditions in the upper river were determined to be relatively stable with little change in sediment deposition. Fine sediment concentrations are consistently higher in the lower river below Ennis Lake (Lohrenz and others, 2019).

II. Objectives; explicit statement(s) of what is intended to be accomplished

The primary objectives of this proposed study are to assess how flushing flows on the Madison River relate to sediment movement and to use that information to build on current efforts to improve mainstem spawning habitats. Some of the questions posed for the evaluation include the following:

1. What is the current availability or potential supply of suitable spawning substrate in various reaches?
2. How does the current flow regime relate to reach-scale sediment transport capacity and storage patterns? What discharge is needed to mobilize different substrate sizes (D5 to D90) under existing channel dimensions?
3. What is the potential to increase the quality and extent of suitable spawning habitat using the following strategies?
    a. flushing flow hydrograph modifications,
    b. channel dimension manipulation (i.e., narrowing or island construction), and
    c. installation of features that induce scour and/or deposition (boulders, wood, etc.).

III. Methods; description of how Project objectives will be accomplished

The purpose of the flushing flows is to maintain and enhance spawning and rearing potential in the Madison River. FWP indicated that a flushing flow "must be large enough to mobilize streambed materials and produce scour in some locations and deposition in other locations" (Moser and Lohrenz, 2017). To that end, this project will evaluate the potential of flushing flows to meet FERC licensing conditions based on the current flushing flow release protocol, sediment availability, sediment transport and river geomorphology. Once these relationships are characterized, the contractor will consider how alterations in the flushing flow hydrograph, channel morphology, and/or concentration of local scour elements may maintain and improve spawning and rearing conditions in the river.

The project tasks will include a broad assessment of sediment recruitment and storage patterns on the river followed by a more detailed analysis of sediment transport conditions within the four monitoring segments established by FWP. These segments are described in Attachment A.

Task 1: Assess the current availability or potential supply of suitable spawning substrate in various reaches

With Hebgen, Ennis, and Quake lakes serving as coarse sediment traps, there is some question as to the locations and nature of spawning gravel sources to the river below Quake Lake. This task consists of a coarse assessment of likely sources of spawning substrates to the river between Quake Lake and Greycliff Fishing Access Site. Sources may include banks, islands, tributaries etc. This task should include a remote mapping task followed by a field inventory of the locations, patterns, and coarse grain sizes of depositional features on the river.

1. Remotely map depositional features and bank erosion sites on aerial imagery from the Quake Lake outlet to Greycliff Fishing Access Site. Flushing flows can be bracketed using imagery from 2005, 2009, 2013, and 2019*. Evaluate spatial and temporal trends of sediment recruitment and deposition.
2. Perform a field verification and further characterization of depositional features and active erosion sites on the main channel and at tributary mouths between Quake Lake and Greycliff Fishing Access Site; document sediment gradations via field photos.
3. In each of the four FWP monitoring reaches, collect four pebble counts that reflect:
    a. Coarse bed substrate (two pebble counts)
    b. Mobile gravels in depositional features (two pebble counts)
2. In each of the four FWP monitoring reaches, generally characterize the role of boulders, wood, and islands in driving local scour of pools and deposition of spawning gravels. Develop coarse size classes for each feature type and, for each class, provide a ratio comparing the number of features creating visible scour to non-scouring elements. Similarly develop ratios for gravel deposition.
4. Generate coarse maps showing gravel sourcing and storage patterns.

***Note: Digitized banklines are available from Varney Bridge to Three Forks for 2013 and 2015. They can be downloaded from the state library site:**
http://geoinfo.msl.mt.gov/data/montana_channel_migration_zones/projects/madison_river.aspx

Task 2: Evaluate how the current flow regime relates to reach-scale sediment transport capacity and storage patterns

With field evidence of erosion/depositional patterns complete, Task 2 is intended to assess hydraulic conditions and sediment mobility at four sites currently monitored by FWP for spawning. These results will then be used to evaluate any potential correlations between calculated sediment mobility and observed sediment sourcing and storage patterns.

1. Identify locations in each FWP monitoring reach to capture morphologic variability (e.g. narrow, wide, simple single thread, simple island, complex island). Provide NWE and FWP with three (3) proposed cross section sites in each monitoring reach for approval.
2. Survey the streambed sufficiently to capture three cross section/slope examples showing morphologic variability. Note that LiDAR data are available for each FWP monitoring reach (See Montana LiDAR Inventory on the Montana State Library Website).
3. Evaluate sediment mobility at each site using pebble count gradations and survey data. The transport assessment should be based on general incipient mobility techniques. Estimate the flow needed to mobilize different substrate sizes (D5 to D90) under existing channel conditions.
4. Develop shear stress rating curves to determine the duration of particle mobility during flushing flows (D16, D50, D84, and D90). Describe any apparent correlations between sediment mobility analyses and observed sediment storage patterns to determine if reaches can be described in terms of overall sourcing/transport/storage.

Task 3: Evaluate the potential to increase the quantity of suitable spawning habitat via flushing flows, alteration of channel morphology, and installation of disturbance-inducing restoration elements.

1. Flushing flows – Evaluate threshold flows for mobilization of key particle gradations at each site. Consider durations of particle size mobilization and assess whether aspects of current flushing flow protocols (ramping rates, total flow) could be altered to improve overall sediment mobilization.
2. Channel dimension manipulation (i.e., island construction)—re-run analyses with incremental approaches to channel narrowing and island construction to determine impact on sediment transport.
3. Installation of features that induce scour and/or deposition (boulders, wood, etc.)—use field indicators of disturbance-generating stream elements to empirically evaluate the potential benefit of these elements to sediment mobility.

Task 4: Summarize Results

Based on the results generated, describe how current flushing flow hydrographs may or may not be expected to maintain or improve spawning and rearing habitats with existing channel morphologies. Provide recommendations for a modified morphologic and/or hydrologic scenario to optimize the value of flushing flow events for spawning and rearing habitats.

IV. Schedule: The project will commence in February 2021 and be completed by October 15, 2021.

V. Personnel; who will do the work? Identify Project leader or principal investigator.

The project will be put out to bid as required by procurement procedures.

VI. Project budget must include amounts for the following:

Senior Engineer: 74 Hours at $150	$11,100
Sediment Transport Engineer: 234 Hours at $130	$30,420
Senior Geomorphologist: 198 Hours at $120	$23,760
GIS Analyst/Surveyor: 132 Hours at $110	$14,520
Digitizing: 30 hours at $70	$2,100
Per Diem and travel:	$2,970

Total Cost: $99,570

Category	Total
Personnel	$96,600
Travel/Per Diem	$2,970
Total	$99,570

VII. Deliverables; describe work product (reports, habitat restoration, etc.) which will result from this Project. How will "success" for this project be monitored or demonstrated?

The deliverable report will provide an analytical and field-correlated assessment of relationships between current flushing flow protocols, channel morphology, substrate, and sediment mobility in several select reaches of the Madison River. Additional analyses will be included to consider potential modifications to the flushing flow hydrographs, channel morphology, and local scour elements to substantially improve spawning habitats within FWP four monitoring reaches. Project success will be demonstrated through subsequent implementation and monitoring of project recommendations.

VIII. Cultural Resources. Cultural Resource Management (CRM) requirements for any activity related to this Project must be completed and documented to NWE as a condition of any TAC grant. TAC funds may not be used for any land-disturbing activity, or the modification, renovation, or removal of any buildings or structures until the CRM consultation process has been completed. Agency applicants must submit a copy of the proposed project to a designated Cultural Resource Specialist for their agency. Private parties or non-governmental organizations are encouraged to submit a copy of their proposed project to a CRM consultant they may have employed. Private parties and nongovernmental organizations may also contact the NWE representative for further information or assistance. Applications submitted without this section completed, will be held by the TAC, without any action, until the information has been submitted.

Summarize here how you will complete requirements for Cultural Resource Management:
Not Applicable

IX. Water Rights. For projects that involve development, restoration or enhancement of wetlands, please describe how the project will comply with the Montana DNRC's "Guidance for Landowners and Practitioners Engaged in Stream and Wetland Restoration Activities", issued by the Water Resources Division on 9March2016.

Summarize here how you will comply with Montana water rights laws, policies, and guidelines:
Not Applicable

REFERENCES

Lohrenz, T., N. Larson, and M. Duncan, 2019. Montana Fish Wildlife and Parks 2019 Madison River Drainage 2188 Monitoring Report: Report prepared for NorthWestern Energy Environmental Division, Butte, MT., 90p.

Moser, D. and T. Lohrenz, 2017. Madison River Drainage Fisheries and Madison River Drainage Aquatic Native Species Conservation and Restoration Program: 2017 Annual Report to NorthWestern Energy Environmental Division, 58p.

R2 Resource Consultants Inc., 2018. Flushing Flow Needs in the Madison River, Montana 2013 through 2017 – Streambed and Aquatic Invertebrate Monitoring Results and Comparison with Results from 1994 through 2012, FERC Project 2188 Article 419 of Project 2188 License, Report Prepared for NorthWestern Energy, Feb 22, 2018, 140p.

Attachment A: FWP Monitoring Segments

Site (Length)	Location	Latitude	Longitude
Pine Butte (3.3 miles)			
	Upper	44.86511	-111.5557
	Lower	44.89847	-111.5913
Varney (4.9 miles)			
	Upper	45.23273	-111.7515
	Lower	45.29577	-111.7557
Norris (4.2 miles)			
	Upper	45.5844	-111.5928
	Lower	45.62024	-111.5541
Greycliff (6,400 ft)			
	Upper	45.71735	-111.5179
	Lower	45.73297	-111.5177

Pine Butte Monitoring Reach

The Pine Butte Reach is in the Upper Madison Valley at Kirby Ranch. It is relatively steep and coarse grained. Small islands exist in this reach, and bed sediment ranges from clearly mobile gravel concentrations to coarse, largely immoble boulder/cobble bed.

Figure 1. Pine Butte Monitoring Reach.

Figure 2. Gravel bar at downstream end of small island, Pine Butte Reach.

Figure 3. Small islands in Pine Butte Reach showing some geomorphic variability in channel cross sections and depositional features.

Varney Monitoring Reach

The Varney site consists largely of a multi-thread mosaic of channels across a broad floodplain.

Figure 4. Varney Monitoring Reach

Figure 5. View downstream of anabranching channel form in Varney Reach (Kestrel Aerial Services).

Norris Monitoring Reach

The Norris site extends downstream from the Warm Springs Fishing Access. The channel is notably wide and lacking in geomorphic diversity.

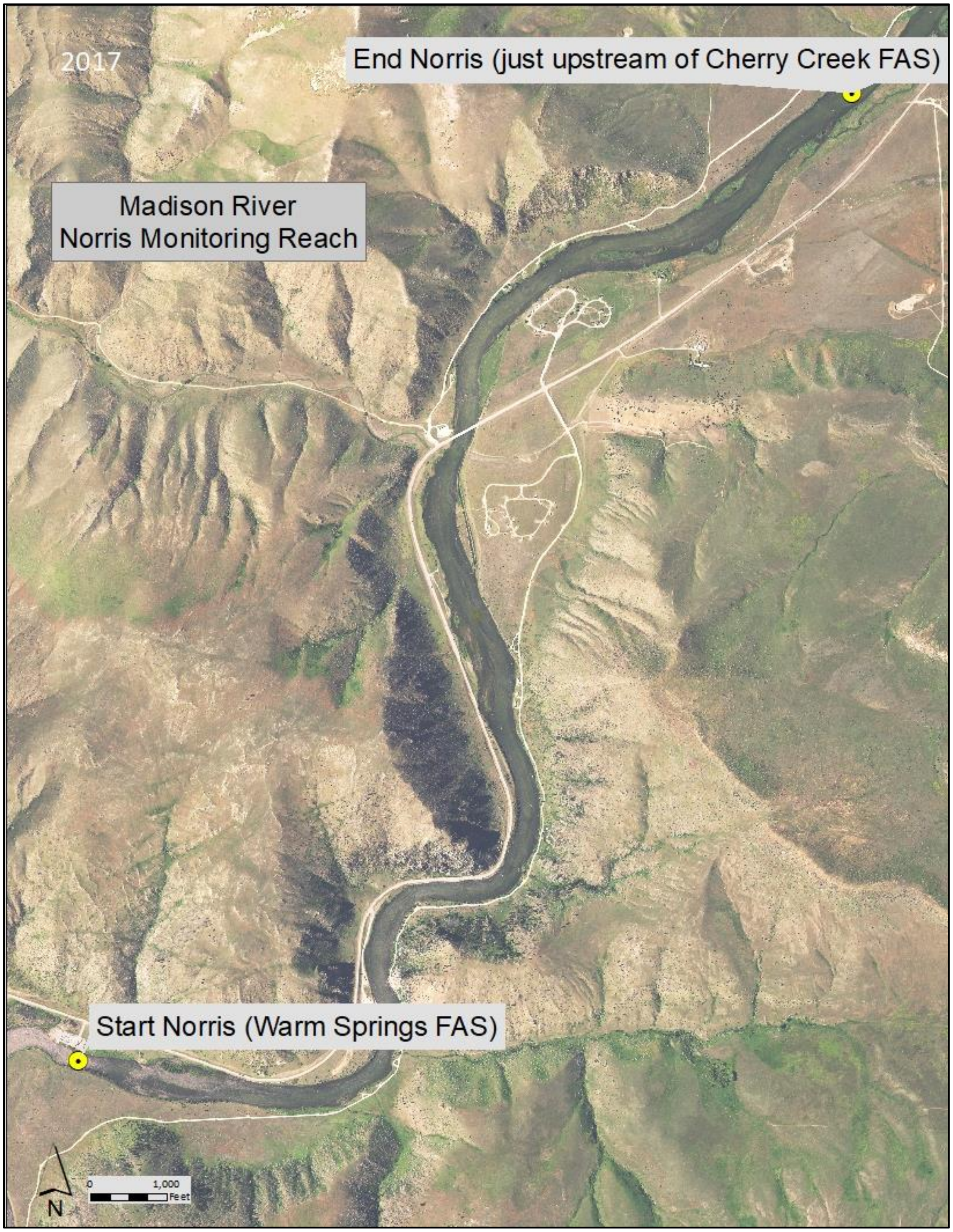

Figure 6. Norris Monitoring Reach.

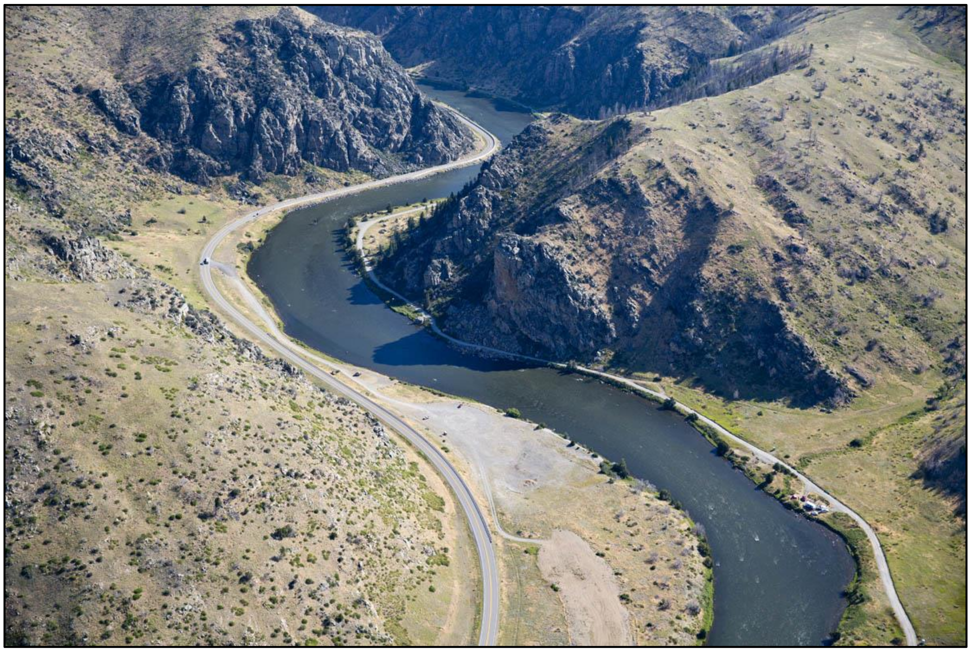

Figure 7. View downstream of Norris Monitoring Reach (Kestrel Aerial Services).

Figure 8. View downstream of small island in Norris Monitoring Reach; spawning in this area is common.

Greycliff Monitoring Reach

The Greycliff Monitoring Reach is less confined than the Norris Reach upstream and supports a complex mosaic of side channels.

Figure 9. Greycliff Monitoring Reach.

Figure 10. View downstream of Greycliff Monitoring Reach showing complex channel planform.