Independent Scientific Review Panel
for the Northwest Power & Conservation Council
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Memorandum (2022-7) **December 21, 2022**

To: Guy Norman, Chair, Northwest Power and Conservation Council

From: Stan Gregory, ISRP Chair

Subject: ISRP Follow-up Review of MFWP Response for Libby Dam Mitigation Project's Fertilization Facility (Project #1995-004-00)

Background

At the Northwest Power and Conservation Council's request of November 1, 2022, the ISRP reviewed a response submittal from Montana Fish, Wildlife and Parks (MFWP), regarding the nutrient fertilization component of Project #1995-004-00*, Libby Reservoir Mitigation Restoration and Research, Monitoring and Evaluation (RM&E)*. MFWP proposes nutrient fertilization in the Kootenai River directly downstream of Libby Dam in Montana. The response submittal is intended to address the last of five conditions placed on the project, by the Council, as part of the *Resident Fish and Sturgeon Project Review* in October 2020. The Council recommended: *"Manager to respond to ISRP conditions in a report no later than March 31, 2021."* The specific conditions, based on the ISRP's review (ISRP 2020-8), requested responses to the five conditions raised in the project review. In March 2021, MFWP provided a response to the five conditions, and in June 2021 the ISRP provided its review (ISRP 2021-5).

The ISRP found the 2021 submittal from MFWP to be comprehensive and detailed in providing information regarding the project's efforts. The ISRP's review stated that the project "partially meets conditions" regarding the response to the five conditions. The MFWP response satisfied conditions concerning desired future conditions, justification for the limited spatial scope of some activities, climate and land use change, and donor stock selection. However, the ISRP found that the condition was not met concerning the proposed nutrient fertilization facility. Although the ISRP appreciated the additional detail provided on the proposed fertilization and acknowledged that the activity may be important for restoring rainbow trout production and controlling *D. geminata*, the ISRP stated that numerous aspects required additional information and discussion. Consequently, the ISRP asked MFWP to prepare a separate document for the fertilization experiment that addresses a list of 16 concerns (outlined below) and provides a long-term implementation plan for the construction, operation, and costs of the facility and associated activities.

In response to the ISRP's review, the Council asked MFWP to address the final condition regarding nutrient fertilization. The Council staff provided this additional context on the condition:

> In staff discussions with MFWP the information regarding the experimental 5-year pilot nutrient addition component and effort (i.e., the condition regarding the nutrient facility) is dependent on collaboration and coordination with the Action Agencies, especially the US

ACOE [Army Corps of Engineers] as it is an effort identified under the Terms and Conditions in the USFWS's 2020 Biological Opinion. Based on this understanding, MFWP needs to continue planning and coordinating with the Action Agencies in planning and evaluating the feasibility of this nutrient facility as a mitigation measure. These coordination efforts will be necessary to produce an implementation plan by March 31, 2022, to address the needed information requested.

MFWP's submittal to address this final Council and ISRP condition includes the following documents:

- Point-by-point Responses to ISRP on the Nutrient fertilization facility
- Responses Appendix A: *Design Specifications for the Kootenai River Nutrient Addition Facility downstream of Libby Dam.*
- *"Implementation Plan for a 5-Year Nutrient Addition Project on the Kootenai River, Montana"*
- *"Best Management Plan For the Proposed Kootenai River Nutrient Addition Experiment Downstream of Libby Dam"*

In our review below, we provide our final recommendation, responses to MFWP's responses to our 16 issues, and comments on their *Implementation Plan* and *Best Management Plan*. We also make a few additional suggestions for the proponents to consider.

ISRP Recommendation

Meets Scientific Review Criteria

The ISRP's 2021 Condition asked the proponents to prepare a separate document for the fertilization experiment. This document was to address the concerns outlined below as well as provide a long-term plan for the construction, operation, and costs of the facility and associated activities (i.e., prepare a separate project implementation plan).

We conclude the revised documents and responses meet conditions. Both the Implementation Plan and the Management Plan are detailed and responsive to ISRP reviews. Procedures outlined in the revised documents and summary responses "Meet" conditions indicated by the ISRP in previous reviews. MFWP's summary responses are concise, considerate, and either adopt recommendations or propose reasonable alternatives that balance cost, scope, and the opportunities that the P-addition experiment offers to deepen understanding of biotic interactions in this system.

While no follow-up comments are required, the ISRP has some lingering questions and concerns about this project. We present these as recommendations throughout the response review and encourage the proponents to consider them as they progress with this project.

ISRP Comments on the MFWP Response for Fertilization Facility Plan

Point-by-Point Review Dialogue: ISRP 2021 Comments, MFWP 2022 Response, ISRP 2022 Response

Condition 4. Nutrient fertilization facility

Specific ISRP Concerns:

1. ISRP 2021-5 Comment: The engineering/physical aspects are not described in the response or in the original proposal. There are possible issues with mixing added nutrients (laminar vs turbulent flow, and the density of nutrient addition water relative to river water) and physical substrate surfaces (armored cobble/bedrock below dam vs cobble farther downstream) that require consideration. A basic description of the facility and the approach to avoid mixing issues would be helpful.

MFWP 2022 Response: MFWP has prepared a Best Management Plan for the nutrient addition facility. This document describes the facility location, specifications and associated infrastructure and equipment required to deliver the ammonium polyphosphate product to the Kootenai River.

The concept of nutrient addition to the Montana portion of the Kootenai River is a larger regional discussion that extends beyond the NPCC's project review process. The US Fish and Wildlife Service has identified nutrient addition as part of the Terms and Conditions listed in the US FWS 2020 Biological Opinion for the Columbia River System Operation and Maintenance of 14 Federal Dams and Reservoirs (US FWS 2020). As a result, the federal action agencies have agreed to collaborate with MFWP to meet these requirements. The agreement between MFWP and the federal action agencies stipulates that the ACOE will complete the detailed engineering design specifications and construction of the nutrient facility including the building and associated infrastructure required to deliver the nutrient product to the Kootenai River, and MFWP will operate the facility and conduct effectiveness monitoring during the 5-year experiment. The US ACOE is currently working on finalizing the design specifications for the nutrient addition facility. Appendix A (separate PDF file) contains draft preliminary design drawings completed by US ACOE.

ISRP 2022 Response:
The response is sufficient. The Best Management Plan (BMP) and the Appendix of design specifications describe in sufficient detail the facility and how nutrients will be mixed and pumped to the river. The proponents did not address in detail how mixing concerns and adequacy of mixing might be addressed in the study. Instead, the proponents simply state that turbulence created by these pilings will facilitate mixing within the river. Although it is reasonable to assume the pilings will do so, the ISRP encourages the proponents to rigorously evaluate the adequacy of mixing in the early phases of the study.

2. ISRP 2021-5 Comment: While the proponents provide adequate justification that most P is trapped behind Libby Dam, there was no evidence demonstrating that rainbow trout growth increased in response to P-fertilization in Idaho (Watkins et al. 2017), even though there was a positive response in other fish species. However, in the Montana portion of the Kootenai River, Dunnigan and Terrazas

(2021) recently demonstrated a positive relationship between the N:P ratio and mark-recapture based growth rates of rainbow trout. Their results provide strong support for hypothesizing that increasing P in the Kootenai River would reduce *D. geminata*, increase benthic invertebrates, and ultimately increase rainbow trout growth.

MFWP 2022 Response: No response required.

3. ISRP 2021-5 Comment: The proponents use dosing recommendations from the Wilhelm et al. (2018) pilot study to establish a 1.0 microgram/L dose for Jan-May. However, it is not clear where the 1.4-3.7 microgram/L dose for June-Sept came from. Please clarify.

MFWP 2022 Response: MFWP has provided additional clarification describing the methodologies used to determine the June-Sept dose rates in the appended Implementation Plan (see pages 13-16).

ISRP 2022 Response:
The response is sufficient. The proponents report that the summer dosing was calculated to achieve in 80% of years a target phosphorus concentration required for a specific increase in rainbow trout growth, based on a model from Dunnigan and Terrazas (2021). The dosing rates are detailed in Table 4 and on p. 15-16 of the Implementation Plan.

4. ISRP 2021-5 Comment: Rigorous and timely analysis of nutrient concentrations and associated water quality parameters are essential to conduct the fertilization successfully and to meet fundamental water quality permit requirements. It would be desirable to obtain and review results within one week of sampling, and anything longer than a week would be inadequate for the study design and for promptly assessing environmental risks. Near real-time information on nutrient concentrations can be used in adjusting nutrient concentrations and ensuring compliance. Having timely P concentrations could be accomplished by contracting with a certified analytical laboratory, one that can guarantee the necessary turnaround time on samples, or by developing an on-site analytical capacity. The ISRP acknowledges that developing an analytical laboratory on site initially would be expensive and time consuming, yet it could be cost effective over the long term and could be an analytical contracting laboratory resource for others in the region. The ISRP would like the proponents to identify their preference for an analytical strategy, and to inform us as to how quickly will it allow nutrient concentrations to be evaluated after sampling.

MFWP 2022 Response: MFWP has a multi-year contract with the University of Montana Freshwater Research Laboratory located at the Flathead Lake Biological Station in Polson, MT for the analysis of water quality samples for the proposed experiment. This facility is located within 1.5 hours driving distance from Libby which eliminates the need for overnight shipping of samples. This laboratory has an excellent performance track record with sufficient detection limits for all analytes (see page 38 of the Implementation Plan). MFWP receives sample results within 2-3 weeks after sample delivery to the laboratory.

MFWP has met several times with MT DEQ over the past several months to discuss permitting requirements for the proposed experiment which has resulted in an agreement related to permitting, compliance and adaptive management requirements for the experiment needed to minimize the environmental risk of eutrophication. MT DEQ has never established nutrient-based water quality standards for the Montana portion of the Kootenai River. The State of Montana recently repealed numeric water quality standards and reverted back to narrative water quality standards on all State waters. As part of this politically charged transition back to narrative water quality standards, MT DEQ has proposed benthic algal metrics as threshold indicators of excessive nutrient pollution (Suplee et al. 2009 and Suplee and Watson 2013) (see Implementation Plan Table 15; page 43) which in addition to the water quality data will be the compliance metrics for the discharge permitting requirements for this experiment. The MT DEQ review process of these compliance metrics is explained in the adaptive management section of the Implementation Plan (see pages 45-46). MT DEQ considered several factors to determine the appropriate adaptive management review process and the likelihood of excessive eutrophication as a result of this experiment including the relatively low historic total phosphorus concentrations of the Kootenai River downstream of Libby Dam, the proposed dose rates for the experiment and the frequent calibration checks on equipment/pump proposed for product delivery (see Best Management Plan p. 18).

ISRP 2022 Response:
The response is sufficient. The proponents developed an agreement with MT DEQ about requirements for this experiment, to avoid excessive eutrophication. The proponents considered reasonable alternatives to measure water quality and nutrients given constraints and are using laboratory analysis. Although the 2- to 3-week turnaround for lab results is longer than the ISRP recommended (1 week turnaround), the proponents have developed a cost-effective and reliable option compared to on-site and remote alternatives.

As the ISRP understands it, the water quality monitoring appears to be a once daily check of discharge (in the morning). Given that discharge from Libby Dam can oscillate broadly within a day or during the night (as evident from the Kootenai River Libby Dam USGS website), we encourage MFWP to consider within-day corrections to dosage. Daily oscillations might be biologically meaningful in terms of short-term dosage concentration. Perhaps these changes in dam operations can be anticipated (i.e., coordinated with dam operators) and incorporated in the daily release of the fertilizer.

5. ISRP 2021-5 Comment: The ISRP also believes that it would be advisable to collect a synoptic longitudinal series at many locations to accurately identify the longitudinal pattern of P and N concentrations. Such synoptic sampling should occur at least at the start, middle, and end of the fertilization period. The P additions will be increasing uptake capacity over the fertilization period and knowing the spatial patterns of P uptake and P concentrations will be essential for understanding the outcomes.

MFWP 2022 Response: MFWP acknowledges the importance of increased spatial and temporal water quality sampling (relative our original proposal reviewed by the ISRP) required to adequately implement and evaluate this experiment. We have accordingly revised the proposal to include expanded longitudinal and temporal components of water quality monitoring that is described within the appended Implementation Plan (pages 36-43; with special reference to Table 15 for a synoptic overview of spatial and temporal monitoring proposed).

ISRP 2022 Response:

The response is sufficient. The extensive monitoring of 6 water quality parameters as well as 7 periphyton measures and the density and biomass of benthic invertebrates at 12 sites ranging up to 60 km downstream from the nutrient addition site, typically at least every month, is suitable to address this ISRP comment. The ISRP found Figure 9 and Table 15 helpful for evaluating spatial and temporal sampling.

6. ISRP 2021-5 Comment: The proponents argue against using N:P ratios as a criterion for adjusting fertilization rates. It is well accepted that the N:P ratio may be more important than the absolute concentrations of P in structuring the periphyton community. As well, Dunnigan and Terrazas (2021) show that the N:P ratio was one of two top predictors of rainbow trout growth and argue that the N:P ratio is a better way of assessing changes in P given detection problems for SRP. The ISRP would appreciate a better justification for using P concentrations rather than the N:P ratio for the nutrient experiment.

MFWP 2022 Response: Balancing total nitrogen to total phosphorus ratios to near optimal ratios (~20-30 molar ratios) is not realistic because it would require large quantities of phosphorus (see Table 10; Implementation Plan). During our discussions with MT DEQ for the permitting requirements for this project, MT DEQ indicated they would not permit concentrations required to achieve optimal ratios and indicated a preference for the methods in the current proposal. MFWP and MT DEQ's preference for the current dosing strategy is largely based on the proof of concept demonstrated by the 17-year long effort on the Idaho portion of the Kootenai River which uses a very similar approach (3 ug/L total phosphorus above ambient during June-Sept.) as our proposal.

MFWP will complete a retrospective analysis at the conclusion of this experiment to evaluate if phosphorus or nitrogen to phosphorus ratios are better predictors the periphyton metrics proposed (see Implementation Plan Table 15). The results of these analyses will be considered if and when nutrient addition continues beyond the proposed experiment.

ISRP 2022 Response:

The response is sufficient. The proponents argue (p. 16 of Implementation Plan) that achieving an optimal N:P ratio would require adding large amounts of P, as well as variable dosing over time and real-time water quality sampling, none of which are practical for this project. Instead, their analysis of past data and a predictive model to estimate the dose of P in winter needed to decrease growth of *D. geminata*, and the dose in summer needed to increase rainbow trout growth to a specific threshold, appears suitable. Because it seems likely the data would be available anyway, both absolute values of P and N:P ratios should be included in report results.

[Note: on p. 13 the proponents state that they used the average coverage by *D. geminata* from the past (2011-2018) to estimate P needed to achieve the target for rainbow trout growth. If so, would this underestimate trout growth, given that the coverage of *Didymosphenia* will likely be reduced by the P treatment?]

7. ISRP 2021-5 Comment: There is no mention of monitoring for co-limitation from other micronutrients (e.g., silica, iron, molybdenum, chromium, and others). With the addition of P, do other micronutrients quickly become limiting to the point of suppressing periphyton growth? This may be an important consideration before launching an expensive multiyear experiment. The project should evaluate the concentrations of potential micronutrients and other studies that have documented co-limitation of primary production to determine the potential likelihood of co-limitation.

MFWP 2022 Response: MFWP does not propose additional monitoring to evaluate potential co-limitation of other micronutrients because we think the likelihood of such limitation is low for the phosphorus concentrations proposed for this experiment. We base this assumption of the following. The Kootenai River periphyton community is generally dominated by diatoms which is the group of periphyton that have also exhibited a commensurate response to nutrient addition in the Idaho portion of the Kootenai River (Hoyle et al. 2014; Gidley et al. 2017; Hoyle 2020) that uses summer phosphorus dosing strategy and concentrations that are very similar to this proposed experiment. Furthermore, Coyle (2016) conducted replicated pilot experiments that manipulated phosphorus concentrations in experimental troughs using Kootenai River water taken directly below Libby Dam and demonstrated a positive algal response that included suppression of *D. geminata* and an increase in other diatom species at phosphorus concentrations similar to those we proposed for this experiment.

MFWP agrees that micronutrients availability could ultimately limit algal growth at very high levels of productivity, but these levels are not likely to be approached within the range of phosphorus enrichment we propose. Finally, the list of potentially limiting micronutrients is large and any monitoring would therefore likely be broad and costly. Given that stoichiometric ratios for most micronutrients are not know and lag effects between micronutrient availability and algal response are common (Currier et al. 2020), interpretations of any such monitoring may be challenging.

<u>ISRP 2022 Response:</u>
The response is sufficient. The experiments by Coyle (2016) along with the experiences just downstream in Idaho with a similar nutrient addition experiment address the concerns of the ISRP.

8. ISRP 2021-5 Comment: Since the experiment needs only P and there is already an apparent abundance of N in the system, why not select a fertilizer that does not add N? Is this a cost/logistics issue where the proponents want to use a highly accessible fertilizer versus one that is actually needed?

MFWP 2022 Response: MFWP acknowledges that ideally, a nitrogen free product that added only phosphorus would be a preferred product for the proposed experiment. We evaluated the feasibility of an alternative nitrogen free product (food grade potassium phosphate) but the product cost was prohibitive. Potassium phosphate also has a relatively high salt out temperature (~50°F) and in conjunction with the logistical constraints of mixing powder formulations at the scale needed, this product was deemed not feasible. We calculated the retrospective total nitrogen concentrations using the proposed monthly ammonium polyphosphate product and estimated the increase in total nitrogen to be equivalent to about a 1% increase above concentrations during recent years (see Implementation Plan; Table 12).

<u>ISRP 2022 Response:</u>
The response is sufficient. Cost and efficacy of nutrient supplements were considered and a reasonable alternative was identified. The information provided on cost and feasibility make it clear that the proponents used sound logic to select the nutrient product for addition. However,

cost information for the nitrogen-free product (food grade potassium phosphate) would have been helpful.

9. ISRP 2021-5 Comment: The proponents provide multiple practical reasons for site selection, though notably none of them is based on ecological factors. The practical reasons are valid, but it seems like some measure of the effectiveness of fertilizing the selected reach is also needed, particularly since the elevated P will only persist and function a short distance downstream, as shown by the Idaho studies. The only ecologically oriented justification is that this section of the river has the lowest P and has high *D. geminata* growth, which appears to be driven by low P. However, if more P is added to the system, is the habitat of adequate quality in this section of the river to support greater abundance of rainbow trout? How will the substrate characteristics in the fertilized reach affect secondary productivity? Most likely the coarse but armored substrate immediately below Libby Dam has less interstitial space, hyporheic exchange, and habitat for macroinvertebrates than bed material lower in the river.

MFWP 2022 Response: The Kootenai River benthic invertebrate community within the 3.5 miles downstream of Libby Dam is dominated by dipterans, compromising on average 74.3 and 56.9% of the density and biomass respectively of all organisms sampled from 2014-2020 (Dunnigan et al. 2021) with the most common family being Chironomidae. On average over the same period, the combined proportion of the total density and biomass of mayflies, stoneflies and caddisflies (EPT) relative to all organisms in this section were 13.4 and 25.2%, respectively. The annual variability of these indices is important and demonstrates the productive capability of this section of the Kootenai River. The annual average family-level biotic index (FBI; Hilsenhoff 1988) (Figure 7; Implementation Plan), the relative proportion, density and biomass of EPT (Dunnigan et al. 2021) in recent years provides evidence of ecological impairment, but the upper range of these indices supports the notion that increased production of the Kootenai River benthic invertebrate community downstream of Libby Dam is biologically possible. These points in addition the fact that our growth targets which were based on 75th percentile of observed growth within this section of the river provide additional support for the notion that our expectations for this experiment are biologically attainable given available habitat. This issue is discussed in additional detail within the Implementation Plan section *Justification for a summer treatment – a case for degradation at multiple trophic levels*.

ISRP 2022 Response:

The response is sufficient. The empirical data from the experiment downstream in Idaho, and the upper ends of the range of invertebrate density and biomass from past sampling in the study reach, provide support for the hypothesis that increasing P concentrations will lead to decreased *Didymosphenia* and increased trout growth.

However, the ISRP notes that ecological systems are complex and results of resource manipulations can be confounded by other effects in the food web. Thus, we strongly recommend that the proponents consider three possibilities in their monitoring and evaluation program (adaptive management) that may seem unlikely, but could occur:

1. The immediate, below-dam habitat presents a unique combination of physical conditions, particularly because of flow, temperature, sediment, and large wood, and thus may behave unpredictably.

2. Is it possible that with regulated flows below Libby Dam, that more primary production could be shunted into predator-resistant grazing macroinvertebrates, as has been found in a coastal California river (Power et al. 2008)? The mechanism is that without floods to crush large-cased caddisflies, these grazers proliferate and outcompete smaller grazers such as mayflies on which trout feed. Thus, the proponents are urged to consider managed environmental flows (e.g., a spring flow pulse) to suppress large macroinvertebrates and reduce accumulation of macroinvertebrate biomass unavailable to fish. This option could be explored if large macroinvertebrates increase in abundance after P addition.

3. Is it possible that given the higher secondary production of benthic invertebrates, more rainbow trout will immigrate from adjacent reaches downstream, thereby increasing density and preventing the higher growth expected? This immigration probably would not be detected by the marking scheme described in the proposal. The ISRP is concerned about the limited sampling window (September only), restriction of sampling to three highly dispersed sites, and weakness in the proponent's monitoring movements of rainbow trout.

    a. Inferences about fish movement from previous research – the proponents report (p. 59) that of 48,366 rainbow trout marked, only 4.5% *of those recaptured* (286 of 6,318 trout recaptured) were found in a different section than where they were originally marked. They conclude from this that trout movement was low.

    b. It is common for investigators to misinterpret results like this from movement studies (see Gowan et al. 1994). The proponents do not report how long their sections were, the length of the entire study reach, nor consider what happened to the other approximately 42,000 fish that were never seen again (87% of the fish marked). Although some likely died, others could have moved beyond the entire study reach, or to many different distances within it that were not sampled.

    c. It is characteristic of trout movement that a large share of the fish (often up to half) remain in their "home" section, but others move and sometimes long distances away (i.e., a leptokurtic distribution, highly peaked but with long tails; see Gowan and Fausch 1996b for one of many examples from the fish movement literature). When investigators sample distant reaches, they often recapture only a few or no marked fish, and thus conclude movement is low. However, if all such reaches up to long distances were sampled, the sum of these low numbers could total many fish.

    d. The fallacy of assuming that little movement occurs is often revealed when weirs or PIT-tag antennas are used and fish are detected moving among reaches.

    e. Hence, if fish from all segments along the river are moving to many different distances, this can lead to fish originating from many different reaches encountering the greater food or habitat resources that are created in any one segment, such as by addition of P (see Gowan and Fausch 1996a for an example). Given this, the proponents might expect that immigration into the dosed reach where invertebrate production is increased could be higher than expected, thereby increasing trout density and decreasing trout growth.

f. In addition, sampling during one month of the year could miss an annual migration pattern associated with spawning or foraging and thus bias the results. For example, if larger, more metabolically active (likely to be influenced by genetic factors) age-1 fish are more or less likely to leave the treatment reach than their smaller cohorts because of quantity of food or habitat, then the sampled population does not represent the potential growth benefit from the nutrient addition.

g. The proponents should consider expanding the fish monitoring effort to quantify the amount of movement of rainbow trout into and out of the treatment reach (as well as other species such as mountain whitefish). This could be done by installing a PIT-tag detection system at strategic locations in the mainstem (especially at the downstream end of treatment reach) and within tributaries to document fish movement. If a PIT-tag detection system suitable for detecting movement in the mainstem proves to be too costly, the proponent should consider an intensive telemetry project.

10. ISRP 2021-5 Comment: The reference sites are located downstream. The justification for selecting these sites is the baseline rainbow trout growth data at the sites, which is sound. The proponents acknowledge this limitation and propose a reasonable analysis strategy (page 31). Even if the BACI results are a bit suspect because of this issue, the ISRP recognizes that rainbow trout growth is an acceptable analytical metric. The proponents should actively watch for changes in the study reach that would invalidate or weaken the before-after comparison.

MFWP 2022 Response: MFWP acknowledges the importance to recognize changes in biological or environmental conditions (other than nutrients) that could confound the before-after experimental comparison and we will remain vigilant to recognize such changes should they occur. Our revised water quality and multiple trophic level biological monitoring plan that includes pre-project data will be extremely valuable to determine if such changes occur.

<u>ISRP 2022 Response:</u>
The response is sufficient. It would be useful to know how much pre-project data is available because this may affect the power of the statistical tests.

11. ISRP 2021-5 Comment: While the location of reference sites may be dictated by physical circumstances, the annual addition of tons of P suggests that both inorganic and organic P will eventually move downstream. Since there are no realistic biochemical mechanisms for long-term storage in the channel or for movement to the atmosphere (as there is for N and C), it is likely that the phosphorus biologically assimilated or physically adsorbed onto organic and inorganic sediments would accumulate in the riverbed and floodplain, both in the 3.5-mile study section and downstream reaches over the long-term. Even P retained in Koocanusa Reservoir can be transported downstream either as resolubilized P from anoxic habitats or entrainment of organic material. Has the project considered the long-term consequences of phosphorus loading in the ecosystem? It is a challenging question that the ISRP feels the proponents should consider in future proposals if the project is to be implemented.

MFWP 2022 Response: Shortly after the construction of Libby Dam, Woods (1982) quantified the effective phosphorus trapping capabilities of the newly created reservoir. A more recent similar study (Yassien and Ward 2018) found that the phosphorus trapping efficiency of the reservoir increased slightly compared to the previous study. Inspection of contemporary measures of total phosphorus downstream of Libby Dam (Table 1; Implementation Plan) provide no evidence that substantial phosphorus transport from the reservoir has occurred. Nonetheless, we acknowledge this possibility and will actively monitor water quality upstream of the nutrient addition zone (site 1; see Implementation Plan Figure 9). The potential for unintended consequences of nutrient loading as a result of this proposal should be viewed in context of the total nutrient supply that would occur downstream of Libby Dam if the reservoir was not present. We have attempted to frame this issue in the Implementation Plan (see pages 21-23). The results of the retrospective analysis we performed using the Yassien and Ward (2018) data estimated that using the proposed monthly dose rates for this experiment, the total added phosphorus load would have averaged 2.9% (range 1.1 – 4.5%) of the total annual phosphorus load retained in the reservoir (see Figure 2; page 22 Implementation Plan) had our proposed nutrient addition occurred during the years of the Yassien and Ward (2018) study. The proposed total annual average load of phosphorus this experiment would add to the Kootenai River (15.01 tons; Table 4; Implementation Plan) is slightly higher than the average total annual load added by the 17-year long nutrient addition project occurring on the lower Kootenai River (11.4 tons per year 2006-2018; Yassien and Ward 2019). The fact that the Idaho experiment and the associated extensive monitoring effort that has not observed substantial unintended consequences, adds additional support that the likelihood of unintended consequences from long term loading is low. Nonetheless, the ISRP point is noted and MFWP will reassess the issue at the conclusion of the experiment should nutrient addition occur beyond the proposed experiment.

ISRP 2022 Response:
The response is sufficient. The proponent adequately described the relative amount of phosphorous they intend to add to the system, and they explained the low likelihood of it being too much. The proposed doses of P to be added are a small percentage (<3%) of the total inflow of P to the reservoir, and these low levels of added P had no observable or measurable unintended consequences in a similar nutrient addition project conducted downstream in the same river. However, the ISRP continues to encourage the proponents to consider the long-term consequences and risks of phosphorus loading in the ecosystem.

12. ISRP 2021-5 Comment: The dosing is based on achieving an increased growth rate of 70 mm/yr in rainbow trout (using growth models), which is a strength (rather than arbitrarily setting a dose). However, the ISRP does not completely understand why 70 mm/yr was decided upon. It seems to be unusually rapid. Why 70 mm/yr vs. 50 mm/yr or 90 mm/yr for an “average” 230 mm rainbow trout? By calculating the 75th percentile of the observed average growth increment of tagged fish within the Dam section from 2011-2018, does this mean that three quarters of the fish grew at a rate of 70 mm/year without fertilization? As well, since growth slows over the life of fish, can other expected age-specific growth rates be estimated in response to the fertilization? The ISRP feels that it would be informative to have the estimated growth projections for rainbow trout of other sizes.

MFWP 2022 Response: The mean annual growth rate (averaged across years 2011-2018 study) for a 230 mm long Rainbow Trout from Libby Dam section of the Kootenai River was 60.1 mm, and the maximum annual average growth rate was 71.4 mm per year (Mean annual growth rate observed in 2014). The 75th percentile of the annual growth rates between 2011 and 2018 for this section; also known as the third, or upper, quartile is the value at which 25% of the annual growth rates are above that value and 75% of the answers lie below that value. We elected to set the target growth rate (70 mm annual growth for a 230 mm long Rainbow trout) at a rate that the river has demonstrated to be biologically achievable yet represents a substantial improvement over contemporary average growth. To help clarify these points, we have added Table 7 in the Implementation Plan.

<u>ISRP 2022 Response:</u>
The response is sufficient. The objective of achieving the 75th percentile growth, as an average, appears logical from an ecological perspective. From an angler's perspective, however, it is unclear whether the cost and effort of nutrient addition would be considered worth the 1/2" of extra growth that is sought for a 9" fish. That is, increasing average growth from 60 to 70 mm (an increase of 17%) for these age-1+ trout (based on Figure 8) seems a modest increase. For example, Figure 8 indicates that rainbow trout from three other Montana rivers achieve lengths 1.5-3.5 inches longer at this stage, to about 10.5 to 12.5 inches vs. 9 inches in the Kootenai segment.

Do the proponents assume that increased growth at all life stages of trout will lead to a cumulative increase in length-at-age? If so, the increases in total length should be greater with each successive year (i.e., the growth curves pre- vs. post-treatment should diverge). Figure 8 indicates that larger trout in the Big Hole River result from greater growth by age-1, whereas in the Missouri and Bighorn growth increments continue to be greater at older ages.

Beyond the narrow focus on growth, other compensatory life-history processes could also confound the outcome and prevent the growth response expected. For example, what if enhanced growth and condition over winter and early spring crosses a threshold that lowers the age at maturity? Earlier maturation could result in more energy being allocated to reproduction than to growth, and hence decrease annual growth achieved. The ISRP believes it is important to understand these interactive feed-back responses. Does basic life history information such as age at first spawning for individual fish exist? Do we know if growth rate varies by sex or how fecundity varies by size?

We would strongly recommend that proponents compile basic life history information on rainbow trout in the Kootenai system as a reference document and as an aid in evaluating potential future changes resulting from nutrient addition.

13. ISRP 2021-5 Comment: Periphyton will be sampled, but the metrics are never identified (other than a visual estimate of the percentage covered by periphyton, which is highly misleading). At a minimum, Chl a per unit area should be quantified as a response to the fertilization. *D. geminata* cover and thickness will be determined but not biomass. That said, standing stock is not a sensitive measure of periphyton production. The standing stock of periphyton, measured either as AFDM or pigments, is what is left over after the invertebrate and vertebrate herbivores have consumed it. It is not a direct measure of the response of algal primary production to nutrient addition (for example, see Gregory 1983, Lamberti et al. 1989). If the proponents want to assess the algal response to the fertilization, photosynthetic rates need to be measured.

MFWP 2022 Response: MFWP recognizes the critical importance of monitoring the benthic algal community response to the proposed experiment and acknowledges our original proposal was inadequate and have revised it to include metrics for chlorophyll-a accrual and biomass, ash-free dry mass (AFDM), *D. geminata* coverage (%), coverage by filamentous algae (%), and periphyton depth (mm) at sites 1-12 (see Figure 9; Implementation Plan) monthly from January through October before (2021-2023) and during (2024-2029) this experiment. Additional sampling details are included in the *Periphyton* section of the Experimental Proposal.

ISRP 2022 Response:
The response is sufficient. The added measures of periphyton standing stock, AFDM, and Chlorophyll-a accrual appear suitable for the purposes of this research. Herbivory also affects Chlorophyll-a accrual, and it should be noted that the rates of Chlorophyll-a accrual are not a measure of primary production rates.

14. ISRP 2021-5 Comment: With the addition of P, there is always the possibility of cyanobacteria emerging to take advantage of the P. Will these cyanobacterial species be monitored and what are the indices that would dictate curtailment of P additions?

MFWP 2022 Response: The ISRP presented a similar question to the Kootenai Tribe of Idaho during a recent project review related to the ongoing nutrient addition project on the Idaho portion of the Kootenai River. The KTOI's fall 2020 response summarized the results of their multi-year monitoring efforts since 2005 in their response. MFWP (with permission from G. Hoyle, KTOI) has summarized that response because we believe it is reasonable to expect a similar periphyton response to the current proposal. The Kootenai River periphyton community is generally dominated by diatoms which is the group of periphyton that have also exhibited a commensurate response to nutrient addition (Hoyle et al. 2014; Gidley et al. 2017; Hoyle 2020). Blue-green algae are present in properly functioning periphyton communities, along with other algae species including diatoms and green algae. Hoyle et al. (2014) showed that the proportion of cyanobacteria within the benthic algal community significantly decreased within the nutrient addition zone during the first five years of nutrient addition on the Kootenai River relative to upstream reference sites. Subsequent reports (Hoyle 2020; Gidley et al. 2017) confirms that this trend has continued. Gidley et al. (2017) also demonstrated that the proportion of cyanobacteria decreased in the nutrient addition zone using a pre- and post-nutrient addition comparison. In general, between 2005 to 2017, some of the toxic blue-green algae species, including *Microcystis* and *Phormidium*, have been found in KTOI the periphyton samples, but at very low numbers. The EPA (2015) defines high densities above 100,000 cells per ml or mm^2 for densities to be at this level before there is concern. Since 2005 when P-addition began, harmful algal bloom numbers within the nutrient addition zone in Idaho have never approached the US EPA criteria and those species that fall within this group that have been found in the Kootenai River KTOI nutrient addition samples are best characterized as incidental sightings of rare, and potentially toxic, cyanobacteria.

Although MFWP believes that likelihood that this experiment will elicit a harmful cyanobacteria response is low, algal taxonomy and species composition will be monitored before and during the experiment. MT DEQ has not established threshold metrics for cyanobacteria as part of the permitting requirements for this experiment, but all the water quality metrics and biological monitoring (including periphyton) metrics collected during this experiment will be reviewed by MT DEQ and used to determine if programmatic adjustments are needed (see *Adaptive Management* Section in the Implementation Plan).

ISRP 2022 Response:
The response is sufficient. The addition of evaluating the taxonomy of periphyton at a set of 7 sites along the 60-km study reach appears suitable for evaluating this ISRP concern.

15. ISRP 2021-5 Comment: The ISRP appreciates the focus on growth responses of trout, yet nutrient addition elicits an ecosystem-scale response. The proponents are choosing not to monitor other fish species due to budget constraints but acknowledge that they also may be affected by the added nutrients. If the proponents wish to truly understand the ecological-scale response, it would be prudent to expand the scope of the investigations during the initial years to other fish species in the community. Community-level response to the fertilization could obscure the response of individual fish species, including the project's rainbow trout growth objectives. The ISRP suggests that the proponents consider measuring length and weight of all fish species when sampling for rainbow trout. Sculpins, in particular, could demonstrate the more localized effects of the fertilization on fish because they have similar food resources as salmonids and they do not migrate or disperse extensively. Collecting 30-60 sculpins, by species if more than one species is present, at several times during the fertilization period at 3-5 sites, and measuring lengths and weight, could be fairly easy and inexpensive.

MFWP 2022 Response: MFWP acknowledges the importance of expanding the scope of our investigation to include other fish species inhabiting the project area. We have therefore, proposed to evaluate annual growth and recruitment of Mountain Whitefish and Largescale Suckers before and after the experimental nutrient addition pilot study using methods similar to those used by Watkins et al. (2017) on the Idaho portion of the Kootenai River (see *Other fish species and secondary metrics* section; Implementation Plan pages 34-35). We have elected to prioritize these two species as secondary metrics for the experiment because they have demonstrated responses to nutrient addition in the Idaho portion of the river (Watkins et al. 2017; Hardy et al. 2022), yet we also acknowledge differences in fish species composition between the Idaho and Libby Dam sections of the Kootenai River (see March 2021 MFWP response to ISRP concerns page 40 for description of relative abundances) are sufficient to warrant also examining growth rates for these two species.

ISRP 2022 Response:
The response is sufficient. The ISRP is encouraged that the proponents plan to measure an index of relative abundance (CPUE), age, growth, recruitment (and perhaps survival, based on the catch curve?) of two non-target fish species, mountain whitefish and largescale sucker, that are more benthivorous than rainbow trout. Measurements will be made in the study reach and two downstream reaches (~4 - 6 km each) at the start (2022-2023) and end (2028-2029) of the study.

These measurements are important because more of the secondary production of benthic invertebrates could be funneled into these more benthivorous fishes (and into sculpin) than into rainbow trout. For example, Bellmore et al. (2013) found that 95% of prey consumption in the main channel of the Methow River, WA flowed to sculpin and mountain whitefish rather than the salmon and steelhead of interest to management biologists. Hence, if after the addition of P, the proponents find a weaker response by rainbow trout than predicted, data on these other non-target fish species will be critical for answering the subsequent questions about why the response was not as predicted.

We also strongly recommend that proponents take abundance, length, and weight data on other fish species.

16. ISRP 2021-5 Comment: Riparian vegetation can sequester added nutrients from river water. The ISRP acknowledges that investigating this in depth would entail considerable effort. Nevertheless, the proponents may wish to consider measuring the growth of representative woody riparian vegetation (tree ring analysis), on a limited basis, before implementing the fertilization and again after 5 years in the reference reach and the treatment reach.

MFWP 2022 Response: MFWP agrees that adding nutrients to the Kootenai River will likely elicit an ecosystem-scale response. An all-inclusive monitoring effort that documents all aspects of aquatic and terrestrial responses is an intellectual temptation but simply is not feasible given the time and budgetary constraints. We have therefore, prioritized our efforts to include the components of the aquatic trophic levels required to evaluate project success and best understand the reasons why the experiment either does or does not confirm our hypotheses and meet objectives.

ISRP 2022 Response:

The response is sufficient. Measuring effects of the nutrient addition on riparian vegetation, while interesting, seems beyond the scope of this project. However, it seems likely that increasing biomass and abundance of benthic invertebrates will increase emergence of adult aquatic insects to the riparian zone, creating benefits for riparian birds, bats, and other riparian predators (e.g., spiders; see Nakano and Murakami 2001; Baxter et al. 2005). This may be an added benefit of the project. Perhaps the proponents could collaborate with other entities, such as graduate students at universities, who might have the interest to conduct sampling for these kind of response metrics.

ISRP Comments on the Implementation Plan

The ISRP found the Implementation Plan to be highly detailed, well organized, and carefully written. It answers most questions we had about project planning and implementation. It is a model for other proponents about the detail and planning required to prepare for such a large project in a large river. It addresses quite thoroughly all the comments raised by the ISRP, and many questions we had. We have added some comments on specific sections that the proponents are encouraged to consider in any subsequent drafts of the Implementation Plan, but no response is required.

Treatment Site Selection

It would have been helpful to include a more sophisticated physical description the section of river directly below Libby Dam to show how it is affected by seasonal and daily flow releases from the dam, and how the dam affects stream temperature, retention of nutrients, invertebrate drift, and available food and habitat for rainbow trout. As is, the reader is provided literature sources to find some of this information, but a few summary paragraphs in this document would make it more coherent and complete. The proponents should address the potential effects of discharge on the treatment section relative to downstream sections, such as a comparison to the downstream control sections and to the treatment section for the complementary project in Idaho.

Program Design

The discharge from Libby Dam can be suddenly increased or decreased within a day or over a series of days. Have proponents considered how this variation could affect the chance for underdosing or overdosing, as well as cost efficiency considering the high price of the fertilizer?

Monitoring and Evaluation: Rainbow Trout Growth

The major fish response metric is growth in length of rainbow trout, especially for age-1 and age-2-year-old fish (i.e., those fish likely to be 230 mm). While we appreciate the focus on a clear objective, other elements of rainbow trout life history in the full Kootenai would help interpreting what is happening to rainbow trout in this reach. As we have noted, other responses by rainbow trout could occur, such as a change in density. To help interpret the potential response of rainbow trout, having a compendium of basic life history information on rainbow trout would be useful. As we have noted, no description of the basic life history of these fish, as expressed in the Montana portion of the Kootenai River system below Libby Dam (beyond size-at-age for early years) is provided. Such a description would help readers understand this experiment and interpret potential results. Further, the Implementation Plan would be a good place for such description of basic rainbow trout life history. The information should include what is known and unknown about when this fish stock was introduced to the system, current hatchery influence, spawning time, spawning locations, migration tendencies, survival (egg-to-parr, parr-to-adult), age at first spawning, age composition, size obtained at older ages, fecundity by age, and retention of rainbow trout in the study area (e.g., portion of time spent in or out of treatment reach).

Collecting fish metrics on rainbow trout and other fish species to assess potential response to the nutrient addition beyond growth of younger-aged rainbow trout is recommended and the data at least archived. It is not at all clear if enhanced growth of younger-aged rainbow trout would enhance fitness, as a function of survival and fecundity. It is not at all clear how much is known about movement of rainbow trout in and out of the treatment reach (annually and over the lifetime of the fish), and how much of this movement might be age, food, and spawning related.

Without considering these kinds of additional metrics, the benefit to rainbow trout and the broader fish community from nutrient addition could be missed. For example, what if fertilization had a larger effect on survival or retention of older rainbow trout in the treatment reach rather than (or in addition to) an increase in annual growth of younger-aged fish? What if more retention (or more migration to the treatment reach from other reaches than just the Flower-Pipe reach) decreased potential annual growth because of density dependence? Metrics that attend to basic ecology, life history, and species interactions are needed to understand the response to fertilization.

Monitoring and Evaluation: Water Quality and Trophic Level Monitoring

For several of the attributes to be assessed (Table 15), three replicates are planned per sampling effort. Has the addition of a fourth replicate been considered for contribution to the power of the test(s), accuracy, and precision?

Monitoring and Evaluation: Control Sites for Before After Control Impact Assessments

Might the use of 230 mm rainbow trout as the modeled fish size be confounded if there is an age shift at which 230 mm is obtained? For example, if some or most 230 mm fish were age-2 pre-treatment but some or most were 230 mm fish at age-1 post-treatment, would that not confound the results on growth because of changing potential for growth dependent on age? Why not also use mean (and/or standard deviation) size at age for the analysis? Why not commit to a wider array of metrics in general?

Adaptive Management

With a narrow focus on growth enhancement of a typical 230 mm rainbow trout, many appropriate biology and sustainability metrics are being ignored. Increases or decreases in other important biological responses (for example: fitness, survival, and/or migration) could be welcomed, undesired, and/or unexpected. If data are lacking to evaluate these responses, this could limit, or possibly confound, the potential knowledge to be gained from this experiment.

ISRP Comments on the Best Management Plan

Introduction, Objectives, and Background

In addition to the two biological objectives (or outcomes) in the plan related to decreasing *D. geminata* and increasing growth of rainbow trout, implementation objectives in the SMART format are needed to match the actions described in the plan (i.e., a nutrient addition experiment).

Implementation objectives would be something like this:
Obj 1: (about site selection)
Obj 2: (about materials handling, product delivery points, delivery system)
Obj 3: (about layout of nutrient dosing facility, power supply, security)
Obj 4: (about nutrient dosing, seasonality, concentration, flow dependence, performance)
Obj 5: (about adaptive management, feedback loops, interaction with assessments of *D. geminata* and fish response)

Materials and Methods: Nutrient addition location and facilities

Was the chance for flooding considered in site selection? How likely is flooding at this site, and what would be the potential consequences?

Materials and Methods: Nutrient Dosing and Measurement

To go along with the suggested Objective 5 (see above), a feedback loop should be described as to when nutrient addition might be increased, decreased, or suspended based on thresholds of dosage metrics and biological response. See above comments under "Introduction, Goals, Objectives, and Background".

Security and Spill Prevention

It was good to see the proponents have a plan for dealing with accidental spillage, when and if it occurs.

References

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