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VIA E-FILING

December 22, 2020

John A. Zygaj, P.E.
Regional Engineer
Federal Energy Regulatory Commission
Office of Energy Projects
Division of Dam Safety and Inspections - Chicago Regional Office
230 South Dearborn Street, Suite 3130
Chicago, Illinois 60604

RE: River Falls Hydroelectric Project, FERC Project No. 10489
Post-Flood Dam Safety Inspection and Repair Options

Dear Mr. Zygaj:

River Falls Municipal Utilities (RFMU), the Licensee of the River Falls Hydroelectric Project, is submitting a response to the Federal Energy Regulatory Commission (FERC) letter dated October 2, 2020, which required a dam inspection report and recommendations for future action with agency consultation. A dam safety inspection was conducted by Ayres on October 19, 2020. Results of this inspection are included in the *Post-Flood Dam Safety Inspection and Repair Options Letter* located in Attachment A.

RFMU has been consulting with the Wisconsin DNR and the Kiap-TU-Wish chapter of Trout Unlimited (TU) regarding the action options presented herein. A draft of the *FERC Inspection Letter and Recommendation for Future Action Options* was sent to Wisconsin DNR and TU prior to a meeting between RFMU, Wisconsin DNR, and TU held on November 19, 2020. During this meeting, RFMU requested comments on the action options presented from Wisconsin DNR and TU by December 15, 2020. As a follow up to the initial discussion, a draft of the *Refill Risk Assessment Report* was sent to Wisconsin DNR and TU on December 4, 2020 for consideration. Comment letters were received from Wisconsin DNR and TU on December 15, 2020 and are included in Attachment B.

Please contact me if you have any questions.

Sincerely,

Kevin Westhuis
Utility Director

City of River Falls Municipal Utilities
222 Lewis Street
River Falls, WI 54022

Attachments:

Attachment A: Post-Flood Dam Safety Inspection and Repair Options Letter
Attachment B: Wisconsin DNR and TU Consultation

cc: Interested Parties Mailing List
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Kevin Griebenow, FERC
Janet Hetzel, FERC
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Janet Oakley, FERC
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ATTACHMENT A
Post-Flood Dam Safety Inspection and Repair Options Letter

December 18, 2020

Kevin Westhuis, Utility Director
City of River Falls Municipal Utilities
222 Lewis Street
River Falls, WI 54022

Re: Post-Flood Dam Safety Inspection and Repair Options Letter for Powell Falls Dam (P-10489)

Dear Kevin:

The Federal Energy Regulatory Commission (FERC) directed the City of River Falls Municipal Utilities (RFMU) to submit two items in the FERC letter dated October 2, 2020:

- A dam inspection report, summarizing observations and findings
- Recommendations for future action, ongoing agency consultation, interim impoundment and powerhouse operations, and other risk mitigation strategies

The FERC's deadline for submitting the above items is December 31, 2020. The FERC also asked the RFMU to submit an impoundment refill plan to the FERC by April 1, 2021.

Selected Portions of Dam History

Powell Falls dam was not constructed all at once in the present-day form. Per the Initial Study Report (January 30, 2020), a wood-framed powerhouse was built at Powell Falls in 1903 with a timber spillway to retain water. A concrete powerhouse was constructed in 1946 - 1947. In 1964, a large flood destroyed the timber dam spillway. A concrete gravity dam was constructed in 1965 - 1966, and that project did not include replacement of the sluiceway walls or powerhouse foundation. Ayres' search of the available historic drawings and records could not confirm that the powerhouse foundation and sluiceway piers are original 1903 concrete, but Figure 1's reinforcement view indicates that the sluiceway wall concrete predates 1947 when ASTM A305 standardized[1] reinforcing deformity patterns.

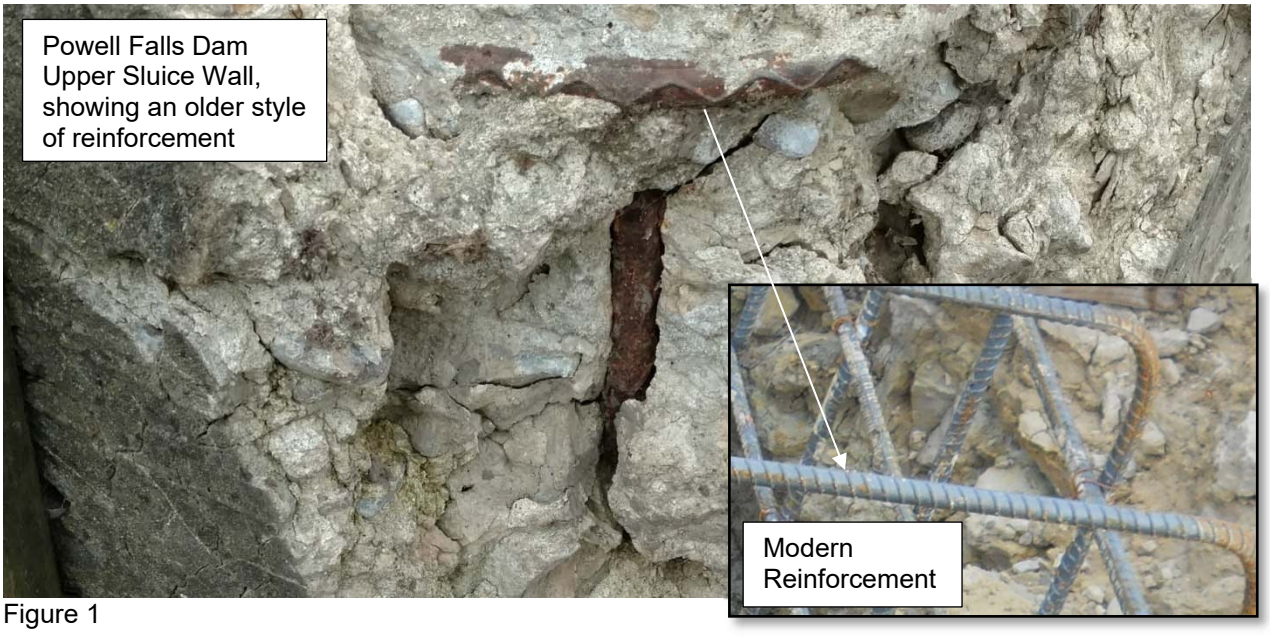


Figure 1

[1] https://crsi.org/index.cfm/basics/history-of-reinforcing-steel

During the project's initial FERC licensure in 1988, the stability analysis required post-tensioned anchors at Junction Falls. After further investigation for both dams, a stability analysis was subsequently completed for Powell Falls in 1991, and the spillway lift joints were found to have structurally inadequate bonds. Anchor lengths changed during construction. The 1992 construction included 13 post-tensioned anchors (rock bolts) to compress the spillway concrete together (13 anchors required) and tie the spillway concrete into the foundation bedrock (7 anchors of the original 13 were anchored into bedrock). Ayres is not fully certain that the designer's stability computations addressed the changed construction conditions.

The Powell Falls dam was inspected multiple times since initial licensure (most recently were December 2009, November 2014, and August 2015). For reference, items discussed in the earlier inspections that are still valid include:

- Deterioration of powerhouse tailrace dewatering slots
- Partial undermining of the powerhouse tail wall
- Deterioration of powerhouse walkway and deck undersides
- Excessive brush and trees around the dam that have roots which could form preferential seepage paths through the adjacent abutments
- Gate leakage
- Significant seepage through the right abutment bedrock

The 2020 inspection is intended to augment those earlier inspections with new observations made after a full drawdown. This 2020 inspection does not include commentary on every crack, spall, or other minor deficiency noted in the earlier reports; but instead, the 2020 inspection seeks to answer the primary question about how suitable is the remaining structure for continued safety during impounded water conditions through the year 2024. Ayres assumes the dam will be fully breached by the end of 2024.

2020 Events Preceding the Dam Inspection

An initial study report was submitted to the FERC on January 30, 2020, outlining a plan to decommission the Powell Falls Dam after 2023 as part of a license application to relicense the Junction Falls Dam.

The spillway passed a significant but unquantified peak flow after a seven-inch rainfall on June 29, 2020, and the RFMU filed a 12.10 dam safety report with the FERC on July 16, 2020. The 12.10 report noted loss of right abutment concrete. A follow-up letter to the FERC dated September 25, 2020, noted uncertainties about how the flood impacted the post-tensioned anchors, scour below Junction Falls spillway, and debris impingement effects on the Powell Falls sluice gate and powerhouse intake.

The RFMU proposed to draw down the impoundment for a dam safety inspection of the Powell Falls spillway lift joints (upstream face), sluice gate, powerhouse intake screen, and Junction Falls tailrace. On October 1, 2020, the FERC authorized an Order granting temporary variance from Article 401 of the project license and authorizing a drawdown from October 2, 2020, to June 1, 2021. The drawdown started on October 2, 2020, but a two-inch rainfall event from 2AM to 4AM caused the impoundment to completely refill by 6:43AM on October 12. Logs jammed in the sluice gate, forcing the RFMU to restart flow through the powerhouse (no load operation) to control impoundment levels. This allowed sand to fill the powerhouse intake bay and part of the turbine bowl but allowed the drawdown to proceed. The turbine flow was stopped at 10AM on October 12 as the impoundment had fallen 4.6 feet in an hour. The debris jam in the sluice gate had apparently released, dropping the impoundment a total of 6.9 feet within hours. Once the debris jam cleared, the RFMU was able to get the impoundment stabilized and continue the slow drawdown through October 15, 2020. At 11:17AM on Thursday, October 15, 2020, the river was no longer hydraulically controlled by the sluice gate.

The realization of how fast the impoundment could rise and fall led Ayres to quickly mobilize to do a dam inspection while the dam was fully drawn down. The inspection was completed on Monday, October 19, 2020.

Dam Inspection Observations and Findings

Ayres' Pete Haug inspected the Powell Falls dam on October 19, 2020. Per the nearest weather station[2], conditions during the survey were 34ºF, and antecedent conditions included a period of higher than normal runoff (2.03 inches of rain on October 12) and a drained impoundment condition (as of October 16). The morning of the October 19 inspection was 22ºF, apparently the first time that local temperatures had fallen below 28ºF since May 13, 2020.

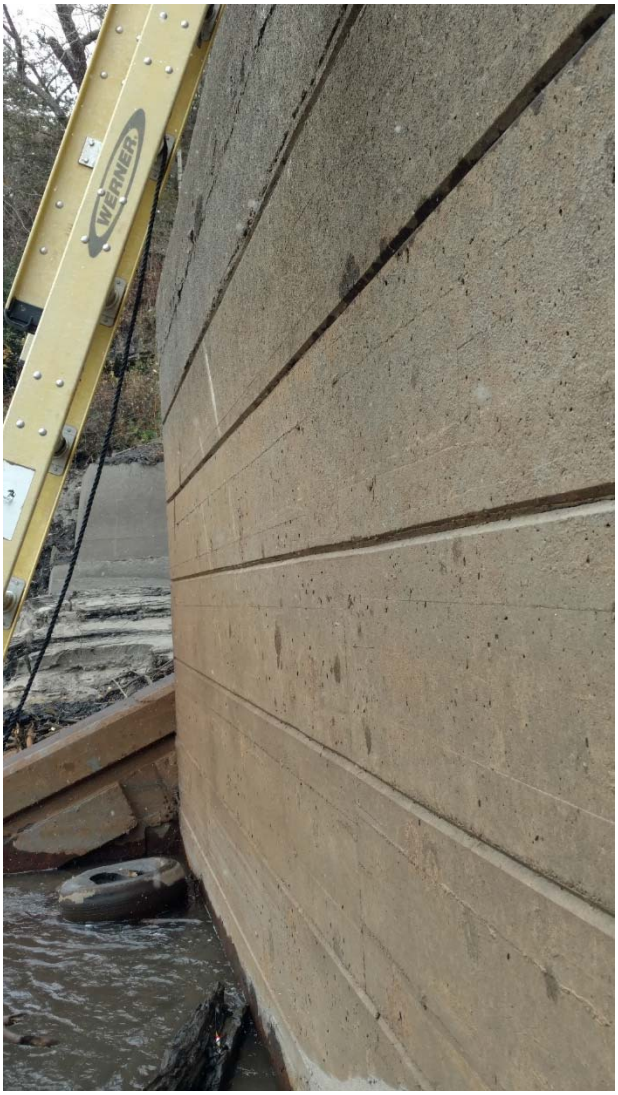


Figure 2, upstream lift joints on left spillway

The RFMU provided a ladder for Ayres to obtain a perpendicular view and up-close visual inspection of the upstream face of spillway concrete (Figure 2). Ayres was able to inspect the left and right ends, plus the third points, of the upstream face with a ladder. The uppermost lift joints had been apparently coated with a flexible (still flexible after installation in 1992) coating shown in Figure 3, though the coating had

2 https://mesonet.agron.iastate.edu/sites/hist.phtml?station=RVFW3&network=WI_COOP&year=2020&month=10

separated from the lift joints in multiple locations and water was found behind the coating in several places. All upstream face concrete (not the coating) sounded solid when struck with hammer.

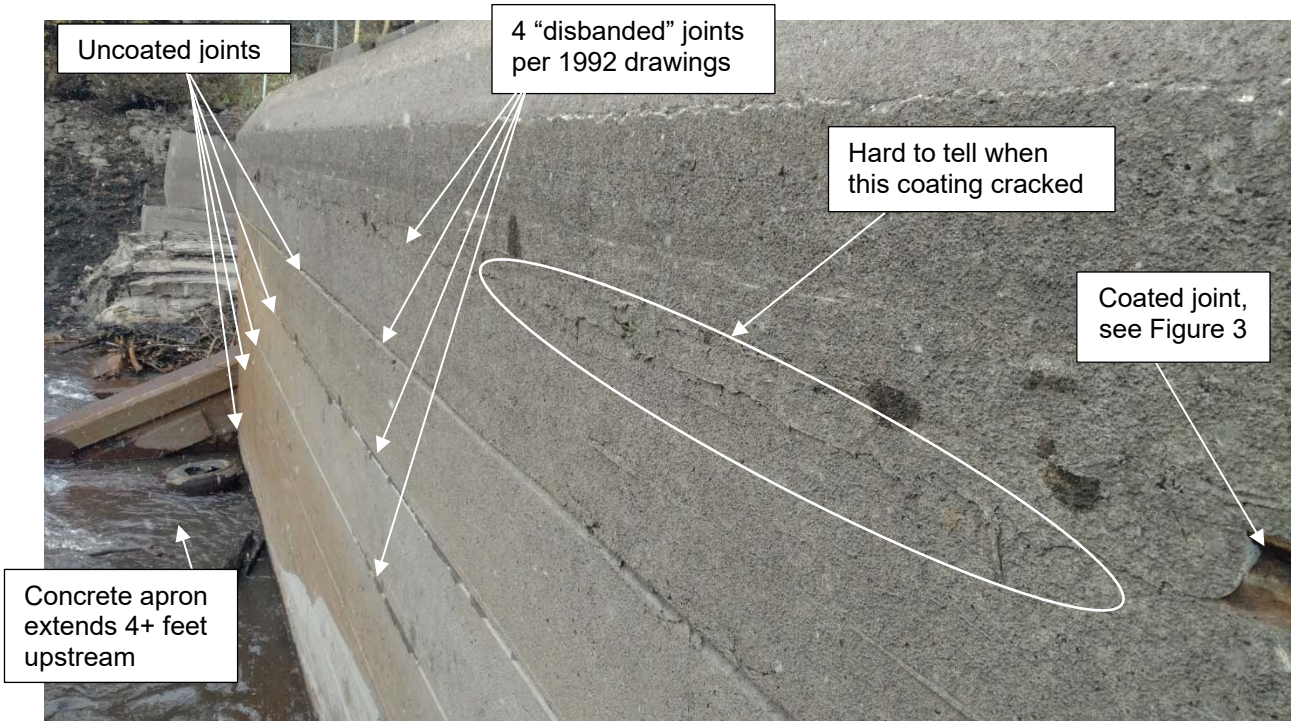


Figure 3. Lift joints, viewed from upstream face of spillway

Figure 4. Closeup of coated lift joint shown on right side of Figure 3, approximate elevation 819.3

Figure 5. Separation of second lift joint, approximate elevation 817.8. Separation does not look recent.

Other than the top two lift joints (Figure 4 and 5), none of the lower lift joints appear to have significant separation. The corner looks tight and free of any major cracks.

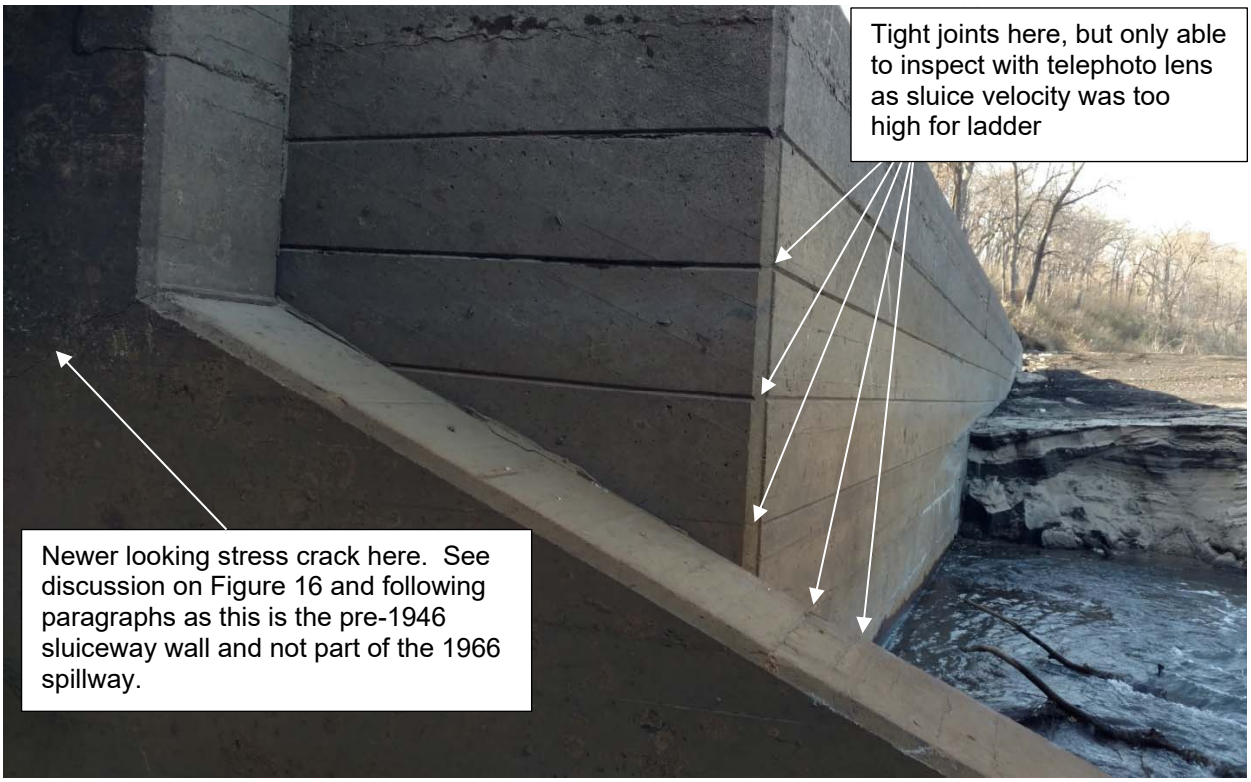


Figure 6. East face of spillway lifts. The sluiceway wall in foreground is much older than the spillway.

Seepage coming from the downstream face of dam near the right abutment was noted from the fourth lift joint down from top. However, Ayres was unable to determine if this seepage was coming from under the right abutment (transferring along crack) or flowing from the impoundment sediments through the crack. Figure 7 shows the lower rock layers are weeping about two feet lower than the lift joint.

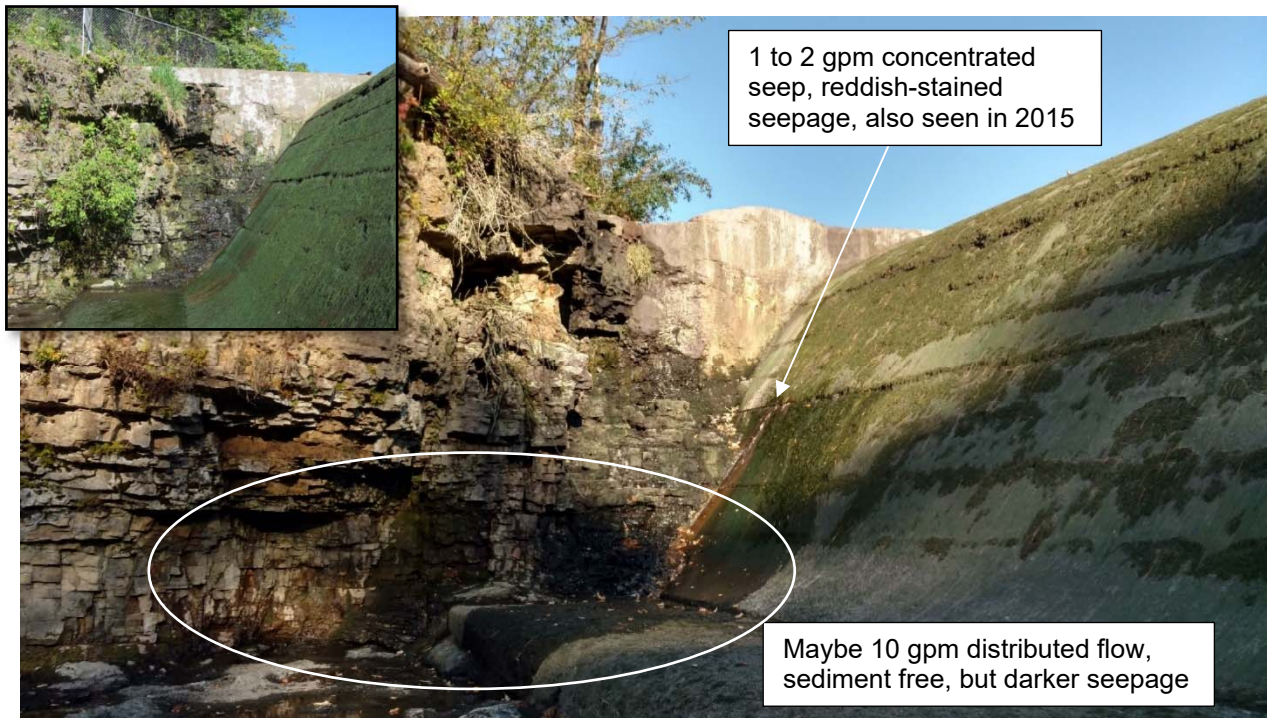


Figure 7. Downstream face of spillway near right abutment. Inset shows condition in 2015.

Figure 8. Typical discharge for clay tile foundation drains, possibly containing iron bacteria (red stains, labeled as “ochre” in the 1992 documents) and indicating significant levels of calcite deposits in drains (2020 minus 1966 is only 54 years, but 6” drain exits are partially blocked with calcite)

Figure 9. Looking eastward along spillway crest at spalling loss of 0.33 feet of concrete depth along deep longitudinal crack that runs from spillway crest down through at least one lift joint. Crack (but not the spall) is shown in October 1992 crack inventory, and no post-tensioned anchor is within damaged concrete area.

Figure 10. Another large spall, looking at top of spillway with upstream face inset to right. This crack extends through at least two lift joints, perhaps this is the same spall noted in 1992 but repaired thereafter. Inset shows view of this crack from upstream after cleaning – note how crack goes down at least through two lift joints (three horizontal monoliths).

Between 9 and 15 inches (variable height along length of prior abutment tie-in wall) of the right abutment concrete and bedrock was removed by the 2020 flood. Figure 11 shows the overall area, and Figure 12 shows the remaining bedrock where the concrete used to hold back headwater.

Figure 11. Looking west at right abutment, noting loss of up to 36 inches of shoreline soil. The tree trunk is approximately 21 inches in diameter at breast height for scale reference. Insets show 2015 condition.

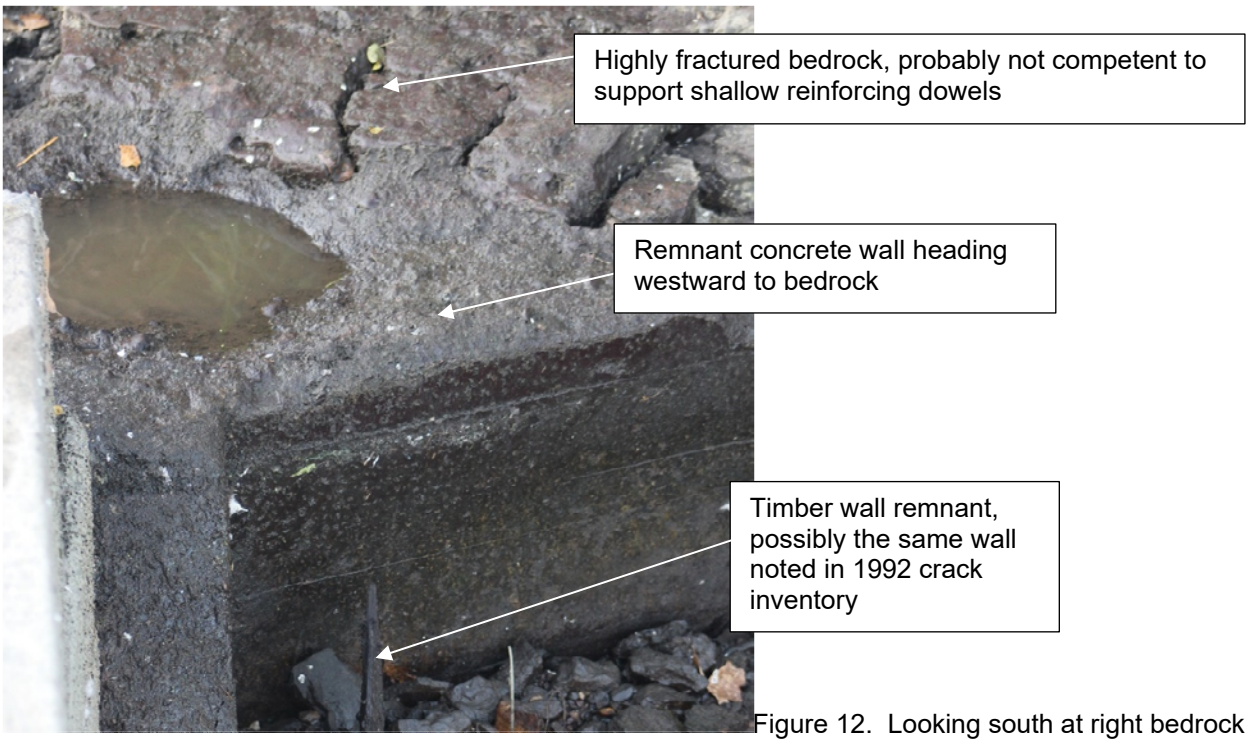


Figure 12. Looking south at right bedrock

The bedrock is most likely the same as recovered in nearby borings to elevation 820 at Junction Falls by SOCON in 1989. If so, this bedrock would be light brown dolomite with vugs, numerous vertical,

horizontal, and inclined joints with intermittent shaley seams and a RQD value of 7%. From Ayres' experience on this same bedrock at other local dams, this type of bedrock is susceptible to freeze-thaw damage (external weathering), internal seepage, and hydraulic plucking during overtopping events.

The left abutment of the spillway is sound, but surface weathering and efflorescence are widespread.

Figure 13. Left abutment of spillway, note all these logs are from the October 12 rain event

Figure 14. Looking northeast at spillway and left spillway abutment on October 5 (note lack of logs shown in Figure 13).

Figure 15. Looking downward at sluice gate stem, note loss of structural section, severe corrosion, and possible bow (dashed lines indicate expected edge of beam). Gate was extremely difficult to operate.

Figure 16. Looking southward at sluice gate, note damage to lower chord (log strikes) and strapping

The crack on the right sluice wall was not written in the October 1992 inventory, and this crack does appear newer than the other cracks on the dam. A differential diagnosis of this crack's cause would

include impoundment ice pushing southward against the relatively thin sluice structure OR thermal expansion differences between the large spillway mass and relatively thin sluice/powerhouse masses. The crack is a concern as it cannot be monitored directly during impoundment refill events. However, Ayres believes if the City wants to refill the lake, then the sluice deck movement could be monitored with a bubble level (simple inclinometer), regular monument surveys, and/or visual checks.

In Figure 17, the powerhouse trashrack is no less than 50% clogged with debris, which is the same clog percentage noted in 1992. Indeed, some of this debris looks very old. Given the large range in trash size and composition and understanding that cleaning a rack 12 feet below the surface is difficult for manual rakes, this rack plugging is most likely due to inadequate reach on the rack cleaning utensils.

Figure 17. Trashrack, plugged 50%. Also note sand deposits faintly visible in intake bay behind trashrack. Powerhouse intake bay gate is also faintly appearing behind trashrack – note that this gate's invert sill is several feet higher than the sluiceway gate.

After looking at the Powell Falls structure, Ayres did travel to the upstream end of the former Lake Louise to look at the Junction Falls tailrace, and Ayres consulted with dam operator Brian Hatch about ongoing Junction Falls turbine performance after the drawdown. The dam operator confirmed that Junction Fall's turbine has indeed now aerated, and he confirmed the turbine is a James Leffel unit (now part of the Canyon Hydro ownership). From a visual observation of the tailrace surface (water clarity was less than 30 inches), Ayres observed that the Junction Falls tailrace scour hole is not large enough to threaten the dam. However, Ayres did not dive or hydrosurvey the scour hole. Ayres did not survey the tailrace but it appears the tailrace lowered one to two feet from pre-drawdown conditions. Ayres did not evaluate how the lowering of Junction Falls' tailwater will impact the long-term cavitation and power production performance of Junction Falls, but a loss of power production efficiency could be expected if the draft tube aerates.

One solution to stop the aeration of the Junction Falls tailrace is to modify the draft tube (see FERC Exhibit F-14 Drawing) to accommodate the new average tailrace waterline. This would decrease aeration but might exacerbate cavitation potential, so more study would be needed if this option is selected.

Figures 18 and 19 show the tailrace of Junction Falls.

Figure 18. Looking upstream at Junction Falls tailrace. Note that waterline of scour hole is well downstream of spillway toe. However, Ayres did not walk on the toe of the Junction Falls spillway, so this view is as close as Ayres was able to safely access during the inspection.

Figure 19. Looking northward at tailrace of Junction Falls. The scour hole along the training wall does not seem to be under the wall, though Ayres did not dive or hydrosurvey the ponded water.

Unintended Refill Risk Estimation

If the RFMU chooses to keep the impoundment drawn down, there is a risk that the lake would refill during large rain events. To inform RFMU how various Powell Falls management options might impact risks of an unintended refill affecting sediment release and debris plugging between now and the end of the project's license, Ayres conducted high flow frequency and flood routing analyses to estimate the risk of the Powell Falls pool refilling in winter, spring, and summer. Three outflow configurations were considered, representing the range of dam modification options considered to be available in the short term (within the next 12 to 18 months). The discharge rating curves developed for each option are representative but not definitive, as the final design details of each configuration could change.

Discharge Configurations

The three configurations considered for releasing flow through Powell Falls Dam were as follows:

A. Existing condition: 69" high sluice opening (maximum the gate will currently open) with sharp gate bottom lip edge exposed and a correspondingly low discharge coefficient; turbine flow available at up to a 60 percent wicket gate opening beginning at pool elevation 815 (NAVD88 datum, typical throughout report). For this case the estimated maximum outflow at elevation 822.1, the dam crest, is 710 cubic feet per second (cfs).

B. Enhanced sluice opening with turbine machinery removed: Maximum sluice opening height 72" and sharp upper edge eliminated to provide a more favorable discharge coefficient; turbine passage flow controlled by intake sill at low impoundment stages, but by draft tube diameter at higher impoundment stages. Turbine is removed by disconnecting shaft and pulling turbine off to side, anchoring turbine to wall and out of the way of flow passage. For this case the estimated maximum outflow at elevation 822.1, the dam crest, is 900 cfs.

C. Replace turbine with a 6' square "window:" Sluice same as existing condition; turbine removed to expose the full draft tube entrance for flow, and additional flow capacity provided through a 6' by 6' opening in the downstream powerhouse wall with sill elevation 808.7. The corresponding estimated flow capacity at the dam crest is 1,130 cfs.

Other discharge configurations are possible but were not studied hydrologically at this time (though they would be studied in more detail later if these options are selected by RFMU). These other alternatives and the reason they were not studied at this time are:

1) Start dam removal early by removing part or all of the spillway. Of all the options available, Ayres believes this option poses the highest risk for unmitigated sediment release unless RFMU is willing to either invest in upfront channel stabilization or wait several years for the channel to naturally stabilize.
    a. After a large opening is cut into the Powell Falls Dam, the RFMU will have no ability to control sediment cutting during large flood events. If vegetation is not established sufficient to withstand the post-removal lakebed shear stresses, an environmental risk exists that as much as 40,000 cubic yards could be released downstream during a single event. To mitigate this risk, sediment management during early dam removal (while sediments are still wet and before they have consolidated or developed a good vegetative cover) would prudently include dredging of the proposed channel and banks to final grade and width, armoring of the channel to prevent rapid incision and banks to prevent lateral migration, and rapid vegetation of the remaining sediments.
    b. Ayres believes this dredging and restoration plan cannot be approved in time for January-February 2021 implementation (when frozen conditions would be expected), so the

earliest realistic timeframe for this option would be dredging between December 2021 and March 2022 (while the ground is still frozen) with spillway removal starting in August 2022. While Ayres acknowledges that spending more money on upfront dredging and restoration would mitigate risks of sediment release during an early removal, a less costly alternative (see end section of this report) is to wait at least two years prior to proceeding with dam removal so that the Lake Louise sediments can slowly dewater and compact and so that the upstream channel and lakebed have time to develop deep rooted vegetation.

2) Create uncontrolled flow openings. Option C is expected to require localized engineering analyses to show that the remaining powerhouse wall structure is stable. This review and construction authorization is expected to take 30 to 45 days to approve by the FERC because it is a situation that can be controlled still by the intake gate. Based on a very preliminary check of the building, a 6x6 foot opening is not expected to require re-analysis of foundation stability or global stability of the overall dam structure. However, cutting an ungated opening in the powerhouse or sluiceway would require more extensive design and a longer permit review period. So, while Ayres acknowledges that larger openings might be achievable by spring of 2022, there are two key downsides to trying to implement a larger opening earlier (assuming the RFMU could even get a license amendment sooner).
    a. First, the flow going through an ungated opening would not be controllable. Similar to the concerns expressed with excessive sediment incision and lateral migration in the above option, Ayres believes the RFMU would have to spend more funds on pre-dredging and bed armoring efforts prior to cutting a large uncontrolled (ungated) opening in the Powell Falls sluiceway or powerhouse.
    b. Second, removal of larger portions of the powerhouse or sluiceway are not expected to be possible without considerable more design effort which may require a pre-construction potential failure modes analysis and possibly more time and money invested in temporarily (3 years) stabilizing the remaining structure.
    c. In other words, it may be easier to proceed with design of full dam removal (see Option 1 above) than accommodating design risks for removing part of the dam now and still having to keep the remaining portions stable for several more years.

For either of the above alternatives, Ayres has assumed that a FERC Amendment to License is required for early dam removal (Ayres assumes 9-12 months), Chapter NR30 individual dredging permit is required (normally a three to six month process) after updated contaminant testing is completed (two month process), and an Army Corps permit is also required (at least a four month lead time). After dredging, Ayres suggests that to reduce the risk of sediment releases, dredged areas need vegetation roots established prior to removing the dam. We reserve the opportunity to revise our opinions on the above alternatives if stakeholder agencies can confirm our assumed timeline is not accurate.

At least within the interim period (2021-2023), Ayres has completed our refill risk study under the assumption that the above two options will be considered by RFMU as either cost-prohibitive or too risky for sediment release potential. In summary, the refill risks for only Discharge Configurations A, B, and C were studied in more detail.

Hydrograph Development

High flow frequency curves for winter (December-February), spring (March-May), and summer (June-August) were developed from daily flow values at the Kinnickinnic River at County F stream gage for the period of record 2003 to 2020. For each year of record, the highest daily flow in the season of interest was extracted, the seasonal series was plotted against a Weibull plotting position formula, and a logarithmic curve was fit to the series. The daily seasonal flow for each return period was then scaled down to the Powell Falls site by a factor of 0.863, representing a drainage area ratio exponent of 0.7.

Once the 1.1-, 2-, 3-, 5-, 10-, and 20-year daily flows at Powell Falls were estimated for each season, representative winter, spring, and summer hydrographs at a two-minute time scale were developed by scaling observed hydrographs of large seasonal events at the County F gage to match the daily average flow. The gaged flows were recorded at 15-minute intervals, but a two-minute time step proved to be necessary for stable reservoir routing in the next analysis steps.

Reservoir Routing

The hydrographs for each season and return period were routed through Lake Louise and Powell Falls Dam using the three discharge rating curves representing the range of alternatives for powerhouse/sluice modification. The reservoir elevation-storage curve was based on the bathymetry presented in the 2016 Inter-Fluve *Sediment Assessment Report*, but was modified to include Ayres' current understanding of the channel that has been incised upstream of the powerhouse. Figures 20 through 22 show the resulting seasonal stage-frequency curves for powerhouse/sluice modification scenarios A, B, and C above.

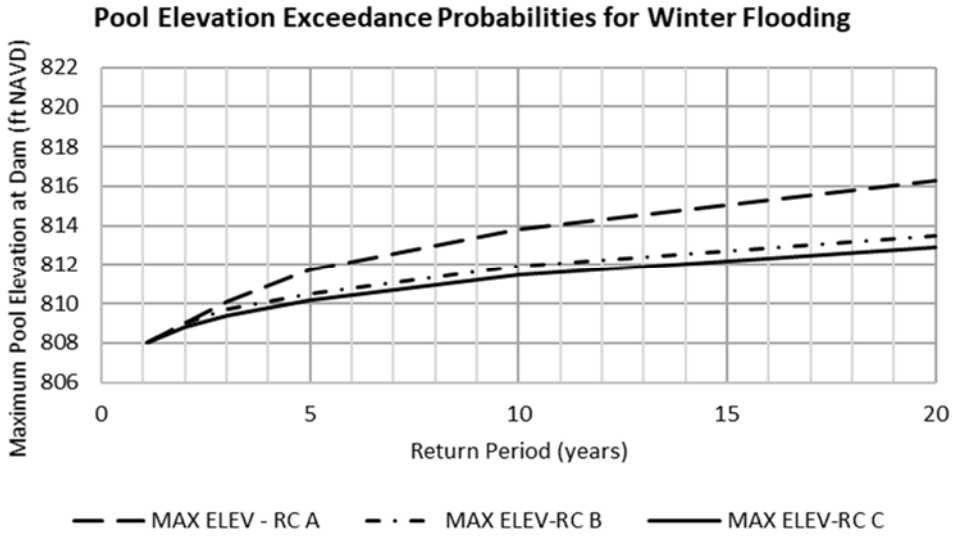


Figure 20

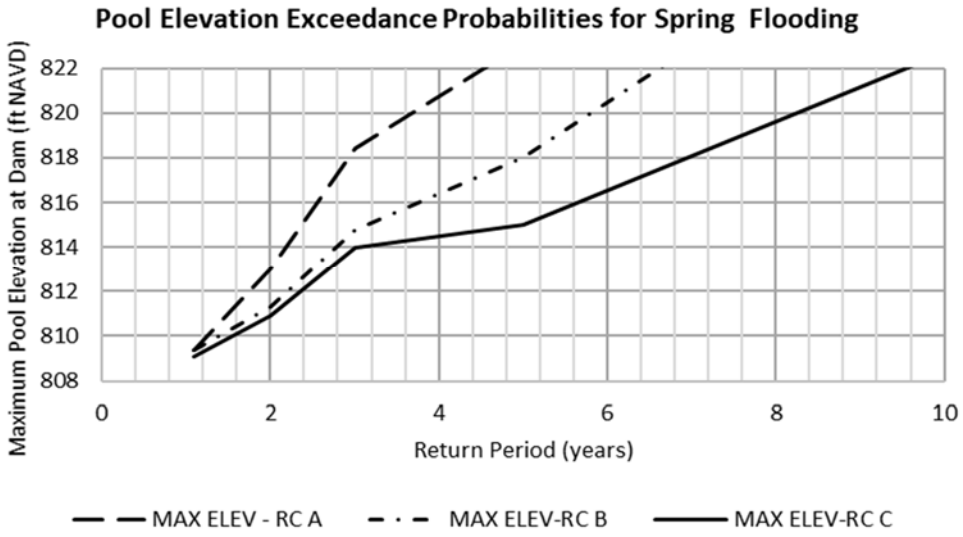


Figure 21

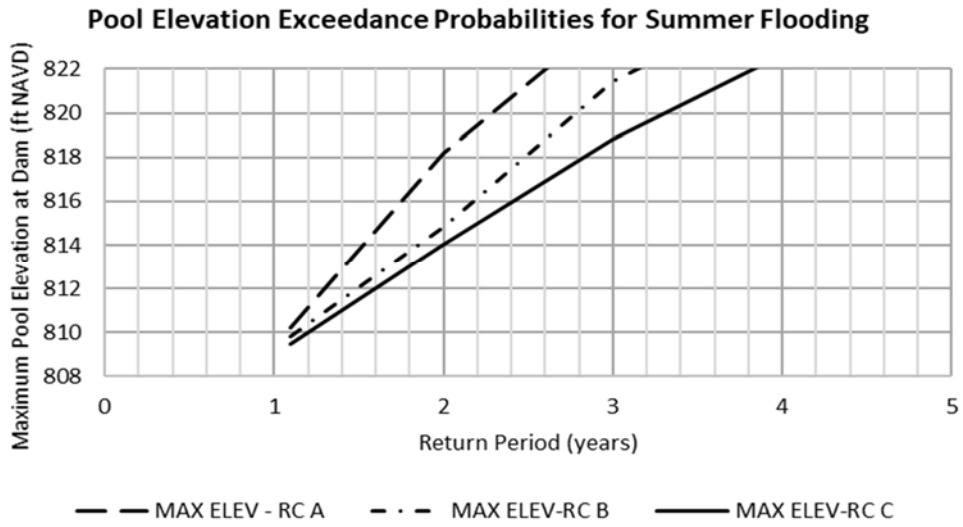


Figure 22

Table 1 summarizes the results shown in Figures 20 through 22 by listing the estimated exceedance probability of two threshold impoundment elevations for each season and discharge configuration considered. The impoundment elevations presented in Table 1 are (a) 822, just below the spillway crest elevation; and (b) 818, or a surface four feet below the spillway crest. This elevation was chosen for listing because it approximately represents the water surface elevation inundating most of the pre-drawdown lakebed, according to the bathymetry presented in the 2016 *Sediment Assessment Report.* Note that the exceedance probabilities listed are seasonal-annual and not overall annual. For example, with the sluice and turbine in their existing condition (Configuration A) there is a 38 percent chance that the dam will be overtopped in any given summer – and there is also a 22 percent chance that the dam will be overtopped in any given spring, including the same year in which a summer overtopping event occurs. Overall, the annual probability of overtopping is larger than either of the individual seasonal probabilities.

Table 1: Estimated Seasonal Lake Louise Elevation Exceedance Probabilities for Three Discharge Configurations				
Season	**Threshold Elevation**	**Discharge Configuration**		
		A - Existing Condition (drawdown)	**B - Improve Sluice Opening Height and Hydraulic Efficiency; remove turbine**	**C - Remove Turbine and Open 6' Square "Window" in Powerhouse**
Winter *(extrapolated)*	822	0.03	<0.02	<0.02
	818	0.04	0.02	0.02
Spring	822	0.22	0.15	0.10
	818	0.34	0.20	0.14
Summer	822	0.38	0.32	0.26
	818	0.50	0.40	0.35

In summary, Ayres found that for any gated option (not an uncontrolled breach) there is little chance of preventing the impoundment from refilling between 2021 and 2023, though the duration of refill may be so small that the reservoir vegetation and bank stability still have a good chance of stabilizing between brief refill events.

Powell Falls' Repair or Management Options

After reviewing the above discharge configurations, do-nothing alternative, and early decommissioning alternative, Ayres believes the RFMU has a continuum of options that can be broken into five option categories as follows:

- Option 1: Repair the dam and refill the Powell Falls impoundment, restoring power generation until a final decision is granted regarding proposed dam removal in 2023.
    - Refill and sediment risk: refill would occur and all sediments will be rewetted. However, the 2024 drawdown will likely face the same challenges observed during the 2020 drawdown. If Option 1 is exercised, Ayres would recommend that this is followed by Option 5 starting in 2024.
    - Repair needs (around[3] $100,000 for design, construction, and permitting)
        - Right abutment must be restored to allow low flow in winter to be distributed across the entire upstream face of spillway to keep ice pressures below the 5000 pounds per linear foot threshold assumed during the 1992 anchor design
            - As a preliminary estimate, this requires 25 cubic feet of reinforced concrete wall, doweled with anchors into the bedrock; and then the upstream bedrock is slush-grouted to prevent seepage through the highly fractured layers of exposed bedrock.
            - A geotechnical engineer should confirm the suitability of this bedrock for reinforcing dowels. From Ayres' surficial inspection, the bedrock is highly fractured, so a geotechnical engineer may prescribe deep dowels and/or removal of the top layer of weak bedrock.
            - Additional concrete placed higher against the right bedrock hillside may be required by the FERC to protect the hillside from further lateral erosion during overtopping events.
        - Divots in spillway should be pressure-washed, cleaned, and repaired in accordance with a suitable concrete repair product. A competent concrete patch should be installed to last at least four years (including three Wisconsin winters).

[3] This opinion of probable project cost is a ballpark estimate based on preliminary data and must be considered no better than 40% accurate.

        - Repair the sluice gate to allow dependable operation during the future proposed decommissioning and dam removal efforts. This repair would include replacement of the gate's bottom chord, strapping, and lift beam, and an overhaul of the gear/actuation system is highly recommended.
        - A thorough trashrack cleaning should be completed prior to refill.
    - Monitoring needs
        - Regular monitoring of the sluiceway deck for movement that might indicate the crack shown in Figure 16 is progressively opening.
        - The powerhouse trashrack should be cleaned completely and adequate utensils procured to allow full rack cleaning. Note that most trashracks are only designed for a few feet of head differential before the rack fails, and debris/ice plugging have been responsible for historical trashrack failures at other projects.
    - Ongoing agency consultation needs
        - Submittal of the FERC required refill plan (due April 2021)
        - Submittal of design report to the FERC division of dam safety for any significant concrete repairs (right abutment wall would be one example) made to the dam.
        - Continued development of a decommissioning plan that includes measures to minimize sediment mobilization downstream (possibly requiring proactive impoundment dredging to pre-form the future channel)
        - Continued monitoring by the state and other stakeholders as budget permits of the downstream reach recovery, especially with regard to how fast or slow sediment is cleared from the tailrace and stabilized in the downstream river reaches.
    - Interim impoundment and powerhouse operations
        - Refill Lake Louise after repairs are made, passing normal flow through the powerhouse and all higher-than normal flows over the spillway
        - Generate power as equipment permits, regularly cleaning the trashrack
        - Do not draw down the impoundment again until final approvals are granted and follow the state and federal conditions of the future dam removal permits.
    - Other risk management strategies
        - Once Lake Louise is refilled, use a barge mounted geotechnical drilling rig to confirm where Lake Louise's historical bed is, particularly with the goal of determining dredging limits.
        - Proactively dredge the future channel expected through Lake Louise after refill in the "wet". Such dredging would need to accommodate new sediment that comes into Lake Louise (like thought probable during the 2020 flood) and excavation to the stable historical bed (possibly deeper than today's channel).

- Option 2: Keep the Powell Falls impoundment drawn down in the current state but do not fix the gate nor pull the turbine. This is the same as Configuration A studied above in this report.
    - Refill and sediment risks:
        - Lake Louise has a 4% chance of rewetting the lakebed sediments at least once per winter, a 34% chance each spring, and a 50% chance each summer.
        - There is a 38% chance each summer that water will pass over the damaged right abutment area, and this becomes a 76% chance of flow passing over this at least once in the next three years.
    - Repair needs (around[4] $10,000)
        - A thorough trashrack cleaning should be completed prior to spring runoff and thereafter as needed to clear the trashrack.
        - Seeding of lakebed in spring 2021 and other stabilization measures as required by the state and federal agencies

[4] This opinion of probable project cost is a ballpark estimate based on preliminary data and must be considered no better than 40% accurate.

        - Lubricate the sluice gate equipment and provide strong City staff to help crank down and up the gate (existing operability) during and after floods.
        - Sandbag the right abutment area to at least two feet above existing spillway crest elevation.
    - Monitoring needs
        - Impoundment levels will vary considerably during even moderate (2- to 3-inch) rainfall events, and it is likely the impoundment will completely refill two to four times per year.
        - Water will need to be passed as much as possible through the turbine and fully opened sluice gate but as the water level falls in the reservoir, RFMU will need to open/close the powerhouse headgate and sluice gate to moderate the rate of water level recession. The goal is to not drop the impoundment levels faster than 6 inches per day to reduce the risk of upstream banks collapse and sudden sediment surges downstream.
        - The trashrack will need to be regularly cleaned after each major flow event.
    - Ongoing agency consultation needs
        - FERC License amendment to keep the reservoir drawn down for the duration of license. It is Ayres' understanding that the FERC considers any drawdown without intent of restoring generation to be an act of decommissioning so a license amendment would be required.
        - Commitment to an interim sediment stabilization plan (perhaps integral with or submitted as a compliment to the decommissioning plan), knowing that the faster that the lakebed can be recolonized by dense roots, the less sediment will remobilize during each impoundment level bounce.
        - Rewriting the decommissioning plan to account for conversion of the lakebed from fully submerged to intermittently submerged to dewatered to stable upland soils.
        - Continued monitoring of the lakebed stability, including frequent drone flights and other monitoring aids as jointly acceptable to RFMU and agencies
    - Interim impoundment and powerhouse operations
        - Pass all normal flow through the sluice, allowing the Lake Louise to refill (in whole or in part) during moderate rainfall events. Larger rainfall events would likely cause the impoundment to overflow the spillway.
    - Other risk management strategies (at additional costs)
        - Consider installing a small jib crane or other hoisting system to allow the dam operator to clean logs out of the sluice gate entrance and off the powerhouse trashrack. A woody debris management plan could also consider whether logs could be captured upstream of Powell Falls' sluice so the risk of plugging was lessened.
        - As part of the interim sediment stabilization plan, proactively grade flatter and armor the toe of banks to improve slope stability.

- Option 3: Keep the Powell Falls impoundment drawn down in the current state but fix the gate and pull the turbine. This is the same as Configuration B studied above in this report.
    - Refill and sediment risks:
        - Lake Louise has a 2% chance of rewetting the lakebed sediments at least once per winter, a 20% chance each spring, and a 40% chance each summer.
        - There is a 32% chance each summer that water will pass over the damaged right abutment area, and this becomes a 69% chance of flow passing over this at least once in the next three years.
    - Repair needs (around[5] $30,000)

[5] This opinion of probable project cost is a ballpark estimate based on preliminary data and must be considered no better than 40% accurate.

- A thorough trashrack cleaning should be completed prior to spring runoff and thereafter as needed to clear the trashrack.
- Seeding of lakebed in spring 2021 and other stabilization measures as required by the state and federal agencies
- Detach the turbine shaft and pull the turbine runners upward to add 30% to 50% more flow capacity to the turbine. Flow would be controlled by the headgate.
- Improve operability and reliability for the gate actuation system to allow the gate to be fully raised to clear the concrete opening and to be regularly lowered to slow the rate of impoundment level recession, with a goal of preventing the impoundment from dropping faster than 6 inches per day following any refill from rain events. This could significantly reduce future riverbank collapses in the impoundment.
- Sandbag the right abutment area to at least two feet above existing spillway crest elevation.

o Monitoring needs
- RFMU will need to be vigilant to monitor forecasted rainfall, be ready to open/close the powerhouse headgate and sluice gate to moderate the rate of water level recession. The goal is to not drop the impoundment levels faster than 6 inches per day to reduce the risk of upstream banks collapse and sudden sediment surges downstream. However, with improved gate operations and a larger flow outlet, it may be possible to keep the impoundment bounce from fully saturating the impoundment bed.
- The trashrack will need to be regularly cleaned after each major flow event.

o Ongoing agency consultation needs
- FERC License amendment to keep the reservoir drawn down for the duration of license. Ayres believes the FERC considers any drawdown without intent of restoring generation to be an act of decommissioning so a license amendment would be required.
- Commitment to an interim sediment stabilization plan (perhaps integral with or submitted as a compliment to the decommissioning plan), knowing that the faster that the lakebed can be recolonized by dense roots, the less sediment will remobilize during each impoundment level bounce.
- Rewriting the decommissioning plan to account for conversion of the lakebed from fully submerged to intermittently submerged to dewatered to stable upland soils.
- Continued monitoring of the lakebed stability, including frequent drone flights and other monitoring aids as jointly acceptable to RFMU and agencies

o Interim impoundment and powerhouse operations
- Pass all normal flow through the sluice and turbine opening, allowing the Lake Louise to refill (in whole or in part) during moderate rainfall events. Larger rainfall events would likely cause the impoundment to overflow the spillway.

o Other risk management strategies (at additional costs)
- Consider installing a small jib crane or other hoisting system to allow the dam operator to clean logs out of the sluice gate entrance and off the powerhouse trashrack. A woody debris management plan could also consider whether logs could be captured upstream of Powell Falls' sluice so the risk of plugging was lessened.
- As part of the interim sediment stabilization plan, proactively grade flatter and armor the toe of banks to improve slope stability.
- As time passes and the lakebed firms up, public will more frequently access the upstream lakebed and Ayres believes the risk increases someone trying to kayak through the dam's sluiceway or wade/fish upstream of this structure. Therefore, site security and public safety should be regularly re-evaluated by decision makers.

- Option 4: Keep the Powell Falls impoundment drawn down and add more flow capacity by opening up a new passage route for runoff to exit the dam
    - Refill and sediment risks:
        - Lake Louise has a 2% chance of rewetting the lakebed sediments at least once per winter, a 14% chance each spring, and a 35% chance each summer.
        - There is a 26% chance each summer that water will pass over the damaged right abutment area, and this becomes a 59% chance of flow passing over this at least once in the next three years.
    - Repair needs (around[6] $100,000 for Option C in this report)
        - Seeding of lakebed in spring 2021 and other stabilization measures as required by the state and federal agencies
        - Detach the turbine shaft and pull the turbine runners upward to add 30% to 50% more flow capacity to the turbine. Flow would be controlled by the headgate.
        - Improve operability and reliability for the gate actuation system to allow the gate to be fully raised to clear the concrete opening and to be regularly lowered to slow the rate of impoundment level recession, with a goal of preventing the impoundment from dropping faster than 6 inches per day following any refill from rain events. This could significantly reduce future riverbank collapses in the impoundment.
        - Remove the powerhouse trashrack. Then open up a section of the powerhouse's southern (downstream) wall to be at least 6 feet wide and 6 feet high. However, flowrate would still be controlled by the powerhouse's intake headgate. A woody debris management plan could also consider whether logs could be captured upstream of Powell Falls' sluice so the risk of plugging was lessened.
        - Sandbag the right abutment area to at least two feet above existing spillway crest elevation.

      Monitoring needs
        - RFMU will need to be vigilant to monitor forecasted rainfall, be ready to open/close the powerhouse headgate and sluice gate to moderate the rate of water level recession. The goal is to not drop the impoundment levels faster than 6 inches per day to reduce the risk of upstream banks collapse and sudden sediment surges downstream. However, with improved gate operations and a larger flow outlet, it may be possible to keep the impoundment bounce from fully saturating the impoundment bed.
    - Ongoing agency consultation needs
        - FERC License amendment to keep the reservoir drawn down for the duration of license and to start early decommissioning (powerhouse modifications).
        - Submittal of a Supporting Design Report to the FERC division of dam safety for work to be done
        - Commitment to an interim sediment stabilization plan (perhaps integral with or submitted as a compliment to the decommissioning plan), knowing that the faster that the lakebed can be recolonized by dense roots, the less sediment will remobilize during each impoundment level bounce.
        - Rewriting the decommissioning plan to account for conversion of the lakebed from fully submerged to intermittently submerged to dewatered to stable upland soils.
        - Continued monitoring of the lakebed stability, including frequent drone flights and other monitoring aids as jointly acceptable to RFMU and agencies
    - Interim impoundment and powerhouse operations

[6] This opinion of probable project cost is a ballpark estimate based on preliminary data and must be considered no better than 40% accurate.

        - Pass all normal flow through the sluice and turbine opening, allowing Lake Louise to refill (in whole or in part) during moderate rainfall events. Larger rainfall events would likely cause the impoundment to overflow the spillway.
    - Other risk management strategies (at additional costs)
        - Consider installing a small jib crane or other hoisting system to allow the dam operator to clean logs out of the sluice gate entrance and off the powerhouse trashrack.
        - As part of the interim sediment stabilization plan, proactively grade flatter and armor the toe of banks to improve slope stability.
        - As time passes and the lakebed firms up, public will more frequently access the upstream lakebed and Ayres believes the risk increases someone trying to kayak through the dam's sluiceway or powerhouse or wade/fish upstream of this structure. Therefore, site security and public safety should be regularly re-evaluated by decision makers.

- Option 5: Proceed with full dam removal (accelerated ahead by two years from schedule presented in January 2020 Initial Study Report)
    - Repair needs ($1.3M to $1.9M[7] with higher end of costs associated with more upfront dredging and lower end of costs associated with a longer period for the impoundment to stabilize prior to removing the dam)
        - Proceed with implementation of decommissioning plan and full dam removal
    - Monitoring needs
        - The impoundment water elevations would not be monitored because the dam operator would have no control over the rate of impoundment rise or fall.
        - However, because there would be no control over velocities within the former Lake Louise impoundment (no gates to close), the monitoring of the wastewater treatment lines will be critical to intercepting backward erosion during large flood events. See risk mitigation measures below.
    - Ongoing agency consultation needs
        - Submit a FERC license amendment to separate/remove Powell Falls Development from the Junction Falls Development license with the intent of starting the physical dam removal process as soon as the amendment is approved.
        - As soon as possible, apply for state and federal permits for the dam removal activities.
        - Monitoring of site environmental conditions as required by permitting agencies
    - Interim impoundment and powerhouse operations
        - Since the lakebed will not be revegetated prior to decommissioning, dredging is recommended with engineered armor on graded banks to stabilize the channel configuration and limit sediment movement.
    - Other risk management strategies
        - Proactively riprap the grades near the wastewater treatment plan crossing (and perhaps also the other sanitary crossing below Junction Falls to better protect these in case a large flood occurs in the future.

[7] This cost opinion is based on preliminary decommissioning plan results, but the cost accuracy is still no better than 25 percent (waiting on stakeholder input for who is funding restoration plan, how much dredging is required, etc.).

Summary

Dam Safety Inspection findings

The following dam safety items should be addressed prior to refilling the lake:

- Restore the right abutment connection concrete
- Fix the gate stem and operator to allow reliable operation
- Develop a monitoring plan for sluiceway section movement, especially during winter conditions
- Clean trashrack
- Restore unit operations
- Patch concrete divots that might allow ice to bond to the spillway's upper lift
- Prepare a plan to prevent ice forces from overloading of spillway post-tension anchors

The following dam safety items should be addressed if the lake is not refilled:

- Figure out a reliable operation plan maintaining drawdown conditions (the levels of repair costs and extents vary with which option is selected)
- Sandbag the damaged right abutment to lessen risks of additional overtopping damage

Options

Table 2 shows a qualitative opinion of risks and costs associated with the above options. Again, these costs are not fully developed and may change depending on how assumptions and regulatory requirements change throughout this process, but in general Ayres feels the relative differences are captured well in the following table.

Table 2. Summary Table

	2021-2023 Constr. Costs	2021 - 2023 Refill risk	Sediment cutting	Bank movement	Vegetation growth
Option 1	$100k	100%	None	None	None
Option 2	$10k	76%	Some	Slow	Moderate
Option 3	$30k	69%	Some	Slow	Moderate to High
Option 4	$100k	59%	Some	Slow	High
Option 5	$1.9M	<10%	Proactive dredging	Proactive dredging	Planted

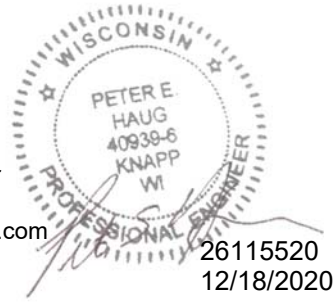
	2024-2027 Constr. Costs	2024 - 2027 Refill risk	Sediment cutting	Bank migration	Vegetation growth
Option 1	upwards of $1.9M	<10%	Proactive dredging	Proactive dredging	Planted
Option 2	$1.3M to $1.5M	<10%	Some	Some	Moderately vegetated
Option 3	$1.3M to $1.4M	<10%	Minor	Minor	Mostly vegetated
Option 4	$1.3M	<10%	Little	Little	Fully vegetated
Option 5	Minor	<10%	Little	Little	Fully vegetated

Ayres presents the above options for RFMU consideration and decision in late January 2021. The RFMU's selected option is expected to be presented by relicensing team during the February 9, 2021, Updated Study Report presentation.

Please feel free to email or call me with questions. As with all feasibility level evaluations of options, Ayres reserves the right to amend our recommendations or findings should new information be provided. Please contact me if you know of additional information that may change the above recommendations.

Sincerely,

Ayres Associates Inc



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26115520
12/18/2020

ATTACHMENT B
Wisconsin DNR and TU Consultation

Meeting Summary

River Falls Hydroelectric Project – Dam Safety Inspection & Next Steps

November 19, 2020, 3 PM CST

Attendees:

Cheryl Laatsch, Wisconsin Department of Natural Resources (Wisconsin DNR)
Mike Rogney, Wisconsin DNR
Dan Baumann, Wisconsin DNR
Kent Johnson, Kiap-TU-Wish chapter of Trout Unlimited (TU)
Kevin Westhuis, River Falls Municipal Utilities (RFMU)
Ellen Faulkner, Ayres
Pete Haug, Ayres
Lesley Brotkowski, TRC
Ben Lenz, TRC

Purpose of call: To discuss status the dam safety inspection and next steps

1) Dam Safety Inspection

- Pete provided an overview of the dam safety inspection, as included in the draft report for FERC that was provided to call participants earlier this week.
- Existing and new cracks were observed, bedrock is in highly fractured near the right wingwall, damage to gate was observed. Heavy debris noted on trashrack; cleaning needed.
- Items that would need to be fixed prior to refill are outlined in Option 1 of the dam safety report. Would require repair approval by FERC.
- The right abutment would require repair to refill. It's safe to continue the operation of refill and drain, but the dam likely would not hold long term without repair if the wingwall was not repaired. Repair would require more than just concrete to stabilize long term; a geotechnical solution would be needed. The dam safety side will play a role in dictating the future proposed condition of repair/refill vs. maintain drawdown.

2) Repair/Refill vs. Maintain Drawdown

- Future Action Options discussed included the following:
    - Option 1: Repair and refill
    - Option 2: Keep Powell Falls drawn down in current state
    - Option 3: Keep the Powell Falls impoundment drawn down and add more flow capacity (which could be accomplished in a few different ways), starting down the path of decommissioning
- Pete walked through Options 2 & 3 in more detail. Both keep the impoundment drawn down, with varying frequency of water level bounce in Lake Louise. Option 3 allows flow and minimizes bounce, but takes away the option to close a gate to reduce flow or manage

sediment. In Pete's experience, the most successful restoration plans have been when the lakebed was exposed for multiple years before dam removal. Option 3 could include a range of flow capacity enhancements between Option 2 and full removal.

- Dam safety is a key consideration and any modifications to the powerhouse or spillway would require FERC approval.
- Keeping Lake Louise drawn down would require a FERC amendment.
- Cost estimates for each option will be provided to the Utility Advisory Board.
- There are a variety of funding programs that could be explored to help offset costs. It may make more sense to invest in #3 vs. #1 for similar costs (more costs up front vs. years down the road).
- Additional sediment sampling for contaminants may be required (January/February when ice is present may be a good time to sample and conduct grading).
- The flooding in 2020 had a big impact on sediment deposition in the Kinni. The drawdown also released sediments downstream that have been deposited in the Kinni.
- TU has discussed which option they would prefer. Kent stated that the group feels there are no environmental benefits to refilling the lake. TU would advocate for a robust restoration plan to be prepared in the next year. Sediment movement out of the lakebed and sediment below the dam in the river is a concern. Come up with a flow plan that minimized sediment transport out of the lake, by minimize sediment transport out of the Kinni. Run of river operation is currently required; should we consider altering flow to move sediment out of the Kinni? Kent suggested fisheries experts at TU and Wisconsin DNR could help with planning, implementation, and funding of the river restoration planning and implementation.
- Wisconsin DNR preference would be to keep the impoundment down and minimize sediment transport as much as possible (Option 2 or 3, with slight preference for #3).
- FERC and state/federal approvals and permits will be required before decommissioning and dam removal can move forward.

3) Next Steps

- Meeting will be held with Utility Advisory Board and City Council on January 19, 2021 to review future action options. Wisconsin DNR and TU will be invited to this meeting.
- Kevin requested letters from TU & Wisconsin DNR for the FERC submittal by December 15, 2020.

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
N7725 Highway 28
Horicon WI 53032

Tony Evers, Governor
Preston D. Cole, Secretary
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Toll Free 1-888-936-7463
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December 15, 2020

Kevin Westhuis, Utility Director
City of River Falls Municipal Utilities
222 Lewis St.
River Falls, WI 54022

Subject: Powell Falls (Lake Louise) Hydroelectric Dam, Recommendation Actions, City of River Falls, Pierce County, Wisconsin

Dear Mr. Westhuis:

Thank you for providing the dam safety information regarding the Powell Falls hydroelectric dam. The Wisconsin Department of Natural Resources (Department) has reviewed the various reports discussing the Powell Falls dam removal project. As part of the agency consultation regarding the Powell Falls (Lake Louise) and Junction Falls (Lake George) dams, the Department is recommending the following actions for the Federal Energy Regulatory Commission (FERC) and the City of River Falls to strongly consider, primarily related to the Powell Falls dam and the drawdown that was initiated on October 2, 2020.

The proposed project of removing the Powell Falls dam can be broken down into three major phases with many moving parts in each phase. Each phase in uniquely different and will require consultation as conditions change and timelines progress.

- Phase one is drawdown and sediment management,
- Phase two is removal of the physical structure, and
- Phase three is the final restoration of the stream channel.

Flood conditions that occurred this past year created a need for an emergency drawdown to assess dam safety concerns this past fall. The need for this drawdown quickly led all parties to phase one. Collectively we need to determine the best path forward given what is known and the conditions that are currently present.

On November 16, 2020, Ayres Associate (Ayres), on behalf of the City of River Falls, provided the draft dam safety inspection report with future action options to be submitted to the FERC by December 31, 2020. The report identified deficiencies of the Powell Falls dam, as well as options for the City of River Falls to consider as part of future actions associated with Powell Falls dam. On December 4th, Ayres provided an augmented report with additional options.

As acknowledged by Ayres, during the November 19, 2020 City of River Falls Utility Advisory Board meeting, the channel in its current state is not stable and may be migrating eastward. Currently, the Kinnickinnic River is being conveyed through a 6-ft. sluice gate opening. Additionally, Ayres commented that the sluice gate may not have sufficient capacity to pass enough flow to keep Lake Louise in a drawn down state. This implies that Lake Louise may refill regularly between now and when the dam is ultimately removed.

Maintain Low Water Levels In Impoundment:

The Department recommends keeping the impoundment drawn down until the Powell Falls dam is ultimately removed. The benefits and considerations of having the impoundment remain drawn down as well as stabilizing or removing sediments until the dam removal is completed are described in the following content.

- The dam safety inspection report identifies various deficiencies, some structural, related to the Powell Falls dam. Of particular interest is the right abutment area, which was damaged and overtopped during the June/July 2020 flood event. In the report, Ayres acknowledges in order to refill the Powell Falls impoundment, the right abutment must be restored. This may include a thorough geotechnical evaluation to verify the integrity of the fractured bedrock, a higher concrete abutment wall to protect the right bedrock hillside from further lateral erosion, grouting, etc.

- By keeping the impoundment in a drawn down state, the storage within the impoundment is maximized. However, should the 6-ft. sluice gate (in addition to the potential opening through the powerhouse) lack adequate capacity to keep the impoundment drawn down, the dam may experience shock loading on a regularly occurring basis. This is a concern for the right abutment, especially given the deficiencies identified in the report. The safety and structural integrity of the dam, as well as overall capacity, should be considered as part of the any action.

- Ayres estimated approximately 8000 cubic yards (CY) of sediment transported during the October 2020 drawdown. In addition to the 8000 CY, Ayres identified an additional 40,000 CY environmental risk (December 3, 2020 Recommendation for Future Action Options Accounting for Risk of Refill letter) and expressed concern with a larger opening in the dam, as it may result in a uncontrolled flow and risk of unmitigated sediment release, than if the flow were conveyed through a smaller, more controlled opening.

- The dam in its existing drawn down state improves thermal regimes in the lower Kinnickinnic River for the cold-water fishery. Repairing the dam and refilling Lake Louise for several years would allow additional sediment to re-accumulate in the impoundment which would require additional sediment mitigation and send another pulse of sediment downstream when the flowage was drawn down again for removal.

Water Management In Lake Louise

During the November 19, 2020 meeting the Department recommended two specific options:

- Utilize the potential frozen substrate this winter (2020/2021) to install grade stabilization measures, channel bank slopes, etc. to assist with channel stabilization to reduce ongoing lateral migration of the river channel. The recommendation considered the risk of spring of 2021 runoff, flooding, etc. to help stabilize the channel and minimize downstream sediment transport.

- Create a larger opening in the dam to reduce the risk of the lake refilling, which may cause additional sediment suspension, prolong the time in which the channel naturally stabilizes, and shock loading of the dam.

The December 4, 2020 report from Ayres identifies options that do not address the Departments concerns to manage sediment movement, water quality impacts to downstream resources, and protect the health and safety of the public.

- The report suggests that only controlled-flow options are feasible between now and April 1, 2021.

- The report suggests the Kinnickinnic River to naturally stabilize, rather than implement proactive sediment management measures.

Fishery and Water Quality Impacts

The Department has concern related to potential high concentrations of total suspended solids (TSS), not just the mass of sediments, routinely occurring between now and when the dam is ultimately removed. There is a strong correlation of

excess TSS and degraded biota and habitat in streams and rivers, supported by numerous studies and sampling results. Turbid waters created by excess TSS concentrations reduce light penetration, which can adversely affect aquatic organisms. Also, TSS can interfere with fish feeding patterns because of the turbidity associated with the TSS. While the Kinnikinic River does see spikes in TSS during runoff events, prior to the drawdown the long-term median TSS measured downstream at County Highway F was relatively low at 5 mg/L.

- Data collected as part of drawdown documented extremely high concentrations of total suspended solids (TSS). The highest concentration appeared to be 3081 mg/L, observed in the City's sample on October 13, 2020.

Although there are currently no numeric criteria for TSS in Wisconsin, Wisconsin data has shown that the target TSS concentration to maintain a healthy stream is between 10 and 15 mg/L. Sustained levels in excess of this results in aquatic life impacts including reductions in macroinvertebrate species richness, the number of intolerant fish species present, and overall declines in fish and macroinvertebrate indices. As noted above, these levels of TSS within the river are exceeded on an episodic basis, however proactive sediment management measures may help reduce the risk of prolonged periods of high TSS, and therefore should be considered as part of future action items related to the Powell Falls Dam.

Conclusion

The Department's position is to protect and minimize any adverse impact to the pristine resource that the Kinnickinnic River has to offer the State of Wisconsin. At a minimum, the Department expects for any action that is pursued by the FERC and the City of River Falls, active sediment management, potential risk to the resource, and life, health and property, be prioritized. This may include proactive measures, such as bank sloping or stabilization, vegetative cover (seeding), sediment removal, etc.

Department committed our own staff to assist with water quality sampling and observations, fisheries expertise, dam safety recommendations, and other resource input during the initial drawdown activities. The Department recognizes that the City's options include social, fiscal, and environmental responsibilities. We will continue to work closely with the City of River Falls, and all the stakeholders. The Department would like to thank the City of River Falls for ongoing efforts and discussions related to the matter at hand.

Sincerely,

Cheryl Laatsch
Statewide FERC Coordinator, Wisconsin Department of Natural Resources

Cc: Cheryl Laatsch, WDNR, FERC Coordinator
Lesley Brotkowski, TRC
Peter Haug, Ayres Associates
Scott Wagner, TU

KIAP-TU-WISH CHAPTER TROUT UNLIMITED
Conserving, protecting, and restoring cold water fisheries and their watersheds in Polk, Pierce, and St. Croix Counties, Wisconsin.

December 15, 2020

Kevin Westhuis, Director
City of River Falls Municipal Utilities
222 Lewis Street
River Falls, WI 54022

Dear Mr. Westhuis,

During the River Falls Utility Advisory Board meeting on November 19, 2020, you mentioned that the Kiap-TU-Wish Chapter of Trout Unlimited should share our recommendation on a preferred post-drawdown option for the Powell Falls Dam and Lake Louise. Kiap-TU-Wish appreciates your invitation and given that the complexity of this situation is beyond our experience, we contracted with Inter-Fluve to advise us on the best route forward. We feel Inter-Fluve's extensive experience with dam removal and river restoration nationally and in Wisconsin can best inform us and everyone working on this issue.

Via the following Technical Memorandum that Inter-Fluve prepared on our behalf, Kiap-TU-Wish recommends that the Powell Falls Dam be removed as soon as possible, as proposed in Option 5 of the Ayres (December 3, 2020) report on future action options. However, recognizing that time will be needed to finalize the decommissioning plan, obtain FERC approval, and secure the funding needed for dam removal and river restoration, we also recommend that interim drawdown management actions be taken as soon as possible, to limit the impact of sediment transport downstream and to prepare the former impoundment for future river restoration. The interim drawdown recommendations are presented in Inter-Fluve's Technical Memorandum, along with recommendations for dam removal and river restoration.

If you deem it appropriate, feel free to include our recommendation in the City's submittal to FERC (Powell Falls Dam inspection report and recommendations for future action) on December 31, 2020, and as input for discussion at the joint River Falls Utility Advisory Board-City Council workshop on January 19, 2021.

Kiap TU Wish recognizes that the unprecedented flood on June 29, 2020 totally changed the trajectory of this project, and that time and resources will be needed to accomplish our proposed recommendations. We believe strongly that the June 29 flood created an emergency for the Utility, and we stand ready to fully support an effort for legislative relief, if the City should choose to go that route. We have also begun a discussion with the Wisconsin Department of Natural Resources (WDNR) on the use of their trout crews to assist with Kinnickinnic River restoration. WDNR and Kiap-TU-Wish have extensive experience as stream restoration partners, and we feel we can provide excellent support for river restoration planning and implementation, as well as project funding and resources.

c/o Scott Wagner, President | P.O. Box 483 | Hudson, Wisconsin 54016-0483 | 715-781-6874

Thank you for your consideration of our recommendation. We look forward to working with you to create a bright future for the Kinni in River Falls. Feel free to contact us with any questions.

Sincerely,

Scott Wagner, President
Kiap TU Wish Chapter
Trout Unlimited

Gary Horvath, Vice President
Kiap-TU-Wish Chapter
Trout Unlimited

Cc: Lesley Brotkowski, Senior Ecologist, TRC

TECHNICAL MEMORANDUM

To: Kiap-TU-Wish Chapter, Trout Unlimited

From: Sean Morrison and Marty Melchior, Inter-Fluve

Date: December 14, 2020

Re: Powell Falls Post-drawdown Preferred Option

Following the October 2020 drawdown of the Powell Falls Impoundment on the Kinnickinnic River in River Falls, WI, Inter-Fluve was contracted by the Kiap-TU-Wish Chapter of Trout Unlimited (TU) to assess the five post-drawdown options proposed by Ayres Associates (2020a) and recommend a preferred option for the impoundment following the drawdown and before completion of stream restoration. Inter-Fluve and TU recommend the Powell Falls Dam be removed and associated river restoration be completed as soon as possible, as proposed in Option 5 of the Ayres (2020a) report on future action options. However, recognizing that time will be needed to finalize the decommissioning plan, obtain FERC approval, and secure the funding needed for dam removal and river restoration, we recommend that interim drawdown management actions be taken as soon as possible, to limit the impact of sediment transport downstream and to prepare the former impoundment for future stream restoration. The interim drawdown recommendations are presented below ("Recommendations", pages 4-6), along with recommendations for dam removal and river restoration (pages 6-8).

PROJECT BACKGROUND

Powell Falls and Junction Falls Dams impound the Kinnickinnic River within the City of River Falls, Wisconsin, approximately 10 river miles upstream of the river's confluence with the St. Croix River and 30 river miles downstream from its headwaters in central St. Croix County. Both dams are currently licensed under Federal Energy Regulatory Commission (FERC) Permit no. 10489. The City of River Falls Municipal Utilities (RFMU) is proposing to relicense the Junction Falls Development and decommission the Powell Falls Development with dam removal. Currently, the City is planning to remove the Powell Falls Development and complete stream restoration by 2026 (City of River Falls 2018). Inter-Fluve has been and continues to be a project partner in the dam removal process (Inter-Fluve 2016, 2017a, 2017b, 2017c, 2020a, 2020b).

The City, along with stakeholder groups, have completed numerous studies on the feasibility and desired outcomes of potential dam removal. This work culminated in the City of River Falls Kinnickinnic River Corridor Plan (HKgi 2019) which indicates that community stakeholders give high priority to the "protection and restoration of the river's ecology and natural

resources." At the request of TU, precedent photos from past river restoration projects completed by Inter-Fluve, which are considered to meet the community's desired outcome, are provided in Appendix A. However, Inter-Fluve and TU recommend that a Kinnickinnic River restoration plan (within the former Lake Louise impoundment) be prepared, identifying the desired ecological goals and objectives for the river and the habitat features needed to achieve them. The river restoration plan should be integrated with the Kinnickinnic River Corridor Plan, to ensure that goals for public use and recreation are met. Examples of river habitat features and recreational improvements could include:

- Bioengineered and/or rock-reinforced streambanks
- Large wood habitat structures
- Deep pool habitat
- Fish spawning habitat
- Backwater areas for rearing habitat
- Habitat boulders
- Floodplain revegetation
- Tributary restoration
- Integrated streambank protection of infrastructure
- Grade control riffles to protect buried infrastructure
- Riverside trails, boardwalks and/or crossings
- Designated river access points for recreational boating and fishing

A list of past planning efforts for River Falls and the river corridor are provided in the Kinnickinnic Corridor Plan (HKgi 2019). Past reports and planning efforts as they pertain to the dam removal are briefly discussed below. The Lake George and Lake Louise Sediment Assessment Report (Inter-Fluve 2016) discusses the sediment size, volume, and sediment chemistry of the impoundments as well as potential mitigation and removal strategies. A dam removal and river restoration feasibility study was conducted and found that dam removal was a "cost-effective method of relieving concerns for public safety, achieving trout stream restoration goals, eliminating long-term dam repair and maintenance, and improving recreational opportunities" (Inter-Fluve 2017b).

In 2018, the city council voted to relicense the Junction Falls hydro facility, but remove the Powell Falls hydro facility and complete associated stream restoration by 2026 (City of River Falls 2018). The 2018 River Falls City Council resolution notes that "The City shall document the Powell hydroelectric facility removal process to evaluate ecological restoration successes and

failures and use those findings to enhance strategies for the ultimate removal of the Junction Falls hydroelectric facilities and associated river restoration" (City of River Falls 2018). To that end, Inter-Fluve and TU will be preparing a monitoring plan to assess the ecological outcomes associated with Powell Falls Dam removal and river restoration. The most recent efforts have focused on developing a Powell Falls Dam decommissioning plan for FERC approval. An initial study report was submitted to FERC on January 30, 2020 which outlined the proposed Powell Falls Dam decommissioning plan (Ayres 2020c).

DRAWDOWN EVENTS

On June 28-29, 2020, a large rain event (6.75 inches in River Falls) caused flooding within the Kinnickinnic River Watershed and the surrounding areas. At USGS gage 05342000, located at the County Road F crossing in Pierce County, discharge peaked at 6,450 cfs at 2:45 pm. For comparison, the 10-year recurrence interval flood at the Powell Falls Dam is 6,800 cfs (FEMA 2011). The June 28-29th flood event damaged the Powell Falls Dam and prompted the River Falls Municipal Utilities (RFMU) and Ayres to lower the Powell Falls Dam impoundment (Lake Louise) to inspect the dam structure (Ayres 2020b).

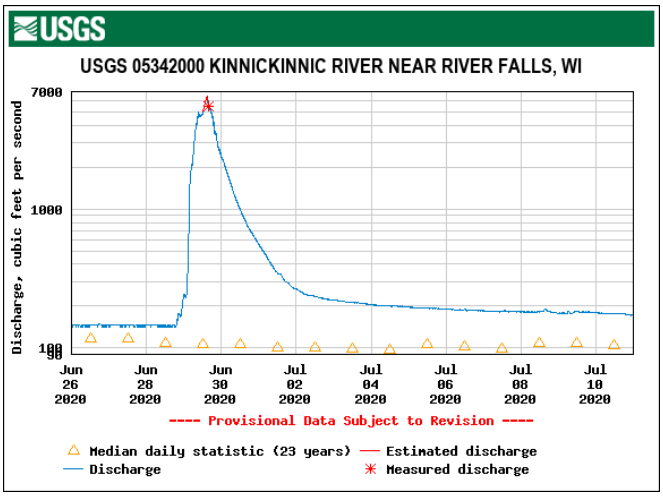

Figure 1: USGS gage data from the flood occurring on June 28-29, 2020.

The drawdown of the impoundment began October 2nd by opening the dam sluice gate. The drawdown was completed on October 15th. The Kinnickinnic Corridor Collaborative and River Sky Drones have been flying repeat drone surveys over the newly exposed lakebed before, during and after the drawdown. Inter-Fluve is in the process of analyzing these data. Initial results show channel formation began by October 4th. A 1.83-inch rain event on October 12th caused the impoundment to temporarily refill. On October 15th, the channel had incised, increased sinuosity and narrowed compared to images collected prior to October 12th. Since October 15th, the channel continues to laterally migrate to widen its channel within the former

impoundment. It is apparent from ground observations and the drone imagery that the refusal surface sampled by Inter-Fluve (2016) for the 100-200 feet immediately upstream of the dam was not bedrock or the former channel bottom, but is likely a layer of sand or sandy gravel that could not be penetrated by the probes. Instead, the future stream profile is likely to more closely resemble the one shown in the Ayres Powell Falls Decommissioning Plan dated January 30, 2020 (Ayres 2020c). The Inter-Fluve sediment probing defined refusal in a wedge from 815 ft to 810 ft between Station 2+00 to 5+00, while the Ayres profile conservatively assumed bedrock at approximately Elevation 805 ft.

POST-DRAWDOWN OPTIONS

The Ayres (2020a) report on future action options presents five options for the Powell Falls Dam post-drawdown and prior to full dam removal. These options are summarized in the Ayres (2020a) report as:

1. "Option 1: Repair the dam and refill the Powell Falls impoundment, restoring power generation until a final decision is granted regarding proposed dam removal."
2. "Option 2: Keep the Powell Falls impoundment drawn down in the current state, but do not fix the gate nor pull the turbine."
3. "Option 3: Keep the Powell Falls impoundment drawn down in the current state, but fix the gate and pull the turbine."
4. "Option 4: Keep the Powell Falls impoundment drawn down and add more flow capacity by opening up a new passage route for runoff to exit the dam."
5. "Option 5: Proceed with decommissioning."

RECOMMENDATIONS

While considering the preferred post-drawdown option, Inter-Fluve weighed options in the context of future stream restoration and recreational development in the former impoundment, as desired by the community and adopted by the City (HKgi 2019). Inter-Fluve also considered potential downstream impacts (Inter-Fluve 2017a), and the preferred option is anticipated to minimize downstream impacts to the maximum extent feasible. The structural integrity of the dam structure was not assessed by Inter-Fluve but is discussed in the Ayres (2020b) inspection report.

The option preferred by Inter-Fluve and TU is Option 5 from the Ayres (2020a) report on future action options. In the paragraphs below, Inter-Fluve makes recommendations for consideration to improve restoration possibilities and save money until decommissioning, dam removal, and stream restoration can proceed. These recommendations are based on experience with over 50 dam removals nationwide. Each recommendation needs to be investigated within the context of safety and structural engineering needs as defined by Ayres and the City. These

recommendations are based on our review of both the Ayres (2020a) report and the decommissioning planset (Ayres 2020c). Interim drawdown recommendations are applicable if options 2-5 are selected.

Interim Drawdown Recommendations

- *Powerhouse flow control* - From now until the time of dam breaching, Inter-Fluve agrees with Ayres that keeping the powerhouse outlets open as dewatering tools is a good approach. Reconfiguration or removal of penstock or other outlet components should consider the potential need for control of water levels. Having a limited outlet flow can help to minimize upstream erosion of impoundment sediment during high water events by creating backwater conditions that reduce upstream shear stresses and erosion.
- *Revegetation* - The plan recommends natural revegetation of the impoundment sediment surface. Seed the former lake bed with a cover crop seed mix, using methods outlined in the Wisconsin DNR's technical standard 1059 and/or the Wisconsin DOT's standard specification 630. Other dam removals in Wisconsin have shown that former dam impoundments, if left to revegetate naturally, become immediately infested with the Eurasian invasive species reed canarygrass (*Phalaris arudinacea*) at coverages exceeding 95%, with two other Eurasian non-natives, giant reed grass *Phragmites australis* and stinging nettles (*Urtica dioica)*, filling the remaining space. Regardless of whether impoundment sediment is going to eventually be removed for floodplain and river restoration, we recommend immediate seeding of the impoundment followed by invasive plant treatment for the next 3-5 years.
- *Sanitary Sewer Protection* – Inter-Fluve concurs with Ayres' recommendations to lower the existing sanitary sewer crossings. We recommend investigation into the wastewater treatment plant's needs for sewer inflow elevations and any lift station or siphon retrofits that might be necessary to lower the pipes. The final configuration of the pipes should be based on the post-restoration/final channel bed elevations as determined in a geomorphic based restoration plan. Grade control riffles can be constructed to add additional protection but should be integrated into the full river restoration plan which considers plan, profile and cross-section requirements.
- *Sediment Trapping* – In order to address downstream sediment accumulation concerns, Inter-Fluve highly recommends a sediment trapping plan be implemented as soon as possible. A sediment trap or traps can be installed both downstream and within the impoundment to capture the larger fraction (sand). Finer material, once in the water column, tends to transport downstream to the St Croix River. A trap cleaning schedule can be implemented once the daily average amount of sediment entering the trap is determined. Access and temporary or final disposal areas would need to be determined.

Trapping is typically done as part of a drawdown plan prior to dam drawdown and breaching, but could be implemented after the fact as well. This approach, in combination with pilot channel excavation, can greatly reduce downstream sediment movement.

- *Pilot Channel Excavation* – To minimize downstream sediment release until full river restoration can be implemented, Inter-Fluve recommends that a pilot channel be excavated that will remove the bulk of sediment in the most likely route for the restored channel. The Lake George and Lake Louise Sediment Assessment (Inter-Fluve 2016) suggests a channel capable of transported bankfull flows has a minimum bottom width of 55 ft with 3:1 side slopes. We recommend excavating this channel through the route suggested in the depth of refusal diagrams from the sediment assessment report. This will not be the full final configuration, but approximates its location. The channel can be excavated wider than the final bankfull channel dimensions in order to reduce shear stress and minimize further bank retreat.
- *Excavated Sediment Disposal* – The disposal locations indicated in the Ayres plan are well sited (Ayres 2020c). Inter-Fluve recommends further discussion with the Wisconsin DNR and US Army Corps of Engineers regulatory staff regarding the placement of impoundment material along the eastern margin of the valley. We recommend placement of a soil prism along the access road coming down from Glen Park. This may require some tree removal, and any monument trees should be surveyed to document potential impacts. Any removed wood could be used in the restoration project and the slope replanted. This minimizes the need for a stream crossing during construction, and potentially reduces costs by allowing for localized dozer pushes of sediment versus excavation and trucking followed by grading. Inter-Fluve has used this method of sediment disposal on many dam removal projects. New riverine wetlands are then created through floodplain restoration techniques, thereby offsetting any potential wetland losses.

Dam Removal Recommendations

- *Coffer Dams* - The plan sequencing for Powell Falls Dam removal calls for the installation of coffer dams and the removal of the western section of the spillway (Ayres 2020c). It is typical for removal to proceed first from the area closest to the low point in the river, or former river bed location. The Ayres plan calls for the opposite of this approach. Unless there is a structural engineering reason for the western approach, we recommend removing the eastern segment of the spillway first, which breaches the dam and reduces the need for expensive coffer dams. This approach also further dewaters the surrounding sediments, and eliminates the need for expensive coffer dams.

- *Spillway Sediment* – It may have been assumed, but the Ayres (2020c) plan for dam removal did not specifically include removal of sediment immediately upstream of the dam. We feel that removal of the spillway will require removal of this sediment prior to any other activity taking place. The amount of material removed will depend on the contractor's need for workspace to remove spillway components.
- *Stabilization for Infrastructure Protection* – Inter-Fluve concurs generally with the Ayres (2020c) plan for stabilizing banks near the River Falls wastewater treatment plant. The vegetated mechanically stabilized earth (VMSE) plans are somewhat outdated and can be modified to improve chances of success. Horizontal willow placement typically results in loss of most or all willows. If they do grow, a monoculture is often the result. Changes to the filter fabric, lift fabrics and planting materials can greatly improve the success of the integrated bioengineering treatment, if this approach is used.
- *Turbidity Control* - The dam removal plans (Ayres 2020c) call for turbidity control as part of erosion control. Inter-Fluve highly recommends discussion with regulatory agencies to reduce the requirement for turbidity control with this project. Controlling turbidity at a dam removal site is nearly impossible without full damming and pumping and multiple settling ponds for filtration. This approach is very costly and should be avoided. We recommend stressing the trapping of sands and coarser material, but natural transport of finer clay and silt particles.

River Restoration Recommendations

- *Large Wood* – Inter-Fluve agrees that the use of large wood in the restored river channel is an excellent way to improve habitat, but we recommend that large wood design be incorporated only into the final river restoration plan. Large wood design on a river with the flood potential of the Kinnickinnic River can be risky and should be designed by an experienced expert in large wood-based habitat design.
- *Stream Restoration* – Inter-Fluve recommends dam removal and stream restoration be completed as soon as possible to minimize downstream sediment concerns. The longer the dam remains drawn down without removal and restoration, the greater the need for sediment remediation measures (e.g. traps) and the greater the risk to river ecology and recreational users.
- *Trails and Recreational River Access* - Inter-Fluve and TU consider the above recommendations to best align with the goals stipulated in the Kinnickinnic River Corridor Plan (HKgi 2019), including trails and recreational river access. The Powell Falls Dam site is an appropriate location for a bridge crossing, angler access, and a kayak/canoe launch. A paddling launch can be designed as a gravel bar that blends in naturally with the surroundings (see Appendix A). Inter-Fluve recommends that any

trails be located away from the banks of the stream (typically 30 feet is a sufficient setback for trails), to minimize behavior impacts to fish and wildlife, increase the success of nearbank and understory vegetation (and bioengineering success), and to reduce the need for trail relocation or long-term hard stabilization to protect trails.

REFERENCES

Ayres. 2020a. Recommendation for Future Action Options After Accounting for Risk of Refill. Dated December 3, 2020.

Ayres. 2020b. FERC Inspection Letter and Recommendation for Future Action Options. Dated November 12, 2020.

Ayres. 2020c. River Falls Decommissioning Plan. Dated January 30, 2020.

City of River Falls. 2018. Resolution (No. 6234) Recommending Relicensing of Hydroelectric Project P-10489. Dated February 27, 2018.

FEMA (Federal Emergency Management Agency). 2011. F*lood Insurance Study. Pierce County, Wisconsin.* FIS Number 55093CV000A. Effective November 16, 2011. 77pp.

HKgi. 2019. City of River Falls Kinnickinnic River Corridor Plan. 108 pp. Adopted January 22, 2019.

Inter-Fluve. 2016. Lake George and Lake Louise Sediment Assessment Report. Submitted to the City of River Falls and Wisconsin Department of Natural Resources.

Inter-Fluve. 2017a. Kinnickinnic River Corridor Plan – Dam Removal Scenario: Summary of Ecological Impacts. Submitted to City of River Falls.

Inter-Fluve. 2017b. Restoration of the Kinnickinnic River Through Dam Removal: Feasibility Report. Submitted to Friends of the Kinni.

Inter-Fluve. 2017c. Kinnickinnic River Corridor Plan Reconnaissance Level Geomorphic Assessment. Submitted to City of River Falls.

Inter-Fluve. 2020a. River Falls Hydroelectric Project Aquatic Invasive Species Survey. Prepared for the United States Army Corp of Engineers – Planning Assistance to States (PAS) Program

Inter-Fluve. 2020b. River Falls Hydroelectric Project Riverine Habitat Evaluation below Powell Falls. Submitted to the City of River Falls Municipal Utilities.

APPENDIX A -
DAM REMOVAL AND RIVER RESTORATION
PROJECT EXAMPLES

North Mill Creek in the former Rasmussen Lake impoundment – 4 months post removal

inter·fluve

This 4,000 ft segment of Minnehaha Creek was restored to capture a meander planform that had been abandoned due to channel straightening in the 1900s.

RIVERSIDE BOARDWALK TRAIL

POST-RESTORATION, MINNEHAHA CREEK, MN

Minnehaha Creek under construction in January 2009. Large wood is installed in the toe while bioengineered banks are installed above.

RIVERSIDE BOARDWALK TRAIL

POST-RESTORATION, MINNEHAHA CREEK, MN

Looking upstream through the Sawmill Dam impoundment prior to dam removal (Eel River, Plymouth, MA). The dam was built in 1790 (see inset).

RIVERSIDE TRAILS AND LARGE WOOD HABITAT

PRE-DAM REMOVAL, EEL RIVER, MA

inter·fluve

Looking upstream through the former Sawmill Dam impoundment 4 months after removal. 6,000 CY of sediment was removed and a boulder step pool channel constructed. Note the high water line of the pond under the tree canopy (dashed line).

RIVERSIDE TRAILS AND LARGE WOOD HABITAT

POST-DAM REMOVAL, EEL RIVER, MA

Sawmill Dam removal segment of Eel River
- under construction, October 2009

POST REMOVAL TROUT HABITAT
UNDER CONSTRUCTION, EEL RIVER, MA

inter·fluve

Under construction, October 2009

TROUT HABITAT RESTORATION

UNDER CONSTRUCTION, EEL RIVER, MA

This segment of the Arden Park restoration (Minneapolis) included dam removal, channel restoration, canoe and kayak access and numerous park amenities. Children are sitting at approximately the former impoundment elevation.

DESIGNATED ACCESS AND RIVER SIDE TRAILS

POST-DAM REMOVAL, MINNEHAHA CREEK, MN

Boulder pocket water features are prominent in this picture which includes riffle, pool and bar features on a constructed segment of Minnehaha Creek (Minneapolis). The yellow arrow denotes the former impoundment elevation.

HABITAT FEATURES AND RIVERSIDE TRAIL

POST-DAM REMOVAL, MINNEHAHA CREEK, MN

The Hemlock Dam Removal in Washington state involved sediment management, alluvial channel reconstruction and floodplain stabilization. Here, an excavator sits atop the last of the impoundment sediment to be excavated, while the rough cut channel begins to take shape.

GEOMORPHIC FEATURE RESTORATION

UNDER CONSTRUCTION, White Salmon River, WA

inter·fluve

Prior to re-wetting the newly built channel, a contractor begins digging pools and casting bar material to the inside of the meander bend.

GEOMORPHIC FEATURE RESTORATION

UNDER CONSTRUCTION, White Salmon River, WA

An excavator fine grades around historic stumps during floodplain excavation at the Hemlock Dam site, Washington.

GEOMORPHIC FEATURE RESTORATION

UNDER CONSTRUCTION, White Salmon River, WA

At the Hemlock Dam removal site, floodplain wood provided initial roughness and protection against avulsion until the aspens took over, as in this photo, taken 10 years post removal.

GEOMORPHIC FEATURE RESTORATION

POST-DAM REMOVAL, White Salmon River, WA

A restored segment of Salt Creek following the removal of a small dam at the Oak Meadows Golf Club.

INTEGRATING PARK AMENITIES

POST-DAM REMOVAL, Salt Creek, IL

Part of a three mile restoration of a tributary to the John Day River involved channel restoration, floodplain excavation and soil remediation, and large wood habitat placement.

GEOMORPHIC FEATURE RESTORATION

POST-DAM REMOVAL, John Day River, OR

The State Hospital impoundment was filled with sediment contaminated with metals and hydrocarbons from nearby industrial uses. 10,000 CY of sediment was removed.

GEOMORPHIC FEATURE RESTORATION

PRE-DAM REMOVAL, Taunton River, MA

State Hospital Dam impoundment following sediment removal and river reconstruction. In 2013, the restored Mill River saw its first run of herring in over 200 years.

GEOMORPHIC FEATURE RESTORATION

POST-DAM REMOVAL, Taunton River, MA

The 18ft high Cedar Creek dam in Ione, WA blocked a major bull trout run. Bull trout are listed as and Endangered Species in the U.S.

GEOMORPHIC FEATURE RESTORATION

PRE-DAM REMOVAL, Cedar Creek, WA

Removal of the Cedar Creek dam included the removal of 20,000 CY of gravel and sand from the impoundment.

GEOMORPHIC FEATURE RESTORATION

UNDER CONSTRUCTION, Cedar Creek, WA

Restoration included channel construction with banks, bars, riffles and pools, and the placement of engineered floodplain and channel large wood. This photo is taken just 6 months after removal. The yellow arrow denotes the top of the sediment deposits.

GEOMORPHIC FEATURE RESTORATION

POST-DAM REMOVAL, Cedar Creek, WA

Constructed bank, riffle and pool features in a newly constructed Cedar Creek following removal of the Cedar Creek Dam. Arrow denotes the former impoundment elevation.

GEOMORPHIC FEATURE RESTORATION

POST-DAM REMOVAL, Cedar Creek, WA

inter·fluve

An angler flycasts in a constructed riffle with boulder pocket water on the Sheboygan River. The gravel bar in the foreground is part of a kayak launch site.

RECREATIONAL AMENITIES

SHEBOYGAN RIVER, WI

A local angler flyfishes for brown trout in the restored Boardman River. The project removed three dams and over 1 million cubic yards of sediment. Six miles of river was restored.

LARGE WOOD HABITAT

POST-DAM REMOVAL, BOARDMAN RIVER, MI

A contractor drives log piles as part of engineered log jam construction on the Boardman River. Wood was used to stabilize banks and provide habitat for resident fish species.

LARGE WOOD HABITAT

UNDER CONSTRUCTION, BOARDMAN RIVER, MI

A tuber floats past large wood habitat at the upper end of the Boardman River restoration. The dam was removed in 2018.

LARGE WOOD HABITAT

POST-DAM REMOVAL, BOARDMAN RIVER, MI

A constructed riffle on the Boardman Dam Removal project. At this, the upper end of the project, only 5-6 feet of sand had to be removed to expose the former floodplain. The former impoundment elevation is clearly visible (yellow arrow).

RIVER RESTORATION

POST-DAM REMOVAL, BOARDMAN RIVER, MI

Large wood installed in backwater wetlands as part of the Sheboygan River AOC restoration project.

LARGE WOOD HABITAT AND BACKWATER AREA

POST-RESTORATION, Sheboygan River, WI

This immobile boundary restoration replaced a concrete lined trapezoidal ditch built in the 1960s.

HABITAT AND RIPARIAN VEGETATION

POST-RESTORATION, KINNICKINNIC RIVER, MILWAUKEE WI

This grade control riffle was constructed to protect a sanitary sewer pipe just below the riffle. The streambank was bioengineered in 2001 and the riffle in 2017.

BIOENGINEERING FOR INFRASTRUCTURE

GRADE CONTROL, MENOMONEE RIVER, MILWAUKEE WI

Large wood was used to define channel boundaries in sandy soils for the Beaver Dam Brook Restoration at Tidmarsh Farms. The wood provides habitat for resident brook trout and migrating herring. The project was featured in the NY Times.

RIVER RESTORATION

POST-RESTORATION, BEAVER DAM BROOK, MA

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