Appendix I – Sediment Study
(filed separately due to file size)

POWELL FALLS DAM REMOVAL SEDIMENT STUDY EVALUATION

RIVER FALLS HYDROELECTRIC PROJECT

FERC NO. 10489

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JANUARY 2021

Powell Falls Dam Removal Sediment Study Evaluation

The City of River Falls Municipal Utilities (RFMU) is proposing to decommission the Powell Falls Development of the River Falls Hydroelectric Project (Federal Energy Regulatory Commission (FERC) Project No. 10489) by removing the Powell Falls Dam. Powell Falls Development is located on the Kinnickinnic River in River Falls, Wisconsin. Removing the dam will involve the drawdown and draining of Lake Louise, the impoundment created by Powell Falls Dam.

On May 26, 2020 FERC issued a Determination on Request for Study Modifications for the River Falls Hydroelectric Project.[1] This determination included a staff recommendation to conduct a sediment study to evaluate the impact of the removal of the Powell Falls Dam. FERC requested two study objectives be addressed: "1) compare the amount of sediment that could be released downstream of Powell Falls Dam to the average annual sediment yield in the Kinnickinnic and St. Croix Rivers to determine the level of ecological risk to downstream geomorphology and aquatic resources; and 2) assess the potential effects on geomorphology and aquatic resources based on the predicted level of ecological risk." Part 1 of this report, "Kinnickinnic River Sediment Analysis for Proposed Powell Falls Dam Removal", addresses Objective 1 of the FERC study request. Part 2 of this report, the sediment study ecological risk assessment, addresses Objective 2 of the FERC study request.

To address Objective 1, Ayres compared the overall sediment influx from storage within the impoundment to yearly rates and depositional features within the Kinnickinnic and St. Croix Rivers. The sediment storage of Lake Louise was compared to other system altering events. River reaches in which sediment transport and deposition relative to other reaches were determined. Short-term processes and responses were determined in each geographic reach. Finally, areas for monitoring vulnerable habitat were identified in the Kinnickinnic River.

To address Objective 2, TRC addressed the combined list of ecological risk assessment requirements found in "Dam Removal Analysis Guidelines for Sediment" (Randle and Bounty 2017) and "Guidelines for Dam Decommissioning Projects" (USSD 2015). An opinion of the removal of the Powell Falls Dam was produced that addresses the following ecological risks and benefits to the Kinnickinnic River ecosystem:

1) Water quality deterioration due to increased suspended sediment levels or contaminants;
2) Burial of downstream aquatic spawning, rearing, and holding areas for threatened or endangered species or species of concern;
3) Burial of downstream aquatic species or life stages that cannot find refuge or quickly mobilize out of sediment impact areas (e. g., mussels and fish eggs);
4) Increased deposition in floodplains that could result in change in riparian vegetation when existing species are not tolerant of burial;
5) Sediment deposition blocking aquatic species migration routes;

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[1] FERC accession number 20200526-3005

6) Restoration of riverine habitat in reservoir area;
7) Restoration of heterogeneous grain sizes and sediment bars that support development of more diverse channel processes such as channel migration;
8) Increase in physical habitat features that provide ecosystem benefits, such as channel spawning gravels, bars, islands, large wood features, and side channel activation;
9) Facilitate growth of invertebrate communities;
10) Natural disturbance and sedimentation required for riparian vegetation.
11) Increased exposure to ice jams whose impact are currently mitigated by the dam and reservoir; and
12) Deposition along recreational use areas including navigation channels and fishing areas.

Study Overview

This report contains two parts that address the two objectives in the FERC study determination. Part 1, *Kinnickinnic River Sediment Analysis for Proposed Powell Falls Dam Removal*, addresses Objective 1 by comparing the amount of sediment that could be released downstream of Powell Falls Dam to the average annual sediment yield in the Kinnickinnic and St. Croix Rivers to determine the level of ecological risk to downstream geomorphology and aquatic resources. Part 2, *Powell Falls Dam Removal Sediment Study Ecological Risk Evaluation*, addresses Objective 2 by assessing the potential effects on geomorphology and aquatic resources based on the predicted level of ecological risk. Part 1 used field data collected by Ayres in the lower Kinnickinnic River prior to the October 2020 drawdown, with conclusions edited to reflect preliminary observations from the drawdown. Part 2 also utilized recently collected water data related to the October 2020 drawdown event, including RFMU water quality measurements and drone imagery from the Kinnickinnic Corridor Collaborative. Part 2 reflects heavily on the analysis provided in Part 1, while at the same time comparing the Powell Falls Dam setting with other pertinent information derived from literature-based research.

Part 1.

Kinnickinnic River Sediment Analysis for Proposed Powell Falls Dam Removal

Kinnickinnic River Sediment Analysis for Proposed Powell Falls Dam Removal

Prepared for:

TRC Environmental Corporation &
City of River Falls

1/15/2021

Kinnickinnic River Sediment Analysis for Proposed Powell Falls Dam Removal

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Project Background

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. Both developments are located on the Kinnickinnic River and licensed by the Federal Energy Regulatory Commission (FERC). This sediment study is based on the premise that Junction Falls, with its upstream impoundment Lake George, will remain in place for the foreseeable future, while the Powell Falls Dam will be removed around 2024 (Ayres, 2020).

Powel Falls Dam is a concrete gravity dam, 110 feet long and 22 feet high, with an uncontrolled overflow spillway. The impoundment, Lake Louise, is 15.4 acres with a normal capacity of 37 acre-feet and a normal water surface elevation of 821.8 feet mean sea level. The decommissioning and removal of the Powell Falls Dam will involve the drawdown and draining of Lake Louise which is impounded by the Dam.

The Draft Decommissioning Plan (authored by Ayres, appended to the January 2020 Initial Study Report to FERC, and as revised throughout 2020) presumes a slow stage drawdown over multiple years to naturally stabilize the fine-grained sediments within the no conveyance portions of the impoundment area. This proposed drawdown is dependent on the reestablishment of natural vegetation on banks of the newly formed channel within the impoundment (Ayres, 2020).

The Initial Study Report proposed a slow drawdown to limit the amount of sediment excavation and transport downstream into the system. The goal is to release sediment gradually over a period of years following the drawdown. The first year expects to see an increase (beyond the 5,000 CY of average annual release) of about 10,000 tons (5,000 CY), or at most 100% of the yearly sediment yield tapering off to 2,000 tons (1,000 CY) an increase of at most 20% of the yearly average sediment yield in the sixth year following removal (Ayres, 2020).

This report's field observations and desktop analyses were completed prior the October 2-15, 2020, drawdown of Lake Louise for a dam safety inspection. However, this report's conclusions have been edited to reflect updated understandings (based on preliminary information as the October drawdown's effects on the impoundment and downstream reach are still being studied) about how lessons learned during the October 2020 drawdown are indicative of future drawdown impacts.

FERC Study Request

Commission staff request that the City of River Falls conduct a desktop sediment study to assess the ecological risks and potential effects of releasing approximately 25,100 cubic yards of sediment on geomorphology and aquatic resources in the Kinnickinnic and St. Croix Rivers. The specific objectives of this study are to:

1. Compare the amount of sediment that could be released downstream of Powell Falls Dam to the average annual sediment yield in the Kinnickinnic and St. Croix Rivers to determine the level of ecological risk to downstream geomorphology and aquatic resources

2. Assess the potential effects on geomorphology and aquatic resources based on the predicted level of ecological risk.

Purpose and Objectives

The Draft Decommissioning Plan details the proposed timing, logistics, sequencing, and potential issues within the dam structure. However, the proposed removal of the Powell Falls Dam represents a marked change in the short-term sediment regime of the downstream system.

The purpose of this study is to understand the potential effect of additional short-term sediment influx from the impoundment during decommissioning on the downstream reaches of the Kinnickinnic River (Figure 1). This will include:

- Comparing the overall sediment influx from storage within the impoundment to yearly rates and depositional features within the Kinninkinnic River and St. Croix River.
- Placing the sediment storage within Lake Louise in context with other system altering events.
- Determining reaches in which sediment will be transported and deposited relative to other reaches
- Determining short-term processes and responses of each geomorphic reach
- Identifying areas for monitoring and vulnerable habitat within the Kinnickinnic River.

This report will rely on estimates of sediment volume within the impoundment, average sediment yield of the Kinnickinnic River, flow estimates of the Kinnickinnic River, and impoundment sediment characteristics calculated and determined within the Decommission Plan (Ayres, 2020).

No numerical modeling was done as a part of this study and conclusions are based on conceptual channel evolution models, field visits, and methods from the Dam Removal Analysis Guideline for Sediment (Randle and Bountry, 2017). A site visit to verify the desktop analysis and examine flood impacts was conducted on September 23rd and 24th, 2020.

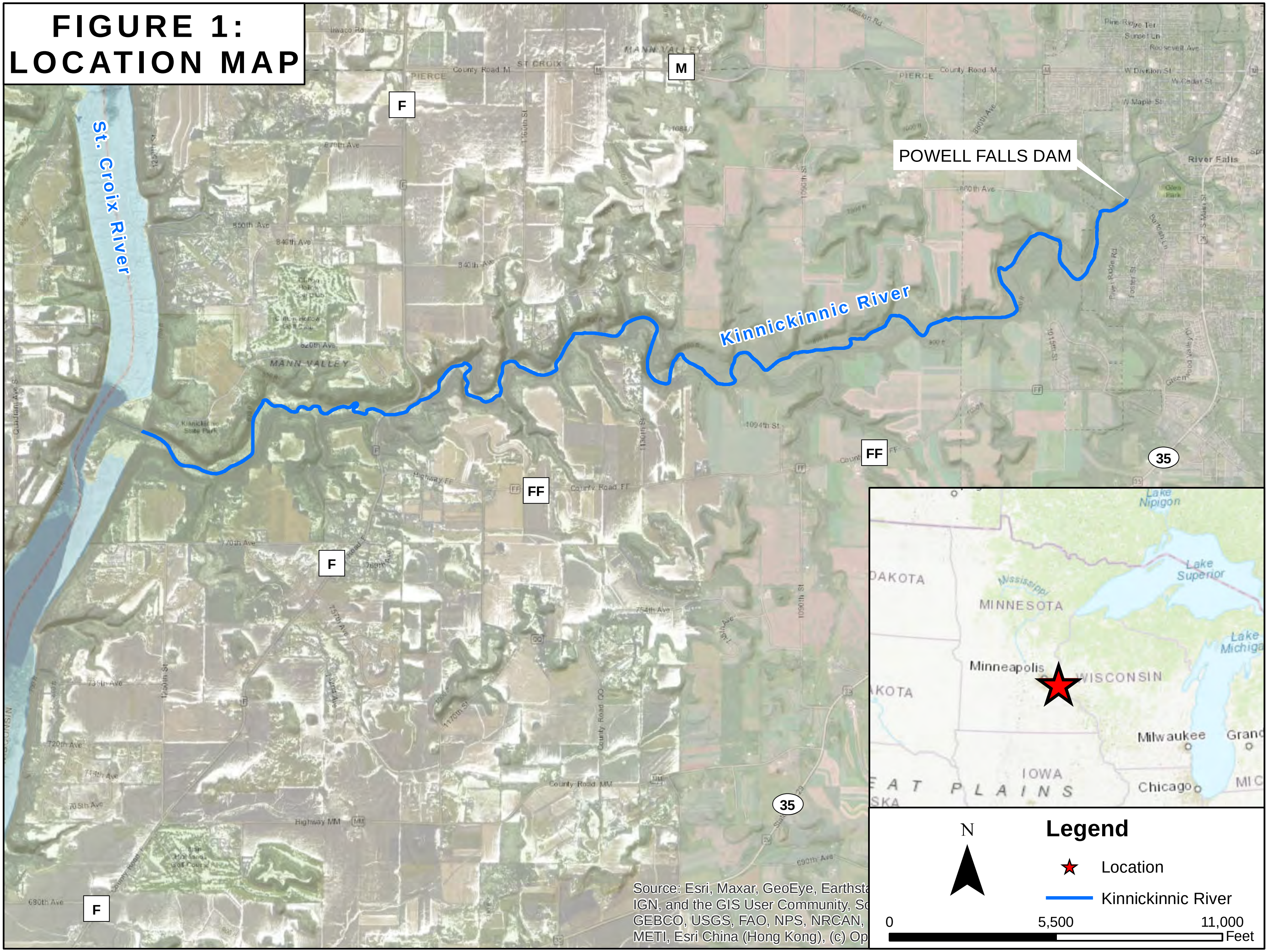

FIGURE 1: LOCATION MAP

Kinnickinnic River Existing Conditions

This study focused on 10 miles of the Kinnickinnic River bounded upstream by the Powell Falls Development and downstream by the confluence with the St. Croix River. This section of river is entrenched within a large valley complex formed by an Early Ordovician sandstone dolomite (Evan et. al, 2007) with the thalweg approximately 125 feet below the top of the valley margin. The watershed of the Kinnickinnic River is located within the extent of the North American continental glaciers, meaning that surficial geology is dominated by extensive surficial deposits of sand, gravel, and glacial till (Kostka, 2004). The Kinnickinnic River watershed specifically is located primarily within the River Falls diamicton, a poorly sorted sand and gravel deposit beneath less than 3 feet of topsoil. The abundant supply of sand in gravel in the upper watershed is responsible for relatively high sediment yield of the Kinnickinnic River. The Decommission Plan estimated that the predicted total sediment yield to the Kinnickinnic River at the Powell Falls Dam is more than 10,000 tons (5,000 CY) per year using USGS gage data (Ayres, 2020). The yearly sediment influx is predominately coarse-grained sandy sediment based on the surficial geology of the watershed.

An intense rainfall event occurred along this reach with approximately seven inches of rain falling within a few hours on June 29, 2020.[1] Based on the gage data, this event is estimated to be a 10-year event with flows reaching approximately 6,000 cfs. This event altered the study reach, which will take several years to recover to pre-flood conditions. The channel response to this flood event offers insight into the anticipated response following removal of the Powell Falls Dam. The flood affected the channel differently depending on the proximity to the dam and the St. Croix. In general, sand was transported from the impoundment and tributary influxes, especially Rocky Branch which is known for large sediment yields, downstream and stored in inundated overbank areas and eddies. It is possible that the impoundment sediment volume was altered[2] in composition and volume during this event, however a reexamination of the impoundment sediment would be needed to accurately calculate changes since the 2015 survey was completed[3]. More of these effects will be discussed in detail within the reach descriptions. The insights provided on channel response and how they relate to the increase in sediment yield resulting from the removal of the Powell Falls Dam will be discussed in the post-removal sections of this report.

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[1] https://mesonet.agron.iastate.edu/sites/hist.phtml?station=RVFW3&network=WI_COOP&year=2020&month=6

[2] The question of whether the impounded sediment volume within Lake Louise increased or decreased is still under future evaluation. Preliminary aerial photography of the drawn down lake bed does indicate that coarser sand (light brown) may have been added on top of the darker black silts of Lake Louise; however, closer to the spillway it appears the lake bed may have been scoured by floodwaters. In short, the impacts of the July 2020 flood on sediment conditions within Lake Louise are not fully understood yet.

[3] "Lake George and Lake Louise Sediment Assessment Report." Inter-Fluve, Inc. 14 March 2016.

Channel Morphology

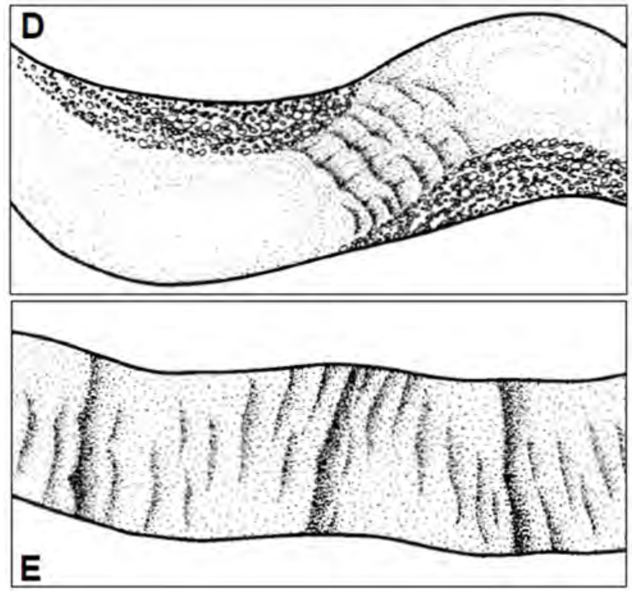

Figure 2: An idealized diagram of a pool-riffle (D) and dune-ripple (E) channel from Montgomery and Buffington, 1997

Channel and bed morphology provide the basis to understand the dominate processes, linkages within the channel network, and overall response to disturbances (Montgomery and Buffington, 1997). Any significant alterations to the channel morphology within a reach are likely the result of a disturbance to or shift in the sediment or hydrologic regime of the reach. The dominate channel morphology is pool-riffle sequences based on the overall channel slope (0.0033 ft/ft) and field investigations.

Pool-riffle channels are characterized by regularly spaced deeps with fine sediment and coarse-grained shallows that create an undulating longitudinal profile at the reach scale, as shown in Figure 2 (Montgomery and Buffington, 1997). These types of channels are extremely common in meandering stream systems. These systems self-maintain with the location and spacing of pools remaining relatively fixed temporally. Typically, these pool-riffle sequences are formed by either an influx of sediment from a tributary, which forms a riffle just downstream or velocity-reversals which occur at high flows (Wohl, 2014). Relative velocities of pools and riffles, where pools are areas of low velocities and riffles areas of high velocities during low flows, reverse during high flow events so that pools become areas of high velocities and riffles experience lower velocities due to friction along the stream bed and turbulence. During these events, bed load in the pools are entrained and transported downstream. As the velocities subside towards the downstream end of the pools, sediment is deposited forming and maintaining the next downstream riffle (Wohl, 2014). Riffles are typically wider and shallower than pools at all flow regimes. This process means that sediment is likely to move in a step-wise fashion downstream, filling pools during low-flow periods and scouring them during flood events (Wohl, 2014).

Roughly at station 60+00 (see Appendix A, page 1), the channel morphology shifts from pool-riffle to dune-ripple due to a reduction in channel slope from the backwater of the St. Croix River. Dune-ripples are a much more uniform channel type with less heterogeneity within the channel (Figure 2). Dune-ripple channels are not stable temporally and will have significant mobility of bed load at all flow regimes, adapting as needed to be most efficient at sediment transport (Montgomery and Buffington, 1997).

The significance of these differing channel morphologies related to the removal of the Powell Falls Dam will be discussed later in this report.

Geomorphic Reach Delineations and Descriptions

Variations in channel confinement, slope, width, valley width, and stream power are the result of changes in underlying geology, boundary conditions, and influxes within a system. Separating reaches based on these variations helps to better understand the response of the overall system and identify specific areas for any disturbance.

Understanding channel interaction with the overbanks and floodplain is essential to analyzing the riparian system. To properly estimate confinement of the active stream channel, a relative elevation model (REM) was generated using GIS software to better evaluate the changes in elevation moving from the thalweg to the overbanks (Figure 3). Fluvial signatures, such as meander scars, cutoff channels, and bars, indicate active stream processes are influencing and shaping overbank areas. By using the corresponding elevations of these features on the REM, the active stream corridor can be delineated within the larger river valley. The width of the active stream corridor can then be used in local hydraulic calculations, like unit stream power.

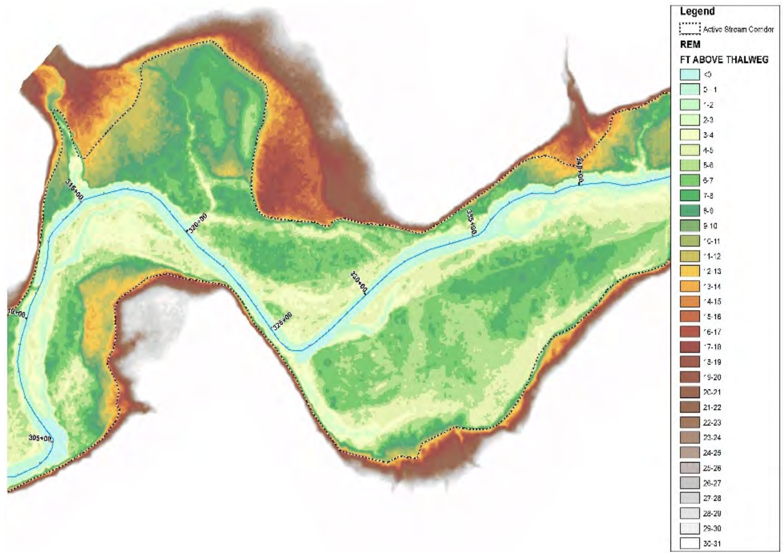

Figure 3: An example of the relative elevation model (REM) used to delineate the active stream corridor and in turn the width for unit stream power calculations.

Unit stream power is an important proxy for the driving forces with a reach. It indicates the capacity of flow to erode and transport sediment throughout a fluvial system (Blazewicz et al., 2020). Lower unit stream power points to more sediment storage while higher values indicate a transport reach with limited opportunity for sediment storage. The variations in unit stream power are a function of the channel confinement (a type of stream width) and channel slope. Figure 4 shows a plot of unit stream power along the Kinnickinnic River calculated using a 10% annual exceedance probability (AEP) storm event. Overall shifts in unit stream power was used heavily in determining reach breaks through the study reach.

Table 1 lists the variations in physical characteristics across each of the four reaches. Note that these reaches are numbered and stationed from confluence and heading upstream, according to the standard

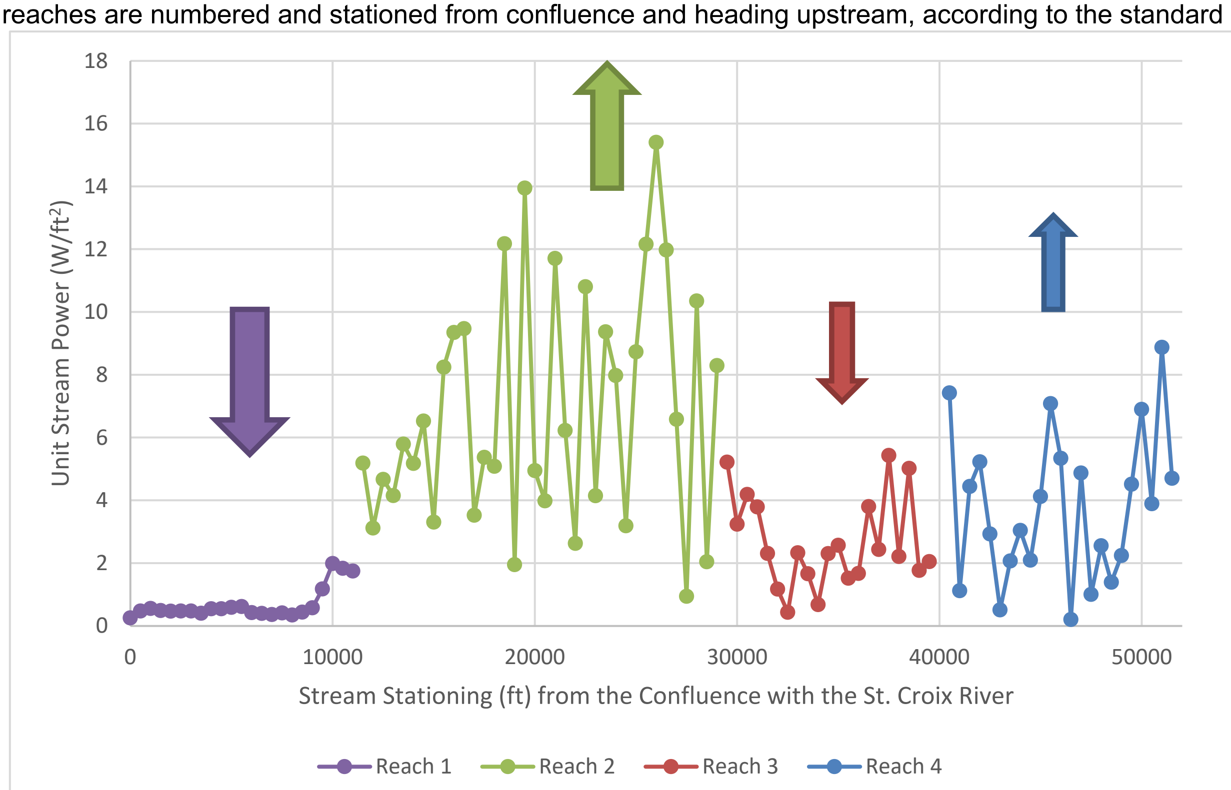

Figure 4: A plot of unit stream power along the study reach of the Kinnickinnic River. The different colors represent the reach breaks within the study reach. The arrows indicate relative change and magnitude compared to adjacent reaches.

convention of hydraulic engineers.[4] The existing conditions of each reach are described in detail below and will determine the response to the removal of the Powell Falls Dam.

Table 1: Reach characteristics for the four reaches delineated along the Kinnickinnic River downstream of the Powell Falls Dam. Figure below table shows reach locations on a Google Earth Pro aerial photograph.

	Channel Slope (ft/ft)	Valley Slope (ft/ft)	Avg Unit Stream Power (Watts/ft^2)	Bankfull Width (ft)	Valley Width (ft)	Alluvial Channel Type
Reach 1	0.0007	0.0008	0.68	73	469	Dune - Ripple / Pool - Riffle
Reach 2	0.0031	0.0035	6.86	57	242	Pool - Riffle
Reach 3	0.0027	0.0032	2.53	48	464	Pool - Riffle
Reach 4	0.0031	0.0035	3.86	52	359	Pool - Riffle

[4] To clarify, the "River Falls Hydroelectric Project Riverine Habitat Evaluation below Powell Falls" report by Inter-fluve, Inc and dated November 2020, uses reach numbers starting at the dam and proceeding downstream. Ayres' Reach 1 is Inter-fluve's Reach 5; Ayres' Reach 2 is Inter-fluve's Reach 4, Ayres' and Interfluve have the same Reach 3; and Ayres' Reach 4 is Inter-fluve's Reach 1 and 2 combined.

Reach 1

Length: 2.1 miles

Station Extents: 0+00 to 113+24

Average Slope (ft/ft): 0.0008

Average Unit Stream Power (Watts/ft^2): 0.68

Channel Morphology: Dune - Ripple / Pool -Riffle

Channel Description:

Reach 1 is the most downstream channel reach of the Kinnickinnic River, extending from the confluence of the St. Croix River (0+00) to the crossing along County Rd. F (113+24). This reach has been altered overtime by the permanent water surface at the St. Croix River upstream of the confluence with the Mississippi River. The increase in water surface elevation has caused a severe reduction in slope to 0.0008 ft/ft and stream power. These reductions have caused the sediment transported by the Kinnickinnic River to aggrade along this reach causing channel widening and a channel morphology shift near 60+00. The lack of energy and abundant sediment supply has caused the river to shift from a pool-riffle to a dune-ripple channel (Wohl, 2014). The shift to a dune-ripple channel reduces roughness and turbulence allowing the channel to maintain sediment transport capacity at a wider range of flow regimes, however these planforms offer less ecological function and habitat heterogeneity than pool-riffle sequences (Wohl, 2014).

Figure 5: A sand deposit (~2,600 CY) in the shadow of a log jam deposited during the large 2020 flood.

2020 Flood Impact:

The recent 2020 flood event has resulted in large amounts of deposition 200 feet past the mouth of the Kinnickinnic River into the St. Croix River, including sand and large wood. The dune-ripple portions of the Kinnickinnic River channel did not appear impacted by flood flows, with minimal log jams and very little scour or channel variations. This reach of the Kinnickinnic River stores significant amounts of sand transported from upstream. Above 60+00, sand has been deposited in at least six areas in velocity shadows and eddies during the flood (Figure 5). The channel was also realigned and diverted back into a cutoff channel following the event.

Reach 2

Length: 3.4 miles

Station Extents: 113+24 to 295+00

Slope (ft/ft): 0.0031

Average Unit Stream Power (W/ft^2): 6.86

Channel Morphology: Pool - Riffle

Channel Description:

Reach 2 extends about 3.4 miles from the crossing of County Rd. F (113+24) to just upstream of 1130th St. (295+00). Valley width has reduced along this reach, likely as a response to more resistant rock comprising the valley margins. This has resulted in an increased slope, confinement (242 ft), and, in turn, stream power. County Rd. F crosses at the downstream boundary of this reach.

2020 Flood Impact:

Similarly, to the upper portions of Reach 1, sand deposits formed during the flood event are present primarily in eddies and on point bars. These bars vary in size and tend to be narrower than the deposits seen downstream. Most of the large wood in this reach is located on the overbanks and wrapped on mature trees. This pool-riffle channel shows evidence of scour on the outside of meander bends, but the positioning of the pool-riffle sequences throughout this reach appear to be stable with very little movement post-flood based on historical imagery.

Reach 3

Length: 2.0 miles

Station Extents: 295+00 to 400+00

Slope (ft/ft): 0.0027

Average Unit Stream Power (W/ft^2): 2.53

Channel Morphology: Pool – Riffle

Channel Description:

Reach 3 is begins upstream of 1130th St. (295+00) and continues 2 miles to station 400+00. This reach is the shortest segment defined by a decrease in confinement leading to a reduction in channel slope and stream power. The valley margins have likely widened because of less resistant margins and the confluence of two large tributary channels.

2020 Flood Impact:

This reach was not walked during the site visit due to access and time constraints.[5] However, based on observation of the adjacent reaches and the relative values of stream power, we can infer that the reach was likely net depositional during the recent flood events. Sand was likely deposited in eddies and velocity shadows, increasing in occurrence with distance downstream from the Powell Falls Dam.

Reach 4

Length: 2.2 miles

Station Extents: 400+00 to 515+81

Slope (ft/ft): 0.0031

Average Unit Stream Power (W/ft²): 3.86

Channel Morphology: Pool - Riffle

Channel Description:

Figure 6: A photo taken looking downstream at the first meander bend where sands and fines have been removed and logs have been wrapped on trees.

The upper most reach extends from station 400+00 to the Powell Falls Dam (515+81), about 2.2 miles. This reach has a similar slope to Reach 2 but has slightly less stream power due to wider valley margins resulting from two large tributary confluences on the north and south side. Rocky Brach Tributary confluences within this reach as well, however the reach separated at this location due to lack of geomorphic channel difference upstream and downstream of the tributary.

2020 Flood Impact:

This reach appears to be historically starved of sandy bed load due the impoundments upstream, as much of the Kinnickinnic River sediment supply to the lower reaches is thought to originate from the Rocky Reach Branch. During the 2020 flood event, a large amount of bed load within the impoundment was is suspected to have been transported downstream, however, due to magnitude of the flow and corresponding velocities, these flood waters were supply limited rather than transport limited, resulting in mobilization of almost all the sands and fines in the reach. It is likely that a large amount of sediment was delivered to the system from the Rocky Branch Tributary, however there was little evidence of this influx during field investigations. The more gradual increase in depositional features is indicative of sediment starved waters coming over the Powell Falls Dam and slowly reaching carrying capacity as they entrain sediment from the channel rather than a sudden shift in sediment yield typical of a tributary influx. Sand deposits within this reach are limited to the overbanks areas.

Expected Removal Impacts

The proposed drawdown approach anticipates releasing sediment gradually over several years following the drawdown. After dam removal, the first year expects to see an increase of about 10,000 tons (5,000

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[5] Note that this report was originally intended (requested by FERC and committed contractually) to be only a desktop study, but Ayres' staff felt it was important to walk selected portions of the Kinnickinnic after the 2020 flood to confirm key points of the desktop study.

CY), or at most 100% of the yearly sediment yield; the sixth year expects to see an increase of about 2,000 tons (1,000 CY), or an increase of at most 20% of the yearly average sediment yield (Ayres, 2020). The worst-case scenario for sediment releases downstream is expected to be a plug of 45,000 CY mobilized within a single event. Both scenarios will be discussed regarding the relative impact to the channel; but the specific reach responses, overall risk, and required monitoring are similar with variations in magnitude and timing. An exhibit summarizing the existing conditions, channel morphology, field investigation, and secondary channel areas is available in Appendix A.

Lane’s Balance and Overall Transport Dynamics

Generalized impacts to the Kinnickinnic River can be theorized using simple concepts and fundamentals of sediment transport. We can expect river processes to work towards maintaining an equilibrium between discharge and sediment yield. Figure 7 shows Lane’s balance, a simple conceptual model for understanding the feedbacks within a river system (Pollock, 2014). Generally, Lane’s Balance states that there is a proportional balance between sediment load and sediment size on one side and discharge and slope on the other ($Q_w{*}S \; \alpha \; Q_s{*}d_{50}$). For example, an increase in sediment load (▲Q_s) with no change in discharge will cause the channel to steepen (▲S) and the average sediment grain size to increase (▲d_{50}). The steepening of the channel will increase the sediment transport capacity in order to maintain equilibrium and enabling fine-grain sediments to be entrained more easily while larger sediment sizes remain. Additionally, the river is expected to decrease in sinuosity and bedform height, again increasing sediment transport to maintain equilibrium (Wohl, 2014).

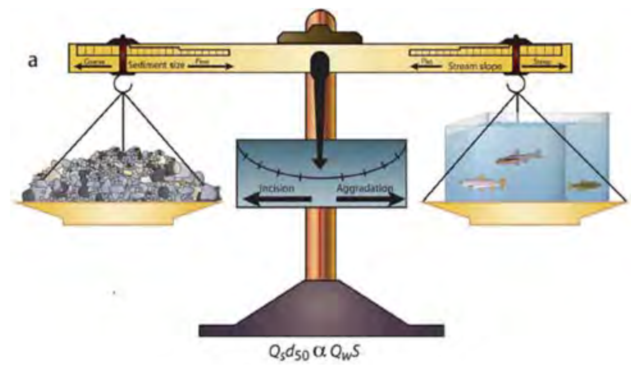

Figure 7: Lane's Balance showing the conceptual response to changes in slope, sediment input, discharge, and sediment size from Pollock, 2014.

In the anticipated drawdown scenario, between 5,000 CY and 2,000 CY would be released from Lake Louise yearly for an estimated period of six years. This sediment would travel as a wave with initially large impacts closest to the source reducing with distance downstream due to the attenuation and storage of sediment (Greiman et. al, 2006). Figure 8 highlights the accumulation that can occur in the upper portions of a reach. This is especially true in a pool-riffle channel where the movement of sediment is limited by the stream’s transport capacity rather than the sediment supply (Wohl, 2014). Ayres expects the sediment to accumulate in the upper reaches, occupying all available channel storage before continuing downstream. The proposed scenario will occur in a normal hydrologic regime meaning that storage and transport will be limited to the bankfull channel. We expect preferential filling of pools, compared to riffles during base flows, which is already evident following the most recent flood event. Scouring and degradation required to maintain pools would depend on high-flow events occurring within this reach (Wohl, 2014).

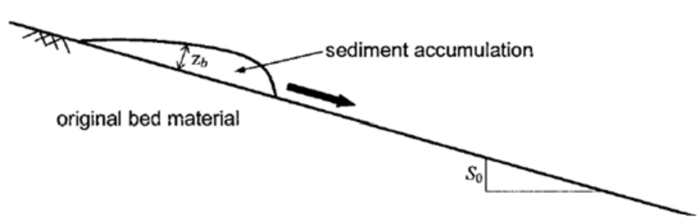

Figure 8: Illustration of a sediment influx moving as a wave along a slope from Greiman et. al, 2006.

The worst-case release scenario is a high flow event that overwhelms the construction site during the Powell Falls Dam removal. Ayres expects the final dam removal activities to accommodate up to a 10-yr flood event, meaning this worst-case scenario would require flows greater than 6,000 cfs. In this scenario, the magnitude of sediment influx to the Kinnickinnic River below the Powell Falls Dam would be much greater, but the long-term effect on the channel would likely be similar in filling and transport activity, though with greater magnitude of effects than expected for the anticipated drawdown scenario. During the worst-case scenario, flow overtops the channel and inundates overbank areas. These areas have little transport capacity causing sediment to deposit on the floodplain (Figure 9 top). Furthermore, deep eddies offer abundant sediment storage vertically (Figure 9 bottom). The sediment entrained in main conveyance portions of the channel will be carried through and out of the system to the lower portions of Reach 1 and the St. Croix. The increased sediment capacity and storage means that the worst-case scenario for sediment release from the impoundment may actually not negatively impact the Kinnickinnic River more than the anticipated drawdown scenario due to magnitude of flows required to overwhelm the sediment mitigation measures installed during the drawdown of the impoundment. In short, either scenario (anticipated drawdown or worst-case) will create temporary impacts on the downstream Kinnickinnic River that could take a decade to equilibrate post-removal sediment deposits with post-removal river transport capacity. This is similar to observations that Ayres has made at other large dam removals such as Grimh Dam (2011 removal; this delta and downstream reach have already reached equilibrium because this dam was half drawn down in 2000) and Gordon Dam (2017 removal; this delta and downstream reach have nearly reached equilibrium because this dam was half drawn down in 2010).

Figure 9: Sand deposited on overbanks and vertically in eddies.

Normally in dam removal scenarios, there is a risk of avulsion, or river realignment to an area that is outside the active stream corridor (Blazewicz et al., 2020). Avulsion occurs when a large influx of sediment fills the existing channel to the extent that the channel is forced into an alignment with a lower elevation than the filled channel. Along the Kinnickinnic River, the risk of avulsion is extremely low because the river is not capable of escaping the entrenched valley which the river occupies. Instead, the Kinnickinnic River is more likely to migrate laterally and occupy secondary channels and meander cutoffs within the entrenched valley for a limited longitudinal extent before rejoining the main channel. This, while not as destructive and uncontrollable as an avulsion, could still pose challenges to the community (especially if the avulsion areas are under private land ownership). Therefore, areas with potential for this to happen have been marked in the *Summarizing Exhibit* in Appendix A. These specific areas will be discussed in the reach specific impacts.

Relative Size of the Sediment Influx

Comparing the relative increase in the sediment input into the system is an important first step in understanding the magnitude of the impact to the downstream systems. Overall, the proposed drawdown and sediment release plan is estimated to initially increase the yearly sediment input into the Kinnickinnic River downstream of the Powell Falls Dam by 100% in the year following drawdown before tapering off to a 20% increase by the sixth year.

The St. Croix is a much larger system with a drainage area of 8,570 mi^2 at nearby Prescott (USGS, 1986). Estimates of sediment loads are difficult, but rough estimates by the USGS at St. Croix Falls

(6,240 mi^2 watershed) is 10,000 CY (25,000 tons) per year of suspended sediment (USGS, 1986). The additional sediment from the removal of the Powell Falls Dam will end up adding to the large depositional bar that has already formed along the St. Croix River. The bar has formed over many years from sand inputs from the Kinnickinnic River that have been pushed along the east bank of the St. Croix by the St. Croix's larger flow and currents. The 2020 flood event in the Kinnickinnic River pushed a large quantity of sediment and debris roughly 200 ft out into the St. Croix channel where it may take years to be pushed downstream and deposited as an extension of this existing sandbar. The effect of this additional Kinnickinnic River sediment on a system as large as the St. Croix is likely to be limited spatially and temporally.

Average Bar Volume Comparison

The Dam Removal Analysis Guideline for Sediment (2016) suggests comparing the sediment volume released to common depositional features within the river to gain an understanding of the impact to the riparian system. This is also helpful in evaluating the abundant depositional features existing within the channel and on the overbanks following the 2020 flood event. The guideline recommends estimating average bar size using the following equation,

*Average Bar Volume = Average Bankfull Depth * Average Bankfull Width*^{2}

So, for the Kinnickinnic River, $7\ ft * (57.3\ ft)^2 = 23{,}000\ ft^3$ *or 854 CY.*

Figure 10: A typical sand bar deposit with dimensions approximately 80 ft x 30 ft x 7 ft (622 CY).

This estimate was confirmed by observations of many depositional bars during the field investigation. Based on the field investigation, these bars typically occur every 1,500 linear feet within Reach 1, 2, and 3 equating to approximately 23 bars. The maximum yearly volume release in the proposed conditions, 5,000 CY, is equivalent to approximately six depositional bars observed within bankfull channel.

In additional to the bars, the backwater from the St. Croix River has created a storage sink for sand. Conservatively, assuming the sand bed is 3 feet deep, the channel is actively storing approximately 50,000 CY of sand within the dune-ripple channel portion. Additionally, high flow events, which inundate the overbanks, can lock large amount of sediment within the overbank soils and vegetation. The sediment stored during the most recent flood event cannot be easily estimated, but likely exceeds 25,000 CY.

Reach Response and Recommended Actions

Consistent monitoring during the removal and continuing at least 10 years after removal ends is the first recommended step to sustaining high ecological function of the Kinnickinnic River. Pools have been identified in the *Summarizing Exhibit* (Appendix A) for monitoring throughout the study area because these bed forms will be at the highest risk for filling during baseflow periods. Filling of the pools is expected, especially in the upper reaches. However, with yearly high flow events, these pools should eventually scour and continue transporting sediment downstream. In addition to the temporary filling of pools, the overall location of the pool-riffle sequences should remain relatively stable and can be monitored using the estimates presented in the *Summarizing Exhibit* (Appendix A). If a reduction in number or extent persists, especially following high-flow events, this may indicate a more large-scale shift in the channel morphology, affecting the ecological function, transport capacity, and sensitivity of the system overall (Wohl, 2014). Additional actions, such as the trapping of sediment from the impoundment or flushing events (if even practicable), should potentially be employed if the high flow periods are inadequate to scour the pools or maintain pool-riffle morphology.

Preliminary visual estimates during the October 2020 dam safety inspection drawdown indicate that between 3500 and 8000 CY of sediment was released from the impoundment; but less than two weeks after the drawdown ended, the turbidity was back down below 60 mg/L. This indicates the rate of downward cutting has slowed in the impoundment, though minor cutting may continue overwinter at a slower pace. Ayres believes the spring floods will initiate the future channel forming events within Lake Louise, though additional field monitoring is needed to confirm how the reservoir fluctuations correlate with channel and bank stability.

St. Croix River Sensitivity, Risk, & Response

Sensitivity & Response to Removal:

Ayres anticipates the impact to the St. Croix to be delayed and limited. The storage and attenuation of sediment within the Kinnickinnic River will delay and dampen in peak influx of sediment to a point that the increase will not be detectable above yearly averages. Most likely sand will be transported just past the confluence with the St. Croix before moving downstream and depositing on the existing sand bar. The bar is unlikely to extend further out into the channel due to the equilibrium between increased channel velocities due to confinement and sediment transport capacity. As the bar extends into the river, the cross-sectional area of the St. Croix decreases resulting in increased velocities and sediment transport capacity. The increased sediment transport capacity will facilitate downstream movement of sand and deposition on the existing bar.

Reach 1 Sensitivity, Risk, & Response

Sensitivity & Response to Removal:

Reach 1 is the least sensitive reach in the Kinnickinnic River because, for most of this reach, a channel morphology shift has already occurred from a natural pool-riffle channel to a dune-ripple channel. There is little evidence that this sediment influx will further degrade the function of this reach.

Figure 11: A pool filling with sand during low flow periods.

Upstream of station 60+00, the stream will respond like the other pool-riffle reaches within the river with pools filling during low-flow intervals and deposition and widening of riffles during high flow events. The sediment from the removal will take many years to be transport down to this reach, due to attenuation and storage within the upper reaches. It will be difficult to decern the provenance of the sediment within this reach because of the abundant sediment stored in eddies and overbanks during the most recent flood event.

Monitoring Pools:

Two pools have been denoted in *Summarizing Exhibit* (Appendix A) for potential monitoring[6].

Secondary Channel Areas:

Only one region has been flagged as having concern for limited channel relocation in an existing meadow adjacent to several tributary channels.

Infrastructure:

There is no known infrastructure at risk within the active stream corridor within this reach.

Reach 2 Sensitivity, Risk, & Response

Sensitivity & Response to Removal:

Based on the relative stream power, this reach is a transport reach. This reach is a pool-riffle channel throughout with many depositional bars and habitat heterogeneity. Despite the high stream power, this reach has abundant sand in storage, on the overbanks and in eddies. This suggests that while this reach has a higher transport capacity, it is still transport limited, which is indicative of a pool-riffle channel.

Normally, as described previously, pools will fill during low-flow periods and scour during high-flow periods. With an increased in sediment influx, these pools are likely to fill further than normal which will cause a decrease roughness and create a more uniform flow-depth and bed-gradient (Wohl, 2014). This will increase the ability of the stream to transport sediment during moderate- and low-flow periods while reducing channel heterogeneity and, potentially habitat. While the higher stream power makes this reach relatively less sensitive, it is also home to many high-functioning pool habitats and channel heterogeneity that may be at increased risk.

Monitoring Pools:

Eight pools were identified within this reach for monitoring following the removal of the Powell Falls Dam.

Secondary Channel Areas:

Two small areas have been identified as having potentially for channel realignment within secondary channel or cutoff channels. The confinement of the channel limits to overall extents and number of these areas.

Infrastructure:

The County Rd F crossing should be monitored regularly, especially following high flow events. Any shift in channel alignment following filling of the channel might increase the overall risk of bridge instability (depending on the bridge foundation design, to be confirmed with the bridge design documents).

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[6] In previous large dam removal permits that Ayres has reviewed, the WDNR conditions the permit upon requiring a three- to five-year period of “monitoring” reaches above and below dam removal sites. To Ayres’ knowledge, the “monitoring” has been done by the WDNR as an informal visual inspection by regional engineers, not as a formal process funded by and reported by the permittee. The WDNR permit language implies the WDNR reserves the right to require the permittee to undertake mitigation measures for excessive changes to the upstream or downstream reaches.

Reach 3 Sensitivity, Risk, & Response

Sensitivity & Response to Removal:

Due to access and time allowed, this reach was not walked during the field visit in September 2020. However, Ayres expects this reach to respond similarly to the adjacent reaches. This reach has the second lowest overall stream power along the Kinnickinnic River meaning the sediment transport capacity is lower. Reach 3 likely has large amounts of sand deposited by the recent flood event, especially in the larger overbank areas and floodplains.

Monitoring Pools:

Three pools for monitoring have been identified within this reach, however these areas were not visited in the field.

Secondary Channel Areas:

The risk of channel realignment into a secondary channel is high in this reach due to the wider valley margins and increased number of tributaries. The wide valley and tributaries increase the ability to the stream to migrate laterally which creates more relic channels and meander scars for the existing channel to reoccupy.

Infrastructure:

There is no known infrastructure at risk within the active stream corridor within this reach.

Reach 4 Sensitivity, Risk, & Response

Sensitivity & Response to Removal:

Reach 4 is the highest risk reach due to its proximity to the sediment influx and the pool-riffle channel morphology. Any sediment released from the impoundment will travel as a wave through the system, filling storage and attenuating in the upper reach before traveling downstream, meaning that pools in Reach 4 will fill first and with the most sediment. This is especially true during low-flow periods when the stream has no ability to store sediment on the floodplain.

Whatever sediment was passed through Lake George and Lake Louise to the downstream Kinnickinnic River during the 2020 flood was quickly scoured as the floodwaters receded, at least in the first 500 feet below the Powell Falls Dam. Downstream further, this reach still appears to be depleted of sand and fine sediment until the Rocky Branch. The Kinnickinnic River upstream of Rocky Branch is a cobble and gravel system that has not had the sediment supply fully replenished following the flood. Initially, the influx of some sand following dam removal will likely create temporary benefits for this reach; but excessive releases of sand (such as the worst-case scenario during dam removal) could negatively affect this reach more than the other three reaches.

Update: After the October 2020 drawdown, sediment has been deposited by the drawdown activities within Reach 4. During the first week of the drawdown, a couple inches of fine silt was deposited within slower pool areas from Powell Falls Dam downstream about 600 feet (to the first major riffle). After a 2-inch rain event on October 12, Lake Louise water levels rose six feet and fell six feet within a day. This lake bounce initiated rapid headcutting and upstream bank instabilities within the impoundment, causing significant sediment movement for the next four or so days. On October 16, sediment cutting appeared to slow again to pre-bounce conditions, but silty sand had nearly filled the pool between Powell Falls Dam and the first major riffle. During a follow-up inspection of the first pool below Powell Falls Dam on November 2, a new channel had been scoured through the new sediment, reaching down to original bedrock grade in several places. In short, the Reach 4 received 3500 cubic yards deposited in 4 days below the dam; but during normal flow conditions that followed, the river had sufficient stream power to reform a channel. At the time of this report's writing, the pool below Powell Falls does have sediment still in the pool, but the new channel has recut to bedrock within this sediment deposit.

Monitoring Pools:

Three pool were identified for monitoring along Reach 4.

Secondary Channel Areas:

Two secondary channel areas were identified along this reach at meander bends and through meander cutoffs.

Infrastructure:

Reach 4 is the most visible portion of the channel with a community trail following the river through most of the reach. It will be important to preserve the trail and historical features along the trail. Kayakers launch on the left bank below the Powell Falls development, and this launch may need to be moved downstream to accommodate sediment movement during decommissioning efforts.

Conclusion

Overall, Ayres expects the impact of the increase sediment load to the Kinnickinnic River downstream of the Powell Falls Dam after dam removal to be on the scale of the impact of the most recent flooding event. The Kinnickinnic River has an abundant sediment supply (~5,000 CY per year) and sediment storage which it transports to the St. Croix while sustaining high-functioning riparian habitat. Ayres estimates that more sediment[7] was stored within the channel and on the overbanks during the most recent flood event than is expected to be released during dam removal efforts. In Ayres' opinion, and especially in the lower reaches, sand stored during the recent flood will pose a larger risk to the channel equilibrium once it is mobilized than the sediment from the impoundment.

Based on time scales of geomorphologic adjustments, the sediment released from Lake Louise will have a disproportional impact on the upper reaches of the Kinnickinnic River. The sediment will likely be released during typical flow regimes which will limit storage to the bankfull channel filling pools in the upper reach more severely and continuously than the lower reaches. This process (albeit currently confined to the first 600 feet downstream of Powell Falls Dam) was confirmed during the October 2020 drawdown.

Monitoring of these pools, especially in the upper reaches, for several years following the dam removal is prudent and a normal expectation of a WDNR dam removal permit. From a hydraulic engineering and river stability viewpoint, monitoring would ideally check for large-scale, long-term, negative geomorphological impacts such as permanent or continuous filling, reduction in volume, or reduction in aquatic biota. For any excessively detrimental impacts noted, the dam removal permits issued by the state usually include a requirement to mitigate impacts (repairs of bank instabilities, sediment removal, check dams, etc.), and therefore, continued state agency involvement is expected for several years after dam removal is complete.

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[7] However, the source of this July 2020 flood sediment is uncertain. Ayres understands that the Rocky Run and other tributaries below Powell Falls Dam are significant sediment contributors, but how these downstream sources compare to sediment volumes coming from Junction Falls and the South Fork is uncertain.

References

Ayres, 2020. *Powell Falls Decommissioning Plan Draft - City of River Falls Hydroelectric Project FERC Project P-10489*. City of River Falls Municipal Utilities.

Blazewicz, M., Jagt, K. and Sholtes, J. 2020. "Colorado Fluvial Hazard Zone Delineations Protocol Version 1.0". Colorado Water Conservation Board.

Evan, T.J., Cordua, W.S., and LePain, D.L. 2007. *Preliminary Geology of the Buried Bedrock Surface, Pierce County, Wisconsin.* Wisconsin Geological and Natural History Survey. Open-File report 2007-08.

Graczyk, David J., 1986. *Water Quality in the St. Croix National Scenic Riverway, Wisconsin*. United States Geologic Survey. Water-Resources Investigations Report 85-431

Inter-fluve, Inc, 2016. *Lake George and Lake Louise Sediment Assessment Report*.

Inter-fluve, Inc, 2020. *River Falls Hydroelectric Project Riverine Habitat Evaluation below Powell Falls*.

Kostka, S.J., Mickelson, D.M., and Baker, R.W. 2004. *Preliminary Quaternary Geologic Map of St. Croix County, Wisconsin.* Wisconsin Geological and natural History Survey. Open-File Report 2004-22.

Montgomery D.R. and J.M. Buffington, 1997, "Channel-reach morphology in mountain drainage basins," Geological Society Bulletin. Vol. 109, No. 5, p. 596-611.

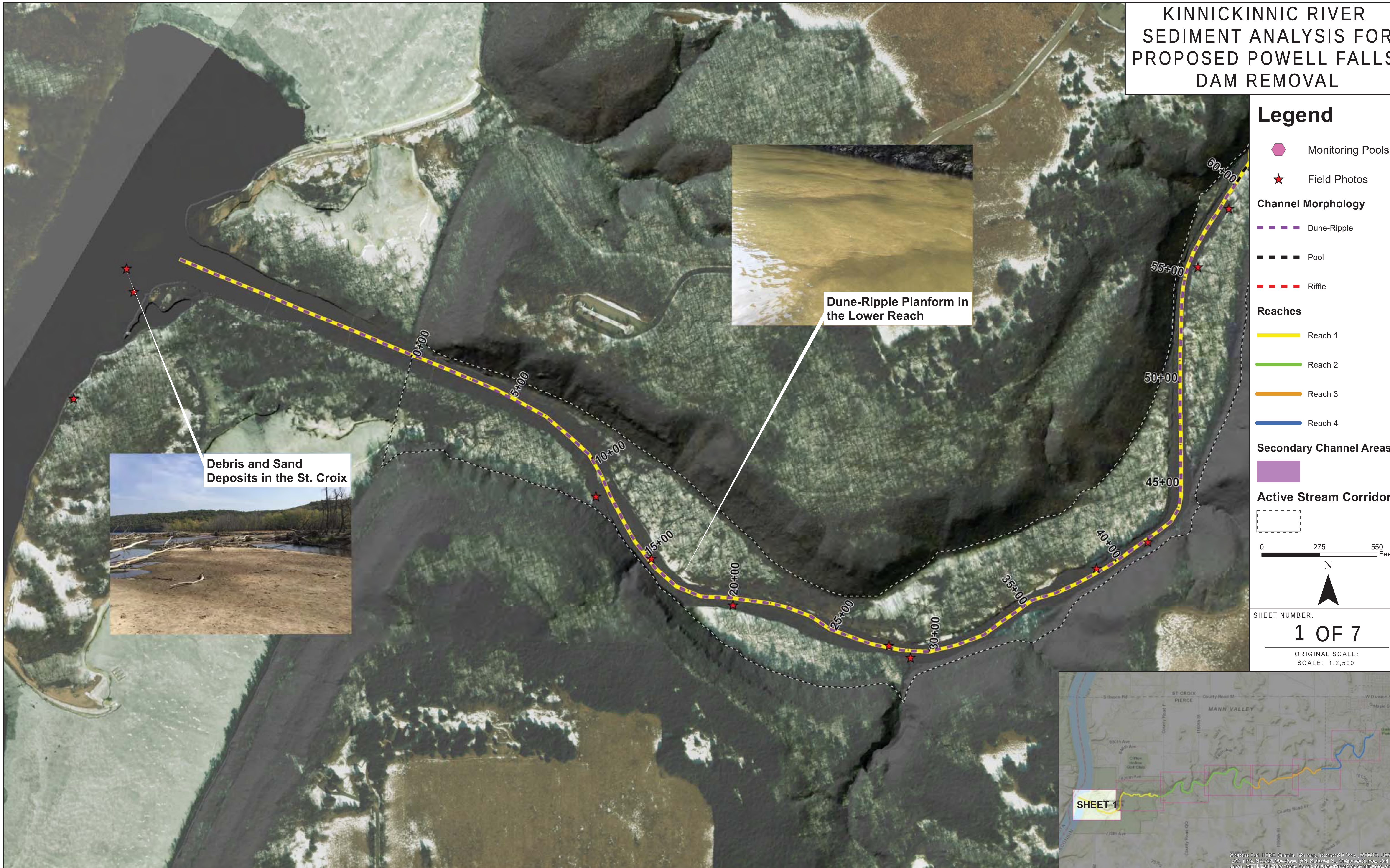
Pollock, M. M. et. al. 2014. "Using Beaver Dams to Restore Incised Stream Ecosystem"*.* BioScience.

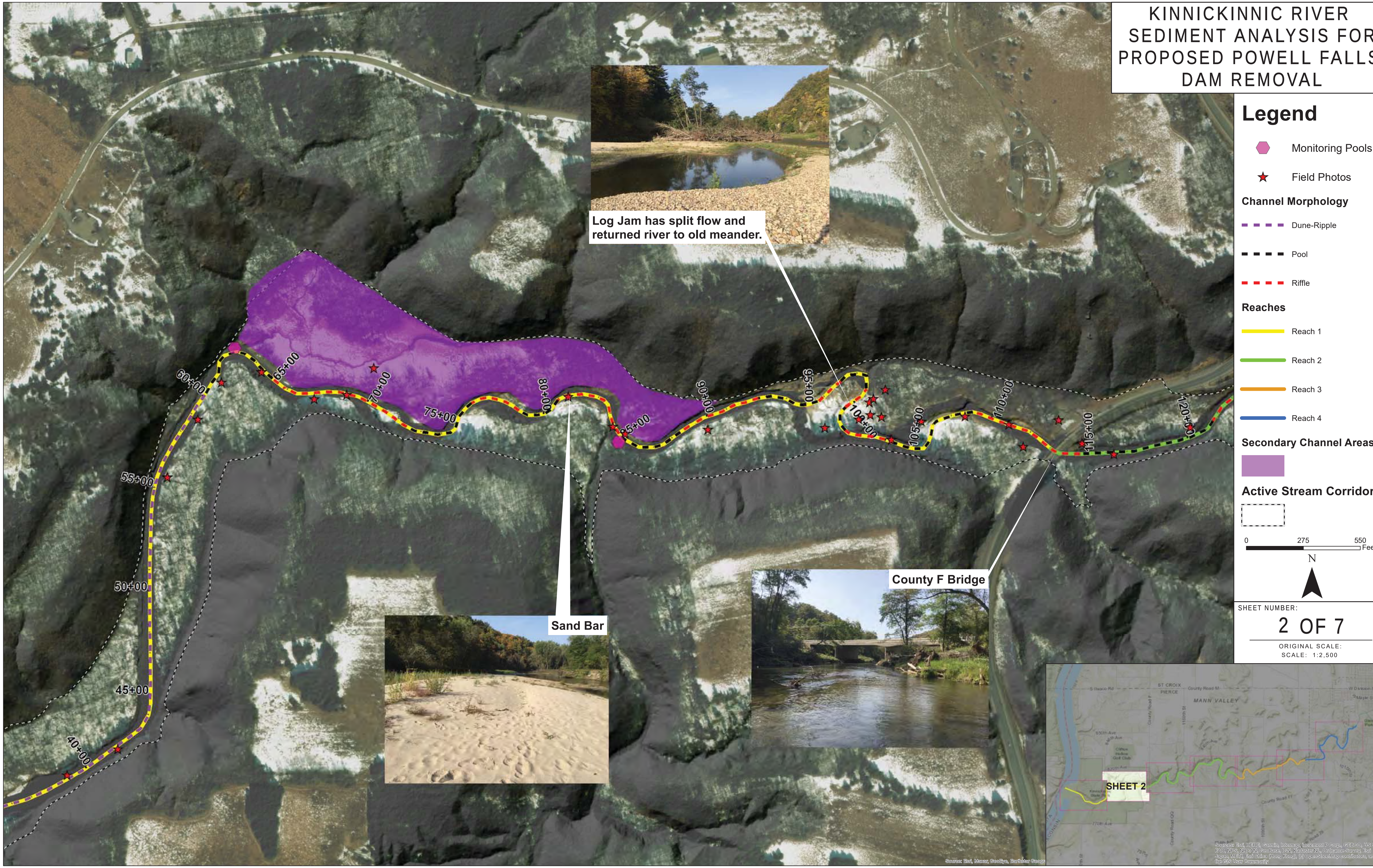
Randle and Bountry, 2017. *Dam Removal Analysis Guidelines for Sediment*. Bureau of Reclamation. U.S. Department of the Interior.

Wohl, E. 2014. Rivers in the Landscape: Science and Management. John Wiley & Sons.

Appendix A

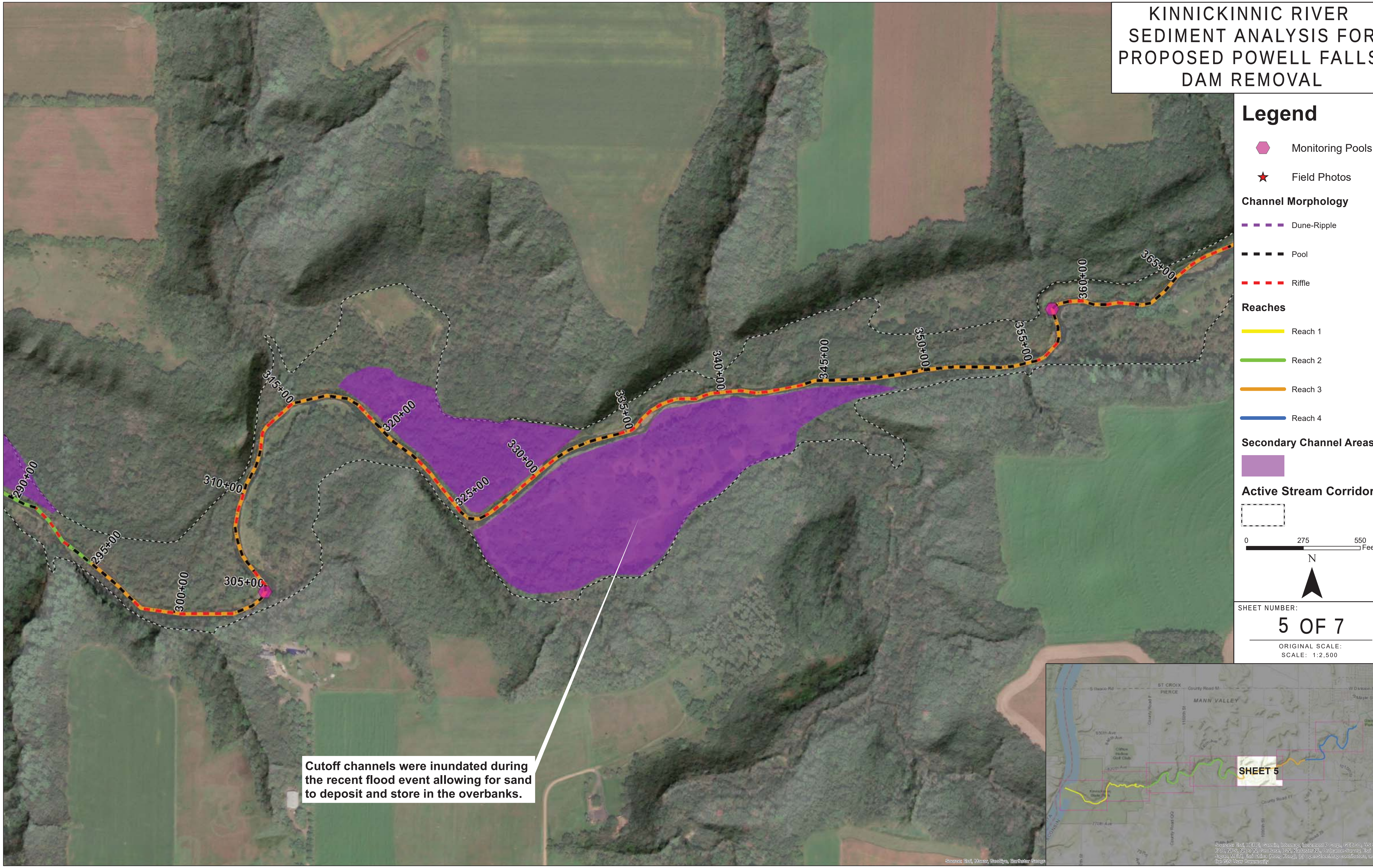
Summarizing Exhibit


KINNICKINNIC RIVER SEDIMENT ANALYSIS FOR PROPOSED POWELL FALLS DAM REMOVAL
Legend
Monitoring Pools
Field Photos
Channel Morphology
Dune-Ripple
Pool
Riffle
Reaches
Reach 1
Reach 2
Reach 3
Reach 4
Secondary Channel Areas
Active Stream Corridor
0
275
550
Feet
N
SHEET NUMBER:
1 OF 7
ORIGINAL SCALE:
SCALE: 1:2,500
Debris and Sand Deposits in the St. Croix
Dune-Ripple Planform in the Lower Reach
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00
40+00
45+00
50+00
55+00
60+00
SHEET 1
MANN VALLEY


KINNICKINNIC RIVER SEDIMENT ANALYSIS FOR PROPOSED POWELL FALLS DAM REMOVAL
Legend
Monitoring Pools
Field Photos
Channel Morphology
Dune-Ripple
Pool
Riffle
Reaches
Reach 1
Reach 2
Reach 3
Reach 4
Secondary Channel Areas
Active Stream Corridor
0
275
550
Feet
N
SHEET NUMBER:
2 OF 7
ORIGINAL SCALE:
SCALE: 1:2,500
Log Jam has split flow and returned river to old meander.
Sand Bar
County F Bridge
40+00
45+00
50+00
55+00
60+00
65+00
70+00
75+00
80+00
85+00
90+00
95+00
100+00
105+00
110+00
115+00
120+00
SHEET 2
MANN VALLEY

KINNICKINNIC RIVER SEDIMENT ANALYSIS FOR PROPOSED POWELL FALLS DAM REMOVAL
Legend
Monitoring Pools
Field Photos
Channel Morphology
Dune-Ripple
Pool
Riffle
Reaches
Reach 1
Reach 2
Reach 3
Reach 4
Secondary Channel Areas
Active Stream Corridor
0 275 550 Feet
N
SHEET NUMBER:
3 OF 7
ORIGINAL SCALE:
SCALE: 1:2,500
Structure Storing Sand
Sand Bar in Eddy
Sand Bar in Eddy
115+00
120+00
125+00
130+00
135+00
140+00
145+00
150+00
155+00
160+00
165+00
170+00
175+00
180+00
185+00
190+00
195+00
200+00
205+00
SHEET 3
MANN VALLEY


KINNICKINNIC RIVER SEDIMENT ANALYSIS FOR PROPOSED POWELL FALLS DAM REMOVAL
Legend
Monitoring Pools
Field Photos
Channel Morphology
Dune-Ripple
Pool
Riffle
Reaches
Reach 1
Reach 2
Reach 3
Reach 4
Secondary Channel Areas
Active Stream Corridor
0
275
550
Feet
N
SHEET NUMBER:
4 OF 7
ORIGINAL SCALE:
SCALE: 1:2,500
Pool Habitat
200+00
205+00
210+00
215+00
220+00
225+00
230+00
235+00
245+00
250+00
255+00
260+00
265+00
270+00
275+00
280+00
285+00
290+00
295+00
SHEET 4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Legend
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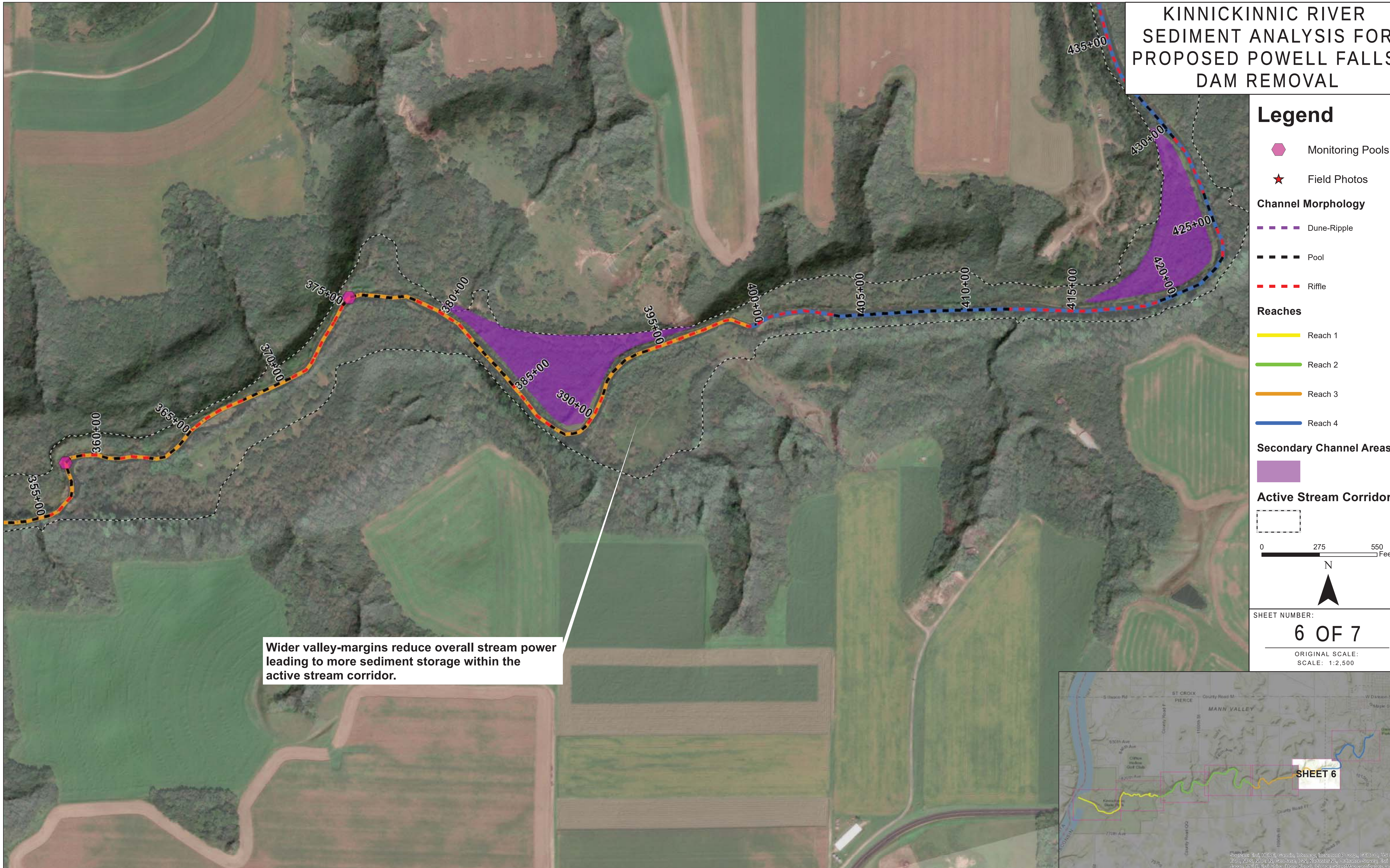
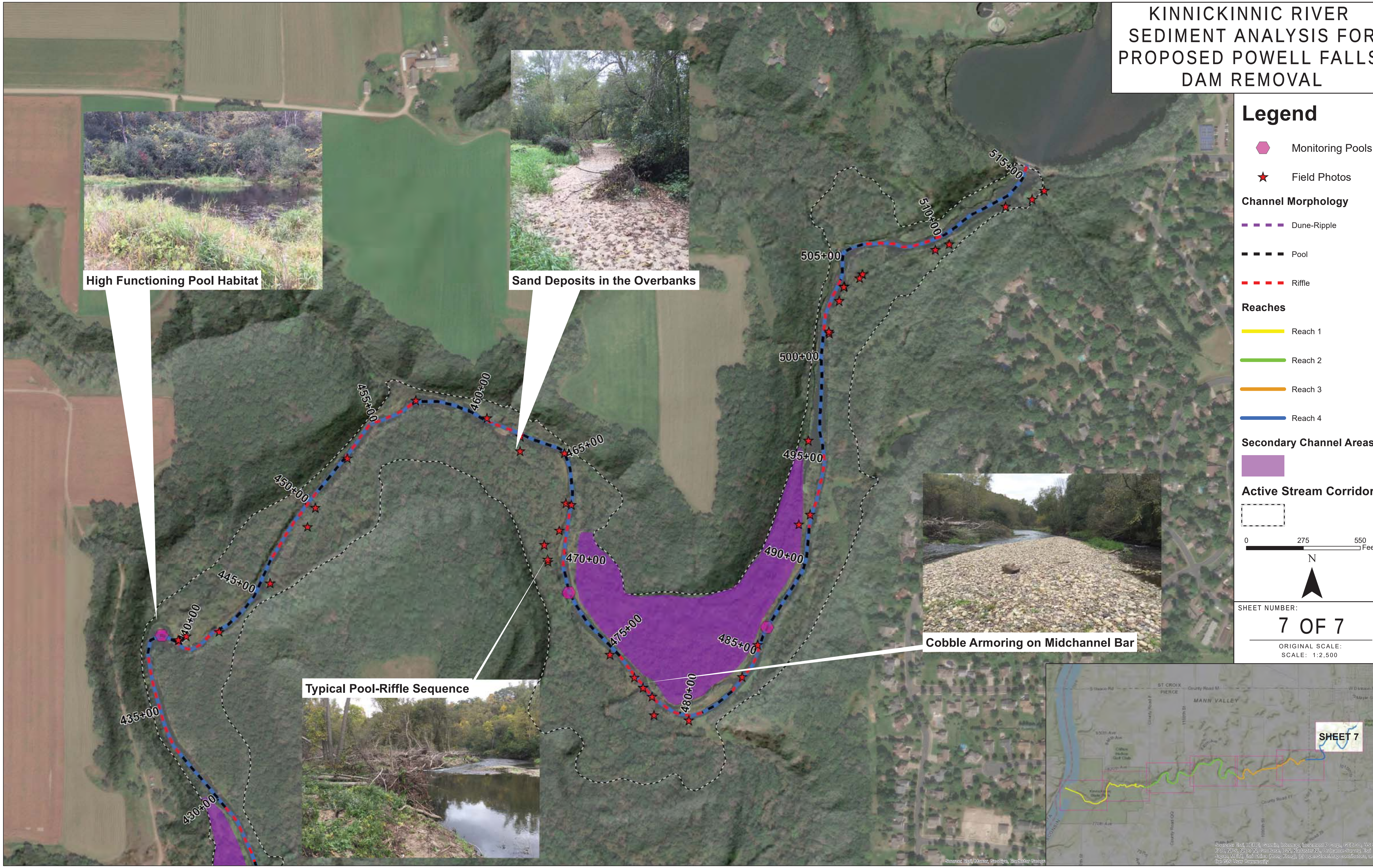
Channel Morphology
Dune-Ripple
Pool
Riffle
Reaches
Reach 1
Reach 2
Reach 3
Reach 4
Secondary Channel Areas
Active Stream Corridor
0
275
550
Feet
N
SHEET NUMBER:
5 OF 7
ORIGINAL SCALE:
SCALE: 1:2,500
290+00
295+00
300+00
305+00
310+00
315+00
320+00
325+00
330+00
335+00
340+00
345+00
350+00
355+00
360+00
365+00
Cutoff channels were inundated during the recent flood event allowing for sand to deposit and store in the overbanks.
SHEET 5
MANN VALLEY



KINNICKINNIC RIVER SEDIMENT ANALYSIS FOR PROPOSED POWELL FALLS DAM REMOVAL
Legend
Monitoring Pools
Field Photos
Channel Morphology
Dune-Ripple
Pool
Riffle
Reaches
Reach 1
Reach 2
Reach 3
Reach 4
Secondary Channel Areas
Active Stream Corridor
0
275
550
Feet
N
SHEET NUMBER:
6 OF 7
ORIGINAL SCALE:
SCALE: 1:2,500
355+00
360+00
365+00
370+00
375+00
380+00
385+00
390+00
395+00
400+00
405+00
410+00
415+00
420+00
425+00
430+00
435+00
Wider valley-margins reduce overall stream power leading to more sediment storage within the active stream corridor.
SHEET 6
MANN VALLEY


KINNICKINNIC RIVER SEDIMENT ANALYSIS FOR PROPOSED POWELL FALLS DAM REMOVAL
Legend
Monitoring Pools
Field Photos
Channel Morphology
Dune-Ripple
Pool
Riffle
Reaches
Reach 1
Reach 2
Reach 3
Reach 4
Secondary Channel Areas
Active Stream Corridor
0
275
550
Feet
N
SHEET NUMBER:
7 OF 7
ORIGINAL SCALE:
SCALE: 1:2,500
High Functioning Pool Habitat
Sand Deposits in the Overbanks
Typical Pool-Riffle Sequence
Cobble Armoring on Midchannel Bar
430+00
435+00
440+00
445+00
450+00
455+00
460+00
465+00
470+00
475+00
480+00
485+00
490+00
495+00
500+00
505+00
510+00
515+00
SHEET 7

Part 2.

Powell Falls Dam Removal Sediment Study Ecological Risk Evaluation

POWELL FALLS DAM REMOVAL SEDIMENT STUDY ECOLOGICAL RISK EVALUATION

RIVER FALLS HYDROELECTRIC PROJECT

FERC NO. 10489

SUBMITTED BY:

CITY OF RIVER FALLS MUNICIPAL UTILITIES
222 LEWIS STREET
RIVER FALLS, WI 54022

PREPARED BY:

TRC
150 NORTH PATRICK BOULEVARD
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JANUARY 2021

CITY OF RIVER FALLS MUNICIPAL UTILITIES

RIVER FALLS HYDROELECTRIC PROJECT

FERC NO. 10489

Powell Falls Dam Removal Sediment Study Ecological Risk Evaluation

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1.0 INTRODUCTION

The City of River Falls Municipal Utilities (RFMU) is proposing to decommission the Powell Falls Development of the River Falls Hydroelectric Project (Federal Energy Regulatory Commission (FERC) Project No. 10489) by removing the Powell Falls Dam. Powell Falls Development is located on the Kinnickinnic River in River Falls, Wisconsin. Removing the dam will involve the drawdown and draining of Lake Louise, the impoundment created by Powell Falls Dam.

On May 26, 2020 FERC requested a sediment study be performed to evaluate the impact of the removal of the Powell Falls Dam. FERC requested two study objectives be addressed: “1) compare the amount of sediment that could be released downstream of Powell Falls Dam to the average annual sediment yield in the Kinnickinnic and St. Croix Rivers to determine the level of ecological risk to downstream geomorphology and aquatic resources; and 2) assess the potential effects on geomorphology and aquatic resources based on the predicted level of ecological risk.” Part 1 of this report, “Kinnickinnic River Sediment Analysis for Proposed Powell Falls Dam Removal”, addresses Objective 1 of the FERC study request. Part 2 of this report, the sediment study ecological risk assessment, addresses Objective 2 of the FERC study request.

2.0 BACKGROUND

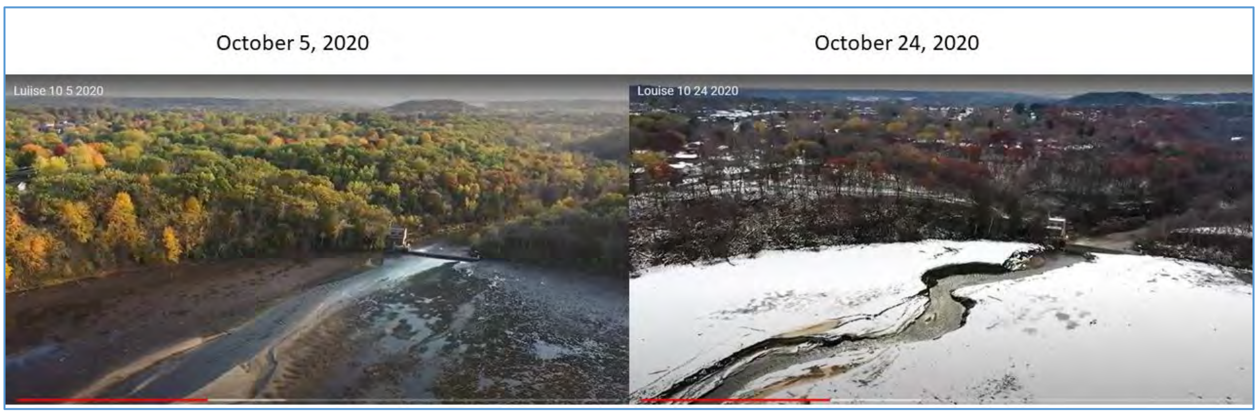
The sediment analysis used to address Objective 1 of this study builds upon the material presented in the draft “Powell Falls Decommissioning Plan” authored by Ayres (January 30, 2020). Included in this plan is the methodology used to estimate the amount of sediment that will be released downstream of Powell Falls Dam post-removal. This estimate of 25,100 cubic yards was produced prior to the 10-year flood event that occurred on June 29, 2020 and the current drawdown that started on October 2, 2020. The drawdown occurred to evaluate the structural damage to Powell Falls Dam from the June 29, 2020 flood (FERC approved the drawdown on October 1, 2020). The amount of sediment that moved downstream of Powell Falls Dam during the June 29 flood and drawdown events is undetermined. However, the remaining channel sediment (that volume naturally incised in the lakebed during a prolonged drawdown period[1]) in Lake Louise is likely less than 25,100 cubic yards, the original estimated

[1] A letter dated 10 November 2020 from Ayres to RFMU explains the sediment volumes in more detail by itemizing them into fouring categories: 1) sediment released in October and November 2020 during and after drawdown ≈8000 CY, 2) maximum sediment expected to be released between now and 2024 if drawdown continues and sediment is not actively dredged ≈25000 CY, 3) sediment necessary to be removed to complete the dam removal and channel stabilization ≈25000 CY, and 4) sediment expected to be caught in turbidity barriers during 2.5 years of construction activities ≈22000 CY. In short, the 8000 CY is an upper end estimate of released sediment already in the Kinnikinnic River below the dam, and the 25000 CY is an upper estimate of what may be naturally released over the next three to four years of drawdown. The last two numbers (25000 + 22000 = 47000 CY) is what Ayres has

amount that would be displaced by the Powell Falls Dam removal referenced in the FERC May 26, 2020 sediment study request (Ayres 2020; Figure 1).

Field data collected during September 21-24, 2020 provided empirical evidence of the June 29, 2020 flood impact to the riverine habitat downstream of Powell Falls Dam. This evidence is presented in Part 1. Supplemental data related to the post-flood habitat conditions were collected and are presented in the draft "River Falls Hydroelectric Project Riverine Habitat Evaluation below Powell Falls" relicensing study report. The field data collection activities for this relicensing study were postponed from 2019 to September 2020. The data from these two sources are used in conjunction to address Objective 2 of this study, predicting the level of ecological risk of removing Powell Falls Dam by assessing the potential effects on geomorphology and aquatic resources.

Figure 1. Aerial images of the Kinnickinnic River channel formation in the bed of Lake Louise during the Powell Falls Dam drawdown event of October 2020.



Source: Kinnickinnic Corridor Collaborative, https://www.youtube.com/channel/UCB-jCo-8r4iQVowaFzC1UhQ

2.1 Objectives

The following are a list of items to be addressed in this report, which cumulatively present an opinion of the level of ecological risk to the geomorphology and aquatic natural resources by removing Powell Falls Dam. This list combines the ecological risk assessment requirements found in "Dam Removal Analysis Guidelines for Sediment" (Randle and Bounty 2017) and "Guidelines for Dam Decommissioning Projects" (USSD 2015). The assessment will address

budgeted for the contractor to remove during the dam removal construction period. The red numbers are the same as the 25,100 number listed in this report, just rounded to acknowledge the appropriate significant digits.

the following Powell Falls Dam removal ecological risks and benefits to the Kinnickinnic River ecosystem:

1) Water quality deterioration due to increased suspended sediment levels or contaminants;
2) Burial of downstream aquatic spawning, rearing, and holding areas for threatened or endangered species or species of concern;
3) Burial of downstream aquatic species or life stages that cannot find refuge or quickly mobilize out of sediment impact areas (e. g., mussels and fish eggs);
4) Increased deposition in floodplains that could result in change in riparian vegetation when existing species are not tolerant of burial;
5) Sediment deposition blocking aquatic species migration routes;
6) Restoration of riverine habitat in reservoir area;
7) Restoration of heterogeneous grain sizes and sediment bars that support development of more diverse channel processes such as channel migration;
8) Increase in physical habitat features that provide ecosystem benefits, such as channel spawning gravels, bars, islands, large wood features, and side channel activation;
9) Facilitate growth of invertebrate communities;
10) Natural disturbance and sedimentation required for riparian vegetation.
11) Increased exposure to ice jams whose impact are currently mitigated by the dam and reservoir; and
12) Deposition along recreational use areas including navigation channels and fishing areas.

2.2 Methods

This desktop study evaluates the potential effects on geomorphology and aquatic resources of removing Powell Falls Dam. The framework of this study utilizes guidance provided in “The Dam Removal Analysis Guidelines for Sediment” (Randle and Bountry 2017) and the “Guidelines for Dam Decommissioning Projects” (USSD 2015). These documents contain methods to evaluate the level of ecological risk and potential effects of sediment on geomorphology and aquatic resources downstream of a dam removal site.

The information collected and analyzed for the Powell Falls Decommissioning Plan (Ayres 2020), Part 1 of this study, the concurrent Riverine Habitat Evaluation (Interfluve and GSRC 2020), and Lower Kinnickinnic River Mussel Survey (Kelner 2020) will be used to fulfill the informational needs described in the Randle and Bounty (2017) and USSD (2015) guidelines. The results of Part 1 of this study provide essential baseline description of the existing geomorphic conditions and potential impact to them by removing Powell Falls Dam. The effort to address Objective 2 of this study is to evaluate the impact described in Objective 1 on existing aquatic natural resources. The site-specific information gathered during the current relicensing and drawdown monitoring studies are used to describe the existing aquatic natural resources. Monitoring of abiotic water quality and habitat conditions during the ongoing Lake Louise drawdown are also used as direct observations of expected conditions during the continuation of Powell Falls Dam removal activities. The library of site-specific information is also compared to the existing body of scientific literature related to this subject. A summary table that qualitatively assigns levels of ecological risk and benefit as low, medium and high for varying timespans, (short-term equal to 1-yr or less, and long-term greater than 1-yr), that reflect the results and discussion for all of the study objectives was produced. This table is a comprehensive summary of the risk-benefit analysis of the Powell Falls Dam removal.

3.0 RESULTS AND DISCUSSION

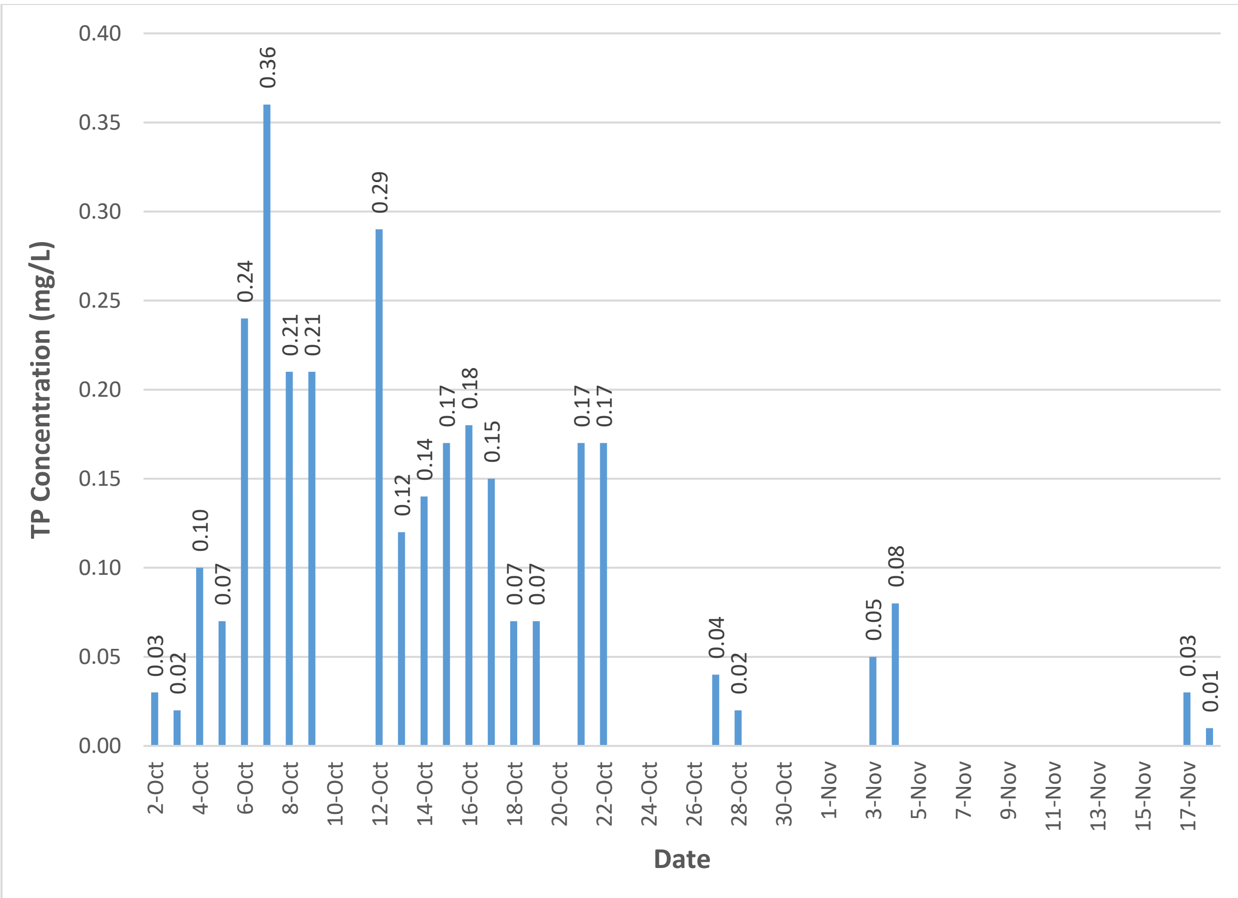
3.1 Water Quality

Restoring impounded rivers to free-flowing conditions can improve water quality. By removing the Powell Falls Dam, the impoundment reservoir, Lake Louise, will change from lentic to lotic habitat. This alteration will reduce the amount of time surface water is pooled and exposed to solar radiation, which will change the thermal regime of this waterbody. The lack of increased exposure to solar energy will result in a decrease in water temperatures below Powell Falls and in the re-established river channel in the Lake Louise bed after dam removal. Reduced water temperature will be beneficial to the popular recreational Brown and Brook Trout (*Salmo trutta* and *Salvelinus fontinalis*, respectively) fisheries that require cold water and exist in the Kinnickinnic River downstream of Powell Falls and in the re-established river channel through the Lake Louise bed.

Dam removal activities can impact water quality conditions by increasing suspended solids and releasing contaminants that were previously stored in the impoundment sediment. Given this concern, RFMU collected two parameters, total phosphorus concentration and total suspended solids, during the Lake Louise drawdown initiated on October 2, 2020 to monitor water quality impacts (results are depicted in Figure 2). Total phosphorus concentration was above the state of Wisconsin standard 13 of the 24 sampling dates. The highest value, 0.36 mg/L, occurred on

October 7. The dates when total phosphorus concentrations were above state standard occurred on or before October 22. Total phosphorus concentrations were below state standard on all sampling dates after October 22.

Figure 2. Total Phosphorus (TP) Concentrations (mg/L) in the Kinnickinnic River downstream of Powell Falls Dam



Note: State of Wisconsin total phosphorus water quality standard for streams is 0.075 mg/L (WDNR 2017).
Source: City of River Falls Municipal Utilities.

Increased levels of phosphorus can impact water quality by increasing primary productivity in a water body. Increased levels of this essential plant nutrient can set off a chain of undesirable events in a waterbody including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals (EPA 2012). There are many sources of phosphorus in the Kinnickinnic River basin, one of which is the point-source wastewater treatment plant that discharges into the Kinnickinnic River upstream of Powell Falls Dam. As a monitoring requirement of this facility's discharge permit, RFMU regularly records total phosphorus concentrations in the wastewater facility outfall. The increased levels of phosphorus during the first week of the drawdown are a result of its resuspension in surface water after being stored in the sediment that composed the substrate of Lake Louise. The rapid decline in total phosphorus after the first two weeks of the drawdown reflects the amount of time it took for the erosive forces of the river channel formation to alleviate. Now that the river channel is present in Lake Louise, continued erosion of the lakebed outside of the channel will be limited, and phosphorus that remains stored in the substrate will not be released into the Kinnickinnic River.

Suspended sediment can alter water quality by causing temperature decreases and turbidity increases (Ryan 1991). To monitor sediment concentration downstream of Powell Falls Dam, RFMU recorded total suspended solids (TSS) during the drawdown of Lake Louise (Figure 3). Soon after lowering the water elevation of the impoundment formed by Powell Falls Dam on October 2, 2020, its bed substrate began to erode as the Kinnickinnic River channel formed (Figure 1). Total suspended solids concentrations remained at low levels for the first four days before a rapid increase occurred on October 7, 2020. Fluctuations in TSS occurred as avulsive episodes released sediment during river channel formation in the bed of Lake Louise until a precipitation event of approximately 2 inches[2] of rain on October 12, 2020 raised TSS to the highest concentration recorded, 3081 mg/L, during the monitoring period. TSS concentrations rapidly declined after the heavy rainfall caused increased erosion of the exposed Lake Louise substrate and returned to levels similar to those prior to the drawdown (Figure 3).

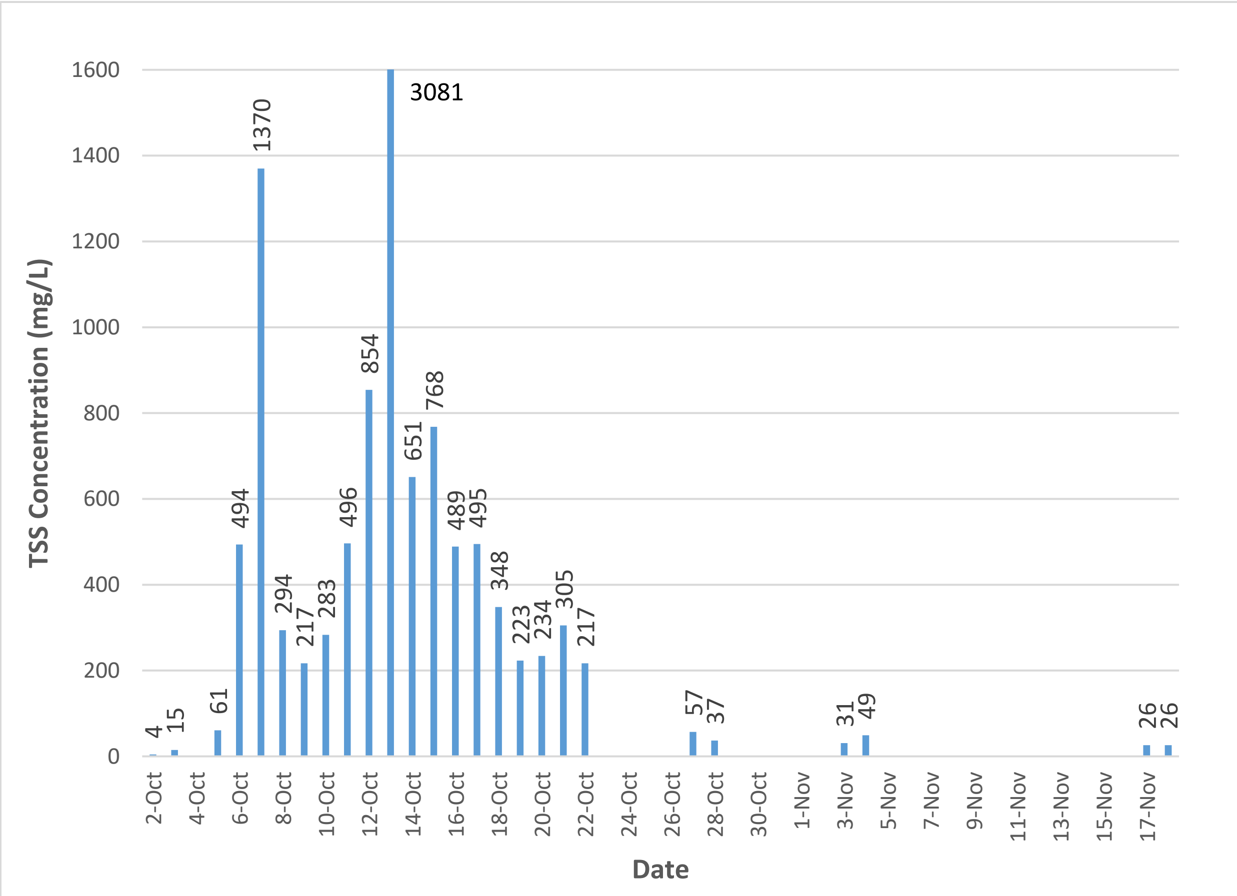
Short-term impacts to water quality of the Kinnickinnic River were observed during the drawdown of Lake Louise created by Powell Falls Dam. Phosphorus concentrations increased for a short period of time during the formation of the river channel in Lake Louise but have decreased to concentrations below the criteria for this nutrient established by the state of Wisconsin. Given that this brief increase in phosphorus occurred during late Fall when primary productivity is diminished, it is unlikely it upset the trophic structure of the lower Kinnickinnic River. Since the phosphorus was not utilized by algae or plants for growth, it likely precipitated and amalgamated with the fine sediment that was conjointly transported downstream during the 2-week time period after the drawdown was initiated. If the drawdown had occurred during a period of increased primary productivity (i.e., Spring or Summer), the increase in the nutrient phosphorus may have caused increased algal blooms and plant growth. Similarly, the increase in suspended solids caused intense yet brief increases in turbidity. Any impacts to water temperature were negligible as the 2-week period when the addition of suspended sediment occurred was late Fall when water temperatures are normally rapidly declining. The degradation of water quality by increased suspended sediment concentrations and the nutrient phosphorus

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

would likely have been of greater consequence if it had occurred during Spring or Summer months.

A contaminant analysis of the sediment in Lake Louise consisting of collecting samples at six locations was performed in 2016. Parameters tested were metals (As, Cd, Cr, Cu, Pb, Ni, Zn, and Hg), organics (polycholorinated biphenyl (PCB), polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides, and petroleum residues), and physical (particle size and percent total organic carbon). PCBs were not detected. Threshold effects concentrations (TEC) of trace metals were not exceeded. Arsenic was found above the probable effects concentration (PEC) in one sampling location. Dichlorodiphenyldichloroethane (DDD) values above TEC were detected at one sampling location. Ten PAH compounds were above TEC at one sampling location. Four PAH compounds were above PEC at one sampling location. All other PAH compounds detected were below TEC. The resulting determination of the Lake Louise contaminant study was the sediment is relatively clean and represented a low risk to the aquatic organisms residing in the Kinnickinnic River downstream of Powell Falls Dam; a critical element in the decision-making to move forward with dam removal (Interfluve 2016).

Figure 3. Total Suspended Solids (TSS) (mg/L) in the Kinnickinnic River downstream of Powell Falls Dam



Source: City of River Falls Municipal Utilities.

3.2 Aquatic Habitat Sedimentation Risks and Benefits

Burial of some of the Brown and Brook Trout available spawning habitat in the lower Kinnickinnic River is a short-term risk due to the removal of Powell Falls Dam. Excess sediment can profoundly affect the productivity of a trout stream by burying the spawning beds (Cordone and Kelly, 1961). Increased fine sediment in spawning gravels cause decreased survival and emergence of salmonid eggs and alevin (Lisle 1989; Tappel and Bjornn 1983). Brown Trout use clean gravel substrate in October and November to spawn. Brook Trout use similar substrate but often migrate to headwater streams to spawn during the same time period. Both trout species find cold clear water to excavate spawning nests or redds by rapidly moving their tails to push aside substrate, which results in a circular or oval depression in the river bottom (Werner 2004). Ideal conditions for Brown and Brook Trout to build redds are often associated with upwellings of groundwater or hyporheic flow (Baxter and Hauer 2000). Cold water seeps or springs adjacent to the mainstem Kinnickinnic River and riffle habitats provide optimum conditions for Brown and Brook Trout spawning. The combination of the upward movement of groundwater and/or hyporheic discharge with the lateral mainstem flow flushes sediment up and away from a trout spawning redd. Additionally, the initial excavation of the redd cleans the substrate of fine sediment and exposes the coarser gravel.

The brief intense pulse of suspended sediment experienced during the October 2020 drawdown occurred at a sub-optimal time to avoid impacts to Brown and Brook Trout spawning. During consultation with Wisconsin DNR, it was noted that trout spawning in the Kinnickinnic River starts by late October and peaks in early November.[3] To minimize risk to trout, it was recommended to initiate the draw down as soon as possible so turbidity would have a chance to clear prior to the start of spawning. It is possible, however, that both species may have initiated spawning activities when the drawdown occurred; however it's more likely that the drawdown occurred early enough in the spawning season that eggs had not yet been deposited. If this is the case, sediment released and transported downstream during the Lake Louise drawdown could have been removed by favorable hydraulic conditions that are associated with trout spawning habitat and by the redd maintenance activities by spawning adults.

Increased sediment transport downstream resulting from dam removals has been documented (Burroughs et al. 2009). The initial movement of finer sediments moving downstream following a dam removal results in a reduction in bed sediment caliber (Wohl and Cenderelli 2000). High stream discharge events driven by precipitation or snowmelt will increase the rate of transport rate and caliber of sediment (Pearson et al. 2011). Aerial imagery collected prior to and after the initial 2-week period of the Lake Louise drawdown provides insight into where the sediment deposited downstream of Powell Falls Dam. A qualitative evaluation of this imagery collected by photographic equipped drone flown at varying elevations above the Kinnickinnic River shows that the bulk of the transported fine sediments settled in the lower velocity pool habitats located within 6,000 ft downstream of Powell Falls Dam. This length of river corresponds with Reach 1 of the Riverine Habitat Evaluation draft report that describes it as a "pool-riffle morphology with large gravels and cobbles in riffles being 20% embedded" (Interfluve and GSRC 2020). Undoubtedly, the embeddedness of the coarser substrates in pool habitat has increased in Reach 1 post-drawdown (Figure 4). Riffle habitats, however, were less susceptible to sediment settling released during the drawdown. The hydraulic conditions associated with riffles inhibit

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[3] RFMU consulted with Wisconsin Department of Natural Resources on September 23rd and 24th, 2020 when it was determined that the drawdown should be completed by October 15, 2020 to minimize impacts to trout and overwintering herptiles. These meeting summaries were included with the *River Falls Hydroelectric Project, FERC Project No. 10489 Plan and Schedule Response to September 10, 2020 letter regarding June 2020 Flooding Damage* filed with FERC on September 25, 2020. FERC accession number 20200925-5137.

deposition by continuously flushing suspended sediment to lower velocity habitat features such as adjoining pools (Figure 5). Since the eggs deposited by Brook and Brown Trout in redds are more likely to occur in riffle habitats, their susceptibility to the increased sediment deposition of the Lake Louise drawdown is lessened. Similarly, larval life stages that remain in riffle habitats are less likely to suffer the effects of increased sediment deposition associated with dam removal activities.

Figure 4. Aerial images of the Kinnickinnic River 200 feet downstream of Powell Falls Dam before and after the drawdown event of October 2020.

Source: GoogleEarth, imagery collection date prior to October 2, 2020

Source: Source: Kinnickinnic Corridor Collaborative, https://www.youtube.com/channel/UCB-jCo-8r4iQVowaFzC1UhQ

Figure 5. Aerial images of the Kinnickinnic River 3,000 feet downstream of Powell Falls Dam before and after the drawdown event of October 2020.

Source: GoogleEarth, imagery collection date prior to October 2, 2020

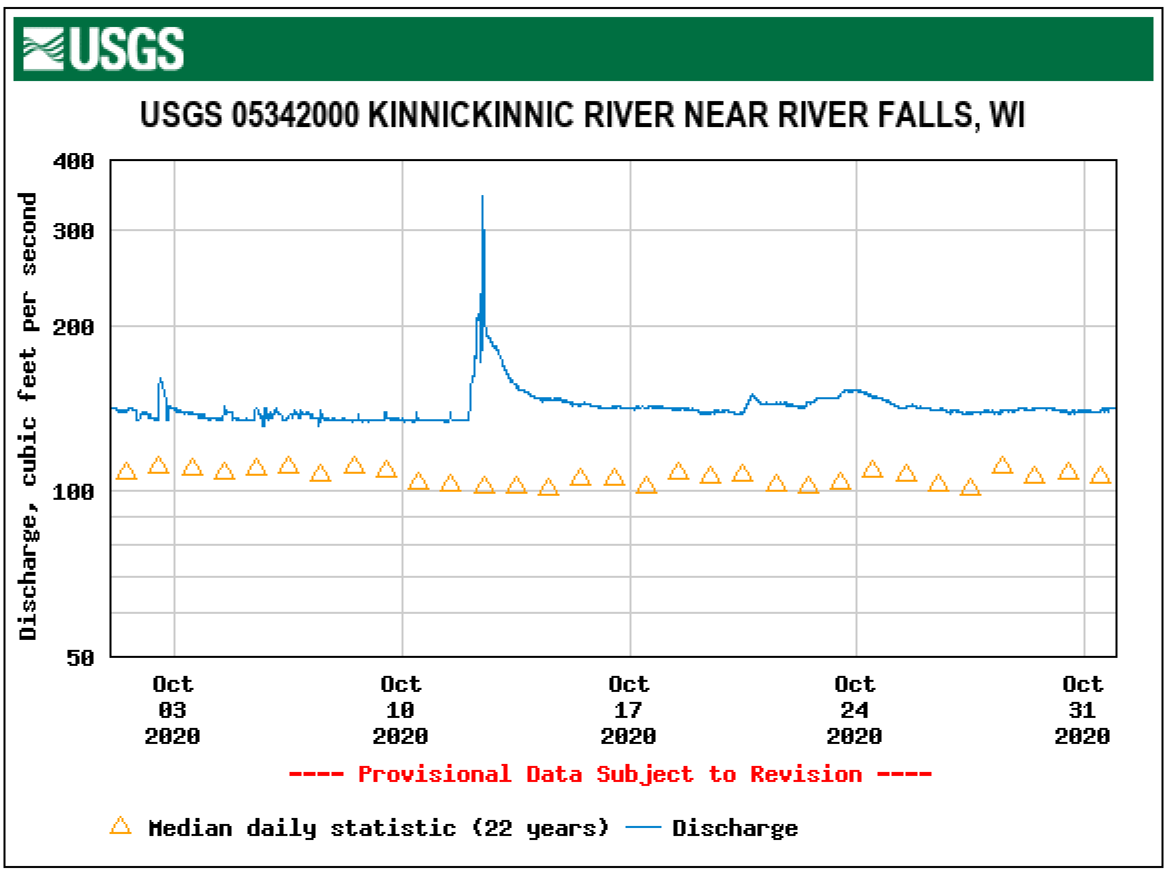
Source: Source: Kinnickinnic Corridor Collaborative, https://www.youtube.com/channel/UCB-jCo-8r4iQVowaFzC1UhQ

These observations demonstrate that the fine sediments released upstream will eventually settle in pool habitats of the Kinnickinnic River. The sediment accumulation in pools will influence the life stage specific behavior of Brown and Brook Trout that use this habitat. Decreased pool depth, i. e., raised channel bed elevation, can lead to decreased use of this habitat type as a holding location for resting or foraging for juveniles and adults. Daily peak water temperatures may increase in shallower pools because of the decrease in water volume, which could deter use by juveniles and adults. Short-term negative impacts to the life stages of Brown and Brook Trout due to increased sedimentation in pool habitats needs to be compared to the long-term advantages of dam removal.

The removal of Powell Falls Dam creates a setting that could produce favorable trout spawning habitat conditions in the reach upstream of the dam. The establishment of a free-flowing stream whose increased flow velocities scour the bed of Lake Louise will benefit trout populations by uncovering the coarse substrates of the original river channel. These coarse substrates are preferred spawning habitat (Werner 2004). Trout production could increase in the years following the Powell Falls Dam removal depending on the amount of quality spawning substrate that is exposed.

The impacts from sediment deposition on pool habitats downstream of Powell Falls Dam will likely be of short duration. First, if productivity was reduced during the spawning season (Fall) of 2020, it will likely recover in following years as the two trout species use alternative spawning habitat locations including ones that are formed through the river channel creation in the bed of Lake Louise. Future dam removal activities that cause sediment releases should not overlap the time period when spawning and egg incubation occurs (approximately October through early March). Secondly, the sediment burden will continue to be transported further downstream by increased discharge events. The October 2020 drawdown occurred during the relatively low discharge conditions typically experienced during this season. Although there was a rapid increase in discharge associated with the October 12 precipitation event, it quickly returned to stable baseline flows (Figure 6). The rapid rise and decline in water elevation likely led to sediment being transported a relatively short distance downstream of Powell Falls Dam. Successive increased discharge events of longer duration and larger magnitudes, e. g., spring freshets, will continue to redistribute the sediment by enhancing scour of the recently created bed formations and transporting sediment farther downstream over extended periods of time.

Figure 6. Kinnickinnic River discharge during the month of October 2020.



Sessile organisms or life stages are more susceptible to sediment deposition. Trout eggs can suffocate from lack of dissolved oxygen as fine sediments accumulate on them in the redd (Argent and Flebbe 1999). This risk is greatest when sediment is released after eggs are present, i. e., spawning season. Brook Trout are naturally adapted to avoid this negative impact by using habitats associated with groundwater upwelling for spawning (Alberto et al. 2017).

Freshwater mussels are a taxon that spend most of their life cycle partially buried in substrate. They respire by siphoning water across filamentous gills to extract dissolved oxygen. They have a muscular organ called a foot that allows them to move through substrate. Their mobility allows them to move vertically in substrate as well as laterally across the surface of the substrate. Chronic exposure to sedimentation and associated turbidity can negatively affect recruitment of freshwater mussel populations (Osterling et al. 2010). Episodic exposure to sedimentation such as those that occur during dam removal activities is less of a risk to mussels.

Five federally endangered species of mussels are known to occur in the lower St. Croix River-spectaclecase (*Margaritifera monodonta*), snuffbox (*Epioblasma triquetra*), Higgins eye (*Lampsilis higginsii*), sheepnose (*Plethobasus cyphyus*), and winged mapleleaf (*Quadrula fragosa*) (USFWS 2019). Extant populations of these species are known to exist in the lower St. Croix River A field survey was performed in the 0.8 miles of the Kinnickinnic River upstream of the confluence of the St. Croix River and downstream of this location to the confluence of the Mississippi River during August 2020 to document mussel habitat (location, depth, and substrate), and the occurrence density, distribution, and relative abundance of any federally listed mussel species present. The results of this survey show the lower St. Croix River harbors a species rich mussel community in the study area with at least 19 live species including the federally endangered Higgins eye in some of the sampled sites, with pockets of moderately densely populated areas that appears minimally affected by zebra mussels at this time (Kelner 2020). A total of 55 live mussels representing 11 species were observed at the sampling location closest to the Kinnickinnic River confluence. *Amblema plicata* was the most abundant, 47.3% of all live mussels, followed by *Obliquaria reflexa*, 12.7%, and *Eurynia dilatata*, 12.7% (Kelner 2020). None of the federally listed species were observed at the site closest to the Kinnickinnic River confluence (Kelner 2020).

The lower Kinnickinnic River is less suitable for use of freshwater mussels due to the presence of loose shifting sand substrate. The Kinnickinnic River is also a coldwater trout stream, which "typically do not harbor diverse mussel assemblages" (Kelner 2020). Kelner performed sampling in the lower Kinnickinnic River in July 2020 and found no evidence of live or relic mussels. No records of native mussels have been identified from the lower Kinnickinnic River (Kitchel pers. comm., as cited in Kelner 2020).

Sediment transport in the Kinnickinnic River can influence the physical characteristics of mussel habitat in the St. Croix River downstream of its confluence. Given that the greatest change in physical habitat conditions due to sediment transport from the October 2020 drawdown occurred in the reach that extends approximately 1 mile downstream of Powell Falls Dam, negative impacts from dam removal activities to the freshwater mussels found at the confluence with the St. Croix River are likely negligible (see Part 1).

Kelner noted that "the flood event that occurred immediately prior to this study provided an opportunity to evaluate the effects of dam removal and resulting increased flows on the lower Kinnickinnic River with possible impacts to mussels in the lower 6-miles of St. Croix River. Given the results from this study it appears dam removal with respect to increased and possibly irregular flows and resulting increased sedimentation into the lower St. Croix would not result in adverse impacts to mussels including federally listed species at least in the short term. However, it's recommended longer term effects to mussels in the lower St. Croix River from dam removal should be evaluated with a single repeat of this study between 10 and 20 years post dam removal." (Kelner 2020)

A risk of sediment deposition in the Kinnickinnic River floodplain changing riparian vegetation community exists. A description of the bed load change from the June 2020 flood event in the reach immediately downstream of Powell Falls Dam appears in page 10 of Ayers 2020. The Riverine Habitat Assessment described the post-flood conditions of this reach as "overbank sedimentation of fine sand varying in thickness from less than 1 inch to 4 feet." Figure 8 of the Riverine Habitat Assessment provides an image of this description (page 14 of Interfluve and GSRC 2020). This reach also experienced the sediment transport impact of the drawdown in October 2020. The flood transported sediment remained in the Kinnickinnic River channel during the drawdown, however. Newly deposited sediment forming bars downstream of Powell Falls Dam is unstable and likely will continue to be transported downstream during future increased discharge events. The magnitude and duration of these events will determine if the sediment deposited during the drawdown will move laterally from the channel to the floodplain or downstream. The dynamic nature of disturbance along the Kinnickinnic River is typical of a palustrine forest, the prevalent floodplain vegetation classification identified in the 2018 River Falls Hydroelectric Project Preliminary Application Document (PAD). This forest type is characterized by woody vegetation 18 ft or taller. It contains broad-leaved deciduous plants that are adapted to seasonally saturated organic soils (USFWS 2018). These floodplain forests consist of numerous small patches of vegetation with different species composition and successional stages. This mosaic of vegetation patches changes along a gradient of flooding frequency and duration (Cohen et al. 2020). Without the dynamic conditions that periodic flooding creates, this vegetation community may cease to exist, i. e., displays intolerance to lack of sediment deposition. Therefore, the associated sediment deposition that occurs during flood events maintains the vegetation community of the Kinnickinnic River floodplain.

Sediment transported and deposited downstream of the Powell Falls Dam during the October 2020 drawdown has not created blockages of upstream migration routes for aquatic species. Aerial imagery of the 3000 ft length of river immediately downstream where the most pronounced sediment deposition occurred post-drawdown does not show any blockages that would restrict fish movement, nor, to our knowledge, have any anecdotal reports of blockages been reported. The June 2020 flood event created or augmented gravel/cobble bars in the river channel (see Figure 3 on page 8 of Riverine Habitat Evaluation; Interfluve 2020). However, these bars were longitudinally oriented with the river channel discharge; no aquatic organism migration blockages were created. As future discharge events of greater magnitude and duration scour and redistribute the bed load that shifted downstream during the October 2020 drawdown, the likelihood of this sediment burden forming blockages will further decrease.

The October 2020 drawdown provided conditions to increase physical habitat features that provide ecosystem benefits, such as channel spawning gravels, bars, islands, large wood features, and side channel activation. In addition to the deposition bars formed immediately downstream of Powell Falls Dam (Figure 4), the continuation of dam removal activities will transport additional sediment for the formation of approximately six depositional bars within the bankfull channel in the lower Kinnickinnic River annually (see Part 1). Reach 3 is a section of the river where the wide valley margins and increased number of tributaries may allow the reconnection of relic channels and meander scars to the existing channel (Ayers 2020). RFMU staff reported having to frequently remove large woody debris that was uncovered from the Lake Louise substrate during the October 2020 drawdown. This beneficial habitat building material will progressively move downstream and once fixed, will create hydraulic conditions that add complexity to the existing habitat composition. Newly created gravel bars that were stripped of fine sediment during the June 2020 flood event will benefit from the delivery of fine sediment to anchor the large woody debris so it is not continuously transported downstream during future increased discharge events. The heterogeneous mix of coarse and fine sediments will benefit organisms that require interstitial habitat complexity to complete their life cycle.

The risk and benefit of dam removal to macroinvertebrate taxon can be subtle and thus challenging to observe. Thompson et al. (2005) recorded a temporary change in macroinvertebrate densities arising from the downstream sediment transport following a dam removal. Chiu et al. (2013) stated that downstream sedimentation following dam removal reduces macroinvertebrate density although timescales appropriate to fully interpret the long-term consequences are important yet rarely observed. Stanley et al. (2002) noted that dam removal caused minor geomorphic and ecological changes in downstream reaches, while the rapid channel formation in the impoundment reservoir created suitable habitat for a more diverse macroinvertebrate community than what existed prior. Heterogeneous habitat composed of fine and coarse substrate, varying depths, and favorable water quality conditions that benefit other aquatic taxa also benefit macroinvertebrates. The re-establishment of the Kinnickinnic River channel in the bed of Lake Louise will create an increasingly complex habitat composition in this previous homogeneous substrate. Macroinvertebrate species diversity is likely to increase in the newly formed river channel upstream of Powell Dam after removal.

3.3 Ice Jams

Ice jams are unlikely to occur during or after removal of Powell Falls Dam. The water temperature of the mainstem Kinnickinnic River is influenced by groundwater, which supplies a constant input of above freezing temperatures during winter (Interfluve 2017). Dam removal will increase flow velocities, which limits ice formation. The combination of a constant groundwater supply and increased velocities following dam removal will limit ice formation in the Kinnickinnic River below Powell Falls Dam. It is possible that ice jams that commonly form in the St. Croix River may build upstream into the downstream reach that forms the confluence with the Kinnickinnic River (https://www.startribune.com/threat-of-minor-flooding-hangs-over-cities-on-st-croix/87538387/). Increased flow velocity after dam removal may alleviate some of the backwater effect from the St. Croix that may push ice into the lowest reach of the Kinnickinnic River.

3.4 Recreational Use

Sediment deposition at recreational use areas that include navigation channels is a risk from dam removal. The informal fishing area and boat launch downstream of Powell Falls Dam experienced alterations due to sediment deposition at this site (see Figure 4 and Photo 9 on page 19 of the Recreation Facilities Inventory; TRC 2020). The pool habitat in the vicinity of this site is currently considerably shallower than prior to the October 2020 drawdown. While the sediment deposition hasn't created a blockage to recreational navigation, the shallow conditions may require in-water portaging (i. e., stepping into the river channel and floating the vessel downstream). It is also possible that this impacted site is less favorable for recreational angling pursuits. This unfavorable condition at this recreational site is expected to change as future discharge events of differing magnitude and duration scour and redistribute the bed load that shifted downstream during the October 2020 drawdown.

4.0 CONCLUSIONS

The primary goal of most dam removal projects is to improve the ecology of the aquatic ecosystem of the developed water course. The ecological benefits of restoring connectivity to upstream reaches of the Kinnickinnic River is a desired outcome of the Powell Falls Dam removal. Understanding the short-term risks to the lower Kinnickinnic River assists in managing the entire dam removal project from start-to-finish by establishing criteria to avoid substantial negative impacts. Recognizing long-term benefits as the established goals of performing the Powell Falls Dam removal can assist in determining acceptable levels of risk. Table 1 provides a summary of that qualitatively assigns levels of ecological risk and benefit that reflect the results and discussion for all the identified impacts of removing the Powell Falls Dam. The most recognizable short-term risks are to trout habitat used by multiple life stages from sedimentation, reduction in substrate complexity in reaches immediately downstream of Powell Falls Dam, and adverse effects on recreational use of the Kinnickinnic River as a navigable corridor. However, the long-term risk for all the identified impacts is low. The long-term benefits are high for many of the impacts identified. The long-term benefits are considered low for freshwater mussels primarily because the Kinnickinnic River has not historically provided preferred habitat for this taxon. Given that long-term benefits are more numerous than short-term risks, the Powell Falls Dam removal is likely to be successful in achieving its restoration goal of the Kinnickinnic River.

Table 1. Ecological risk and benefit analysis of removing Powell Falls Dam.

Impact	**Risk**		**Benefit**	
	Short-term	*Long-term*	*Short-term*	*Long-term*
Water quality	M	L	L	H
Sedimentation				
Trout habitat	H	L	L	H
Freshwater mussels	L	L	L	L
Floodplain vegetation	M	L	L	H
Fish movement	L	L	L	H
Impoundment				
Riverine conditions	L	L	M	H
Instream Habitat				
Substrate complexity	H	L	M	M
Invertebrate taxa	M	L	M	M
Ice Jams	L	L	L	M
Recreation	H	L	L	H

Short-term = ≤1 year; Long-term = ≥ 1 year
L = low, M = medium, H = high

5.0 REFERENCES

Alberto, A., S. C. Courtenay, A. St-Hilaire, and M. R. van den Heuvel. 2017. Factors influencing Brook Trout Egg Survival and Development in Streams influenced by agriculture. Journal of Fisheries Science

Argent, D. G. and P. A. Flebbe. 1999. Fine sediment effects on Brook Trout eggs in laboratory streams. Fisheries Research 39: 253-262.

Ayres. 2020. City of River Falls Hydroelectric Project FERC Project 10489 Powell Falls Decommissioning Plan: Draft. City of River Falls Municipal Utilities. January 30, 2020.

Baxter, C. V. and F. R. Hauer. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by Bull Trout, *Salvelinus confluentus*. Canadian Journal of Fisheries and Aquatic Sciences 57(7): 1470-1481.

Burroughs, B.A., Hayes, D.B., Klomp, K.D., Hansen, J.F., and J. Mistak. 2009. Effects of Stronach Dam removal on fluvial geomorphology in the Pine River, Michigan, United States. Geomorphology 110, 96–107.

Chiu, M. C., C. H. Yeh, Y. H. Sun, and M. H. Kuo. 2013. Short-term effects of dam removal on macroinvertebrates in a Taiwan stream. Aquatic Ecology 47: 245-252.

Cohen, J.G., M.A. Kost, B.S. Slaughter, D.A. Albert, J.M. Lincoln, A.P. Kortenhoven, C.M. Wilton, H.D. Enander, and K.M. Korroch. 2020. Michigan Natural Community Classification [web application]. Michigan Natural Features Inventory, Michigan State University Extension, Lansing, Michigan. https://mnfi.anr.msu.edu/communities/classification.

Cordone, A.J. and D.W. Kelley. 1961. The influences of inorganic sediment on the aquatic life of streams. Reprint from California Fish and Game. Vol. 47, No. 2. California Department of Fish and Game, Inland Fisheries Branch. Sacramento, CA. 41 pp.

Environmental Protection Agency (EPA). 2012. Water Monitoring and Assessment: Phosphorus. https://archive.epa.gov/water/archive/web/html/vms56.html

Interfluve. 2016. Lake George and Lake Louise Sediment Assessment. River Falls Municipal Utilities. 3/14/2016.

Interfluve. 2017. Kinnickinnic River Corridor Plan Dam Removal Scenario: Summary of Ecological Impacts. River Falls Municipal Utilities.

Interfluve and Gulf South Research Corporation (GSRC). 2020. River Falls Hydroelectric Project Riverine Habitat Evaluation below Powell Falls. River Falls Municipal Utilities.

Kelner, D. 2020. Mussel survey for the River Falls Hydroelectric Project (FERC No. 10489): Lower Kinnickinnic and St. Croix Rivers, Pierce Col, Wisconsin and Washington Co., Minnesota: Draft Report. River Falls Municipal Utilities. U. S. Army Corps of Engineers, St. Paul District Regional Planning and Environmental Division, St. Paul, MN.

Lisle, T. E. 1989. Sediment transport and resulting deposition in spawning gravels, north coastal California. Water Resources Research 25(6): 1303-1319.

Osterling, M. E., B. L. Arvidsson, and L. A. Greenberg. 2010. Habitat degradation and the decline of the threatened mussel Margaritifera margaritifera: influence of turbidity and sedimentation on mussel and its host. Journal of Applied Ecology 47: 759-768.

Pearson, A.J., Snyder, N.P., and M. J. Collins. 2011. Rates and processes of channel response to dam removal with a sand-filled impoundment. Water Resources Research 47 (8).

Randle, T.J. and J. Bounty. 2017. Dam Removal Analysis Guidelines for Sediment. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Ryan, P. A. 1991. Environmental effects of sediment on New Zealand streams: a review. New Zealand Journal of Marine and Freshwater Research 25: 207-221.

Stanley, E.H., Luebke, M.A., Doyle, M.W., and D.W. Marshall. 2002. Short-term changes in channel form and macroinvertebrate communities following low head dam removal. Journal of North American Benthological Society 21(1): 172-187.

Tappel, P.D. and T.C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3: 123-135.

Thompson, J. R., D. D. Hart, D. F. Charles, T. L. Nightengale, and D. M. Winter. 2005. Effects of removal of a small dam on downstream macroinvertebrate and algal assemblages in a Pennsylvania stream. Journal of North American Benthological Society 24(1): 192-207.

TRC. 2020. Recreational Facilities Inventory. River Falls Municipal Utilities.

United States Fish and Wildlife Service (USFWS). 2018. National Wetlands Inventory. https://www.fws.gov/wetlands/index.html

United States Fish and Wildlife Service (USFWS). 2019. Midwest Region Endangered Species: Mussels of the St. Croix River. https://www.fws.gov/midwest/endangered/clams/stcroix.html

United States Society on Dams (USSD). 2015. Guidelines for Dam Decommissioning Projects. USSD Committee on Dam Decommissioning.

Wisconsin Department of Natural Resources (WDNR). 2017. Guidance for Implementing Wisconsin's Phosphorus Water Quality Standards for Point Source Discharges. Guidance Number 3400-2011-02 Ed. 2.

Werner, R. G. 2004. Freshwater Fishes of the Northeastern United States. Syracuse University Press. Syracuse, New York.

Wohl, E.E., Cenderelli, D.A., 2000. Sediment deposition and transport patterns following a reservoir sediment release. Water Resources Research 36: 319–333.

Wohl, E. 2014. Rivers in the Landscape: Science and Management. John Wiley & Sons.

Appendix J – Powell Falls Decommissioning Plan
(filed separately due to file size)

City of River Falls
Hydroelectric Project
FERC Project P-10489

Powell Falls
Decommissioning Plan

Prepared for:

City of River Falls
Municipal Utilities
River Falls, WI

January 30, 2021

City of River Falls Hydroelectric Project
FERC Project P-10489

Powell Falls Decommissioning Plan

January 28, 2021

Engineering analyses used to support this plan are made with information available at the time of the report's publication with the intent that this plan lays the foundation of future considerations but not necessarily the exact details of construction activities. This plan anticipates adaptation and verification to new information later. Ayres expects that the final permit applications and drawings and specifications will be independent of this report.

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Introduction

The City of River Falls Municipal Utilities (RFMU) is preparing an application for a new hydropower license for the River Falls Hydroelectric Project in Pierce County, Wisconsin. The existing Federal Energy Regulatory Commission (FERC) license for Project P-10489 currently includes two developments, Junction Falls (upstream dam that impounds Lake George) and Powell Falls (downstream dam that impounds Lake Louise). The entire project is within the city limits of River Falls.

A large flood in 2020 damaged the existing Powell Falls dam, and generation is not expected to pay for all of the repairs necessary[1] to restore the dam to current FERC standards. While RFMU is submitting a final license application due in August 2021 to continue hydropower generation at Junction Falls Development, the RFMU believes there are too many fiscal and environmental concerns with refilling the Lake Louise impoundment and continuing power generation at the Powell Falls Development. In March 2021, RFMU proposes to submit an application to amend the current license to remove Powell Falls Development from the FERC license but with the intent to keep facilities in place and proceed with dam removal through the state process. RFMU's intent is to continue negotiations about dam removal options and permit needs with the Wisconsin Department of Natural Resources and US Army Corps of Engineers following receipt of the FERC amendment to remove Powell Falls from the FERC license.

This study on decommissioning and dam removal options is intended to develop overall removal goals, consider lessons learned at other nearby dam removals, and describe risks associated with dam removal so that regulatory agencies and stakeholders understand the potential impacts of the project. This study is current through January 2021, but the final removal plan and permit applications are expected to adapt to newly released studies[2,3] and future information[4].

Definitions

In this report, "decommissioning" is defined to mean the whole process of ceasing licensed operations, including a physical disconnect from the utility grid (pulling breakers, locking out equipment controls), the permitting process for dam abandonment, dam removal (a "subtask" of decommissioning), and mitigation required in terms of sediment management and site restoration. Decommissioning does not typically include[5] larger recreational improvements (corridor plans, new recreational facilities) or extensive habitat improvements (especially those not directly correlated with mitigating advese impacts caused by the physical act of dam removal). "Removal" refers to physical construction activities intended to reduce

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[1] "Post-Flood Dam Safety Inspection and Repair Options Letter for Powell Falls Dam (P-10489)." Ayres. December 18, 2020.

[2] "Kinnickinnic River Hydraulic and Hydrologic Analysis." US Army Corps of Engineers. January 2021. Report just received and under review now.

[3] "Appendix 1: Climate Change Analysis." US Army Corps of Engineers. January 2021. Report just received and under review now.

[4] The final restoration goals for the project's lakebed are not finalized, nor are the river corridor improvements fully designed and funded. The removal project is expected to be adaptive to both environmental goals (restoration and sediment management), recreation goals (trout habitat improvements, kayaking improvements, park amenities), and budget (grant cycles, rate-payer impacts, etc.).

[5] While these extra amenities are sometimes done simultaneously to improve construction efficiencies, often different permits are used for dam removal and extra amenities.

public safety risk, eliminate hydraulic impacts to the river, and restore the site to the desired natural functionality while protecting critical infrastructure. Decommissioning is the whole process, usually lengthy and with a complex regulatory and legal review[6], and dam removal is usually the final subcomponent of the longer decommissioning process.

Public and Agency Involvement

Through the Kinni Corridor planning process, the City of River Falls has proactively engaged the community upfront on the proposed removal project. The Kinnickinnic River Corridor Plan, adopted by the City Council in January 2019 after public consultation, includes removal of the Powell Falls Dam in 2026. The Plan also addresses recreational, aesthetic, ecological, land use, and economic objectives for the Kinni Corridor, all of which are closely linked to the presence or absence of the dams.

A continuing high level of public interest is expected for this project. A continuing high level of public interest is expected for this project. RFMU will continue to engage agencies, Tribes, and stakeholders through the FERC Integrated Licensing Process (ILP) to facilitate positive collaboration during the planning and implementation of dam removal activities. Presentations made to the RFMU Utilities Advisory Board have been recorded and are publicly available through the City of River Falls website.

The Wisconsin Department of Natural Resources (WDNR), Trout Unlimited (TU), and local stakeholders have been regularly engaged with updates about the 2020 flood damage, drawdown impacts, inspection results, and repair options. The WDNR and FERC staff assisted the design team's understanding of what regulatory options existed for maintaining a safe drawdown overwinter and how different repair and sediment management options could benefit the project and downstream resources. TU and their consultant offered insight into desirable mitigation for downstream amphibian and trout habitat impacts, and the Kinni Corridor Committee's relationship with River Sky Drones provided valuable aerial images of the changing lakebed and sediment movement patterns.

In summary, this decommissioning report attempts to present a balanced perspective on a cost-effective removal option, an environmentally conscious sediment management plan, flexibility to keep the permitted actions of removal separate from the long-term restoration goals, and the ability to adapt to new information learned through the process. The report's authors acknowledge that a wide variety of opinions exist on dam removal, sediment mitigation, and restoration strategies; but this report is written from the perspective of the licensee's preferred path forward.

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[6] Margaret Bowman. "Legal Perspectives on Dam Removal: This article outlines the legal issues associated with dam removal and examines how environmental restoration activities such as dam removal fit into the existing US legal system." BioScience, Volume 52, Issue 8, August 2002, Pages 739-747. Downloaded at https://academic.oup.com/bioscience/article/52/8/739/255099.

Anticipated Schedule

The decommissioning process for the Powell Falls Development is expected to follow this schedule:

Milestone	Deliverable(s)	Estimated Time of Completion
Initial Study Report Submittal	Draft Decommissioning Plan	January 31, 2020
Initial Drawdown for Inspection	Inspection Report and Refill Options	December 18, 2020
RFMU Workshop on Options for Plan Forward	Decision on Preferred Plan and Schedule for Decommissioning	January 19, 2021
Updated Study Report Submittal	Final Decommissioning Plan	January 30, 2021
Updated Study Report Meeting	Virtual Meeting	February 9, 2021
License Amendment Application Submitted to FERC	Request to remove Powell Falls from existing FERC license	March 2021
Lakebed Seeding (1)	Hand seeding of lakebed	March 2021
Applications Submitted	Permits for sediment management and access road improvements	March 2021
Permits Issued by WDNR and USACE		Late April 2021
FERC Authorization Received to Improve Flow Management and Temporary Abutment Protection	Turbine removed, sluice gate operation improved, right abutment sandbagged	June 2021
Lakebed Seeding (2)	Drone seeding of lakebed	June 2021
Monitoring of Infrastructure	Wastewater line crossings monitored, adaptive management for repair needs	2021-2026 with riprap placed prior to the start of river diversion (large opening)
Sediment Management	Removal of tailrace sediments and installation of sediment trap	Summer 2021
FERC Amendment Decision	FERC decision received	April 2022
Sediment Management Annual Evaluation	Evaluate need to remove tailrace sediments	Annually until dam removal is complete
Final Design of Dam Removal	Plans and Specifications	Fall 2022
Final Restoration Plan	Plans and Specifications	December 2022 [7]
Permit Applications Submitted	Removal permit applications	December 2022 [8]
Contractor Mobilization	Notice to Proceed	June 1, 2023
Dam Removal Completed	Dam removal phase completed	December 31, 2026
Restoration Monitoring, Management, and Implementation	Recreational, Habitat, and Corridor Use Improvements; Invasive Species Monitoring	June 1, 2023 to December 31, 2028

Table 1. Anticipated schedule

[7] The dam removal permit (Chapter 31 plan approval with Chapter 30 individual permit) would likely be separate from the restoration permit (Chapter 30 individual permit for wetland and waterway work), but there may be some overlap. Once the license is surrendered, more consultation is needed to determine the WDNR's preferred permit route and also allocating stakeholder responsibility for funding, permits, etc.

[8] This schedule may be impacted by the availability of funds to remove the dam and the need to comply with grant schedules.

Project Description

Powell Falls Dam consists of a concrete gravity dam, 110 feet long and 22 feet high, with an uncontrolled overflow spillway. 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. Following the project's initial FERC licensure in 1988, 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). The 1991 inspection team collected concrete cores that indicated an unconfined compressive concrete strength of 5,400 to 5,800 pounds per square inch.

Per the August 1991 engineering analysis by Ayres, the entire dam is founded on and abutted by dolomitic bedrock. Silt on the dam was 4 feet below the crest at the right end of the spillway and 13 feet below the center of the spillway crest.

The existing spillway is separated into three vertical sections with vertical monolithic joints as shown in the plans. The spillway has horizontal monolithic joints held together with post-tensioned and fully grouted rock bolts, and the 50,000 pounds of tension in these bars shall be safely released prior to concrete demolition. The rock bolt manufacturer (Williams Form) has been contacted and has suggested methods for safely releasing the rock bolt stresses. The existing spillway had disbanded lift joints prior to the rock bolt installation, so the removal methods and sequencing will need to balance rock bolt demolition with lift joint stability.

An integrated powerhouse / penstock structure is at the left abutment. The impoundment, Lake Louise, is 15.4 acres with 37 acre-feet of normal capacity. Normal pool elevation is 821.80 feet mean sea level.

A 6-foot by 6-foot vertical lift waste-gate sits between the spillway and powerhouse. Next to the waste-gate is the intake gate that allows water to enter the hydroelectric facility.

The hydroelectric facility at Powell Falls was updated in 1948 when equipment was installed to replace the original equipment from 1903. The current powerhouse consists of a brick superstructure above a concrete substructure and a single General Electric generator (rated at 125 kW, 165 kVA, 2300 volts, 0.8pf, 3 phase, Type ATI) which is coupled to a Leffel hydraulic turbine (20-feet design head, 80bhp, 134kW, 240 RPM, Type F, year 1917). The transmission line is approximately 2,500 feet long from the powerhouse to the control room at the Municipal Power Plant building, where it connects to the existing bus and to the 12.4kV distribution system through a 2400V-12.4kV transformer.

The average flow rate of the river at Powell Falls is 94 cfs, based on data recorded at USGS gage 05342000 between 2002 and 2018. At the site of the dam, the historic flood of gaged record (1916 to 1921, 1998 to 1999, and 2002 to present) occurred in March 1920 and is estimated by a drainage area transfer to be 4,020 cfs. A similarly large flood occurred in August 2010 (estimated peak flow 3,690 cfs) and June 2020 (estimated peak flow 3,900 cfs but is only a preliminary value at time of this report draft).

The sediments within the impoundment were sampled by Inter-Fluve in 2016 and submitted to the WDNR for confirmation that impounded sediment is not contaminated. In an email from Danny Helsel, dated June 17, 2020, the WDNR provided these comments from the Waste and Materials Management (WM) & Remediation and Redevelopment (RR), and comments are updated in {} to reflect follow-up conversations with the WDNR:

1. {The 2016} sediment sampling from Lake Louise does not currently indicate significant exceedances of sediment quality guidelines (with the exception of sample location LL-C1A).
2. However, at the time of dewatering, when existing sediments become exposed and sediment data collected from Lake Louise will be representative of land surface, relevant soil standards will be applicable and direct contact residual contaminant level (RCL) exceedances will exist for benzo(a)pyrene at all sample locations. These exceedances will require regulatory oversight by the Remediation and Redevelopment program. However, there is a draft rule-making process that is proposing to revise the standards for benzo(a)pyrene, and if that draft becomes law then only a small area of the basin would exceed the RCL limits. {DNR suggests resampling near that higher concentration area to confirm extent of benzo(a)pyrene exceedances.}
3. With the exception of sample location LL-C1A, the WM and RR staff consider concentrations of arsenic to be reflective of naturally occurring background levels and no additional investigation or remedial action would be necessary if the material is to be left in place after dewatering. LL-C1A appears to be {either an anomaly or area to test further} and confirmation sampling will be required to determine if additional delineation and/or potential remedial action is appropriate. {DNR suggests resampling near that higher concentration area to confirm extent of arsenic exceedances.} If soil/sediment is to be removed it will need to be managed appropriately. {Suggested restrictions might include separation of sediment stockpiles from groundwater, capping sediments that exceed RCL limits, and/or obtaining an industrial status and low-hazard waste exemption permit.}
4. {Prior to the 2020 flood,} the WM and RR programs recommend further evaluation of soil/sediment after drawdown occurs.
    a. Confirmation sampling will be necessary in the area of LL-C1A to determine if elevated levels of arsenic observed at that location can be reproduced. If elevated levels of arsenic are confirmed, additional delineation and/or remedial action may be necessary.
    b. Levels of benzo(a)pyrene observed in all samples exceed current direct contact standards; however, standards for this compound are proposed to change. The programs recommend comparing the levels of benzo(a)pyrene to Wis. Admin. Code NR 720 soil standards after drawdown occurs.
    c. Data from additional samples collected from the sediment, especially near the {higher} arsenic {sample}, to be excavated would allow for better representation of the sediment and more accurate decisions to be made on the disposal or use options. Currently three to four samples are being used to represent the quality of approximately 40,000 cubic yards of sediment from a long stretch of waterway. {A higher testing density is requested and the WDNR would work with RFMU on what a more comprehensive testing plan might involve.}

Based on drone footage, the 2020 flood and subsequent drawdown appear to have significantly changed the impoundment's bedforms and sediment elevations. The licensee is evaluating options to resample the sediment and remap the Lake Louise bathymetry, at least within the proposed future channel areas and those areas of sediment significantly affected by the recent flood. Sampling would also attempt to resample higher concentration areas of benzo(a)pyrene and arsenic to determine acceptable disposal options.

Even with the initial sediment sampling efforts pre-drawdown, construction observation crews will need to confirm excavated removed sediments and foundation materials have no odor of contaminants and appear to be uncontaminated as indicated by earlier sediment investigations.

Project Removal Description

The design intent of the Powell Falls Development decommissioning includes the following goals for removal:

1. Until dam removal is complete, sediment release shall be managed by maintaining a drawn down impoundment, slowing the rate that floods can increase and decrease impoundment water elevations, proactive seeding of the former lakebed, sediment removal as prudent and practicable to protect the downstream resource, and working with stakeholders on early implementation of the final restoration plan[9]. A multiyear draw down will allow continued vegetation growth upstream of the dam and slow natural cutting to reach stable channel configuration, all with the licensee's ability to close gates and mitigate any rapid changes in infrastructure stability or massive sediment release.
2. During construction, removal activities will be completed in a safe manner to minimize the risk of a sudden uncontrolled release of impoundment water during flood situations. Engineering oversight will include structural performance monitoring, review of contractor means/methods, and intercession as needed to preserve dam safety.
3. Construction traffic will be limited to designated streets and specific hours, and the disposal site for removed materials will be established and secured. The preferred access route avoids all residential developments and would allow construction workers to efficiently utilize off-road equipment without damaging existing roads and sidewalks. Some limited truck traffic is expected on residential streets for downstream sediment removal.
4. Construction activities will comply with Wisconsin standards for noise, vibration, dust, sediment tracking, and erosion control.
5. No concrete remnant of the Powell Falls Development spillway shall be visible after construction is complete. Concrete grout from bedrock dowels or anchors may still exist inside the bedrock layers, but all concrete above the bedrock shall be removed as reasonably practicable.
    a. The lower part of powerhouse will stay in place, but the sluiceway and powerhouse superstructure will be removed.
    b. The lower half of the powerhouse will be stabilized with added weight to allow beneficial reuse as part of future amenities to the Kinni Corridor Plan. Those future amenities are beyond the scope of this report.
6. Invasive species will be monitored and managed during impoundment drawdown and restoration. Details will be included in the final restoration plan, to be submitted with permit applications.

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[9] A detailed restoration plan is not yet developed for this site. The RFMU has options to do a dam removal restoration plan with just temporary cover crops and soil / sediment stabilization, but various stakeholders have expressed an interest in expanding the restoration plan to include trout habitat improvements, recreational improvements, possible prairie restoration, bird watching platforms, and other amenities. One benefit of separating this complex restoration plan from the FERC process is increased flexibility under a variety of state and local permits and grants. Continued discussions with stakeholders and permitting agencies is recommended to develop the most efficient route toward a final restoration plan (or plans).

7. The Lake Louise sewer main crossings and wastewater plant bank may need to be armored to resist post-removal conditions. Armoring the two sanitary crossings would require an engineered channel (stabilized against design shear stresses and velocities), but if excessive headcutting cannot be controlled then the crossings may need to be lowered 10 feet or more down to bedrock. To protect critical infrastructure, the wastewater plant bank may also need additional riprap protection if adequate bedrock is not already present. As part of final design, Licensee will complete a review of proposed infrastructure protection plans and costs. The Licensee believes relocation of the sewer lines will be cost prohibitive but will research options and costs in more detail as part of the final design.

Overview of Project Features

Project features and facilities discussed in the following sections and Appendices are shown below. These include the Powell Falls Dam, disposal site, two wastewater crossings, and the contractor access points. The river channel between the Powell Falls Dam and 24-inch sanitary sewer ("Wastewater Crossing 1") is the primary reach for channel stabilization efforts. A second sanitary sewer ("Wastewater Crossing 2" is also of concern because no engineering drawings exist to confirm the foundation for this critical infrastructure. The project components are located as shown in the Appendix 1 Drawings and in the image below.

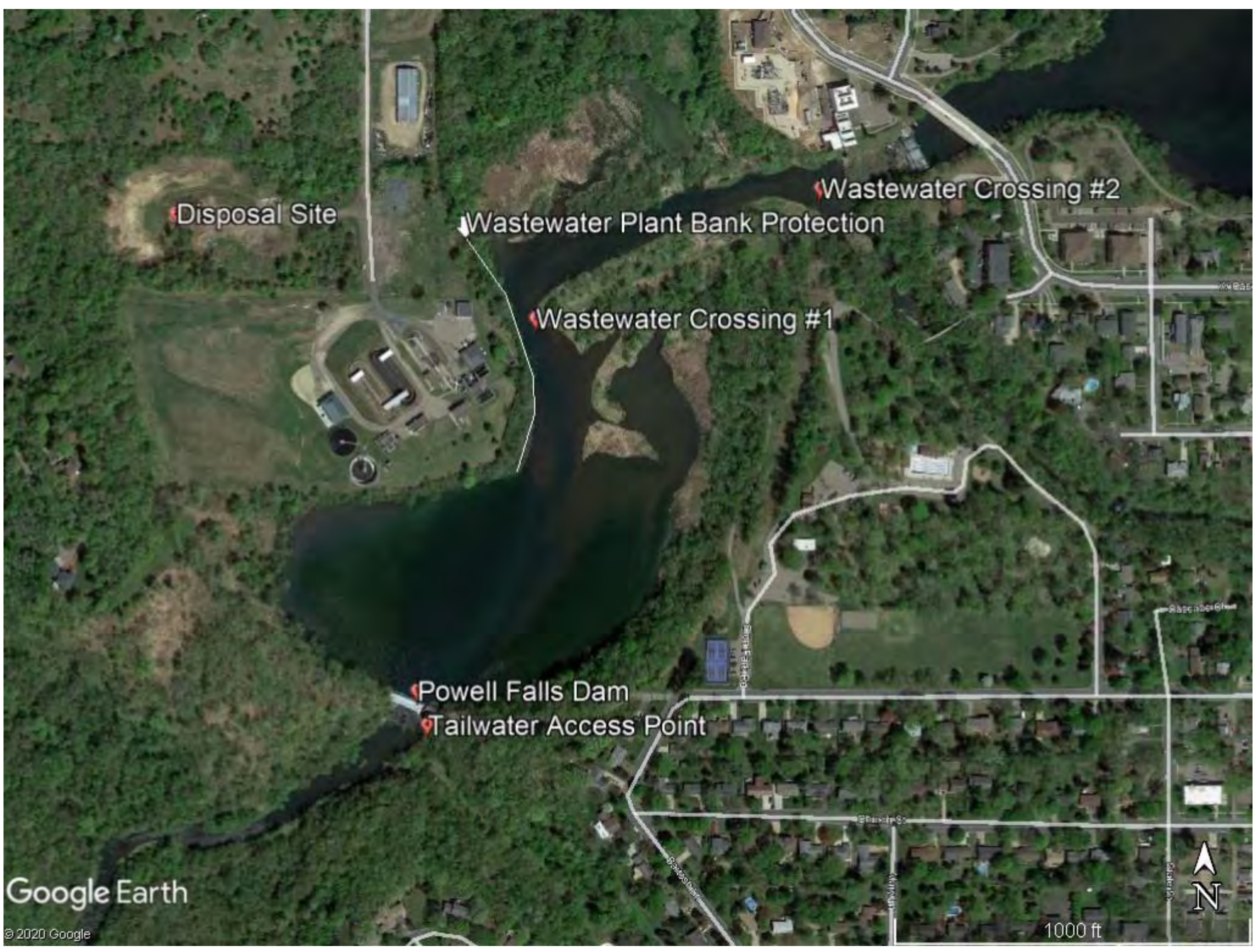

Figure 1. Location of Dam (used under license agreement with Google Earth Pro)

Existing Project Operations Description

The Powell Falls Development operates in run-of-river mode per the existing license agreement (FERC P-10489). While the project is operated in run-of-river mode at full impoundment, the project's trashrack cleaning effort does require short outages at the plant on a regular basis. An amendment to the operating license issued in 1997, 81 FERC 62,087 (1997), states the operators use a prescribed outline when ramping the units up or down for intake cleaning and/or maintenance, with a 5kW increase or decrease no more often than every 15 minutes. This is to ensure smooth flow transitions downstream. Ramping for intake grate cleaning is done only on an as-needed basis and scheduled so as not to be done at both Junction Falls and Powell Falls the same day. Heavy leaf load in the river during fall and excess debris in the spring often require operators to deenergize units and let the debris flow over the spillway. With the discontinuation of the diesel generation at the River Falls Municipal Power Plant, the plant no longer has an operator onsite full-time. The operator makes daily visits to the Junction Falls Hydro Facility and weekly to the Powell Falls Hydro Facility.

While the project is in a drawn down condition, the impoundment elevation is expected to vary, potentially refilling the impoundment once or more every two years. As described in detail within Ayres' 18 December 2020 letter report[10], the drawn down impoundment in its current condition has a 50% annual risk of refilling to elevation 818 feet or higher and a 38% annual risk of refilling to pass water over the spillway. This risk of refill will decrease if the turbine is pulled and the right overbank is sandbagged, but in general the risk of spilling water in any given year remains significant. Based on the hydrologic analysis for risk of refill, Ayres believes the lake will refill two or three times between now and the start of dam removal[11]. During these lake refill periods, it will be necessary to close the sluice gate and powerhouse gate partially to allow the lake to drain no faster than 12 inches per day to minimize sediment release downstream.

Land Ownership around Existing Facilities

RFMU owns all the land around the Powell Falls Development, the wastewater plant, and the disposal site as shown in the appended Drawings. Construction equipment is not expected to cross private property at any point in the decommissioning process. Drawings include a table of contacts that should be notified as part of the construction activities in the event that equipment noise impacts adjacent properties.

Case Studies

During the Initial Study Report comment period, stakeholders requested Ayres document case studies of how the approach for Powell Falls Dam removal compared to other similar dam removals. The case studies below present the similarities and differences of the dam removal case studies to Powell Falls dam removal such as: (1) watershed size and land use; (2) stream flow characteristics (mean, maximum, and minimum); (3) sediment size distribution and volume; (4) sediment control measures used, the use of

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[10] Available online at https://elibrary.ferc.gov/eLibrary/filelist?document_id=14916806&optimized=false

[11] In the case of the October 11-12, 2020 event, a 2-inch rain event filled the impoundment in a few hours as woody debris plugged the gate. While removing the turbine and having the gate open fully will help slow the lake rise speed, Ayres understands that there is little the RFMU can do to prevent lake rise during intense rainfalls, but the gate operations can help slow the rate of drawdown after the rain stops.

bedload-retaining barriers placed across the stream; (5) construction sequence; and (6) successes and failures.

A summary of the case studies compared to the Powell Falls removal project is shown in Table 2.

Variable	Units	Powell Falls	Minnesota Falls	Gordon	Grimh	Woodley/Ridler
Distance and Bearing from Powell Falls	miles and direction	0.0 miles	140.6 W	104.3 NNE	93.4 NE	40.0 NNE
Latitude	degrees	44.850926	44.790643	46.23721	45.760986	45.39636
Longitude	degrees	-92.638993	-95.499553	-91.78397	-91.220336	-92.36385
Water Impounded	name	Kinnikinnic River	Minnesota River	Eau Claire River	Couderay River	Apple River
County	name	Pierce	Yellow Medicine	Douglas	Sawyer	Polk
Power Production Developer	name	River Falls Municipal Utilities	Xcel Energy	Dalhberg Light and Power	North Central Power Co	Wisconsin Valley Improvement Co (per DNR)
Hydropower Production	rated kilowatts	125 (1 unit)	500 (1 unit)	321 (2 units)	306 (2 units)	< 100 (1 unit)
Structural Height	feet	21	21	33	30	18
Overall Length	feet	155	600	1550	1200	300
Spillway Width	feet	112.5	358	27	56	73
Normal Storage	acre-feet	65	520	461	374	80
Drainage Basin	square miles	116	6390	33	149	151
Design Discharge	cubic feet per second	2930	43,000	2500	5200	1400
Acreage of Impoundment	acres	15	500	56	86	19
Impoundment Depth	feet maximum	13	12	22	16	12
Jurisdictional Agencies		FERC, DNR (full)	FERC, DNR, PCA, SWCD	DNR dam safety	DNR dam safety	DNR dam safety
Estimated Sediment Yield In Stream	tons per year passing dam	>10,000	420,000	762	1,461	n/a
Estimated Sediment Yield Rate	tons per square mile / yr	>50	66	11	8	n/a
Sediment Estimated in Lake	cubic yards	> 40,000	> 30,000	19,730	> 115,000	< 20,000
Sediment Dredged/Excavated	cubic yards	unknown	8,342 from forebay	6,211 turbidity barriers + 13,500 embankments	4,716 from forebay + 2,000 embankments + 600 CY contaminated	6512 from forebay
Sediment Released Naturally Over 6 Years	cubic yards	unknown	unknown	5000 - 10000	50000 - 80000	5000 - 10000
Infrastructure Improvements		Wastewater line(s)	Ethanol plant intake	Bank Stabilization (DNR required)	Bridge Piers (DOT did this work in-house)	Snowmobile Bridge (Owner did this)
Complexity Factor*		788	2179	405	365	151
Year Removed		2025	2013	2015	2012	2009
Construction Cost at End of Removal		to be determined	confidential	$501,000	$355,000	$162,000
Removal Cost in 2025$		> $1M	>> $1M	$677,000	$527,000	$245,000

Table 2. Summary of Nearby Dam Removal Case Studies since 2009 [12]

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[12] As explanation for how Ayres estimates costs for dam removals, Complexity Factor* is defined as $(H^{1.5} + 0.1*L + 0.05*S + Q^{0.5})^F$ and the variables are as follows: H = Structural height of dam in feet from top of foundation to point of dam overtopping; L = Length of dam's spillway, powerhouse, and embankments in feet; S = Normal storage in lake at normal operating pool in acre-feet; Q = maximum flood capacity of existing dam at point of overtopping in cubic feet per second; and F = regulatory factors. Wisconsin's dam removal guidelines are favorable for removals (starting F=1.0), but the F variable is increased by the value in parentheses due to these items:

A. FERC license surrender process with multiple agency and stakeholder study requests (+0.1),
B. Dredging of half (+0.1) to all (+0.2) of the lake sediments
C. Presence of contaminated sediments (+0.1 for low hazard to +0.3 for high hazard),
D. Extensive stream restoration / aquatic organism passage / invasive barriers (+0.1),

Ayres agrees that lessons learned from recently completed dam removals help anticipate permit obstacles, set the standard of care for future dam removals, and inform the public about reasonable expectations and end goals of dam removal. Multiple case studies and a literature review are included to support this report's conclusions made for methods most practicable for the Powell Falls dam removal. The foundation of these case studies described in detail in Appendix 2 are presentations[13,14] by the author to the 2011 Hydrovision conference, 2012 Association of State Dam Safety Officials conference, and 2016 United States Society on Dams conference and as updated since.

Lessons learned from case studies

The lessons learned from the above case studies include the following (ordered by author's opinion of priority):

1. Floods large enough to cause dam safety concerns often occur during dam removal activities. Compounded probability theory states that there is a 27% chance that a "10-year" flood will happen during a three-year long dam removal project. This poses a significant risk to cofferdam loss and structural damage, so the lessons learned from the case studies are to 1) draw down the lake early and 2) not rely on cofferdams for long term protection of the worksite.
2. Because floods capable of transporting sediment occur so frequently, impoundment sediments are best controlled with a long pre-removal drawdown. This allows soft and loose lakebed sediments to compact and consolidate, vegetation to grow on the lakebed, and banks to reach a stable slope.
    a. The channel forming flood is 750 cfs[15] for Powell Falls (approximately 1050 cfs at the downstream gage), this event has occurred[16] in 15 of the 25 years of combined gage record. There is a 93% chance that a channel forming flood will occur during a three-year long dam removal project.
    b. Allowing the impoundment to stay drawn down with the dam in place allows lakebed vegetation roots to start stabilizing impounded sediment with less risk of sudden sediment releases during channel forming floods. Should a channel forming flood occur when the impoundment is drawn down and the dam is in place, the lake will refill but little sediment or vegetation uprooting will occur.
3. Mechanical removal of wet sediment from an impoundment is difficult, but reaching the sediment from the dam (using the dam as a sediment trap during removal activities) and reaching the sediment collected in full-width turbidity barriers are both common practices. Another common practice is excavation in mid-winter after ground frost allows the frozen lakebed to support tracked excavating equipment.
4. The drawn down lakebed contains many dormant seeds. The lakebed at all of the case study sites established green growth within the first month of growing season following the initial

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E. Extensive historical preservation mitigation or archeological protection measures (+0.1),
F. Extensive infrastructure improvements (+0.05 per water intake, bridge pier, or wastewater crossing).
G. For Powell Falls, the regulatory factor F is assumed to be 1.3 (to be re-evaluated later).

[13] https://www.ayresassociates.com/wp-content/ayres_images/Permits%20for%20Low%20Hazard%20Dam%20Removal.pdf
[14] https://www.ayresassociates.com/wp-content/ayres_images/Managing%20Uncertainties%20during%20Hydropower%20Dam%20Removals.pdf
[15] See figure 6 from the USACE publication ERDC/CHL CHETN-VIII-5, December 2000. Accessed at: https://www.spa.usace.army.mil/Portals/16/docs/civilworks/regulatory/Stream%20Information%20and%20Management/ERDC%20Channel%20Forming%20Discharge.pdf
[16] https://nwis.waterdata.usgs.gov/wi/nwis/peak/?site_no=05342000&agency_cd=USGS plus this flow was exceeded in 2020.

drawdown. By the end of the second growing season, all of the dam removal case study sites had woody vegetation growing on silt deposits of the former impoundment. The Gordon Dam site had the most difficulty in establishing vegetation because little silt was present in the river bank materials.

   a. For Lake Louise, a cover crop will help stop rainwater erosion of soft lakebed soils.

5. Turbidity levels created by dam removal activities are similar to those created by large flood events, and river systems with frequent turbidity releases will experience few long-term detriments from dam removal sediment releases.
6. Asbestos, lead paint, and contaminated foundation materials are occasionally found during dam removal processes.
7. Allowing the contractor to wet breach (remove concrete structures in flowing water) where stability permits is faster and less costly than a dry breach (working behind a cofferdam). However, a wet breach must have a robust turbidity containment and cleaning system downstream to avoid introducing concrete fines into the downstream channel.
8. Typically, dewatering costs are 20 to 30% of Ayres' construction project costs.

Since sediment is usually the largest driver of regulatory concern, Ayres' general philosophy for sediment management follows these guidelines:

1. Deep root growth and dense cover of vegetation is a proven stabilization measure for soft reservoir soils.
2. Bankline collapse is the largest contributor to sediment supply once the initial drawdown has channel incision.
3. Due to the laboratory test results for sediment, the least risk of contaminant remobilization is to remove the sediment completely from the basin and store it in a pit out of the 100-year floodplain. As far as practicable, the stockpiling of sediment should not impact wetlands, floodplains, or future areas of expected development (including recreational amenities).
4. Sediments are slow to dewater, and in some places the existing lakebed will take months to dewater down to pre-dam groundwater conditions. A higher refill risk is correlated with a higher risk that construction equipment will not be able to access all areas of the lakebed for grade stabilization efforts.
5. Removing sediments along the upstream face of the dam before the dam is fully removed allows the dam to function as a sediment trap while the upstream channel stabilizes. This is not a regularly cleaned trap, but rather the upstream face of dam may only be cleaned three times a year (due to equipment access issues).
6. The easiest place to collect sediment during most dam removals is from dedicated sediment traps downstream of the dam, created by a well-placed and well-anchored full-width turbidity barrier. Downstream traps are cleanable even during wet periods, while upstream traps are usually too wet to access during post-runoff periods.

Based on dam removal permit conditions from the reviewed case studies, Ayres is proactively assuming these permit conditions for the Powell Falls removal:

I. Procedural:
   a. Dam abandonments are a type III action under Wis. Admin. Code NR 150.03.03(8)(f)4, and do not require the preparation of a formal environmental impact statement.

II. Dam Safety:
   a. The dam must be removed in the exact sequence proposed by the engineer and under the limits (cofferdam requirements, maximum working water elevation) shown on the approved drawings.
   b. The permit holder must provide plans to ensure public safety including fencing of dangerous worksite areas and signage for unfenced soft sediment areas that could entrap people or animals. Signage shall clearly explain "Danger: Deep Mud, Keep Out" or equivalent messages to alert the public of entrapment risk.

III. Drawdown conditions following impoundment refill during flood events:
   a. Drawdown rate due to gate operations must not exceed six inches of impoundment decrease per day, but the impoundment refill rate is not limited (and cannot be limited due to inadequate gate capacity).

IV. Construction equipment in waters:
   a. All equipment, barges, boats, hoses, sheet pile, and pumps shall be de-contaminated for invasive and exotic viruses and species prior to use and after use. This included a) inspection, b) draining of water, c) disposal of aquatic organisms in trash, and d) washing equipment with >140F water OR allowing equipment to dry thoroughly for five days.
   b. Nothing containing hazardous materials may be stored behind the temporary cofferdams when the contractor is not onsite.

V. Sediment and erosion control:
   a. Effective soil erosion and sediment control measures shall be in place during the entirety of the project.
   b. Construction shall be accomplished in such a manner as to minimize erosion and siltation into surface waters and as specified in the plans and procedures that are part of or approved pursuant to this permit.

VI. Sediment, concrete, and non-hazardous waste stockpiles:
   a. The permit holder must not deposit or store any of the graded or excavated materials in any wetland or below the ordinary high-water mark of any waterway. All graded or excavated materials must be placed out of the floodway of any stream.
   b. The permit holder must remove and properly dispose of any debris, such as reinforced concrete, pieces of metal, or any other debris that may have been deposited in the reservoir or on the bed of the river.
   c. Removed sediment shall be properly disposed of and must comply with all Department solid and hazardous waste requirements.
   d. The existing structures that are proposed to be abandoned must be completely removed from the site and properly disposed of and must comply with all Department solid and hazardous waste requirements.

VII. Reservoir restoration:
   a. The permit holder must stabilize all sediment outside of the river channel in the manner specified in the Erosion Control Plan and approved by the Department.
   b. Any exposed slopes after drawdown that appear to be erodible as identified by Department staff must be adequately stabilized. This could include the use of erosion control best management practices, recontouring of slopes, placement of riprap, etc. The upstream riprap and bank repairs are subject to the post-drawdown conditions and may be subject to change.
   c. The waterway for flow and navigation in the vicinity of the removed structure shall be restored as nearly as practicable to the conditions prior to the original construction of the dam.
   d. The permit holder must remove the dam in the manner that will result in minimal long-term sediment deposition downstream from the dam. The permittee shall cease or modify drawdown at the require of the Department if the Department determines that detrimental sediment deposition is occurring in the downstream reach. The permit holder shall make reasonable efforts acceptable to the Department to stabilize and restore downstream areas impacted by significant sediment deposition associated with dam removal.
   e. Final site stabilization requires the re-establishment of native vegetation and invasive species will be managed per the approved Site Restoration plan.
   f. There must be a post-abandonment site review performed by Department staff to assess navigation, fish passage, bank stability, and conformance to the approved drawings and specifications.
   g. The dam owner must monitor the project site for a timeframe not less than five years after the dam is substantially removed. Any substantial excessive erosion

or channel failure at the project site within five years must be mitigated in accordance with applicable state or federal code requirements.

Powell Falls Site Conditions

In review of the above case studies, several parameters are important for decommissioning design.

River flowrates of importance include base flowrate, cofferdam overtopping flowrate, and dam safety flowrate. Base flowrate determines the average daily flow expected during dam removal operations. Cofferdam overtopping flowrate is the maximum flowrate expected to be withstood by the dewatering works prior to failure of the dewatering protection system (not the dam). Dam safety flowrate is the maximum flowrate expected to be withstood by the dam (or dam remnants) prior to collapse of significant project structures. Sediment and turbidity are usually environmental concerns, but both parameters impact construction means and methods.

This section will include a brief summary of parameters specific to the Powell Falls site.

Flowrate

One definition of base flow is average daily flowrate for which half the records exceed and half the records are less than this value. Based on the USGS gage records for the Kinnickinnic River and adjusted for drainage area and flowrate ratios, the annual flow duration curve at Powell Falls was computed as shown in Figure 2 and the baseflow computed as 86 cfs.

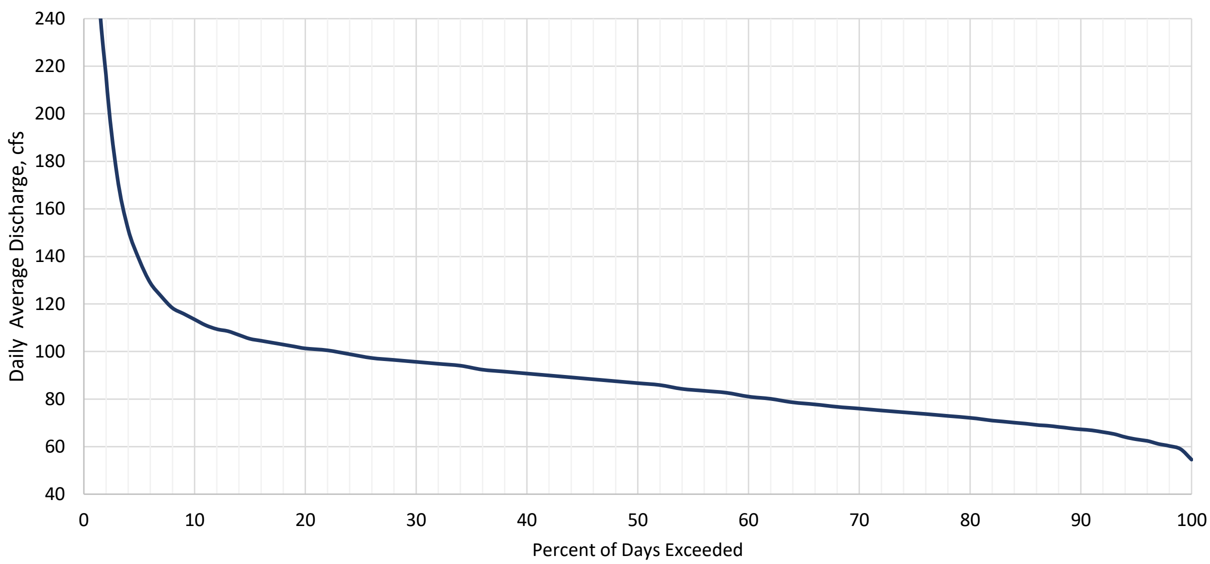

Figure 2. Flowrate-duration curve for Powell Falls Dam

The adopted Flood Insurance Study (55093CV000A) for the Powell Falls site lists the Kinnickinnic River downstream and upstream of Powell Falls Dam as having the flood frequency shown in Table 3. The cofferdam overtopping flowrate for Powell Falls was selected by the design team as the 10% annual chance event, which is 6,800 cfs. Because the dam is a low hazard structure, the dam is normally designed to only withstand the 1% annual chance event, which is 16,900 cfs.

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES(cfs) 10-PERCENT ANNUAL-CHANCE	2-PERCENT ANNUAL-CHANCE	1-PERCENT ANNUAL-CHANCE	0.2-PERCENT ANNUAL-CHANCE
KINNICKINNIC RIVER					
Downstream and Upstream of Powell Falls Dam	109.66	6,800	11,000	12,800	16,900

Table 3. Flood insurance flowrates for Powell Falls Dam

Sediment / Turbidity

Sediment quality measurements at the Kinnickinnic River near River Falls were taken by the USGS[17] from 1997 to 2000 and is plotted in Figure 3. USGS parameter 80155 is suspended sediment discharge in short tons per day, and 18 discrete measurements were taken across all months of the year except January. When this data is correlated with river flowrate, a reasonable trendline can be developed as shown in Figure 4.

Between 2013 and 2015, a continuous sediment sampler was deployed by the USGS. However, data plotted from this period shows hysteresis and drift, so only a few peak flow events were used to develop the upper flow portion of Figure 4.

From the trendline developed, a daily estimate of sediment transport can be developed for the complete USGS flow record, and this is plotted in Figure 5 for the period of USGS flow records since 1997.

[17] https://nwis.waterdata.usgs.gov/wi/nwis/qwdata/?site_no=05342000&agency_cd=USGS

USGS Measurements for Kinnickinnic River

	Flowrate (cfs)	Computed Suspended Load
3/21/1997 10:47	126	3.1 tons per day
2/18/1998 13:20	311	211 tons per day
4/1/1998 13:00	640	733 tons per day
6/25/1998 16:30	301	258 tons per day
7/28/1998 13:40	114	4.9 tons per day
10/23/1998 13:40	117	3.2 tons per day
11/18/1998 13:00	117	2.7 tons per day
12/8/1998 10:05	117	1.3 tons per day
2/22/1999 14:40	102	1.1 tons per day
3/10/1999 13:15	93	0.74 tons per day
3/22/1999 13:15	109	3.8 tons per day
4/6/1999 10:30	191	21 tons per day
4/28/1999 11:00	92	1.6 tons per day
5/18/1999 10:50	145	8.1 tons per day
6/22/1999 11:10	80	0.81 tons per day
7/3/1999 16:40	156	21 tons per day
8/19/1999 12:15	128	2.1 tons per day
9/16/1999 17:40	98	1.8 tons per day
AVERAGE =	112	71 tons per day
MEDIAN =	106	3 tons per day
MAXIMUM =	283	733 tons per day

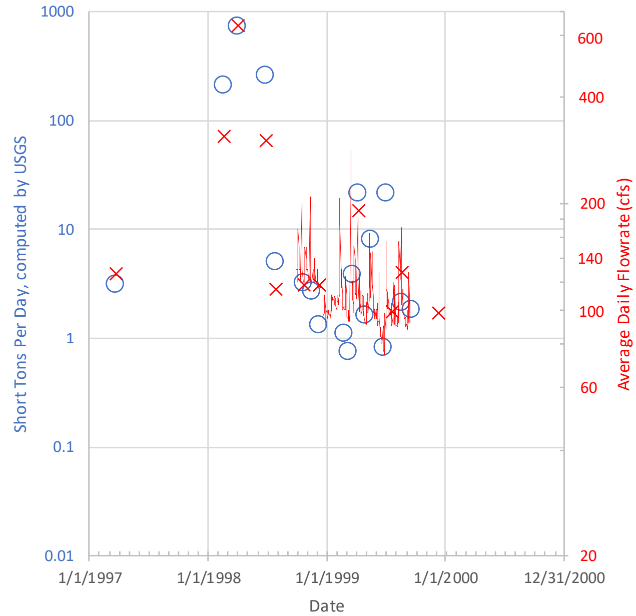

Figure 3. USGS measurements of suspended sediment load in the Kinnickinnic River

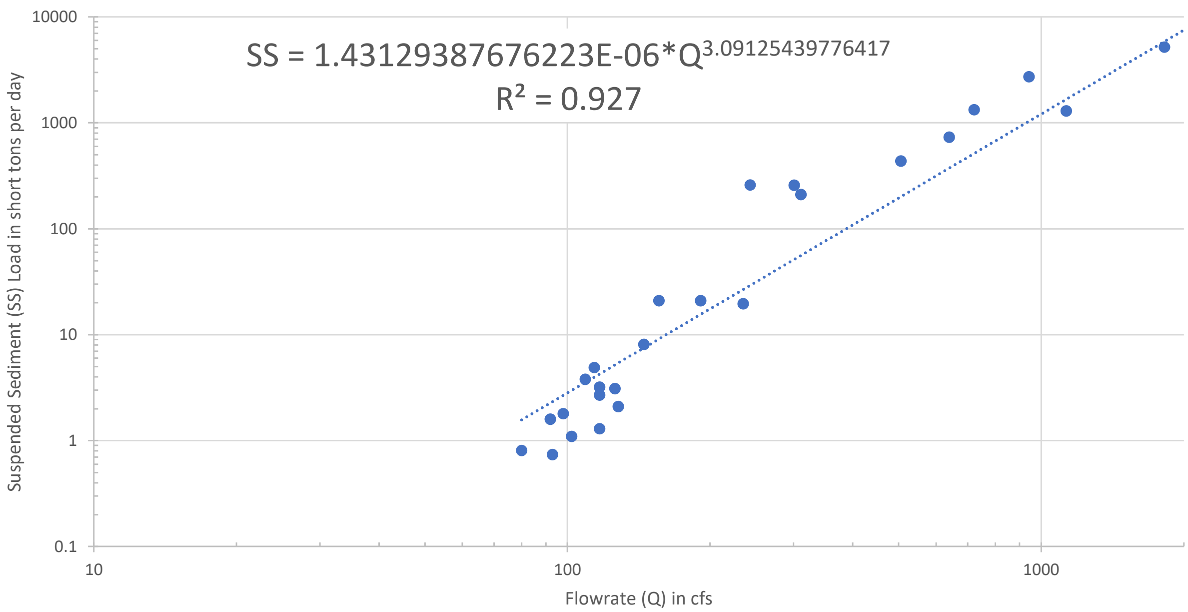

Figure 4. Correlation of suspended sediment load with flowrate

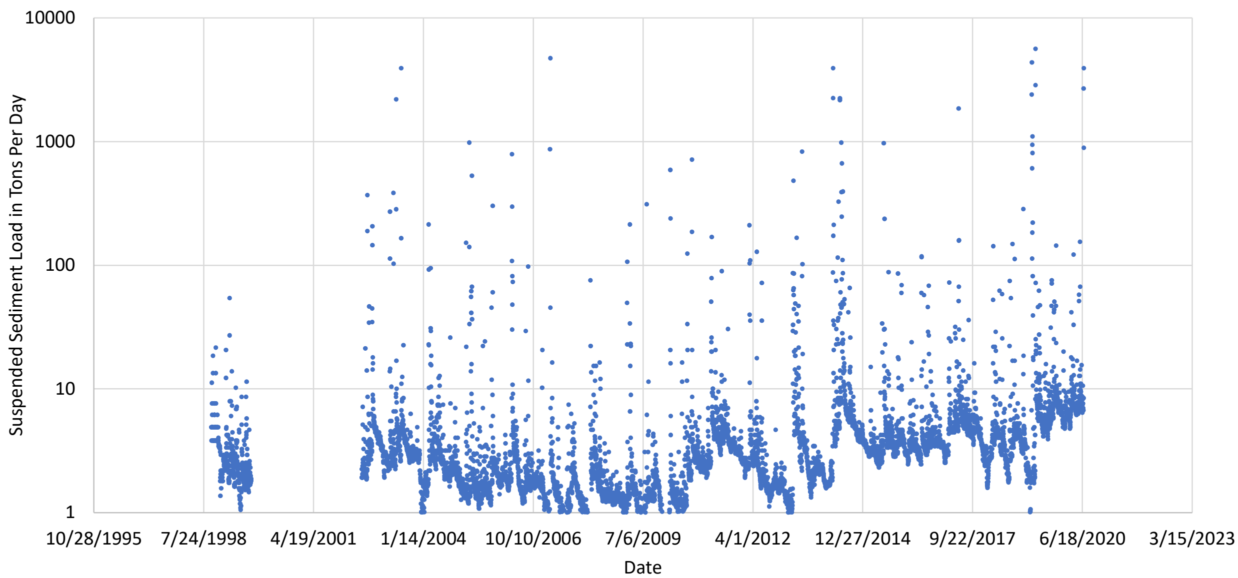

Figure 5. Variability in daily suspended sediment load for the Kinnikinnic River

While Figure 5 is only as accurate as Figure 4's trendline's accuracy, it is important to understand that suspended sediment transport (and associated turbidity) is extremely variable for the Kinnickinnic River. Since data shown in Figure 5 is predicted at the USGS gage location, the suspended sediment load must be reduced to account for the watershed area difference (Powell Falls has only 71% of the drainage area that the USGS gage has). Therefore, the average suspended sediment transport at Powell Falls Dam is 17.4 tons per day or 6,400 tons per year. For dams with shallow or drawn down impoundments, the suspended load is not likely to be reduced by the dam. For the same river flowrate, the post-removal suspended load during floods is expected to exceed that shown in Figure 5 because bank instability will augment suspended sediment levels passed through the dam.

Ayres has not found a study for bedload transport in the Kinnikinnic River near Powell Falls Dam. However, bedload transport downstream of the dam is expected to include a combination of bedload arriving into Lake Louise, bedload stored in or released from the impoundment, and bedload arriving into the Kinnickinnic River from tributaries and floodplain sources downstream of the dam. With the recent 2020 drawdown, it is expected that the sediment deposition within Lake Louise will cease until a contractor has removed silts and creates new pools to impound sediment (traps).

The predicted total of suspended sediment load (6400 tons per year as mentioned above) and bedload contributed to the Kinnikinnic at Powell Falls (expected to be at least 3500 tons per year, though possibly three times that in wet years) is more than 10,000 tons per year, but Figure 5 shows that 7500 tons (more than 4000 cubic yards) of suspended sediment (plus a not-yet-quantified amount of bedload) was likely passed downriver in 72 hours during the June 29 to July 1 flood of 2020.

Expected impacts of the dam removal sediment on downstream habitat were addressed in the Powell Falls Dam Removal Sediment Study Ecological Risk Evaluation report submitted by TRC in January 2021. That report concluded short-term risks associated with dam removal sediment load include high risks of adversely impacting trout habitat, substrate complexity, and recreation; medium risks of adversely- impacting water quality, invertebrate taxa, and floodplain vegetation; and low risks of adversely impacting freshwater mussels, fish movement, impoundment riverine conditions, and ice jam potential. However, none of these short-term impacts are expected to continue for more than one year. The long-term benefits to dam removal are many, including a high probability of improving trout habitat, floodplain vegetation, fish movement, impoundment riverine conditions, and recreation.

Decommissioning Plan

The decommissioning plan establishes the design intent for the overall project for application to future plans and specifications. The plans and specifications would then be submitted for permits from federal, state, and local agencies; and once permits are in hand, bidding would follow. As RFMU is a municipality, bidding laws prevail such that the lowest responsible bidder would be awarded permission to proceed with the removal process. However, the decommissioning plan covers much more than construction and removal. The plan also addresses pre-construction drawdown efforts, construction monitoring, adaptive management for issues discovered after construction starts, material disposal, determining when construction is complete, and long-term monitoring after the construction contractor has demobilized.

Project Photographs

Photographs shown in Figures 6 to 12 show various features discussed in the Decommissioning Plan. In Figure 6, note the variable bedrock height along the downstream end, or “toe” of the spillway. Note that “left” and “right” when referring to dam structures typically take the perspective of a viewer facing downstream.

Figure 6. Right abutment bedrock (left side of figure) and main spillway (right side of figure)

Figure 7. Left abutment (far right side of figure), powerhouse draft tube discharge (lower right, under the sign), powerhouse generating bay (upper right, above sign), and sluice or “waste” gate (lower center).

Figure 8. Looking west along dewatered spillway

Figure 9. Interior of powerhouse generating bay, showing generator (left)

Figure 10. Interior of powerhouse, showing typical lubricant containers (right side of figure), slug fuse cutouts (center) and camp stove (left)

Figure 11. Looking east toward dam at typical normal pool conditions with 107 cubic feet per second of discharge (71% of the recorded flowrate at https://waterdata.usgs.gov/usa/nwis/uv?05342000)

Figure 12. Sluice gate (looking from upstream side)

Figure 13. Trashrack, looking from upstream side

Figure 14. Proposed disposal site for concrete and sediments

Construction-Related Plans

Several construction-related plans are necessary to define the decommissioning goals and outline the success strategies. Note that the Cultural Resources Management Plan will be included with the draft license application.[18] Since no historic property will be removed, there is no Historic Properties Management Plan necessary for this project.

Noise and Vibration Control

Noise and vibration control provisions will incorporate the following measures in the specifications:

- Equipment will be in compliance with federal, state and local noise standards (e.g. exhaust mufflers, acoustically attenuating shields, shrouds, or enclosures)
- Truck loading, unloading, hauling will be scheduled during the daytime to reduce nighttime noise impacts to extent feasible
- Appropriate blasting techniques will be used to minimize noise and vibration to the extent feasible
- Notify residents of hours and duration of construction activities

Traffic Management Plan

Contractor access is a critical consideration of this project. The City prefers to limit heavy equipment transport through residential neighborhoods for many reasons (citizen safety, street damage, noise, traffic congestion), and the use of off-road equipment is often more economical for contractors. Therefore, the appended drawings show the City's preferred access plan is along the west side of Lake Louise. The contractor would construct a "causeway" of coarse stone placed on the lakebed at a sufficient depth to support construction traffic. The causeway would extend from the wastewater treatment plant to the dam,

[18] A Phase I Archaeology Survey will be conducted in 2020 to determine if cultural resources are present within the Powell Falls Area of Potential Effect.

generally following the future proposed biking / hiking trail alignment shown in the City's Kinni Corridor Plan. See Appendix 1: Drawings for more details.

If the City is unable to obtain the necessary permits and approvals to construct the causeway, a Traffic Management Plan will be necessary to maintain efficient and safe movements along public streets. Techniques to reduce public risk include, but are not limited to, the following:

- Notify residents of current or upcoming interruptions to the local or state road network
- Provide advanced notice to motorists of potential traffic delays through portable changeable signs or stationary mounted signs

Erosion Control and Spill Prevention Plan

The erosion control and spill prevention plans will be included with the final permit applications.

Shoreline Assessment, Stabilization, Management Plan

This project will create about 4,000 linear feet of new shoreline. The project is anticipated to include a slow staged drawdown over multiple years, and natural processes would dictate the shoreline location and composition. Sediment retained by the dam's concrete structures would be excavated to make room for demolition equipment, and sediment would be removed / graded so tie into the upstream channel at no steeper than a 5H:1V grade. Riprap would be necessary to stabilize areas that cannot retain a stable slope, such as non-bedrock knickpoints adjacent to the dam and outside bends of channel meanders. Sediment mobilized and passing through the dam would be captured by the turbidity barriers and sediment trap pool, and trapped sediments would be regularly removed when the trap volume drops below 25% remaining capacity. The design goal for the remaining impoundment sediment is self-armoring of the new channel by natural flood processes, natural bank meandering (possibly to a wider extent than would happen for other options), and natural revegetation. At any point the design team or regulatory agencies decide that the risk of rapid channel incision or widening is too great, additional bank armoring and channel stabilization measures would be implemented through permitted conditions.

The design team proposes the range of sediment to be removed from the site will be 10,000 to 25,000 cubic yards of sediment near the dam and 5,000 to 22,000 cubic yards of sediment trapped upstream of the turbidity barrier. The remaining sediment within the active channel is expected to slowly pass downstream over a period of years after the dam removal is complete. By starting the drawdown early and allowing the impoundment bed to stabilize naturally, Ayres expects the sediment cutting to not exceed 10,000 cubic yards or 20,000 tons per year in 2020 and then taper down to about 1,000 cubic yards or 2,000 tons per year by 2025. The natural sediment transport of the river is no less than 10,000 tons per year according to the USGS regressions, so the dam removal will double the sediment transport in 2020 but be back to nearly normal by 2025 if the dam remains drawn down henceforth.

However, even with the design approach listed above, an adaptive management approach is preferred to allow flexible responses and future innovation to curb excessive sediment passage. For example, initial tests of the sediment response could be conducted by drawing down the entire impoundment through the sluiceway and then monitoring to determine how the banks hold up before starting any spillway removal. If the banks are sound and quickly dewater (see Table 4), the contractor could continue without intervention. If the banks are deemed unstable, construction would likely be halted to allow for earlier mechanical intervention to stabilize the banks.

It is important to note that access to the new shoreline will be very difficult once the impoundment is lowered and soft soils prevent heavy construction equipment access. Sediment must dewater for a sufficiently long period to allow pore water to drain and sediment particles to gain strength to support construction equipment. The time to dewater impounded sediment is related to the permeability coefficient and seepage path length. Permeability can be estimated from the Hazen (1930) empirical formula, path length can be estimated from sediment core locations and the proposed channel location separation, and grain size is provided in Appendix C-2 of the Lake George and Lake Louise Sediment Assessment Report (2016). Based on these data, the time to dewater the impounded sediments in Lake Louise varies as shown in Table 4 (for locations shown in Figure 13).

Core (2016)	k (ft/min)	Distance (ft)	Days to Dewater
LL-C1	5E-04	100	131
LL-C2	1E-01	10	0.05
LL-C3	5E-02	5	0.1
LL-F1	2E-03	200	81
LL-F2	1E-02	290	15
LL-F3	5E-04	280	366

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Table 4 (top) and Figure 13 (bottom). Dewatering Time Estimated for 6 Sediment Samples

Based on Table 4, the contractor would need 131 days of drawdown before the soils near Inter-Fluve's sediment core LL-C1 would be dewatered. Based on Table 4, the anticipated future floodplain (LL-F3) would take over a year to fully dewater.

In summary, shoreline management is proposed to be an adaptive management process that has the primary goal of minimizing adverse sediment releases and secondary goal of balancing budget with bank stabilization performance.

Dust Control Plan

The final Dust Control Plan will incorporate the following techniques to minimize dust during construction activities. Techniques include, but are not limited to, the following:

- Water trucks will be the primary means of dust abatement during all phases of construction.
- Contractor will limit the speed of construction vehicles on unpaved surfaces

Quality Control and Inspection Plan

Several phases of the removal project will require onsite engineering oversight. Dam safety and hydraulic structure engineers should be present for these activities:

- Preconstruction kickoff meeting onsite
- Present to inspect the drawn down impoundment condition
- Midpoint of structural dewatering after each new cofferdam construction
- Initial release of at least the first three rock bolts, with the option to attend the release of the remaining bolts
- Any post-flood activity that follows a cofferdam overtopping event
- Final inspection of the bedrock surface for each feature removed
- Final inspection of any restoration component

In addition to engineering inspection, a stormwater / erosion control inspector should schedule regular (but unannounced and randomly timed) visits to confirm that the planned measures and expected outcomes are occurring for soil disturbing activities. Visits should also occur after each 0.5-inch rainfall event. The inspector's checklist should include the following:

- Spot surveys of sediment depths behind turbidity barriers
- Silt fence inspections
- Bank stability (noting areas that appear to be slumping or have failed)

Emergency Response Plan

As part of the contractor's submittals, an emergency response plan and a health and safety plan will be required to show that the contractor has thought through emergency situation responses for the contractor's chosen access route and demolition methods.

Applicable emergency scenarios include, but are not limited to, the following:

- Medical (injury or illness)
- Fire
- Traffic incident, including construction traffic in the worksite
- Hazardous spill
- Flooding

- Dam failure
- Catastrophic emergency (high wind event)
- Security threat

Hazardous Material Management Plan

Project specifications are expected to include the following hazardous material management strategies:

- Asbestos Containing Material (ACM), lead based paint (LBP), and polychlorinated biphenyls (PCBs) may be present in building materials based on the timeframe construction occurred. Prior to removal, the contractor will sample and test for ACM, LBP, and PCBs at all structures that are to be removed. The contractor will handle and dispose of any abated material with asbestos, lead, and or PCBs which exceed hazardous waste criteria levels as hazardous waste at approved hazardous waste facilities in accordance with applicable federal and state regulations. The contractor will dispose of remaining materials as non-hazardous construction debris.
- Notice to the state is required for demolition activities; and permits may also be required, even if no hazardous materials are onsite.
- A spill management plan will be submitted with the final permit application.

Construction Methodology, Sequencing, and Schedule

Anticipated construction sequencing is shown in the drawings. Based on the case study lessons learned, a vertical[19] removal is proposed for the Powell Falls Development as follows.

1. Stage 1 – preparation

    a. Prior to contractor mobilization, the City will pull the fuse cutouts from the Powell Falls powerhouse and de-energize the 2400-volt interconnection breaker at the Junction Falls facility. This will isolate the Powell Falls facility and allow the following to be safely completed.
    b. A stepdown transformer and meter will be installed at Powell Falls on the power pole nearest the dam. This low voltage power source will be provided for contractor connection, and future lighting for the public access areas. Security cameras may be installed in the future after a fiber optic line is added from Glen Park to the dam.
    c. The breaker at Junction Falls will be re-energized, converting the interconnection lines to distribution lines.
    d. Erosion control and sediment control measures would be in place prior to starting any earthwork. This includes turbidity barriers, tracking control measures, silt fence, and other best management practices required by the specifications and/or drawings.

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[19] The physical structure can be removed in two directions – vertical or horizontal. Vertical dam removals consist of removing one feature of the dam completely, then passing water through that new opening, and then starting work on another feature. Most dam removals completed in Wisconsin have used the vertical removal pattern, like Grimh Dam and Gordon Dam. Horizontal removals consist of layered removals where a large length of spillway crest is lowered, usually in four-foot vertical increments starting at one end and progressing laterally until the entire spillway is uniformly lowered. Then the process is repeated. The Elwha Dam removal in Washington State is a prime example of a horizontal removal.

e. An access road to the tailrace may need to be one of the first earthwork disturbances necessary for this project. Currently Ayres expects the route down Bartosh Canyon is the only feasible tailrace option until the dam is breached, but the RFMU is still evaluating options for tailrace access.
f. The turbine shaft would be disconnected from the turbine and the turbine pulled to allow flow to pass through the unobstructed discharge ring. Note that the intake headgates will remain in place (permanently lowered) to allow refilling of the powerhouse with stabilizing weight (needed for future beneficial reuse options).
g. The 18-inch and 24-inch sanitary sewer crossings would be inspected to see how the drawn down condition is affecting structural stability, and the structure should be relocated deeper if necessary. The inspecting engineer will also check the adjacent bank to confirm if riprap is necessary to protect it against undermining during drawn down conditions.
h. Additional riprap should be added to the east bank of the wastewater plant as needed.
i. The sanitary sewer crossings will be lowered as needed to accommodate erosion expected during spring floods and ice passage. As preventative measures against channel incision and sanitary crossing damage, an engineered channel (riprap over bedding) will be added to protect infrastructure as needed.

2. Stage 2 – initial removal
    a. The causeway (see Traffic Management Plan) or construction access route would also be implemented at this time.
    b. A cofferdam (likely integral with the causeway) will be constructed on the upstream side of the dam to isolate the western monolith. The cofferdam materials will be contractor choice, as long as the cofferdam is stable and does not release fines to the river.
    c. The water volume impounded between the cofferdam and dam (either groundwater or floodwater) will be pumped into a settling basin. The cofferdam and all causeways should be placed prior to trout spawning season.
    d. Upon receiving permission to proceed from the engineer, the contractor will start removing the upper lift of the monolith, being careful around rock bolt locations to avoid damaging the tensioned nut and base plate.
    e. The contractor will propose a plan for releasing bolt tension, in response to specification requirements and subject to addressing objections and concerns of the engineer and rock bolt manufacturer.
    f. After release of the bolt tension, the deconstruction will continue, lift by lift, until the entire monolith is removed to bedrock.
    g. Because the dam has very limited discharge capacity at a drawn down state, any major flood (1-year event or larger) is expected to refill the impoundment. Once the flood recedes and the impoundment is lowered again, an engineer will inspect the worksite after each flood event to confirm suitability for continued dam removal.
    h. The powerhouse superstructure will be removed but the remainder of the powerhouse, up to the present walkway elevation, will be left in place and filled to improve stability during future flood events. The access stairs leading down from the hillside will be left in place.
    i. The contractor will remove the upstream cofferdam and all impounded sediment between the removed dam area and the active river channel.
    j. If banks need stabilizing upstream, this work will be completed prior to starting Stage 3.

(Note: depending on the final selection of an access route, the west-to-east work sequence may be reversed to minimize disturbance of the new channel).

3. Stage 3 – remaining spillway removal

    a. Stage 3 will start with a smaller cofferdam placed upstream of the remaining spillway to divert all river flow through the western dam opening and powerhouse. Cofferdam materials will be the contractor's choice, as long as the cofferdam is stable and does not release fines to the river. Note that this cofferdam will need to resist higher velocities than previous cofferdams, but the minimum height of this cofferdam is much lower than that for Stage 2.
    b. The water volume impounded between the cofferdam and dam will be pumped into a settling basin, and the dewatered dam will be inspected by an engineer.
    c. Prior to any demolition on the spillway, the concrete deck above the sluice gate will be saw cut and separated from the powerhouse to prevent transfer of excessive vibration or lateral loads. The sluice gate will then be removed and left permanently open.
    d. Upon receiving permission to proceed from the engineer, the contractor will start removing the upper lift of the spillway monoliths, being careful around rock bolt locations to avoid damaging the tensioned nut and base plate.
    e. After safe release of the bolt tension, the deconstruction will continue, lift by lift, until each monolith is removed to bedrock.
    f. The contractor will remove the upstream cofferdam and all impounded sediment between the removed dam area and the active river channel.
    g. If banks need stabilizing upstream, seeding, planting, and / or riprap stabilization will be completed prior to demobilizing.
    h. Once the disposal site stops receiving materials from the dam removal and bank stabilization project, the disposal site will be graded to stable slopes, covered with topsoil, and seeded with an appropriate standard seed mix. Erosion control measures will be removed after the site is vegetated.

Restoration and Post-Removal Activities

Ayres understands that unlike many other dam removals in Wisconsin, the Kinnickinnic is a Class I trout stream, and therefore trout habitat advocates have a vested interest in creating trout and amphibian habitat within the former lakebed. RFMU's goal for dam removal is to remove the dam and temporarily stabilize the impoundment until a final restoration plan can be implemented. For now, the temporary stabilization measures are expected to include fast-germinating grains (rye, oats, wheat) and management of invasive species. While it is true that reed canary grass and other invasive species are often found upstream of dam removals, Ayres has had good success with temporary grain cover followed by prairie restoration at Grimh Dam and temporary grain cover followed by natural plant growth at Gordon Dam.

In Ayres' opinion, the restoration plan for the upstream impoundment needs to be fully developed prior to starting dam removal. Some aspects of lakebed work may work better while using the dam as a "cofferdam" in case a large flood happens prior to reaching a final stable channel shape. Other aspects of lakebed work may have to wait until after dam removal, such as plantings of prairie plants that cannot withstand even brief submergences. An adaptive management plan for vegetation is expected, including covering bare soils with grains quickly to prevent runoff, continued monitoring for invasives, and synchronizing the dam removal activities to facilitate restoration goals. After the dam is removed, the site will continue to be monitored for several years as outlined in the Construction-Related Plans. An adaptive management strategy will be implemented to review plan goals against site conditions with adjustments made to strategies as necessary. Specific items to be monitored after construction is complete include the site restoration performance (including continued invasive species monitoring), long-term bank stability, and upstream infrastructure stability (wastewater crossings, Junction Falls tailrace submergence on the draft tube, etc.).

In summary, site restoration is expected to be in two parts – the first, an immediate response to stabilizing sediment and banklines; and the second, a long-term plan to restore the former lakebed with consideration for management of trout habitat, recreational amenities, native vegetation plantings, invasive species monitoring and management, and other habitat considerations. For purposes of the initial phase of this project, Ayres has proposed to outline only the first site restoration phase. The RFMU expects to cooperatively work with various local stakeholders to develop the second restoration phase for approval prior to starting the dam removal construction activities.

Dam Removal Restoration Plan (First Part)

The dam removal restoration plan was developed in consultation with TRC, and reflects the design intent of stabilizing bare site soils but not preventing the Lakebed Restoration Plan (Second Part) or future recreational amenities. The dam removal restoration plan includes design goals of vegetation establishment on the exposed lakebed.

Initial vegetation establishment is expected through cover crops of oats (*Avena sativa*, spring / summer), barnyard grass (*Echinochloa crus-galli*), and/or winter wheat (*Triticum aestivum*, fall). Laydown and disposal site areas would likely include standard WisDOT mixes applied according to the WDNR Conservation Practice Standard 1059.

The former lakebed of Lake Louise will be monitored and managed for invasive species. Monitoring and management of purple loosestrife and giant reed grass will take place each year. Invasive species management for purple loosestrife and giant reed grass would include herbicide treatment, following label instructions and aquatic application license requirements. The lakebed should be monitored for invasive species through final restoration.

Given the length of time between initial drawdown and final dam removal, Ayres expects the impoundment lakebed will fully revegetate with native species (existing seedbank on the lakebed and whatever seeds reach the site after drawdown). Experience at other local dam removals indicates that within three years after drawdown woody vegetation will likely include ½-inch to 1-inch saplings. As an example of supplementing native seed mixes supplementing native plant growth from the existing seedbank, TRC has suggested using native wetland and upland seed mixes with the understanding that seed mixes that include native species known to occur at the Project (as documented in the 2019 Wetland, Riparian, and Terrestrial Resources Survey included in the Initial Study Report) should be modified to accommodate the final restoration plan goals.

Final Restoration Plan (Second Part)

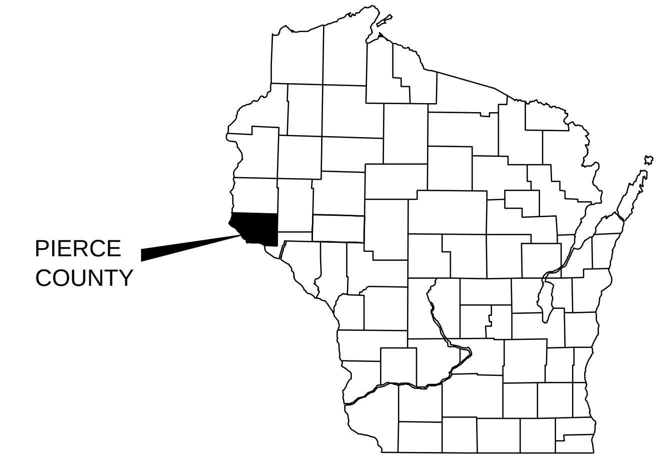
Ayres anticipates the final restoration plan will be developed in consultation with local stakeholders to balance funding availability, grant requirements, corridor plans, recreational goals, and other concerns. A final restoration plan is not available at the time of this report's publication.

Concluding Statement

Ayres appreciates the opportunity to assist the RFMU with continuing the Powell Falls decommissioning process, including dam removal. We look forward to addressing questions about this report and a successful project completion that benefits the City and community for decades to come.

Appendix 1:
Drawings

RIVER FALLS DECOMMISSIONING PLAN
CITY OF RIVER FALLS
JAN 2021 UPDATED STUDY REPORT



COUNTY MAP

CITY OF RIVER FALLS

UTILITY CONTACTS

RIVER FALLS PUBLIC WORKS
MIKE STIFTER, DIRECTOR
222 LEWIS STREET
RIVER FALLS, WI 54000
(715) 426-3406

RIVER FALLS MUNICIPAL UTILITIES
KEVIN WESTHUIS, UTILITY DIRECTOR
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415 S. SECOND STREET
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(715) 425-6177

TDS TELECOM
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APPLETON, WI 54911
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JEFF KULAF
853 MCINTOSH STREET
PO BOX 1818
WAUSAU, WI 54402
(715) 301-4075
MOBILE (715) 302-1483

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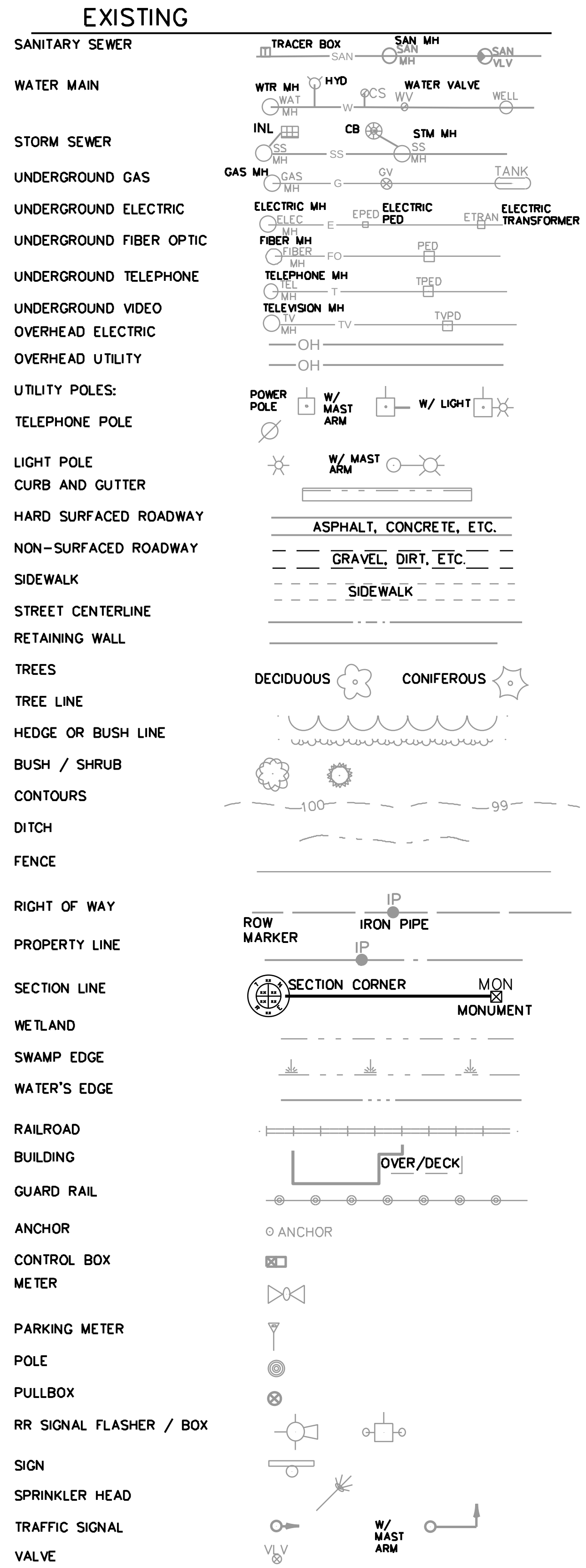
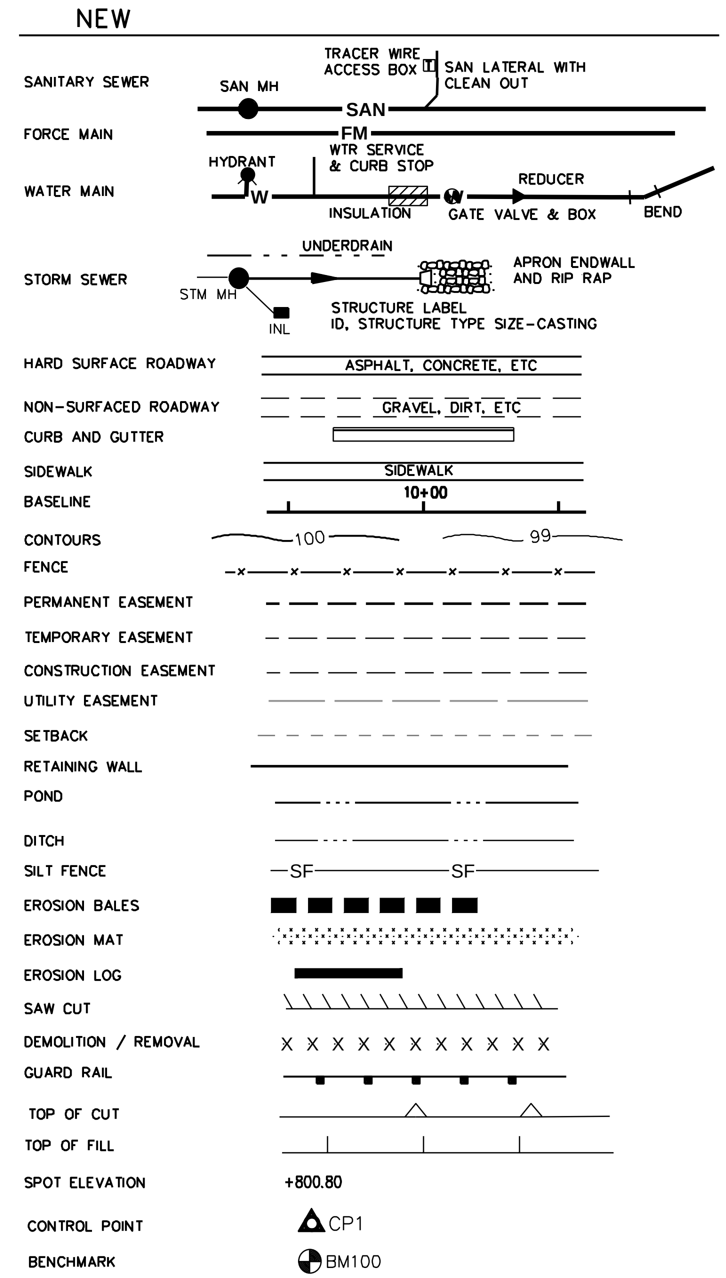
DR BY ARR	PROJ NO 26-1155.00	NO / DATE / REVISION	AYRES Eau Claire, WI 54701 715.834.3161
CHK BY EF	DATE JAN 11, 2021	NO / DATE / REVISION	TITLE SHEET
			SHEET NO. 1





AB	ANCHOR BOLT
ABV	ABOVE
ADJ	ADJUST
AFF	ABOVE FINISHED FLOOR
AL	ALUMINUM
ALT	ALTERNATE WITH
ALT/	ALTERNATE
APPROX	APPROXIMATE
ASPH	ASPHALT
AUTO	AUTOMATIC
AVE	AVENUE
@	AT
B CRS	BASE COURSE
BC	BACK OF CURB
BD	BOARD
BEL	BELOW
BETWN	BETWEEN
BF	BACK FACE
BFV	BUTTERFLY VALVE
BIT	BITUMINOUS
BLD	BLIND
BLDG	BUILDING
BLK	BLOCK
BLKG	BLOCKING
BLVD	BOULEVARD
BM	BENCHMARK
BO	BREAKOFF
BRG	BEARING
BRK	BRICK
BS	BACK OF SIDEWALK
BTM	BOTTOM
BV	BALL VALVE
℄	BASELINE
B/	BOTTOM OF
C&G	CURB AND GUTTER
CB	CATCH BASIN
CF	CUBIC FOOT
CHKD P	CHECKERED PLATE
CI	CAST IRON
CJ	CONTROL JOINT
CL / ℄	CENTERLINE
CHL	CHLORINE
CLG	CEILING
CLR	CLEAR
CMP	CORRUGATED METAL PIPE
CMU	CONCRETE MASONRY UNIT
CO	CLEANOUT
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCTION
CONST JT	CONSTRUCTION JOINT
CONT	CONTINUOUS
CONTR	CONTRACTOR
CONTR JT	CONTRACTION JOINT
COR	CORNER
CP	CONTROL POINT
CPLG	COUPLING
CRS	COURSE
CSP	CORRUGATED STEEL PIPE
CTG	CASTING
CTH	COUNTY TRUNK HIGHWAY
CULV	CULVERT
CV	CHECK VALVE
CW	COLD WATER
CY	CUBIC YARD
DEFL	DEFLECTION
DEG / °	DEGREE
DF	DRINKING FOUNTAIN
DI	DUCTILE IRON
DIA	DIAMETER
DIM	DIMENSION
DISCH	DISCHARGE
DN	DOWN
DP	DEPTH
DR	DOOR
DTL	DETAIL
DW	DRIVEWAY
DWG	DRAWING
E	EAST
EA	EACH
EF	EACH FACE
EFF	EFFLUENT
EJ	EXPANSION JOINT
EL	ELEVATION
ELB	ELBOW
ELEC	ELECTRICAL
EQ	EQUAL
EQUIP	EQUIPMENT
ER	END OF RADIUS
EST	ESTIMATE
EW	EACH WAY
EWC	ELECTRIC WATER COOLER
EX	EXISTING
EXH	EXHAUST
EXP	EXPANSION
EXT	EXTERIOR
FD	FLOOR DRAIN
FDN	FOUNDATION
FERT	FERTILIZER
F-F	FACE TO FACE
FGL	FIBERGLASS
FIN	FINISHED
FL	FLOWLINE
FLG	FLANGED
FLR	FLOOR
FM	FORCE MAIN
FN	FENCE
FT (')	FOOT
FTG	FOOTING
FUT	FUTURE
G	GAS
GA	GAGE
GAR	GARAGE
GEN	GENERAL
GRD	GRADE, GROUND
GV	GATE VALVE
GRAV	GRAVEL
GW	GROUNDWATER
HB	HOSE BIB
HM	HOLLOW METAL
HORZ	HORIZONTAL
HSE	HOUSE
HT	HEIGHT
HW	HOT WATER
HWR	HOT WATER RETURN
HYD	HYDRANT
ID	INSIDE DIAMETER
IF	INSIDE FACE
IN (")	INCHES
INCL	INCLUDE
INF	INFLUENT
INL	INLET
INSUL	INSULATION
INT	INTERIOR
INV	INVERT
IP	IRON PIPE
IPS	IRON PIPE SIZE
JT	JOINT
KGV	KNIFE GATE VALVE
LAB	LABORATORY
LAV	LAVATORY
LC	LENGTH OF CURVE
LF	LINEAL FEET
LG	LENGTH
LOC	LOCATION
LP	LIGHT POLE
LR	LONG RADIUS
LS	LUMP SUM
LT	LEFT
MAS	MASONRY
MAX	MAXIMUM
MECH	MECHANICAL
MFG	MANUFACTURER
MH	MANHOLE
MIN	MINIMUM
MISC	MISCELLANEOUS
MJ	MECHANICAL JOINT
MP	MID POINT
MTL	MATERIAL
N	NORTH
NF	NEAR FACE
NIC	NOT IN CONTRACT
NO	NUMBER
NOM	NOMINAL
NPW	NON-POTABLE WATER
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
OE	OVERHEAD ELECTRIC
OF	OUTSIDE FACE
OH	OVERHEAD
OPG	OPENING
OT	OVERHEAD TELEPHONE
PC	POINT OF CURVE
PE	PRIVATE ENTRANCE
PED	PEDESTAL
PERF	PERFORATE
PI	POINT OF INTERSECTION
PKG	PARKING
P	PLATE
PL	PLACE
PL ℄	PROPERTY LINE
PP	POWER POLE
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PT	POINT OF TANGENCY
PV	PLUG VALVE
PVC	POLYVINYL CHLORIDE
PVMT	PAVEMENT
PW	POTABLE WATER
%	PERCENT
QTY	QUANTITY
RAD	RADIUS
RCP	REINFORCED CONCRETE PIPE
RD	ROAD
RD	ROOF DRAIN
RDWY	ROADWAY
RED	REDUCER
REF	REFERENCE
REINF	REINFORCING
REM	REMOVE
REPL	REPLACE
REQD	REQUIRED
REV	REVISED
RM	ROOM
RR	RAILROAD
RT	RIGHT
RW	RIGHT OF WAY
S	SOUTH
SAN	SANITARY
SAMH	SANITARY MANHOLE
SCH	SCHEDULE
SEC	SECTION
SF	SQUARE FOOT
SHT	SHEET
SIM	SIMILAR
SL	SLOPE
SPA	SPACE
SPEC	SPECIFICATION
SQ	SQUARE
SS	STAINLESS STEEL
SSMH	STORM SEWER MANHOLE
ST	STREET
STD	STANDARD
STH	STATE TRUNK HIGHWAY
STL	STEEL
STM	STORM
STP	SEWAGE TREATMENT PLANT
SURF	SURFACE
SW	SIDEWALK
SWR	SEWER
SY	SQUARE YARD
SYS	SYSTEM
T&B	TOP & BOTTOM
TC	TOP OF CURB
TELE	TELEPHONE
THK	THICKNESS
THRU	THROUGH
TP	TELEPHONE POLE
TYP	TYPICAL
T/	TOP OF
UG	UNDERGROUND GAS
UE	UNDERGROUND ELECTRICAL
UNEXC	UNEXCAVATED
UNO	UNLESS NOTED OTHERWISE
USH	UNITED STATES HIGHWAY
UT	UNDERGROUND TELEPHONE
UV	UNDERGROUND VIDEO
V	VALVE
V&B	VALVE & BOX
VAR	VARIABLE
VER	VERTICAL
VC	VERTICAL CURVE
W	WEST
W/	WITH
W/O	WITHOUT
WD	WIDTH
WM	WATER MAIN
WS	WATER SURFACE
WTP	WATER TREATMENT PLANT
WTR	WATER
WWF	WELDED WIRE FABRIC
WWM	WOVEN WIRE MESH
WWTP	WASTEWATER TREATMENT PLANT

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POWELL FALLS DECOMMISSIONING PLAN
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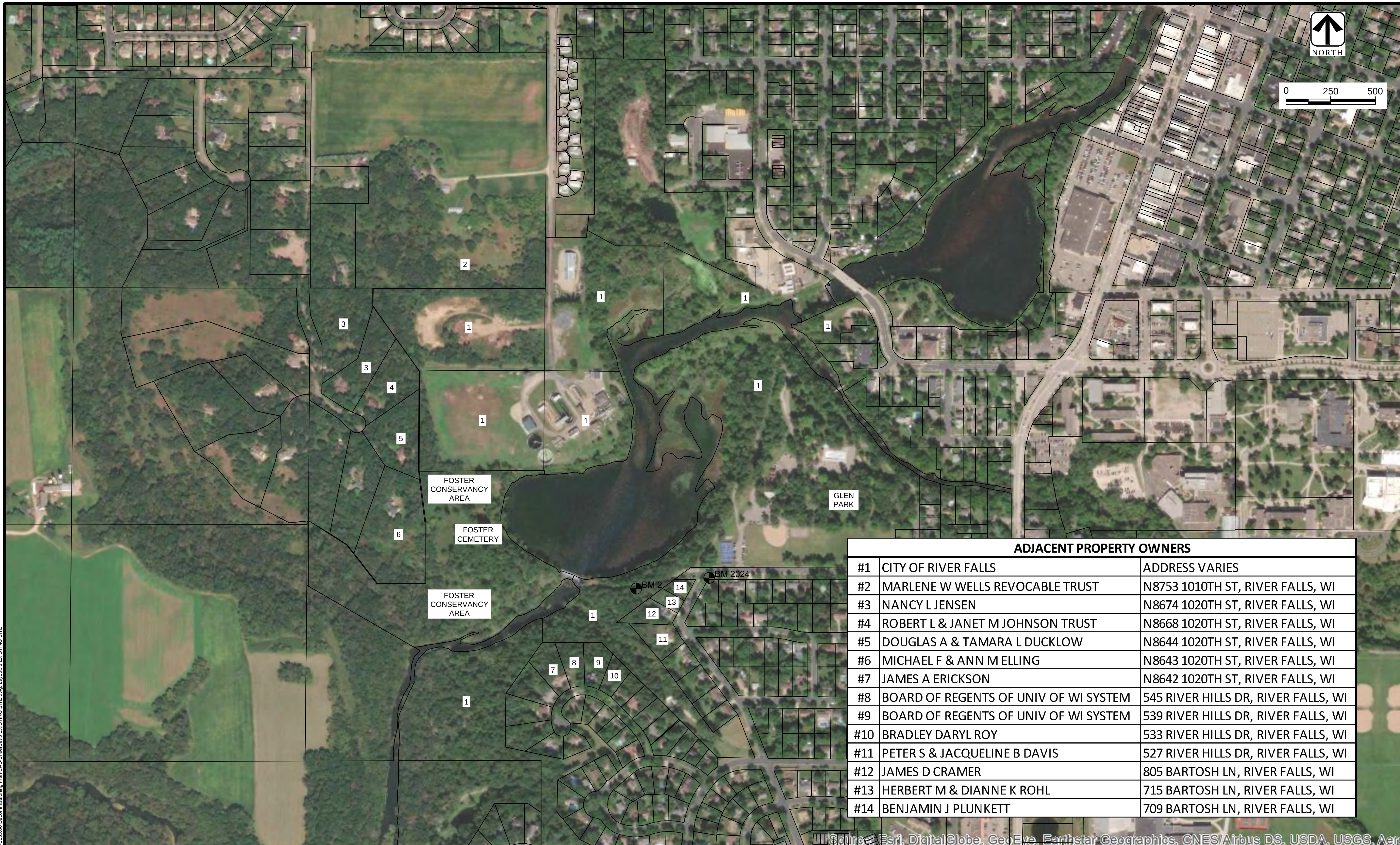

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#2	MARLENE W WELLS REVOCABLE TRUST	N8753 1010TH ST, RIVER FALLS, WI
#3	NANCY L JENSEN	N8674 1020TH ST, RIVER FALLS, WI
#4	ROBERT L & JANET M JOHNSON TRUST	N8668 1020TH ST, RIVER FALLS, WI
#5	DOUGLAS A & TAMARA L DUCKLOW	N8644 1020TH ST, RIVER FALLS, WI
#6	MICHAEL F & ANN M ELLING	N8643 1020TH ST, RIVER FALLS, WI
#7	JAMES A ERICKSON	N8642 1020TH ST, RIVER FALLS, WI
#8	BOARD OF REGENTS OF UNIV OF WI SYSTEM	545 RIVER HILLS DR, RIVER FALLS, WI
#9	BOARD OF REGENTS OF UNIV OF WI SYSTEM	539 RIVER HILLS DR, RIVER FALLS, WI
#10	BRADLEY DARYL ROY	533 RIVER HILLS DR, RIVER FALLS, WI
#11	PETER S & JACQUELINE B DAVIS	527 RIVER HILLS DR, RIVER FALLS, WI
#12	JAMES D CRAMER	805 BARTOSH LN, RIVER FALLS, WI
#13	HERBERT M & DIANNE K ROHL	715 BARTOSH LN, RIVER FALLS, WI
#14	BENJAMIN J PLUNKETT	709 BARTOSH LN, RIVER FALLS, WI

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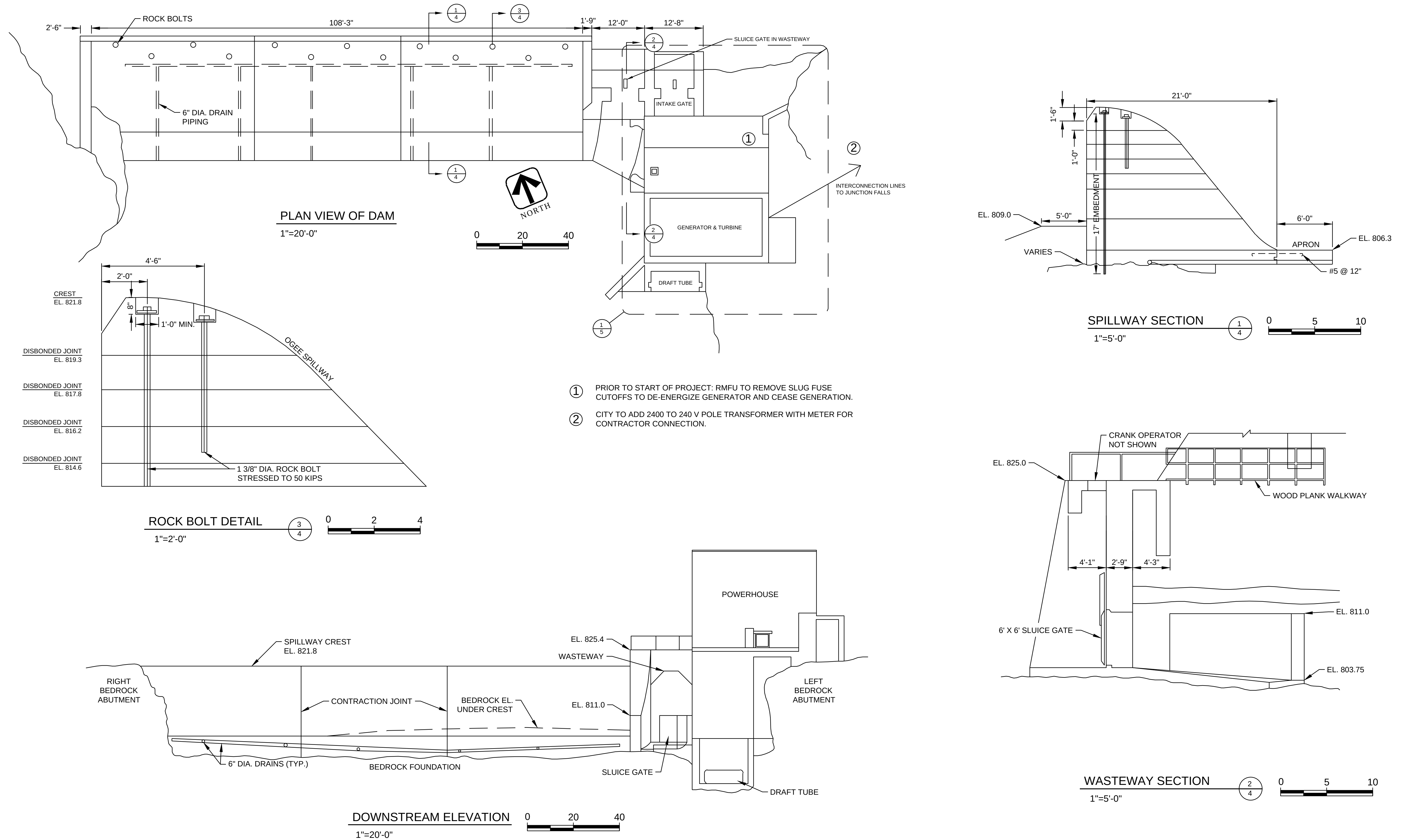

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EXISTING CONDITIONS

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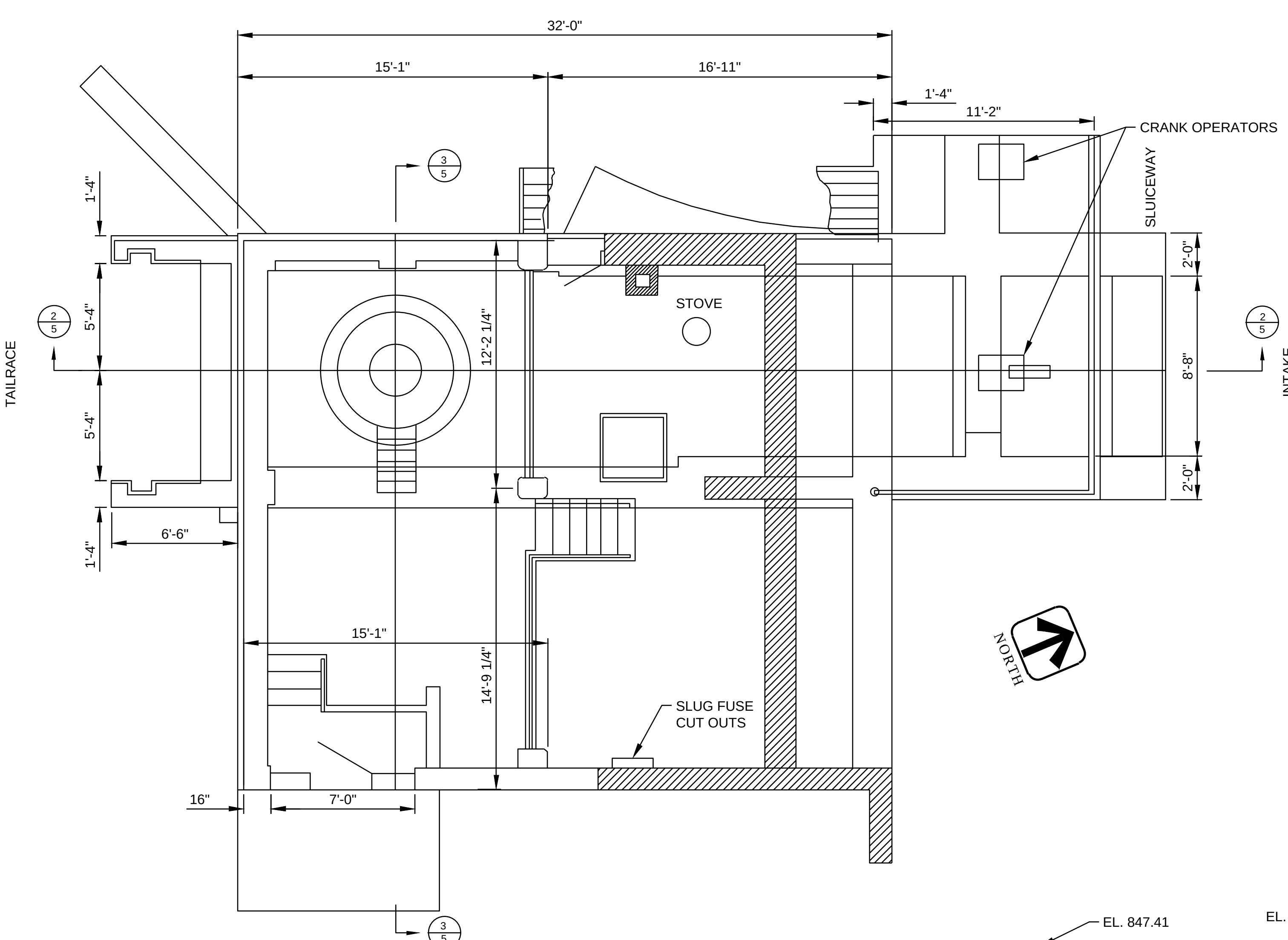

POWERHOUSE PLAN
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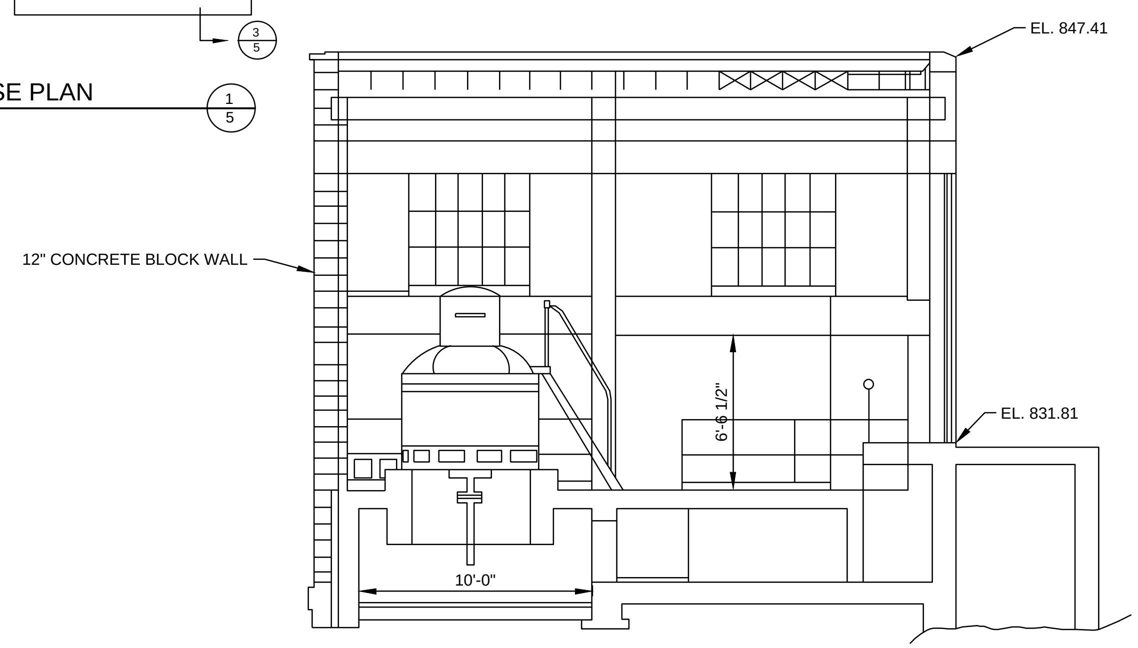

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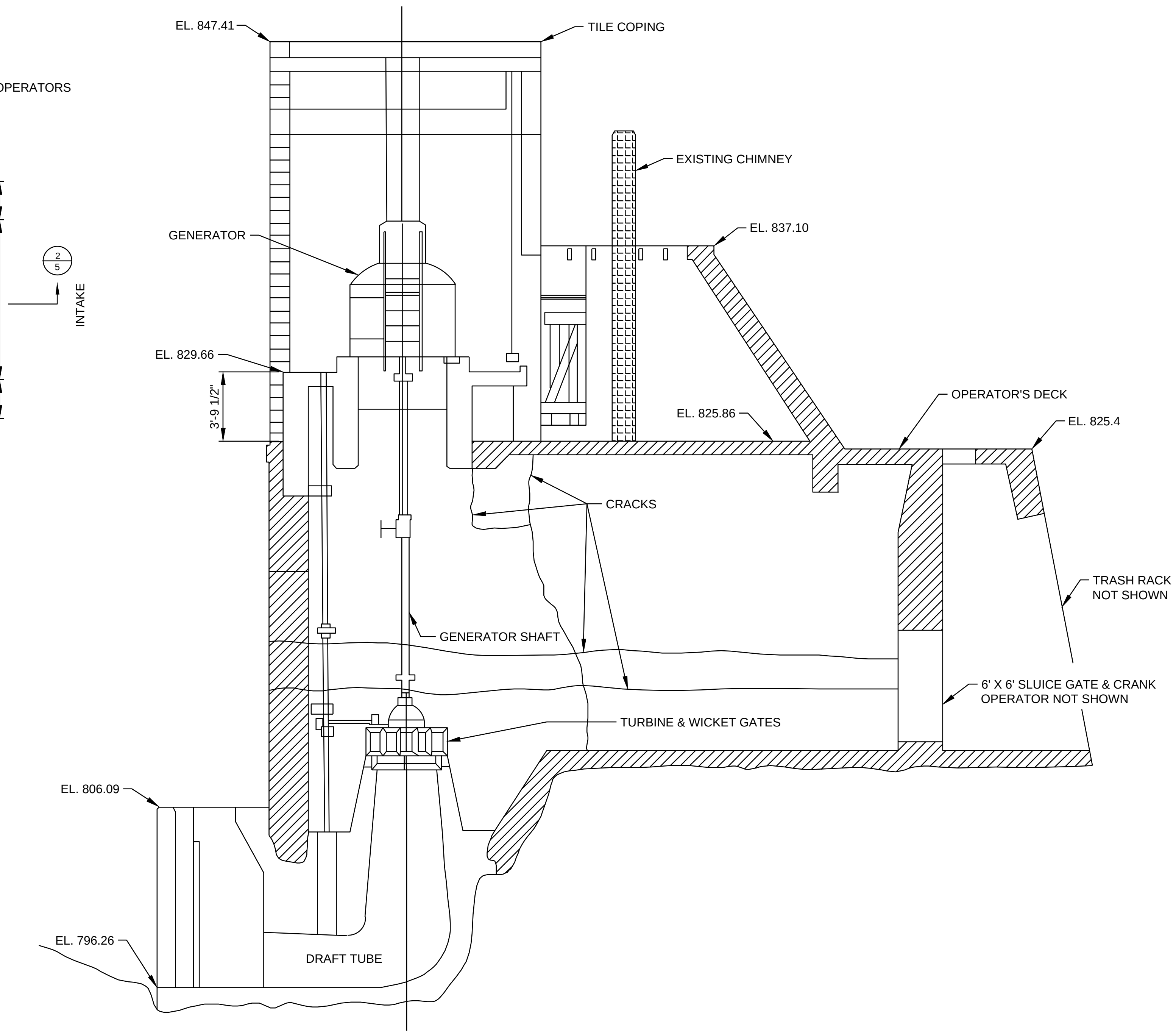

SECTION THROUGH INTAKE & GENERATOR
1/8"=1'-0"

0 4 8

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EXISTING POWERHOUSE CONDITIONS

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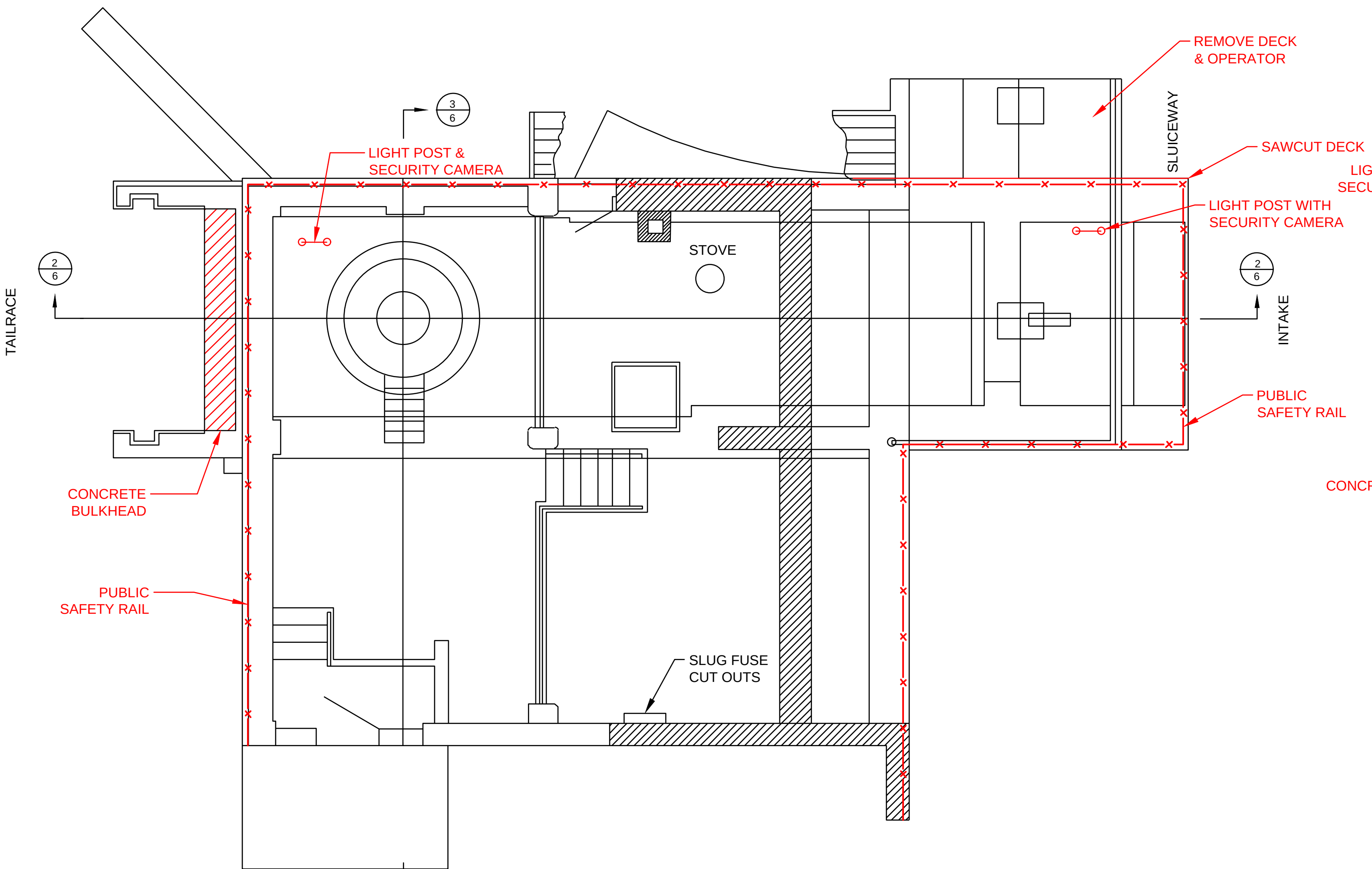

POWERHOUSE PLAN (1/6)

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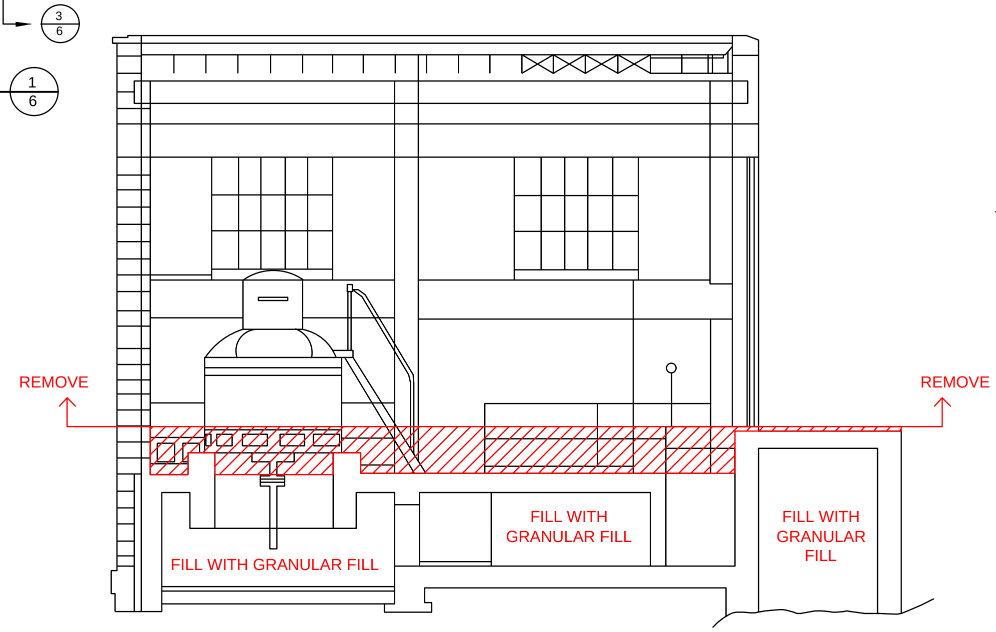

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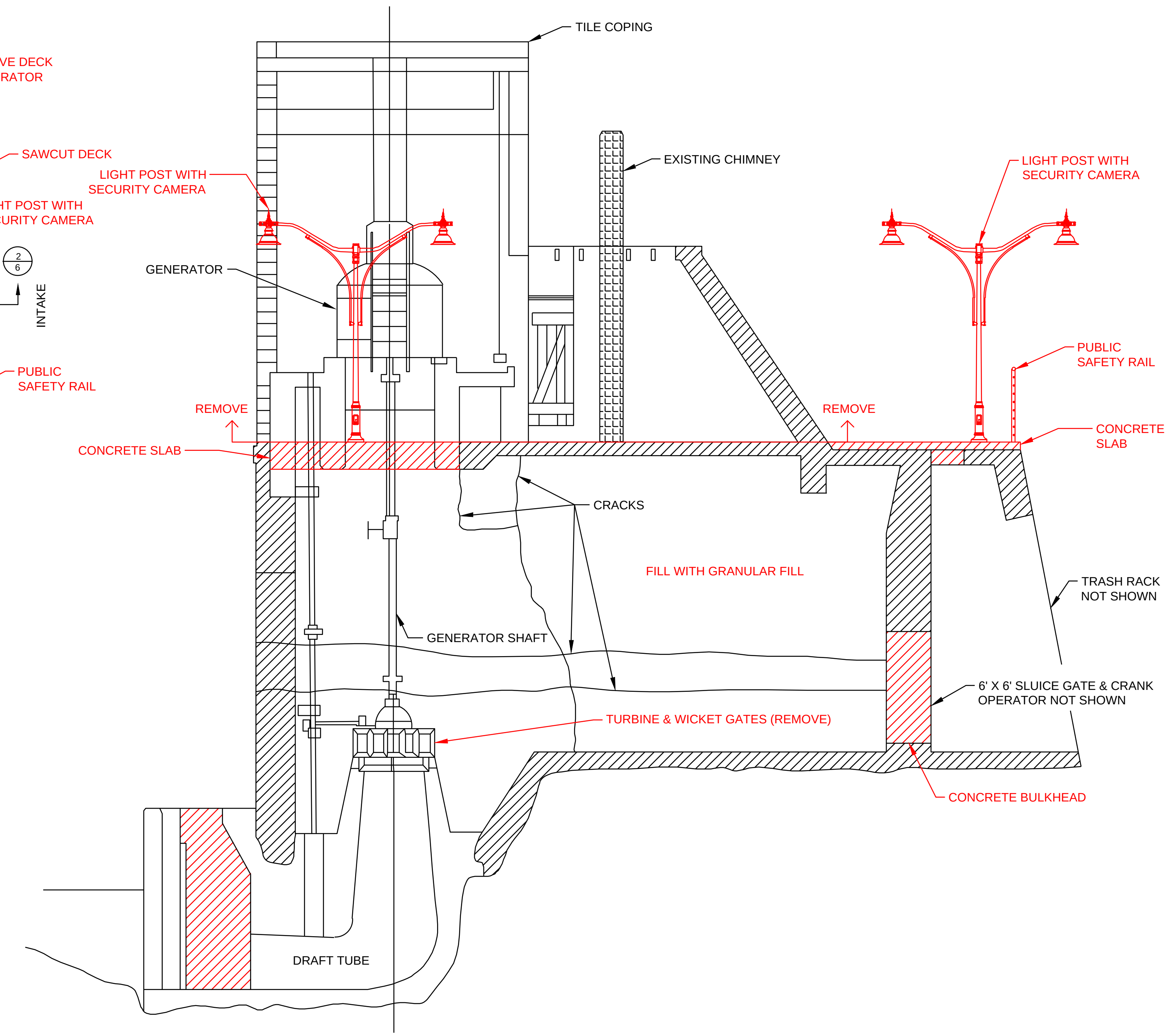

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*NOTE:
PROPOSED ADDITIONS SHOWN IN RED

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NO	DATE	REVISION

NO	DATE	REVISION

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PROPOSED POWERHOUSE CONDITIONS

SHEET NO. 6

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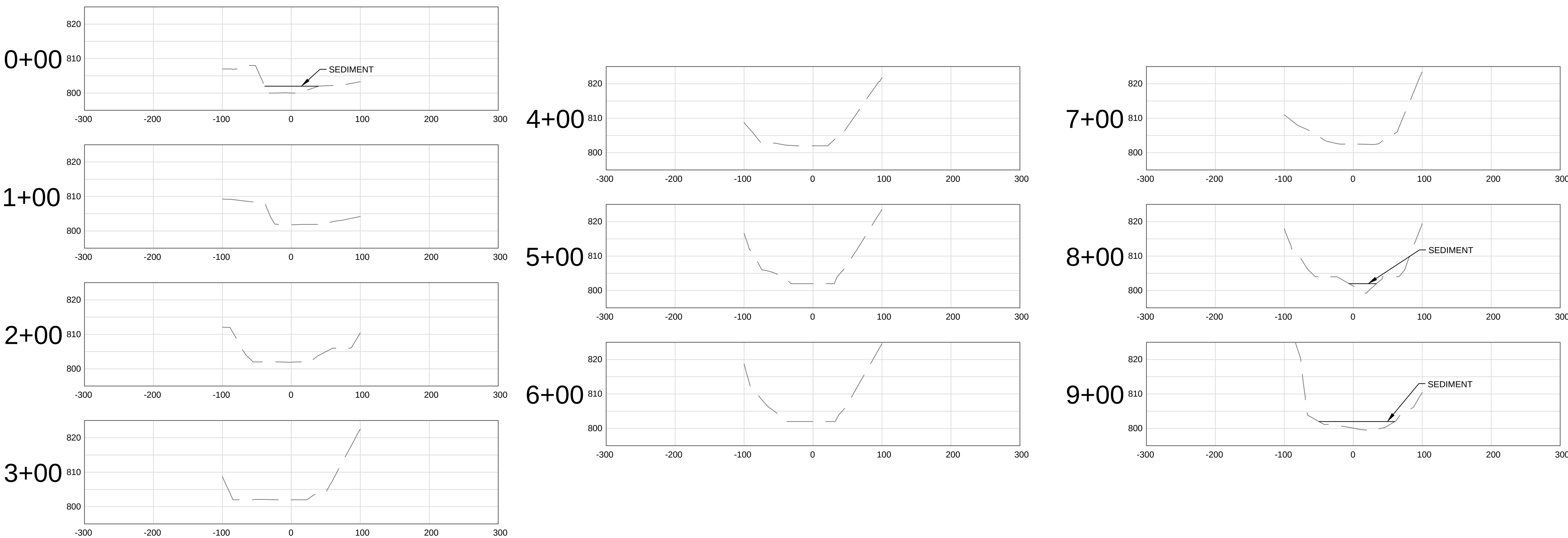

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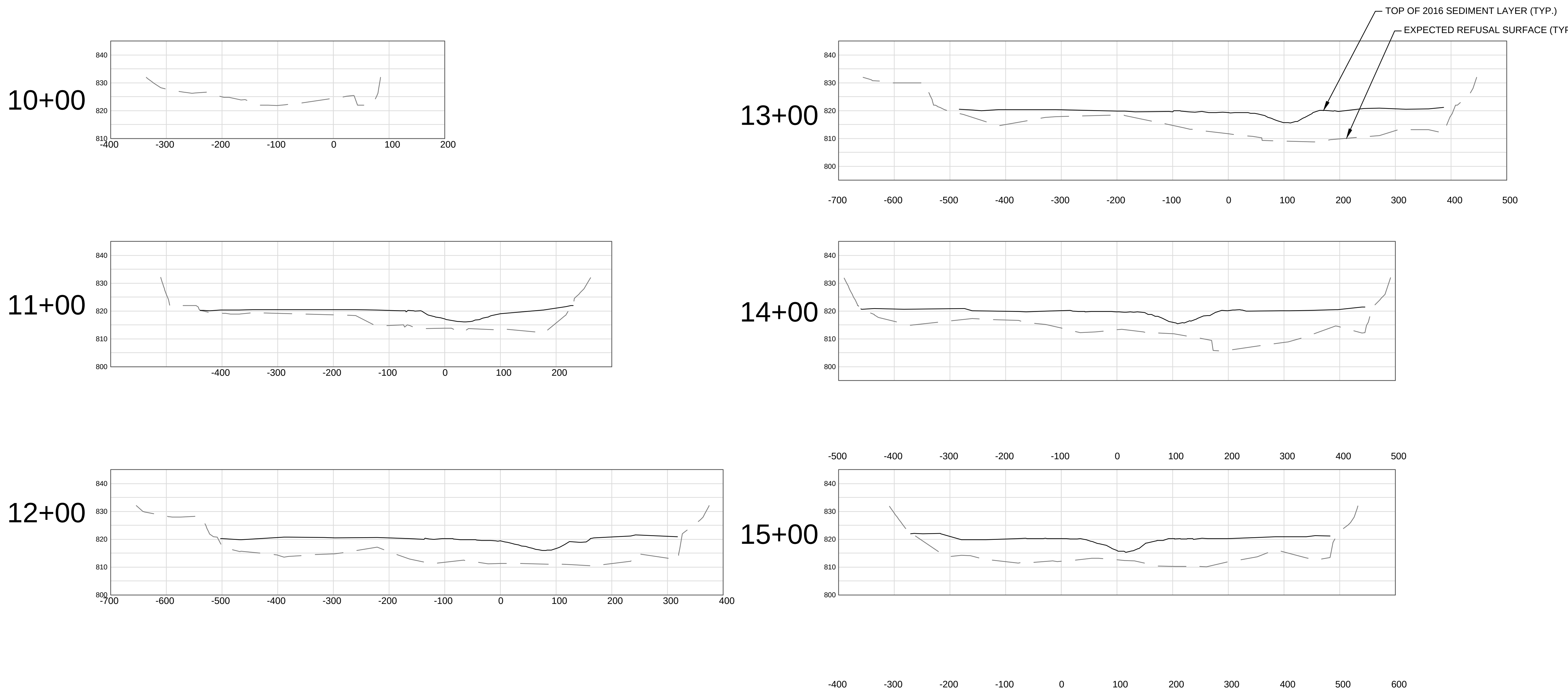

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EXISTING SECTIONS STA. 10+00 TO 15+00

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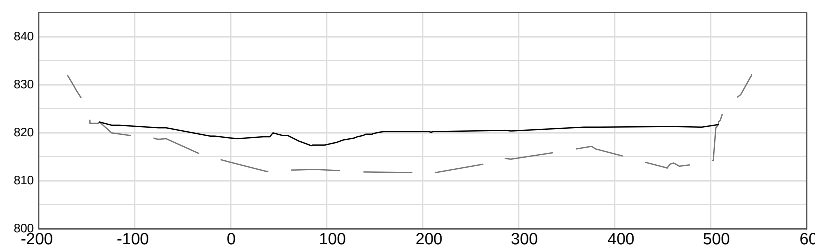
16+00



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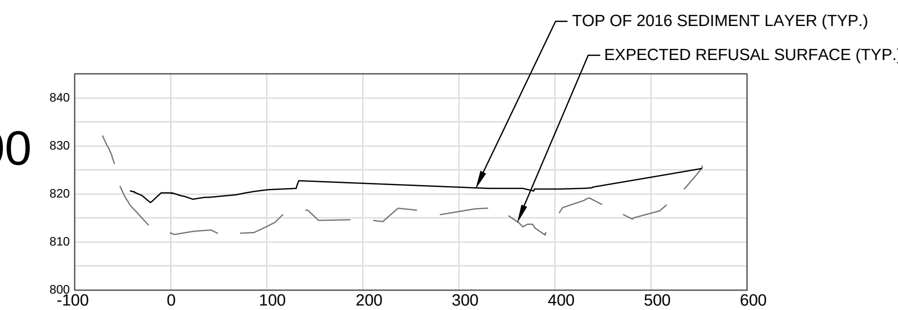

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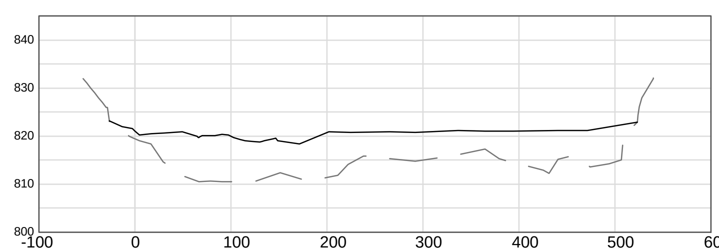

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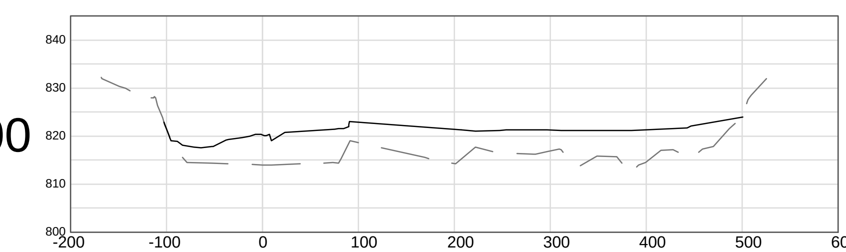

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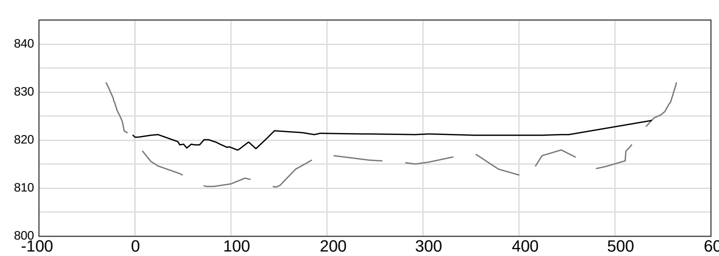

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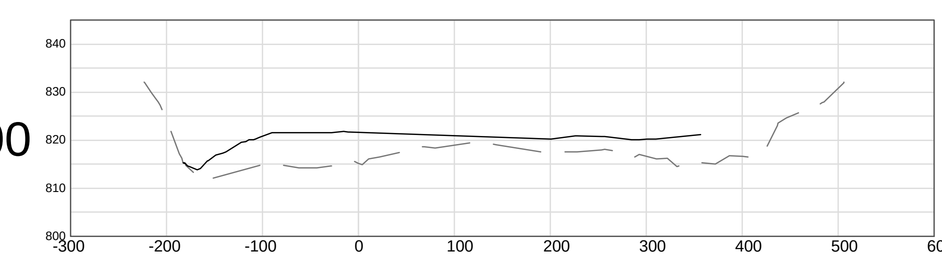

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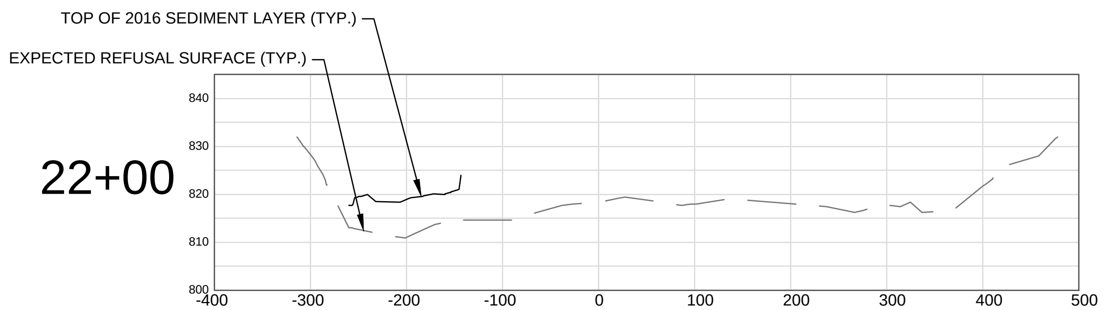
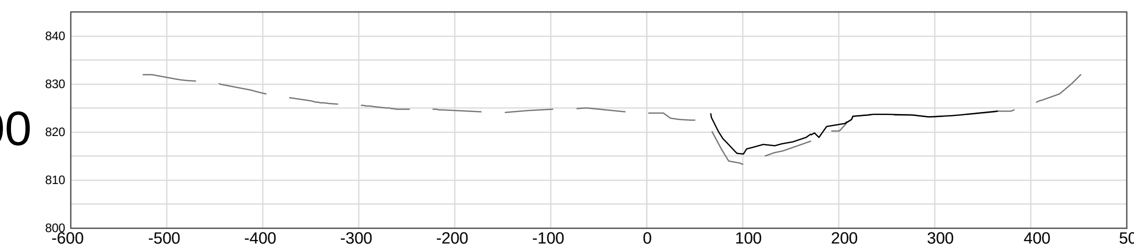
22+00



26+00



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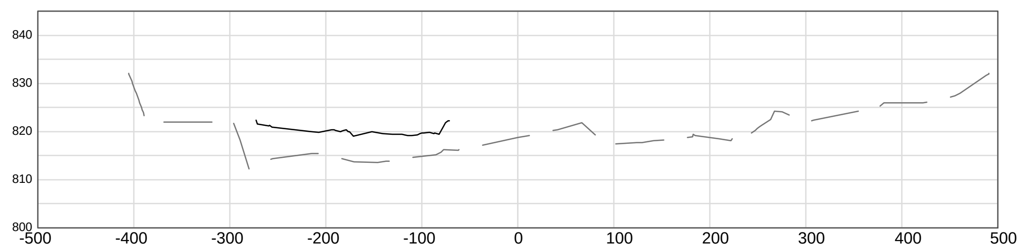

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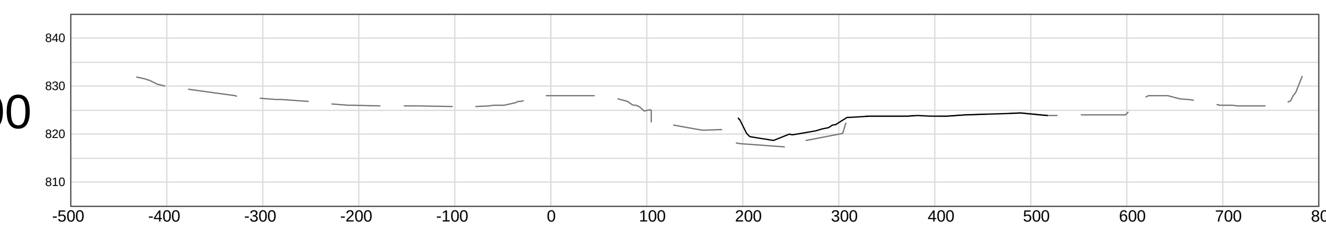

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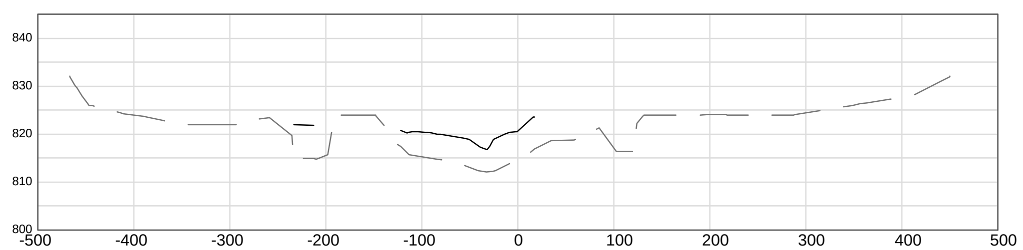

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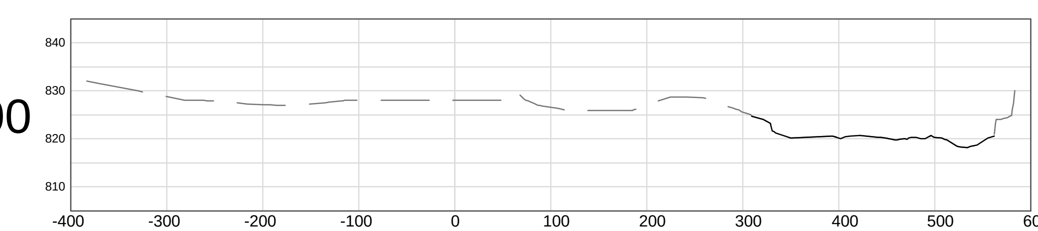

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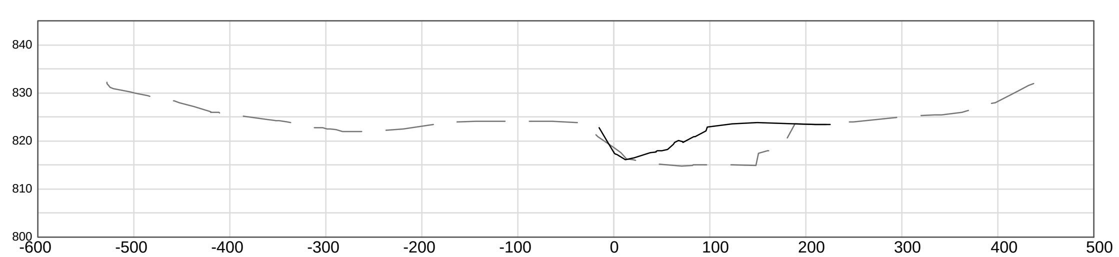

DES BY PEH		NOT FOR CONSTRUCTION	POWELL FALLS DECOMMISSIONING PLAN FERC PROJECT NO. 10489-016-WI	AYRES Eau Claire, WI 54701 715.834.3161	SHEET NO. 11
DR BY ARR	PROJ NO 26-1155.00	NO / DATE / REVISION	EXISTING SECTIONS STA. 22+00 TO 28+00		
CHK BY EF	DATE JAN 11, 2021	NO / DATE / REVISION			

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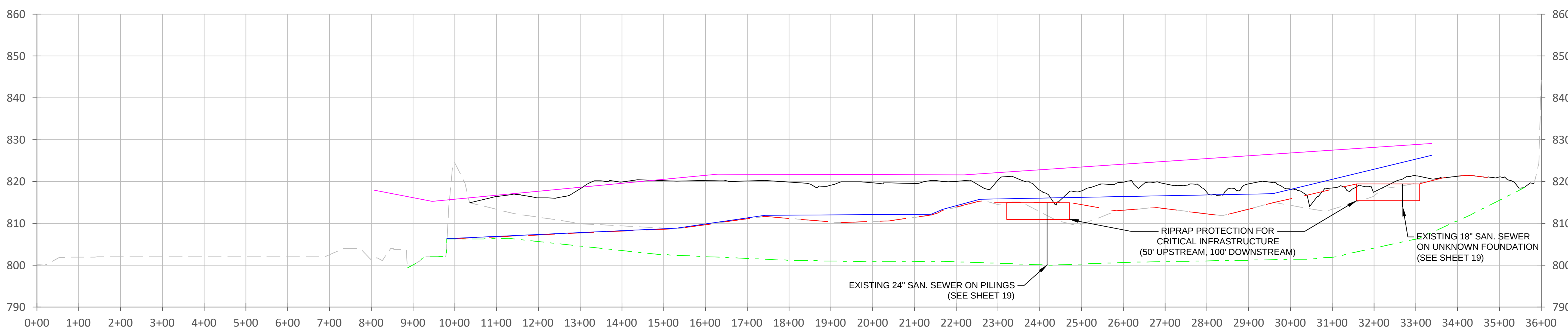

LEGEND:

- LIMIT OF SEDIMENT PROBES*
- EXISTING RIVER BED*
- RIVER BED AFTER REMOVAL**
- Q NORMAL AFTER REMOVAL**
- Q100 WATER SURFACE AFTER REMOVAL**
- ASSUMED BEDROCK**

FUTURE RIVER CHANNEL CENTERLINE

DATA SOURCES:
* INTER-FLUVE. LAKE GEORGE AND LAKE LOUISE SEDIMENT ASSESSMENT REPORT, 2016.
** INTERPRETED BY AYRES.

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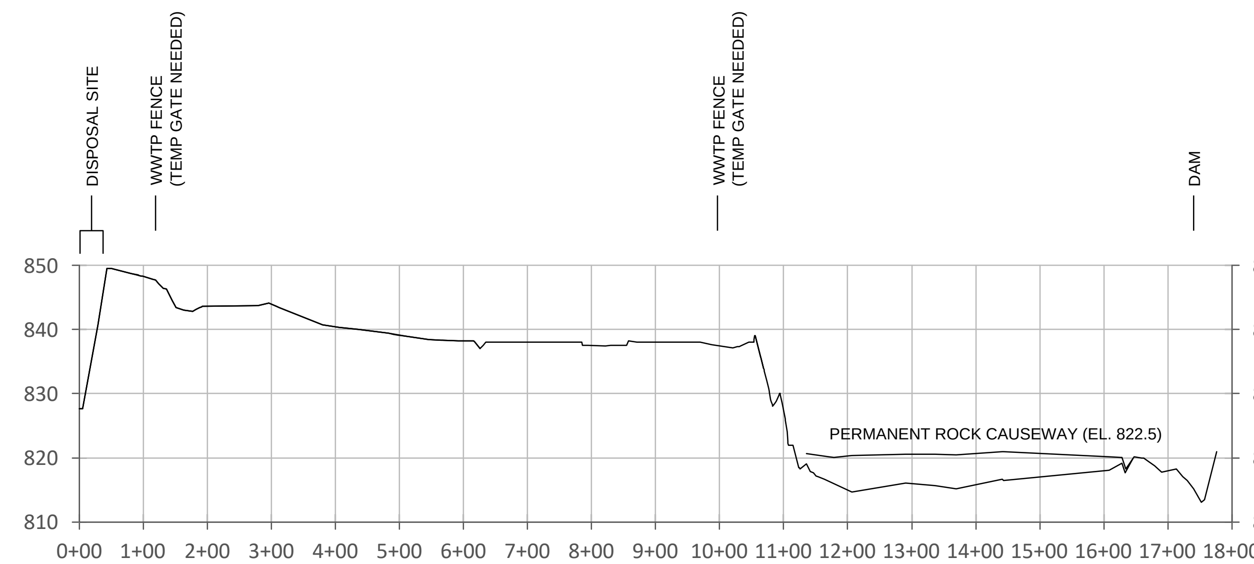
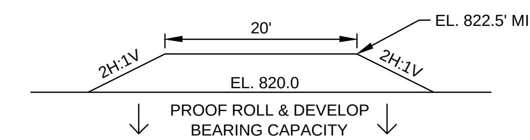
I:\26\TRC\River Falls\26-1155.00 Decommissioning Plan\CAD\SheetSet\3 EXISTING SITE.dwg, Layout: 12 PROFILE THROUGH THALWEG

DES BY	PEH		NOT FOR CONSTRUCTION			POWELL FALLS DECOMMISSIONING PLAN FERC PROJECT NO. 10489-016-WI	AYRES Eau Claire, WI 54701 715.834.3161	PROFILE THROUGH THALWEG	SHEET NO. 12
DR BY	ARR	PROJ NO 26-1155.00							
CHK BY	EF	DATE JAN 11, 2021	NO DATE REVISION		NO DATE REVISION				

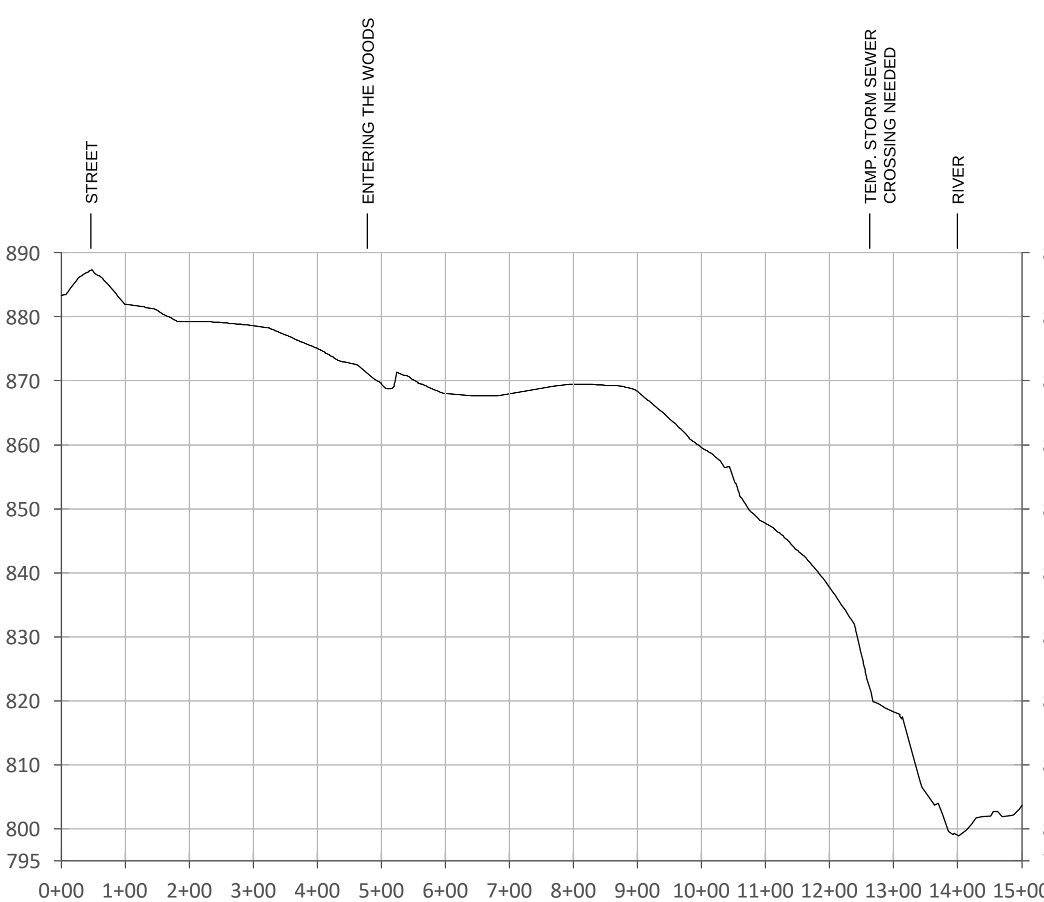
DES BY	PEH	NOT FOR CONSTRUCTION			POWELL FALLS DECOMMISSIONING PLAN	AYRES	ACCESS PLAN OPTIONS	SHEET NO.
DR BY	ARR	PROJ NO 26-1155.00			FERC PROJECT NO. 10489-016-WI	Eau Claire, WI 54701 715.834.3161		13
CHK BY	EF	DATE JAN 11, 2021	NO DATE REVISION	NO DATE REVISION				



FOREBAY ACCESS ROUTE PROFILE



TYPICAL CAUSEWAY



TAILRACE ACCESS ROUTE PROFILE

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DES BY PEH		NOT FOR CONSTRUCTION	POWELL FALLS DECOMMISSIONING PLAN FERC PROJECT NO. 10489-016-WI	AYRES Eau Claire, WI 54701 715.834.3161	ACCESS ROUTE PROFILES
DR BY ARR	PROJ NO 26-1155.00	NO / DATE / REVISION			SHEET NO. 14
CHK BY EF	DATE JAN 11, 2021	NO / DATE / REVISION			

DES BY	PEH		NOT FOR CONSTRUCTION			POWELL FALLS DECOMMISSIONING PLAN	AYRES	PROPOSED EROSION CONTROL	SHEET NO.
DR BY	ARR	PROJ NO 26-1155.00				FERC PROJECT NO. 10489-016-WI	Eau Claire, WI 54701 715.834.3161		15
CHK BY	EF	DATE JAN 11, 2021	NO / DATE / REVISION		NO / DATE / REVISION				

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DES BY	PEH		
DR BY	ARR	PROJ NO	26-1155.00
CHK BY	EF	DATE	JAN 11, 2021

NOT FOR CONSTRUCTION

NO	DATE	REVISION

NO	DATE	REVISION

POWELL FALLS DECOMMISSIONING PLAN
FERC PROJECT NO. 10489-016-WI

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Eau Claire, WI 54701
715.834.3161

PROPOSED EROSION CONTROL & WETLANDS

SHEET NO.
16

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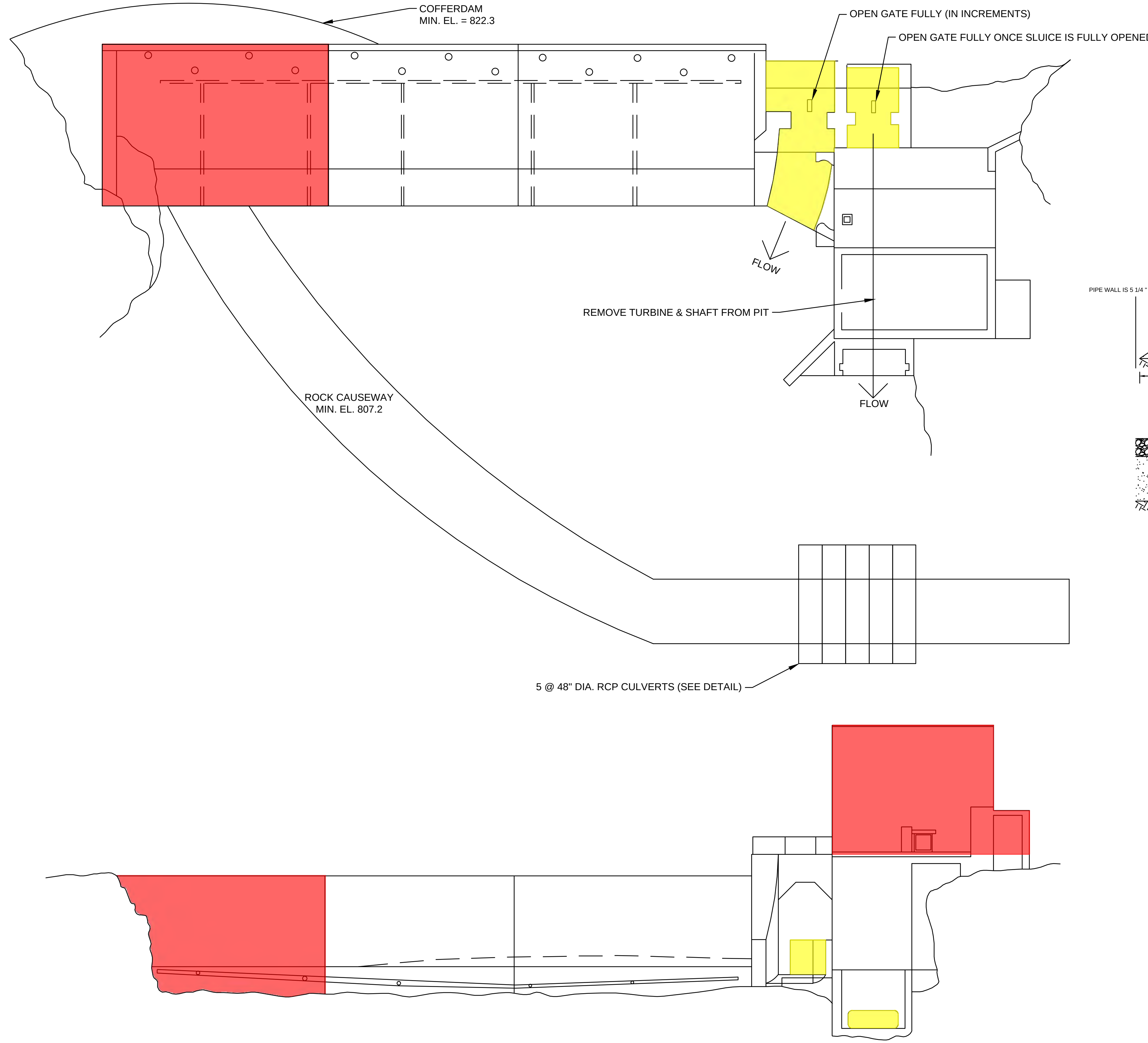
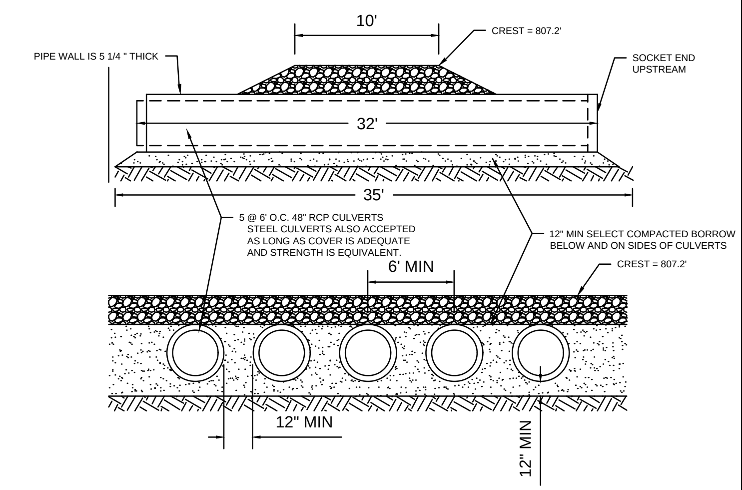
LEGEND:

- REMOVAL AREA
- FLOW AREA

STEADY STATE RATING CURVE:

CHANCE	FLOW	HW	TW
1%	12800	830.7	814.0
2%	11000	829.9	813.1
10%	6800	827.9	810.5
50%	2500	824.9	806.7





ROCK CAUSEWAY DETAIL

N.T.S.

NOTE:
SEE DECOMMISSIONING PLAN FOR DETAILED DESCRIPTION OF STAGES

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DES BY	PEH		
DR BY	ARR	PROJ NO	26-1155.00
CHK BY	EF	DATE	JAN 11, 2021

NOT FOR CONSTRUCTION

NO	DATE	REVISION

NO	DATE	REVISION

POWELL FALLS DECOMMISSIONING PLAN
FERC PROJECT NO. 10489-016-WI

AYRES
Eau Claire, WI 54701
715.834.3161

REMOVAL SEQUENCE 1&2

SHEET NO. 17

LEGEND:

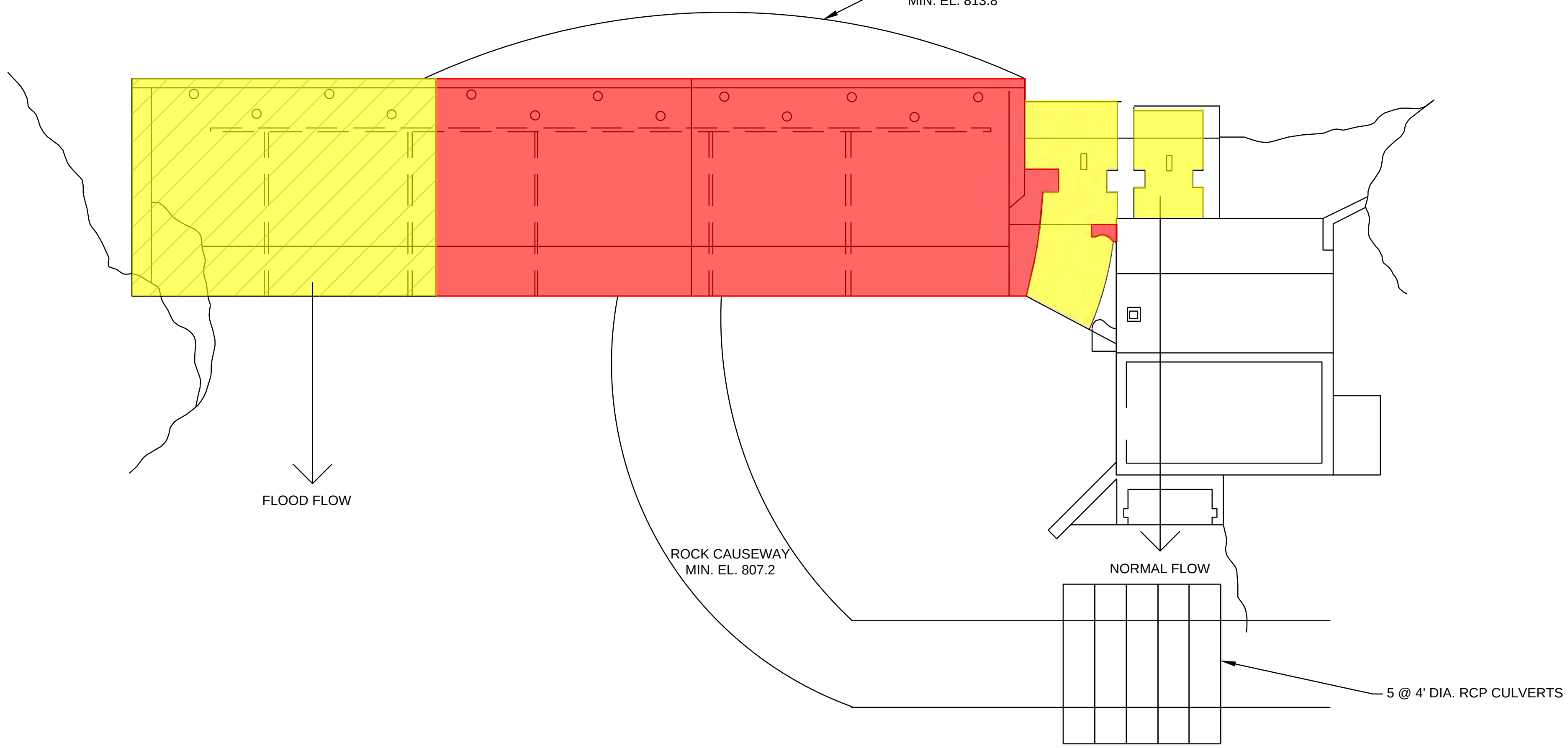
REMOVAL AREA

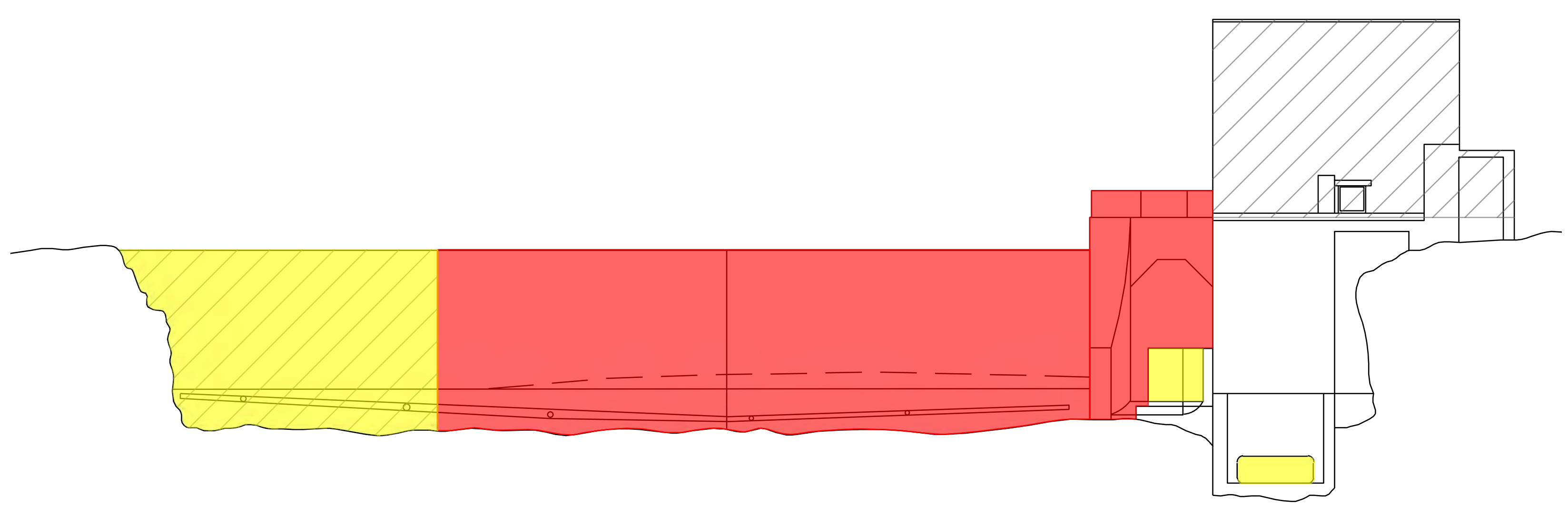
FLOW AREA

PREVIOUSLY REMOVED AREA

STEADY STATE RATING CURVE:

CHANCE	FLOW	HW	TW
1%	12800	824.1	814.0
2%	11000	822.9	813.1
10%	6800	818.8	810.5
50%	2500	813.3	806.7





DES BY	PEH	NOT FOR CONSTRUCTION
DR BY	ARR	PROJ NO 26-1155.00
CHK BY	EF	DATE JAN 11, 2021

NO	DATE	REVISION

NO	DATE	REVISION

POWELL FALLS DECOMMISSIONING PLAN
FERC PROJECT NO. 10489-016-WI

AYRES
Eau Claire, WI 54701
715.834.3161

REMOVAL SEQUENCE 3

SHEET NO. 18

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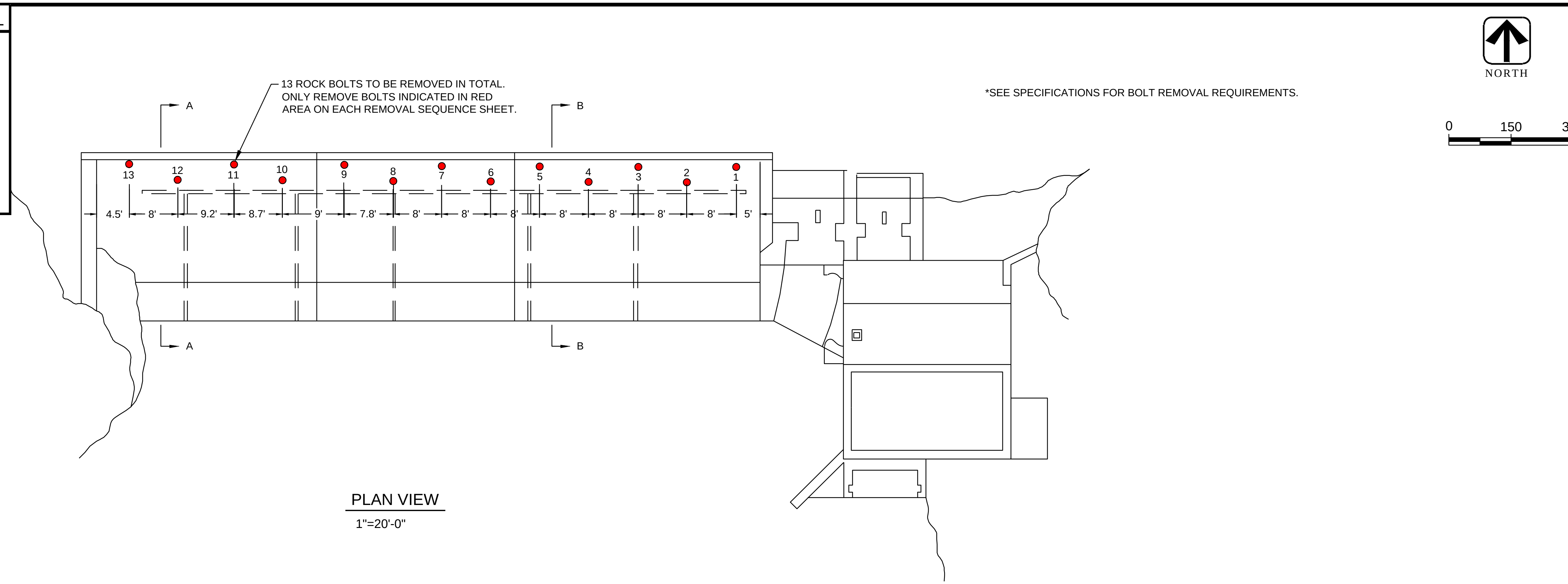
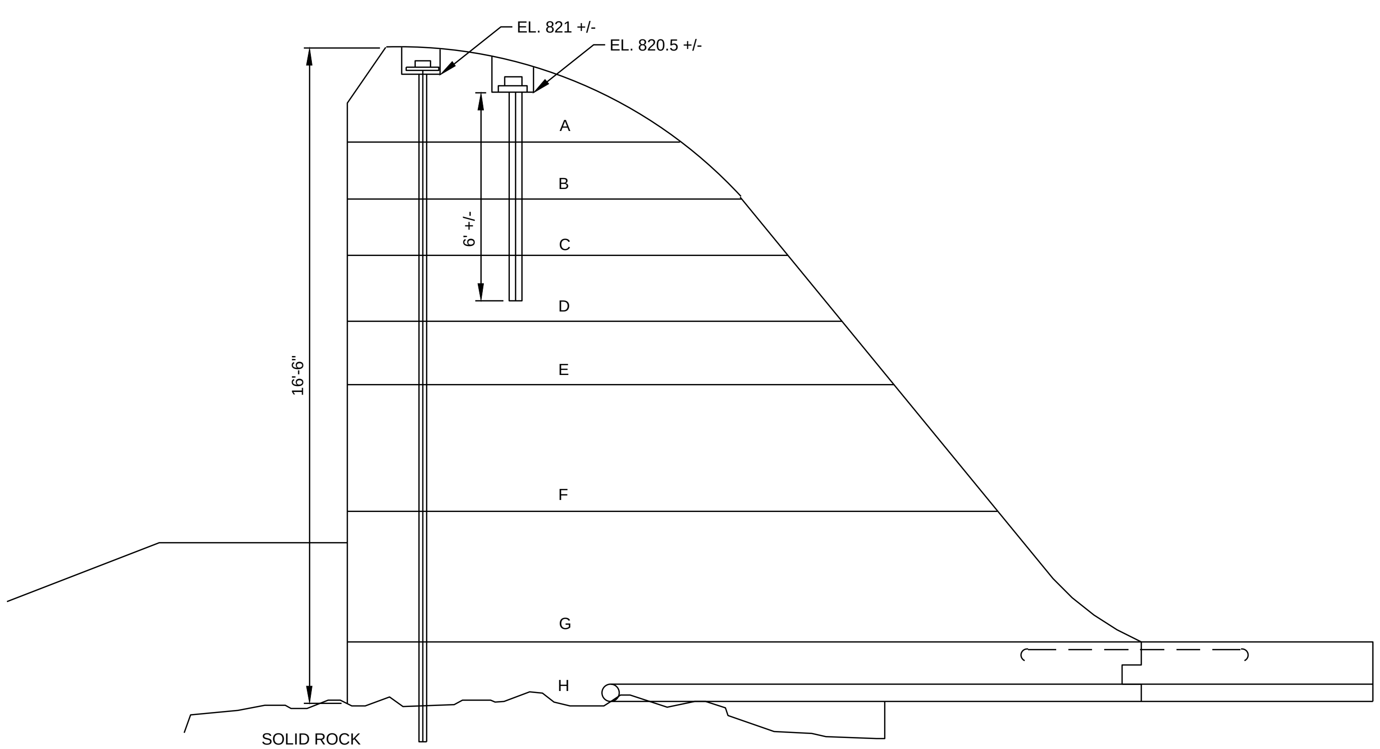
Rock Bolt	Crest EL	Bedock EL	Cored EL
1	821.80	807.97	806.22
3	821.81	808.56	806.81
5	821.83	808.16	805.16
7	821.81	807.64	805.64
9	821.82	805.97	804.32
11	821.81	806.35	805.31
13	821.80	807.40	805.59

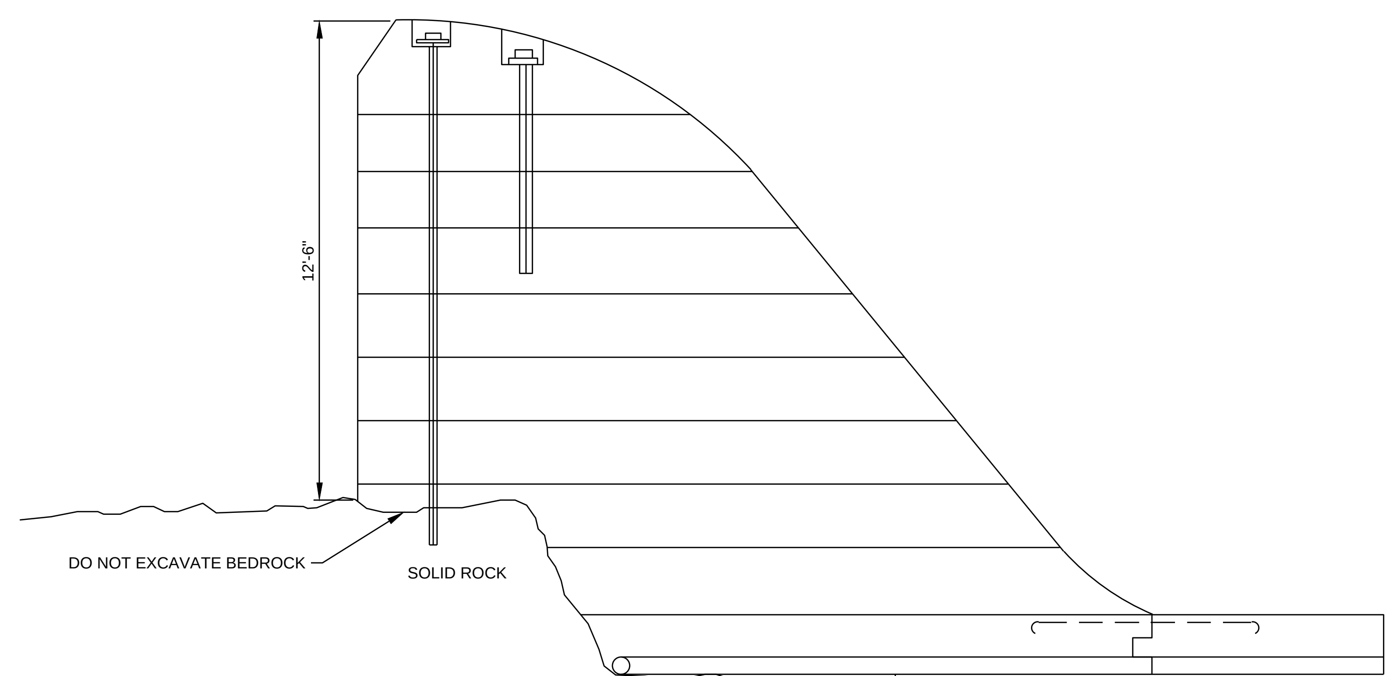
*SEE SPECIFICATIONS FOR BOLT REMOVAL REQUIREMENTS.



PLAN VIEW
1"=20'-0"



SECTION A
1"=5'-0"

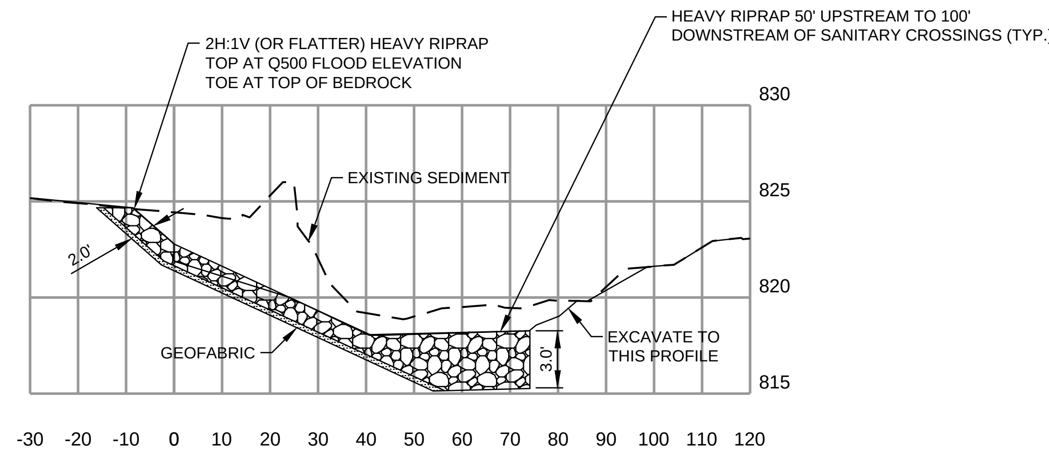


SECTION B
1"=5'-0"

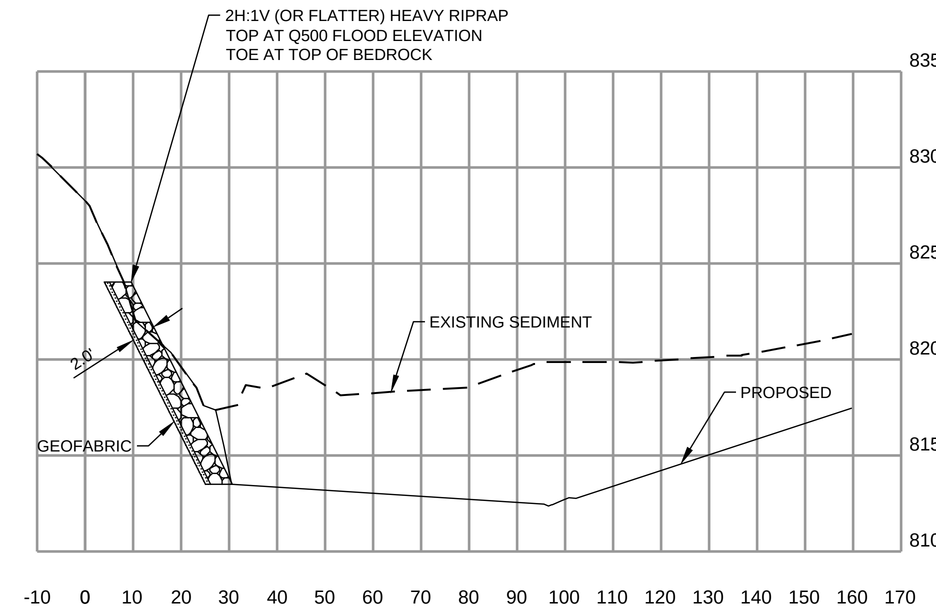
DES BY	PEH		NOT FOR CONSTRUCTION	POWELL FALLS DECOMMISSIONING PLAN FERC PROJECT NO. 10489-016-WI	AYRES Eau Claire, WI 54701 715.834.3161	ROCK BOLT REMOVAL	SHEET NO. 19
DR BY	ARR	PROJ NO 26-1155.00	NO / DATE / REVISION				
CHK BY	EF	DATE JAN 11, 2021	NO / DATE / REVISION				

AA-Standard.stb 1/26/2021 I:\26\TRC\River Falls\26-1155.00 Decommissioning Plan\CAD\SheetSet\20 DRAFT RESTORATION PLAN.dwg, Layout: 20 DRAFT RESTORATION PLAN

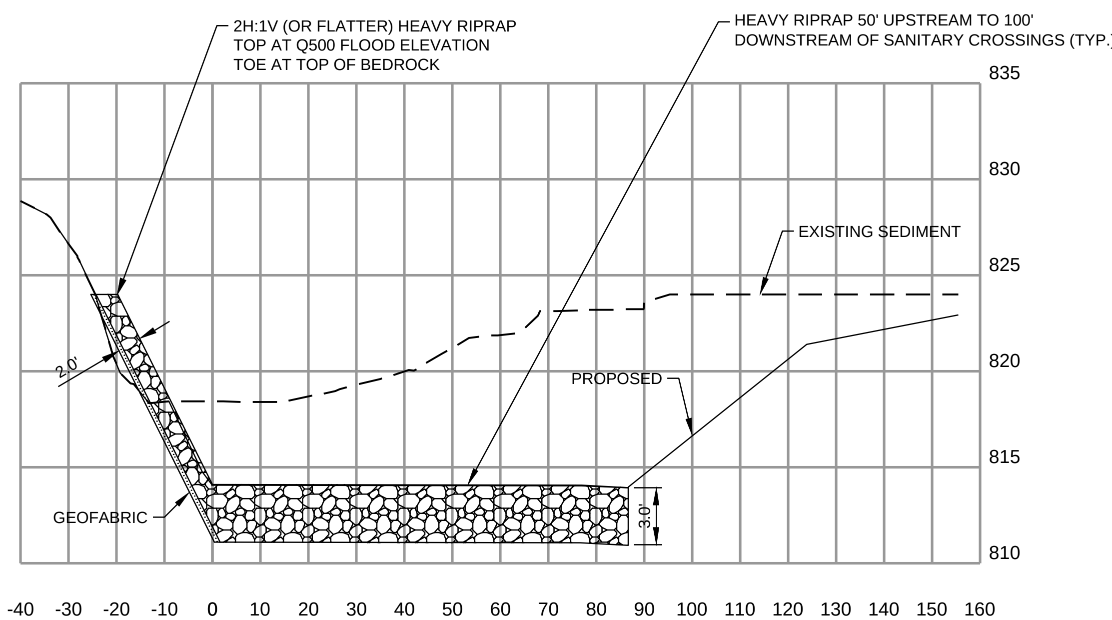
DES BY PEH		NOT FOR CONSTRUCTION		POWELL FALLS DECOMMISSIONING PLAN FERC PROJECT NO. 10489-016-WI	AYRES Eau Claire, WI 54701 715.834.3161	DRAFT RESTORATION PLAN	SHEET NO. 20
DR BY ARR	PROJ NO 26-1155.00						
CHK BY EF	DATE JAN 11, 2021	NO / DATE / REVISION	NO / DATE / REVISION				



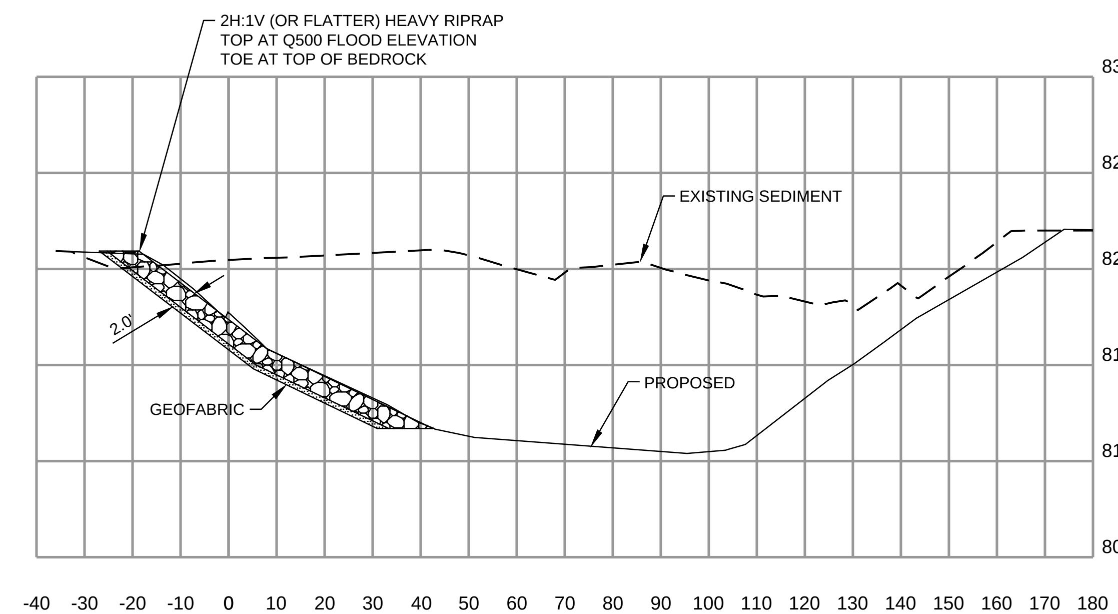
CROSS SECTION 1



CROSS SECTION 2



CROSS SECTION 3



CROSS SECTION 4

NOTE:
SEE SHEET 20 FOR CROSS SECTION LOCATIONS

DES BY	PEH		NOT FOR CONSTRUCTION	POWELL FALLS DECOMMISSIONING PLAN FERC PROJECT NO. 10489-016-WI	AYRES Eau Claire, WI 54701 715.834.3161	PERMANENT RIPRAP DETAILS	SHEET NO. 21
DR BY	ARR	PROJ NO 26-1155.00					
CHK BY	EF	DATE JAN 11, 2021	NO / DATE / REVISION				

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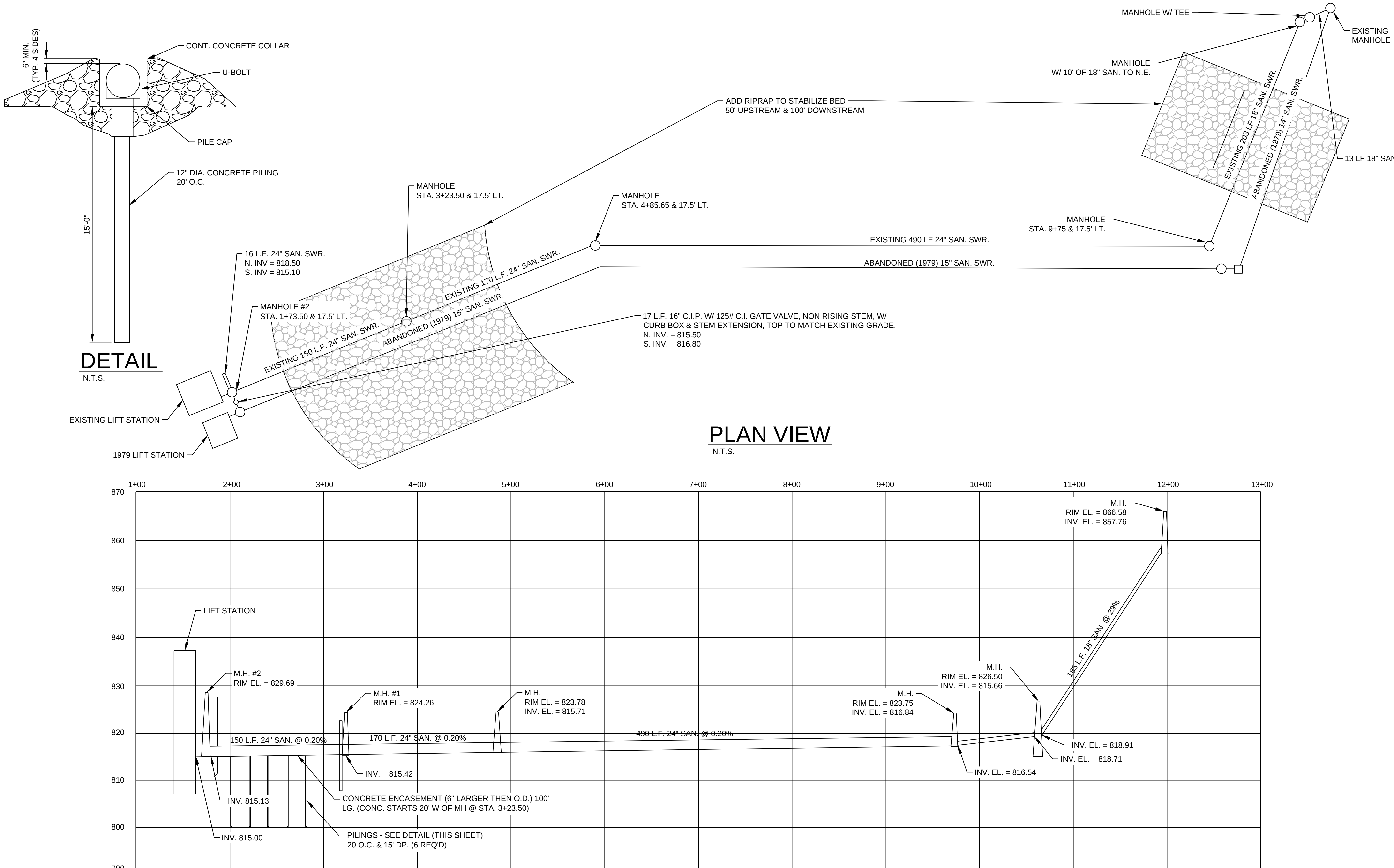

DES BY	PEH		
DR BY	ARR	PROJ NO	26-1155.00
CHK BY	EF	DATE	JAN 11, 2021

NOT FOR CONSTRUCTION

NO	DATE	REVISION

NO	DATE	REVISION

POWELL FALLS DECOMMISSIONING PLAN
FERC PROJECT NO. 10489-016-WI

AYRES
Eau Claire, WI 54701
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SANITARY CROSSING DETAILS

SHEET NO. 22

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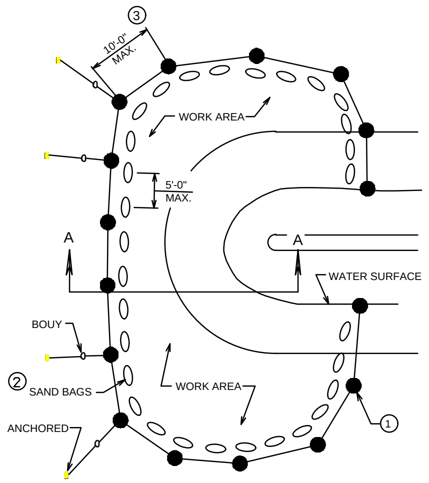
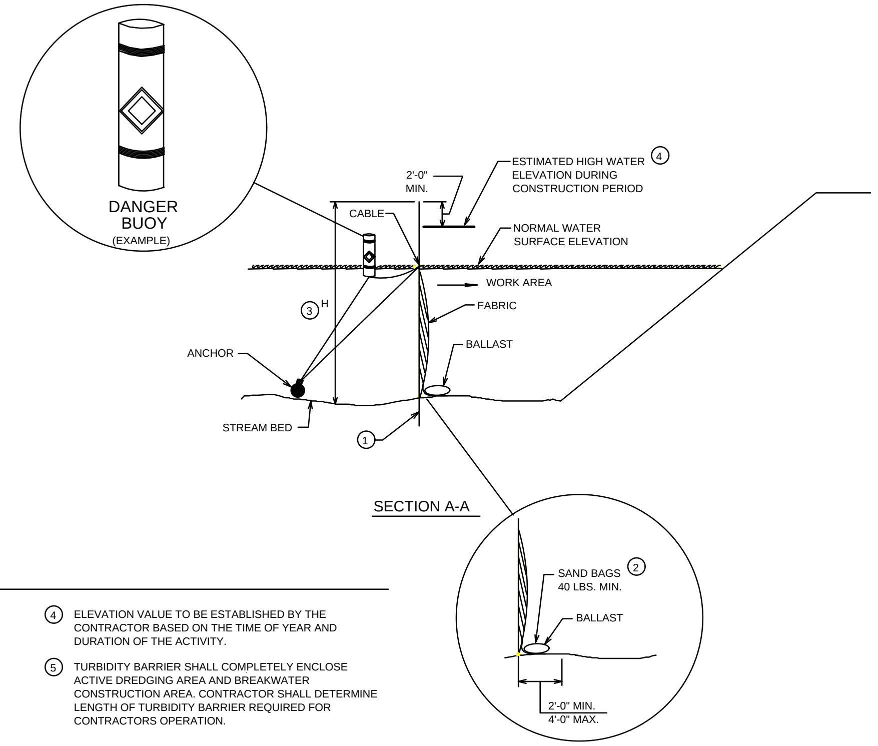


PLAN VIEW (TYPICAL)



SECTION A-A

NOTES:

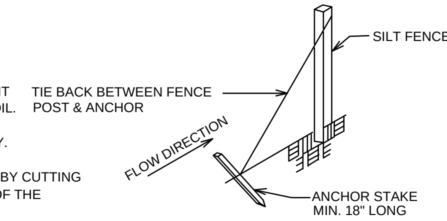
1. DRIVEN STEEL POSTS, PIPES, OR CHANNELS. LENGTH SHALL BE SUFFICIENT TO SECURELY SUPPORT BARRIER AT HIGH WATER ELEVATIONS.
2. SAND BAGS TO BE USED AS ADDITIONAL BALLAST WHEN ORDERED BY THE ENGINEER TO MEET ADVERSE FIELD CONDITIONS.
3. WHEN BARRIER HEIGHT, H. EXCEEDS 8'-0" POST SPACING MAY NEED TO BE DECREASED.
4. ELEVATION VALUE TO BE ESTABLISHED BY THE CONTRACTOR BASED ON THE TIME OF YEAR AND DURATION OF THE ACTIVITY.
5. TURBIDITY BARRIER SHALL COMPLETELY ENCLOSE ACTIVE DREDGING AREA AND BREAKWATER CONSTRUCTION AREA. CONTRACTOR SHALL DETERMINE LENGTH OF TURBIDITY BARRIER REQUIRED FOR CONTRACTORS OPERATION.

1 TURBIDITY BARRIER DETAIL

N.T.S 0156203

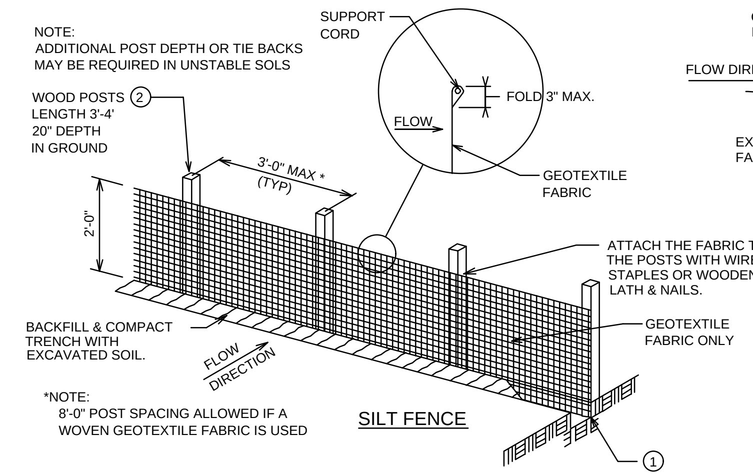
GENERAL NOTES:

1. TRENCH SHALL BE A MIN OF 4" WIDE & 6" DEEP TO BURY AND ANCHOR THE GEOTEXTILE FABRIC, FOLD THE MATERIAL TO FIT TRENCH AND BACKFILL & COMPACT TRENCH WITH EXCAVATED SOIL.
2. WOOD POSTS SHALL BE A MIN SIZE OF 1 1/8" x 1 1/8" OAK OR HICKORY.
3. CONSTRUCT SILT FENCE FROM A CONTINUOUS ROLL IF POSSIBLE BY CUTTING LENGTHS TO AVOID JOINTS. IF A JOINT IS NECESSARY, USE ONE OF THE FOLLOWING TWO METHODS;
   A. TWIST METHOD -- OVERLAP THE END POSTS AND TWIST, OR ROTATE, AT LEAST 180 DEGREES.
   B. HOOK METHOD -- HOOK THE END OF EACH SILT FENCE LENGTH.



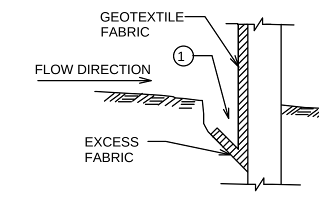
SILT FENCE TIE BACK
(WHEN ADDITIONAL SUPPORT REQUIRED)

NOTE:
ADDITIONAL POST DEPTH OR TIE BACKS MAY BE REQUIRED IN UNSTABLE SOLS

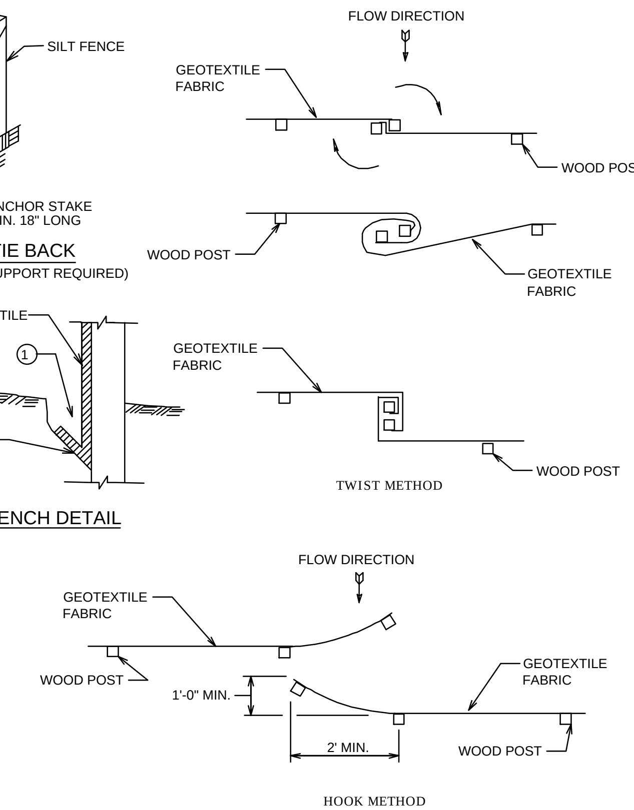


*NOTE:
8'-0" POST SPACING ALLOWED IF A WOVEN GEOTEXTILE FABRIC IS USED

SILT FENCE



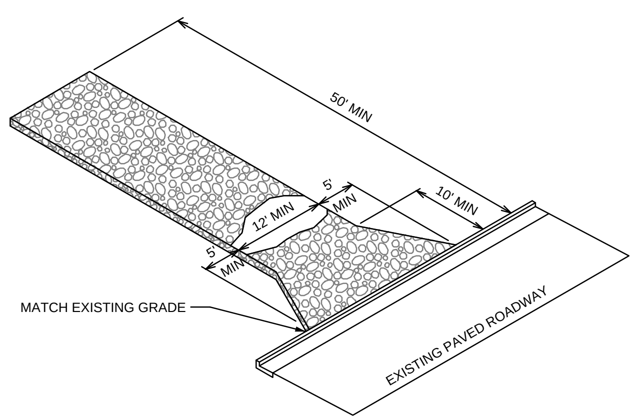
TRENCH DETAIL



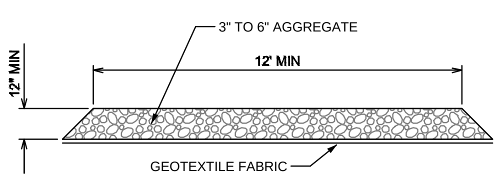
JOINING 2 LENGTHS OF SILT FENCE 3

2 SILT FENCE DETAIL

0156201



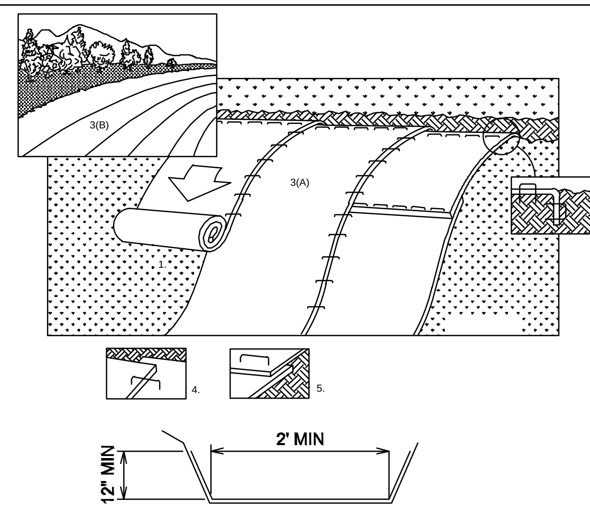
PLAN



SECTION

3 STONE TRACKING PAD

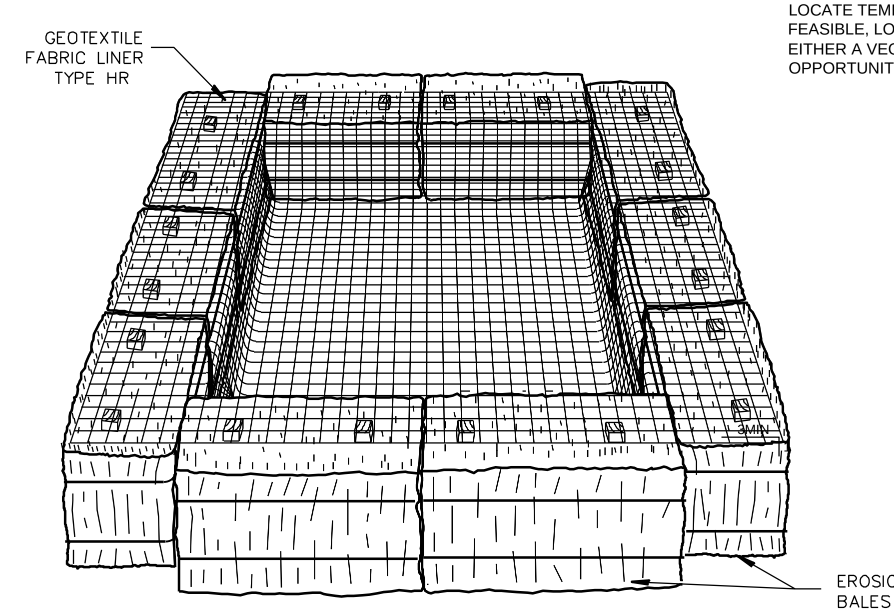
0156201



CHANNEL INSTALLATION

1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING SEED.
2. BEGIN AT THE TOP OF THE SLOPE OR CHANNEL BY ANCHORING THE BLANKET IN 6" DEEP X 6" WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.
3. ROLL THE BLANKETS (3A.) DOWN OR (3B.) HORIZONTALLY ACROSS THE SLOPE.
4. THE EDGES OF PARALLEL BLANKETS SHALL BE STAPLED WITH 4" OVERLAP.
5. WHEN BLANKETS MUST BE SPLICED DOWN THE SLOPE OR CHANNEL, PLACE BLANKETS END OVER END (SHINGLE STYLE) WITH 6" OVERLAP. STAPLE APPROXIMATELY 12" APART.
6. ALL BLANKETS MUST BE SECURELY FASTENED TO THE SLOPE OR CHANNEL BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS RECOMMENDED BY THE MANUFACTURER.
7. USE EROSION CONTROL REVEGETATIVE MAT (ECRM) CLASS-1, TYPE-B.

4 EROSION MAT INSTALLATION DETAIL



LOCATE TEMPORARY SETTLING BASIN ON LEVEL OR GENTLY SLOPED TERRAIN. WHERE FEASIBLE, LOCATE BASIN OUTFALL SO THAT DISCHARGED WATER DIRECTLY ENTERS EITHER A VEGETATED AREA OR THE WATERWAY SO THAT EFFLUENT HAS MINIMAL OPPORTUNITY TO ENTRAIN SUSPENDED SOLIDS AFTER THE SETTLING POND.

(SIZE TO BE DETERMINED IN FIELD AS INDICATED BELOW:)

STORAGE VOLUME (SV in C.F.) = 16 X GPM (PUMP RATE)

EXAMPLE:
CONTRACTOR INDICATES PUMP CAPABLE OF 50 GPM
HEIGHT OF BALES = 1.5 FT.

SOLUTION:
SV in C.F. = 16 X 50
SV = 800 C.F.

$\frac{800 \text{ C.F.}}{1.5 \text{ FT.}}$ = 533 S.F.

USE A 20 FT. X 27 FT. BASIN

5 TEMPORARY SETTLING BASIN

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CHK BY	EF	DATE JAN 11, 2021	NO / DATE / REVISION	NO / DATE / REVISION				

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Appendix 2:
Case Studies for Similar-Sized and Similar Location Dam Removals

Introduction

Case studies are presented for five dam removals. The location of the dam removals is shown below in Figure 1.

Figure 1. Locations of Case Studies in relation to Powell Falls Dam

Case Study 1: Polk County Woodley Dam

Polk County's Woodley Dam (45.39636º, -92.36385º) is 40.0 miles north-northeast of Powell Falls. In 2001, Woodley Dam's embankment nearly overtopped during a large flood event, and the Wisconsin DNR soon ordered a mandatory drawdown until repairs could be completed.

Figure 2. Woodley Dam, prior to 2002 (photo courtesy[20] of Woodley Dam Front)

Citing excessive repair expenses, the grist mill building (last producing hydroelectric power in 1994 but never licensed under FERC jurisdiction) was removed in 2003 with little opposition (Figure 3), but the County's subsequent application for dam removal in 2003 was met with opposition.

Figure 3. Woodley Dam in 2007 (powerhouse removed in 2003 and reservoir drawn down in 2001).

The WDNR permit for the Woodley Dam removal was contested because the Apple River Association and Kiap-TU-Wish Chapter of Trout Unlimited opposed[21] the permitted activities as "not in the public interest and would unnecessarily and unreasonably harm the fisheries, scenic beauty, and other public trust resources of the Apple River." The contested permit items included riprap stabilization (alleged environmental pollution and navigation hazards), dredging (citing environmental pollution), and later the addition of a snowmobile bridge (deemed as not in the public interest). Arguing that the riprap fish weirs and boulders (designed to restore fish passage without allowing steep grades to cut into upstream sediments) prevented a "free-flowing, natural stream," the constituents requested the WDNR order a wider dam removal and removal of more reservoir sediments. Geofabric underlayment of the riprap was

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[20] http://www.deerparkwi.org/flood/woodleydam.html accessed electronically on July 15, 2010.
[21] Petition for Contested Case Hearing. Apple River Association and Kiap-Tu-Wish Chapter of Trout Unlimited v. Wisconsin DNR. May 9, 2007.

also contested as not environmentally responsible. Additionally, a local snowmobile advocacy group contested the dam removal permit, arguing that loss of the dam prevented them from using the dam as their river crossing.

While the dam owner argued the right to remove the dam in court, the plaintiffs disagreed on whether the restoration plans were in the public interest. The competing restoration goals (three way – owner's budget, snowmobile crossing, anti-riprap advocates) halted the project as the case proceeded to an administrative law judge. As a measure to progress the removal permit, the dam owner conceded to dredge an extra 1,300 cubic yards, limit riprap use to protection of the bridge structure and outer bends of riverbanks, and add a new snowmobile bridge (an additional cost of $197,000 in 2025 dollars). In addition to the construction cost increases, the new bridge and riprap revisions to the dam removal plan and permits required an additional 25% in engineering fees. Upon receiving the above concessions, plaintiffs dismissed their contested case and the legal hearing was discontinued. The WDNR issued permits based on the concessions, and the dam was removed in 2009 as shown in Figure 4. While the actual deconstruction required only five months, the engineering design and permits had taken five years to complete.

Figure 5 shows the site, two years after removal. The revised design (outer bend riprap and re-grading) successfully stabilized lateral bank stability, and the former scour hole below the dam had refilled with silt without leading to upstream migrating headcuts. The disposal site was stable and well vegetated.

Figure 4. Woodley Dam in fall of same year as removal, note active sediment transport (bedload)

Figure 5. Woodley Dam two years post-removal (same view as Figure 3), note little sediment transport

Case Study 2: Sawyer County Grimh Dam

Sawyer County's Grimh Dam (45.760986°, -91.220336°) is 93.4 miles northeast of Powell Falls. When North Central Power Company decided to remove the 30-foot-high, 1200-foot-long Grimh Dam (Figure 6) in a sparsely populated region of northern Wisconsin, few anticipated the legal, environmental, and public safety challenges ahead. Grimh Dam originally supplied power to a local shingle factory, and the resulting Village of Radisson expanded around the Grimh Dam impoundment. As the shingle business faded, the dam was raised nine more feet to produce hydroelectricity for the region's wood-products industries and surrounding communities. By 1997, the dam required significant repairs to meet the Federal Energy Regulatory Commission (FERC) standards, so rather than complete the FERC licensure process, the owner published a legal notice to abandon the dam. The removal process was delayed during attempts to sell the dam to the community and other hydropower producers.

Figure 6. Grimh Dam in 1990, Pre-Removal

In 2000, the WDNR required a drawdown to address unrepaired safety concerns. This drawdown initiated a civil lawsuit from local property owners who had become dependent on the lake to support shallow wells and sentimentally attached to the Village's flowage for recreational and aesthetic reasons. Local residents claimed their shallow wells were losing water, the once pristine fishing area was destroyed, and property values were lowered because of the unsightly mud flats where the reservoir once flowed. Because objecting to the WDNR drawdown for dam safety was not successful, plaintiffs quickly turned to contesting the dam abandonment permit, and an administrative law judge was appointed to oversee eight months of legal arguments about dam removal. In 2008, the judge ruled that the owner and DNR had sufficient rights to proceed with removal, but afterwards the WDNR requested additional justification for the sediment management plan to handle 115,000+ cubic yards of silt in the main channel behind the dam plus revised plans to accommodate native species and stream restoration concerns.

Several key permit conclusions and conditions from in the 2008 Wisconsin judicial decision for the Grimh Dam abandonment are listed below, paraphrased and grouped in areas relevant to the current dam removal study:

VIII. Procedural:
  a. Dam abandonments are a type III action under Wis. Admin. Code NR 150.03.03(8)(f)4, and do not require the preparation of a formal environmental impact statement.

IX. Dam Safety:
  a. No construction is allowed during periods of high water OR between April 1st and June 1st of any calendar year.
  b. The permit holder must provide plans to ensure public safety which may include monitoring for soft sediment areas that could entrap people or animals or the placement of "No Trespassing" or warning signs to alert waterway users both upstream and downstream of the project site.

X. Drawdown conditions:
  a. Drawdown must be staged over two growing season intervals (two year time period) to minimize the transport of sediment downstream and allow time for natural vegetation to stabilize the site and prevent erosion.
  b. Drawdown rate should remove approximately half the reservoir volume per year.
  c. Drawdown rate must not exceed six inches per day.
  d. The drawdown may commence no earlier than June 1st and must be completed by September 15th of any year.
  e. The permit holder shall inspect the flowage during drawdown to determine if fish or aquatic life are stranded. To the extent practical, living fish and mussels shall be returned to the water as soon as practicable.

XI. Construction equipment in waters:
  a. All equipment, barges, boats, silt or turbidity curtain, hoses, sheet pile, and pumps shall be de-contaminated for invasive and exotic viruses and species prior to use and after use. This included a) inspection, b) draining of water, c) disposal of aquatic organisms in trash, and d) washing equipment with >140F water OR high-pressure water OR allowing equipment to dry thoroughly for five days.

XII. Sediment and erosion control:
  a. Effective soil erosion measures shall be in place during the entirety of the project.
  b. Construction shall be accomplished in such a manner as to minimize erosion and siltation into surface waters and as specified in the plans and procedures that are part of or approved pursuant to this permit.

XIII. Sediment, concrete, and non-hazardous waste stockpiles:
  a. The permit holder must not deposit or store any of the graded or excavated materials in any wetland or below the ordinary high-water mark of any waterway. All graded or excavated materials must be placed out of the floodway of any stream.
  b. The permit holder must remove and properly dispose of any debris, such as old concrete, pieces of metal, or any other debris that may have been deposited in the reservoir or on the bed of the river.
  c. The existing structures that are proposed to be abandoned must be completely removed from the site and properly disposed of and must comply with all Department solid and hazardous waste requirements.

XIV. Reservoir restoration:
  a. The permit holder must stabilize all sediment outside of the river channel in the manner specified in the Erosion Control Plan and approved by the Department.

b. Any exposed slopes after drawdown that appear to be erodible as identified by Department staff must be adequately stabilized. This could include the use of erosion control best management practices, recontouring of slopes, placement of riprap, etc.
c. The waterway for flow and navigation in the vicinity of the structure shall be restored as nearly as practicable to the conditions prior to the original construction of the dam.
d. The permit holder must remove the dam in the manner that will result in minimal long-term sediment deposition downstream from the dam. The permittee shall cease or modify drawdown at the require of the Department if the Department determines that detrimental, long-term sediment deposition is occurring. The permit holder shall make reasonable efforts acceptable to the Department to stabilize and restore downstream areas impacted by significant sediment deposition associated with dam removal.
e. Final site stabilization requires the re-establishment of native vegetation and "must not contain any exotic species."
f. There must be a post-abandonment site review performed by Department staff to assess fish passage and to assure portions of the dam structure have been removed from the channel.

The removal of Grimh Dam helped to shape dam removal designs currently accepted by Wisconsin regulators as many lessons were learned. First, large flood risks cannot reasonably be mitigated. As with many dam removals, Grimh Dam had insufficient flow capacity prior to decommissioning, and when cofferdams were constructed upstream the dam had even less flood capacity. Historically, cofferdams were seldom used, and many dams were "wet breached" such that the dam was demolished while retaining water and silt – posing risks to sudden releases of water and sediment downstream if the weakened dam remnant suddenly slid downstream or toppled. However, most state and federal dam safety regulators today require engineered cofferdams to isolate sections of large dams to remove water and silt loads prior to starting a controlled demolition sequencing. While this is safer during dry seasons, there is a risk that the cofferdam itself cannot withstand moderate flood events. In Wisconsin, a still-commonly accepted practice (listed in the WDNR's Waterway Handbook) is to use a 10-year flood as the minimum a dam must pass with cofferdams in place. However, the 10-year flood is based on historical flows (which seem to underpredict future flood intensity) and compounded annual overtopping risk creates a 10, 19, or 27% risk of overtopping in a one, two, or three year construction period, respectively. As luck (or unluckiness) would have it for Grimh Dam, two rainfall events (4.0 inches of rain in seven hours and a separate event of 5.5 inches of rain in two days) both produced the then-accepted 10-year flood. The first flood overtopped the first stage cofferdam in early September and the second flood nearly overtopped the second stage cofferdam in one month later (during the normal low-flow month of October).

Grimh Dam also exposed the environmental unknowns associated with historical structures. The turbines were coated in lead paint, and asbestos was prevalent throughout the building's roofing and window frames. The project's asbestos items were fairly inexpensive (approximately $11,000) to abate in the first weeks of construction, and lead was addressed by selling the turbines intact to a turbine restoration company. During the project's second year and after demolition of the top powerhouse layers, fuel-contaminated soil was discovered in soil lenses between the foundation boulders and below the concrete slab of the powerhouse's old diesel generator building. Fuel leaking from a diesel generator or adjacent fuel tanks over many decades had reached groundwater levels and created a plume of diesel range organic exceedances. The unexpected contamination required extensive remediation of the dam's right embankment, including an additional $100,000 to haul contaminated soils to a landfill and complete the required DNR testing and site deed restriction paperwork.

The biggest challenge for the Grimh Dam removal designers and regulatory reviewers was the sediment that had filled the reservoir. During 75 years of project operation, the reservoir had amassed 115,000+ cubic yards of extremely soft sediments. As mentioned in the permit conditions, the WDNR required the owner to post warning signage around the flowage to keep unwary trespassers from sinking into many feet of soft sediment. While typical riverine sand drains easily, it became apparent that the impounded silts and clays were going to take many years to dewater and stabilize. Through frequent, purposeful communication with the WDNR and owner, Ayres was able to inform all parties about risks of sediment mobilization during each removal phase. While the WDNR retained the right to stop the removal process at any time, the WDNR did acknowledge that the project would release sediment and no practicable alternative existed to prevent the release of impounded sediment downstream. During discussions with Ayres, the WDNR acknowledged the following risk reduction measures: 1) sediment "dilution" since the larger Chippewa River was only 1.5 miles downstream of the dam, 2) partial sediment "consolidation / stabilization" since the reservoir had been half way drawn down for 10 years prior to removal, and 3) natural sediment "accommodation" as a slow release of the reservoir's remaining volume over two growing seasons would give time for the downstream reaches to adjust. These items were anticipated by the judicial permit conditions, and this framework of risk reduction measures was reiterated often in Ayres' future discussions with DNR staff.

Even after a decade of the lake drawn down halfway and a slow methodical drawdown and removal sequencing plan, sediment management was a significant challenge when compounded with high water events. For dam safety reasons, the WDNR permit restricted any work done onsite during high water, and this permit condition was implemented twice. Grimh Dam's cofferdam overtopped as four inches of rainfall fell in seven hours on September 25, 2010. An unknown quantity of sediment (possibly 5,000 to 10,000 cubic yards) was released during this single event to the Couderay and Chippewa Rivers. Consultation with DNR dam safety and permitting staff was frequent, and all parties agreed that dam safety was the highest priority throughout the flood. Turbidity was high for three days (Figure 7), but then the river returned to normal color. Since the lake had refilled during the flood, the WDNR and Ayres waited for the lake to return to a drawn down condition for inspections of the remnant site. Within two weeks, Ayres' inspections of the rivers below the removal site found no evidence of new sandbars, no change in bedforms, and little evidence that a large volume of silt had been released. However, the reservoir clearly showed signs that up to three feet of channel bed incision had occurred during this single event. The contractor was allowed to resume work once the high water period had passed.

Figure 7. Couderay River below Grimh Dam during September 2010 flood event

Figure 8 shows how difficult construction access was, because protected wetlands downstream of the dam and fifteen feet of muck upstream of the dam limited contractor access to slowly working from dam ends toward the dam's middle.

Figure 8. Difficult site access at Grimh Dam, looking upstream at powerhouse

Figure 9 shows the site, looking downstream at the previous powerhouse location during the substantial completion inspection. This project was a highly collaborative project and also highly regulated with frequent DNR visits to the site. Figure 9 shows 4 DNR staff onsite during substantial completion and in the two years after completion many DNR upper management staff visited the site to see the results.

Figure 9. Complete removal of powerhouse by end of 2011, looking downstream at powerhouse site.

Throughout the three years of this project (2010 to 2012), deconstruction of Grimh Dam proceeded tenuously with uncertainty of not knowing when or if the WDNR would halt the construction activities due to sediment flux. While the WDNR did not require upfront dredging at Grimh Dam, the design team and owner had many conversations with the WDNR about what additional sediment stabilization measures might look like, and these conversations continued even up to the last month of deconstruction. In fact, at the end of the project all reservoir sediments had been exposed to at least two growing seasons, had vegetation growing on them, and yet were still easily liquefied by passing construction traffic. One sediment stabilization measure implemented was an additional 132 cubic yard berm of riprap to lessen headcutting into the final western channel bank, a good measure to retain 15 feet of soft sediments uphill of the new stream channel. After this riprap berm was placed, Ayres and DNR staff monitored the project through three additional years of slow head-cutting upstream before the head-cuts halted in a reach of large boulders. In short, sediment removal could have added $500,000 to $800,000 in construction costs, but the above risk reduction measures allowed a good balance between economical and environmental concerns by permitting the project to 1) slowly release sediments at the rate at which the natural environment could accept them and 2) undertake only reactive repairs to discrete areas of bank instabilities.

So how much of the 115,000+ cubic yards of impounded sediment actually passed through Grimh Dam? Interestingly, the dam appears to have contained more sediment than could have reasonably accumulated during the project lifetime. Ayres used the USGS' "Measurement and Prediction of Sediment Yields in Wisconsin Streams" (Water Resources Investigations 54-75) to estimate that the annual sediment transport budget in the Couderay River was about eight tons per square mile or 1500 tons per year reaching the Grimh Flowage. Over the project's lifetime this translates to about 60,000 cubic yards, but this means that the flowage must have contained either soft sediments retained upstream of the original rapids – or this sediment was more likely decomposed sawdust and lumber waste from the logging days. Regardless of sediment origin, the potential for a sudden release of 115,000+ cubic yards of impounded sediment was a great concern during the project. Ayres did not have full time observation onsite for the Grimh Dam project, but the contractor only removed 5,000 cubic yards of sediment from the forebay (mechanical dredging). The two floods that happened during the project each released another 10,000 to 15,000 cubic yards, based on the headcutting and bed elevation changes observed on the dewatered lakebed after the floods receded. By the end of two years of post-project monitoring, the former impoundment appeared to have lost 50,000 to 80,000 cubic yards, with the higher end assuming no dewatering compaction and the lower end assuming that many sediments reduced in volume due to dewatering and compaction. In summary, of the original 115,000 cubic yards, 5% was removed by the contractor through mechanical dredging, 20% was removed during two large floods, 5% (assumes compaction) to 30% (assumes no compaction) passed through the site in the two years of post-project monitoring, and the other 30% to 55% appears to have remained in the former impoundment (though still might be mobilized during future large flood events).

Figures 6 and 10 show, respectively, the before and after removal photographs (note the same house under the red arrow, though 15 years later).

Figure 10. Grimh Dam site three years post-removal

For Grimh Dam, the total dam decommissioning to removal process elapsed 15 years between the first newspaper publication of impending dam removal and the removal contractor's demobilization. The engineering, litigation, and permitting iterations took 12 years and approximately $200,000 in 2025 dollars, and construction took 3 years and $527,000 in 2025 dollars. Based on the final restoration outcomes (Figure 10), Ayres believes the Grimh Dam restoration is the best example of a dam removal in Wisconsin that balanced project costs and project outcomes.

Case Study 3: Douglas County Gordon Dam

Douglas County's Gordon Dam (46.237312°, -91.784047°) is 104.3 miles north-northeast of Powell Falls Dam. After a protracted search for a buyer, Dahlberg Light & Power decided to remove the 33-foot-high, 1550-foot-long Gordon Dam in 2010. An earlier FERC Petition for Declaratory Order and attempts to relicense the dam were stalled by requirements to increase hydraulic capacity and fix embankment seepage issues. Gordon Dam had very little public interest in preserving the lake because the dam owner, the State of Wisconsin, and a large timber company owned 95% of the flowage perimeter. The impoundment had minimal sediment near the dam, mainly because while the impoundment was full the river's sediments had dropped out in a long delta about a mile upstream of the dam. (These sediments remained stationary once the dam was half drawn down in 2010, but they did re-mobilize after the full drawdown was completed.) Environmental risk was also less. While there was some mercury found in the local soils and a few leaking underground storage tanks within the watershed, the sandy sediments in the upstream delta were not likely to contain heavy metals or other contamination sufficient to require dredging. Therefore, no dredging was budgeted for this project, and sediments removed from the site were considered acceptable for reuse as future road sands. Third, since lake sturgeon was the main species of interest in the watershed, stream restoration was designed to mimic the natural streambed downstream of the dam removal site.

Figure 11. Gordon Dam Pre-Removal

Ayres involved the WDNR and Corps of Engineers staff early in the Gordon Dam removal design process to discuss removal risks and reduce project uncertainties. DNR dam safety staff considered a cofferdam sized for the 10-year event to be sufficient, but desired the remaining reservoir head to be drawn down slowly over two construction phases. The WDNR set the removal expectations as removal of all the dam's concrete to either two feet below grade or bedrock (never found), and the WDNR requested the remaining embankments 1) not cause any backwater during the 100-year flood and 2) include at least some flat area as an overbank to mimic the floodplain of the downstream channel. These preferences were accepted early in the removal design phase and allowed both the owner and engineer to proceed with more certainty about project costs and review schedule.

The design uncertainty was reduced by following regulatory recommendations, extensive site testing, and collaborative restoration planning. First, Gordon Dam has no record of diesel generators near the waterway (these were downstream of the project and in an upland area), so the WDNR did not require tests for contaminated embankment soils. However, due to a state-owned facility upstream (a prison) and uncertainty about previous watershed activities, the reviewers requested that reservoir sediments be tested for heavy metals. Therefore, 25 holes were drilled through the ice to probe for sediment depths and collect samples for metals testing. The resulting field sampling and laboratory testing program reduced design risk by informing both the owner, DNR, and USACE that the bed sediments were primarily coarse sands and not soft silts. Since silts tend to carry more contaminants and mobilize easier than coarse sands, the design team could recommend faster drawdowns and less sediment excavation during construction. Second, native species seeding was recommended as the preferred restoration plan, especially for areas below the Ordinary High Water Mark because any seed sown on the exposed reservoir bed have a good chance of being transported during floods to environmentally sensitive areas downstream. Therefore, a three-step seeding plan (dry, mesic, and wet) was specified for this project to protect the downstream wild rice and wetland areas. Third, construction costs were more certain without the unknowns of impoundment stabilization (minimal sediment adjacent to the dam, but still used a double containment system for turbidity), contaminated soils (not found), or protracted delays due to contested case litigation (only one private landowner).

A USACE 404 CWA Permit and a DNR 401 WQC were required for the Gordon Dam removal. The WDNR also issued a Chapter NR 30 individual permit for dam abandonment. Key permit conditions for removal activities included:

1. All equipment, barges, boats, hoses, sheet pile, and pumps shall be de-contaminated for invasive and exotic viruses and species prior to use and after use. This included a) inspection, b) draining of water, c) disposal of aquatic organisms in trash, and d) washing equipment with >140F water OR allowing equipment to dry thoroughly for five days.
2. Nothing containing hazardous materials may be stored behind the temporary cofferdams when the contractor is not working.
3. No fill may be placed during freezing conditions.
4. All concrete portions of the dam and powerhouse must be removed in their entirety. (This permit condition was modified through consultation with the WDNR as controlled blasting was used to disintegrate the deep powerhouse foundation rather than remove it. The foundation was stuck in hardpan underlying five feet of quicksand, and the contractor proposed a method to blast the concrete foundation so that the reinforcement could be extracted. Reinforcement and concrete chunks larger than 24-inches diameter were removed, but shot rock / concrete was not removed.)
5. The staged drawdown and removal sequencing provided by the engineer must be followed exactly.
6. The upstream riprap and bank repairs are subject to the post-drawdown conditions and may be subject to change.
7. Dam owner must monitor sediment transport and notify GLIFW if wild rice beds are affected by sediment.
8. The dam owner must monitor the project site for a timeframe not less than five years. Any substantial excessive erosion or channel failure at the project site within five years must be mitigated in accordance with applicable state or federal code requirements.
9. The upstream channel may not be used as a heavy equipment route. (This permit condition was subsequently waived after an amended application explained why construction equipment required access and the lakebed access route was the least environmentally sensitive route.)
10. Effective soil erosion and sediment control measures shall be in place during the entirety of the project.

Figure 12. Gordon Dam removals' double turbidity containment system and diversion channel (image courtesy of and used under license of Google Earth Pro, 2020)

Removal of the Gordon Dam was completed by the same contractor (different foreman, different crew) who had removed Grimh Dam. However, the contractor had problems dedicating sufficient workers to the project on a regular schedule. For the first stage of construction (horizontal dismantling of the spillway), the intermittent construction schedule was not an adverse impact to the project as the slow reservoir drawdown kept the upstream banks stable However, as soon as the spillway was removed and the river entered the bypass channel shown in Figure 12, the sand delta upstream of the impoundment began cutting quickly which filled up the contractor's turbidity barriers (a double barrier system that included two sediment removal pools with a total usable sediment capacity of 400 cubic yards) faster than the contractor could remove sediment trapped by the barriers. During the first few months after the full drawdown, a four-person crew was required for four days a week just to keep the sediment traps cleaned. The contractor required significant pressure from the WDNR, owner, and Ayres to maintain turbidity barrier cleaning on a regular schedule. As with Grimh Dam, the WDNR prohibited dam removal progress during winter months due to environmental concerns, but with the sand bars coming downstream the WDNR did make the contractor clean the turbidity barriers' sediment traps all winter long, though cleaning slowed from twice weekly at first to once a month by the end of winter. Ayres regularly sent crews to the site all winter to wade pools or drill monitoring holes through the ice and check for sand levels.

Figure 13 shows the second-year removal (powerhouse foundation still shown), and this view shows the channel is carrying a significant bedload of sand nearly ten months after the full drawdown was completed.

Figure 13. Gordon Dam during second year of removal (image courtesy of Frank Dallam, DNR)

By the end of the Gordon Dam project, the contractor had emptied the double turbidity barriers about 16 times. Ayres used the USGS' "Measurement and Prediction of Sediment Yields in Wisconsin Streams" (Water Resources Investigations 54-75) to estimate that the annual sediment transport budget in the Eau Claire River was about 10 tons per square mile or 762 tons per year reaching the Gordon Dam delta. Over the project's lifetime this translates to about 33,000 cubic yards, all collecting in the delta until the dam removal drawdown was complete. Of this 33,000 cubic yards, 20% was removed by the contractor in the two sediment traps (double row of turbidity barriers), 30% passed through the site in the two years of post-project monitoring, and the other 50% appears to have remained in the upstream delta (though still might be mobilized during future large flood events).

To remove the 13,500 cubic yards of embankment fill and clean concrete chunks, Ayres requested and received permits to store the removed materials onsite. Figure 14 shows the berm built into the hillside, capped with topsoil and seeded. The relatively silt-less sands collected by the turbidity barriers were donated to the local township's borrow pit for possible reclamation as future road sand.

Figure 14. Gordon Dam's onsite permanent stockpile for removal materials

Figure 15 shows bank restoration efforts at two cut banks within the former flowage. The contractor used riprap and filter sand along the toe and regraded slopes to 3H:1V (horizontal to vertical; the site's round glacial sands required flatter than normal grades for stability).

Figure 15. Bank restoration efforts at Gordon Dam

Case Study 4: Yellow Medicine County Minnesota Falls Dam

The best-documented (and available for Ayres review) recent dam removals in Wisconsin are the above three case studies. However, the FERC license surrender process adds complexity that cannot be reflected in these three case studies. To help illustrate the likely complexity involved with decommissioning the Powell Falls project, Ayres believes the Minnesota Falls (44.791173°, -95.500250°) decommissioning project provides a more useful analogy, particularly in terms of a FERC license surrender, consultation, and subsequent regulatory conditions imposed for decommissioning[22]. The Minnesota Falls Dam facilities (Figure 16) were owned by Northern States Power d.b.a. Xcel Energy, but the City of Granite Falls was given preliminary licenses by the FERC over several years to generate 4.1 gigawatt-hours annually. Table 2 shows the MnDNR's Environmental Assessment Worksheet for this dam and lists the applicable permits.

Regulating Agency	Xcel Energy Minnesota Falls: Elapsed Time Since Scoping Meeting and Action	
State Historic Preservation Office	0.0 yrs	Cultural resource survey submitted to SHPO
All other agencies on this list	0.0 yrs	A scoping meeting was held in January 2010 with agencies
Environmental Assessment Worksheet (DNR)	1.5 yrs	Environmental impact study was not needed
State Historic Preservation Office	1.6 yrs	Ruled not eligible for the National Register of Historic Places
DNR Ecological and Water Resources	2.2 yrs	Permit authorizing removal
Yellow Medicine Co SWCD	2.4 yrs	Wetland Conservation Act Notice of Decision
Chippewa Co Land and Resource Mgmt	2.5 yrs	Land use permit application (grading and filling)
Yellow Medicine Co Zoning	2.5 yrs	Land use permit application (grading and filling)
Pollution Control Agency	2.7 yrs	401 water quality certification (monitoring plan approval)
Pollution Control Agency	2.7 yrs	Minn. Stats chap. 115 and 116 Clean Water Act
Mn Board of Water & Soil Resources	2.7 yrs	Withdrawal of wetland bank credits for mitigation
Pollution Control Agency	2.8 yrs	Construction stormwater permits
Army Corps of Engineers	2.8 yrs	404 Certification (discharge of fill into stream)
Upper Sioux Community	2.8 yrs	Restoration agreement between USACE, Sioux, and Xcel
DNR Ecological and Water Resources	2.9 yrs	Contractor's Water Control & Dredge Management Plan
Army Corps of Engineers	2.9 yrs	Notice to Proceed
Contractor Mobilization	2.95 yrs	Work began on December 14, 2012
Contractor Work Completed	3.15 yrs	Work was completed on February 4, 2013 (62 days later)

Table 2. Permits required for Minnesota Falls Dam Removal project[23]

Note that the timeline in Table 2 started after expiration of the last FERC license. Also note that the permitting process took about three years between the initial agency contacts in January 2010 and the contractor mobilization in December 2012. The Corps of Engineers and DNR also reviewed and approved a separate water level control permit[24] for cofferdams and dewatering (these are the 2.9 year milestones listed in Table 2).

The Minnesota Falls Dam Removal project costs are not available for public release[25] but they are commensurate to those expected by Ayres for the Powell Falls project.

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[22] Barr Engineering states that the Minnesota Falls removal was one of the few complete dam removals in Minnesota and established a permitting process for future dam removals. https://www.barr.com/projects/2387100300

[23] Xcel Energy. "Construction Documentation Report: Minnesota Falls Dam Removal Project." Dated December 2013. See also the Minnesota Falls Dam Removal. "Environmental Assessment Worksheet." Signed by the Environmental Planning Director on 28 June 2011.

[24] http://www.crookstontimes.com/article/20121129/News/121129485

[25] Xcel Energy. Email to Pete Haug from Elizabeth Karels Elizabeth.b.karels@xcelenergy.com received March 9, 2015. This information was released to Ayres Associates as sensitive information, acceptable to send to other FERC clients but not approved for release to the general public.

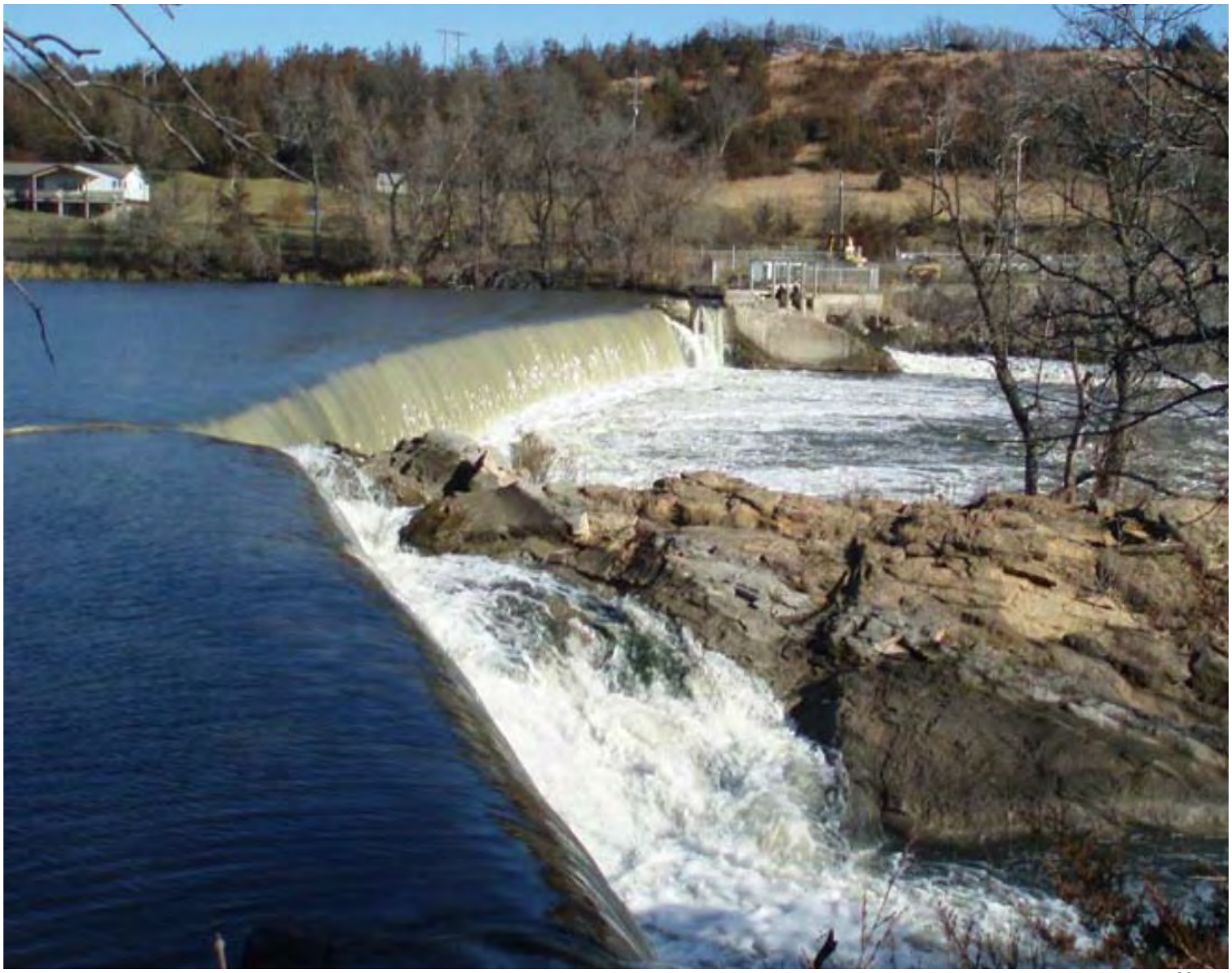
Figure 16. Pre-removal condition at Minnesota Falls Dam Removal (photo courtesy of Xcel Energy[26])

Citizen feedback[27] received during the Minnesota Falls Dam Removal project included a variety of concerns:

- Property value decline after removal
- Groundwater wells and a golf course holding pond drying up
- River water intake modifications (Granite Falls Energy's ethanol plant engineer originally estimated modifications to cost $2M, though they hired a contractor to relocate their intake after the dam was removed at a final cost of about $250,000)
- Loss of views for Granite Falls historical museums and parks

Most of the residents wanted the dam removed but preferred that a series of rock arch rapids be built to retain the previous headwater elevation upstream of the removed dam.

The Minnesota Pollution Control Agency required the project owner to complete extensive sediment contaminant testing. Sediment upstream of the Minnesota Falls Dam contained measurable amounts of arsenic, copper, nickel, total Kjeldahl nitrogen, phosphorus, and total organic carbon. However, none of

[26] Xcel Energy. "Construction Documentation Report: Minnesota Falls Dam Removal Project." Dated December 2013. Photo 1.
[27] "Attachment A: Public Comments Received on the Minnesota Falls Dam Removal Environmental Assessment Worksheet." 26 August 2011.

the metals were above the soil reference value guideline criteria, so the dam removal could reuse dredged materials in bank restoration projects. Less than 9,000 cubic yards of sediment were dredged for this project, just enough to remove the silt off the concrete structures and establish a stable grade back upstream to the new channel.

The total quantity of sediment released during the project is unknown. However, Minnesota State University and the USGS have determined the river passes a daily sediment load of 2700 tons, or 986,000 tons per year for the 14,900 square mile watershed supplying sediment to the USGS gage at Mankato.[28] The annual sediment load is approximately 66 tons per square mile of watershed. One interesting fact is that Minnesota DNR allowed winter drawdown and winter removal of Minnesota Falls Dam for the following reasons:

1. With less algae and less runoff, river disturbances were more easily monitored so that the contractor could adapt means and methods based on visual observations of turbidity. The contractor was permitted to release river turbidity at 25 NTU, a standard that could not have been met during normal summer flows;
2. Freezing conditions allowed dredged materials to be more easily transported (chunks rather than slurry); and
3. Colder water appeared to limit extent and duration of resuspension of sediments.

After expiration of the FERC license, the timeline of the Minnesota Falls Dam Removal project was typical. Plans[29] to remove the dam were submitted to regulating agencies in January 2010 and the dam was removed[30] in February 2013 (Figure 17). The construction was completed during low river flow conditions in mid-winter, and turbidity was monitored downstream of the worksite for most of the 62-day construction period. Construction was completed by equipment working in water to hydraulically hammer and demolish the structure in place. Once demolished, crews hauled sediment and clean concrete fragments to an onsite disposal location and other materials to approved landfill or recycling centers. The winter drawdown and dam removal efforts were successful at meeting the turbidity standards set by the state reviewers. Vegetation at the removal site was stabilized by September 2013, and the construction report (including post-construction monitoring provisions) was issued in December 2013.[31]

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[28] https://mrbdc.mnsu.edu/sediment-minnesota-river-basin and https://waterdata.usgs.gov/nwis/inventory/?site_no=05325000&agency_cd=USGS
[29] "Dam Removal." Drawings marked "Preliminary Draft," submitted to Xcel Energy, and dated 01 July 2010 and 17 June 2010. Drawings were incorporated into the Environmental Assessment Worksheet.
[30] http://www.minnpost.com/minnclips/2013/04/timelapse-minnesota-falls-dam-removal. Article shows a timelapse video of the dam removal.
[31] Xcel Energy. "Construction Documentation Report: Minnesota Falls Dam Removal Project." Dated December 2013. Pages 1 and 2.

Figure 17. Post-removal view of Minnesota Falls Dam (photo courtesy of Xcel Energy[32])

After upgrades to the local ethanol plant's water supply system and site restoration, the removal of the Minnesota Falls Dam was deemed successful by the project's owner. Ayres was unable to find online public opinions about how issues presented during the Environmental Assessment[33] (public enjoyment of the free-flowing stream, leaving a barrier to Asian Carp, sediment releases, well level impacts, etc.) were judged after project completion. A time lapse of the project available through the link below[34] shows the wet-breach and removal of the concrete spillway from left to right, looking downstream.

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[32] Xcel Energy. "Construction Documentation Report: Minnesota Falls Dam Removal Project." Dated December 2013. Photo 35.
[33] http://files.dnr.state.mn.us/input/environmentalreview/minnesota_falls/minnesota_falls_public_comments.pdf
[34] https://www.youtube.com/watch?v=C-VmAnmDyGA